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Medical Study of the Experiences of Submariners as Recorded in 1,471 Submarine Patrol Reports in World War II

IVAN F. DUFF

Commander, Medical Corps, U. S. N. R.

P-1295

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Preface

During World War II American submarines made approximately 1,520 war patrols in all areas of operation. At the completion of each patrol the commanding officers submitted a patrol report to the Chief of Naval Operations. To these, reviewing authorities attached appropriate summarizations and comments.

In the early days of the War these reports were often incomplete. They were quickly standardized, to include not only the daily log but detailed information or "paragraphs" on such subjects as "weather conditions", "enemy anti-submarine activity", "materiel casualties", "ration", "health of the crew", etc. Accumulation of these hundreds of successive reports has resulted in a valuable library of submarine experiences, copies of which exist in several Naval activities. As Naval tactical records their value must be tremendous. As records of great human interest and excitement they are sometimes not to be surpassed. They frequently contain passages of brilliant pungent writing such as is produced by men under stress.

The aim of this work has been to discover and assemble from these patrol reports all information which could possibly be related to the human factor in combat problems. The range of subjects, as perusal of the table of contents and index will reveal, is wide and varied.

What application may be made of these data? In this last War a large number of men made submarine war patrols, often of 50 to 60 or even 80 days' duration, during which time they lived under conditions peculiar to submarines. Information about their physical and mental response to this kind of warfare is of interest for the record alone, and was apparently almost totally lacking when this War started. Beyond this, their experiences can not be ignored in the preparations which must be made in the eventuality of future wars.

The author became interested in the contents of submarine war patrol reports early in his Naval career, especially those reports that applied to the habitability of the ships and health of the crews. While on duty at the U.S. Navy Bureau of Medicine and Surgery, Research Division, and with the encouragement of Rear Admiral H. W. Smith (MC) USN (Ret.), Capt. E. W. Brown (MC) USN (Ret.), and Capt. T. L. Willmon (MC) USN, the author undertook this project in the late fall of 1945. Through the courtesy of Capt. Karl G. Hensel, USN, at the Submarine Desk, Fleet Maintenance Section, Office of the Chief of Naval Operations, in the Navy Department, 1,471 of these patrol reports were made available for study. Return to civilian status has delayed completion of the survey until this time.

Answers to many medical questions probably will not be found here, or at the best may not be immediately apparent. The reason becomes obvious when one considers the conditions under which the patrol reports were written and the insignificance of medical information compared with data referring more specifically to the submarine's mission. Commanding officers, who wrote the reports, were not trained to make medical observations, and consequently the emphasis which they placed on the human factor depended to a large extent on personal aptitudes and interest.

For submarine personnel the author has not only great respect and admiration but also friendliness and affection. The temptation to laud these men unstintingly is great. There may be those who would have deleted or temporized some of the reported incidents, particularly those pertaining to personnel performance. To be of value, a record of this kind must be honest, especially when used to prepare for future eventualities. It is hoped the reader will peruse those particular pages with understanding and constructive criticism. If this report is worthy of dedication let us think of those of our friends who did not return from war patrols.

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Ann Arbor
29 April 1947

Explanatory Notes

The exact number of patrols which were made in all areas of operations in World War II is not known to the author. A total of 1,520 was reported from the Submarine Base at New London. Fourteen hundred and seventy-one reports were available for study in this project, of which 1,389 were from fleet-type submarines and 82 from S-type submarines. The following 56 submarine patrol reports were not available for analysis. Presuming that these are somewhere in existence, the total number of patrols made by American submarines would approximate the New London figure of 1,520.[1]

S-type Submarines

S-18 No. 4
S-30 No. 1,2,3
S-31 No. 1,2
S-32 No. 1,2
S-33 No. 1
S-37 No. 1,2,3,4,5,6
S-38 No. 1,2,3,4,5,6,7
S-40 No. 1,2,3,4,6
S-41 No. 1,2,3,7
S-42 No. 5
S-43 No. 1
S-46 No. 1,2
S-47 No. 5,6

Fleet-type Submarines

Bass No. 2
Bonefish No. 6
Gudgeon No. 3
Gunnel No. 1
Haddo No. 3
Herring No. 5
Narwhal No. 2
Pike No. 4
Plunger No. 9
Puffer No. 6
Saury No. 4
Shad No. 5
Spot No. 2
Thresher No. 1
Runner No. 2
Swordfish No. 4
Triton No. 1,2
Guardfish No. 9

[1] Data from 78 of the fleet-type reports, which has been included in this study, were collected previously by the author ("Account of the Health of the Crews and the Habitability of the Submarines of Squadron Eight Under Wartime Conditions", Conf. Report to Chief, BuMed, 1 Feb. 1945).

Submarines Overdue in World War II

Source: All Hands, Bureau of Naval Personnel Information Bulletin, Dec. 1945, p. 69.

Note: Ships = sunk by surface ships.
Exercises = overdue on exercises.

Submarines	Operations Area
Albacore	Overdue, Japan, Nov. 1944.
Amberjack	Overdue, off New Britain, Feb. 1943.
Argonaut	Ships, off New Britain, 10 Jan 1943.
Barbel	Overdue, off Borneo, Feb. 1945.
Bonefish	Overdue, Japan, May 1945.
Bullhead	Overdue, Java Sea, Aug. 1945.
Capelin	Overdue, Celebes Sea, Dec. 1943.
Cisco	Overdue, S. Pacific, Oct. 1943.
Corvina	Overdue, Marshalls, Nov. 1943.
Darter	Grounding, Palawan Passage, 24 Oct 1944.
Dorado	Overdue, Canal Zone, Oct. 1943.
Escolar	Overdue, Japan, Oct. 1944.
Flier	Overdue, off Borneo, Aug. 1944.
Golet	Overdue, Japan, Jun. 1944.
Grampus	Overdue, off New Britain, Feb. 1943.
Grayback	Overdue, Ryukyus, Feb. 1944.
Grayling	Overdue, Philippines, Aug. 1943.
Grenadier	Overdue, Malaya, Apr. 1943.
Growler	Overdue, Philippines, Nov. 1944.
Grunion	Overdue, Aleutians, Jul. 1942.
Gudgeon	Overdue, Marianas, May 1944.
Harder	Overdue, Philippines, Aug. 1944.
Herring	Overdue, Kuriles, May 1944.
Kete	Overdue, Ryukyus, Mar. 1945.
Largarto	Overdue, S. China Sea, Jun. 1945.
Perch	Ships, Java Sea, 3 Mar 1942.
Pickerel	Overdue, Japan, May 1943.
Pompano	Overdue, Japan, Sep. 1943.
R-12	Exercises, off Key West, 12 Jun 1943.
Robalo	Overdue, off Borneo, Jul. 1944.
Runner	Overdue, Japan, Jun. 1943.
S-26	Collision, Gulf of Panama, 24 Jan 1942.
S-27	Grounding, Aleutians, 19 Jun 1942.
S-28	Exercises, off Oahu, 4 Jul 1944.
S-36	Grounding, Makassar Str., 20 Jan 1942.
S-39	Grounding, off Rossell I., 14 Aug 1942.
S-44	Overdue, Kuriles, Oct. 1943.
Scamp	Overdue, Japan, Nov. 1944.
Scorpion	Overdue, E. China Sea, Jan. 1944.
Sculpin	Overdue, Gilberts, Dec. 1943.
Sealion	Bombed, Cavite, P.I., 10 Dec 1941.
Seawolf	Overdue, off Morotai I., N.E.I., Oct. 1944.
Shark I	Overdue, Molucca Sea, Feb. 1942.
Shark II	Overdue, off Hong Kong, Oct. 1944.
Snook	Overdue, off Hainan I., Apr. 1945.
Swordfish	Overdue, Ryukyus, Jan. 1945.
Tang	Overdue, Formosa, Oct. 1944.
Trigger	Overdue, Ryukyus, Mar. 1945.
Triton	Overdue, Admiralties, Mar. 1943.
Trout	Overdue, Ryukyus, Feb. 1944.
Tullibee	Overdue, off Palau I., Apr. 1944.
Wahoo	Overdue, Japan, Oct. 1943.

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Chapter 1

Health of Personnel and Habitability of Combat Submarines in World War II

Introduction

During World War II some 1,520 war patrols were made in all areas of operations by American submarines. There was an approximate average of 75 enlisted men and 8 to 10 officers aboard on each patrol, making a grand total of 126,160 man-patrols. Since the major function of the submarines was to sink enemy ships, any cause or combination of causes which operated to prevent the accomplishment of the primary mission had military significance. Illness or impaired habitability in some instances was related to inability of the ship's crew to function efficiently and purposefully. The importance, in this light, of the overall picture of health of personnel and acceptability of habitability features of combat submarines becomes obvious.

DEATHS OCCURRING ABOARD SUBMARINES ON WAR PATROLS

Throughout the war, as far as can be determined from available patrol reports, some sixty-two submarine personnel lost their lives on thirty-one patrols. These have been classified as follows:

Table 1.

Cause of Death	Number of Men	Patrols Reporting
Asphyxiation	26	1
Drowned - lost over the side	17	13
Killed - battle injuries	12	10
Killed - accidental	3	3
Suicide	1	1
Pneumonia	1	1
Malignancy	1	1
Unknown	1	1
Total	62	31

U.S.S. Bass, No. 4.

DEATHS DUE TO ASPHYXIATION

One of the more tragic episodes occurring aboard submarines during World War II took place on the fourth patrol of the BASS when, consequent to a fire in the after battery compartment, 26 crew members trapped in this compartment were asphyxiated. Details of this accident will be found under that section dealing with fires aboard operating submarines.

DEATHS DUE TO DROWNING - LOST OVER THE SIDE

As will be observed, 17 men on 13 patrols lost their lives consequent to drowning. The cause of these deaths has been analyzed in that section dealing with injuries aboard combat submarines. In general, men were lost from the bridge in severe weather (hurricanes and typhoons) on diving, and while working topside "shifting the vents", inspecting battle damage, battle surface, repairing of deck guns, manning the anchor watch, retrieving flotsam, etc.

DEATHS DUE TO BATTLE INJURIES

These deaths have been discussed in detail in the section "Injuries Aboard Combat Submarines". Of approximately fifty men injured in battle surface, ten were either killed instantly or died aboard the submarines of their wounds. Two men, in addition, were killed when submarines were strafed by enemy planes.

ACCIDENTAL DEATHS

Three men lost their lives accidentally aboard operating submarines. On the BLUEBACK (No. 4) the gunnery officer was instantly killed while checking the twin machine gun topside, when two .50 caliber bullets passed through the lower part of his chest. On the ninth patrol of the POLLACK, one man, sustaining a head injury when caught between two torpedoes, died approximately ten hours later of severe intracranial injuries. On the first patrol of the TULLIBEE a man, who incurred internal injuries when thrown hard against the lookout platform railing by a large wave, died approximately 17 hours later.

MISCELLANEOUS

Prior to the first patrol of the LARGARTO, during the training period at Panama, "a Chief Petty Officer died aboard". No further details concerning his death are known. On the first patrol of the HAKE one man died at sea "apparently from an internal hemorrhage--". "Investigation by the squadron medical officer indicated that the cause of death may have been a malignant growth." Aboard the GUITARRO (No. 3) one man died while on the patrol of DU (pneumonia); no further details concerning this death are known.

On the first patrol of the BUGARA, enroute to Saipan from Pearl Harbor, one man committed suicide. A suicide is known to have occurred on a second submarine, a Manitowoc boat, at the time it was being ferried down the Mississippi River. An officer from the LARGARTO was killed in an automobile accident on the island of Saipan while that ship, on her first patrol, was undergoing voyage repairs enroute to her area of operations. An enlisted man from another submarine, undergoing a refit at Midway, was lost when a plane, which he was aboard as a passenger, crashed at sea. At the end of the first patrol of the SEA FOX, while refitting at Guam, several members of the crew were injured--some fatally by Japanese guerrillas.

HEALTH AS A LIMITING FACTOR IN DURATION OF SUBMARINE OPERATIONS

In this last war on approximately 29 patrols, health was a major or a contributing factor limiting the duration of operations. These instances have been grouped as follows:

Table 2.

Condition	Number of Patrols
Excessive personnel fatigue	9
Illness of commanding officer	6
Battle casualties	5
Appendicitis, acute	2
Multiple asphyxiations	1
Injuries	1
Pneumonia	1
Mumps	1
Mental disease	1
Copper sulfate poisoning	1
DU (fever)	1
Total	29

EXCESSIVE PERSONNEL FATIGUE

This subject has been discussed fully in the section entitled "Personnel Endurance in Submarine Warfare in World War II". Suffice it here to list those patrols, with a few descriptive remarks, on which excessive personnel fatigue was a major factor in limiting the endurance of the submarine:

"Physical endurance of personnel was '0' days. Patrol ended by fatigue and sickness (60 sick days, generally upper respiratory infections) of officers and enlisted personnel" (GUDGEON No. 2).

"On March 18, due, in part, to extreme physical exhaustion of all hands--started south by shortest route" (PORPOISE No. 2).

"On 11 May, headed for the barn; all hands completely beaten down. It was not until the first day of surface cruising on the 17th that I considered either myself or the crew capable or competent to go into action again" (S-42, No. 1).

The second patrol of the GATO was terminated, in part, due to "the end of personnel endurance--poor habitability, long hours submerged, cold water, acute communicable disease with 35 sick days".

"During the last week or ten days on station, increasing personnel fatigue was primary cause of ending the patrol" (GREENLING No. 2, 29 sick days).

"Illness and personnel fatigue on 40th day--became too great for additional effective patrol on station" (GREENLING No. 4, 43 sick days).

"Fatigue of personnel was a factor of endurance which ended this patrol" (GRAYLING No. 2).

"Heavy taxation of the crew and officers led the commanding officer to discontinue the patrol a few days early" (GRAYBACK No. 3).

"Fuel, torpedoes, and provisions were available for a much longer stay in the area but human endurance was lacking" (GROUPER No. 1).

The following patrols were concluded with personnel endurance at a minus quantity and would have terminated the cruise had operations orders not done so: NAUTILUS No. 4, PLUNGER No. 4, S-34 (No. 3), S-43 (No. 2), and the S-33 (No. 2).

ILLNESS OF COMMANDING OFFICERS

Illness of commanding officers on a few occasions was reason for terminating submarine operations as follows:

On the second patrol of the POMFRET: "On--the commanding officer collapsed losing partial use of his legs due apparently to a spinal or nervous system injury--with severe pain in the back and thighs. This unfortunate illness--necessitated return of the submarine to Saipan."

The fourth patrol of the HAMMERHEAD and the fifth patrols of the HARDHEAD and the PERCH were terminated by illness of the commanding officer, concerning which no further details are known.

The second patrol of the SPEARFISH was terminated upon the commanding officer's request for relief of his command: "I have reported--to ComSubPac--and believe that I am wasting the time and submarine's efforts when I expose it to attack and then fail to realize on the risk. I need rest."

On one other patrol (GRENADIER No. 1): "The commanding officer said he returned because he was tired."

BATTLE CASUALTIES

Serious battle casualties were responsible for terminating patrol operations in the following instances:

"The patrol was terminated one day prior to that scheduled by the operations orders to bring the two wounded men (battle surface) to port" (HALIBUT No. 9).

"It was considered inadvisable to keep the three wounded men (battle surface) aboard thirty days without a doctor's attention unless the military situation in the area required it" (SEA POACHER No. 2).

The second patrol of the GUAVINA was "terminated in that one of the twelve pilots rescued required surgical attention". The sixth patrol of the POMFRET and the third patrol of the THREADFIN were also terminated for the same reason.

APPENDICITIS

Although, as will be seen in the following section, appendicitis interrupted several patrols, according to the reports it was the cause for termination of operations in only the following instances:

"The patrol was terminated due to the expenditure of torpedoes, low fuel and serious condition (appendicitis) of the pharmacist's mate" (PARCHE No. 2).

The REDFIN on her third patrol, was "ordered to return to base one week early prior to termination of the patrol because of one man seriously ill with an attack of acute appendicitis".

MISCELLANEOUS

The fourth patrol of the BASS was terminated by a serious fire in the after battery compartment with the asphyxiation of 26 members of the crew. On the third patrol of the S-23: "with two emergency hospital patients aboard, stood into Dutch Harbor". The first patrol of the S-35 was terminated by a contagious disease, mumps. The sixth patrol of the S-18 was "interrupted on orders--because of the presence aboard of a mentally ill patient". A patient, seriously ill with pneumonia, was cause for termination of the third patrol of the PLAICE. The third patrol of the ANGLER was "terminated early due to the sudden outbreak of poisoning which incapacitated most of the officers and crew". It was believed due to contamination of the drinking water with excessive amounts of copper sulfate.

On the ninth patrol of the SHAD, one man with DU (fever) was apparently responsible "for orders ending the patrol two days earlier than the terminating date given in the operations orders. This man had a high temperature for four days with headache, chills, rash, swollen throat; intravenous feeding was necessary for five days."

HEALTH AS CAUSE FOR INTERRUPTION OF PATROL OPERATIONS

Upon a number of occasions, for various reasons, health was cause for temporary interruption of submarine operations. In so far as it has been possible, these have been collected as follows:

ILLNESS OF COMMANDING OFFICERS

On the third patrol of the S-31, the commanding officer received serious chest injuries (the ship did not carry a Pharmacist's Mate) for which he was transferred, at sea, to a PBY. Eight or nine days after leaving Saipan the CAIMAN (No. 1) returned to transfer her commanding officer with DU (appendicitis). On the first patrol of the SKIPJACK the commanding officer's shoulder was dislocated. "Previous experience has proven that it takes about a week before the arm can be used; therefore, it is considered inadvisable to carry out Serial No.---- until it is possible for the CO to go up and down the ladder and operate the periscope." In the third patrol report of the CHARR appears the statement: "Captain ill--intend to proceed slowly until his health improves." On the sixth patrol of the MUSKALLUNGE: "In the patrol area, Comdr.---- from the COD relieved Lt. Comdr.---- as commanding officer due to illness of the latter." (Transferred to Guam for treatment).

Illness of the commanding officer is mentioned in the following patrol reports: GAR No. 13, POMFRET No. 4 (measles), SEARAVEN No. 5 (measles), SAURY No. 11 ("gum infection"), SKIPJACK No. 10 (battle surface wound), TRUTTA No. 1 ("mangled hand" - periscope injury), WHALE No. 2 (arthritis), S-41, No. 5 (severe cold), S-35, No. 5 (bridge injury). The commanding officer of the HADDOCK (No. 11) was seriously wounded while

ashore on the island of Saipan. A second officer from another submarine was killed in the same accident (LARGARTO).

MASS ILLNESSES

As observed elsewhere, upon occasion mass illness among submarine crews was the cause of interruption or impairment of patrol operations, for details of which readers are referred to the following reports:

Excessive copper sulfate content of the drinking water on four patrols (SARGO No. 3, ANGLER No. 2, RASHER No. 2, REDFIN No. 2) had sufficient effect to seriously impair the efficiency of the ship, causing termination of one patrol (ANGLER No. 3).

It appears certain that the use or presence of carbon tetrachloride accounted for serious illness aboard a number of submarines, sometimes having an adverse effect on battle efficiency (BLACKFISH No. 9, STEELHEAD No. 1, BAYA No. 3, COD No. 2, SWORDFISH No. 5 and 6, PLAICE No. 1).

Mass illness, unexplained, possibly in the nature of "food poisoning", copper sulfate or carbon tetrachloride poisoning, occurred aboard the GRAMPUS No. 1, SKIPJACK No. 2 and 3, POLLACK No. 3, STURGEON No. 7, BLUEFISH No. 5, RAZORBACK No. 2, SEADRAGON No. 1 and 8, and SKATE No. 2.

BATTLE CASUALTIES

Battle casualties caused interruption of the following patrols: SKATE No. 1, SNAPPER No. 10, SNOOK No. 3, and COBIA No. 4.

An accidental gunshot wound aboard the APOGON (No. 3) was cause for the return of the submarine to Johnston Island for transfer of the patient.

APPENDICITIS

As observed above, DU (appendicitis) was cause for interruption of the first patrol of the CAIMAN. It was also cause for interruption of the following patrols: FINBACK No. 1 (six day interruption to deliver patient to Dutch Harbor), HADDOCK No. 4 (the commanding officer, who had assisted on the operation aboard the SILVERSIDES, decided to return to Midway with a case of appendicitis), PIPEFISH No. 3 ("On--departed company of SEARAVEN to proceed independently to Saipan to obtain medical aid for a man suffering from acute appendicitis"), SEARAVEN No. 13 ("On--enroute to Saipan left formation to proceed with best speed with case of appendicitis aboard"), SHAD No. 8 ("On 9 Nov PhM reported possible case of appendicitis--changed course for Saipan. On 10 Nov disappearance of pain and fever was reported--could only infer that appendix had ruptured or that original diagnosis was incorrect--proceeded on patrol"), and STEELHEAD No. 7 ("On 1 June appendicitis patient reported--requested rendezvous for transfer--departed patrol station off Truk for rendezvous with USS OSMUS"). On the fifth patrol of the S-35 rendezvous was made and a patient was transferred with this diagnosis to a destroyer.

MISCELLANEOUS

The fourth patrol of the COBIA was interrupted twice for reasons of health. On 21 February, following an engine room casualty, the submarine returned to Exmouth Gulf with two men who had suffered from exposure to smoke--"the next day, having shown no improvement, reversed course and proceeded full speed for Exmouth and medical assistance". On 26 February, in a gun battle with two sea trucks, one man was seriously injured. "--the Pharmacist's Mate decided that there was a chance of saving his life if we could get him to a hospital--." The man died the following day. Aboard the LAPON (No. 4) "because of serious condition of man (septicemia) headed for Exmouth". The patient was transferred, the submarine continuing on her patrol. The tenth patrol of the SHAD was interrupted when on "4 August--commissary officer had acute renal colic; course reversed". (Transferred next day to PC-1598). On the tenth patrol of the KINGFISH: "Requested rendezvous for transfer of a sick officer (acute tonsillitis)" --transferred to SPEARFISH.

Table 3.--MILITARY SIGNIFICANCE OF DEFECTIVE HABITABILITY ABOARD SUBMARINES ON WAR PATROLS

In these series of reports, note was made of patrols on which limitation of endurance could be attributed to various unfavorable features of habitability. Special details of these patrols are presented elsewhere. It will be observed that the total number, in comparison with the total number of patrols made during the course of the war, is very, very, small.

Submarine	Patrol No.	Year	Limiting Factor of Endurance
Porpoise	2	1942	Lack of air conditioning.
Tautog	1	1942	Limitation potable water capacity.
Bass	4	1942	Serious battery fire.
S-35	5	1942	Serious control room fire.
Angler	3	1944	Excessive copper salt content drinking water.
S-47	3	1942	Fresh water a factor limiting patrol duration.
S-38	8	1942	In part, amount of drinking water consumed.
Apogon	2	1944	Fresh water shortage contributed to ending patrol.

UNFAVORABLE HABITABILITY AS CAUSE OR RELATED TO REDUCED EFFICIENCY OF SUBMARINES ON PATROL

(In a few instances impaired habitability was the cause of or contributed to reduced efficiency of submarines while on patrol. These, discussed in detail elsewhere, are listed here.)

Submarine	Patrol No.	Year	Limiting Factor
Nautilus	4	1943	Poor air conditioning (excessive heat and humidity and fatigue of crew) contributed to decision not to engage the enemy.
Tambor	2	1942	"Lack of air conditioning decidedly had a debilitating effect on crew and slowed their reactions."
Plunger	5	1943	Faulty air conditions (excessive heat and humidity and fatigue of crew) led to breaking off enemy contact.
Tautog	2	1942	Faulty air conditions (excessive heat, humidity, and lack of ventilation) led to reduced efficiency of control party in long approaches.
S-42	1	1942	"In enemy controlled tropical waters without air conditioning, the crew of a 20 year old 'S' boat are subjected to severe strain with a serious loss of efficiency."
S-43	2	1942	"Habitability poor--with personnel exhaustion due to high temperatures and humidity in all day dives."
Spearfish	8	1943	After prolonged submergence (22 hr) broke off enemy contact--"the very foul air had visibly affected all hands".
Pike	8	1943	"Crew worn out from intense heat and high humidity--twenty men incapacitated for duty." "The intense heat generated in maneuvering room when rigged for depth charge in tropics gives cause for concern."
Triton	5	1943	"--the heat was so great as to most certainly impair our efficiency had enemy attacks continued." (silent running)
Skipjack	3	1942	"--we had been down 16 hours now--the air is bad and all hands are pretty well exhausted--."
Puffer	1	1943	After 37 hours of submergence--"toward the end stations were manned by volunteers and by men who had stamina and will to move and think. Many of others past stage of caring what happened."
Grenadier	4	1942	"Chlorine gas--affected efficiency of entire personnel for several days."
Blackfish	9	1944	"Patrol somewhat handicapped by poisoning (carbon tetrachloride) which affected majority of crew over ten day period." "Battle efficiency has been practically zero, especially at night."

Submarine	Patrol No.	Year	Limiting Factor
Steelhead	1	1943	"Patrol undoubtedly handicapped by sickness which affected a large number of crew over two week period while in patrol area." (Possibly due to carbon tetrachloride).
Cod	2	1944	"The fact that 90% of the officers and crew suffering from carbon tetrachloride poisoning--was in great measure--responsible for the failure to develop an attack--."
Sargo	3	1942	"Poor quality of water (excessive copper salt content) could not help but lower the general efficiency of the ship as a fighting unit."
Angler	2	1944	"In last week of patrol, one-third of officers and crew vomiting (excessive copper salt content of drinking water)."
Redfin	2	1944	"This deficiency in the water system (excessive copper salt content) greatly reduced efficiency of the officers and the crew."
Rasher	2	1944	"Debilitation and lowered efficiency among crew (possibly excessive copper salt content of water) throughout the patrol."
Grampus	3	1942	"Sickness (possibly excessive copper salt content of drinking water) seriously affected efficiency of the boat and its recurrence is matter of serious concern."
Lapon	6	1944	Unable to follow up military advantage because of mass illness "attributed to excessive fatigue and carbon dioxide poisoning."
Gato	2	1942	Patrol terminated in part due to end of personnel endurance due to "poor habitability, high humidity, cold water, long hours submerged".
Narwhal	4	1943	"Overcrowding, excessive carbon dioxide, seasickness and long exhausting trip by submarine" contributed to deterioration of physical condition of troops while aboard.

Chapter 2

Health of the Crew

Paragraph "P" in submarine war patrol reports was concerned, in part, with the health of the crew. The significance of medical information contained within these reports has been questioned. In most instances, the pharmacist's mate, at the end of the patrol, made a written report to the commanding officer which was commonly incorporated into the official war patrol report. The limitations of pharmacist's mates in collecting such information was real but most of them did a good if not an excellent job. Sometimes, the commanding officer wrote his own report of the health of the crew and habitability of the ship which may or may not have agreed with that submitted by his hospital corpsman.

These reported and encountered diseases and conditions aboard combat submarines have been classified according to the official diagnostic nomenclature as listed in the Manual of the Medical Department, U.S. Navy. Bearing in mind the limitations of our source of information, it is felt that the following figures do indicate trends and are valuable in depicting the general picture of the health of submarine personnel.

Table 4.--COMPARATIVE STANDING OF ENCOUNTERED DISEASES AND CONDITIONS

Diagnostic Title and Classification	Patrols Reporting	Cases Reported	Patrols Reporting Sick Days	Sick Days Reported
Communicable Diseases (VIII-X)	402	2,363	213	1,078
Injuries (XXV)	687	1,212	164	1,069
Diseases of the Digestive System (III-IV)	332	1,758	149	1,094
Diseases of the Skin (XIX, XXII, XXIII)	196	1,340	25	167
Diseases of the Infectious Type (XIII-XIV)	248	374	100	621
Diseases of the Genito-Urinary Tract (VII-XII)	171	338	44	307
Diseases of the Ear, Eye, Nose, and Throat (V-VI)	136	273	34	148
Miscellaneous (XXI)	65	712	6	12
Dental Diseases (XXVII)	71	155	19	73
Diseases of the Mind and Nervous System (XV-XVII)	59	62	9	32
Diseases of the Motor System (XVI)	21	27	8	83
Diseases of the Lung (XVIII)	8	9	2	4
Diseases of the Blood and Circulatory System (I-II)	7	7	2	22
Poisonings (XXVI)	(*)	(*)	(*)	(*)
Submarines reporting sick days without cause being known	16	(*)	(*)	289
Total	2,419	8,630	775	4,999

Statistical and factual information concerning encountered diseases and conditions as reported occurring aboard submarines on war patrols in World War II.

DETAILED DIAGNOSTIC CLASSIFICATION OF DISEASES AND INJURIES

Table 5 — COMMUNICABLE DISEASES

Disease	Patrols Reporting	Cases Reported	Patrols Reporting Sick Days	Sick Days Reported
"Colds"	83	1,419	25	94
Catarrhal Fever, Acute	133	404	109	416
Angina, Vincent's	36	176	2	7
"Sore Throats"	32	155	10	38
Tonsillitis, Acute	48	92	29	146
Influenza	13	23	9	74
Mumps	10	21	4	35
Measles, German	14	18	2	22
Fever, D.U.	6	19	6	83
Malaria, D.U.	10	15	5	54
Pneumonia, D.U.	10	11	6	56
Dengue Fever	2	5	2	33
Chicken Pox	2	2	2	20
Meningitis, D.U.	2	2	2	(*)
Scarlet Fever	1	1	(*)	(*)
Total	402	2,363	213	1,078

* Unknown.

Table 6 — INJURIES

Disease	Patrols Reporting	Cases Reported	Patrols Reporting Sick Days	Sick Days Reported
Wounds, Lacerated	235	446	47	331
Contusions, Sprains & Abrasions	190	295	45	215
Burns, Unclassified	70	101	18	70
Wounds, Shrapnel, Gun Shot	33	73	11	100
Fractures, Unclassified	67	71	18	195
Heat Exhaustion	29	74	5	15
Sunburn	6	32	1	2
Asphyxiation	3	29	†0	0
Rupture, Traumatic				
Hernia, Inguinal	5	22	4	67
Ear Drum	(*)	10	2	7
Amputation, Traumatic	15	16	4	13
Dislocations	11	13	1	20
Intracranial Injury	8	12	3	14
Submersion, Non Fatal	6	8	4	10
Foreign Body, Traumatic (eye)	6	7	1	10
Electric Shock	3	3	‡0	(*)
Total	687	1,212	164	1,069

* Unknown.
† Twenty-six killed.
‡ Two fatal.

Table 7 DISEASES OF THE DIGESTIVE SYSTEM

Disease	Patrols Reporting	Cases Reported	Patrols Reporting Sick Days	Sick Days Reported
Gastro-Enteritis, Acute	108	854	52	317
Constipation	46	691	2	12
Appendicitis*	116	127	67	578
Abdominal Pains, D.U.	19	30	8	36
Diagnosis Undetermined	25	27	15	108
Hemorrhoids	8	15	1	3
Ulcer (Mouth)	3	7	1	20
Ulcers (Gastric), D.U.	3	3	0	0
[illegible]	3	3	1	7
Obstruction, Intestinal	2	2	1	7
D.U. (Gall Bladder)	1	1	1	6
D.U. (Thyroiditis)	1	1	1	7
Total	332	1,758	149	1,094

* Diagnosis Appendicitis includes: Appendicitis, acute, 68; D.U. (appendicitis), 48; Chronic appendicitis, 11; Total, 127.

Table 8 DISEASES OF THE SKIN

Disease	Patrols Reporting	Cases Reported	Patrols Reporting Sick Days	Sick Days Reported
Fungus Infections	63	645	9	60
Heat Rash	25	322	2	8
Pediculosis, Pubis	21	126	0	0
Scabies	25	104	2	13
Dermatitis, D.U.	24	83	2	26
Cyst, Sebaceous	16	26	7	29
Ulcer, Skin	5	13	1	21
Urticaria	8	9	0	0
Ingrowing Nail	3	6	0	0
Herpes	5	5	2	10
Lung Tumor, D.U.	1	1	0	0
Total	196	1,340	25	167

Table 9 DISEASES OF THE INFECTIOUS TYPE

Disease	Patrols Reporting	Cases Reported	Patrols Reporting Sick Days	Sick Days Reported
Cellulitis	135	193	66	386
Furuncles	74	131	16	62
Jaundice, Acute Infectious	14	21	5	68
Lymphadenitis	9	11	5	39
Abscess	8	10	3	17
Rheumatic Fever	6	6	3	30
Carbuncles	2	2	2	19
Total	248	374	100	621

Table 10 DISEASES OF THE GENITO-URINARY TRACT

Disease	Patrols Reporting	Cases Reported	Patrols Reporting Sick Days	Sick Days Reported
Gonorrhea Urethra, Acute	37	109	5	45
Urethritis, Acute, Non-Venereal	33	67	6	26
Gonorrhea Urethra, D.U.	25	56	5	31
Prostatitis, Unclassified	8	24	1	6
Penile Lesions, D.U.	18	20	5	28
Syphilis	11	16	3	52
Renal Disease, D.U.	10	15	3	22
Calculus, Urinary System	12	13	7	35
Epididymitis, Acute and Orchitis, Acute	10	11	5	25
Cystitis, Acute	5	5	3	29
Balanoposthitis	1	1	0	0
Varicocele	1	1	1	8
Total	171	338	44	307

Table 11 DISEASES OF THE EAR, EYE, NOSE, AND THROAT

Disease	Patrols Reporting	Cases Reported	Patrols Reporting Sick Days	Sick Days Reported
Otitis, Externa (Otomycosis)	22	84	2	14
Conjunctivitis, Unclassified	37	67	20	55
Earache, D.U.	14	32	1	3
Eye Complaints (Strain)	9	28	0	0
Sinusitis, Acute	14	17	3	28
Otitis Media, Acute	11	13	2	7
Ear Infections, D.U.	9	11	4	29
Tonsillitis, Chronic	6	6	0	0
Stye	5	6	0	0
Mastoiditis, Acute, D.U.	5	5	2	12
Ear Wax, Accumulated	4	4	0	0
Total	136	273	34	148

Table 12 MISCELLANEOUS

Disease	Patrols Reporting	Cases Reported	Patrols Reporting Sick Days	Sick Days Reported
Headache	28	624	0	0
Seasickness (Motion sickness)	36	87	5	11
Anti-Inoculation	1	1	1	1
Total	65	712	6	12

Table 13 DISEASES OF THE BLOOD AND CIRCULATORY SYSTEM

Disease	Patrols Reporting	Cases Reported	Patrols Reporting Sick Days	Sick Days Reported
Heart Disease, D.U.	5	5	1	16
Hemophilia	1	1	1	6
Epistaxis	1	1	0	0
Total	7	7	2	22

Table 14 POISONINGS*

* Insufficient data for compilation.

Table 15 DISEASES OF THE MOTOR SYSTEM

Disease	Patrols Reporting	Cases Reported	Patrols Reporting Sick Days	Sick Days Reported
Arthritis, Unclassified	10	11	4	41
Bursitis, Acute	6	7	3	34
Myositis, Acute	3	3	1	8
Rheumatism, Muscular	1	5	0	0
Osteomyelitis, Acute, D.U.	1	1	0	0
Total	21	27	8	83

Table 16 DENTAL DISEASES

Disease	Patrols Reporting	Cases Reported	Patrols Reporting Sick Days	Sick Days Reported
Toothache	50	85	16	68
Gingivitis, Unclassified	14	52	1	2
Extractions	7	18	2	3
Total	71	155	19	73

Table 17 DISEASES OF THE LUNG

Disease	Patrols Reporting	Cases Reported	Patrols Reporting Sick Days	Sick Days Reported
Tuberculosis, Pulmonary	3	4	0	0
Pleurisy, D.U.	4	4	2	4
Asthma	1	1	0	0
Total	8	9	2	4

Table 18 DISEASES OF THE MIND AND NERVOUS SYSTEM

Disease	Patrols Reporting	Cases Reported	Patrols Reporting Sick Days	Sick Days Reported
Psychoneurosis, Anxiety*	23	†25	1	4
Psychoneurosis, Hysteria	8	9	1	2
Psychoneurosis, Unclassified	6	6	0	0
Psychosis, Unclassified	5	5	1	11
Neuritis, Unclassified	6	6	1	10
Paralysis, Unclassified	2	2	3	1
Paralysis, Facial Nerves	2	2	0	0
Epilepsy	2	2	0	(‡)
Migraine	2	2	1	2
Diagnosis Undetermined (Syncope)	2	2	1	2
Diagnosis Undetermined (Vertigo)	1	1	0	0
Total	59	62	9	32

* U.S. Navy Medical Department Nomenclature (1945).
† Classified as nearly as possible from the sometimes sketchy case histories obtainable from the patrol reports.
‡ Unknown.

COMMUNICABLE DISEASES ABOARD SUBMARINES

As is evident from Tables 4 and 5, communicable diseases (Class VIII, IX, and X) were reported as having occurred on 400 submarine patrols and accounted for an impressive number of sick days and lost man days, (1,068 days on 211 patrols). Despite the obvious incompleteness of the reporting, some details in regard to these illnesses are pertinent and of interest.

COLDS, "CAT FEVER", "SORE THROATS", AND TONSILLITIS, ACUTE

As in any branch of the service, these 4 diseases were very common. Relatively speaking, but few patrols were made without a varying incidence of these infections. In many instances, they were merely indicated as present, prevalent, etc. In some 140 patrol reports, however, they were sufficiently common to be cause for special notice.

Colds, Etc., Contracted on Leave, in Training, Etc.

The virus of these infections was naturally brought aboard the submarine by men returning from shore leave--whether it was spent in Australia, the "States", at the Royal Hawaiian Hotel in Honolulu, or at some tiny atoll at an advanced base. As the following excerpts indicate, these could be traced, among other things, to unavoidable contact with shore based personnel, many times to lowered individual resistance during stay ashore, inclement weather during training period, etc.

"Numerous colds when left Australia" (JACK No. 4, KINGFISH No. 9, LOGGERHEAD No. 2). "Epidemic of mild 'cat fever' that had started prior to leaving Pearl Harbor continued throughout the patrol, involving practically 20 men; seven turned in from 3 to 8 days" (SUNFISH No. 6). "On departure two-thirds of the crew had colds which persisted for several days with noticeable reduction in efficiency--two sick days" (S-47, No. 2, tropical patrol). "In the first 15 days of the patrol (in Palau area) 22 cases of mild upper respiratory infections occurred--attributed to the disagreeable weather conditions during the latter part of the recreation period and the overworked and rushed activities immediately preceding leaving on patrol" (DACE No. 3). "The patrol was started after 5 days in port. As a consequence, personnel were pretty well worn out with lowered resistance and practically all hands developed bad colds and coughs" (SAILFISH No. 2). "This patrol (22 days duration, winter, China Sea) began 7 days after the first (52 day) patrol. Health of crew was beginning to wane--as evidenced by an enormous increase of colds--affecting more than half of the officers and crew" (SPEARFISH No. 2). "For the first 3 weeks more cases of illness occurred than previously experienced (unusual incidence of tonsillitis, sore throats and moderate colds) due, in part, to the fact that this was the first patrol following an Australian refit with unaccustomed food, water and living conditions" (CROAKER No. 4). "The last leave period was spent in unhealthy surroundings (Subic Bay). Since that time and until almost the end of the patrol there was an unusually high incidence of sore throats, colds, two abscessed throats, etc." (BECUNA No. 4, tropical patrol). "Health was poor--traced to the stay on Guam with continuous inclement weather lowering resistance to infections--there being 19 cases of 'cat fever' as well as tonsillitis and sinusitis" (PICUDA No. 5, winter patrol in Formosa area). "Many colds contracted on leave and in the training period, rapidly cleared as the submarine entered warmer climate" (REDFIN No. 3). "The majority of the men and officers departed with heavy colds as the result of foul weather encountered in the training period--" (CABRILLA No. 5). "A minor epidemic of colds and 'cat fever' commenced during the training operations and persisted the first two weeks of the patrol" (COBIA No. 5). "Many colds and skin rashes contracted during trial runs had practically disappeared after two weeks" (SAWFISH No. 8, Formosa area, fall).

On one occasion in Pearl Harbor, a large number of men at the Submarine Base were hospitalized with virulent sore throats, said to have been traced to an improperly cleaned "mechanical cow". This epidemic had interesting reflections in the crews of two submarines. The SEAWOLF (No. 11) was held at Midway for 24 hours due to the presence of 10 sore throats among her crew upon arrival enroute to her area from Pearl Harbor. The next day, after liberal spraying of the throats of all hands, there being no new cases, the submarine departed. "Health was not as good as on the previous patrol. Sore throats persisted off and on the first two weeks out of Midway. There were several cases of 'cat fever' and one case of swollen jaw that looked like the mumps. Another case the next day made it appear as if we were in for an epidemic but both cleared after a couple of days with sulfathiazole." The SHAD (No. 7) commented in regard to this incident: "Shortly after leaving Pearl Harbor several cases of severe septic throat occurred--believe infected from the epidemic raging at the Submarine Base upon departure. It was necessary to transfer two men at Midway because of this. Other cases were brought under control by the use of sulfa." On this patrol in which two typhoons were encountered, there were reported two cases of acute sinusitis, two cases of acute tonsillitis and five "septic" sore throats.

Colds, Time Interval on 100 or so Patrolling Submarines

Commonly (reported from "S" and Fleet Class patrols) "epidemics" of colds, etc., were experienced within the first one to three weeks of the cruise, not infrequently before the submarine reached her area of operations. Typical reports in this regard are as follows: "An epidemic of colds was experienced the first ten days out of Midway" (HADDOCK No. 13). "A small epidemic of colds (16 colds, 4 tonsillitis, 2 earaches, 2 'cat fever') occurred in the first two weeks" (ARCHER FISH No. 1). "The usual run of sore throats and minor colds in the first two weeks" (GREENLING No. 12). "An initial epidemic of colds and sore throats occurred between Pearl Harbor and Midway" (BOWFIN No. 6). "A mild epidemic of colds, sore throats in the first week involving 80% of the officers and crew" (CROAKER No. 1). "On leaving Midway two cases of 'cat fever' under treatment spread to ten inside of three days; a minor 'epidemic' cleared up after the first week" (BATFISH No. 9, spring, Japanese Sea). "In the first week there were 14 colds and 3 tonsillitis; in the third and fourth weeks 21 had sore throats, 4 had 'cat fever'" (BLACKFISH No. 2, Atlantic, winter). "One day after departure a small epidemic of 'cat fever' (involving 70% of the complement) occurred--materially lowering efficiency" (GRAMPUS No. 3). "Weather very humid and hot, sea becalmed. In the second and third weeks, all hands had heavy colds" (PERCH No. 2). "Health below par; large proportion of colds (28 colds, 5 'cat fever') during the training period at Saipan and enroute to the area" (PLAICE No. 4). "Shortly after leaving Midway and before arriving in the area a siege of colds and coughs accounted for 20 sick days" (SEARAVEN No. 12). "Colds caused considerable discomfort during the first ten days on station" (GUARDFISH No. 11). "Health was poor at the start of the patrol with many colds; as the patrol progressed cold germs gradually retreated" (TRIGGER No. 9). "Numerous colds developed in the early part of the patrol with three cases of 'cat fever'. This tendency was quickly checked by the addition of a small quantity of creosol--to the dishwater, the epidemic of colds subsiding two days after this precuation was taken" (TUNNY No. 3). "Colds were numerous the first part of the patrol; as we became acclimatized and took the proper precautions, these cleared" (WAHOO No. 1).

Duration of Colds Aboard Submarines

As indicated, generally these infections were short lived, reaching their peak in the first and second weeks and disappearing thereafter. Upon occasion, however, colds, "cat fever", sore throats, etc., persisted throughout the patrol. "In part, the patrol was handicapped by unfavorable weather, mountainous seas, colds, materiel defects and an abnormal amount of 'cat fever'--there being 23 cases of 'cat fever', 1 German measles, 1 acute otitis media, 2 acute tonsillitis--during the period in the area half of the crew had colds, ascribed to the sudden passage from the warm to cold climate" (SHAD No. 8, winter patrol, Formosa area). "A mild epidemic of colds in the latter part of the patrol occurred believed due to lowering of resistance because of the length of the run" (HAWKBILL No. 3, spring, Java Sea, 61 days, 47 days submerged). "A few cases of 'cat fever' at the end of the patrol" (PAMPANITO No. 2, summer, extended submerged periods in cool water). "There were 4 cases of mumps, 1 case of measles, and 2 cases of 'cat fever'--the latter on the sick list on arrival at Midway at the end of the patrol" (TARPON No. 5, spring, tropical). "Much condensate, rough weather, the crew was tired, 3 cases of 'cat fever'; toward end of the patrol the number of colds and sore throats had increased" (ARGONAUT No. 1, winter, 47 days submerged, off Midway). "Fifty per cent of the crew had colds--still had some at the end of the patrol" (S-17, No. 7, winter, Aleutians). Approximately 70% of the crew suffered from colds and 'cat fever' (61 colds, 4 'cat fever', 2 DU (otitis media). The combination of colds, lack of sleep (materiel casualties) and lifeguarding resulted in a certain nervousness and irritability which fluctuated in intensity with the magnitude of the three items mentioned" (PLUNGER No. 12, Truk area, summer). "Numerous colds were experienced in the first two weeks--in three cases these persisted the entire patrol" (RUNNER No. 2).

Colds and Area of Operations

Generally speaking, patrols made in northern operation areas, particularly in the winter, were especially apt to be handicapped by these acute infections. Submarines operating in the Aleutian, Bonin and Kurile Islands areas in 37 reports mention colds, etc., as prevalent. In 60 patrols carried out in temperate water (the greater portion of which were in the winter and spring months) colds were reported at some time or other. Interestingly enough, however, the reports of 43 patrols made in tropical operation areas were concerned with these illnesses.

The universality of acute communicable diseases was due, in part, to commonly encountered weather conditions. Mention has been made elsewhere of operating conditions so frequently to be expected in the far northern circuit--of the foul weather, driving rain, hail and sleet storms, the fog and drift ice. In addition, the boats, especially the "S" class, were uncomfortable, being cold and damp due to the excessive condensate formation. Heaters fre-

quently had to be used sparingly. We have observed, too, the inadequacies of the present standard issue of foul weather clothing, particularly in meeting the requirements of the bridge watch in this type of weather. "With 27 consecutive days spent submerged the boat was cold and damp; health was only fair, 50% of the crew had colds" (S-33, No. 3, fall, Aleutians). "Health was average; severe colds. The boat was cold and damp; foul weather clothing was not satisfactory" (S-33, No. 5, winter, Aleutians). "The boat was cold, wet and overcrowded on 14 hour dives. There were 21 colds, 2 sore throats and 5 with rheumatic pains--all in men over 30" (S-34, No. 3, winter, Aleutians). "The majority of the crew developed sore throats ten days out--believe transmitted through the mess gear, facilities not permitting disinfection" (S-31, No. 3, Bering Sea, summer, 46 men with 38 bunks). "Many colds; the fact there is only one head to 45 men is believed to have contributed materially to the prevalence of headaches, constipation, and colds" (S-33, No. 2, summer, Aleutians). "Temperature in the conning tower varied between 22 degrees and 32 degrees F.; bridge personnel were constantly drenched with salt water spray, hail and snow; ice accumulated 2 inches thick on the boat at night. One man developed pneumonia" (S-18, No. 2, spring).

"The boat was very wet in the cold water. In the first three weeks the majority of the crew had colds" (HAKE No. 2, spring, Atlantic). The 7th patrol of the PERMIT, made in cold water, was accompanied by 20 colds, 3 cases of "cat fever", and 1 chronic sinusitis. The commanding officer of the PLAICE (No. 5), after a spring patrol in the Kurile Islands area, observed that "operating in a cold climate (average temperature 34 degrees F.) eliminated the generally encountered fungus, etc., but reciprocates with a number of minor colds (60 without sick days)". "Health was fair; approximately 30 men had colds and there were 5 cases of mild tonsillitis. This frequency of colds was the result of the great amount of condensate and dampness caused by operations in cold water" (RAY No. 7, spring, Yellow Sea). "There were 14 colds and sore throats accounting for 23 sick days--attributed to the lack of sunshine, damp cold weather, decrease in amount of fresh vegetables available--" (SHAD No. 2, Atlantic, winter). "Minor head colds were experienced in the Arctic Circle--" (SHAD No. 4, TINOSA No. 11). "The ship was cold and damp. Air conditioning was not used because the boat was already too cold. At least 75% of the officers and men were affected by an epidemic of 'cat fever' in the first three weeks--" (SKATE No. 5, summer, Kurile Islands). "Colds as usual on the first encounter with cold weather" (SPADEFISH No. 2, Yellow Sea). "Several colds and 4 cases of 'cat fever'--health in general was good. A long patrol in Kurile Island weather at this time of the year (winter) would undoubtedly be difficult from a health standpoint" (TAUTOG No. 10, 34 day patrol, 17 days submerged). "Habitability fair due to the extreme cold (30 degree F. injection temperature, 28 degree air temperature), heavy seas, light coating ice topside formed at night. About 50% of the crew had colds; one developed 'cat fever'."

Again colds were commonly experienced (as observed in 26 reports) with the passage from warmer climate to cooler operation areas, particularly if the refit was conducted at a tropical or semi-tropical base. "Health was definitely below standard. Almost the entire crew had colds at various times. The sudden shift from the subtropical to cold damp climate of the Aleutians, the necessity of keeping the main induction closed, thereby sending a stream of cold air through the main living spaces, the dampness (heaters were used sparingly), and the crowded conditions all contributed to the catching and spreading of colds" (CACHALOT No. 3, winter, Aleutians). "An epidemic of colds broke out as the result of change in climate from Guam to the cold dampness of weather in the Japanese Sea made in little more than a week" (CREVALLE No. 7). "Numerous colds because of the consistently damp weather in the area" (CROAKER No. 3, tropical). "An epidemic of colds occurred after departure--the damp raw weather of the area was not conducive to the prompt cure of colds" (HERRING No. 3, spring, Atlantic). "Weather was foul--influence was more apparent at the first of the patrol as the physical condition of all hands was tuned up to the balmy weather of Guam. There were numerous colds. One officer was transferred at sea with severe tonsillitis and signs of prospective pneumonia" (KINGFISH No. 10, winter, Nampo Shoto). "Ninety per cent of the crew had colds--due more or less to the sudden change of climate from Pearl Harbor to Dutch Harbor" (NAUTILUS No. 5, spring). "In the first few days of cold weather there were many colds and coughs attributed to the change in climate and insufficient foul weather clothing--none being available in Saipan" (REDFISH No. 2, winter, Nansei Shoto). "More colds than usual--believe can be attributed to the rapid change of climate between Guam and the Empire" (TIGRONE No. 2). "Colds were prevalent the first week in the area--attributed to the fact that the ship had been operating in the tropics steadily for 7 weeks on the previous patrol" (SEGUNDO No. 3, winter, China Sea). "The several colds which were experienced cleared on reaching the warm weather" (SNAPPER No. 1, winter, China Sea). "On the return trip, there were two cases of 'cat fever' when experienced cold weather" (TREPANG No. 2).

As noted above, colds were not uncommonly experienced on tropical patrols aboard submarines entering their area from tropical or subtropical bases. "It was uncomfortably hot on all day dives. Health was fair with many colds; two were admitted to the sick list with 'cat fever'" (CAVALLA No. 5, spring, tropics, 30 days submerged). "A high incidence of coughs and colds (two cases of 'cat fever') coincided with passage across the equator" (CROAKER

No. 5, 22 days submerged). Aboard the REDFIN (No. 3) "many colds contracted in the leave and training period--were observed to clear rapidly as the submarine entered warmer climate." At the conclusion of the 7th patrol of the DRUM it was reported: "The usual colds were experienced concomitant with the shift from a cool climate to the tropics." One man on this patrol was given oxygen through an escape lung "to aid his breathing while suffering from a severe chest cold".

Colds and Submerged Operations, Etc.

In a few instances, the onset of colds, etc., was related to submerged operations. "After the first all day dive (13 hours) 20 men developed colds--but the epidemic was of short duration." (CABRILLA No. 1). "A severe epidemic of common colds was experienced at the start of daylight submerged patrolling" (SPEARFISH No. 9, tropical). "Numerous colds in the first two weeks during the daily submerged periods" (TRITON No. 3, spring, Wake and Marcus Islands). "In spite of the unusually mild weather, 35 per cent of the crew had chest colds--the unusually long dives (averaging 18 hours) may have lowered the resistance of the crew" (S-33, No. 7, summer, Kuriles). "Numerous colds--many of which were due to dampness of the boat during the 19 hour daily dives" (S-18, No. 3, spring, Aleutians).

In a few other instances, colds, etc., were related to peculiarities of the ventilation and air conditioning. "There were a few colds, the majority being in the engineering force--and attributed to prolonged exposure to high temperatures and to impudently 'cooling off' under the blower when relieved" (GRAMPUS No. 1, tropical). "The two light cases of 'cat fever' and sore throat which occurred were directly traceable to standing watch in the conning tower submerged with the air conditioning unit blowing directly on the men concerned" (HAWKBILL No. 3, tropical). "There has been present a great many cases of virulent sore throats (20 to 30). The 'black gang' has been hit much harder than the deck force. Getting up into the fresh air apparently is one of the best preventives. The crew is in poorer physical condition than on the preceding patrol--one reason for which perhaps is the carry over and cumulative effect of so much submerged time and faulty air conditioning with the debilitating effects of profuse perspiration" (SAURY No. 2, tropical).

Effect on Health of Crew and New Strain for Invading Organisms

As we have observed, once the colds, etc., ran their course and everyone became immune, so to speak, to the common organism, generally but little difficulty was experienced thereafter, leaving the group, however, prone to infection by different strains should the opportunity arise. Submarines stopping over night for voyage repairs, at advanced bases sometimes, after departure, experienced epidemics of colds which could be directly attributed to mingling with shore based personnel. "Colds were acquired at Midway" (JACK No. 3, stopping off there over night enroute to her station). Four cases of "cat fever", acute, were observed to develop aboard the PETO (No. 9) after a short stop over at Saipan. The BESUGO on her 4th patrol, sank a German submarine from which one survivor was rescued. "The German had a cold when captured. He brought a new variety of cold germs aboard, resulting in another epidemic of colds and sore throats." On the 7th patrol of the BONEFISH (spring, China Sea) a Japanese aviator was rescued. Health on this patrol was described as "fair". Five men developed complications from colds and were admitted to the sick list for 1 to 5 days. "After leaving the area we had 4 cases of influenza occur simultaneously." As noted elsewhere, SEALION, on her second patrol, participated in the mass rescue of British and Australian prisoners of war. Some 20 per cent of these men after hospitalization (148th General Army Hospital, Saipan), were found to have had an acute bronchitis which developed within a few hours after their rescue. Nine showed X-ray evidence of acute bronchopneumonia. Aboard the SEALION, among whose passengers several cases of bronchopneumonia occurred, it was reported: "The health of the crew was excellent until the survivors were put ashore at Saipan. Several men subsequently developed mild cases of 'cat fever' and seven or eight severe colds and sore throats were scattered among the crew. The outbreak probably resulted from overcrowding, loss of sleep, irregular meals and routine while the survivors were aboard."

SUBMARINE PATROLS MADE WITHOUT ACUTE COMMUNICABLE DISEASES

In most instances, if health had been good, with colds absent, no mention was made of acute communicable diseases in the patrol reports. In a few instances commanding officers specifically commented upon the absence of colds.

Aboard the "S" class of submarine it is difficult to understand why, inasmuch as these boats were operating under more or less the same conditions, one submarine would be plagued with colds and another left free; but it happened not infrequently. Aboard the S-31 (No. 5) there were only a very few colds, although the temperature averaged between 37 to 50 degrees F.,

condensate was prevalent and the patrol was made in the Kurile Island area in the fall of the year. Aboard the S-28 (No. 4) there were "comparatively few colds despite the intense cold and damp weather to which bridge personnel were subjected--feel that this is largely due to the fact that the men were taking vitamins". The commanding officer of the S-35 (No. 3) after an Aleutian patrol attributed "fewer colds to the warmer weather and the fact that the crew became acclimatized to the cold and dampness". On the first patrol of the S-28 (spring, Aleutians) habitability was poor with a cold and damp boat, hot bunking and 18 hour dives. The crew took vitamins, to which "their freedom from colds, despite conditions ideal for their inception and spread is believed due".

Aboard fleet type submarines, the same situation sometimes existed. "In spite of the excessive condensate, low temperatures and 17 hour dives, there were very few colds" (CABEZON No. 1, spring, Kuriles, 31 submerged days). "We had expected several colds due to the cold and damp weather--surprisingly all colds cleared up and no new ones developed--this was especially surprising in that several members of the crew still had colds and coughs hanging on that they had gotten in the 'States'" (SUNFISH No. 7, summer, Kuriles). The 8th patrol of the SNOOK, made in the Kurile Island area was conducted in extremely cold weather (temperature in conning tower was 23 degrees F.), in mountainous seas and with the topside covered with ice despite which there were "few colds for such severe conditions". In all, similar situations were described in 13 patrol reports after cruises in the Kurile Islands, Yellow Sea, China Sea, and Tokyo Bay area for the most part in the winter or fall of the year. The commanding officer of the PERCH in this respect commented: "There seemed to be less common colds than when patrolling on the surface." The commanding officer of the PLAICE (No. 6) suggested "that the crew was thoroughly rested during the last refit in a healthy and invigorating area probably accounted for the complete lack of colds and 'cat fever'." In this respect, comments made concerning site of refit for submarines following patrols are of interest: "The commanding officer (BLUEBACK No. 4) is inclined to agree with the consensus of opinion that tropical patrols should be followed by tropical refits when conditions are such as to make this possible"--having in mind the preference shown for the Perth-Fremantle area over the Subic Bay for recuperation purposes. In this respect, it is interesting to comment upon the desirability of refitting submarine crews in tropical or subtropical areas and then sending them on cold water operations. Undoubtedly, with the change of climate made in relatively few days, there is little opportunity for acclimatization. Whether or not the incidence of acute communicable diseases would be lessened by having crews refit in the vicinity of the area (as Dutch Harbor) can not be answered. It is true that the number of "S" boats operating out of Dutch Harbor which made no mention of or specifically commented upon the absence of colds is about equal to the number, working under the same conditions, and reporting excessive incidence of these infections.

Upper Respiratory Infection and Air Conditioning and Ventilation System of Submarines

In these patrol reports there exists but little information concerning the relation of acute communicable diseases to air conditioning and ventilation. Condensate formation was often times excessive aboard submarines patrolling the Arctic Circuit. Air conditioning was sometimes used to reduce dampness. Other commanding officers preferred dampness to the additional lowering of the temperature by the running of the air conditioning unit. As we have observed earlier, aboard the GRAMPUS (No. 1), colds in the engineering force were ascribed to sudden body cooling after prolonged exposure to high temperatures under the blowers. Aboard the HAWKBILL (No. 3), two cases of "cat fever" were ascribed to direct exposure to the cooling effect of the air conditioning unit in the conning tower. Aboard the APOGON (No. 5) while in the Kurile Island area (fall), the boat was chilly but not damp, one air conditioning unit being kept running to keep the boat dry. "Believe this factor was prime in the scarcity of colds. Fewer colds were experienced than expected. Those who had colds were able to shake them off in a remarkably short time." Aboard the GABILAN (No. 5), while on a patrol in the Java Sea, "it was noted that after 2 to 3 hours of running silent with the air conditioning secure, 50 per cent of the crew caught colds".

Use of Germicidal Lamps Aboard Submarines

The HARDER, equipped with ultraviolet, germicidal lamps in her ventilation system made 5 patrols before she was lost. Concerning the efficacy of this installation, the following comments were made at the conclusion of the first patrol: "Common colds were at a minimum. Whether this results from the action of the lamps is not a matter for a layman to assert. However, it is definitely felt that the lamps reduced considerably the characteristic smell and eye irritation developed at the end of all day dives. This might be the result of the production of ozone by the lamp" (a 33 day patrol, 10 days submerged, made in June and July of 1943, off the coast of Japan). At the end of the second patrol (August and October 1943, 45 days, 21 days submerged, Empire waters) it was said: "The near absence of colds and the complete absence

of contagious diseases indicates the likelihood that the experimental germicidal lamp installed on this ship is proving itself a most valuable piece of equipment." No comments concerning the lamp or health (other than it was excellent) are available in the third patrol report (October and December 1943, 31 day patrol, 8 submerged, Marianas). At the conclusion of the fourth patrol (March and May 1944, 45 days in length, 22 days submerged, area unknown), the commander of Task Group 71.3 observed: "It is noted that the battery of ultraviolet lamps in the ventilation system is considered to have contributed materially toward better living conditions." The commanding officer observed: "Satisfactory living conditions were aided in great part by the battery of 30 ultraviolet lamps in the ventilation system. The original objective was the elimination of air-borne bacteria in the recirculated air while submerged. To a layman it seems that the results were gratifying inasmuch as colds have been at a minimum on patrol - however, the most comforting result of the lamps is their faculty to kill the odor and eyeburn that is normally characteristic of all day dives. Again recommended that these lamps be installed on all submarines." On this patrol the submarine was submerged while on station for 211 hours (eight plus days). On the fifth patrol (May and July 1944, 46 days duration, 18 days submerged, Celebes Sea), "habitability was reported as having been impaired due, in part, to the lack of efficiency of the air conditioning unit and to the fact that there were 89 officers and men aboard". No further mention is made of the lamps nor is there any mention of the health of the crew except for one case of sunstroke, one lacerated scalp wound, many cases of heat rash, and markedly reduced personnel endurance attributed to the strain of the patrol. A report of the effectiveness of the lamps is said to have been made to the Bureau of Ships. Curiously enough excess amounts of ozone (associated with "Precipitron" installations made within generators aboard the SS-482 and SS-484 submarines) has been associated as the source of eye irritation.

The eighth patrol of the SNAPPER of 56 days duration (27 days submerged) was made in the Empire area. On this patrol an epidemic of colds was observed in 75 per cent of the men and officers without sick days. The commanding officer stated: "It is felt that this epidemic was caused by the difference in weather conditions between Pearl Harbor and the area. Possibly the installation of ultraviolet germicidal lamps in the ventilation system, as described in the HARDER's patrol reports, might prevent such epidemics."

ACUTE COMMUNICABLE DISEASES ABOARD SUBMARINES

Vincent's Angina

In all, some 176 cases of Vincent's angina were noted in 36 patrol reports, an average of almost 5 cases per patrol. The pharmacist's mate of the SEAWOLF (No. 13) treated 30 patients with this infection, a "minor epidemic, some which were remaining at the end of the patrol". Aboard the SNAPPER (No. 2) 28 men so infected were given treatment. On the TAMBOR (No. 11) 6 days after departure on patrol "seven cases of 'V.A.' were discovered; 17 others were given prophylactic mouth washes after a general examination of all hands". Aboard the PETO (No. 6) seven cases were treated "five of which originated at the Rest and Recuperation Annex, Pearl Harbor. Due to the effectiveness of preventive measures, only two cases developed on station." From the BLUEFISH (No. 4) it was reported: "a slight epidemic of 'V.A.' occurred involving one man with a bad case and 8 others slightly infected. All were treated."

It should be pointed out that the above were clinical diagnoses. The fact that routine physical examination of submarine personnel at the end of a war patrol not infrequently revealed men with oral infections leads one to accept the above reports. It was true, however, that gingivitis was very common among the crews, some of which cases may have been incorrectly diagnosed.

In most instances the infections were fairly easily controlled as is evidenced by the fact that they accounted for only 7 sick days on two patrols. Aboard the BLACKFIN (No. 2) "One 'V.A.' spread to a second which was cleared up within a week's time." Aboard the APOGON (No. 4) "four cases were cleared up in 2 to 3 days". Different specific methods of treatment were used. In general, measures were taken to isolate and sterilize infected mess gear, etc. Submarine personnel habitually drink much fluid--whether coffee, tea, coca cola, root beer, etc.--and the fact that cups were often times common property may have contributed to spread of these infections.

In one instance, aboard the KINGFISH (No. 10) one officer acutely ill with an infection of the throat was transferred at sea for medical treatment. This may very well have been a virulent Vincent's angina.

Malaria

On 10 patrols, 15 cases of malaria were reported. The majority of these were subsequent to tropical or subtropical refits. Six patrol reports mentioned instigation of prophylactic courses of atabrin. "Antimalarial prophylactic instructions were carried out one week prior to entering the malarial area in accordance with Seventh Fleet Medical Directive" (BLUEGILL No. 5). Three submarines reported symptoms of intolerance to drug which may, as aboard the BRILL (No. 2) have followed incorrect dosage: "The pharmacist's mate misinterpreted the instructions concerning atabrin dosage with resultant discomfort, nausea, cramps and diarrhea among the crew." The possibility of malaria should be kept in mind by pharmacist's mates in making a differential diagnosis of persistent and high grade fever occurring in personnel upon submarine patrols--particularly if the ship has refitted in areas where the disease is endemic.

Pneumonia

Ten patrol reports mention the occurrence of 11 cases of DU (pneumonia). Eight of these cases occurred on cold water operations; one occurred on a tropical patrol. Aboard the S-18 (No. 2) on an Aleutian patrol, the average air temperature in the conning tower was between 22 and 32 degrees F. Bridge personnel were constantly soaked with ice salt water. Ice collected on the boat up to two inches or more in thickness. "One man with pneumonia was given sulfathiazole." Aboard the SUNFISH (No. 1) on an Arctic patrol on which much drift ice was encountered, there were, in addition, "several colds and one case of measles." On the second patrol of the GUDGEON (No. 2) made in cold, damp weather there were "several cases of 'cat fever' and two men had severe influenza bordering on pneumonia." Personnel endurance at the end of this patrol was reported in terms of "0" days. The case which occurred aboard the SEADOG (No. 4) was mentioned in relation to the cold and damp weather encountered in the Sea of Japan. No information is available concerning cases occurring aboard the TRIGGER (No. 6) and TAMBOR (No. 10).

On the seventh patrol of the FINBACK the pharmacist's mate treated one case of "lobar pneumonia" (25 sick days) for which he was commended by his commanding and division officers. "The fine performance of --- in treating a serious case of pneumonia is a tribute to his profession." On the fourth patrol of the BESUGO a badly burned Japanese survivor was recovered. Second and third degree burns covered over 60 per cent of his body surface. He was in severe shock and completely covered with fuel oil. The fact that CPhM G. A. Geibel brought him back alive is no doubt due as much to his good sense as to his judicious use of morphine and some 750 cc of plasma which he administered. Because of difficulties encountered in administering plasma he also used serum albumin. On the fourth day with the use of a dampened sheet, a six foot length of hose taken from the escape trunk and a flask of aviation oxygen this form of treatment was started. At the end of 19 days his results were adjudged excellent. This case indicates the need aboard submarines for means of quick and convenient administration of oxygen.

Two of these cases diagnosed as pneumonia later were proven to be tuberculosis. In the second patrol report of the GUNNEL it is stated: "Two cases of 'cat fever' occurred. One man had a relapse with temperature, pulse, respirations rising over a period of 20 hours to 103.8, 118 and 26 respectively. A make-shift oxygen tent with a celluloid window was constructed and used for 16 hours. The patient showed rapid improvement. After the tent was removed he was given plasma and sulfathiazole. CPhM Williams is worthy of highest commendation for the successful handling of a severe case of pneumonia. The ingenuity and resourcefulness of our submarine pharmacist's mates, particularly H. C. Williams, CPhM, in this case is again worthy of praise." Investigation revealed the man to be suffering from far advanced bilateral tuberculosis with a markedly positive sputum. He later died. Screening of the entire crew revealed 2 other cases that were considered to be due to this close exposure. On the third patrol of the PLAICE a patient was diagnosed as having lobar pneumonia. Treatment aboard the ship consisted of "absolute bed rest, sulfadiazine, codeine." Oxygen therapy was prepared but was not needed--this apparatus consisted of a compartment oxygen flask, a welding torch as a metering device, a gallon mayonnaise jar as a humidifier and a catheter. The patient's fever and induced delirium necessitated continuous watch for 4 days--at the end of which "headed out for Saipan with the patient seriously ill." Endorsement to this patrol by the squadron officer stated: "According to the medical officer present the PhM of the PLAICE did everything that could have been done for the patient and undoubtedly saved his life." This patient was later suspected of having tuberculosis and all hands aboard were X-rayed, all being reported as negative. A third case of what was undoubtedly acute miliary tuberculosis occurred aboard the ASPRO (No. 5). This patient, too, had been treated for "cat fever", acute and pneumonia.

Mumps

Nine submarines on 10 war patrols reported 21 cases of mumps. The BOARFISH (No. 4) departed on her patrol on 5 July 1945. Five days later "I discovered we had a case of mumps aboard--originally diagnosed as mastoiditis but when the orchitis set in, the diagnosis was changed. Twenty-seven men and 2 officers are susceptible. It is useless to attempt complete isolation for all susceptibles. However, if all of them should contact the disease, I would still have two full sections to work the ship." Fortunately, only one other case developed--and that on the 30th of July. The fact that in addition, the executive officer dislocated his finger, that there were 2 cases of "cat fever" and that a torpedoman suffered a severe laceration of the ear led the commanding officer to observe: "The loss of the services of the above put a strain on our organization. Carrying only 74 men leaves no spares in case of sickness or disability."

On the fifth patrol of the FLYING FISH there were 3 cases of mumps, 2 of whom developed orchitis. After removal to the rest camp, 4 more men from this ship, including one officer, developed the disease--interestingly enough all 4 of whom had an orchitis. The sixth patrol of the TARPON was plagued with acute communicable diseases. There were 4 cases of mumps, 1 case of German measles, 2 cases of "cat fever". One case of mumps occurred on the ninth and tenth patrols each of the SAWFISH. On the fifth patrol of the PORPOISE (tropical patrol underway on 6 February 1943) - on 11 March one seaman complained of a sore throat and some fever. He was put on the binnacle list for 4 days. "Thought we had a mild case of influenza until 1 April when a torpedoman and the pharmacist's mate came down with the same thing with swelling on each side of the neck, recognized by the pharmacist's mate to be mumps."

On the second patrol of the BUGARA "one case of mumps was diagnosed, isolated in one of the high bunks in the after torpedo room and a strict surveillance was maintained over all mess gear, etc. There were no other cases." The BLOWER (No. 2) reported: "Lt.--- was isolated with mumps for 10 sick days. Almost immediately a chief radioman came down with the disease. For a time the ship looked like an isolation ward with colds and sore throats much more prevalent than on the last patrol." The factor terminating the first patrol of the S-35 was contagious disease--one case of mumps, in a mild form, concerning which ComSubPac stated: "A patrol should not be terminated for such a reason until it becomes apparent that the efficiency of personnel has been impaired by spread of the disease." On the third patrol of the COBIA, 22 days after the start of the patrol, one man reported with a swelling of the left parotid gland. This was diagnosed as mumps and isolated in the after battery compartment. Fifteen men were aboard who had not had mumps. They were shifted as far from the patient as possible. On the 13th day of the disease, a second man presented himself with bilateral swelling of the jaw. He stated that he had had mumps before. Four days later the swelling subsided and the diagnosis was changed to an infected wisdom tooth. Ten days later both testicles became swollen and he was turned in. This same day the third patient reported with swollen testicles. The squadron commander congratulated the pharmacist's mate for measures which he had taken to prevent an epidemic of mumps.

Measles

Fourteen submarines on as many patrols reported 18 cases of "measles", generally specified to have been of the "German" variety. The fifth patrol of the SEARAVEN was made with 4 cases of acute pharyngitis, 1 case of influenza and 5 cases of "German" measles. The commanding officer was turned in for "influenza" for a few days; about 11 days later he "came down with 'German' measles." A second commanding officer (POMFRET No. 4) was treated for influenza and measles while on patrol.

The number of instances in which measles and mumps were associated with acute respiratory infections is striking. On the fifth patrol of the BLUEGILL in addition to the 1 case of measles there were 41 men with colds, 3 complaining of earache and 1 man with acute sinusitis. On the eighth patrol of the SHAD over half of the crew while in the area, had colds. Twenty-three men were treated for "cat fever", 2 for acute tonsillitis and 1 man for sinusitis. There was, in addition, 1 man with measles. Curiously enough other than for the SEARAVEN as indicated above, measles did not spread from the original case.

Acute Infectious Jaundice or Hepatitis

Thirteen submarines on 14 patrols reported 21 cases of what was variously called "infectious hepatitis", "acute hepatitis", "infectious jaundice", or "catarrhal jaundice" all of which had in common the presence of icterus.

Nothing definite can be said about 5 of these cases. One, occurring aboard the HAWKBILL (No. 1, October 1944) was diagnosed as "catarrhal jaundice" by medical officers from the U.S.S. Holland, and was "successfully treated at sea". One case occurred aboard the HADDOCK (No. 1) and the TARPON (No. 1) early in the war. On the sixth patrol of the SWORD-

FISH mass illness occurred assumed due to the use of carbon tetrachloride. One man, during the patrol, is stated to have "had yellow jaundice, mild--and was turned in for 10 sick days." One case occurred on the POLLACK (No. 5) in 1943.

The remaining 16 cases all occurred in 1945 between the months of January and April. It is believed that probably half again as many cases occurred which were not mentioned in the patrol reports or which developed after the submarine had put into port. All cases, it is believed, can likely be traced to a variable period of time spent on Guam. In general, most of these cases engendered about 10 to 14 sick days. The relation of the infection to other diseases is interesting. "Health was below par; there was a large proportion of colds among the crew during the training period at Saipan and enroute to the area. Twenty-eight men were treated for colds; there were 5 cases of catarrhal fever combined with 6 cases of jaundice" (PLAICE No. 4). "Health was poor--traced to the stay on Guam with the continuous inclement weather lowering the resistance to infections. There was one case of yellow jaundice, 13 cases of enteritis directly traceable to Guam; 19 cases of 'cat fever' as well as tonsillitis, sinusitis, etc. There were several cases of low grade food poisoning without sick days due to a brand of orange juice. There was, in addition, one case of gastroenteritis, acute, 1 case of catarrhal fever and one case of jaundice." (DRUM No. 13). One case of "hepatitis acute" was reported on the third and fourth patrols of the RAZORBACK.

Miscellaneous

Two cases of chickenpox were reported to have occurred on the sixth patrol of the SAWFISH appearing approximately 22 days after departure of the submarine on patrol. The 13th patrol of the PERMIT was underway on 29 June 1944. On 1 July a DU (scarlet fever) diagnosis was made. On the third of July, the patient having been isolated in the captain's stateroom, the diagnosis was positively made, the patient's condition being unchanged. In accordance with dispatch order from ComSubPac all hands "were fed sulfathiazole. The patient recovered in a week with no apparent after effects. There were no further cases." On the fifth patrol of the SPEARFISH it was reported: "About 20 per cent of the crew and 3 officers suffered from prolonged coughing spells which had the effects of whooping cough without nausea or vomiting. This persisted throughout the patrol and did not incapacitate anyone for duty." Five cases of dengue fever were reported from 2 boats, after tropical refits. Two cases of "meningitis" were reported from 2 submarines.

The Tuberculosis Problem Aboard Submarines

As indicated above, 3 men are known to have been treated for pneumonia while on patrol, in whom, subsequently, the diagnosis was changed to pulmonary tuberculosis (GUNNEL No. 2, PLAICE No. 3, and ASPRO No. 5). The only other reference to tuberculosis appearing in the patrol reports was found in the 7th report of the APOGON: "Two crew members were found to have advanced tuberculosis at the end of the sixth patrol at Mare Island. The commanding officer feels that had these men been given a careful physical examination at the end of the fifth patrol, this condition would have been discovered and treatment commenced 3 months sooner." The author knows of 2 men who, while aboard submarines, developed massive pleural effusions. As far as is known, neither one of these were proved tuberculosis in origin.

INJURIES ABOARD COMBAT SUBMARINES

Injuries were the second most common type of medical condition encountered aboard submarines as evidenced in these patrol reports, the majority of which were traumatic in origin. The nature and frequency of some 1,208 of these injuries has been presented in Table 6. It will be observed that 164 injuries were associated with 1,069 sick days (an average of 6.5 days per injury).

Approximately 61 per cent or the majority of the injuries fall into the category of lacerations, contusions, sprains and abrasions; and account for better than half of the total number of accumulated sick or lost man days in this class. These hazards, as listed in the Diagnostic Nomenclature of the Manual of the Medical Department include: (1) falls and slipping on hatchways and ladders; (2) falls or injuries following upon rolling and pitching of storms at sea; and (3) injuries due to the mechanism of engines and machinery. To be added to this list are the injuries sometimes sustained in aerial bomb and depth charge and surface attacks.

TOPSIDE INJURIES

Injuries Sustained in Clearing the Bridge

Injuries were most commonly sustained by personnel of the bridge watch, particularly in the lightening-like maneuvers necessary to clear the topside of 8 or 10 men in the relatively few seconds that elapse between the time the diving signal is given and the submarine is 30 to 60 feet below the surface of the sea. Smashed fingers, broken ribs, dislocations, bruised shoulders, lacerations of various degrees were commonly engendered in the mass exodus of men from the bridge through a twenty-four inch hatch and down the slippery and precipitous ladder into the conning tower. Some patrol excerpts in relation to such injuries are as follows: "Two lookouts twisted their ankles clearing the always slimy and wet bridge" (SUNFISH No. 3). "One man in jumping from the bridge during a quick dive--struck right shin against top rung of conning tower hatch with a laceration requiring sutures and 5 sick days" (TINOSA No. 1). "In making routine dive, fireman broke right arm above the elbow, catching it between the deck and the upper conning tower hatch--could not be properly splinted and set with materials at hand" (RASHER No. 5). "A lookout got his foot caught topside--went through the hatch head first. The OOD, half way through, realized the man was hanging upside down and checked his dive" (HAMMERHEAD No. 5). "While clearing the bridge a lookout struck his mouth and broke off 3 teeth, 2 of which were forced into his upper jaw. One tooth was extracted" (BAYA No. 5). SEAOWL No. 3 reported a similar accident. "There was one fractured finger caused when someone stepped on it while the man was clearing the bridge" (SEARAVEN No. 6). "The commanding officer fell down the steps leading to the cigarette deck and dislocated his right shoulder" (SKIPJACK No. 1--a chronically dislocated shoulder). "One lookout dislocated a knee in clearing bridge" (POMFRET No. 3). "A Lt.--in clearing the bridge got a wound which became infected--7 sick days" (SEAHORSE No. 7).

Foul Weather and Topside Injuries

The bridge of a submarine affords scant protection against heavy weather. Not infrequently it may be inundated to the extent that men stand waist deep in water. Personnel were frequently thrown about the bridge and against the periscope shears by the rough seas, sustaining painful and serious injuries.

"At four engine speed the boat literally dove under a wave. A port lookout was knocked unconscious" (RAZORBACK No. 3). "The quartermaster sustained 2 fractured ribs when he was washed against the ammunition locker in heavy seas--off duty for 18 sick days" (GUARDFISH No. 12). "One after lookout cut his knee and leg when he was thrown by heavy seas against the 40 mm. gun" (BOWFIN No. 8). "One man suffered a broken arm when tossed about the bridge by the heavy sea." "Lookout cracked 2 ribs when heavy seas swept him over the bridge" (BILLFISH No. 5 and 7). "One lookout sustained a broken knee cap when he was swept off the lookout platform by a very high wave" (DEVILFISH No. 2). "A starboard lookout sustained lacerations of the leg and 2 broken teeth when thrown against the railing around the lookout platform by a heavy sea" (FINBACK No. 7). "Two lookouts on the bridge level were knocked down and washed aft. One struck the machine gun and ammunition stowage breaking off a tooth and a rib, and possibly sustained a broken arm" (The other man was shaken and bruised) (FLYING FISH No. 8). "On one occasion a heavy sea came over the bridge and swept the after lookout off the cigarette deck. He managed to save himself by hanging onto the rail and was pulled back up to the cigarette deck by other bridge personnel" (POMFRET No. 4). "The OOD was washed from the forward end of the bridge to the after end of the cigarette deck repeatedly. One lookout was washed from the platform and ended up hanging onto the trailing edge of the periscope shears by one hand" (SEAL No. 12). "A port lookout was knocked out temporarily by a huge green wave coming over the bridge. A torpedoman was washed off the starboard high lookout station and landed on the main deck. All stop--he made his way to the conning tower ladder but was swept away; this time hanging upon a life line. He made his way again to the ladder and was hauled to safety by eager hands" (TINOSA No. 8). "One officer had 2 teeth broken and one knocked loose when thrown against the spray shield on the bridge" (S-23, No. 5). "A torpedoman, a lookout, died from internal injuries incurred when a large wave threw him hard against the platform railing--approximately 17 hours later" (TULLIBEE No. 3).

"During the typhoon--the boat took a 53 degree roll. Lookouts were brought down from their usual station in the A-frames. One lookout was barely saved from being washed overboard by bumping into the JOOD" (THRESHER No. 14). "Once in 4 successive storms of cyclonic type--footing could not be maintained on the bridge. One man with a DU (fracture, hand) and another with a DU (fracture, rib) were incidental to the rough weather" (SWORDFISH No. 10). "In the Akutan Pass, took 30 feet waves over the bridge at the rate of 5 every 30 seconds. The bridge was flooded solid 5 times in a minute. The OOD was thrown against the shears

and broke 5 ribs. The quartermaster received contusions about the face and arm. With two emergency hospital patients, stood into Dutch Harbor" (S-23, No. 2). "On 1 January decided to remain submerged to rest the crew, several of whom had been badly shaken by the heavy seas. Submerged 2 January--to rest the crew and dry out clothing. During the night bridge watch was pounded down to the deck by heavy seas on an average of once every fifteen minutes. On 4 January port lookout suffered a broken nose and badly bruised leg when heavy seas flooded the bridge and threw him from the port after corner to the starboard forward corner" (S-38, No. 4). "Lt.--received a severe head wound when, in a typhoon, a wave almost knocked him overboard" (SILVERSIDES No. 11).

At the conclusion of the first patrol of the SILVERSIDES, "Forrox" plastic was applied to the bridge and lookout platform to reduce slipperiness. The commanding officer of the GUARDFISH (No. 10) observed: "The low life rail around the after bridge deck, made necessary upon installation of a 40 mm. aft, has created an additional hazard for personnel when in heavy seas. On one occasion the after lookout, who was holding onto the after TBT at the time, was washed off the bridge deck but fortunately managed to land on the main deck. During the next refit a more secure platform for the after lookouts will be designed and installed."

Men Swept Over the Side of Submarines on Patrol

In view of the above conditions of weather it should not be difficult to understand how men could have sometimes been washed overboard. From available patrol reports it is known that, through the course of the War, some 34 men were swept overboard from submarines on war patrols. Seventeen of these were recovered, seventeen were lost. Five men swept over the side are known to have been wearing life jackets, 2 of these were lost presumably from injuries incurred at the time they went over the side. Fifteen men were not wearing life jackets. Of these only 4 were recovered. Information concerning the remaining 13 men is incomplete, 4 of whom were not recovered.

On the second patrol of the BILLFISH an officer was swept overboard from the after TBT platform by a heavy sea, dressed in a full suit of foul weather clothing. He was successfully rescued when a second officer went over the side on a tended line and swam the 15 or 20 yards that the men were then too exhausted to swim. Both officers were later turned in; one for head injuries, the second for the effects of the submersion. Aboard the TREPANG (No. 3): "In a force four sea, an unexpected wave broke over the bridge and lookout platform, sweeping the number one lookout overboard at 1931. He was located at 1940 when he was heard calling. When recovered at 1956 he was so weak from cold, exhaustion and the result of an injury to his leg that he had to be assisted aboard." On the seventh patrol of the MINGO, during a hurricane, the OOD and 1 lookout were washed over the side during a hurricane in which the wind force was 80 knots and the sea force seven. The men were not recovered after a 34 hour search. Aboard the SEGUNDO (No. 2) a port lookout was washed overboard by a mountainous wave in a typhoon. As he went over the side he was seen to hit the hull. Search was abandoned some 37 minutes later. "Although you do everything you can there remains an empty feeling inside--'so near and yet so far away'. Since then we have kept a supply of whistles hanging in the control room for the use of lookouts. It is not voluntary but most of them use it and put it around their neck before going on the bridge. The next time we are in port we will try to draw some small 'man lights' that are so valuable in locating survivors." In commenting upon this incident ComSubPac stated: "--a regrettable casualty considered incident to war operations and one to whom no blame is attached." The division commander added: "--loss brings out the necessity of the wearing of life belts by bridge watches in heavy weather. The man was undoubtedly knocked unconscious in falling against the hull and consequently was unable to inflate the one he was wearing." On the fifth patrol of the CREVALLE the OOD was lost overboard. A second man "washed overboard but was recovered." The port lookout was washed overboard on the TAMBOR's twelfth patrol, being recovered in 23 minutes.

On one occasion aboard the HADDO (No. 9): "The after lookout's absence was discovered--HADDO surfaced and after 3 hours and 16 minutes of well planned searching in a heavy fog recovered the missing man who in time of distress had shown exceptional coolness and presence of mind by inflating his dungaree trousers and using them as a life jacket. The injection temperature of the water was 65 degrees F., despite which he was in a surprisingly good condition." On the first patrol of the HALIBUT: "When the order was given the ship was fired upon by an enemy freighter. There were 5 people on the bridge--the port, starboard and after lookout, the captain and the OOD. No one missed the starboard lookout who failed to clear the bridge prior to diving. No reason can be advanced for his failing to get below unless he slipped and fell over the side. He was reported missing from his battle station by the after torpedo room." Higher authority observed: "The possibility of such losses do exist when operating under pressure." In this case it was concluded: "The commanding officer had no adequate check to determine when all hands were below. Standard directives should provide for the OOD seeing that the bridge is cleared of all but one man who stands by the hatch and follows the officer below." "In a routine dive a lookout in the crow's nest failed to hear the

'Clear Bridge'. By the time he was aware, from the sound of the vents, that the ship was diving and had reached the hatch, it was closed. He dove over the side and was later recovered none the worse for this experience" (GURNARD No. 5).

Aboard the TROUT (No. 7): "In battle surface practice, a stray wave upset the gun crew washing the gunnery officer overboard. He was recovered within 5 minutes." On the eighth patrol of the GUDGEON: "In a gun battle Lt. (jg)--was struck on the head by an empty shell case as it was ejected from the gun. The blow evidently knocked him unconscious. He fell overboard and was never seen again." On the sixth patrol of the GUNNEL: "In battle surface, just as the deck was cleared and the diving alarm was sounded and the last man was going down the hatch one man was reported overboard. He was the gun captain and investigation disclosed that he had been knocked overboard by the recoil of the last shot fired by the deck gun. He was last seen astern, clear of the screws and swimming."

Seven men were swept over the side (four of whom were lost) who were topside engaged in rigging fuel ballast tank vents to main ballast tank vents. On the eighth patrol of the PUFFER "a man was recovered who had been washed overboard during the conversion of ballast tanks in a thrilling night rescue. In the dim light afforded by the moon, he was seen to have been swept loose and was being carried along by the water. He was carried slightly aft and hit the life line opposite the after 5 inch gun platform where there is a double wire only about 18 inches apart. Here he was caught momentarily--suddenly rising hope gave way to desperation as the impact of the water tore loose his grip on the wire and swept him over the side. Though shocked by the force of the seas, he had the presence of mind to take it easy, conserve his strength, check his lifebelt (which he later lost) remove his shoes and outer clothing and start to whistle. He could no longer see the submarine. He was discovered with a search light. A swimmer was dispatched with a buoy and line to the rapidly tiring man." On the fourth patrol of the PARCHE 2 men were lost overboard while converting number three and five fuel ballast tanks to main ballast tanks, in a sea of force three to four. "The men had entered the deck lockers. As an Ensign went aft to the number four vent--a short, quick swell from the port side threw him overboard. Stopped and a life ring was thrown over. Men ordered to bridge. The Ensign was rescued 8 minutes later. It was thought that all men in the party had returned to the bridge but a motor machinist's mate had gone back down from the bridge to get the last man who was just aft of the conning tower. When the Ensign was sighted, the 2 men were reported overboard--and were not recovered." In rigging the number four fuel ballast tank to main ballast tanks with personnel on deck one man was swept overboard from the PAMPANITO (No. 4) but was promptly recovered. On the tenth patrol of the TAUTOG: "--lay to convert the tanks--. As the deck was being secured, a wave broke over the gun platform and a motor machinist's mate was lost over the side. The wind, sea, air and water temperature made his struggles practically helpless." It was observed: "In connection with making necessary topside repairs at night recommend in addition to life jackets that each man of the working party be furnished a waterproof flashlight." On the first patrol of the SEAROBIN, while converting number four fuel tank, one of the men topside was washed overboard and lost. "He was wearing a life belt--a freak cross sea swept across the deck aft about one foot deep. The man was seen to go overboard to port. He was lying flat on the deck when he went over the side and it is believed that he hit his head on the 5 inch gun or the deck, there being no outcry or struggle. Searched for 7 hours." It was further observed in connection with the loss of this man: "Means of shifting the forward ballast tank vents to main ballast tank vents without sending men into the superstructure is a must. Several men have been lost shifting the vents. Under the most favorable conditions the boat and the lives of the men doing this job are jeopardized. In rough weather when it is impossible to shift these vents it is usually most desirable to have them shifted."

In a number of instances men were lost over the side while working on the exposed deck other than as above. "While inspecting damage to the superstructure following a severe depth charge Lt. (jg)--lost his balance and went over the side. He was dressed in heavy winter clothing. With the temperature 28 degrees F. it is doubtful if he could have survived more than 10 or 15 minutes" (CABRILLA No. 7). "On--while repairing damage, one man was swept over the side. He was recovered--in bad condition from shock, fatigue, and an overdose of salt water" (RONQUIL No. 2). On the sixth patrol of the COD, a serious fire in the after torpedo room necessitated opening of the after torpedo room hatch. In so doing, 2 men were washed over the side at about 2135. One was rescued at 0540 "utterly exhausted" wearing a life jacket. The other man, who did not have a life jacket, was not recovered. On the first patrol of the STERLET "in a strong wind and sea a heavy wave washed Lt.--overboard". A float light was put over immediately with the ship backing down and twisting in order to keep the light in sight. The recovery of this officer "may be attributed to quick action on the part of the submarine, the brave action of a coxswain who went to his rescue and a liberal measure of good fortune. It is suggested that all submarines provide personnel going on deck at night for any purpose with an abandon ship flashlight. This is a two-cell, red lens, watertight light which is prevented from accidental loss by a short lanyard with a battery clamp in the end. An acceptable substitute would be the standard Navy watertight flashlight." On the seventh patrol of the SWORDFISH,

in attempting to secure the deck anchor, a man was lost overboard but was recovered in 5 minutes "rather exhausted". Prior to the first patrol of the FLIER, while aground, two men topside on the anchor watch were swept over the side. One was recovered, having fractured his arm. A second man was not seen again. Aboard the HOE (No. 7) one man was "washed overboard while working on the 3 inch gun". The life belt which he was wearing saved him. On the first patrol of the SUNFISH "while maneuvering to recover a life ring from a Japanese ship in a smooth sea, two waves were taken over the bow. One man was taken over the port side into the water and carried rapidly astern. He was not seen again; 3 other men sustained injuries when swept from their feet by the wave." On the tenth patrol of the TUNA "after the target had sunk, the chief of the boat was lost overboard while retrieving floating crates--he lost his footing and being swept over the side in a calm sea was observed to sink and drown after about 4 minutes in the water." On the eighth patrol of the PUFFER, a chief torpedoman was accidentally drowned.

BELOW DECK INJURIES

Below deck all hands, to a lesser degree, were subject to the fury of the weather. Men were sometimes thrown from their bunks. "One man in the storm, was thrown from his bunk and sustained a laceration of the lip and lost a tooth in colliding with flood valve operating gear" (SNAPPER No. 8). An impressive number of men were burned subsequent to the spilling of hot coffee or food in sudden roll of the ship. One man received second degree burns of both legs when a boiling coffee pot overturned. Treatment consisted of morphine, tetanus toxoid, vaseline gauze and pressure bandages, bed rest and a liquid diet. With infection of the wounds in about 10 days, treatment was changed to warm normal saline dressings and sulfathiazole. The man was almost completely recovered by the end of the run.

Injuries Associated with Routining of Torpedoes

Necessary work when underway, in association with the routining, loading and shifting of torpedoes, was sometimes accompanied by painful and serious injuries. "While shifting torpedoes in the forward room, a torpedoman caught his ear between the skids. A large section of the ear lobe was torn away" (BOARFISH No. 4). "While routining torpedoes and the tubes, a MK 18 torpedo had been withdrawn approximately 5 feet in order to secure it with the Pearl Harbor design holding strap. An inboard slug was fired. When this was done (using 45 lbs. impulse pressure) the torpedo was forceably ejected into the torpedo room, carrying away the holding strap deck padeyes, and crashing into and smashing a bunk and fracturing the leg of a man who was in its path" (ICEFISH No. 4). "At the time of the bombing a torpedo in the forward room was pulled half way out of the tube for normal routining. It was being started into the tube when the emergency dive was begun. The large down angle caused the holding line to part and the torpedo started to slide forward. A torpedoman, who placed his foot against the tail vane, pulled forward until he came up against a stanchion, sustaining DU (contusion and fracture) of his foot; a second man, who had placed his right leg between the tail vane and the tube, suffered minor contusions of the leg and ankle" (MUSKALLUNGE No. 2). "--fractured his left foot and dislocated his right ankle when he was struck by a sliding torpedo" (SAURY No. 7). "One man received a laceration of the forearm when with a roll of the ship, he was thrown against the propeller of a torpedo" (SCORPION No. 3). Aboard the GURNARD (No. 1), one man sustained injuries to his abdomen and back when "squeezed between two torpedo racks while handling torpedoes". On the third patrol of the BLUEBACK, while routining torpedoes "the skid shifting in a sea way, a first class torpedoman's skull was caught between the two torpedo skids with resultant severe lacerations and possible skull fracture." On one occasion aboard the POLLACK (No. 9): "At 1700 a torpedo skid in the after torpedo room slipped athwart ships and crushed the head of a torpedoman between two torpedoes. The man did not lose consciousness. He was immediately put to bed and treated for shock. His pulse and respirations soon returned to normal. He was dead at 0300. He had been observed to be sleeping a half an hour before his death and breathing somewhat heavily. Entered the area feeling as if we had already completed an arduous patrol." On the PARGO (No. 3) a "torpedoman was bruised and his foot cut when a torpedo on the rack slipped and caught his foot between the horizontal rudders of two torpedoes." Aboard the TREPANG (No. 1) "one man while rigging his bunk in the forward torpedo room attempted to hold the heavy folding section of the after torpedo track upper skids by placing his index finger in a hole in this piece while he removed the toggle pin with the other hand. The folding section fell when the ship rolled, amputating his right index finger between the distal and middle phalanges." A second man on this patrol was "knocked out and bruised when breech door flew open and hit him in the face and chest during reload when he failed to determine that all of the pressure was out of the tube before opening the door."

Burns

As observed above, burns were frequently sustained with the spilling of hot food or coffee. On occasion, chemical burns were sustained in association with the batteries. Electrical burns were frequent. Aboard the GROWLER an electrician received a severe electric burn of the hands while "attempting to shift the field excitation of number two auxiliary engine from the after auxiliary distributing panel to self excitation". A second man sustained an electric burn subsequent to leaning against a hot panel in the main cubicle. Aboard the STURGEON (No. 8) one man received a deep and severe local electric burn of the hand "caused by high voltage, high frequency current while improperly handling SJ radar equipment". Aboard the S-31, No. 3: "The commanding officer received serious chest injury from the explosion of a Mark-X Emergency Identification Flare; transfer at sea to a PBY was necessary." Aboard the SARGO (No. 5) a fireman was knocked unconscious when he came in contact with "bus bias of number two auxiliary generator". He was quickly revived by the pharmacist's mate. Aboard the WAHOO (No. 1) one man was "temporarily blinded by flash when drew an arc in pulling a fuse from auxiliary power board on a hot circuit". "While rigging submersible pump and putting it across 250 volts on forward distributing board, terminal fell across air conditioning circuit and arced--a chief electrician's mate receiving severe flash burns to the eyes" (PLAICE No. 6). Six other instances of "flash burns" were noted in this series of reports.

Periscope Injuries

Injuries were sometimes sustained in connection with the periscope. One man suffered a painful injury when his foot was crushed between the hoist cable and the periscope shear. Aboard the SPEARFISH (No. 10) "one man crushed his foot, catching it in the periscope hoist cable drum." Aboard the GUITARRO (No. 5) "a quartermaster, while greasing number one periscope, had his hand around the cable. The man on the periscope watch inadvertently raised it--mangling the other man's middle and right fingers." On the seventh patrol of the PIKE the commanding officer was painfully bruised (nose) at the periscope "when the shock of the first explosion occurred". Aboard the TRUTTA (No. 1) "while raising the periscope to observe a small ship passing by, the commanding officer's hand became jammed between the handle and a metal seat with a resultant severe contusion and DU (fracture)". Aboard the NAUTILUS (No. 5): "One officer was incapacitated for a few days as a result of accidentally injuring his right foot in lowering the periscope."

Ammunition Handling, Injuries, Etc.

Injuries were sometimes incurred in handling ammunition. One man aboard the APOGON (No. 7) "lifted the automatic loaded for the 40 mm. Several hours later he complained of sharp pain in the right groin, was unable to maintain regular diet, and was presumed to have 'ruptured' himself". Another man suffered a hernia while handling 5 inch ammunition. A third hernia resulted while boarding the submarine from a rubber raft. A fourth hernia occurred aboard the SEARAVEN (No. 13) when an OOD cleared the bridge, it being necessary to confine him to his bunk for the remainder of the patrol. On REDFISH (No. 2) two men had hernias associated with handling 97 pound 5 inch shells. On the fourth patrol of the HARDER "while attempting to clear a jammed 20 mm., a gunner's mate amputated the tips of two fingers." Aboard the BOARFISH (No. 2) a gunner's mate ran a 30 caliber ramrod through the palm of his left hand while running it through a machine gun silencer. Aboard the SAURY (No. 7), while attempting to eject a jammed cartridge from a 20 mm. gun, one man amputated the terminal phalanges of his ring and middle fingers.

Miscellaneous

Aboard ship other injuries were in the nature of contusions and abrasions sustained in stepping into opened hatches, particularly when red illumination was being used. "Four sick days were due to lacerations of the knee of a lookout who fell through the after battery hatch while wearing night adaptation glasses." "One man fell through an unlighted hatch in the control room to the storeroom sustaining a two inch laceration of the shin, a DU (fracture) and a laceration of the scalp." (SEGUNDO No. 1). Aboard the GABILAN "one man stumbled into open magazine hatch and fell head first into the magazine, striking arm just below elbow with severe laceration." "One man fractured his arm in falling through the deck hatch" (SEARAVEN No. 6). Fingers were bruised, crushed and sometimes amputated when caught under hatches and in doors: "One man caught his index finger in water tight door while cleaning the operating mechanism causing a compound fracture of the bone and nearly severing the end of the finger" (SUNFISH No. 10). "One compound fracture of the ring finger and simple fracture of index finger when storeroom hatch cover fell on man's hand. Boat dived to 100 feet to furnish a stable platform for setting the bones and suturing the fingers" (SUNFISH No. 4). "One man had his right thumb badly fractured in several places by falling hatch" (THRESHER No. 15).

Aboard the TARPON (No. 12) one man, while grinding in an engine exhaust valve amputated a finger. Aboard the PUFFER (No. 8) an officer while working on the main engine fractured his left wrist and lacerated several tendons. Because of the serious nature of his wounds he was transferred to Makin Island for treatment. Aboard the TINOSA (No. 3) one man sustained lacerations of the face when the handle of the engine inboard induction flapper snapped out of catch. Aboard the GURNARD (No. 2) "during silent running and in hand operation of the plane's steering, an officer, while attempting to operate the stern planes by hand, was struck and injured by the hand power operating handle (power was cut in at the panel aft, by-passing the stern plane pilot circuit, thereby spinning the handwheel which struck the officer's exposed hand)." Aboard another submarine, while working in the bow plane rigging gear, a man caught his hand between the chain and sprocket of the gear with traumatic amputation of the tips of three fingers. Aboard the TAMBOR (No. 11) a man was injured when a high pressure air line ruptured, sustaining lacerations, first and second degree burns and ruptured blood vessels. Aboard the GRAYBACK (No. 5) one man received a laceration of his heel while passing through an airlock door, the foot being caught as the door closed. This same accident occurred aboard another submarine (PETO), the Achilles tendon being nearly severed.

An officer, aboard the PADDLE (No. 7), while attempting to fire a MK-I signal projector amputated three fingers. Aboard the S-31 (No. 4) one man fell into the C & R Air Compressor lube oil pump in the motor room, badly mutilating his arm, for which he was transferred at sea to a PBY. The commanding officer of the FINBACK (No. 12) in commenting on the health of his crew stated: "The only cases necessitating medical attention were several cases of head wounds caused by binoculars striking the face when clearing the bridge." Aboard the SILVERSIDES (No. 12) there were "eight lacerations, most of which resulted from lookouts being hit by binoculars while clearing the bridge".

Sometimes during depth charge attacks, men were injured when knocked from their feet or when hit by flying gear. "There were minor lacerations and back sprains during the depth charge attacks" (HALIBUT No. 10). "There was one scalp wound when a man was struck by a heavy chain fall after the fifth destroyer had blown up above us" (HARDER No. 5). "One man was injured when a watertight door jolted loose and hit him in the head, practically severing one ear, requiring nine sutures" (REDFISH No. 2).

On a few occasions foreign bodies, particularly in the eye, became problems of treatment. Aboard the BAYA (No. 5) a chief motor machinist's mate received a piece of metal imbedded deep in the cornea of the eye. This was removed surgically. The corneal ulcer which resulted was "cured by the use of penicillin". Aboard the TUNA (No. 1) and SEGUNDO (No. 1) the bulb of a portable electric light exploded close to the eye of a motor machinist's mate. Many small pieces of glass lodged in both eyes. The pharmacist's mate removed a number of pieces with cotton swabs, washed out the eye with boric acid and instilled an ophthalmic ointment. Wet boric compresses and irrigations were used thereafter and the man was confined to his bunk. Some of the remaining pieces were subsequently removed and the rest came out by themselves. Aboard the WHALE (No. 9) one man's cornea was punctured by a flying chip of brass. He was later transferred to another submarine for medical treatment. When seen aboard a tended ship he had a panophthalmitis. Eventually surgical removal of the eye was necessary.

INJURIES ABOARD SUBMARINES ASSOCIATED WITH STRAFING AND BATTLE SURFACE ATTACKS

Some of the most stirring chapters of submarine warfare are concerned with gun engagements, literally duels to the death, between enemy surface craft and submarines. "There are 939 recorded gun attacks made by U.S. submarines on enemy ships of all sizes and classes with accredited sinking of 722 vessels--" (ComSubPac, Conf. "Enemy Anti-Submarine Measures", page 12). Exciting though these encounters always were, they sometimes exacted their price in terms of painful shrapnel and bullet wounds.

Number of Personnel Topside on Engagements with the Enemy

The number of men topside during these engagements varied. Ordinarily the gun crew of the deck gun would consist of about 8 men (1 officer, a pointer, a trainer, a gun captain, a sight setter, a first and second loader--in addition to 1 or 2 ammunition handlers). The two 20 mm. guns, one forward and one aft of the conning tower, were manned by 2 men each, a gunner and a loader. Two 50 caliber guns on the main deck were each manned by a gunner and loader each with an officer in attendance. The total number of men involved in surface action with these guns would thus vary from 12 to even 20. If the ship was equipped with 40 mm. (there being two--one aft and one forward--each with a loader, gunner, pointer, trainer, gun captain and 1 officer) and a 30 caliber (usually one, as on the conning tower) additional men were topside.

Special Hazards of Surface Engagements

Surface engagements were accompanied by special hazards. First of all, the men were exposed not only to the enemy but to the weather. "The 4 inch gun crew became congealed with cold from the icy sea. The trainer had both hands frost bitten" (SKIPJACK No. 10). "Battle surfaced--seas making firing difficult with the crew drenched with icy water. In battle surface seas made gun platform wet and unsteady" (TAUTOG No. 10 and 12). Aboard the SEACAT (No. 2) gun crews exposed on the open decks with the heavy seas breaking over them became thoroughly chilled in the cold air at a temperature of 38 degrees F. "Battle stations--deck covered with ice. Man had trouble toting shells from the ready locker--. Wind 25 to 30 knots, snow flurries, spray icing all over the topside." (ATULE No. 2).

On occasion men were injured as aboard the TIGRONE (No. 2): "During a turn, while at battle surface, several seas washed over the main deck throwing the gun crew against the guns with multiple lacerations and contusions." "In gun attack a large wave washed over the forward deck knocking the gun crew from their feet with some men sustaining sprains and lacerations" (CAVALLA No. 1). "Choppy seas made pointing erratic and several times the gun crew were knocked away from the gun. Battle surfaced; high seas picking the gun crew up from their stations and piling them against the life line. The gunnery officer actually went between the line but saved himself by grabbing the lower wire with both hands--his left hand was torn from the wire by the weight of the water and his class ring was stripped from his finger" (SAWFISH No. 1). "In battle surface practice--stray wave upset gun crew; washed gunnery officer overboard--recovered in 5 minutes" (TROUT No. 7). Aboard the HOE (No. 7) and the RONQUIL (No. 2) men working on the deck gun were swept over the side but recovered.

Aboard the PLUNGER (No. 6) there "was no stopping of the 3 inch although the gun had to be pushed back to the battery by hand after the first 100 rounds. A muscular negro cook worked his way up to the ammunition line from the mess room to the gun as the less stalwart were relieved." As the commanding officer of the SEGUNDO (No. 1) pointed out: "Five inch shells weighing about 100 lbs--passing them up through the gun trunk is awkward in smooth water and dangerous in rough water." Two hernias were reported on the REDFISH (No. 2) "both men had been previously handling--five inch shells when they complained of pain." Aboard the TUNA (No. 11) one man was reported to have burned his cheek while handling hot shell cases.

As observed elsewhere, TAUTOG No. 6, POLLACK No. 2, TRITON No. 3, STURGEON No. 6, POGY No. 5, GAR No. 12, BOWFIN No. 9, the five inch shells and tracers of the 20 mm. and 20 caliber weapons are associated with a flash which, particularly at night, may be blinding. "--in battle surface--after the 40 mm. partially blinded the 5 inch crew the blast from the 5 inch trained well forward almost lifted the 40 mm. crew out of their seats" (TIRANTE No. 1, April 1945). The concussion of the large deck gun not uncommonly was sufficient to rupture ear drums (reported in 15 instances), often bilateral. "Two men temporarily became deafened from the blast of the 5 inch gun when the cotton became dislodged from their ears during the attack" (PARCHE No. 5). "After each gun action many headaches were complained of by members of the 5 inch gun crew--probably the result of the concussion and the noise" (SEA POACHER No. 3). "During the shelling--the gun spotter sustained irritation and inflammation of his eyes from the muzzle smoke and gas" (ROCK No. 6).

Accidents Associated with Deck Armament and Small Arms

A number of accidents were associated with deck armament and small arms aboard submarines. "Our first loader received a badly bruised hand when struck by the breech block in loading the last projectile" (SKIPJACK No. 10). Another man received a laceration of the face when hit by the recoiling gun. "A torpedoman, while acting as the first loader on the 5 inch deck gun in firing at an enemy mine, sustained a laceration of the face when an ejected shell case rebounded off the life line" (BAYA No. 4). Aboard the BOWFIN (No. 9) one man on the 50 caliber sustained a broken rib during action. On the NARWHAL (No. 5) "during the rapid influx of the gun crew into the forward gun access trunk one man sustained a fractured ankle". Aboard the BOARFISH (No. 2) "a gunner's mate ran a 30 caliber ramrod through the palm of his left hand while running it through a machine gun silencer." Aboard the HARDER (No. 4) "in attempting to clear a jammed 20 mm. one man amputated the ends of two fingers just short of the first joint." Aboard the NAUTILUS (No. 5) "two men were wounded when a projectile exploded in and burst a 20 mm. gun barrel."

Aboard the GAR (No. 7) "A gunner's mate was slightly wounded with shrapnel in the chest when a 20 mm. shell exploded inside the gun." On the eleventh patrol of the KINGFISH: "In training exercises, the after 20 mm. gun was fired for test. Shortly after this, one round--prematurely exploded near the muzzle of the gun, throwing fragments of metal about the deck, and injuring one officer in the leg; a second man received a deep laceration of the scalp." Aboard the SEA POACHER "Four members of the 5 inch gun crew were unfortunately injured by an explosion of the barrel of the 20 mm. gun--. The exact cause can not be determined

but it is believed that some error in loading or handling the magazine resulted in the first projectile being improperly loaded. About six inches of the barrel was blown off, injuring four men and cutting short this aggressive and alert patrol. It was considered inadvisable to keep three wounded aboard for 30 days without a doctor's attention unless the military situation in the area required it." Aboard the WAHOO (No. 3) "Three men were injured by a 20 mm. explosion--a misfire--in one case necessitating amputation of two toes." Aboard the APOGON (No. 3), "In preparing to clean a gun (in which one line of cartridges had been accidentally left in a .30 caliber machine gun) the bullet discharged striking the deck and ricochetting into the leg of a man nearby"--causing the submarine to return to Johnston Island for transfer of the injured man the next day.

On the ninth patrol of the KINGFISH, enroute to Midway, 2 men were wounded when a .45 caliber pistol accidentally was fired--in the crew's mess, wounding 1 man in the arm and another man's hand. Aboard the SEA FOX (No. 3): "A seaman was accidentally shot in the chest with a 45 caliber slug by a gunner's mate striker which penetrated below the right nipple, slanted upward and emerged posteriorly at the shoulder." With excellent care from the pharmacist's mate and considerable good fortune the man was up and about at the end of 7 days. On the fourth patrol of the BLUEBACK while "the gunnery officer and a gunner's mate were checking .50 caliber twin machine gun topside--the gun accidentally fired. The officer was instantly killed by two .50 caliber bullets passing through the lower part of his chest."

Injuries and Deaths Incurred in Surface Engagements with the Enemy

Beyond these accidents, in a few instances men were injured and killed in surface engagements with the enemy. The number of these injuries, in comparison to the number of gun attacks that were made (939) is surprisingly small. Approximately 50 men were injured in battle surface, of whom 10 were killed instantly or died later. This does not include 11 men that were injured and 2 who were killed when submarines were strafed by enemy planes.

Deaths

Five gunshot wounds were sustained by personnel aboard the GROWLER on what was probably one of the more dramatic and tragic experiences encountered by submarines during the war. "While on patrol in enemy waters, contact was made with an enemy vessel. During the ensuing surface approach, the GROWLER rammed the enemy ship. The enemy immediately commenced firing with a .50 caliber machine gun, concentrating on the bridge of the submarine. Approximately 50 bullet holes were later found in the bridge superstructure. After the word was passed to clear the bridge, 2 badly wounded lookouts were pulled through the conning tower hatch. Due to the heavy enemy fire it was impossible to send anyone on the bridge. The conning tower hatch remained open for about 30 seconds and no other persons could be seen attempting to enter the boat. In order to save the ship and crew, the boat submerged. Upon surfacing, the body of one man was found with numerous bullet holes and the remains consigned to the sea. The other two bodies, those of the captain, Commander Howard Walter Gilmore, and the junior officer-of-the-deck were washed overboard and were not recovered."

On the first patrol of the SCORPION: "In the midst of a gun attack on a patrol vessel, Lt. Comdr.--who was firing from the bridge railing received one enemy bullet in the center of the forehead--. He was lowered to the deck aft of the bridge and the firing continued." Later, the body having been prepared for burial, the submarine was forced to submerge to 150 feet by a plane, which dropped 2 depth charges. During the dive the body was lost from the gun platform. Concerning this tragedy the division commander stated: "--we are now one hundred per cent in the firing line and all of us have been given a personal grudge. Each ship of this division will dedicate one full tube next forward to Lt. Comdr.--."

On the fourth patrol of the COBIA: "--two sea trucks were engaged separately by the experienced gun crews of this submarine which had accounted for 6 small craft by gun fire in 4 patrols. Unfortunately, return fire from the second target wounded 2 members of the 20 mm. crew--. At 1847 (approximately 45 minutes later) one man appeared to be dying. At 1930 he rallied and the pharmacist's mate decided that there was a chance of saving his life if we could get him to a hospital. He died at 0534 the following day, being buried at sea."

Aboard the MUSKALLUNGE (No. 7): "Seven sea trucks were engaged--. At this time learned that--who was manning .50 caliber on the high lookout platform was badly hurt and unconscious. The pharmacist's mate was summoned from the conning tower and a pressure dressing was applied to a .30 caliber wound under the man's jaw and he was carried below. Word came back shortly that he was dead. The bullet had first hit his gun then ricochetted upward passing through his neck into his brain. Two men received minor wounds from flying shrapnel. The loss of--was keenly felt. It was indeed a misfortune that one accurate burst of enemy fire during the shooting should eliminate this man's life. His loss leaves heavy hearts."

On the first patrol of the SILVERSIDES: "--encountered enemy trawler--engaged him with deck and machine guns. He replied with machine guns and rifles. In closing to finish him off he got in one burst at the gun crew and the bridge, killing the second loader instantly."

Aboard the BILLFISH (No. 7): "one man was lost in gun battle--fatally wounded by rifle fire (head injury) from one of the schooners, dying about 10 hours later." A second man was wounded in this same action.

On the eighth patrol of the GUDGEON: "In a gun battle Lt. (jg)--was struck on the head by an empty shell case as it was ejected from the gun. The blow evidently knocked him unconscious. He fell overboard and was never seen again."

On the first patrol of the THRESHER one man is said to have been killed in a surface engagement with the enemy. No details are available since this patrol report could not be obtained for study.

Injuries, Non-fatal

Injuries during surface engagement with the enemy were sustained on the following patrols. "Three men were injured in battle surface with 3 heavily loaded camouflaged sea trucks--when action took place within range of automatic weapons. One of the sea trucks was quickly silenced by 4 inch hit and fire from the forward 20 mm. gun but the after 20 mm. jammed and one of the sea trucks was able to rake the bridge with .50 caliber fire which injured 3 men. One man's life was saved when his helmet deflected a bullet. Two men were injured in the scramble for the hatch on clearing the bridge" (BLUEGILL No. 3). Aboard the BATFISH (No. 3) a loader of the 4 inch gun crew was wounded behind the knee by a .30 caliber bullet. On the seventh patrol of the BOWFIN a torpedoman received shrapnel wounds in both legs--"the left one had both bones splintered and the right had a flesh wound". Aboard the BESUGO (No. 1) "flying fragments from .50 caliber armor piercing shell which struck the periscope shear wounded a lookout in the leg and the gunnery officer in the hand." On the fourth patrol of the BURRFISH "two members of the gun crew received painful wounds from enemy fire when the range closed to 700 yards (one was wounded in the leg, a second had a bullet in his diaphragm)." On the ninth patrol of the HALIBUT: "In the second gun attack the number two and four loaders were hit by a burst of enemy fire and made their way below in spite of their painful wounds. A lookout was wounded by shrapnel. One loader was seriously injured in the chest with a complicating hemothorax; the other man had numerous shrapnel wounds of the shoulder." The patrol was terminated. Excellent care from the pharmacist's mate undoubtedly saved the life of the one especially seriously injured man.

On the fourth patrol of the SENNET one man was wounded by shell fragments. One man aboard the REDFISH (No. 2) received a scalp wound when hit by a ricochetting bullet. On the tenth patrol of the SKIPJACK in a "courageous gun attack made upon a sea truck or lugger--the commanding officer was unfortunate enough to receive a--bullet wound of the left hand." On the eleventh and last patrol of the SALMON, in her epic surface engagement with the enemy, 3 men received minor shrapnel wounds, 1 man sustained a laceration of the hand, and a fifth was struck just below the knee by a bullet or shrapnel which carried away part of the tibia. On the third patrol of the SNOOK a gun attack was made on a small wooden vessel. Four men were wounded, at a range of about 700 yards, apparently by action of a sniper aboard the vessel. On the twelfth patrol of the TAMBOR "in battle surface--counter-action by the enemy wounded one man--" (compound fracture of leg) who was later transferred at sea to a destroyer for medical care. On the seventh patrol of the TROUT, at a range of 1,000 yards, 9 men were wounded by enemy gun fire (one compound fracture of leg, 2 possible fractures, 3 gun shot wounds and 3 shrapnel wounds). Four of these men were confined to their bunks--none of the wounds became infected or complicated. "The outstanding performance of the gun crews under fire is typical of the wholehearted enthusiasm and cooperation shown by every officer and man in the crew throughout this patrol. The chief pharmacist's mate is to be particularly commended for the excellent manner in which he handled the casualties and for the subsequent care and treatment rendered. The 4 wounded men confined to their bunks deserve due consideration for their conduct, having suffered their injuries cheerfully and patiently without complaint or regret." On the second patrol of the SPOT, 2 men received shrapnel wounds.

Surface Engagement Injuries and Body Armor

The commanding officer of the SILVERSIDES (No. 12) recommended some sort of gun shield for exposed members of the gun crew. In which respect at the end of the third patrol of the SEA POACHER on which 5 gun attacks were conducted "no body armor was issued".

Deaths and Injuries Associated with Enemy Strafing

On the first patrol of the SKATE: "Lt. (jg)--died from wounds received in action against the enemy, being wounded in the first strafing--he died two days later. The officer at the time

the Japanese zero dove suddenly out of a nearby cloud and started strafing us, was standing on the port side behind the periscope shears. It is difficult to see how he was hit unless by a ricochetting bullet--which struck the right side of his back between the hip and shoulder, apparently lodging in the stomach. Two days later, because of his critical condition, the submarine set course for a rendezvous--" but unfortunately help was not available in time and the officer died aboard the submarine and was buried at sea. On the next patrol on which a 6,000 ton freighter was sunk "all hands agreed to dedicate--this--to the memory of the late Lt. (jg)--the target blowing up with a tremendous explosion which sent fire and flame shooting into the air and was plainly visible for over 50 miles." On the tenth patrol of the SNAPPER "while performing lifeguard duty and running on the surface, SNAPPER was strafed by a Japanese zero breaking from cloud cover. Before she could submerge the zero had killed one enlisted man and wounded three other persons including the commanding officer. Two wounded men were transferred at Majuro and the submarine returned to her area. The lookout was killed instantly--as he was half way through the hatch. A second man received multiple shrapnel wounds, a third and fourth (the commanding officer) were also wounded by shrapnel and metal splinters." The commanding officer in commending the pharmacist's mate stated: "PhM 1st class--is commended for the efficient manner in which he handled all casualties--. With two very seriously wounded men on his hands he calmly administered all the necessary aid and did all that was possible with the equipment that was available--." The PLUNGER, on her ninth patrol, was similarly strafed by an enemy plane, in which six men wounded by shrapnel, were transferred within 30 hours to two surface craft for medical care. "About 10 hours later ComSubPac told us that they were out of danger."

MISCELLANEOUS PATROL INJURIES TREATED BY PHARMACIST'S MATES

Pharmacist's mates were frequently called upon to treat injuries which could be attributed to other sources than these natural hazards of submarine life. Prisoners of war, when taken aboard, were frequently found to be seriously injured. It can be pointed out with pride that the care furnished these unfortunates by the representatives of the medical profession aboard submarines was always adequate and often times brilliant. Readers interested in this subject would do well to consult the following patrol reports: ALBACORE 9, ANGLER 1, ANGLER 5, BARB 12, BATFISH 6, BOWFIN 6, BESUGO 4, BLENNY 3, BLUEFISH 2, BOREFISH 7, BREAM 3, BUGARA 2, CERO 7, COBIA 3, COD 4, 5, and 6, DRUM 10, HADDOCK 11, HAWKBILL 4 and 5, ICEFISH 5, MINGO 5, NAUTILUS 4, PIPER 3, POGY 6, PUFFER 2, RAZORBACK 3, REDFIN 4, REDFISH 1, SCABBARDFISH 2, SEADEVIL 3 and 4, SEAHORSE 6, SEAROBIN 2, 3, and 4, SKATE 3, SARGO 9, SPEARFISH 12, STICKLEBACK 1, SPOT 1, STINGRAY 12, TAMBOR 3, THREADFIN 3, TILEFISH 5, TINOSA 5, TROUT 10, and TUNA 10.

AIR-SEA RESCUE OPERATIONS

The thoroughness of the training and caliber of the performance of submarine pharmacist's mates is nowhere more apparent than the care afforded survivors recovered in air-sea rescue operations. This is a story complete in itself. It can be pointed out here that throughout the war, 110 U.S. submarines in 200 separate pick-ups recovered a total of 542 American and Allied airmen downed in Pacific waters in operations extending from Tokyo Bay to the Solomon Islands. Two hundred and fifty-nine of these survivors (48%), when recovered, required medical care, essentially for exhaustion and primary shock consequent to overexertion and over-exposure. Ten per cent of these airmen were suffering from severe wounds with severe secondary shock. Nine aviators, when recovered, were dead. Only 2 aviators died aboard submarines and under the care of pharmacist's mates. This record alone is one that the entire medical profession may view with great pride.

EXCERPTS FROM PATROL REPORTS

To conclude this section dealing with injuries treated by pharmacist's mates and to illustrate some of the conditions described above, the following authentic excerpts from patrol reports have been selected:

"One man received a severe laceration of the right forearm which required 7 stitches. Two men were injured by misfire of the 20 mm. gun. In one of these cases it was deemed necessary to amputate 2 toes of the right foot. Due to a shortage of surgical instruments (this was early in the war) a pair of sterilized side cutters were used to cut portions of shattered bone. Because the phalanges--were completely shattered they were not sutured but left open to allow to drain. A generous amount of sulfanilamide powder was used. The other man was wounded in the shoulder but no lead or foreign body could be located. This man was back to duty in 3 days with no complications" (WAHOO No. 3).

"The Medical Department in the person of the chief pharmacist's mate did a particularly capable job in handling the Jap prisoner of war recovered after his plane was shot down. Though suffering from shock, second degree burns of the face and hands and several other serious wounds from gunshot and the crash, he was brought around very well and will probably arrive in port almost fully recovered--" (ATULE No. 3).

"Two wounded men were in excellent hands under the care of the chief pharmacist's mate. Their recovery from wicked flesh wounds caused by a Jap .50 caliber machine bullet is a tribute to his skill and ability. Two men, with multiple shrapnel wounds were admitted to the sick list for a total of 60 man-lost days. An injured German prisoner was treated for a dislocated left knee, broken right collar bone, badly lacerated mouth and nose and three missing teeth. Recovery to date is satisfactory except that he succeeded in misaligning his clavicle after it was lined up properly" (BESUGO No. 1).

"The price of sinking one sampan, damaging one and learning the use they are put to (submarine traps) was three men wounded. One man received two .25 caliber hits in the left side just beneath the floating ribs, the bullet ranging upward, fracturing the rib and puncturing the left lung (hemothorax); the other bullet lodged in the diaphragm above the stomach. A second man received 5 hits in the right shoulder over the scapula; the third was struck in the right hip by a piece of flying metal as the target exploded. In view of the nature of the wounds, left the area 24 hours early, setting course for Midway at best speed. The chief pharmacist's mate--is particularly commended for his quick and efficient action in caring for these three wounded shipmates. By his proficient skill and painstaking efforts he prevented complications of severe wounds and enabled return of his patients to the facilities of a hospital, well on the road to recovery. He has been recommended for promotion and the Bronze Star Medal" (HALIBUT No. 9).

"One man suffered a compound fracture of his right ring finger and a simple fracture of his index finger when a storeroom hatch cover fell on his finger. The boat was dived to a hundred feet to furnish a stable platform for sewing up the fingers and setting the bones. While the finger tips are still stiff one month after the accident, they have healed nicely and PhM1c--is to be commended for his efficiency and skill" (PETO No. 4).

"The TIGRONE, on her second patrol, established an all time record for the recovery of friendly aviators when in 5 rescues she picked up a total of 30 men. The first man was recovered on 25 May 1945 with severe lacerations and second degree burns. Five days later 5 more were recovered, all in good condition, 18 minutes after their plane had crashed. On 29 May 16 were rescued, 2 of whom were seriously injured, one with severe head and body injuries, the second with a possible fracture of the back and skull. One man of this group died about 6 1/2 hours after recovery and was buried at sea on 30 May. On the afternoon of the same day 7 survivors from an Army bomber, clinging to a life raft buffeted in tremendous sea with waves at least 30 feet high, were brought aboard. One of these men had a bullet wound of the foot, a second a fractured clavicle." The problems which confronted the CPhM during this six day period must have been at times overwhelming. On 1 June a medical officer from a destroyer boarded the submarine; on the same day the survivors were transferred at Iwo Jima.

"One man--while engaged in surface battle with the enemy was struck below the knee by shrapnel which tunnelled its way through the head of the tibia and emerged on the opposite side of the leg. The treatment, excellently planned and carried out by the chief pharmacist's mate, consisted of irrigation, tying off of bleeders, local sulfonamide, pressure bandages, application of a splint, plasma, tetanus toxoid, followed in two days by debridement of bone and tissue fragments" (SALMON No. 11).

DISEASES OF THE DIGESTIVE SYSTEM

As will be observed in Table 7, the four most common medical conditions belonging to this class appear to be in order of their frequency, acute gastroenteritis, chronic constipation, acute appendicitis and Diagnosis Undetermined (abdominal pain). Most cases of gastroenteritis and practically all cases of constipation were not admitted to the sick list. The bulk of sick days attributed to this class (578 of a total of 995) were consequent to acute or chronic appendicitis.

GASTRO-ENTERITIS AND FOOD POISONING

Careful analysis reveals notations concerning food poisoning in only 34 out of 1,489 patrol reports, in only 9 of which was food definitely incriminated. Offending agents were listed as canned orange juice, canned sardines, custard pie, beef, ham, surveyed Avoset, spoiled chicken, tinned hash and tinned salmon (2 instances). The remaining reports mentioned the occurrence only in general terms.

That mass food poisoning aboard an operating submarine may not only be incapacitating but cripple the striking force of the ship is illustrated by the following excerpt: "Food poisoning occurred on the 7th to 9th of July--believed due to frozen chicken served for dinner on 7 July. Two-thirds of the crew and all of the officers were involved, with diarrhea and vomiting. Two men were still vomiting after 5 days and were not fully recovered 10 days after they had been stricken." The submarine sighted a carrier on 10 July, concerning which higher authority observed: "Loss of depth control on the one attack made was most unfortunate in that it prevented firing at a carrier. The order to make ready the tubes was given rather late; this was combined with personnel errors in hurriedly preparing all tubes. At this time nearly all of the crew was handicapped by sickness from the food poisoning" (HALIBUT No. 5).

Other episodes involved a varying number of men: "Fifty per cent of the crew involved" (BLUEFISH No. 5), "seventeen men with diarrhea--" (CAPITAINE No. 1), "fifteen men with diarrhea" (GATO No. 13), "six men" (JACK No. 6), "forty per cent of the crew affected" (PERMIT No. 9), "sixty-five per cent of the crew had food poisoning" (PIPER No. 1), "fifty per cent of the crew involved with 26 sick days" (RASHER No. 2), etc.

Interested readers are directed to those sections dealing with the occurrence of mass illness aboard operating submarines related, in most cases, to excessive copper sulfate content of the drinking water, or to the use of carbon tetrachloride. Submarine pharmacist's mates and physicians should keep in mind these three possibilities in attempting to determine the cause for mass illness aboard operating submarines.

CONSTIPATION PROBLEM ABOARD SUBMARINES

Constipation being almost an occupational disease is generally taken for granted among submarine personnel. The following excerpts from patrol reports will illustrate its frequency. The problem admittedly in the last quotation was over-emphasized and over-treated. "Constipation was the most common complaint, being most prevalent in the first 2 weeks of the cruise; after this period the requests for laxatives dropped off to the level observed in normal operation (peace time) conditions" (GRAMPUS No. 1). "The most common complaint was constipation, involving 90 per cent of the crew." This pharmacist's mate (it was the first patrol of the ship early in the war) stated that on a 56 day patrol with a crew of approximately 75 men he had dispensed 3 quarts of mineral oil, 1 pint of castor oil, 2 pounds of Seidlitz powder, 3 bottles of cascara, and 20 soap and water enemas! (ARGONAUT No. 1).

Constipation, as pointed out by others, is associated with the problems of diet (the small amount of available roughage, insufficiency of fresh fruit, excess of carbohydrates), improper eating habits, irregularity of meals and sleep, lack of exercise, motion of the ship and heads which are sometimes difficult to operate. When intelligently managed by the pharmacist's mate, constipation was not, however, an insurmountable problem. It was, on more than one patrol treated as acute appendicitis. On one occasion through a diagnostic error a patrol was interrupted to transfer a patient thought to have acute appendicitis. Though the resultant loss of man hours, confusion and anxiety felt by all hands, may be and was deplored, it can not be denied that these factors were relatively unimportant when contrasted with the disaster that might have resulted had the pharmacist's mate made the reverse diagnostic error and instituted vigorous treatment.

APPENDICITIS ABOARD COMBAT SUBMARINES IN WORLD WAR II

Probably no other single disease is cause for more anxiety to submariners than is appendicitis. Early in the war before the proper method of treating appendicitis had been disseminated, it was not at all uncommon to have the commanding officer of a submarine greet his newly reported pharmacist's mate with, "Can you help me take out an appendix?".

It being obvious that medical officers could not be carried on submarines, it became doubly important to formulate a policy governing the treatment of all cases of appendicitis and to promulgate it as widely as possible. This was done. All officers at the Submarine School in New London, both in the basic class and in the class for prospective commanding officers, and of course all pharmacist's mates entering the service and enrolled in the "School for Pharmacist's Mates" were carefully indoctrinated.

They were taught that the diagnosis of appendicitis is difficult and that errors may be made. That, as a matter of fact, without laboratory facilities and in relatively untrained hands, errors in diagnosis might exceed the correct diagnosis. Gastric and gastro-intestinal disturbances, as constipation lead to increased difficulty in differential diagnosis. Moreover, even if the diagnosis is certain, with conservative treatment more cases will recover than will go on to rupture.

The conservative treatment recommended was NO food by mouth; NEVER give a cathartic to a case of suspected appendicitis; absolute bed rest; the smallest sips of water by mouth (any evidence of dehydration was treated by intravenous fluids); a low gentle enema repeated if necessary until results were satisfactory (many cases of acute appendicitis are cured this way); sedation until resting quietly; icebag over right lower quadrant (a debatable point); sulfa drugs in adequate dosage; and as it became available, penicillin. They were then taught that even though their patient might turn out to belong to the small per cent that would go on to rupture, the odds were still in the patient's favor--that he would wall off the infection and develop an abscess which could be easily drained. Realizing all of this and, most importantly taking into account the almost impossible conditions under which an operation would have to be undertaken the final obvious order was--NEVER resort to surgery.

INCIDENCE AND MORTALITY RATES OF APPENDICITIS IN CIVILIAN PERSONNEL

The incidence of acute appendicitis in a civilian group of comparable size and age to the one with which we are dealing is unknown. According to the Public Health Service (Public Health Reports, Reprint No. 1981, Vol. 53, No. 36, September 9, 1938) in some 8,758 families of all ages who were under observation in 18 states during 12 consecutive months, appendicitis developed at a rate of 6.6 per thousand in males and 12.3 in females. For males, the incidence per age group was:

Table 19.--

Under 5 years	1.8 per thousand
From 5 to 9 years	5.0
From 10 to 14 years	8.3
From 15 to 19 years	9.8
From 20 to 24 years	10.1
From 25 to 34 years	12.1
From 35 to 44 years	7.0
From 45 to 54 years	2.7
From 55 and over	2.4

These figures are of interest because they indicate that between the ages of 15-34 appendicitis is very common-- "the most common major surgical disease". According to the Metropolitan Life Insurance Company (The Diplomat, Vol. 18, No. 5, pg. 164, May 1946, "Mortality Rate from Appendicitis in U.S. Decreased") "between 1940-1943, the latest years for which data are available, the number of deaths due to this disease decreased from 9.9 to 6.1 per 100,000." In part this gratifying decrease is attributed to the use of chemotherapy and national programs of education.

INCIDENCE AND MORTALITY RATES OF APPENDICITIS IN PERSONNEL ABOARD COMBAT SUBMARINES

The average complement aboard submarines on war patrols was approximately 75 enlisted men and 8 officers. The average age of the officers was about 26.7 years and about 22 years for the enlisted men. At the conclusion of the war, in a group of 318 submariners picked at random for study, the average man had made approximately 6.17 war patrols. The average strength of the Submarine Force in 1943 was about 8,755 men; in 1944 it was about 13,345 men. At no time during the conflict did the entire Submarine Force exceed a strength of 25,433 men.

According to the Statistical Division of the U.S. Navy Bureau of Medicine and Surgery, the diagnosis of acute appendicitis was made 78 times in 1943 (or 8.9 cases per thousand) and 124 times (or 9.2 cases per thousand) in 1944 among personnel attached to submarines, but not necessarily on war patrols. Frequently men were transferred directly to the submarine tender where the diagnosis was made or they were picked up while in rest camp or on leave and thus the case was not counted in the actual submarine war patrol report. It is assumed that these diagnoses followed surgical treatment for the disease. Comparable figures from Naval surface craft for the same period are not available, presumably they do not differ markedly from those given above.

From information available in the submarine patrol reports, it appears that pharmacist's mates made the diagnosis of appendicitis (acute, chronic or Diagnosis Undetermined--admitted for observation) on 116 war patrols in 127 instances during the entire war. On eight patrols more than one man was admitted with the diagnosis. In 16 instances one case of appendicitis was reported from the same submarine on two successive patrols, presumably by the same pharmacist's mate.

The author knows of instances in which, during a 2 week period spent at a rest camp between war patrols, the diagnosis of acute appendicitis in more than one individual from the same boat was verified surgically. And although there is no doubt that submarine crews were sometimes "appendicitis conscious" a few pharmacist's mates were plagued, on successive patrols, by different individuals who undoubtedly had appendicitis.

In the majority of instances from information available in patrol reports, the diagnosis as made by pharmacist's mates can not now be verified. There can be no doubt, however, that in 34 instances their patients were sufficiently ill to warrant eventual transfer for medical treatment, frequently at sea from one submarine to another. In only 11 instances was acute appendicitis the cause for submarines to either leave their areas of operation, their formation, or terminate their patrol (CAIMAN 1, STEELHEAD 7, HADDOCK 4, FINBACK 1, PARCHE 2, PIPEFISH 3, REDFIN 3, SEARAVEN 13, SHAD 8, S-35 No. 5, APOGON 4). Twelve cases of appendicitis occurring on patrol, upon arrival at port, are known to have been followed by surgical treatment. Ten of these men were either definitely stated to have had or likely had ruptured appendices (CABRILLA 2, CAVALLA 3, BUMPER 1, GRAYBACK 5, PIKE 6, PETO 8, SCAMP 1, PADDLE 3, GREENLING 9). This series of cases accounted for a total of almost 578 sick or man-lost days--while on patrol--an average of about 4.6 sick days per case. In a few instances following return to port, prolonged hospitalization was necessary.

To the best of the author's knowledge and experience, throughout the war in the Submarine Force, in not one single instance has a death been reported due to or related to acute appendicitis arising on a submarine war patrol. "For the Navy the statistics vary little from year to year, the figures for the last five years available show the number of deaths from appendicitis of all types to be well under 1 per cent of operations for the disease" (U.S. Naval Medical Bulletin, Vol. 35, 1937, The Navy and Appendicitis, L. W. Johnson, Captain (MC) USN, H. R. Boone, Commander (MC) USN, pg. 44). Commanding officers and higher authorities were so impressed by the performance of pharmacist's mates in handling these truly acute emergencies that in 22 instances they were especially commended in official patrol reports.

PATROL REPORT EXCERPTS WITH REFERENCE TO ACUTE APPENDICITIS

Let us see what the patrol reports and the official medical records show concerning this problem and how it was handled on our submarines on war patrols.

"The most disconcerting thing that happened during the entire patrol (early in 1942) was the case of acute appendicitis that fortunately turned out to be something else. The patient had all of the symptoms of acute appendicitis. The decision was made to operate; preparations were being made when the patient was seized with a violent spell of vomiting and cramps. The pain subsided and the temperature increased to 104 degrees F. with symptoms indicating the appendix had ruptured. Further observation indicated a gastro-intestinal disorder and at the end of 4 hours the temperature had decreased to 101 degrees F. where it remained for 8 days. At the end of 2 weeks the patient was able to be up and about" (GROWLER).

"The third day out of 'Pearl' a signalman came down with an acute attack of appendicitis. The 'doctor' was ordered by the commanding officer not to operate, and was instructed to keep the patient quiet, start treatments, and get him well. It seemed to me that there had been too much publicity lately about such cases and I thought we'd do our best to lick it and try to prevent an 'epidemic' of appendicitis. The patient was confined to his bunk and ice packs were given continuously for 4 days. The morning after the initial attack, sulfathiazole was administered every 4 hours for next 4 days. The patient had no more sharp attacks but the area remained tender for the next 2 days, after which the tenderness subsided and he was allowed up and about. No recurrent symptoms during the remainder of the patrol. The pharmacist's mate--is to be commended for his devotion to duty and his efficient handling of this case" (POLLACK No. 6).

"The quick diagnosis and correct treatment of a case of acute appendicitis, is deserving of particular attention and commendation. When the patient was turned over to the Medical Officer at Darwin, he was well along the road to recovery. This reflects credit not only on the individual but the medical service and the medical course at New London, Connecticut."

"--had an attack of acute appendicitis, commenced ice packs and sulfadiazine treatment (May 1944). Temperature varied from 101.5 to 99.6 for next 2 days and pain became progressively worse. Medical officer from a destroyer came aboard to check patient's condition. Because of better facilities and probability of operation prior to arrival in Majuro, patient was transferred to the destroyer."

"Shortly after reaching the patrol area, one man was suspected of acute appendicitis. The treatment used was preventive with the aim of minimizing the possibility of the appendix rupturing; or in the event that it did rupture, this man was made a strict bed patient. Daily treatment consisted of ice bag to abdomen, frequent administration of morphine tartrate to relieve the pain and control intestinal peristalsis, sulfathiazole and sodium bicarbonate 4 daily doses of each, and a 5 per cent dextrose saline injection and no food by mouth. Sulfathiazole was discontinued after 3 days as it brought on vomiting. On the fifth day the ice bag was replaced with a hot water bottle; this was continued for 6 days. The chief pharmacist's mate is commended for his quick diagnosis and application of preventive measures. His professional ability is considered to be outstanding."

"One case of chronic appendicitis incapacitated one man for 2 weeks. The patient has a previous history--so it is felt that any such history should disqualify the man until the appendix has been removed" (LAPON No. 5).

"One man treated for appendicitis acute has a history of recurrent attacks and further treatment ashore is indicated" (TAMBOR No. 11).

"One man was treated for DU (appendicitis) for which he had had previous treatment. To duty in 4 days" (MANTA No. 1).

"One man had acute appendicitis--which he had apparently recovered from once before. There was a good chance the attack might recur before the end of the patrol" (TREPANG No.5).

"One man with a mild attack of acute appendicitis was put to bed for observation for 2 days. The second day he was up had a recurrence of symptoms which did not subside for 17 days--the remainder of the patrol--" (HAKE No. 2).

"Received appendicitis patient from the SILVERSIDES--transferred to the U.S.S. Vinson the same date and received 5 gallons of ice cream in return" (GATO No. 11).

APPENDECTOMIES PERFORMED ABOARD SUBMARINES ON WAR PATROLS

Considerable publicity was given two appendectomies performed by pharmacist's mates at sea aboard submarines. For the sake of completeness and for their interest the three appendectomies which were actually done are verified as follows: Concerning the first, done on the fourth patrol of the SEADRAGON (W. B. Lipes, PhM 1/c) on 11 September 1942, but little technical information is available. Subsequent to the operation, which lasted about 3 hours, the patient was on the sick list for 14 days. The second man, who had been ill for about 48 hours, was operated upon aboard the GRAYBACK (5th patrol) on 14 December 1942 by H. B. Roby, PhM 1/c USNR. At the operation, which lasted about 1 1/2 hours, the appendix was discovered to be ruptured; sulfanilamide powder was instilled locally, drainage was instituted (an elastic rubber band)and the abdomen was closed. Ether was used as an anesthesia, the first assistant was a motor machinist's mate 1/c. "Spoons were flattened and used for retractors; long nose pliers from the engine room were utilized. A submarine escape 'lung' mouth piece was used for administering the ether."

The third and last case was performed aboard the SILVERSIDES (4th patrol, T. A. Moore, PhM 1/c) on 22 December 1942. The patient had been ill for about 12 hours prior to the operation, which was performed on the wardroom table, with the submarine submerged at 100 feet. The effectiveness of the spinal anesthesia having worn off, "Ether was administered, following the directions on the can. This anesthetized the operating staff as well as the patient. One hour after completion (the operation lasted about 4 hours) we tangled with a destroyer. The patient convalesced the following morning--to the tune of torpedo firing, 2 depth charge attacks, 2 'crash dives' and an aerial bombing which knocked him out of his bunk. The conduct of the patient--was exemplary throughout the operation and the period following."

Comments made by the commanding officer of one submarine (SILVERSIDES) concerning the operation performed aboard his ship are highly pertinent and in light of the above circumstances, understandable: "It is recommended that all men who have a previous history of or indications of chronic appendicitis not be sent out on a patrol until their appendix has been removed. This also applies to any other ailment which may require an emergency operation at some future date." Higher authority observed in connection with the operation on the SEADRAGON: "The incident--is believed to be the first of its kind in submarine history. While this case had a happy ending it is pointed out that this particular pharmacist's mate had had considerable experience in assisting at surgical operations--it is hoped that his success will not encourage others to take--risks."

One point of great interest to doctors charged with planning for any future emergencies is to be emphasized. With the remarkable history of NO mortality in the 127 cases of appendicitis recorded in the patrol reports and with the low morbidity, there need not be cause for the undue alarm which was experienced at least early in the war, as illustrated by the following: "On--a seaman collapsed with the symptoms of acute appendicitis. Temperature was 101.8 degrees, pulse 100, complaining of severe pain in the region of the appendix, delirious. Felt much better at midnight and believe the attack will be short lived. Followed the prescribed treatment. Decided to watch closely for improvement before abandoning patrol area." A few hours later: "Condition has not improved as had expected--". Plans were made so that a "rendezvous could be effected which would remove the man to more expert medical attention. I have no desire to carve anything but turkey for Christmas." This man was transferred to a destroyer 4 days after the onset of his attack; 7 days later he was operated upon for acute appendicitis. It is believed that this patrol (S-35, No. 5) was made without a pharmacist's mate. Medical officers may, with confidence, continue to teach conservative measures for the treatment of acute appendicitis with the assurance that the best possible treatment is being given to the men of the submarine service.

Medical officers should appreciate the fear of acute appendicitis, in the absence of a doctor or hospital facilities, shared by many submarine men, including the pharmacist's mates. Because of this, even were the disease not so common, a careful evaluation should always be made of a suspected case before the man is sent to sea. Sometimes the symptoms may not be typical and the diagnosis uncertain especially after having been treated, weeks before, on patrol with sulfonamide drugs and penicillin.

In not a few instances submarine personnel returning from war patrols on which they had had an attack of acute appendicitis were completely recovered when seen by medical officers. The decision as to whether such a man should be permitted to remain aboard submarines once having had an attack of appendicitis and without surgical treatment must be governed by local circumstances. In general, if conditions permit, an interval appendectomy is believed a wise decision.

DISEASES OF THE SKIN ABOARD COMBAT SUBMARINES

Complaints of a dermatological nature are frequent among submarine personnel. As indicated to some extent by Table 8 those conditions most commonly encountered on post-patrol physical examinations were: heat rashes, fungus infections, acne vulgaris, furunculosis, scabies and pediculosis. The nature and frequency of these is often times expressive of the ship (its general state of cleanliness, adequacy of air conditioning and water for bathing and washing clothes). It may be, to a lesser extent, that the incidence of skin rashes is related to lack of sunlight. As one commanding officer observed: "There were no cases of skin infections. That only 6 days were spent submerged and that the entire crew was fresh and was rotated through the sun lookout watches may have had some effect on this."

HEAT RASH AND AIR CONDITIONING

Reading patrol reports one can not help but be impressed by the relationship between "heat rashes" and efficiency of air conditioning. The first patrol of the DOLPHIN, made with incomplete air conditioning very early in the course of the war, was concluded with the remarks: "In the first week of diving almost every man aboard broke out in heat rash causing great discomfort. This began to disappear at the end of the second week with only one severe case left (47 day patrol off Truk). Blondes were more easily affected than brunettes. Bicarbonate of soda helped but it is believed that the heat rash eventually cleared up only when the human body had finally adapted itself to existing conditions--the average temperature aboard the submarine was 97 degrees F. with relative humidity of 98 degrees." At the conclusion of the second patrol of the S-38 the commanding officer stated: "The heat rash lotion 'Lotio Faberi' secured at Soerabaja gave tremendous ease to those affected--30 per cent of the crew; it stops the stinging and seems to prevent the small ulcers from developing. It is recommended that this preparation be supplied submarines of this unit. A large quantity of rubbing alcohol was also used and is highly recommended."

The first patrol of the S-47 (tropical) was made without air conditioning: "Habitability was poor on long dives, the temperature in the boat generally being about 96 degrees F. with relative humidity 100 per cent. There were many cases of heat rash--worse in the men whose bunks were not in air stream from the blowers or fans. Mattresses became soaked with perspiration and bunks generally uncomfortable. Most of the crew preferred the torpedo room deck." On the second patrol of the SARGO: "The forward part of the ship was very uncomfortable in that had to use forward air conditioning unit for refrigeration. The temperature of the supply air of the ventilation system ranged from 95 degrees to 104 degrees F. during the entire patrol" (17 days duration; had 24 passengers aboard). "Almost all personnel berthed

forward and personnel standing control room watches developed heat rashes which materially increased their discomfort. In some cases the heat rash covered their entire body."

On the third patrol of the TAMBOR the supply of Freon Gas was expended when the ship reached her area: "Temperatures averaged well over 100 degrees with high humidity--making it practically impossible to get any rest while submerged. Nearly all of the crew had prickly heat--some cases covered the entire body. Thirty per cent of the crew developed some type of fungus infection; in order to obtain sleep the men and some of the officers resorted to sleeping in the torpedo room bilges where it was not quite so hot." On the second patrol of the TAUTOG: "There was much serious discomfort and loss of sleep with prickly heat involving over 90 per cent of the crew." "Ninety per cent of the officers and crew had bad prickly heat; 68 per cent of the men had 'Guam blisters', 20 per cent had boils and carbuncles, 12 per cent had ear fungus. Bedding had not been aired for many days--and little laundry was done to conserve water" (PERMIT No. 3). "Health was excellent. The only trouble was heat rash--20 bad cases developed due to lack of air conditioning with resultant high temperature and excessive humidity in the boat throughout the patrol. Most of the cases cleared up after surface running was resumed" (GUNNEL No. 6).

The above, it will be observed, were patrols made early in the war. On the third patrol of the CAIMAN (Java Sea, June 1945): "Habitability was excellent in the first phase of the patrol. In the second phase it deteriorated, the air conditioning plant being unable to cope with the higher air and injection temperatures. The result was a cropping out of heat rash and tropical itch, particularly among personnel stationed in the forward torpedo room and the control room. These ailments, uncomfortable to the extreme, became a menace to the general health of the crew." "The motor machinist's mates and the bakers had heat rash in the first half of the patrol--there were times when air conditioning could have been better" (CHUB No. 2, Java Sea patrol, terminated 1 June 1945). "Health was excellent. Conspicuous lack of heat rash attributed to improved air conditioning--also the lack of boils and other minor disturbances" (CREVALLE No. 4). "Heat rash occurred in 50 per cent of the company during the protracted periods of running silent when it was very hot and humid" (PERMIT No. 10, September 1943). At the end of the sixth patrol of the SUNFISH it was reported: "Usual increase in 'spic itch' of the feet. In this connection intend to carry a supply of anti-fungus infection foot powder on board for the daily use of the crew when in the tropics" (SUNFISH No. 6). Aboard the POMFRET (No. 5) "large number of fungus infections was attributed to the number of men using the limited washing facilities and the general dampness of the washroom while operating in semi-tropical water with an average inside temperature of 85 degrees F."

Relation of Skin Infection to Heat Rash, Lowered Resistance, Vitamin Deficiencies, Area of Operations

As indicated above, and borne out by Table 7, excessive heat and humidity with concomitant heat rash was associated with furuncles, cellulitis, etc. This was particularly true among the engineers because, perhaps, of their contact with grease and lubricating oils. There seems to be evidence, too, that when the general physical condition of a crew was poor, these skin infections were prone to develop. "The crew seemed to have lowered infection resistance. Some of the many cases of boils developed into serious ulcers necessitating complete relief from duty. One man had 7 large ulcers on one leg. One infected finger was so bad it was feared for a while that it would have to be amputated." "Men making their third patrol were more easily fatigued than before and--had a lowered resistance to infections, small cuts and bruises being slow to heal and often developing into severe ulcers." "There were numerous boils in the latter part of the patrol" (KETE No. 1).

In these patrol reports there are very few indications of vitamin deficiencies among the submarine personnel. The only specific reference was found in the second patrol report of the SAURY: "Toward the end of the patrol several of the officers and crew developed a peculiar scale over the entire body--diagnosed by a medical officer as the effect of vitamin A deficiency--."

In general, patrols made in tropical areas were accompanied by a higher incidence of skin diseases. "This was the first cold water patrol--health and skin troubles were much better" (SAILFISH No. 7). The commanding officer of the PLAICE (No. 5) after a spring patrol in the Kurile Island area observed "operating in a cold climate (average temperature 34 degrees F.) eliminated the generally encountered fungus, etc., but reciprocated with a number of minor colds--."

One or two so called "tropical ulcers", developing after bruises and abrasions of the skin (especially in clearing the bridge) particularly over the bony prominences, are commonly seen in the course of examining a submarine crew, returning from patrols. The healing of these lesions is difficult and sometimes extends over a period of months. Aboard the submarine it is almost impossible of accomplishment.

SCABIES, PEDICULOSIS, ETC.

Routine physical examination of submarine personnel not infrequently disclosed the presence of a few cases of body lice and scabies. The prevalence of these infections can be sometimes related to the general hygienic conditions aboard the ship. "Put to sea with about 20 mild cases of scabies--which cleared up in the first 2 weeks" (TROUT No. 9). At the conclusion of the second patrol of the REDFIN it was reported: "Habitability was excellent. Scabies and cockroaches reappeared this patrol in increasing numbers (there were 10 cases of scabies). It is requested that thorough fumigation and renovation of mattresses be accomplished during the refit." At the end of the first patrol of the S-28 (Aleutian, boat cold and damp, limited water supply) it was stated: "One-third of the crew had scabies--spread of this rash is believed to have been accelerated by the hot bunking that was necessary. When it became known, personnel were segregated which checked further spread." On the sixth patrol of the WAHOO, 16 men were treated for "crabs". "Due to the small amount of mercurial ointment aboard, men sponged with diesel oil, followed in one hour with a shower. Three days later 4 men still were infected. They repeated the treatment and became free of the organisms." "Five cases of 'crabs' occurred aboard the HOE (No. 6) in the first 12 days of the patrol." "Seventeen cases of scabies occurred. These could have been prevented by a more thorough examination prior to departure on the patrol" (THRESHER No. 7). The presence of head lice was reported aboard the HAKE (No. 2).

"SUBMARINE EDEMA"

Aboard Japanese submarines (which, in general, were not equipped with air conditioning) a high incidence of prickly heat, epidermophytosis, personnel fatigue, and "submarine edema" is said to have existed. This latter condition appeared in the enlisted men about the mid-point of a long patrol. It was chiefly facial although the arms were sometimes swollen. It was apparently not observed in the lower extremities. It was common in all submarines involving a variable percentage of the crew and causing considerable distress. Sometimes circumorbital swelling impaired vision. Swelling began to subside about the time the ship left the area when the crew was commonly allowed topside, 10 minutes three times a day. Upon reaching port it had disappeared. It did not appear among the officers or lookouts. The Japanese thought that perhaps it was related to heat, humidity and perhaps psychological factors. They denied any relation to allergy, renal lesions or vitamin and dietary deficiencies.

Aboard American submarines no exactly similar condition has been described. The commanding officer of the S-43, at the end of that ship's first patrol made without air conditioning stated: "Completion of this alteration would not only improve habitability of the boat but would also improve morale and efficiency of personnel--. All hands suffered from heat rash. Two men had heat prostration and 4 had swollen ankles." Reference has been made to the very poor features of habitability which existed aboard the PERMIT on her third--a tropical patrol--on which 90 per cent of the crew had heat rash. The patrol was terminated on 6 February 1942--80 per cent of the crew not having been topside since 10 December 1941. "Lt.--has been on the sick list since 21 January suffering from swollen feet and hands, accompanied by a fever and elevated pulse." The fifth patrol of the PARCHE, of 45 days' duration was made off the coast of Japan--in severe cold weather. "Habitability was not good; the boat being cold and damp--especially the torpedo rooms which were dripping and very near the injection temperature at the end of a long day dive. Living compartments were fairly comfortable. Upon departure from the area a large percentage of personnel complained of aching and swelling feet probably due to the sharp increase in temperature." The sixth patrol of the BURRFISH, of 50 days' duration, was made in the Formosa area in early spring. "Habitability was above average. Several enlisted personnel were troubled with swelling of the arms and feet which resembled boils but was not painful--this existed early in the patrol." The information available on these few instances is so meager that nothing positive can be deduced. It is possible, however, especially on tropical patrols that swelling of the feet may be related to standing on warm or hot deck plates--especially in the battery compartments after and during the time the batteries are charged.

MISCELLANEOUS

The tenth patrol of the PLUNGER was made arduous by loss of air conditioning and reduction in the amount of condensate water available for bathing. The fresh water situation was further aggravated by accidentally salting 600 gallons. "Health was good, there were a few colds. There were a few cases of fungus infections of the ears, possibly related to bathing at Midway." Concerning the fifth patrol of the ARCHER FISH, the commanding officer stated: "During this patrol there was an unusually large number of infections of various sorts causing numerous sick days. It is possible that they were contacted in Saipan during the 2 days spent there. Almost all of the men affected had been swimming (over the side and along the tender) just prior to our departure; there were 4 furuncles, 3 cases of cellulitis, 6 cases of impetigo and numerous styes."

On the SEGUNDO's fourth patrol a chief motor machinist's mate was received from another submarine while at sea with "an infection covering his skin from head to foot, especially on the ankles - a severe fungus infection. The man was in bad shape. Isolated, including his mess gear. After a short time of surface running he began to improve."

Five boats reported 5 cases of "herpes"; 8 reported 9 cases of urticaria. Two instances (THRESHER No. 9) are known in which individuals were apparently sensitized to the battery fumes, which in one case, necessitated removal of the man from submarines.

"Health was excellent. There were no sick days--this was the first patrol on which health has been so good. To reduce the amount of skin rashes bunk covers were removed and stowed away at the beginning of the patrol. All hands were required to remove their outer clothing before getting into their bunks--and to change mattress covers periodically. Rigid enforcement of this order paid off in better all around health and better performance of duty because the 'loggy' feeling one feels after sleeping fully dressed was eliminated" (PINTADO No. 3).

DISEASES OF THE GENITO-URINARY TRACT ABOARD SUBMARINES

On some 166 patrols diseases of the genito-urinary tract were reported in 328 instances. The majority of cases developing on the patrol were gonorrheal in origin, as indicated by Table 10.

VENEREAL DISEASES

In the great majority of cases gonorrhea was treated with the sulfonamide drugs and, later, with penicillin. Though some of these cases proved refractive to treatment they were only the cause of 45 reported sick days (5 cases).

The following excerpts from patrol reports concerning venereal diseases aboard submarines are quoted for their interest: "Four men with gonorrhea were taken to sea (early 1942) and given a short course of sulfathiazole tablets orally as prescribed and furnished by Dutch doctor at Submarine Base, Soerabaja. The treatment was apparently 100 per cent effective in 3 of the cases and partially effective in the other case."

"One case of gonorrhea appeared shortly before arriving at Saipan enroute to the area. Sulfa drugs were administered aboard and he was treated with penicillin upon arrival at Saipan. The patient made the patrol with no apparent ill effects."

"There is one suspected case of chancroid which developed about 3 weeks after departure on patrol. Subject man has been isolated to the extent necessary to prevent contamination of other personnel."

"One case of Diagnosis Undetermined (syphilis) was noted and precautionary measures were used until a positive diagnosis could be established."

"One case of venereal disease developed after departure Fremantle that required transfer at Darwin enroute north due to the fact that his health record contained the statement that he should not be given sulfa drugs for treatment of any illness."

"One case of gonorrhea incapacitated for 34 days; did not respond to sulfathiazole or sulfadiazine. Strongly recommend that submarines be supplied penicillin."

In as far as may be adjudged from the patrol reports, venereal diseases were singularly free of complications aboard submarines. In 2 patrol reports mention was made of men experiencing severe discomfort both of whom were treated with Silvol irrigations (sulfonamide drugs not being available). At the time the GRENADIER was lost, 3 men were under treatment for gonorrhea. When they left the ship, they were equipped with sulfonamides of which they were shortly relieved by the Japanese. Two of these men, in prisoner of war camps, made uneventful recoveries. The third, however, developed a severe gonorrheal periurethritis with abscess formation.

As will be observed, penile lesions were not infrequently reported of which 15 are known to have been luetic in origin. Upon one occasion a submarine, at the conclusion of a long patrol, underwent a 2 weeks' refit at an advanced base. Upon arrival of the ship, post-patrol physical examinations were confined to a discussion with the pharmacist's mate. A few weeks before the termination of the next patrol one man who had made all patrols advised the pharmacist's mate of a penile lesion which he had concealed for a period of at least 6 weeks and during the last refit. Examination disclosed the presence of multiple penile and perineal lesions. When the ship finally came alongside another tender, the lesions were easily proven to be syphilitic in nature. In addition, the patient had an acute cerebrospinal form of syphilis. The entire crew was given blood serological tests for syphilis, all of which were negative.

The above incident is reported in some detail to emphasize two points: (1) Apparently, aboard submarines, the hazards of contacting a venereal disease by casual contact are at a minimum, despite the necessity of sharing bunks and the markedly limited lavatory facilities; (2) Post-patrol physical examinations were admittedly a chore, time consuming and productive of but little in the way of actual and interesting pathology. Nevertheless carefully conducted examinations pay dividends. Such cursory "examinations" are to be deplored and may well, upon occasion, prove embarrassing to the examining physician.

OTHER GENITO-URINARY DISEASES

The occurrence of calculi of the urinary system among submarine personnel is worthy of a few words. The incidence of "kidney stones" is not known in the general population. It will be observed that some 13 cases were reported in 12 patrol reports. The author, aboard a submarine tender, has observed that the diagnosis among submarine and tender personnel was not infrequently made. All cases occurring aboard submarines were, in as far as is known, treated without incident. "Two serious illnesses occurred on board during the patrol but both patients were returned to base or safely transferred. One man was transferred with acute rheumatic fever, with which he had suffered for approximately 40 days. He had lost 23 pounds of weight. A second patient developed acute renal colic; course reversed--transferred the next day to the PC-1598" (SHAD No. 11). One case of ureteral colic recurred in a man, while on patrol, who a few days before the submarine departed had been under treatment with the same diagnosis aboard the tender.

Inasmuch as this diagnosis is not uncommon, submarine pharmacist's mates should keep it in mind in making a differential diagnosis in a patient complaining of acute abdominal pain. Centrifuging urine specimens to detect the presence of hematuria is possible aboard submarines--through utilization of the centrifuge in the engine room.

DENTAL DISEASES ABOARD SUBMARINES

INCIDENCE

Dental conditions treated by pharmacist's mates aboard operating submarines (Table 16) totaled 155. Fifty patrol reports mention 85 men who were treated for "toothache". On 7 patrols, 18 teeth were extracted.

The incidence of dental defects was always surprising on post-patrol examinations. Over an 8 months' period at the Submarine Base at Midway, the crews of 30 ships (2,363 men and officers) were examined. Thirty-one per cent of the men had dental caries; extractions were indicated in 7.3 per cent of the men examined; 13.4 per cent of them had gingivitis; 1.2 per cent had Vincent's angina. Of this number 835 returned to sick bay for dental appointments, 823 restorations being completed. In many instances only those men most urgently needing care could be given attention by the one dental officer, Lt. W. E. Covington, and his one corpsman then on duty at the dispensary.

Aboard one submarine tender, a comparative study on the crews of 17 submarines returning from war patrols (1,243 men) was carried out (Van Der Aue, O.E., and Cullen, W. R., "Gingivitis Among Submarine Personnel", U.S. Naval Bulletin, 44:811-816, April 1945). It was found that "bleeding gums" among submarine personnel returning from war patrols was more common than among personnel of the tender in the ratio of 5 to 3. Careful examination of submarine personnel reveals little or no clinical evidence of avitaminosis and their diet is generally adequate in all respects. The obvious conclusion is that the gingivitis in these instances was not due to the lowering of general and local immunity to the organisms by avitaminosis but due solely to the lowering of local immunity by local trauma or irritation and poor oral hygiene.

Lt. Comdr. W. B. Martin (DC) USN, accompanied the SEA FOX on her first war patrol "with the view of studying the dental situation under combat conditions". In reporting his experiences he pointed out ("Dental Problems of Submarines", Lt. Comdr. Walter B. Martin (DC) USN, U.S. Naval Medical Bulletin, Vol. 46, No. 6, June 1946, pp. 898-900): "it is imperative that the oral tissues of submariners be placed in good condition prior to extensive patrol periods in war areas. Toothache or tissue infections render a man impotent as a fighting man when his time and his efficiency are vital factors in the success of a submarine attack." "Submarine crews 'present an alarming susceptibility to dental diseases'." "Dental caries are rampant and can be laid to diet very high in carbohydrates and very poor oral hygiene. Most all submariners are heavy coffee drinkers and they drink it black and sweet." "Long patrols with necessary abstinence from alcoholic beverages seem to create a desire for sweets. A continued carbohydrate diet of this type increased susceptibility to dental caries." "On the actual patrol, conditions are unfavorable for good dental hygiene." "Water--is insufficient for frequent bathing and the shower room is secured most of the time unless a water reserve has been built up. Dental hygiene is closely allied with bathing habits and upon questioning many of the men admit their toothbrushes remain unused day after day." "The submariner just doesn't seem tooth conscious." "Lack of good oral hygiene leads to loss of tissue tone. Resistance to oral infection is low and gingival recession is prevalent. One submarine captain, through his welfare fund, purchased all available dental floss and constructed an adequate dispensary to be placed in the control room for all hands. A page from a dental journal illustrating correct use of dental floss was secured to the bulkhead alongside. This captain had become alarmed at the large number of cavities developing in the teeth of his men and wanted to do something about it."

It is highly desirable that all submarine personnel prior to departure on "new or old construction" from the continental limits receive careful medical and dental examinations and indicated treatment. The reasons are threefold: First, as noted above, the nature of submarine duty demands the constant maintenance of high standards of physical fitness and mental alertness; second, it seems not unlikely that the incidence of certain dental conditions--gingivitis, Vincent's infection--is more common among submarine personnel returning from war patrols than is generally appreciated; third, medical and dental facilities aboard tender ships and ashore at advance bases are at the disposal of the crews of submarines "stopping off" or undergoing a normal refit prior to entering the war zone. These facilities are adequate for the correction of emergency dental and medical conditions developing in a crew previously checked in the States. Lack of time and trained personnel makes difficult the furnishing of extensive and detailed treatment sometimes necessary in neglected crews.

The dental care which submarine personnel sometimes received in the States prior to their departure for patrol areas was inadequate. At one time at the Submarine Training Activity, Manitowoc, Wisconsin, 68 men attached to the crew of a new submarine, having just arrived from New London where they had been "certified to be dentally fit, were examined by the district dental officer. Of this group, 3 were found to require urgent dental treatment and 13 required treatment in the near future. The remaining men had all visible carious areas restored but in no cases were the restorations found to be finished and polished (Ltr. District Dental Officer, ND9/A10/P5, Insp. PW-veb, 18 May 1945 to Chief, BuMed).

PATROL EXCERPTS

The following patrol excerpts are quoted to emphasize need aboard combat submarines of a satisfactory dental emergency kit. Some submarines were provided such kits by their tenders (USS Sperry). "Departed on patrol with one man with an abscessed tooth with the blessing of the medical and the dental officers--had to later transfer him back to Darwin" (ASPRO No. 6). "The first case was a completely decayed tooth which was removed and the man quickly recovered" (ATULE No. 4). "Forty men are in need of dental work--an unusually large number" (FLOUNDER No. 1).

The commanding officer of the GUDGEON, at the end of her first patrol in 1942, recommended that submarines carry simple dental equipment as forceps. "The pharmacist's mate extracted one abscessed tooth. While it was not difficult it was possible only because the executive officer happened to have a pair of extractors, which are not furnished the ship as a part of its medical equipment" (POMPON). "One man with an abscessed tooth--consulted with the pharmacist's mate. The decision was reached to pull the tooth. A large pair of water pump pliers were selected to remove the tooth, there being no dental instruments aboard. Upon sighting this rather awesome tool, conversations were resumed as to the wisdom of the extraction. The pain caused by the tooth brought the man back to argue the point and the tooth was removed" (SEAWOLF No. 13). "The pharmacist's mate handled two painful dental cases which were a little out of line, in a very efficient manner, it is considered. It was, however, a rather gruesome sight to see him working with a machinist's hand drill" (SHAD No. 10,

June 1945). Aboard the S-30 (No. 4): "The epidemic of sore mouths experienced on the previous patrol was forestalled by the use of chloramine-T as a mouth wash." With relation to the spread of "mouth infections" one submarine recommended the installation of special lavatory for washing the teeth.

DISEASES OF THE EYE, EAR, NOSE, AND THROAT

OTOMYCOSIS

Mention has been made in the preceding section of the prevalence of otomycosis among submarine personnel which is presumed to likely account for the relative frequency of the complaints of "earache" and "ear infections".

AUDITORY ACUITY AND NOISE LEVEL

The commanding officer of the SEADRAGON (No. 4) reported: "Engine room watch standers are becoming increasingly deaf from constant exposure to the high noise level of the engine room." No other mention of this situation is found in other patrol reports. Post-patrol examinations from time to time revealed individuals with dulling of auditory acuity which could be traced to noise of the engines. Eventually all submarines carried a supply of "ear wardens". In general, it is felt that they were not very popular.

TRAUMATIC RUPTURE OF EAR DRUMS

Mention has been made of the some 15 cases of rupture of the ear drums from the concussion of the deck guns. Some of these were bilateral. Members of the gun crew commonly used cotton to protect their ears which, with the blast, was apt to fall from their ears--and in the stress of the situation could not be replaced readily.

INABILITY TO EQUALIZE PRESSURE

On the first patrol of the S-42 (No. 1) during a period of silent running, the pressure within the boat "built up very rapidly--the barometer needle sticking at 10. There were many headaches and some earaches." On the second patrol (also tropical) the commanding officer speaks of the "usual run of earaches and minor skin ailments." Aboard the SHAD (No. 8) "One seaman received from the relief crew at Midway burst his ear drum on the first occasion when the pressure in the boat exceeded one inch. He stated that he had never had a pressure test. As it is believed that facilities for this test are available to all submarines, it is felt that all relief crews should be required to subject all men to pressure tests before transferring them to operating submarines. One fireman received from SubDiv 82, just before getting underway, was found to be totally deaf in one ear. He was also unable to adjust himself to the pressure differential between the engine room and the after battery compartment." Five submarines reported 5 cases of "mastoiditis". Details concerning these illnesses are too sketchy for further comment except to say that, on one occasion, a commanding officer of a submarine on war patrol was treated for this condition.

EYE STRAIN

Eye strain was not uncommonly mentioned. "Considerable fatigue and eye strain was shown by the officers and the lookouts in the last week of the patrol--the result of so much surface running in an unusually long patrol" (DARTER No. 2, 68 day patrol). "Radar operators and lookouts complained of minor eye strain." "Numerous cases of mild conjunctivitis toward the end of the period spent in the patrol area" (PADDLE No. 1, 2, 3). "The eyes of the bridge lookouts, quartermasters and officers suffered severely from strain" (PICKEREL No. 3). "The patrol lasted too long and excessive fatigue was noticeable. Nervous tension and eye strain appeared in the officers. The ship (PICKEREL No. 2) has been submerged for 51 consecutive days." Aboard the CREVALLE (No. 2) the pharmacist's mate gave special attention to the eyes and ears of the lookouts.

"Eye strain, headache, and 'sunburned eyes' with conjunctivitis consequent to prolonged exposure to sunlight, were not uncommonly seen in submarine personnel returning from a cruise." A "Special Lookout Training Program" has been outlined (BuMed News Letter, Vol. 7, No. 7), which might be well adopted by submarine pharmacist's mates. In part, it stresses the importance of protective measures including the area of the malar prominences, against reflected rays of the sun on those occasions when sunglasses are removed. Personnel should remember that exposure to sunlight by day may reduce vision in the late twilight and night time by 50 per cent, that a few hours' exposure will result in retinal damage lasting for days and a week's exposure may require a month for recovery. The available sunglasses (No. 1 type) are not designed for sun gazing.

NIGHT VISION

There is relatively little of value to be obtained from those patrol reports concerning night vision. Early in the war, as the following reports will indicate, personnel were much concerned with the relationship between night vision and possible dietary deficiencies. "It is suggested for consideration that all personnel of this ship be retested for night blindness on return to port. A reduction may have occurred due to lack of fresh food while on the patrol" (S-38, No. 2, tropical patrol in February to March 1942). "Gradual but noticeable reduction in night vision on the part of the officers and lookouts has been noted" (PERMIT No. 1). "Night vision seemed to deteriorate somewhat during the last 2 weeks of the patrol. Several of the officers and myself noticed that our own ability to see at night is not as good near the end of the patrol as it was at the beginning. All hands took vitamins regularly" (SKIPJACK No. 2). "All lookouts and officers received 5 drops of halibut oil and viosterol daily with vitamin capsules every other day may have helped vision" (SKIPJACK No. 3). "Toward the end of the patrol several of the officers and crew developed a peculiar scale over the entire body--diagnosed by a medical officer as the effect of vitamin A deficiency--while not serious it is known that this definitely reduces night visual acuity" (SAURY No. 2). "Recommend vitamin pills for the whole crew--living conditions are so different that recourse to sandwiches and a cup of coffee is the usual case. Night turned into day. Concentrated vitamin A should be fed to the officers, quartermasters, and the lookouts to sharpen their vision" (SAILFISH No. 1). The commanding officer of the SEADRAGON (No. 4) recommended that "at least 24 goggles for dark adaptation be issued to each submarine".

IMPAIRED VISION

The commanding officer of the STINGRAY (No. 1) reported an interesting occurrence: "On the 21st I sighted a ship--my OOD and QM reported that they could make out her outlines. I could not and did not fire--. It is suggested that commanding officers be given a rigid physical examination every few months. I have had very good to excellent eye sight with my last physical examination in March of 1940--believe that my eye sight has deteriorated since the last examination--because in several instances episodes as the above have taken place." Reference has been made elsewhere to the occurrence of mirages on a tropical patrol (SUNFISH No. 1) and on a northern patrol (BARB No. 8).

OCULAR BURNS ASSOCIATED WITH USE OF PERISCOPES

In the sixth patrol of the SILVERSIDES the following statement appears: "One man either strained his eye or slightly burned it from the flash of the sun through the periscope--with impairment of vision." One officer stated that an acquaintance had received a severe corneal burn (requiring later corneal transplantation) from gazing at the sun through high power periscope (Memo of M. H. Young to Capt. Shilling, 26 Nov 1945, Med.Res.Dept., Submarine Base, New London, Conn.).

MISCELLANEOUS

Irritation of the eyes consequent to the muzzle (deck gun) smoke and gas is mentioned by ROCK (No. 6).

Note has been made elsewhere of the frequency with which lookouts received bruises and lacerations of the face consequent to the use of the binoculars. Binoculars sometimes in driving spray and rain because of flooding and fogging are practically useless. Condensate formation on the periscope eye piece was sometimes a nuisance when submerged (BALAO No. 8). One man aboard the S-33 (No. 7) was reported to have had a chronic nose bleed. Foreign bodies in the eyes were reported which, on one occasion (WHALE No. 9), led to transfer of a man at sea because of the development of a panophthalmitis.

EYE IRRITATION ABOARD SUBMARINES

Concerning this subject, there is but little information in the patrol reports. The commanding officer of the HARDER (No. 1 and 4) in reporting upon the efficacy of the battery of ultraviolet lamps installed in the ship's ventilation system stated: "--it is definitely felt that the lamps reduced considerably the characteristic smell and eye irritation developed at the end of all day dives. This might be the result of the production of ozone by the lamps. The original objective of this battery of lamps was the elimination of air-borne bacteria in the recirculated air while submerged--the most comforting result of the lamps has been their faculty to kill the odor and eye burn that is normally characteristic of all day dives."

Others have observed the irritation to be especially apparent at meals or after smoking. Possible etiological factors have been listed: (1) tobacco smoke; (2) acrolein from fat in cooking; (3) aldehydes from diesel engine exhaust leaks; (4) sulphuric acid vapor from storage batteries and (5) fumes from lubricating and fuel oils. "It is undoubtedly the diffusion of cooking vapors to adjacent compartments which is the principal cause. Aboard most submarines the hood over the galley range collects fumes and conducts them into the main exhaust duct. There is a removable mesh screen in the hood which collects grease. It is not an efficient filter. The elimination of much of the irritation could be accomplished by increasing the ventilation in the galley. It is conceivable that tobacco smoke might be an important cause of eye irritation--where ventilation conditions are even worse than those known to produce symptoms in ordinary living and working spaces" (BuMed Memo X-BLK:II, P3-1/SS, 6 Oct 1945 to Med. Res.Dept., U.S. Submarine Base, New London, Conn.; Memo to Capt. E. W. Brown (MC) USN (Ret.) from Capt. C. W. Shilling, New London, Conn., 3 Dec 1945).

Irritation of the eyes was reported from the SS-482 and 484 to the Bureau of Ships. Tests conducted to determine the source of this irritation, although not completed, have indicated ozone (formed in "Precipitron" installations within the generators) to be the offending agent.

Individuals unaccustomed to the environment of a submarine and coming aboard, particularly under operating conditions, may have experienced this smarting of the eyes described above, and observed the gasoline-like odor in the air presumably associated with the diesel and lubricating oils. All doctors who have examined a submarine crew returning from a patrol will recall the peculiar oily odor which emanated from their clothing and even their skin and lingered in the sick bay after they had departed.

SEASICKNESS AMONG SUBMARINE PERSONNEL

Chronic and acute seasickness among submarine personnel, especially in men new to the ship, is a problem commonly encountered by the Medical Department of a Submarine Base or a tender ship, especially in the winter months. The solution, sometimes difficult, must be arrived at through consideration by the personnel and medical officer of the several factors involved.

"There was more seasickness than on the previous patrols. Those ill were mostly officers and men who had made 3 or more patrols" (FLYING FISH No. 4). "Seasickness was quite prevalent during the two typhoons encountered with 4 sick days lost (35 men were ill). Two men with chronic seasickness will be transferred" (SHAD No. 7). "A large percentage of the crew was seasick in the heavy weather encountered. There was one case of chronic seasickness" (POLLACK No. 9). "One officer suffered from chronic seasickness and has requested transfer. Disqualification in submarines is under consideration. He is able to perform all his duties in a very capable manner at all times but lost considerable weight through inability to retain nourishment. Incapacitation for duty could have been expected had the patrol extended its normal length and had rough seas been encountered" (PERCH No. 1). "There was one case of chronic seasickness. The man was distressed on all but the mildest days. In rough weather it was necessary to confine him to his bunk sometimes for days. He was given intravenous glucose" (PILOTFISH No. 1). The commanding officer of the CABRILLA (No. 4) requested that seasick "pills" be issued submarines. "Six days after coming aboard an Ensign--was transferred at Midway for chronic seasickness" (HALIBUT No. 3). "Two men were transferred at Midway because of chronic seasickness. Although it is realized that chronic seasickness is relatively rare, the training period and the four day trip from Pearl Harbor to Midway is considered a fair trial. Men as sick as these two could be taught nothing and were of no value to the ship" (FLYING FISH No. 9).

"Seasickness was very prevalent among the new men on the way to the area, making them in a few cases unfit for duty. Strongly recommend that refit crew personnel be combed of men subject to chronic seasickness to avoid what could easily become a dangerous situation to submarine on a patrol." In this respect it might be emphasized that this is essentially a task of the Medical Department. Health records, especially of incoming men to the relief crews should be scrutinized for information relating to this condition. Medical officers should make certain that the proper entry is placed in the health record of a man removed from a submarine because of chronic seasickness. Moreover, it would seem fair to assume that the man is, therefore, physically disqualified for submarine duty.

HEADACHES

Headaches among submarine personnel are common, especially during prolonged submerged operations because of the slight build up of pressure within the ship, and because of the vitiation and depletion of oxygen and increase in the carbon dioxide content of the air. Headaches are also related to "the close confinement, noise of the diesel engines, battery gases, increasing nervous tension, fatigue and perhaps inadequate lighting." Patrol excerpts concerning headaches were as follows.

At the conclusion of the first patrol of the TUNA in March of 1942, it was reported: "At first there were many complaints of headaches which were associated with charging the batteries after surfacing. The complaint normally lasted only a short time and was probably due to low individual tolerance to carbon dioxide since the incidence decreased as the men became accustomed to the long dives." It is said that 500 headaches were treated on this patrol and 81 on the second concerning which the commanding officer stated: "There was a marked increase of headaches this patrol as compared to previous runs. This was apparently due to ventilating the hull outboard" (GAR No. 4 and 5). "There were numerous cases of headaches during the patrol caused by the long daily dives" (GRENADIER No. 2, GRAYBACK No. 1, and SALMON No. 1). "Eight men complained of headaches--believed due to the carbon dioxide generated during all day dives--which despite the use of carbon dioxide absorbent was 2.5 to 3 per cent at the end of 17 to 18 hour dives" (S-40, No. 8). "Dives were long, lasting from 16 1/2 to 17 hours. This with the increase of complement made the air pretty bad. Smoking was restricted to 5 minutes every 2 hours. On days when we were depth charged oxygen and carbon dioxide absorbent was used but there were still some headaches" (SAILFISH No. 7). "Rigged up a hose between an oxygen bottle and the ventilation supply line by-pass intake in the forward engine room, bleeding oxygen into the boat at the rate of 35 pounds per square inch per hour. Had no more complaints of headaches" (PUFFER No. 7). "There were several cases of unexplained headaches" (SEAWOLF No. 11). "There were fewer headaches on this than on previous patrols" (BONEFISH No. 7).

The commanding officer of the FLYING FISH observed at the conclusion of her sixth patrol "there were numerous headaches among the crew--found to be primarily among men with a large number of patrols to their credit and with a great deal of time aboard submarines." "There were more headaches than usual--possibly due to the increase of normal pressure in the boat--seldom less than 3 inches at the end of all day dives--caused by use of air for ventilating the Mk-18 torpedoes while they were being charged" (SAWFISH No. 4). "The lookouts and the radiomen suffered most of the headaches from breathing oil fumes from a leak into the boat from No. 7 normal fuel oil tank" (TUNNY No. 7). "Gas escaped from the forward air conditioning unit. On surfacing, several officers and men experienced severe headaches." "Headaches were experienced by the members of the 5 inch gun crew probably due to the concussion and noise" (SEAPOACHER No. 3).

"One man after treatment for appendicitis developed a violent headache. This, it is believed, was caused by a combination of the disease, an old head injury, and heavy and severe depth charging" (FLASHER No. 5). "The usual headaches were experienced after the long siege of depth charge" (SCULPIN No. 5).

"Vitamin tablets were extensively used--headaches which developed may have been caused thereby" (SAWFISH No. 2). "The fact that there is only one head aboard for 45 men is believed a contributory cause to the prevalence of headaches, constipation and colds. A larger supply of mineral oil, APC and aspirin tablets should be carried aboard" (S-33, No. 2).

TRANSFER OF ILL OR INJURED PERSONNEL AT SEA

This subject has been considered, in part, in that section dealing with air-sea rescue operations.

Occasion not infrequently arose to transfer mail, spare parts, and ill or wounded men from one submarine to another while at sea. In a rough sea such a transfer may be laborious and involve many anxious moments. For the sake of information, these methods of transfer used and comments concerning them are reported.

On the eighth patrol of the PETO it was necessary to transfer a man critically ill at sea to the BURRFISH. "At 1105 preparations were commenced for the transfer. The wind and seas were rough for rubber boat operations, being force three. Attempts to calm the seas with oil were unsuccessful. On the first attempt to launch the rubber boat it was swamped and while hauling it back aboard, the line carried away leaving the boat adrift. The first throw of the grapnel hook sank the boat (four man type). While rigging a second boat an unidentified plane hove into sight. It was an exciting few minutes until the plane was identified as 'friendly'. At 1255 transfer of the patient and mail and movie films was completed." An attempt to transfer a patient from the SCORPION to the HERRING (No. 6) was given up because of the risk.

Probably the most common means of transfer was by rubber life raft or boat. "Anyone who has manipulated a rubber life raft in a rough sea knows the difficulties of conveying survivors by such a method. Commonly three men accompanied the patient who, on a Stokes litter, was laid crosswise in the gunwales and in the center of the raft. One man on either end paddled and the third kept the survivors from being dumped into the sea." Sometimes the raft, controlled by heavy lines, was guided by one submarine as it was towed to the other (WHALE No. 11). On another occasion 5 survivors, one with a compound fracture, were transferred by rubber boat secured with light lines on bridge at both ends hauled back and forth between the submarines, flooded down to take the men aboard. The transfer required about an hour and a quarter. GABILAN (No. 6) took two aviators from STERLET in a heavy sea in a rubber boat using 4 men. "They hardly got wet. This was the simplest and most expeditious operation yet. The same day we received 3 from the TORO the same way. The seas were extremely rough and several times we were certain they could not make it." On one occasion PETO "received Lt.--from the TRUTTA by rubber life raft." Transfer was accomplished by TRUTTA casting him adrift in the raft and PETO making an approach and picking him up. This was surprisingly easy in heavy seas although the passenger was half under water in his raft. POMFRET (No. 6) faced with the transfer of 5 men at sea, one of whom was unconscious from a probable skull fracture, recommended that submarines carry a 5 man rubber life raft--rather than the 3 man size since the latter is too small for the proper handling of stretcher cases when transfer at sea is necessary.

On the first patrol of the TORSK a patient was transferred to the BALAO--effected by means of a rubber boat. "It was rather a rough ride and certainly not calculated to improve the patient's condition. The transfer of a badly injured man by this means would be a most doubtful procedure." Concerning this transfer BALAO stated: "Lay to across the wind and flooded down. TORSK made a bow to beam approach from the windward and SANDLANCE beam to beam from the leeward. Received lines by line-throwing gun from each side. SANDLANCE sedately launched their boat over the side. TORSK 'catapulted' hers! Looked like she vented everything except No. 7 and the boat paddled off the forecastle. Her bow must have been 10 inches under. Received appendicitis case from TORSK and 300,000 units of penicillin. Received man with amputated finger from SANDLANCE. Both transfers underway at 1215, completed by 1258."

Concerning the transfer of an appendicitis patient to a seaplane, the commanding officer of the S-38 (No. 8) stated: "Patient was transferred to U. S. Navy Catalina plane, using a rubber boat--getting him thoroughly drenched in the process due to the rising sea and inability of the plane to maneuver." The STINGRAY commented upon such a transfer as follows: "Transfer of an appendicitis patient to a PBY plane for medical treatment required about an hour. A motor boat was used. Had we had a small collapsible rubber boat aboard, the one hour period required to get the boat in and out of the water and restowed could have been eliminated. All of this time we had about 10 men on the deck, various gear about and were in no condition to dive."

The GUAVINA, on her sixth patrol, "passed 27 bags of mail at sea using a breeches buoy rigged with a cargo net which was large enough for 2 bags--no strain." On the fourth patrol of the SEGUNDO: "Transferred an ECM at sea to the TREPANG--facilitated and rendered fool-proof by her modified breeches buoy which they had made up and which rigged very easily. A stout 3 inch line was secured to the top of our periscope shears. TREPANG ran the other end through a block hanging from the top of her shears and tendered the free end to keep all slack clear. It was a clever method. We could have transferred a man as easily as the ECM." Mention is made of a "fancy adaptation of a breeches buoy" used by the GURNARD on her ninth patrol. On the seventh patrol of the HAMMERHEAD a breeches buoy between the shears of one boat and the cigarette deck of another was used for the transfer of ammunition at sea. On the twelfth patrol of the TAMBOR a patient with a compound fracture of the tibia was transferred to a destroyer. "The sea was too rough for boating. A breeches buoy and a Stokes stretcher were used. The seamanlike manner in which it was carried out was nothing short of but excellent and with the least possible discomfort and disturbance to the patient."

On the second patrol of the SEA ROBIN: "Transfer at sea was made of mail--by both boats running down sea at 500 turns about 100 feet apart with SEA ROBIN maneuvering to maintain proper distance. A line was passed and secured to the tip of the shears of the boat receiving the mail and run through a block fastened to the top of our shears and tendered on our bridge to take care of the rolling of the boat and variance of distance between us. This line acted as a trolley for a large canvas carrier. The carrier was supported by a large shackle which slid along the trolley line as the carrier was pulled back and forth by the use of heaving lines secured to it. Mail bags were put in the carrier. They were so heavy they had to be divided into half. Sixty-four bags of mail were successfully transferred to PAMPANITO in a state 3.5 sea; not more than 22 bags could be passed per hour." On the fourth patrol of the TILEFISH in "8 to 10 foot swells, 5 movies and an ECM were transferred from the SCABBARDFISH--wrapped in rain clothing and tied in a waterproof bag--being received damp and completely flooded."

On one occasion the POMPON and the RAY, while underway and maneuvering to keep their sterns apart, swung their bows together until they almost touched, enabling 10 airmen to quickly step from one ship to the other. SPADEFISH (No. 1) found that the transfer of a prisoner of war was most easily effected by having him swim with a life jacket the short distance between the two boats. Another transfer was effected by passing a heavy line to second submarine and towing an aviator across in his life belt.

PSYCHIATRIC CASUALTIES IN SUBMARINE WARFARE

HAZARDS OF SUBMARINE WARFARE

There can be no doubt that the traumata sometimes experienced by personnel in the submarine service were as great, if not in excess, of that experienced by any other group in the war. Allied submarines enroute to and from their area of operations could not claim immunity from attack by "friendly planes". While patrolling enemy-held waters they were "lone wolves" subject to vicious attack when sighted by enemy air and surface antisubmarine units. The depth charge was the Japanese antisubmarine weapon. With every attack the officers and men could not help but wonder when the next aerial bomb or depth charge would make a direct hit. They all knew that submarines were being lost to enemy counterattacks. While being hunted, unable to fight back, the submerged submarine "ran silent". All men except those necessary to control the ship were in their bunks. Those up and about removed their shoes. Talking and unnecessary noise was kept at a minimum. With all ventilation, air conditioning and refrigeration units secured, the interior of the boats became excessively hot and humid. The enforced inactivity and helplessness of their situation and the actual trauma of the exploding depth charges was enough at times to terrify the bravest of men.

Other encountered hazards, such as the continual harassment of enemy radar-equipped night planes, floating mines, shallow water operations, air-sea rescue operations, etc., could not help but impose severe emotional strain. If we add to these the strain of reconnaissance operations, mine laying and fruitless days of patrolling without enemy contacts, the stamina required of individual men and the very high caliber of leadership demanded of the commanding officers become apparent. In spite of the great responsibilities vested in commanding officers, there is patrol report evidence of only four cases in which the men apparently lost confidence in their commanding officers or the commanding officer lost confidence in himself or his boat.

The following excerpts from patrol reports vividly illustrate the type of emotional trauma sometimes encountered:

"A terrific explosion jarred the boat. All hands not holding on to something were knocked from their feet. At 300 feet: 'Fire in the maneuvering room, all power lost.' Thick toxic smoke filled the maneuvering room and after torpedo room. All hands aft were sick. We went up and down three times and had started down the fourth time before power was regained. In the maneuvering room, the situation was bad. All hands were violently ill."

As described in another patrol report: "For the first two hours we were in a mighty tough spot. Extreme discomfort was suffered from the accumulated heat and humidity. All hands stripped down to shorts and the men took off their shoes and socks--. The predicament of the ship was a fact fully recognized by the older and more experienced men. As the youngsters folded up, the others took over. The most startling effect was the apathy engendered by the combination of heat, pressure, physical effort and mental stress. Some without permission, others after requesting relief, would seek the closest clear space on the deck, lie down, and fall asleep. Most stations ended up with two men taking turns, relieving one another when necessary, the off-watch resting on the deck beside his station."

Other reports vividly portray the tense situation: "Men quickly shed their shoes without orders on the first and last attack. While things were quiet overhead it was noticed that flashlights, wrenches and valves were moved with the greatest of caution and stealth and the movement of all hands was done with forethought and deliberation. Conversation was unconsciously carried on in whispers when there was a lull in an attack and it looked as though we were getting clear."

"The most discouraging moment of the patrol was the realization that these fellows returning seemed to eliminate practically all doubt that they were looking for us with a pretty good idea where we were. We felt as though we were surrounded by a thorough radar network about whose existance we could do nothing and whose multiplicity made analysis very sketchy and uncertain."

"Kamikaze drew off and commenced a deliberate and systematic search and approach and passed directly over the conning tower. The roar of his screws heard through the hull was a sound none of us will ever forget. We held our breaths but nothing happened." (Eighteen minutes later): "He passed directly overhead the second time. Again nothing happened. We can not understand it--we can hear him pinging even through the hull; he certainly has spotted us. Issued brandy to all hands--a great morale booster and nerve steadier."

"They started going off 6 minutes after firing and there were only 8 charges dropped but the next hour was the most harrowing of my experience--. There were two sets of screws, one fast and one slow. They would ping and listen. I tried to put them astern; only to have him make a run across to our other bow, passing ahead or directly over. They stayed one on either bow most of the time and would turn and make their runs one to the other side. And all of this was carried on in the utmost silence. Not a charge was dropped after the first 2 minute barrage. It is impossible to describe the tension attached to listening for the charges when you know the scoundrel is in good dropping position and does not drop. I found myself wishing that some charges would be dropped so that we might speed in on the occasion and get away."

"The boat was absolutely quiet and though no one removed their shoes, people walked on tip-toe and talked in whispers. Drawing a glass of water from the wardroom spigot sounded like Niagara Falls. Heard a loud clanking noise as if a chain was being hauled across the boat; this made a terrific clatter lasting several seconds. Either they were dragging across us or the bridge was falling off. No attack developed after this so we sat tight."

ENCOUNTERED PSYCHIATRIC CASUALTIES

The following brief resumes indicate in general the types of psychiatric casualties encountered and described on submarine war patrols as a result of the conditions peculiar to submarine warfare just described. Each quotation represents an episode on an individual submarine on patrol unless otherwise noted.

The general manifestations evidenced by men under the stress of the psychic trauma and the physical strain of repairing materiel casualties in excessive heat, humidity and pressure are described as excessive physical weariness with headaches, lethargy, and sometimes heat exhaustion. General sequelae sometimes observed after such experiences were described as follows:

"It was noted that within a period of 24 hours following the depth charge attack, several cases of mild gastric disturbance consisting of slight nausea and cramp-like feeling developed; rapid recovery without treatment followed."

"It is interesting to note that approximately one-half the crew complained of headaches, slight diarrhea and acidosis for 3 or 4 days following the depth charge attack."

"Five cases of acute gastro-enteritis were treated with Amphojel. The worst case started about 2 days after our most severe depth charging and put one man to bed for 3 days--. The other 4 were treated during the 3 days following our gun action with the patrol vessel and two trawlers. One case of psychoneurosis developed during the depth charge attack. Though the subject man was able to perform his duties during the attack his obvious strain affected several other members of the crew. He has requested transfer to surface craft."

"In the first part of the patrol there were no sick days. In the latter part of the patrol, the health of the crew fell off considerably with a telling effect upon the nervous system. Many complained of upset stomaches and overall tired feeling. This reduction in efficiency is felt entirely due to the continual nervous strain and shock of the depth charges. This condition also entirely disappeared after a few days departure from the area and the entire crew was able to get some fresh air and sunshine--quickness with which health of crew snapped back to normal during return from patrol seemed to justify rotation of all members of crew through day look-out watch in addition to regular 8 hours of watch."

Notation of generalized impairment of appetite for a period of 18 hours or so following a severe depth charging attack was made by another commanding officer.

Some individuals manifested gastric symptoms to the exclusion of others; for instance: "One petty officer, making his first patrol, suffered attacks of acute nausea (vomiting blood) during the depth charge attack. These attacks continued for the next 5 days. He was extremely nervous for the remainder of the patrol, and will be transferred upon arrival in port and temperamentally disqualified for submarine duty."

And: "One man during depth charge attack became very nervous and nauseated." And again: "One man has been extremely nervous during this run. Has been complaining of almost constant headaches, dizziness, spots before the eyes, gripping pains in the stomach, all of which certainly are a product of the mind."

"There were numerous headaches among the crew--found to be primarily among men with a large number of patrols to their credit and with a great deal of time aboard submarines."

Upon occasion men experienced symptoms of strain before reaching the area of combat: "One enlisted man suffered from nervous strain prior to arrival on station. Settled down and performed well throughout remainder of patrol."

"One chief petty officer suffered from nervous strain prior to arrival on station. Recovered sufficiently well to perform all duties capably while on station. Will be transferred to the relief crew for proper rest period upon arrival in port."

More commonly, however, acute manifestations of strain were seen during or immediately after enemy counterattacks: "One chief petty officer definitely cracked under the strain of too much bombing, depth charging and deep diving. He was unable to eat or sleep for a period of four days. Codeine produced no effect and as a last resort morphine was used. He had a very bad influence on the rest of the crew throughout the patrol and could not be trusted to man his regularly assigned station without supervision."

"Only one man on his first patrol showed obvious signs of being temperamentally unsuited for submarine duty. He became extremely nervous and overwrought during a heavy depth charge attack. The fact that this man had suffered a severe injury of his finger earlier in the patrol may have been a contributing factor."

Sometimes as observed, the acute symptoms subsided, allowing the individual to carry out his duties with varying degrees of impairment or none at all. In other instances symptoms recurred (sometimes with successive enemy counterattacks) or persisted throughout the patrol, making it necessary to remove the man from the watch list.

"After the severe bombing attack--two men suffered psychoneuroses and were extremely nervous the remainder of the run. Both men are being disqualified from submarines."

As illustration of the multiple complicating factors which render a diagnosis difficult, this report further states: "Three other men suffered heat exhaustion on the same night during the 4 hour dive without the ventilation system running."

Other excerpts illustrating the sometimes incapacitating effects of these experiences are as follows:

"A 45 year old chief radioman with previous 'S' boat experience (war patrol) suffered from nervous exhaustion following the bombing. He continued on duty, insisting he was all right, as soon as we received a message telling us when to terminate the patrol. Three weeks after the bombing he collapsed on watch and later recovered sufficient strength to return to the watch list. The crew's nervous tension relaxed after 28 December 1944. We had attacked an air and surface escorted convoy and escaped without being detected by either planes or surface escorts. Confidence had returned."

And: "Two officers were unnerved to the point of being unreliable in their performance of duty and were setting a bad example for the crew. This was the eighth patrol for one officer and the first for the other. Only two enlisted men became obviously unreliable in their performance of duty."

"Two key men--so nearly approached complete nervous and physical collapse that it was necessary to place them on the sick list relieved of all duties. One of these was in charge of an operation that nearly wrecked No. 4 torpedo tube--one of two serious casualties resulting from what, in normal times, could only be called sheer stupidity."

These acute symptoms were sometimes seen in men making their first patrol, on occasion before the submarine reached its area; others were manifested by men who had had previous combat experience or who made successive war patrols.

"One soundman second class, the battle station bow planesman, was unable to undergo the mental strain of depth charging or explosions of any nature. This was his second offensive patrol, the first having been made on this boat. This man appeared jittery at times on his first patrol, but went to pieces completely on the second. He was treated by the pharmacist's mate. At all times when danger was not immediately apparent, his performance of duty was satisfactory. He was transferred to the relief crew of an advance base."

And: "An electrician's mate who had been given a rest period of 8 months in the relief crew was taken aboard, but unfortunately this did not cure him of excessive nervousness when under enemy counterattacks."

"One man making his first patrol shows signs of excessive explosion shyness traceable, no doubt, to having been in a gun turret explosion aboard a cruiser earlier in the war. He will be better off elsewhere than on a submarine."

On occasion hysterical symptoms were reported in men under great strain. Early in the war one of our older submarines, on her first patrol, sank a Japanese cruiser. Concerning the immediate and severe depth charging which the ship experienced, the commanding officer stated: "This was a new experience for us all, and I consider the behavior of the officers and crew, with one exception, to have been excellent. This one man got hysterical and had to be held down by others."

And again on another submarine: "Health was good with the exception of an attack suffered by a torpedoman second class who has made 8 previous patrols. This man went into a coma for the better part of 2 days during which time he could neither talk nor understand what was being said to him. He would sit upright in his bunk for hours with all muscles tensed and during these periods had difficulty breathing. When he finally came out of it, the only explanation he could give was that he had had a bad dream."

"During the first depth charging one man who had had previous war patrol experience in Asiatic station 'S' boats broke down and later said that he had lost his nerve. On subsequent depth chargings this man proved unstable and broke down and cried on several occasions."

"In leaving Saipan, transferred--to escort vessel via rubber boat. Subject man, who had been received from SubDiv 81, relief crew, the previous day, had fainted as we left the harbor and later complained of bad cramps, nausea, etc. Decided then and there that he would be a source of worry for the remainder of the patrol. Upon aiding him to the deck for transfer he fainted again. It was with a sigh of relief that we finally saw him safely aboard the escort."

Two instances of partial facial paralyses were observed in these patrol reports, both of which were associated by the commanding officer with psychic strain. Concerning one of these episodes, it was stated: "A surprise night bombing on the fifth night in the area was a distinct shock to the crew. Much enemy night air activity necessitated frequent night dives. The attendant nervous tension coupled with prevalent rough seas interfered materially with the sound sleep of the crew. A 21-year old machinist's mate with no previous war patrol experience developed a partial paralysis of the left side of his face following the above bombing. He appeared otherwise normal."

As noted earlier there were 4 recorded instances in which commanding officers lost confidence in themselves or in their ship. These are presented as follows:

In connection with repeated torpedo misses the following statement appears in one patrol report: "--the commanding officer was so completely demoralized and disheartened by repeated misses that he had little stomach for further action--until the finger could be put upon the deficiency or deficiencies responsible and corrective action taken."

One submarine, on her first patrol, "could not press home an attack; the commanding officer choosing evasive rather than aggressive tactics"--in the battle of Midway. On one occasion she was forced to a considerable depth. In the report of the following patrols this statement occurs: "It is particularly gratifying to note that the success of this patrol has instilled confidence in the personnel and increased their morale."

"Submerged at 0445 on 25 February 1942. At 1150 enemy torpedo fired at while submerged. At 1303--sighted two CA's and two DD's. Went to battle station and delivered four torpedo attacks. Received two depth charges; one destroyer remained in the vicinity for two hours. Surfaced at 1901 and changed course." "Missed--I am bitterly disappointed at having failed to make the most of it after having attained a favorable attack position--". "It is believed that had I not altered course to the left just before firing to speed up the problem I would have definitely sunk a heavy cruiser. A hero or a pauper on a hairline decision." "I feel that my judgement was not normal due to physical and mental strain that resulted in my nervousness at that all important moment just before firing. I have reported this to ComSubPac and believe that I am wasting time and a submarine's efforts when I expose it to attack and then fail to realize on the risk. I need rest." "Received orders to go to--where I will be relieved of command. Hope this is only temporary."

"Morale is definitely at a low ebb, this being the second patrol in the last three spent in the Truk area in which no target has been sighted or opportunity to fire. Needless to say, this is the hardest and most exacting kind of a patrol. There is a definite lowering of confidence in the ship and in myself, clearly demonstrated in the pessimistic attitude taken by most members of the crew when there is hope of making contact."

There were 5 cases reported which were likely in the nature of frank psychoses. One of these occurred on an Aleutian patrol early in the war and was apparently the cause of considerable apprehension aboard the submarine, it being written: "One man suspected of being mentally unbalanced was put under close observation and removed from the watch." "Our patient is definitely unbalanced and a menace to the safety of the ship. Confined to the ward room, guard posted." It was necessary to recall the submarine from patrol nine days after she reached her area of operations to remove this patient.

Transfer of a second psychotic patient was made at sea, in enemy controlled waters, from one submarine to another in order that he might be returned for medical care. His management en route proved difficult and restraint was necessary. "His obstreperous behavior demoralized every compartment in which he was confined."

A third case involving a pharmacist's mate was later hospitalized with a diagnosis of dementia praecox.

The following information is available concerning the fourth psychotic episode: "During the close depth charge attack one man, a chief commissary steward, a veteran of patrols on other submarines, showed extreme nervousness and mental depression. Later he was caught in the act of apparently committing suicide by the pharmacist's mate who took an open knife

from his hand as he attempted to slash it across his throat. Three other men witnessed this scene. Early in the patrol he was given small amounts of sodium amytal and elixir of phenobarbital to quiet his nerves. He kept bothering the pharmacist's mate for more after the depth charging. He reported aboard the day before we left for patrol. Found in his jacket was a recent request for his own disqualification for submarine duty. His presence aboard is a definite hazard to our morale and he will be temperamentally disqualified and transferred upon arrival for mental observation."

A fifth psychotic individual took his life aboard a submarine enroute to the operations area. Information concerning this case was collected as follows: This man, about 26 years of age, had been in the Navy for 7 years, being first associated with submarines in 1942. Having made 7 war patrols he returned in the spring of 1944 to the "States" for "new construction". At the Submarine School, New London, he was, for the second time, found physically qualified for submarine duty, being assigned to the USS----on which he remained until the time of his death.

Nothing is known concerning his early medical record. During his Naval career he had not been ill. He had attended the twelfth grade in school. At the Submarine School he graduated 52-2 in a class of 97-21. He had been married for about a year. According to friends the marriage was very successful. As far as is known, there were no financial difficulties. No evidence of disciplinary action of importance was available in his Naval service record. He was a moderate drinker; gambled as much as the average sailor and shared their superstitions.

Three close and personal friends, serving with the patient throughout the 7 war patrols aboard the SS-----and aboard the new submarine and with him at the time of his death volunteered the following: All agreed that he was one of the most popular men aboard the ship, being a big, hard working and unusually conscientious person. "He was always doing something, helping someone, anything to keep himself busy." Early in 1944 the submarine on which he was serving inadvertently submerged with the upper conning tower hatch open which resulted in serious flooding of the ship. The resultant situation was harrowing and hazardous. Our patient was greatly impressed by this incident. On one occasion, following repair of the damage to the submarine: "We were making a night surface approach on a ship over a period of 3 or 4 hours. The smoking lamp was out and we just sat around waiting. He was more nervous than usual. A couple of us noticed that all of a sudden he jumped up and tried to hide behind a warhead to smoke a cigarette. When he lit the match we could see how shaky his hands were. After that he kept walking up and down."

Following this patrol the 4 men were transferred back to the States. At the time men began to assemble for the new submarine our patient was advised by one friend--that "he had had enough and should stay in the States."

At one time arrangements were made for his transfer but he decided, at the last moment to remain with his friends. Once, after they had departed he told a friend; "I'm kicking myself--because I didn't take that swap. I hate like hell to go out now because I know if I make one run I'll be a nervous wreck." All agreed that very soon during trial runs the old nervousness returned. "He began biting his fingernails. Once or twice we took a few off-angle dives--. Every time we'd do this he'd be upset, biting his nails and lips. He was a very light sleeper. Sometimes he'd jump up in the middle of the night--look all around, take his flashlight and check all of the valves in the compartment. He used to worry about making a wet dive (flooding) one time he said: 'If this boat ever makes a wet dive, I'll never go to sea in subs again!'"

Prior to the departure of the new submarine from Pearl Harbor a new type of weapon was taken aboard. Although the patient was specially trained in these, "Taking them aboard--made a big difference in him. He wanted off and said that he didn't want to have charge of them. The first night they were aboard he wouldn't sleep in the compartment. He'd just go near them and sweat and tremble all over. When he came back to the compartment to sleep I noticed that sometimes the slightest noise would wake him. He'd jump out of his sack and run over to them with his flashlight and examine everything. I don't think that from the time we took them on until he killed himself that he had more than 3 hours of sleep."

From this time on increasing nervousness was observed by his intimate friends in his behavior. A last minute request for transfer at Pearl Harbor, lacking adequate reason, was refused. When underway, he requested sleeping tablets from the pharmacist's mate on a few occasions. A few days later he locked himself in the lavatory, shooting himself through the head. Shortly before his death he wrote two letters in one of which the statement was made: "I have hated submarines since one day a year ago when the-----flooded her conning tower but came back up."

No mention of homosexual behavior occurs in these patrol reports. However, the author knows of 9 cases, 3 of which were detected aboard combat submarines or in men who had had submarine duty. The remaining six men had had no experience aboard submarines.

CLINICAL HISTORIES

The following case histories were taken by the author from patients seen over a period of a year at an advanced submarine base, and are quoted for their interest:

One man stated that he had been perfectly content with his duty aboard the USS----- on her first patrol--until the initial depth charges. In describing these he said: "My nerves seemed to give out; I shook all over; I couldn't keep my hands still and I stammered. I couldn't seem to breathe and sweated all over. When I would lie down black spots came in front of my eyes and it seemed like I was going to faint. I wanted to scream and wrapped my head in a pillow so I wouldn't. After that I lost my appetite and couldn't sleep. When I did get to sleep, I'd dream of terrible things and would awaken with a great start as though someone was calling me. The second attack we had was the same way. Now whenever the diving alarm sounds I start to shake all over. I wouldn't like to go out again unless I have to. I'm afraid that I couldn't take it the next time."

A second man had reported aboard the USS-----as an emergency replacement. At the conclusion of this patrol, his first, of some 63 days length, he was put ashore for administrative reasons. Two weeks later he appeared requesting: "I want to be disqualified from submarine duty because my nerves can't take it." On this particular patrol the ship had received severe and prolonged depth charges. "The first depth charges weren't so bad; I was scared, sure, everybody was scared, but I thought they had gone. Then when they came back for the second time I was stunned beyond the point of being scared; I couldn't move, sleep, or think. I felt anxious, weak, and jittery. I don't want to make no more runs. I don't think that I can take it."

A third man had returned from a long and arduous patrol, the first part of which had passed without incident following which he described the gradual onset of fatigue and nervousness. On one occasion, while standing lookout, in severe storm: "The ship took a 50 degree roll, staying in that position for at least a minute. I was wedged in on the bridge; the seas were mountainous and passing over me. I was looking down straight into the ocean, the waves breaking over my head. The hatch was open but I couldn't possibly get down. I had given up all hopes for us but finally the ship righted itself. I was very scared and couldn't get over it. Then I thought I had but it wasn't so and each time upon the bridge, in a storm, I was frightened. When we arrived here I felt that it would be all right. The recuperation period went well. On our first trial run, yesterday, I took several messages. I knew what was going on; I knew what they were as I took them but then I couldn't remember them. In emergencies I can't seem to think; I seem to be paralyzed. When we dive I'm afraid. I thought I could stick out the patrol but I can't go through with it. I feel afraid the minute I go below and I'm afraid that I'll do something that will endanger everyone."

On one occasion a pharmacist's mate brought a patient from a submarine enroute to its area of operation to the dispensary at an advanced base. The patient's chief complaint was abdominal pain. After examination, it was decided that his difficulties were likely due to chronic constipation. Note was made of the presence of many tattoos, there being scarcely a square inch of skin which was not covered with some design or another. He had been a tattoo artist in civilian life. No notice was made of constriction of the pupils which surely must have been present. Some two weeks after the submarine had departed he confessed being a morphine addict upon apprehension at attempted theft of the submarine's supply of the drug. The subsequent withdrawal symptoms proved difficult to manage and were most intense at a time when his services were badly needed as a radar technician.

STATISTICAL ANALYSIS

All of the cases described in the patrol reports which could possibly be diagnosed as neuropsychiatric or emotional casualties have been presented in Table 17.

It has been pointed out that diagnosis (psychoneurosis, anxiety) is too infrequent, and that a trained and emotionally neutral observer during any depth charge attack would almost certainly detect true symptoms in many of the crew. However, perhaps some slight disturbance was considered to be a reasonable and normal reaction to the situation. At any rate it is apparent that only those reactions interfering with performance of duty were recorded. "The depth charge attacks had little effect on personnel. They came to be expected and accepted as routine and to all appearances were ignored. The experience of the heavy grapnel banging against the ship's hull at 340 feet caused some raised eyebrows, the commanding officer's being as high as any."

To evaluate the true significance of this total of 56 possible psychiatric casualties (neuritis not included), it is necessary to have information concerning the number of men exposed to the emotional trauma so vividly described in the patrol reports and so indelibly recorded in the memory of all submariners.

There were, as noted earlier, 1,520 war patrols (all areas) and there was an approximate average of 75 enlisted men aboard on each patrol, making a grand total of 114,000 man-patrols. There were 12,160 officer-patrols. Human nature being what it is, officers were as prone to "break" as the men, and perhaps more so, because they more fully realized the dangers and responsibilities.

This total of 126,160 man-patrols and 56 possible psychiatric casualties gives the amazing percentage of .00044 casualty cases of a psychiatric nature occurring per man-patrol.

Another method of approach is to take the average number of patrols made per submariner. From the thousands of questionnaires returned after the war, in connection with a survey which was conducted on submarine personnel, a random sample of 318 returns was tabulated. The maximum number of patrols made by one man was 14 in this group and the average number was 6.17 patrols per man. Thus, if we divide the man-patrols (126,160) by the average patrol per man (6.17) we have 20,447 men making an average of 6.17 patrols. Again, 56 cases is an amazingly low figure.

"It is interesting to note that during the six war patrols made to date and in spite of the severe depth charging on each patrol involving a total of over 500 depth charges, only one man has cracked up. This was on the first patrol and the man was a veteran of several war patrols on another vessel."

To approach the problem in another way: the maximum number of men attached to submarines, relief crews, rest camps, and administrative staffs, never exceeded 25,433 individuals. Even if we made the erroneous assumption that these were the only men attached to the submarine service throughout the war, we would have an admission rate of only 2.2 per thousand.

Though these figures may be somewhat incomplete and under-estimated, nevertheless, it must be obvious that the submarine service had a very enviable record as far as emotional or psychiatric breaks are concerned.

The reasons for this record are important, particularly in the light of planning for any future national emergency. The author believes they may be completely summarized under the following general headings:

(1) Selection.--Foremost to be considered in a discussion of selection for the submarine service is the fact that every man is a volunteer. He may have been drafted into the Navy, but he goes into the submarine branch of his own free will. This not only is a selective process in itself, but also a motivating force for the man to remain associated with submarines.

Much has been written about the process of selection for the submarine service. Here we will be content to mention that all the men were required to meet rigid educational, psychometric, and psychiatric, as well as physical fitness standards. An attempt was made in the screening process to eliminate all those with obvious and latent defects, as indicated by the psychological and psychiatric evaluations. That only one case of dementia praecox and two cases of epilepsy were reported on submarines during the war indicates that the effectiveness of this screening was of an extremely high order. None of the other reasons---training, morale or rest could account for this.

(2) Training.--Training was conducted in an exceptionally proficient manner by the Submarine School, which is an established activity of long standing and known excellence. "Refresher" training and "New Construction" training courses were also conducted in order to keep both officers and men up to standard. A man who is sufficiently trained and drilled in his job has a maximum of confidence in himself and is most likely to withstand the trauma and rigors of warfare. He knows what to do and how and when to do it, and reacts automatically in times of emergency.

(3) Morale.--There is no question but that from start to finish the submarine service engenders in men a special spirit which undoubtedly served to carry them over many a tough spot. They realized fully that they were a part of an organization with a reputation to live up to, and of which they could be proud. They lived together as one family and they realized that if one man failed, all would fail in their mission. For this reason there was less likelihood that they would allow themselves to give way to the pressure of the moment.

(4) Pre and Post-Patrol Physical Examination for Continuance on Patrol.--Pre and post-patrol physical examinations undoubtedly served to detect men in need of a period of rest and rehabilitation, and thus forestalled many emotional "breaks".

(5) Rest Camps and Rotation.--An important factor enabling the submarines to attain their excellent record was the generous use of rest camps and rotation of duty. It was a general policy that no man should make more than two consecutive patrols without spending a period of time in a rest camp. An equally important factor was occasional rotation to the United States to "pick up" a new boat. The incidental leave of course was an effective form of rehabilitation.

(6) Confidence in Submarines, Officers, and Shipmates.--The construction of the submarine, its demonstrated ability to withstand enemy counter-attacks, and the demonstrated effectiveness of their weapons could not but engender confidence in all the men. In addition

to this, they were well aware that both their officers and shipmates had not only been very carefully selected but highly trained, thus assuring the maximum in efficiency and mutual protection.

(7) The lessons to be applied in the planning of any future conflict have been amply covered in this discussion of why the submarine service fared so well in contrast to other services insofar as psychiatric casualties are concerned. It is apparent that by selection, by training, and by building morale, by frequent examinations, by generous use of rest camps, and by instilling confidence, the "breaking point" was indefinitely deferred and psychiatric casualties were largely eliminated under conditions which submarines encountered in World War II.

PATROL REPORT COMMENTS CONCERNING AVAILABLE MEDICAL FACILITIES

The overall performance of medical personnel connected with the Submarine Force during World War II, particularly with reference to the Hospital Corpsmen, was excellent. Those concerned with the development of screening and selective processes for submarine personnel did a commendable job as evidenced, among other things, by the remarkably low incidence of psychiatric casualties in the Service. Those responsible for the training of submarine pharmacist's mates did a magnificient job, to which the non-existent mortality rate for appendicitis and low mortality rate for injured aviators treated aboard submarines well testify.

Upon occasion in these patrol reports, criticism was made of medical facilities and care available in the field. These have been collected as follows.

POST-PATROL PHYSICAL EXAMINATIONS

The post-patrol physical examinations were a headache to everyone concerned. Submarine personnel (the day they arrived in port) resented the several hours spent in the sick bay and dental office for these examinations. Medical personnel disliked the examinations because of the work involved and because, generally, they were so routine and revealed but little in the way of interesting pathology. It is the opinion of the author that these examinations, conducted with thoroughness, were well worth while. They certainly contributed to the low psychiatric casualty rate in that on occasion men were detected whose removal from active duty aboard submarines, at least temporarily, was indicated. Occasionally important pathology was observed. They did, moreover, bring the medical officer closer to the men riding the submarines.

Apparently early in the war, there was no standardized procedure regarding these examinations. At the conclusion of the second patrol of the CUTTLEFISH (June, 1942) the commanding officer stated: "Recommend that the officers and crews of submarines be given a thorough physical examination, including a complete blood count, urine analysis and dental examination immediately after each patrol. Doubtful cases should be examined again a week before the beginning of the next patrol. It is felt that by doing this in lieu of the present system of cursory examination of the genitalia, groin and teeth, the medical department can compile useful data on personnel endurance which will assist high commands in determining relief and replacement policies and can assist the commanding officer by discovering early in the refit men who must be replaced." The commanding officers of the SUNFISH (No. 3, June 1943) and S-33 (No. 7) suggested that all of the men be given a physical examination during the refit. The commanding officer of the STINGRAY (No. 1, Dec. 1941) suggested commanding officers be given a rigid physical examination every few months. "I had very good to excellent eye sight on my last physical examination in 1940--believe that my eye sight has deteriorated since the last examination because in several instances episodes as the above have taken place."

With the passage of time, these examinations came to be routine. Concerning the examinations the following comments were observed: "Departed with two men on the sick list, one man with an injured back and one man with an abscessed tooth--with the blessing of the medical and dental officers. The man with the back injury had to be later transferred at Darwin, where three men received dental treatment. One man received from the relief crew complained of tooth trouble enroute to Darwin--where 10 cavities in 8 teeth were discovered. That such a condition existed in a man newly reported aboard is faint praise for the thoroughness of the physical examination reputedly given him before reporting aboard" (ASPRO No. 4, Aug. 1944). "Routine treatment for minor ailments. One man left Saipan with an abscessed tooth. The first case to occur on patrol was a completely decayed tooth which was removed and the man quickly recovered" (ATULE No. 4, Aug. 1945). "One infected jaw due to a recent tooth extraction worried us for a few days" (SEA OWL No. 1). "There was a high frequency of dental complaints" (PERMIT No. 11, March 1944). "Forty men are in need of dental work, an unusually large number" (Squadron Commander's endorsement to first patrol report of FLOUNDER, May 1944). "Five cases of crabs were discovered in the first twelve days of the patrol" (HOE No. 5, Aug. 1944). "Put to sea with about 20 mild cases of scabies" (TROUT No. 9, July 1943). "There were 17 cases of scabies. These could have been prevented by a more thorough examination prior to departure on the patrol" (THRESHER No. 7, March 1943).

"The first day on station one man was transferred to the QUILLBACK with chronic renal colic. This man was received from SubDiv 162 in Saipan six days before. At that time, he had been out of the sick bay for about four days following a previous renal colic attack" (BATFISH No. 7, Aug. 1945). "One seaman received from the relief crew at Midway burst his eardrum on the first occasion when the pressure in the boat exceeded one inch. He had never had a pressure test and was transferred to the Fulton. One fireman received from SubDiv 82 just before getting underway was found to have impetigo and to be totally deaf in one ear. He was also unable to adjust himself to the pressure differential between the engine room and the after battery room and will have to be transferred. It is believed that facilities for pressure tests are available. It is felt that all relief crews should be required to subject all men to pressure tests before transferring to operating submarines" (SHAD No. 8, Jan. 1945).

"Fifteen man days were lost by a patient with a hernia which became swollen and sore after the slightest exertion. This case was detected after the previous patrol but operation was not performed because of lack of bunk space on the U.S.S. Clytie" (LAMPREY No. 2, June 1945). Mention has been made in the section dealing with venereal diseases of one man removed from a submarine with multiple perineal and penile lesions and an acute form of cerebro-spinal syphilis. This man had been aboard the submarine and had concealed his illness for at least three months during which time, at a refitting base, the routine physical examination was confined to a "discussion with the pharmacist's mate". "Two crew members were found to have far advanced tuberculosis at the end of the sixth war patrol at Mare Island. The commanding officer feels that had these men been given a careful physical examination at the end of the fifth patrol, their condition would have been discovered and treatment for recovery commenced three months sooner" (APOGON No. 7, July 1945).

In connection with the above, it may be pertinent to mention that medical officers in charge of the health of relief crews should assume the responsibility of checking their health records. Particular reference should be paid to the completion of innoculation records. References to chronic sea sickness, inability to equalize pressure, and previous temperamental or physical disqualification for submarine duty should be carefully scrutinized.

COMMENTS CONCERNING MEDICAL AND NON-MEDICAL SUPPLIES CARRIED ABOARD THE SUBMARINES

Dental Supplies.--As observed in that section dealing with dental diseases, there exists aboard operating submarines a real need for an emergency dental kit. The following patrol reports recommend or request more adequate instruments for treating dental patients: GUDGEON No. 1 (1942), POMPON, SEAWOLF No. 13 and SHAD No. 10 (June 1945).

Oxygen Administering Apparatus.--Upon a number of occasions need existed aboard submarines for administering oxygen. On the BASS (No. 4) with the asphyxiation of 26 members of the crew, considerable difficulty must have been experienced with the apparatus available in the administration of "free oxygen" to the victims of the fire. On the fourth patrol of the COBIA, in a casualty in the engine room two men were overcome by the exhaust gases, to one of whom continued administration of oxygen was necessary. Concerning this episode the commanding officer stated: "Some form of an oxygen mask or tent would have been more efficient than the cloth and smoke mask that we used." It was necessary on the seventh patrol of the DRUM to administer oxygen by the use of an "escape lung". The third patrol of the PLAICE was terminated to return a patient with DU (pneumonia) for medical treatment. It had been planned to utilize oxygen aboard the vessel--"the apparatus consisting of a compartment oxygen flask, a welding torch as a metering orifice, a gallon mayonnaise jar as a humidifier, and a urethral tube as a catheter." On the seventh patrol of the FINBACK, a chief motor machinist's mate was put in an oxygen tent for the treatment of pneumonia. A man was treated aboard the GUNNEL (No. 2) for pneumonia using a make-shift outfit oxygen tent with a celluloid window for 16 hours. On the fourth patrol of the BESUGO the chief pharmacist's mate administered oxygen to a badly burned Japanese survivor by the "use of a dampened sheet, a 6 foot length of hose taken from the escape trunk and a flask of aviation oxygen."

Fire Fighting Apparatus Aboard Submarines.--Need exists for a review of the adequacy of other pieces of apparatus used in fighting fires aboard submarines. Aboard the BASS: "Rescue work was hampered in that all work had to be done using smoke masks and working in heavy smoke and intense heat." "The Momsen lung was used for rescue work. Its use was made hazardous by the danger experienced of chance losing the mouthpiece with the individual's attempt to turn his head or raise his head above the horizontal. The hands, moreover, could not be used to hold it in place while holding a stretcher. Sometimes the eyepieces of the goggles fell out and it was difficult to keep the nose clamp secure, especially when the skin became wet." Stated the commanding officer of the COBIA: "I have gone to some length in this account to emphasize the toxic blinding and demoralizing effect of a smoke filled compartment and the necessity for a thorough and frequent instruction in the operation of the cumbersome Navy oxygen rescue breathing apparatus."

An equally serious fire occurred aboard the S-35 (No. 5) after which it was reported: "Attempts to enter the control room with the smoke lungs were not successful due to the fact that the fire had consumed the oxygen in the compartment (the lungs were subsequently charged with oxygen). The carbon dioxide fire extinguishers were ineffective in checking the fire." Following a fire in the auxiliary engine on the PILOTFISH (No. 4) it was recommended that "the allowance of fire extinguishers be increased inasmuch as one serious fire seriously reduces the availability of fire extinguishers for subsequent fires." After a maneuvering room fire on the SILVERSIDES (No. 4) "some insulation with a higher ignition temperature (than cork) is indicated. It is recommended that a permanent shock proof carbon dioxide system be installed that will quickly blanket and extinguish these fires. As a temporary expedient more portable carbon dioxide fire extinguishers are recommended."

Aboard the COD (No. 5) following a torpedo battery fire, it was stated: "The after torpedo room was filled with a dense suffocating smoke. The smoke lungs were totally inadequate. This left our two rescue breathing apparatuses and our one shallow water diving mask which could be used and permitted only three men to enter the torpedo room to fight fire. At this point the commanding officer would like to point out the inadequacy of the present submarine allowance of the rescue breathing apparatus. The old smoke type of canister, as everyone knows, is of no value whatsoever. At Pearl Harbor the ship attempted to draw four of the rescue breathers but only two could be obtained (the ship's allowance). Thus, when this fire occurred, two rescue breathing apparatuses were available (one at each end of the ship) and only two men could work in the compartment. At one time a smoke canister and lung was authorized for each compartment. It would seem to follow, therefore, that a rescue breathing apparatus should be authorized for each compartment on the ship. This change is recommended for submarine allowance."

Litter Requirements of Submarines.--In that section dealing with air-sea rescue operations, mention is made of the need for investigation and study of some pieces of standard life saving equipment. In particular the present stretcher available to submarines (NMRI semi-rigid canvas litter) should be investigated under trial operations in all kinds of weather as to its suitability for ease and quickness of application to wounded and exhausted men in the sea or aboard open rafts or boats, comfort when applied to survivors for prolonged periods, adaptability when used to hoist injured men aboard the submarine, to lower them below through the narrow inner hatches and for intra-compartmental transportation. Definite need exists for the improvement of available means to transfer injured men at sea in inclement weather, from one submarine to another or to surface craft or planes. If the NMRI stretcher does not meet these needs, a stretcher or piece of equipment should be developed which does. In this connection the ninth patrol report of the PETO mentions the presence aboard of a stretcher devised by a medical officer from the Orion, Lt. Cdr. M. T. Friedell (MC) USNR.

Inadequacies of Medical Commissioning Outfit.--Need exists for study and revision of the medical commissioning outfit (as of 21 Sep 1945) for newly commissioned submarines by medical personnel familiar with the need of submarines. Patrol excerpts in relation to this are as follows: "In connection with treating the wounded survivor, found that there was no tetanus toxoid aboard; it was not available before leaving on this patrol" (BASHAW No. 3, Oct 1944). "On 9 August received a patient from the RASHER--a DU (fracture of humerus)--improved a Thomas arm splint and traction applied" (HOE No. 5, Aug 1944). Similar need for a traction splint is apparent from the eighth patrol report of the PARGO. Following air-sea rescue operations BALAO (No. 9) stated: "The allowance of 200,000 units of penicillin and sufficient dried blood plasma for three transfusions is insufficient. A greater allowance should be made if it can be spared." RASHER No. 6 and SEALION No. 4 recommended that submarines be provided with penicillin which, of course, they were as soon as it could be made available.

Aboard the WAHOO, due "to a shortage of surgical instruments" amputation of a crushed toe using a pair of "sterilized side cutters" was carried out. Following the appendectomy aboard the SEADRAGON (No. 4) it was stated: "Recommend that more medical equipment be provided each submarine in order to permit them to adequately care for emergencies. The present allowance is considered insufficient." In the second patrol report of the LAPON the following statement appears: "From comments made to the commanding officer by a visiting medical officer, it is considered advisable that a study be made of the submarine medical requirements with a view toward a revision and expansion of medical supplies and instruments." In the fifth patrol report of this ship, it is stated: "A need is felt for some convenient means of sterilizing dishes of patients with communicable diseases. It is felt that a small electric sterilizer could be easily installed." The commanding officer of the PIKE recommended the procurement of good medical text book. "The Hospital Corps Handbook does not fulfill the existing needs." (A Minor Surgery Textbook is supplied newly commissioned submarines--there is no good general medical textbook provided).

UNFAVORABLE REACTION TO SULFONAMIDE DRUGS

As is to be expected upon a few occasions, unfavorable or unsatisfactory reaction to sulfonamide drugs was reported. "One man was treated for a urethral discharge--he developed a fever and recovered when the treatment was discontinued" (SCORPION No. 3). "One case of gonorrhea incapacitated one man for 34 sick days. He did not respond to sulfathiazole or sulfadiazine. Strongly recommend that submarine be supplied with penicillin" (SEALION No. 5). "Four men with gonorrhea were taken to sea and treated with sulfathiazole. The treatment was apparently 100 per cent effective in 3 of the cases and partially effective in the other case." "One case of venereal disease developed after departure from Fremantle that required transfer at Darwin due to the fact that his health record stated that he should not be given sulfa drugs for treatment of any illness."

GENERAL INFORMATION OF A MEDICAL NATURE

The commanding officer of the GRAYLING (No. 2) comments upon the "usual loss of weight." At the conclusion of the sixth patrol it was stated: "Two cases of excessive weight loss with other symptoms are probably indicative of nervous strain." Some investigating medical officers have stated that men on submarine patrols generally gain weight. Others have contended that weight is lost by the majority of men. Whether or not men gain weight is an individual matter and is not, generally, of particular importance. Examining physicians should keep the possibility in mind when examining men returning from submarine patrols. Excessive loss of weight is associated with chronic seasickness and with the impairment of appetite that comes with "operational fatigue". Very commonly men reported that they lost a few pounds while on patrol, which they more than regained in the period of time spent at the recreation camps.

On a few occasions in these patrol reports mention is made of generalized lowered resistance of the crew. "The resistance of all hands was lowered--there were many fungus infections of the feet and a few severe cases of acne. Cuts were hard to heal. There were two boils and one large abscess of the wrist for which sodium pentothal was given intravenously at the time it was incised" (SEA FOX No. 3). "The health of the crew was not as good as on the previous patrol. They seemed to have lowered resistance to infections." "Health was fair; there were numerous infections and colds showing lowering of resistance" (SENNET No. 2). The sixth patrol report of the TUNA mentions the development of multiple boils in one man following a severe case of "heat rash". One commanding officer observed a marked decline in boils and other skin infections when all bunk covers were removed and personnel were compelled to remove their outer clothing before lying down on their bunks.

Not infrequently it appeared that submarine personnel reported back aboard their submarine, following a period of time spent at the recuperation camps, in worse physical health than at the time they had departed. The crew returning "from the rest camp brought back the usual assortment of minor disorders--cuts, colds, crabs, and skin eruptions, several cases of Vincent's angina and tonsillitis, one case of gonorrhea and several DU (penile lesions)" (CROAKER No. 6). "There were the usual minor skin infections picked up by the men in the rest camp (Subic Bay)" (LAMPREY No. 3). Sometimes "coral wounds" sustained during refit, were reported to heal slowly (KINGFISH No. 10). Prior to the first patrol of the BRILL the following conditions were treated: One tonsillitis, one man with pneumonia, one fractured finger, one intracranial injury, six cases of "cat fever", two men with appendicitis acute, and one man with DU (osteomyelitis).

USE OF VITAMIN PREPARATIONS AND SUN LAMPS ABOARD SUBMARINES

All submariners know about vitamins. In these reports mention is made of their use on 74 or so patrols.

Early in the war some ships bought their own supply through the Welfare Fund. On others men supplied themselves with vitamin preparations. "All the officers and many of the crew provided themselves with vitamin pills at their own expense. The supply did not last. Concentrates are considered to be most beneficial" (PICKEREL No. 3, March 1942). "Night blindness was serious even amongst the best lookouts. Fortunately, the officers were able to see satisfactorily as they had vitamin pills of their own. Recommend that vitamin pills be supplied the boats in sufficient quantities to keep the lookouts up to standard--" (SALMON No. 2, March 1942). "All the bridge personnel took the prescribed daily doses of halibut liver oil with Viosterol with noticeable improvement resulting in night vision. In addition, all officers took one Abidon (Vitamin A, B, B_1, C, and D concentrates) pill every other day with improvement in the general health. Recommend that this preparation be supplied for the entire crew" (SCULPIN No. 3, April 1942). "Vitamin pills are recommended for the whole crew. The living conditions are so different that recourse to sandwiches and a cup of coffee is the usual case. Day is turned into night. Vitamin A should be fed to the officers, quartermaster and to the lookouts to sharpen their vision" (SAILFISH No. 1, December 1941, after a 9 day patrol).

With time, the above recommendations were carried out to the point that all of the submarines were stocked with a multi-vitamin preparation. It was thought that one capsule per day would supply approximately one-half the minimum daily requirements. In general the submarine rations were so varied as to contain all of the required vitamins and nutritional elements. However, in order to be certain that there would be no deficiencies, the use of the multiple vitamin capsules was recommended and encouraged.

Of the 73 patrols in which use of vitamin preparations is mentioned, 32 gave no details other than that the pills were accessible to the crew. On eighteen patrols at least one capsule per day per person on reaching the area was mandatory. On twelve patrols from 50 to 90 per cent of the officers and men are reported to have used them. In 5 instances the officers and lookouts specifically were required to take vitamins. On 6 patrols the preparations were used sparingly.

An evaluation of the efficacy of the multi-vitamin capsule from patrol reports or other available information is now impossible. Such comments of interest are as follows: "Vitamin tablets were used, apparently to good purpose"; "consumption of vitamin pills was thought beneficial"; "vitamin capsules were taken; it is recommended that the allowance be increased to 4,000 per patrol"; "the vast majority of the crew took vitamin pills. Believe that they have a certain physical and psychological effect. When it was discovered that the night lookouts were required to take them, the rest of the crew took them as a matter of course." In a few instances freedom of the crew from upper respiratory infections while on patrol was associated with the use of vitamin preparations.

In five or so instances the available preparations were unpopular and but little used, "The supply of vitamin pills was used sparingly because of their unpleasant taste and odor." "Vitamin pills were available and nearly everyone took their quota and regularly even if not with relish." "Half of the vitamin pills aboard at the start of the patrol had an imperfect candy coating and were not used. There was a sufficient supply of acceptable tablets." "Football shaped vitamin pills are much easier to swallow." "Vitamin and salt tablets were used; one man with acne became worse." "There were a number of colds in the early part of the patrol. Vitamin tablets were taken extensively after this; the colds disappeared but headaches developed which may have been caused by the vitamins." "Vitamin pills were used by only 3 or 4 of the men without noticeable results." "Fifty per cent of the crew took vitamin pills without apparent effect."

Sun Lamps.--The sun lamps were mentioned in 29 of these patrol reports. In 9 patrols the lamps are mentioned as having been used without further details. Four reports state that the majority of the crew used them; 4 observed that they were used by 50-90 per cent of the crew and officers. Four reported that "they were used by several men". Five boats reported that the lamps were not used because they were unsatisfactory. Three stated that the installation had not been used, no explanation being given.

"The lamp was used by the majority of the men." "Fifty per cent of the crew used the lamp in the latter days on station." "One painful attack of sciatic neuritis was treated by the sun lamps with considerable benefit" (TRIGGER No. 5). "Several cases of heat rash were successfully treated with the sun lamp" (SUNFISH No. 3). "The use of vitamin pills and sun lamp measurably improved the general health of the crew over that of previous patrols" (SNAPPER No. 3).

"The two sun lamps were at first very popular. However, after the war began, most people were more concerned with getting some sleep in their leisure moments than they were in keeping a sun tan" (TRITON No. 2). "The ultraviolet lamp was not used due to its location in the forward torpedo room where, when the injection temperature of the water is 50 degrees F. or lower, it is too cold for the men to remove their clothing" (POGY No. 1). "During the hot weather the sun lamps were not used much" (TROUT No. 9). "But few of the men used the sun lamp" (PLUNGER No. 10). "Only 3 or 4 of the men used the lamps without noticeable results" (SILVERSIDES No. 2). "Some of the men are pale due to failure of the sun lamp" (THRESHER No. 7). "The sun lamp was unsatisfactory because of early blowing out of the quartz tube. Rotation of the crew through the sun lookout has compensated for loss of use of the sun lamp (quartz tube not available)" (BECUNA No. 2).

Chapter 3

Habitability Features of Combat Submarines

Habitability aboard a submarine reflects, in part, the adequacy of provisions for light, air, heat, water, rest, and recuperation for the crew. It is influenced by weather, the nature of operations, and by special hazards, as fires, battery gases, and explosions. In this series of patrol reports those conditions most frequently commented upon as influencing habitability were: the adequacies and inadequacies of ventilation and air conditioning surfaced, submerged or running silent; the discomforts incident to long dives (as carbon dioxide accumulation, depletion of oxygen and increase of pressure within the boat); the influence of weather as reflected in the comfort of prolonged surface running in favorable seas or the discomfort of cold, wet and rough weather; overcrowding; deficiencies of the water supply and sanitary tanks; fires; certain noxious agents as chlorine gas, carbon tetrachloride and materiel damage consequent to depth charging, accidental flooding, etc.

Many times direct reference to habitability was not to be found in paragraph "P" of the patrol reports, indicating, it is presumed, that it was favorable if not good. Commonly, it was referred to in general terms of: "excellent", "good", "fair", or "poor". In most instances these terms were qualified. "Poor" or "fair" reports were always accompanied by explanations. Some reports were limited to "excellent" or "good" which comments by no means always indicated that a perfect condition of habitability existed, but rather that it was compatible with the commanding officer's standards of what habitability aboard a submarine should be for satisfactory performance.

STATISTICS

From 21 S-boats habitability was reported in 61 war patrol reports as follows:

Table 20.--S-BOATS

	Excellent	Good	Fair	Poor	Total
Number of reports	3	12	18	28	61
Percentage (61 reports)	5	20	30	46	--

The majority of these patrols were made in the Aleutian area. A few were made without air conditioning. The fact that 76 per cent of them were reported as either fair or poor, is felt to be expressive of living conditions aboard this type of ship in Northern waters.

Commanding officers of 282 fleet-type submarines in 748 patrol reports (57 per cent of the total number available for study) made reference to habitability as follows:

Table 21.--FLEET-TYPE SUBMARINES

	Excellent	Good	Fair	Poor	Total
Number of reports	106	408	171	63	748
Percentage (748 reports)	14	54	24	8	---

As they stand these figures have little significance; they do not reflect the improvements made in the various features of habitability on new and old construction, nor the areas in which the patrols were made. The following table presents a breakdown of these figures according to the year in which the patrols were carried out.

Table 22	1941		1942		1943		1944		1945	
	No.	%	No.	%	No.	%	No.	%	No.	%
Excellent	0	0	8	8	24	16	41	14	33	16
Good	5	50	34	34	82	55	170	59	117	58
Fair	3	30	33	33	36	24	55	19	44	22
Poor	2	20	25	25	7	5	23	8	6	3
Total	10		100		149		289		200	

Grand Total 748

SUMMARY

	1941	1942	1943	1944	1945	Total
Total number reports for year	19	197	268	456	371	1,311
Total number S-boat reports for year	0	61	23	1	0	85

Grand total 1,396

It is believed the above figures indicate the improvement of habitability in submarines as World War II progressed. Thus, after 1942, the percentage of excellent reports was doubled; the percentage of fair reports was significantly lowered; the percentage of poor reports was better than halved in 1943 and 1944 and was at an all time low in 1945, at the close of the war. The percentage of reports of "good habitability" rose to remain at a level between 55-60 per cent. It can be said that almost 70 per cent of all patrols reporting on habitability throughout the war were made under either good or excellent living conditions. Without a doubt, conditions were equally favorable on the majority of patrols (658-43 per cent) on which an opinion on habitability was not expressed.

The other side of the picture, however, exists. That 30 per cent of the reports indicated habitability to be fair or poor is a matter of record. The above tables also indicate that in 1945, as compared to 1944, the period in which many new boats appeared in the Service, other than for halving the number of poor reports, the number of those commenting on habitability in terms of "excellent", "good", or "fair" did not really significantly change--contrary to what one might expect.

The role which submarines played in winning the war against Japan is well known. Throughout the war, of 63 patrols experiencing poor habitability, 39 (62 per cent) were successful and 22 (35 per cent) were unsuccessful (ComSubPac), the success being unknown in 2 instances (3.1 per cent). The figure of 35 per cent is misleading--actually not more than 23 submarines on patrols suffered undue inefficiency because of poor or unfavorable habitability. In 8 instances unfavorable habitability in one form or another was a factor limiting patrol endurance. While these will be discussed elsewhere it can be concluded here that though life aboard submarines may frequently have been uncomfortable and rugged it seldom reflected unfavorably in enemy tonnage sent to the bottom or the carrying out of special missions.

VENTILATION AND AIR CONDITIONING ABOARD COMBAT SUBMARINES

There is no more important measure of the habitability of a submarine on a war patrol than the adequacy of its ventilation and air conditioning systems, the subject throughout the war, aboard fleet type submarines, for critical comment in over 400 instances, better than half of which offered suggestions for improvement. Early patrols demonstrating the paramount importance of habitable conditions of air temperature and moisture content, all fleet and S-type submarines were eventually equipped with air conditioning. On most fleet type ships this originally consisted of two, four-ton air conditioning units installed in the ventilation supply lines in the crew's quarters and in the after engine room. Ventilation, while submerged and underway, was "outboard" or "inboard"; while surfaced, air was "recirculated".

FAVORABLE COMMENTS CONCERNING VENTILATION AND AIR CONDITIONING

As noted earlier, 658 (43 per cent) of these patrol reports made no mention of habitability and it seems fair to assume that conditions of ventilation and air conditioning were good. Of the 748 who did make note of habitability, 135 reports briefly noted it to have been "good" without specific comment.

In 40 reports from 35 ships (6 in 1942, 13 in 1943, 12 in 1944 and 9 in 1945) specifically commenting upon ventilation, satisfaction was expressed with the original system of ventilation and air conditioning, 17 being after tropical cruises, 22 were made in temperate waters and 1 was made in the vicinity of the Kurile Islands. Nine of these reports judged habitability to have been excellent.

Typical reports made after cruising in temperate and cold water with satisfactory standard air conditioning and ventilation were as follows: "The air conditioning plant made the boat comfortable; all day dives were never a hardship" (PLAICE No. 1, Summer 1944, Bonin Islands, 18 submerged days on station). "An average injection temperature of 65 degrees kept the temperature inside comfortable with but little moisture collecting due to continuous operation of air conditioning" (BONEFISH No. 7, Spring 1945, China Sea). The POLLACK (No. 1) returning from a winter patrol in the vicinity of Japan stated: "Habitability was good; air conditioning worked well, electrical shorts due to moisture were almost entirely absent." The BATFISH (No. 1) after a winter patrol in the same area reported the boat comfortable "blankets being used habitually." The SEAL (No. 11, Fall 1944), after a Kurile Island patrol reported habitability to have been excellent, "the air conditioning plant being secured and moisture not excessive." The TRUTTA (No. 1, early Spring of 1945) after a patrol on the Yellow Sea reported habitability to have been excellent, "heaters being used on station with the air conditioning secured." The TREPANG (Summer 1945, Honshu) spent most of her fifth patrol in weather "with an average air temperature of 50 to 60 degrees which made the inside of the boat ideal."

Concerning habitability on tropical patrols the following comments are typical: "Air conditioning proved adequate to provide comfortable living conditions submerged even though the injection temperature was 76 to 78 degrees. The boat was actually more comfortable submerged than on the surface" (SAWFISH No. 2, early Spring of 1943). The PORPOISE (No. 5, early Spring of 1943) observed: "Our first patrol in tropical waters--since the installation of the air conditioning which made the ship comfortable and contributed greatly to cleanliness, stopping all rash and prickly heat." And the GRAYBACK (No. 6): "Improvement in the operation of the air conditioning made the boat much more habitable--especially after a few days of surface running on the equator when the battery temperature dropped over 10 degrees." On a tropical patrol the FLOUNDER (No. 3, Fall 1944) after an extensive study of the capabilities of the air conditioning reported the habitability improved. "The air was kept drier and cooler by ventilating the engine room through the main induction piping and operating the blowers at half rheostat. This also brought the battery temperature down." The ROCK (No. 3, Summer 1944) reported habitability as good on a patrol made with the average injection temperature 86 degrees F., "air conditions being very satisfactory". And the TAMBOR (No. 6, early spring of 1943) reported the air conditioning to have functioned properly on a tropical patrol: "Health and personnel endurance were excellent--at last we found out that submerged time need not be a taste of hell--this is the first patrol that this boat has been anywhere near livable. General improvement in the condition of personnel and reduction of heat rash and skin disease was quite noticeable in contrast with previous patrols."

The first patrol of the ALBACORE (1942) was made in tropical waters with an injection temperature of from 80 to 85 degrees F., using air conditioning units to offset the heat and the humidity while on station, the ship was kept relatively cool and comfortable, the health of the crew being excellent with but 3 days lost to illness. "The following temperatures taken in September at about 1500 are indicative of the conditions on an all day dive. Minimum temperature, 86 degrees F. in the crew's quarters; the maximum temperature was 90 degrees F. in the after engine room, maneuvering room, and after torpedo rooms; the average temperature was 88 degrees. The relative humidity was 76 per cent; the battery temperature was 103 degrees." On the first patrol of the GATO, 1942, made in tropical waters, 29 consecutive days were spent submerged, averaging slightly less than 15 hours per day in sea waters of 81 degrees F. "The maximum temperature of the batteries reached 132 degrees. The maximum hydrogen content in the boat at the end of the dive, prior to surfacing was 0.6 per cent (average of about 0.3 per cent). Both air conditioning units were run continuously." The AMBERJACK, at the conclusion of her first patrol, 1942, reported that "air conditioning made the ship quite comfortable during the entire stay on station, even though the temperature of the sea was from 85 to 86 degrees F. and the battery temperature stayed around 122 degrees F. The fact that the air conditioning units were constantly in operation was believed to have prevented many colds."

Other boats (BARB 11, BLUEFISH 1, PINTADO 1, RASHER 1, SAURY 6) found that patrols, particularly if of brief duration, with extended surface running, fresh air and sunshine made for more normal living conditions when combined with adequate functioning air condition-

ing and ventilation and "that while inherently decreasing the amount of sleep obtained, increased the general well being of the crew, particularly when they could be rotated through the lookout watch." "On submerged patrol, surfacing for a few minutes at noon, as for a sun sight (DRUM 11) made the boat more comfortable during the day." The TAUTOG (No. 2) departed from the Truk area with personnel worn down by a strenuous patrol. "After leaving the area with a tranquil passage westward, the crew were considerably improved with rest and surface running. The patrol could have been continued for 10 days."

UNFAVORABLE COMMENTS CONCERNING STANDARD SYSTEM OF VENTILATION AND AIR CONDITIONING

In a rather large number of patrol reports unfavorable comments were found concerning the standard systems of air conditioning, ventilation and battery ventilation. For convenience and brevity these criticisms have been tabulated as follows:

Table 23

1. Combined inadequacy of air conditioning and ventilation systems		17
2. Criticism of standard hull ventilation design:		
(1) Unequal distribution of air between the forward and after compartments		53
(2) Inadequate output capacity of ventilation system		12
a. Insufficient capacity of supply blower	7	
b. Dissipation of air in long lengths of ventilation piping or torturous outlets	4	
c. Inadequate size of Main Induction Valve	1	
(3) Deficient exhaust system		7
a. Lack of exhaust outlets	6	
b. Incorrect specifications (impeller)	1	
(4) Inappropriate placement of various intake valves		8
(5) Lack of a satisfactory method of ventilating "inboard" while on the surface and necessity when submerged for circulation of air through section of piping external to hull		1
3. Criticism of air conditioning system:		
(1) Inadequate or poor distribution of cooling capacity		54
a. To forward battery and forward torpedo room	42	
b. To maneuvering room	6	
c. To conning tower	3	
d. To control room	1	
e. To radio shack	1	
f. To engine rooms	1	
(2) Materiel defects or malfunction of air conditioning system.		
4. Miscellaneous:		
(1) Poor design of torpedo room		1
(2) Inadequate insulation		2
(3) Lack of doors between crew's mess and sleeping quarters		1
(4) Insufficient number of bracket fans		1
(5) Excess heat from electrical and sound equipment.		
5. Criticism of batteries:		
(1) As cause for high levels of humidity and temperature		10
a. Excessive battery temperature	10	
(2) Criticism of ventilation system		5

COMBINED INADEQUACY OF AIR CONDITIONING AND VENTILATION SYSTEMS

In approximately 17 reports comments were made concerning the combined inadequacy of ventilation and air conditioning systems. The TAUTOG, at the end of her third patrol in 1942 reported habitability and personnel efficiency to have been lowered during tropical operations due to inadequate air conditioning capacity (insufficient cooling coil area) and poorly designed air distribution. "This situation has existed since commissioning and every effort by the ship's force to remedy it or have it remedied has met with failure." The SEAHORSE, in 1944,

at the end of her fifth patrol reported: "Ventilation forward is inadequate. This condition has existed to lesser degrees in previous patrols but reached aggrevating proportions this patrol because of higher battery temperatures involved. The forward battery has always had the highest temperature of any living compartment but several times this patrol sleeping was prevented because of excessive heat. Believe trouble lies in fact that the present blowers do not furnish a sufficient volume of air and that the capacity of the present air conditioning system is inadequate to cope with conditions encountered on a war patrol like the SEAHORSE just completed. The complete answer to the ventilation problem is redesigning of both the supply blower and the air conditioning system to provide a sufficient volume of air with a cooling capacity adequate to meet the most diverse conditions likely to be encountered." The commanding officer of the STICKLEBACK at the end of that ship's first patrol in 1945 reported: "Ventilation is inadequate in the forward torpedo room and in the forward battery compartment. Air conditioning is also inadequate in warm climates."

CRITICISM OF THE STANDARD HULL VENTILATION DESIGN

Unequal Distribution of Air.--Fifty-three reports described unequal distribution of air between the forward and after compartments of the ship. As illustration, the following reports are typical: HADDO (No. 4, Feb 1944) reported fair habitability: "a readjustment of the distribution of air between the forward and after parts of the ship should be undertaken." TUNA (No. 13) in March of 1945 reported fair habitability with the comment: "A rebalancing of the fresh air supply is considered necessary in order to meet the proportionate requirements in the living spaces." The PAMPANITO and the PIPEFISH in 1944 reported after their first patrols in the vicinity of Marcus Island, "the present ventilation system is not satisfactory. There is insufficient circulation of air in the forward battery and forward torpedo room--a fault in design." The PARCHE at the end of her first patrol in 1944 (Formosa) reported habitability to have been good. "The present arrangement of hull ventilation is unsatisfactory due to the unequal distribution of air forward and aft. During surface running the temperature of the forward battery can only be reduced to within 6 degrees of the outside temperature while at the same time both air conditioning plants are required to reduce humidity to a point compatible with comfort in warm weather."

INADEQUATE OUTPUT CAPACITY OF VENTILATION SYSTEM

As can be seen from the prepared table, the ventilation system was criticized for a number of faults beyond unequal distribution of air. The commanding officer of the ENTEMEDOR at the close of the war stated: "Ventilation system was deficient in capacity output. A larger supply blower or booster blower is recommended. The present supply blower operated in an overspeeded condition. Ventilation of fleet submarines has long been a sore point. With the addition of more and more electronic apparatus in the radio room, control room and conning tower nothing has been done about a change in the ventilation system. During trials of the ship it was found that the capacity output of the supply blower when taking a suction from the outside was deficient. Subsequent tests on sister ships showed the same problem. It is hoped that during the early days of peace a more correctly designed ventilation system will be forthcoming."

Reported the STURGEON at the end of her eleventh patrol: "Anticipating an alteration to the ship's ventilation system we kept the hull induction closed all the time on station and took a suction with the supply blower from the control room and conning tower hatches. This provided adequate ventilation in spite of the warm weather but habitability can be improved by providing larger louvres in the suction side of the blower and a more direct flow to the blower." The SNAPPER (No. 10) recommended a larger air conduit. BILLFISH (No. 1) considered defective ventilation forward of the control room due to a re-arrangement of the ventilation piping necessitated by the installation of the gun access trunk. REDFISH (No. 1) considered means for the egress and exhaustion of fresh air in the crew's quarters unsatisfactory.

FLYING FISH (No. 12) stated: "Ventilation in the forward battery is not adequate--although not an expert, I will hazard an opinion that the air supply is cut down tremendously by its long and hazardous passage through the individual bunk outlets. Request replacement of the standard circular louvres by short leads, one to each stateroom."

The commanding officer of the PIRANHA at the end of her first patrol observed: "The air conditioning unit installed in the forward battery in Pearl Harbor helped to improve habitability by lowering the temperature but the air is still bad. There is still an insufficient supply of air getting beyond the control room bulkhead--due to the crazy house circuit the supply line makes leading into the forward battery."

DEFICIENCIES OF THE EXHAUST SYSTEM

In a few reports, deficiencies of the ventilation exhaust system were described. The commanding officer of the CATFISH (No. 1) after a patrol in September of 1945 wrote: "Ventilation of this class of boat is below standard--the conning tower is exceptionally hot when submerged particularly so when the ST radar is used. There are no exhaust outlets--which are needed as all the hot air in the boat eventually finds its way to and remains in the conning tower. The ship's force overhauled the air conditioning unit in this compartment which aided some, but exhausts at the end are needed." The commanding officer of the CABRILLA (No. 1) in 1943 wrote: "Habitability not very good, every conceivable method of ventilation was tried but without satisfactory solution. Ventilation is particularly inadequate when patrolling at slow speeds on the surface. The exhaust system is believed to be the cause of the trouble."

The BLACKFISH (No. 11) after the installation of a new hull ventilation supply and exhaust blower impeller reported: "The volume of circulated air even in the forward torpedo room was twice as much as on the past five patrols. The old impellers installed with the boat may have had incorrect specifications."

The commanding officer of the REDFISH (No. 1) as noted, commented upon unsatisfactory sleeping conditions in the after battery compartment due in part to fault of exhaust of "bad air." The commanding officer of the SPRINGER (No. 1) in March of 1945 reported: "Ventilation in forward torpedo room is unsatisfactory and conducive to ill health; only two exhaust louvres are in this compartment, one in the officer's shower and one in the officer's head. A compartment which berths 16 men needs some positive exhaust." The PETO (No. 8) in April 1946 observed: "Ventilation is still inadequate in the forward torpedo room..another exhaust outlet besides the one in the officer's head would improve conditions."

The CROAKER (No. 5) in June of 1945 reported: "The ice cream machine heated up the crew's living spaces. An exhaust duct from the unit to the ship's exhaust ventilation line will solve the problem."

INAPPROPRIATE PLACEMENT OF VARIOUS INTAKE VALVES, ETC.

Several commanding officers considered various intake valves to be incorrectly located. The APOGON (No. 1) in 1943 stated: "When running on the surface at 3 or 4 engines full speed the ventilation system is robbed by the engines--so that insufficient circulation is obtained in the ends of the ship. As recommendation for future designs it is believed that better circulation would be obtained if the hull induction was led into some other compartment other than the engineering room." The commanding officer of the SNOOK (No. 5) stated: "With the present arrangement for hull ventilation, in rough seas, it is impossible to ventilate normally without shipping water into supply blower--." And the SPEARFISH (No. 12, January 1945) observed: "Believe habitability of ship would be improved if a method could be devised to draw sea water and spray from the ventilation system before it enters the system. In heavy weather the galley mess room and magazine were flooded constantly by spray or salt water entering through the ventilation supply valve. When this condition became intolerable and we had to run with this valve closed, air in the boat became relatively stale in short order."

The commanding officer of the SALMON (No. 8) made suggestions for proposed alterations to improve the hull ventilation system: "There are two main defects. The present ventilation system is basically unsound in that (1) there is no method of ventilating inboard while on the surface; and (2) the method of doing so while submerged necessitates circulation of air through a section of pipe outside of the hull--there is no advantage to this. The most objectionable feature of the present system, however, is found when on the surface in a rough sea. In order to run the system properly to ventilate the hull and batteries, it is necessary to run with various valves open--an open invitation to disaster and grounded electrical equipment if water is taken through the valve." Similar complaints have been made by HADDOCK (9 and 10), SEGUNDO (No. 2), GUARDFISH (No. 10).

The CACHALOT (No. 2) in 1942 in the cold damp climate of the Aleutians reported that "health of the crew dropped below standard, due, in part, to the necessity of keeping the main induction closed most of the time, thereby sending a stream of cold air through the main living quarters, engine room, control room, and conning tower." The SEALION (No. 4) after a patrol in the China Sea reported "recirculation of air through the after engine room induction when submerged helped greatly in keeping down the temperature."

CRITICISM OF THE AIR CONDITIONING SYSTEM

Inadequate or Poor Distribution of Cooling Capacity

About an equal number of reports indicated impaired habitability to have been mainly the result of inadequate air conditioning facilities. Most of these reported the cooling effects especially impaired in the forward battery and torpedo compartments.

BRILL (No. 1) in 1945 observed: "The after battery averaged 10 to 20 degrees cooler than the forward battery and torpedo room--an air conditioning unit for the forward part of the ship would be a welcomed addition." The PICUDA on her first and second patrols in 1944 reported air conditioning as inadequate in the forward battery and torpedo room where the temperature averaged between 95 to 110 degrees; "correction of this defect would do much to improve morale and health. Frequent long and hot all day dives--are accompanied by a natural deterioration of effectiveness." The BANG (No. 1) in 1944 reported uncomfortably high temperatures in these compartments on submerged days in warm water although both air conditioning plants were operated at full capacity. "The after battery, in contrast, was so cool that blankets were required." The POLLACK (No. 11) reported habitability as fair, "air conditioning not being adequate for patrols in warm water; compartments forward of control room not receiving sufficient cooling effect." The SNOOK in 1943 (No. 3) remarked that "air conditioning experts state a larger capacity plant is needed to improve cooling of the forward part of the ship." The ARCHER FISH (No. 2) observed that the effect of air conditioning appeared to be incorrectly distributed by the ventilation system to the forward battery compartment.

The commanding officer of the RAZORBACK (No. 1) observed that although habitability was good "air conditioning equipment is entirely inadequate. We seem to have gone backward in habitability on board these new boats." The MACABI, one of the newest of Manitowoc boats, reported at the end of her patrol in August 1945, the "usual inadequacies, particularly of the air conditioning equipment, were evident though partially modified by the inclusion of a booster blower in the forward battery." The ALBACORE in 1944 on her tenth patrol reported the forward battery very uncomfortable in hot weather and thought the installation of a cooling unit was particularly desirable for this compartment.

Inadequate Cooling of Maneuvering Room

The maneuvering room was reported next most frequently as being insufficiently cooled. The severe conditions of heat which may exist in this compartment have been well described by PLUNGER (No. 5) and PIKE (No. 7).

ASPRO (No. 1) and CROAKER (No. 1) in 1944 reported that this was the least comfortable compartment on the ship. The HADDOCK (No. 7 and 10) stated that excessive heat usually prevailed here "because the hull induction can not be judiciously opened, except when excellent sea conditions exist." Installation of an air conditioning unit was recommended to serve this compartment and the after torpedo room, the unit to be installed in the space commonly occupied by the maneuvering room head.

Inadequate Cooling of the Conning Tower

The NAUTILUS (No. 6 and 7) in 1943 reported air conditioning adequate except in the conning tower. The TAUTOG (No. 2) stated that, after her second near equatorial patrol during which the temperature in the ship during all day dive was excessive (with average temperature well over 92 degrees) "the conning tower was particularly bad. The high temperature and humidity together with inadequate ventilation reduced the efficiency of control party during long approaches." WHALE (No. 4, June 1943) requested an air conditioning unit for the conning tower in that "the efficiency of the control party during an approach is greatly handicapped by existing crowded and overheated conditions."

The THRESHER (No. 7) in March of 1943, the first boat to report upon the effects of an air conditioning unit placed in this compartment reported it to have "helped immeasurably", similar comments being made by the RASHER (No. 1), NAUTILUS (No. 8), and TAUTOG (No. 7). The APOGON (No. 1) in 1943 commented: "The air conditioning unit in the conning tower made it the coolest spot on the whole ship when submerged" despite injection temperature of 83 to 84 degrees F. The TROUT (No. 10) and TRITON (No. 5) commented on improved habitability in this compartment especially during submerged approaches and attacks not requiring silent running.

As noted above, the CATFISH at the end of the war in September 1945 after her first patrol reported: "The conning tower is exceptionally hot when submerged particularly so when the ST radar is used. There are no exhaust outlets from the conning tower. These are

needed as all the hot air in the boat eventually finds its way to the conning tower and remains there. The ship's force overhauled the air conditioning unit in the compartment; this aided some but exhausts at either end should be added."

Inadequate Cooling of Other Compartments

The MUSKALLUNGE (No. 1) recommended the installation of a small air conditioning unit in the radio room. The GRAMPUS (No. 2) in 1942, in reporting upon a tropical patrol stated that it was not possible to get compartments below an average temperature of 89 degrees F. The NAUTILUS (in February 1943) in reports on her fourth patrol stated that her two, six-ton air conditioning units were completely inadequate for a South Pacific patrol in calm hot weather. During the 37 days of submergence the average room temperature (at 1200 and 1600) was 94 degrees F. with 81 per cent humidity. The conning tower, maneuvering room, engine rooms and control room being particularly bad. "The entire engineer and electrical force and after torpedo room personnel, roughly half of the crew, lived in an average temperature of 96 degrees F." The PADDLE in July of 1944 (No. 4) after a tropical patrol reported the temperature inside of the boat generally to have been equal to that of the surface water.

The SKIPJACK (No. 3) stated that the temperature of the engine room spaces was always 105 to 115 degrees F. submerged. "An additional air conditioning unit for these compartments would greatly add to habitability." SPEARFISH (No. 4) reported habitability excellent except in the engine room. "These spaces especially are warm during prolonged dives after high speed running on the main engines or after end-around runs at high speed and diving for an attack." TULLIBEE (No. 3) suggested that the effectiveness of air conditioning plants could be improved "by the installation of a detached circular pump for the main engine to take away the heat from the engines after they stopped."

SNAPPER (No. 7) reported the "experimental main engine submerged cooling system rendered the remaining one-third of the vessel quite habitable by reducing the engine room temperature 15 to 20 degrees F. The strongest possible endorsement for the efficacy of the system is that every man in the engine room force is highly enthusiastic about the system and that body rash, formerly quite prevalent, has entirely disappeared." HADDO (No. 4) and DACE (No. 4) made similar favorable reports of cooling water circular pumps. BLUEFISH (No. 5) agreed and added that running the vapor compression stills while on the surface helped to keep the temperature down.

The PUFFER (No. 3) stated: "The two four-ton plants are just sufficient to take care of the ship in hot areas when functioning properly; a slight maladjustment or maloperating results in inefficient air conditioning with consequent lowering of the crew's efficiency; recommend two six-ton plants." GREENLING (No. 10) stated that the high injection temperature burdened the capacity of the air conditioning to the utmost although the boat was comfortable for the most part. ARCHER FISH (No. 7) in September 1945 after a Navy Yard overhaul and despite the presence of a booster battery in the control room, reported that habitability was still not satisfactory. The temperature recorded in a series of tests while in warm water (average injection of 84 degrees F.) were as follows: after battery, 90 degrees, control room, 93 degrees, forward battery, 90 degrees. SWORDFISH (No. 5) reported that the total capacity of her plant was insufficient for the operating conditions encountered and recommended installation of a ten-ton capacity unit in the unused after torpedo room shower.

MATÉRIEL DEFECTS OR MALFUNCTIONS OF AIR CONDITIONING SYSTEM

Matériel defects of the ventilation and air conditioning apparatus played highly significant roles in the production of impaired habitability.

Insufficient Supply of Freon Gas

Reference will be made later to the experience of the PORPOISE (No. 2) consequent to inability to obtain freon gas and failure of the air conditioning system (No. 3) due to leakage of freon on a tropical patrol in the South Pacific in December and March 1942. Several boats in the early days of the war experienced similar difficulties, the gas being unobtainable in quantities at ports (Java, Corregidor) where the submarines refitted (TARPON 3, SCULPIN 1, SAURY 2, SNAPPER 3, SUNFISH 1 and 3, TAMBOR 2 and 3, STINGRAY 3 and 4, SWORDFISH 2 and 5). The SEAL (No. 1) and SKIPJACK (No. 6) reported air conditioning as inadequate in forward areas due to loss of refrigerant with decided decrease in comfort. "The icebox refrigeration plant being inoperable, the after air conditioning plant was run on the icebox while surfaced and on the air conditioning when submerged."

Flooding

Flooding of the ventilation system not uncommonly resulted in impaired habitability. The HALIBUT (No. 3) and SNOOK (No. 5) after taking water down the hull induction reported that the blades of the supply blower impeller were stripped. TUNA (No. 1) reported a similar casualty resulting in grounding of the after battery for 1 1/2 hours with consequent contamination of the air with acid fumes. SEARAVEN (No. 13) in heavy weather once took 2 inches of water into the after battery compartment through the hull induction, wetting bunks and bedding. A similar casualty was reported by the SPEARFISH (No. 12).

ANGLER (No. 7) reported: "Backing up of condensate from air conditioning system into booster blower in control room resulted in the blower sometimes malfunctioning." BLACKFISH (No. 10) reported: "Habitability good until supply and later exhaust blowers were put out of commission by taking water down conning tower hatch and outboard induction. Ship's supply blower impeller was damaged beyond repair. From that time on the boat was very hot and uncomfortable at all times."

Both air conditioning compressors were put out of commission on the SEAL (No. 8) consequent to flooding of the conning tower. POMPON (No. 7) dove with the conning tower hatch open; before the lower hatch could be closed, the pump room was completely flooded, habitability being impaired thereafter.

In a depth charge attack two plugs in the main engine salt water pumps were blown out on the GUITARRO (No. 2) with flooding of the main engine air conditioning induction and ship's ventilation line. SEAHORSE (No. 7) and SPEARFISH (No. 11) reported habitability excellent until depth charges knocked out part of the air conditioning unit after which they malfunctioned.

Noisy Air Conditioning

Noise associated with the air conditioning units was sometimes cause of trouble. The PLUNGER (No. 5) in intensive and protracted contact with the enemy, experienced severe habitability impairment due, in part, to noisy air conditioning equipment which had to be secured while making an attack with consequent temperature of 130 degrees F. in the maneuvering room. The BARB (No. 1) once reported that although air conditioning kept the boat comfortable it made sound reception difficult, being secured when cruising below periscope depth.

MAINTENANCE OF AIR CONDITIONING UNITS

PUFFER (No. 3) reported habitability poor due to malfunction of air conditioning and lack of trained personnel to keep it running efficiently, with humidity and temperatures in the ship averaging about 89 degrees F. "Dirty coils, not accessible for cleaning while at sea, were in part responsible. The two four-ton plants were just sufficient to take care of the ship in hot weather when functioning properly--any slight maladjustment or maloperation results in inefficient air conditioning with consequent lowering of crew's efficiency." PADDLE (No. 3) reported that "although her air conditioning was operating incorrectly it could not be put out of commission for repair because of the high temperature and humidity."

COMMENTS CONCERNING IMPAIRED HABITABILITY AND MALFUNCTIONING AIR CONDITIONING

TRIGGER (No. 9) reported: "At no time did the air conditioning equipment function properly. Ship personnel never stopped working on the compressor. There were many cases of heat rash, health became progressively more poor." GRAYBACK (No. 5) and GUNNEL (No. 6) have further commented upon the relation between the prevalence of heat and skin rashes and poor and ineffective air conditioning. The SARGO (No. 2) carrying 24 passengers, reported that the forward part of the ship was very uncomfortable in that they had to use forward air conditioning unit for refrigeration. The temperature of the supply air of ventilation system ranged from 95 to 104 degrees F. during entire patrol--"almost all personnel berthed forward and personnel standing control room watch developed heat rashes; in some cases it covered the entire body."

SALMON (No. 2) stated: "Proper function of air conditioning can not be stressed too greatly. Throughout the patrol the boat was damp and moist and everyone perspired a great deal. Had several cases of heat rash and a few cases of mild heat prostration. The crew could not get the proper amount of sleep and night blindness was serious even among the best lookouts"--and again (No. 1) "the air conditioning system was out of order during the day submerged. At surfacing several men had headaches and there was noticeable fatigue among the crew." STINGRAY at the conclusion of her fifth patrol, December 1942, reported: "For the first time in the history of the boat both air conditioning units kept in operation."

Further reports of impaired habitability consequent to inefficient operation of the air conditioning or ventilation system may be found in the following patrol reports: DOLPHIN 4, GAR 4, HAKE 3, HARDER 5, HOE 5, PLUNGER 5, POGY 8, PORPOISE 2 and 3, SAURY 7, TUNNY 5, WAHOO 1, SHAD 9, ALBACORE 8.

EFFECT OF INADEQUATE AIR CONDITIONS ON ELECTRICAL GEAR

Inadequate or malfunctioning air conditioning has a direct influence upon the operation of man-made machines too--particularly the electronic and electrical gear. DOLPHIN (No. 1) having made a patrol without air conditioning reported that its lack adversely affected performance of electrical equipment. POLLACK (No. 6) observed that long periods of running silent with air conditioning plant secured put a great strain on engineers and electricians particularly—and that when air conditioning worked well electrical shorts due to moisture were almost entirely absent.

MISCELLANEOUS CRITICISMS

There were other miscellaneous criticisms of habitability with regard to ventilation and cooling features of submarines.

The BANG (No. 5) in February 1946, after making a patrol in the China Sea described habitability as poor, especially in the forward battery and forward torpedo room due to lack of booster blower, there being much condensate in the torpedo room. It was suggested that the after torpedo room be better insulated with additional cork on the overhead and insulation under the linoleum on the deck. TARPON (No. 12) in October 1944, after a tropical patrol reported that transfer of heat through ventilation supply pipes, nullified the effect of air conditioning in forward areas of the ship. "This condition exists as result of only a coating of cork paint because of insufficient space for proper lagging."

KINGFISH (No. 9) reported that installation of a door at the forward end of the crew's living quarters, thus isolating it from the galley, improved the cooling and habitability of this space for sleeping. SEA WOLF (No. 13) recommended that additional bracket fans be placed in the after battery compartment.

As the war progressed, more and more electronic apparatus (particularly in the radio, radar, and sonar fields) was added to the radio rooms, the control room and the conning tower "with (ENTEMEDOR) nothing of a concrete nature being done about a change in the ventilation system" to compensate for the increased heat. CATFISH (No. 1) commented upon the especially hot condition in the conning tower particularly when submerged and using the ST radar. TILEFISH (No. 6) reported that continual use of the SV and the new hydraulic plant caused a considerable increase in the control room temperature. SKIPJACK (No. 3) reported: "There is so much heat given off by the electrical gear that when submerged, once the air conditioning plant is shut down, temperature and humidity jump at once making living conditions very trying." BARBERO (No. 2) reported the sound equipment had a tendency to heat the forward torpedo room when submerged.

Other factors adding to the strain imposed on the ventilation and air conditioning systems include: prolonged unfavorable conditions of the sea, high injection temperature of the water, prolonged period of submerged operations "as in Northern waters, with long hours of daylight" or forced submergence by the enemy with frequent necessity for "running silent," overcrowding, etc. Several of these factors will be discussed later.

Excessive Heat and Humidity Associated with Batteries

Discomfort consequent to heat and humidity evolved by charging batteries was not infrequently mentioned.

POGY (No. 7), CAVALLA (No. 5), HARDER (No. 5), and THORNBACK (No. 1) reported impaired habitability due in part to high battery temperatures especially on all day dives. SEAHORSE (No. 5) in 1944 reported that the most uncomfortable conditions existed while charging the batteries on the surface with the four engines running. RATON (No. 5) reported the forward battery compartment uncomfortably warm during battery charges.

SHAD (No. 9) in March of 1945 observed: "As never before, the battery charging requirements of these days resulted in battery temperature maintained at close to the maximum allowable temperature of 130 degrees F., with a consequent heavy demand on the one operating air conditioning unit." WHALE (No. 8) reported a fairly high temperature throughout the boat on a few days succeeding equalizing charges. BLACKFISH (No. 10) reported excessive humidity associated with the charging of batteries. SANDLANCE (No. 2) reported: "Heat in the forward area from the batteries was stifling. Stepping into this compartment from other adjacent ones was equal to being slapped in the face with a wet steaming towel."

Criticism of Battery Ventilation Systems

The ARGONAUT (No. 2), 1942, while taking Marines to Makin Island experienced poor habitability: "A contributing factor to which was the fact that when ventilating inboard, battery ventilation exhausts into the control room." TUNA (No. 1) reported that in rough weather with outboard battery and hull ventilation valves closed battery ventilation was at fault. "The only way in which ventilation could be accomplished was by circulation of the air through the ship, contaminating the boat with acid fumes." Possible correlation of prevalent headaches to charging of the battery was made by the GUARDFISH.

POLLACK (No. 7) in 1943 reported habitability fair, with high temperatures and poor ventilation when submerged. "A new battery charging order which required longer times in the finishing rate kept the batteries very hot and the boat uncomfortably warm during all day dives. The arrangement of hull ventilation is such that the exhaust blower discharges into the after battery compartment. Since the battery ventilation goes into the exhaust ventilation, too, this makes the forward battery uncomfortably warm. The recirculation line is outside the hull and is not equipped with a quick closing hull stop and is, therefore, considered unsafe to use as a matter of general practice." SHAD (No. 6) commented: "Improvement of ventilation in the forward battery during the last half of the battery charge is needed. Warm battery gases back up in the exhaust system making the forward battery air quite bad."

PARGO (No. 9) had this comment to make concerning the present battery ventilation system: "The four ventilation blowers from the two batteries discharge into the forward hull ventilation exhaust line. During a battery charge, while on the finishing rate, because of the high voltage, the hull ventilation blowers must be placed in series and in order to keep the hydrogen content below 2.5 per cent the battery blower must be kept operating at full speed. It is necessary to secure the air conditioning plant. This results in the battery blower exhausting more air than is taken in by the forward hull ventilation blower. Thus the battery exhaust gases back up through the hull ventilation line into the forward battery and torpedo room, creating a very intolerable if not dangerous situation. Alteration of battery ventilation is required so that the after battery blower discharges into the after hull ventilation exhaust line." On the following patrol (No. 10) she reported further trouble in obtaining adequate ventilation when batteries were charged with exhaust blower rotating in reverse direction.

The SKIPJACK (No. 1) reported the boat as being hot during dives and battery gases in forward compartment very noticeable while charging due to exhaust blower failure on third day of patrol.

CURRENT METHODS OF IMPROVEMENT OF VENTILATION AND AIR CONDITIONING

Auxiliary Ventilation and Air Conditioning Installations.--Mention has been made of improved habitability consequent to installing an individual air conditioning unit in the conning tower. Brief reference has been made also to the one-ton air conditioning unit and booster blower placed in the ventilation supply main in the control room or forward battery compartment. Through the course of the war, some 49 boats in 62 patrols in patrol reports requested these facilities. The number of such installations placed aboard fleet-type submarines is unknown. Some 50 reports from 46 boats reported habitability improved by the additional air conditioning unit and/or the booster blower. Ten of these ships (12 reports) are known to have had both facilities. Sixteen boats (17 reports) specifically mention the additional air conditioning unit. Sixteen boats (16 reports) specified having the booster blower.

Typical comments concerning the effectiveness of these installations are as follows: "The booster blower and the cooling coil in the control room have solved the problem of cooling the forward part of the boat nicely." (BLACKFISH 12). "Habitability forward greatly improved by the installation of the booster blower and cooling unit during the refit" (ASPRO No. 6). "Habitability excellent--the air conditioning unit in the supply line in the control room effected a tremendous improvement in temperature and humidity of forward part of the ship" (BANG No. 2). "Installation of the air conditioning unit in the forward battery payed huge dividends" (QUEENFISH No. 1). "For the first time since the boat was commissioned the forward battery and torpedo room were comfortable due partly to the low temperature of the operating area but some credit is due to the booster blower" (PETO No. 7). "Habitability excellent except during the periods of running silent; addition of the booster blower, in Pearl Harbor, improved the living conditions forward by 100 per cent" (BLENNY No. 1). "With the installation of a booster blower and the air conditioning unit, habitability was better this patrol than any other time and ventilation in all compartments is considered adequate. In the latter part of the patrol one air conditioning unit was secured because of the low outside temperature" (WHALE No. 10). "Long awaited auxiliary blower in forward torpedo room supply duct added much comfort" (PIRANHA No. 5). "Habitability very good. Installation of booster blower and auxiliary air conditioning unit coil in control room very effective in helping out the forward battery. After 5 patrols in tropical water it is quite an experience to be cool all the time, both surfaced and submerged" (PUFFER No. 6).

ADVERSE CRITICISMS OF AUXILIARY VENTILATION AND COOLING INSTALLATIONS

A total of 21 reports made by 19 ships turned in adverse criticism of these auxiliary ventilation and cooling features.

BATFISH (No. 4) in a previous refit had had ventilation augmented by the addition of a booster blower and air conditioning unit in the control room. "This arrangement served the purpose very well but had the drawback of robbing Peter to pay Paul. The blower, a 500 cfm impeller type, partially cut down the ventilation in the crew's mess, magazine, and radio shack and took all the air intended for the conning tower and pump room. In addition it is prohibitively noisy and it is believed that both situations would be improved if the blower were replaced by a smaller one of 200 cfm". LAMPREY (No. 1) and GABILAN (No. 2) commented upon the "disadvantage of the noise made by the high speed blower in the control room and the additional load on the IC motor generated by the surge of the air conditioner blower." BANG (No. 2) noted: "In future installations it is believed that a variable speed motor for the fan in the after air conditioning unit would be more desirable than the constant speed air conditioner motor by reason of greater flexibility thereby afforded the system." PARCHE (No. 2) observed that "despite the presence of the cooling unit and booster blower in control room, in water with an injection temperature of 85 degrees F. the temperature still averaged 90 degrees throughout the boat."

In a number of instances installation of a booster blower alone in the main supply line in the control room was reported to be insufficient. "The booster blower aided in keeping the forward battery cool; however, that compartment became warm and uncomfortable during charges; believe air conditioning unit should be installed in forward battery to remedy the situation." "It would be still better if a small freon unit were installed in the supply line" (PAMPANITO 3, POGY 7 and 8, CHUB 1, SEALION 3, MACABI 1). "Booster blower installed in control room to force air forward is not satisfactory alone. It is uncomfortably warm in both battery compartments causing loss of sleep and numerous cases of prickly heat. Several tests taken in warm water were as follows: after battery 90 degrees, control room 93 degrees, forward battery 90 degrees, in average injection of 84 degrees F." (ARCHER FISH No. 7). On one occasion aboard the ANGLER (No. 8) condensate from the air conditioning system backed up into booster blower in the control room; "since then blower occasionally fails to start."

Similarly, installation of an auxiliary air conditioning unit without benefit of a booster blower was sometimes reported insufficient. "Habitability good. Recommend booster blower in ventilation line; recently installed coils in control room have not added much to comfort of the ship. Forward torpedo room is especially hot, as it has always been in tropical waters. Suggest a second air conditioning unit installed in each individual compartment" (RAY 6 and 8).

SHAD (No. 8) reported that despite the presence of standard air conditioning unit and ventilation, plus an auxiliary air conditioning unit and a booster blower in control room, "habitability in forward battery is still not satisfactory." PETO (No. 8), PUFFER (No. 8): "The auxiliary air conditioning unit put in the forward battery helped improve the habitability by lowering the temperature but the air is still bad--there is still insufficient air getting beyond the control room bulkhead. Installation of a booster blower is requested." PIRANHA (No. 1): "Addition of a small conning tower type air conditioning unit in forward battery improved the habitability of the compartment but sleeping quarters in after battery are still decidedly unsatisfactory." "Temporary air conditioning in the forward battery has improved conditions a great deal but forward torpedo room is still too warm for comfort on all day dives" (REDFISH No. 1).

MISCELLANEOUS

We have already observed in passing, some of the practices commonly followed aboard submarines to improve the ventilation and habitability, as "taking a suction by leaving the air lock and watertight doors open, closing the starboard supply damper in after battery and taking a partial suction through the conning tower hatch."

A survey of available methods of ventilation and air conditioning was carried out and recommendations made available to Submarine Force. These, in part, recommended facilities for dissipation of heat from the ship to cooler sea water by selective use of fuel oil and emptying of the tanks. Thus the tank outboard the forward torpedo room was used early in order to have sea water which has a higher heat conductivity constant than oil next to pressure hull. In addition, fuel oil tanks were rigged to main ballast tanks as soon as fuel was used in order that a considerable amount of heat be taken from pressure hull, on diving, by water filling the tanks.

An outline of the operation of air conditioning for improvement of habitability (ComSub Pac ltr Serial 1045, 30 May 1945) was followed by CREVALLE (No. 4) with "resulting improvement of habitability and conspicuous lack of heat rashes, boils, and other minor disturbances, although the forward battery compartment and forward torpedo room remained

uncomfortably warm." FLOUNDER (No. 3) reported improved habitability and lowered battery temperatures consequent to an extensive study of the capabilities of the air conditioning system--"the air being kept drier and cooler by ventilating the engine room through the main induction piping and operating the blower at half rheostat."

PUFFER (No. 5) reported improved habitability consequent to following recommendations contained in BuShips Bulletin of Information, No. 14, of April 1944 on the "Proper Operation of Submarine Air Conditioning Unit." "Though it did not eliminate need for additional cooling coils in forward battery compartment."

PLAICE (No. 6) reported: "It soon became apparent after the start of the patrol that the air conditioning system could not handle the entire boat. Instructions for operating air conditioning in tropical climates were followed. A constant watch was required to see that the supply outlet in the control room and conning tower was kept closed while on the surface, with resultant satisfactory improvement of the habitability of the rest of the boat though the control room was hot." "Intense heat generated in the conning tower at night by the SJ radar prompted us to open the supply blower there and this bettered conditions. Sleeping conditions in the forward battery and torpedo room were good. As ammunition was stored in the forward torpedo room, no smoking in this compartment helped conditions as much as anything." LAPON (No. 4) reported improvement of maldistribution of air known to exist in the forward and after parts of the boat by a ventilation splitter (Mare Island modification). "Habitability having remained just fair, the forward battery continues to be worse offender." PAMPANITO (No. 2) reported improved habitability due in part while operating in cold water, to blocking off some outlets in the after part of the ship.

EFFECT OF LACK OF OR MALFUNCTIONING OF AIR CONDITIONING AND VENTILATION ON THE HABITABILITY OF A SUBMARINE AND THE EFFICIENCY OF PERSONNEL

Without air conditioning and adequate ventilation, whatever the cause, the habitability of a submarine on an active war patrol may become so poor that through materiel defects and/or lack of personnel endurance and efficiency, the safety of the submarine and ability to carry out her mission may be seriously compromised.

HABITABILITY WITH MALFUNCTIONING OR INEFFICIENT AIR COOLING AND VENTILATION

NAUTILUS (No. 2, 4).--Much has already been said concerning conditions reported by NAUTILUS on her various patrols, particularly with reference to excessive accumulation of carbon dioxide and depletion of oxygen on long dives. On her second patrol, made with 186 people aboard, the commanding officer reported: "Spot air conditioning units were installed in the torpedo room (which gained about 800 per cent in personnel) forward to offset the effects on temperature and humidity of increased personnel and the warm sea water. These units were inadequate. Temperatures in the living spaces were 93 degrees F. with relative humidity of 85 per cent on the hottest days. For longer trips more air conditioning would be imperative." "As usual personnel endurance is a difficult item to estimate. The men seemed more tired after this operation than at any time during the first patrol. This was caused by lack of sleep and extreme heat of all day dives. Prickly heat was much in evidence and with more diving it might have become serious."

On her fourth patrol this ship recovered 29 people from Bougainville. "Air conditioning installations proved inadequate, failing to keep the temperature or humidity at reasonable figures on any day while in the operations area. The highest temperature and humidity level recorded was 124 degrees F. and 98 per cent during an invasion period lasting for about 13 hours during which practically all hands just about passed out from extreme heat." The average room temperature during the 30 days spent submerged was 94 degrees F. with average humidity of 81 per cent roughly half of the crew lived in an average temperature of 96 degrees F. "Excessive heat and humidity reduced the efficiency of all hands to a marked degree after about 2 weeks of operation." "On one occasion the ship might have surfaced and destroyed a freighter with her deck guns--the fact that this was the 34th day in the patrol area and that the previous day and evening had been abnormally active, and fatigue undoubtedly had some bearing on the commanding officer's decision not to do so." "Personnel endurance was a minimum quantity at the termination of the patrol though operation orders ended it."

PLUNGER (No. 5).--The PLUNGER's fifth patrol made in the Makin Island area from 16 Feb to 27 Mar 1943, was made especially arduous by noisy air conditioning. "The crew, during the afternoon and night of 27 February, had been at battle stations in a successful attack against the enemy. Shortly after midnight on 28 Feb (at 0018) PLUNGER at full speed, dove on four engines, the ship being as hot as a fireroom that has been secured. Noisy air conditioning equipment was shut down as we went in across the bow of the escort. Temperature in the maneuvering room was 130 degrees F. and the engine rooms were about the same."

"At 0155 men in these two compartments were near prostration from the heat; one man was already receiving treatment. The men on the wheels and planes were being rotated every 5-10 minutes by which time they were totally exhausted. Men had never before been seen to sweat so profusely. There was cheerful chatter by the men on station about how much Tojo had to pay for his high grade of depth charging but response was slow and acuity dull. Errors were prevalent. It was evident that the ship no longer was in condition to fight or defend itself." "At 0235 the executive officer and the engineering officer advised me to surface before dawn to rehabilitate the ship and crew if at all possible."

SHAD (No. 7), GUNNEL (No. 6), TAMBOR (No. 2, 3, 4, 5, 6).--The commanding officer of the SHAD (No. 7) reported: "Being submerged about 14 1/2 hours daily for 30 continuous days gave the vessel a severe test of habitability and generally it was found not wanting. In this regard it should be noted that without air conditioning (forward and after units plus additional units in the conning tower and forward battery) and operating in a sea temperature of 85 degrees F. or more the patrol would have been utterly impossible both from a materiel and personnel view."

These opinions have been borne out time and again as the following excerpts illustrate: The sixth patrol of the GUNNEL, made in July and September of 1944, of 55 days duration (30 submerged) was made in the Luzon area. Immediately upon encountering warm water and weather, it was found that the forward air conditioning unit was not functioning properly. The air after leaving the coils was found to be only a few degrees different than the supply air from the engine room which was around 100 degrees. By making adjustments the temperature of the air, after it crossed the coils, was finally reduced to 84 degrees F. but it was not constant. The boat, from the engine room forward, was most uncomfortable. "Habitability was very poor and the lack of conditioning was keenly felt because the area assigned required 30 days of submerged running. The health of the crew, in general, was excellent; the only trouble experienced was that of the prevalence of heat rash, a total of 20 bad cases developing. In addition, there were 4 mild cases of cellulitis. There were no sick days." "One does not realize the blessing in disguise afforded by air conditioning until a patrol is made without it in these waters. It takes a lot out of a person to spend day after day gasping for breath and dripping with sweat."

The TAMBOR's second patrol of 59 days duration was made in the region of the Marshall Islands. "Due to faulty air conditioning units (leaks in refrigeration piping) the boat was oppressively hot and humid and there was a strong tendency for electrical grounds and short circuits to develop and for the finely adjusted contraptions and mechanism to become inoperative through corrosion. After two weeks of all day submergence all the bunks were wet and sticky. Clothing in the lockers in the forward and after torpedo rooms was green with mildew; practically everyone had a heat rash. There were two cases of heat exhaustion. The third patrol of 57 days duration was made in the Truk area. Trouble continued to be had in maintaining the tightness of the piping of the air conditioning and the reserve supply of Freon had been expended on reaching the area." "Temperatures well over 100 degrees F. with high humidity levels made it practically impossible to get any rest while submerged. Even at night with charging of the batteries the crew had prickly heat. Some cases covered the entire body. Thirty per cent of the crew developed some type of fungus infection. In order to obtain sleep the men and some of the officers resorted to sleeping in the torpedo room bilge, where it was not quite so hot; it being impossible to use either battery compartment for sleeping quarters. Lack of air conditioning decidedly had a debilitating effect on the crew and slowed their reactions." The fourth and fifth patrols were made with similar impaired habitability due to defective air conditioning. On the sixth patrol the commanding officer reported: "At last we have found out that submerged time need not be a taste of hell--this is the first patrol this boat has been anywhere near livable. General improvement in the condition of personnel and reduction of heat rash and skin diseases was quite noticeable in comparison with previous patrols."

SALMON (No. 1, 2), TRITON (No. 2), SKIPJACK (No. 6), PADDLE (No. 3), TAUTOG (No. 2), WHALE (No. 4), SEAL (No. 2, 3), PERMIT (No. 3).--The SALMON on her first patrol observed on one occasion: "Surfaced; air conditioning out of order during this day submerged. At the time of surfacing several men had headaches and there was noticeable fatigue among the crew. It is obvious that the resistance of all hands has been considerably reduced during the patrol." On the second patrol (31 days duration in the Philippine area) it was observed: "Proper functioning of the air conditioning can not be stressed too greatly. Throughout the patrol the boat was damp and moist. Everyone perspired a great deal; several bad cases of heat rash and a few cases of mild heat prostration occurred. The crew could not get the proper sleep and night blindness was serious even amongst the best lookouts."

The second patrol of the TRITON (42 days duration, off Wake Island) was made with good habitability until the air conditioning shut down "when the situation became very uncomfortable in the conning tower while submerged. This, the vital center of the ship, was the

most uncomfortable place in the ship. Ventilation was entirely inadequate and the large number of electrical devices and indicator lamps installed there were a constant source of heat."

On the sixth patrol of the SKIPJACK (April 1943 off Wake Island) frequent breakdown of the air conditioning resulted in impaired habitability, with two cases of heat prostration occurring in men in the pump room, and the loss of 3,200 pounds of meat. PADDLE (No. 3) spent 34 out of 53 days submerged. On this patrol air conditioning apparatus was not operating correctly and couldn't be put out of commission for repair because of the high temperatures and humidity. "During a period of silent running lasting for 6 1/2 hours the boat became unbearably hot; several men were incapacitated for duty by heat prostration and were under the care of the pharmacist's mate."

The TAUTOG, on her second patrol, reported that the temperature in the ship during all day dives near the equator was excessive and averaged well over 92 degrees F. with a humidity of 70 per cent. "The high temperature and humidity in the conning tower together with inadequate ventilation reduced the efficiency of the fire control party during long approaches. There was much serious discomfort and loss of sleep and over 90 per cent of the crew had prickly heat. When ventilation and air conditioning was shut down even for short periods during silent running these conditions rapidly reached an intolerable state. During two days on which air conditioning was out of commission, rapid debilitating effects of high temperature and humidity were felt by all hands. There were 2 cases of heat prostration." "It is evident that in event of complete failure of air conditioning plant in the tropics the factor of personnel endurance would terminate a patrol." "At the time of departure from the Truk area personnel were worn down from the strenuous patrol and enervating effects of high temperature and humidity during submerged periods. After tranquil passage to the westward, the patrol could have been continued for 10 days." A similar condition of affairs existed on her third patrol.

WHALE (No. 4) reported concerning conditions in the conning tower: "The efficiency of the control party during an approach is greatly hampered by crowding and the overheated conditions which exist there." The SEAL on her second and third patrols had these observations to make concerning the effects of impaired habitability subsequent to impaired air conditioning: "Without air conditioning each man has to get more tired to get to sleep in the humid air and in his wet bunk. This results in generally lowering the efficiency of the individual." On the third patrol of the PERMIT it was reported that 90 per cent of the officers and crew had prickly heat and 68 per cent "Guam blisters," 20 per cent had boils and 12 had fungus infections of the ears. Air conditioning, it is presumed, was poor.

HABITABILITY WITHOUT AIR CONDITIONING

DOLPHIN (No. 1, 2).--As noted in the early days of the war a few fleet-type submarines and several of the S-boats were without air conditioning units. A stark picture of habitability on war patrols is depicted in these reports, as the following graphic details well illustrate. The DOLPHIN's first patrol, beginning on 7 December 1941, carried out in the Truk area and extending over a 47 day period, was made without air conditioning. Thirty consecutive all day dives were made, a total of 405 hours being spent submerged (13.5 days). "In the first week of diving almost every man broke out in a heat rash causing great discomfort. This began to disappear at the end of the second week with only one severe case left. The human body had finally adapted itself to the existing conditions. The average temperature was 97 degrees F., the relative humidity was 98 per cent. There were few headaches. Due to the high temperatures and humidity of the boat during dives an abnormal amount of water was drunk. The men were not able to bathe or do their laundry for over a month and after working for several hours in a hot compartment, merely wiped off the sweat and laid down in their hot damp bunks. Though the boat was ventilated at night, when weather permitted, a tendency was observed for the clothing, bunks, mattresses, and even portions of the overhead to become moldy. Due to the excessive perspiration and mold, practically all of the mattresses are unfit for further use. The lack of air conditioning affected the performance of the electrical equipment." Habitability on the second patrol was reported as greatly improved by the addition of air conditioning.

PORPOISE (No. 2, 3, 5).--The PORPOISE began her second patrol (9 Feb to 30 Mar 1942) unable to obtain a supply of Freon gas for the refrigeration and air conditioning plants. The latter were not available for use at all and the former lasted only 10 days. 604.3 hours (25.1 days) were spent submerged. Six days before the patrol was terminated she encountered a cyclone. Habitability was very poor. "Without air conditioning the ship became extremely hot--much worse than an S-boat. About 10 days of fresh provisions had to be jettisoned due to inability to keep them from spoiling and the diet for the last 40 days of the cruise was correspondingly curtailed both in quantity and nutrition value." On 10 March--"the ship's company show the effects of fatigue and heat to a marked degree; reactions are slow, tempers short and nerves on edge. There are all types of skin diseases; general health is poor."

On 13 March: "submerged at 0445; surfaced at 2035, having received 12 depth charges--heat on the dive was almost unbearable, the majority of the crew having severe headaches. Pressure in the boat was 6 inches of Hg on surfacing." On March 19: "Due to extreme physical exhaustion of the crew and the physical and nervous exhaustion of myself, together with the approaching exhaustion of provision, I decided to start south by the shortest route possible--the patrol had to be abandoned because of the utter exhaustion of all hands at the end of 38 days." On the third patrol of this ship the air conditioning failed after 3 days of use. On the fifth patrol the commanding officer reported: "First patrol in tropical waters since installation of air conditioning unit made the ship comfortable and contributed greatly to cleanliness, stopped all rash and prickly heat (submerged for 446 hours - 18 days)."

S-42 (No. 1), S-35 (No. 7, 8), S-47 (No. 1), S-43 (No. 1, 2), S-45 (No. 5), S-21 (No. 1), S-40 (No. 7).--The S-42 on her first patrol, from 26 April to 20 May 1942, underwent an equally trying experience. On this patrol 90 per cent of the crew never saw the topside, the submarine being submerged an average of 13 hours a day. On 11 May a 12,050 Japanese cruiser was sighted at 0439; submerging at 0441, torpedoes were fired at 0450, the ship being hit. From 0516 until 1130 (6 hours and 24 minutes) the ship was rigged for silent running; she surfaced at 1830 (14 1/2 hours). In the severe counter measures, carried out by two participating destroyers very near and ready to hear the propellers of the submarine, the first one was entirely unexpected. "For the first two hours we were in a mighty tough spot." Extreme discomfort was suffered from the accumulated heat and humidity. "All hands stripped down to shorts and the men took off their shoes and socks. Everyone drank a great deal of water; salt pills and aspirins were used; there were many headaches and some earaches. During silent running the pressure built up very rapidly within the boat--by 0730 the barometer needle had stuck at 10." The predicament of the ship was "a fact fully recognized by the older and more experienced men. As the youngsters folded up, the others took over. The most startling effect was the apathy engendered by the combination of heat, pressure, physical effort and mental stress. Some without permission, others after requesting relief, would seek the closest clear space on the deck, lie down, and fall asleep. Most stations ended up with two men taking turns, relieving one another when necessary, and the off-watch one resting on the deck beside his station." "Throughout this experience new for all of us behavior, with one exception, was excellent. This one man got hysterical and had to be held down by another. Another man threw a fit but this simply was a case of heat exhaustion after too long a track at the wheel. He was revived by a shot of whiskey and after 30 minutes was sufficiently recovered to offer to go back on watch." On surfacing the conning tower was flooded to about 4 inches. There was 5 feet of water in the control room bilges. Four air banks were empty. "All hands were completely whipped down physically and mentally." On 11 May--"Headed for base--all hands completely beaten down." 12 May--"all hands still tuckered out." On the 15th of May--"An inexperienced sound man picked up a noise which he could not identify. Because of our inability to control the ship when changing depths and the mental and physical conditions of all the officers and crew, decided to evade if possible. Rigged for depth charging, silenced the ship and balanced as closely as possible at 120 feet. One man in the after battery was hysterical and was being held down by force." "It was not until the first day of surface cruising, on the 17th, that spirits began to revive and not until then that I considered either myself or the crew capable or competent to go into action again."

Several other S-boats made patrols without air conditioning. The S-38 on her eighth patrol in the Gilbert Island area in September and October of 1942, reported: "In all day dives humidity approached that of a tank full of saturated steam--this condition will no doubt be partially relieved upon installation of air conditioning. Habitability was bad but we can take it." On the seventh patrol of the S-38 the commanding officer stated: "Little remains to be added to what has already been said about the habitability of an 'S' class submarine not fitted with air conditioning and operating submerged in the tropics except to remark that should we be so unfortunate to lose the ship and escape to an uninhabited island the natives would not find it necessary to cook us before eating since the constant parboiling to which we have been subjected should have us reasonably tender." The S-47's first patrol, 30 days duration, 19 of which were submerged (an average of 13.8 hours), was made in April and May of 1942 in the Rabaul area without air conditioning. "Habitability was poor on long dives, temperature of the boat was usually 96 degrees F. with relative humidity of 100 per cent. Except when in contact with the enemy, air circulated through the high induction and battery ventilation in the engine room provided an appreciable decrease in discomfort. Keeping the pressure below 2 inches by use of the air compressors was also a help. There were many cases of heat rash, worst in men whose bunks were not in an air stream from the blower or fans. Everything became mildewed and musty, particularly leather articles as shoes, books, clothing, leatherette bunk covers. Steelwork throughout the boat rusted. Mattresses became soaked with perspiration bunks being uncomfortable, most of the crew preferred the torpedo room deck. Salt tablets were very useful but the small supply was quickly exhausted. Salt solution was not too pleasant to drink. There was an increase in its use after one man collapsed from heat exhaustion. Considerable amounts of food had to be surveyed because of spoilage."

The S-43 on her second patrol in July and August of 1942 in the New Ireland area, after 20 days of patrolling, reported that "the high temperature and humidity in the ship was not conducive to good appetites. Personnel were exhausted due to high temperatures and humidity on all day dives." It is presumed the ship was not equipped with air conditioning.

On the fifth patrol of the S-45, made in the Solomons Islands area, habitability was reported as very poor "due to the high humidity. The average boat temperature was 96 degrees F. with approximately 96 per cent relative humidity. The use of silica gel was tried but no results were obtained. The lack of air conditioning was keenly felt."

S-21 made her first patrol of 17 days duration in December and January of 1942 off Panama without air conditioning. "The auxiliary induction was left open while on patrol so that the forward battery would have ample change of air. Health was good; there were some cases of prickly heat; salt tablets were kept near the scuttlebutts and all hands utilized them." The S-40 (No. 7) in October and November of 1942 made a 31 day patrol, eight of which were spent submerged, patrolling in the Makin area without air conditioning. Habitability was reported as poor when submerged. Similar reports were made by the S-43 (No. 1).

By way of contrast to these tropical and temperate patrols made by S-boats without air conditioning the comments of the S-46 (No. 3) are reported. This patrol of 31 days duration, 19 of which were submerged, was made in September and October of 1942 in the Solomons Islands area: "Air conditioning improved habitability immensely. Personnel were able to sleep submerged with comfort and able to do their jobs efficiently the entire patrol which was not possible before. After ten all day dives on previous patrols I estimate the efficiency of personnel to have been reduced 25 per cent with a further reduction as the patrol progressed."

SILENT RUNNING AND CONDITIONS OF HABITABILITY

The great necessity and value of adequate ventilation and cooling systems is perhaps best illustrated by the conditions encountered when, to elude enemy anti-submarine measures, the submarine is "running silent," all devices for recirculating and cooling the air being secured. The effects on personnel can not be measured in terms of any one deleterious factor; indeed, the combination and accumulative effects of several factors must be borne in mind in evaluating the conditions of personnel to be described--excessive heat, high percentages of humidity, excessive accumulation of carbon dioxide and depletion of the air of oxygen, the effects of accumulated pressure within the ship, conditions of excessive fatigue prolonged, it would seem, beyond endurance by constant materiel casualties, and the psychological effect of the enemy above with his traumatizing weapons. The only patrol report discovered in which habitability during silent running was good was made by the QUEENFISH (No. 2).

LAPON (No. 6), PLUNGER (No. 5), SPEARFISH (No. 8), CUTTLEFISH (No. 3).--Detailed attention has already been given to the conditions encountered by the officers and men on the LAPON (No. 6), especially with reference to the effects of excessive fatigue and toxic accumulations of carbon dioxide which resulted in incapacitation of the majority of her crew after 17 hours of constant contact with the enemy. LAPON, in consequence, was unable to follow up a military advantage which she, under more normal circumstances, would have, undoubtedly, handled with her characteristic dispatch. We have taken up in detail too the discomfort and disabling and crippling effects suffered by the PLUNGER (No. 5) when her noisy air conditioning had to be secured and she was forced, in consequence of extreme heat, etc., to break off an enemy engagement.

The following additional excerpts further emphasize, the military value of air conditioning. The SPEARFISH on her eighth patrol encountered severe enemy anti-submarine measures: "Surfaced at battle stations with all tubes ready. We had been submerged for 22 hours. He was not in sight in the moonlight. The battery was about flat. The very foul air, in spite of oxygen replenishment, had visibly affected all hands. Neither the ship nor the personnel were ready to search for and attack the escorted damaged freighter, so we decided to chase the convoy to the south. Will give us about 18 hours to recover our breath--." CUTTLEFISH (No. 3) reported: "The oppressive heat and humidity during silent running would be a serious factor in prolonged depth charge attacks." Enervation is so extreme "that any physical exertion is exhausting. The exertion required to maintain depth control and particularly to change depth with the planes in hand power and using slow speed, when combined with excessive heat and humidity exhausted a planesman in 15 minutes. Our best bow planesman suffered a strained groin on the plane during a depth charge attack and had to be permanently relieved for the duration of the attack." "It is hoped that our silencing program will soon reach the point where refrigerated air conditioning and power control of planes can be operated in silent running."

BLACKFISH (No. 6), PIKE (No. 8), POLLACK (No. 6), RAY (No. 1), THRESHER (No. 4).--The commanding officer of the BLACKFISH (No. 6) expressed the belief that extreme heat has a worse effect on morale than has depth charging. The PIKE (No. 8) in reporting on conditions

encountered during a depth charge attack said: "Because of a leaky exhaust valve, bucket brigade was established for the bilges. Four men collapsed from the extreme heat. The heat in the maneuvering room was intense. The crew were worn out from the intense heat and high humidity. There was only one qualified controllerman left on his feet. Twenty men were incapacitated for further duty. The electrical officer, formerly a controllerman, was at the controls and going out rapidly. All the controllermen were incapacitated. Some of the cases of collapse were due to heat exhaustion, some to nervous strain. The fact that all but one officer and 50 per cent of the crew had previously complained of upset stomachs (apparently caused by serving of canned shrimps at the evening meal) only aggravated the situation. Fresh air on the surface cooled the boat quickly and brought most of the men back to batting." "The intense heat generated in the maneuvering room when rigged for depth charging in the tropics gives cause for concern. A small air conditioning unit installed there would be of great benefit." (Controllermen are on duty in the maneuvering room.)

POLLACK (No. 6) observed that long periods of silent running put a great strain on the engineers and electricians. RAY (No. 1) observed that heat and humidity were especially excessive, during silent running, in the maneuvering room and the engine rooms after end-around runs at high speed and then diving for attack. Three men became faint in the engine room on one occasion due to heat from the engines. THRESHER (No. 4) reported a similar case of heat exhaustion in the engine room with securing of the air conditioning and hull ventilation.

TRITON (No. 5), SKIPJACK (No. 3), BARBEL (No. 1).--TRITON (No. 5) commented upon a depth charge attack at 2243 as follows: "This fellow definitely is on the first team. He was pretty well battering us about the head and face but we hope he didn't know it. The heat and humidity in the ship was now terrific. Men on the rudder and planes were becoming visibly exhausted. The decks were so wet with perspiration as to look like they had been sprayed with fire hoses. All clothing was drenched--even our shoes and slippers could be wrung out like rags. Relieved men after several had approached heat prostration commenced giving salt pills to all hands--we needed them. In the first depth charge attack a helmsman became overheated and suffered from severe heat prostration; his temperature was 103.8 degrees, pulse greater than 160 and respiration 32." The third attack took place at 2327: "In spite of the terrific heat and persistent attacks by the enemy and jarring explosions the crew performed like the veterans that they were. They were concerned, yes, but doing their respective jobs beautifully; still able to grin and wisecrack with such as 'Go 'way, Oscar'----'Hold your hats'. I'm proud of these fellows." The fourth attack took place at 2354: "the heat was so great as to most certainly impair our efficiency had enemy attacks continued." Surfaced at 0106 and made a successful attack on an enemy convoy 34 hours later.

SKIPJACK (No. 3) described conditions as follows: "Habitability okay except when running silent. This condition lasted for about 6 hours. There is so much heat given off by electrical gear that once the air conditioning plant is shut down the temperature and humidity jump at once making living conditions very trying. The temperature of the engineering spaces is always about 105-115 degrees. The entire complement of officers and men wilted. Upon surfacing that evening 75 per cent of the personnel were nauseated and had lost their appetite. This condition gradually wore off with the next 48 hours for the majority; although, in about 4 cases this condition continued to incapacitate the men for 5 days. A silent air conditioning plant using a heat source instead of a compressor similar to the 'electrolux' refrigerator, would be a great boon during silent running. In the above period had the beginning of a few cases of prickly heat and one case of hives."

The following excerpt is taken from the first patrol of the BARBEL: "We have been down 16 hours now. The battery is low, the air is bad, and all hands are pretty well exhausted. Have spread CO_2 absorbent. Two ships have us pretty well bored in." At 2025: "One ship still is waiting for us to surface. We are in pretty bad shape. CO_2 - 3 per cent, hydrogen - 2 per cent, the battery getting lower, and all hands getting more exhausted. Offered a fervent prayer to God to turn the Japs east. Surfaced at 2137, secured from battle station, prepared to eat a hot meal, the first in 26 hours."

FLYING FISH (No. 2), GRAYLING (No. 4), CUTTLEFISH (No. 2), SAURY (No. 1).--The FLYING FISH (No. 2) reported: "Nervous tension and physical exertion at constant stations during attacks undoubtedly accounted for the numerous cases of near heat prostration so frequently noted when the ship's ventilation and air conditioning was secured. Men quickly shed their shoes without orders on the first and last attack. While things were quiet overhead it was noticed that flashlights, wrenches and valves were moved with the greatest of caution and stealth and the movement of all hands was done with forethought and deliberation. Conversation was unconsciously carried on in whispers when there was a lull in an attack and it looked as though we were getting clear. Morale was visibly affected following the last attack, Key men started making mistakes and constant attention was necessary to see that instructions were carried out properly and promptly. Little food was eaten for about 18 hours after a particularly strenuous period. The symptoms were noticeable following each attack. Men would quietly

ask for a relief, shove off, lie down on the deck anywhere and remain there till their services were needed elsewhere." "There was no indication of hysteria whatever and every individual did his duty to the limit of his endurance through each prolonged attack." GRAYLING (No. 4) observed with silent running and long hours of repair work, a noticeable increase in accidents, fatigue and nervous tension.

CUTTLEFISH (No. 2) commented on this same line: "Believe that heat took nearly as much out of the men as did the nervous strain. After the first hour the decks were slippery with sweat, and towels used to keep perspiration out of the eyes were wringing wet. For purely psychological reasons, recommend felt slippers be obtained and issued to submarines for use during silent running. There is probably no more disturbing noise in the world than the clamp of work shoes on steel deck plates during evasions."

SAURY (No. 1) reported: "This has been a nerve racking day on the officers and crew who are exhausted mentally and physically. While running silent, men on stearing bow and stern planes had to be spelled frequently. The ship's air is stifling, the decks are wet with sweat after running silent for 3 hours." "Officers and crew came away from operations at Lingayen Gulf 'punch drunk.' It was several days before the effect wore off." Similar reports concerning the effects of silent running and nervous tension were made by the commanding officers of the GRAYLING (No. 4) and TRIGGER (No. 9).

Brief comment concerning the relation of habitability to inefficient air control are to be found in the following patrol reports: DRUM 1, HALIBUT 5, WAHOO 2, FLASHER 3, ICEFISH 1, FINBACK 2, HAKE 5, SEAL 3, STEELHEAD 2, GRAYLING 3, PICKEREL 3, and SCORPION 1.

Reference has been made elsewhere to the cold experienced in the conning tower of the SCAMP (No. 1) in silent running. GABILAN (No. 5) noticed after 2-3 hours of silent running with the air conditioning secured that 50 per cent of the crew caught cold.

PUFFER (No. 1).--In further illustration of the extremes of punishment to which the human machine may be subjected during "evasive measures" an account of conditions developing aboard the PUFFER will conclude this section. This excellent report has been taken from a confidential monograph "Enemy Anti-Submarine Measures" prepared by ComSubPac, Pearl Harbor.

> "The submarine on her first patrol submerged at 0525 on 9 October 1943 while patrolling the Makassar Straits. An attack was made on a merchantman at 1100. Between 1125 and 1145 9 depth charges were received, 6 of which were very close aboard. Ten minutes later there was 1 depth charge. Fifteen minutes after that 4 charges went off overhead, staggered in depth. A second anti-submarine vessel joined the first at 1820. The two of them kept with her all night. The last depth charges were dropped at 0115 on 10 October but the enemy kept over PUFFER making dry runs until 1225 on the 10th, 31 hours after the submarine submerged and more than 25 hours after the attack on the merchantman. At 1910, 37 hours and 45 minutes after diving, she surfaced into the bright moonlight.
>
> "The damage to the PUFFER from the first depth charge attack, most of which went off close and directly overhead, was not severe. The conning tower hatch and the conning tower door lifted off their seats, admitted a spurting shower of water, and then reseated. A number of sea valves backed off their seats. A plug in a sea valve casting in the after torpedo room was loosened and the resultant leak eventually admitted much water. The rudder and stern planes apparently suffered some damage for there was increased noise of operation and the motors appeared to be overloaded. The gaskets were blown out of the main engine air induction valve and the ship's ventilation supply valves flooding the main induction and supply lines. There was considerable miscellaneous and minor damage and lots of flying cork and glass. Difficulty was experienced in depth control. There was much water in the bilges. The leak in the after torpedo room was continually adding to the weight aft and the trim pump refused to pick up a suction on the after torpedo room bilges. The ship gradually worked down until the control room was at over 500 foot pressure within the boat accumulated to about 12 inches. Air conditioning was stopped to conserve power and to prevent noise. A bucket brigade was formed to keep the bilge water from grounding out the electrical motors. CO_2 absorbent and oxygen was used after the ship had been submerged about 12 hours.
>
> "What happened to PUFFER's machinery and the detail of corrective measure is of little lasting interest. What is of paramount concern is how her officers and men stood up under it, how they behaved and what they were thinking about. The minds of men can be conditioned by drill, training, and education. The disciplined crew is not very apt to panic. They will continue to behave in a rational manner long after an unorganized body of men would have destroyed themselves. But the mental reaction of men under great stress does not change with the times.
>
> "With the air conditioning shut down the temperature within the ship went to a high figure. A temperature of 125 degrees F. was reported in the maneuvering room. The after torpedo room and the engine room were the coolest parts of the ship. The

forward torpedo room was practically unbearable. The humidity must have been very high, but higher in the cooler rooms than in the hot spots like the maneuvering room and the conning tower. The decks and bulkhead became clammy with condensed moisture. Rivulets of sweat would form and follow right behind a towel rubbed over a man's body.

"Although the temperature in the after torpedo room was probably well over 100 degrees F. men going from the maneuvering room to the after torpedo room reported that they shivered and shook with the chill. The human body possesses no mechanism for reducing its temperature below ambient wet bulb temperature. It is, therefore, very probable that in such places as the maneuvering room the men had a high fever. Although there were no reports of delirium the sudden chill may have been an indication that such fever did exist. The liquids available for drink, fruit juices, coffee or water, soon reached room temperature. Frequently swallowing these liquids induced vomiting, yet thirst was so great the men were constantly drinking, vomiting, and then drinking again. All of the men were nauseated. Seventy-five per cent were vomiting, especially the diving officer (confirmed with commanding officer). Profuse sweating and difficulty in keeping liquids down produced severe dehydration in many cases. No one cared to eat anything.

"The bucket brigade struggled against the mounting water in the motor room bilges and against extreme fatigue, being practically out on their feet. As the hours wore on the air commenced to get bad. Both CO_2 absorbent and oxygen were used but despite that the air was very foul toward the end of the dive." Prior to the attack, the cooks had removed rabbits from the icebox so that they might thaw preparatory to cooking. The odor from them became extremely disagreeable. "Breathing was very difficult and headaches were severe. An officer making the rounds from control room to after torpedo room had to stop and rest several times on the journey. A good many of the men were in a state of physical collapse. From the stupor in which they sank, it became impossible to arouse them to go on watch. Toward the end, stations were manned by volunteers and by men who had the stamina and the will to move and think. Many of the others were past the stage of caring what happened.

"The physical conditions were severe and had much to do with the mental reactions. Both officers and men state that the first mental reaction was anger. They were mad at everything and anything. They were particularly mad at themselves for allowing themselves to be caught in such a situation. They cursed themselves for being such fools as to serve in submarines. They cursed the enemy for their persistence. They spent much time day dreaming about what they could do to the torpedo boat above them--discussing such fantastic ideas as discharging acid around the ship to eat holes in the hull. There is no doubt but that the necessity of taking a beating without being able to fight back made a lifetime impression on the minds of these men.

"Suspense was the hardest thing to bear. The officers state that because of this, the ordeal was harder on the men that it was on the officers. The officers, when on watch, were in the conning tower or control room. They then knew the proximity of the enemy, the state of the battery, what was being done to evade and in general were busy in some manner or other. On the other hand, men not engaged in some useful task could only sit and think and frequently they lacked information. To remedy this, officers occasionally went through the boat and told the men what was happening. The use of the public address system was annoying to many and a feeling existed that the noise of it might disclose the location of the submarine. The conning tower telephone talker described what was happening to the other talkers on the fire control telephone circuit. This was the best method of spreading the word and later became standard practice.

"The universal advice the men would give to anyone else who might have to go through a similar experience is 'Find something to do to keep busy.' To idle men, it was almost unbearable to realize that an hour or so had gone by since the last attack, and another would soon be due. Then to hear the screws on the approaching vessel, the pinging of her echo ranging as she deliberately and methodically probed for the submarine, finally the rush of racing screws and the shattering detonation of a salvo of depth charges carried the suspense to a maddening pitch.

"None of the officers report any difficulty in reaching decisions, pointing out however that no close or rapid fire decisions were called for. The major issue was whether or not to surface and fight it out with the gun--a truly desperate action with a Chidori. The next possible question involved a choice between speeding up for evasion action or conserving the remaining battery and waiting until dark. In this connection, one of the enlisted men reports that he was asked by somebody to vote for or against an immediate rise to the surface. He reported that he was willing to go along either way but he refused to accept the responsibility of committing himself one way or the other.

"The desire for having deck armament seems to spring from a psychological abhorrence of sitting still and taking it without being able to fight back. One man was reported to have suggested flooding everything and getting it over with quickly in sort of a mass suicide for the ship and crew. Another man had received a minor but painful injury and he quite evidently was incapable of understanding what went on about him toward the end of the dive.

"Both officers and men seem to have reached the conclusion that they would never come out of it. The persistence with which the enemy located and relocated the submarine forced them to this pessimistic conclusion. This feeling was climaxed, when after being at deep submergence for many hours, all hands were ordered to put on life jackets. In the engine room one of the men broke out of his locker three cans of pineapple juice and passed them around. It was no longer necessary to save anything 'for when things get worse.' Everyone questioned had a vivid recollection of the tremendous psychological blow caused by the order to don life jackets. The adverse effect experienced on this occasion points to the necessity of some preparation being made in advance before the order is given. It can not be stressed too strongly that the mental state of the crew of a submarine is one of the greatest factors in determining whether or not she will win through.

"There is practically universal agreement that it was a mistake to shut down the air conditioning. A submarine crew in such a tight situation is very allergic to noise, a squeaky pair of sandals being recalled by one man. Nevertheless they would all take the noise of the operation of the air conditioning machine and ventilation blowers in preference to enduring the heat and humidity. They feel that the additional noise is less dangerous than the slowed down mental reaction of extreme fatigue.

"Despite the fact there was nothing for many of them to do they got very little sleep. An officer states that in 4 hours off watch he got a nap of about 15 minutes. He recalls this bitterly because the nap was broken by being awakened to don life jackets. They spent all the time they could, huddled around anything that was comparatively cool, hunched against an uninsulated portion of the hull or wrapped around an exposed circulation water pipe.

"On surfacing, with a sharp port list, due to the free water and the flooded induction lines, it was nearly an hour before she could be brought to an even keel. During that hour it would have been difficult to use the 3 inch gun. Contact with an enemy patrol was made about 15 minutes after surfacing and was successfully evaded. At 0450 on 11 October she was able to make a trim dive and found no serious leaks. She stayed down all day to rest the crew and then returned to port. Upon surfacing the commanding officer has stated that, with contact with the fresh air, there was almost universal violent nausea within 5 minutes and some were vomiting. After getting out of danger the crew recovered physically with great rapidity. Within 24 hours they were normal physically. For days, however, they were very nervous. If the diving officer wanted to open the vents, he had to pass the word quietly through the boat before hand. The noise of opening the vents, without preliminary warning would bring every man out of his bunk standing.

"There were several important suggestions by the officers. When a submarine has gone through such an experience, the crew should be broken up. The common experience of such an ordeal knits them together in such a bond that no one else can penetrate the inner circle. Men who subsequently made successful patrols on PUFFER were still not members of the gang, if they hadn't been through the depth charging. Another point was well brought out: Be careful and slow to form an estimate of a man's value until he has been observed under stress. To a great extent the men who were on their feet, working to save themselves and the ship, when the long dive was over, were not the normal leaders of the crew. The people who lasted out were those of a more phlegmatic disposition who didn't bother too much when things were running smoothly. The worriers and the hurriers had all crapped out, leaving the plodders to bring home the ship." In the patrol report special mention is made of a motor machinist's mate first class doing a seemingly tireless job in keeping the bucket brigade going and cheering the entire crew. The battle sound operators did an outstanding good job keeping the two attacking vessels in contact with one sound head which had to be trained by hand, making it possible to maneuver the ship to the best advantage. Four men were reported to have suffered from the nervous strain during the depth charge but "seemed all right two days later."

On the vessel's sixth patrol the commanding officer wrote: "In the last 2 patrols we have received 203 depth charges and a total of 14 anti-submarine vessels were searching for us. I feel that leaving the auxiliary machinery running keeps the ship more comfortable, has a less depressing effect on the crew, and does not seem to aid counteraction. Only once in the last 2 patrols have we had to secure auxiliary machinery and that on the last patrol during the last few hours of a 19 hour search by 5 fleet destroyers.

RELATION BETWEEN DURATION OF SUBMERGED OPERATIONS AND HABITABILITY

The average duration of 1,386 patrols (66,781 days) was about 48.18 days. On 967 patrols an average of 16.31 days were spent submerged. Four hundred and seventy-four of these patrols (49 per cent) spent 15 days or less submerged; 230 (23.7 per cent) spent 25 days or more submerged; 45 (4.6 per cent) spent more than 35 days submerged; and 7 (0.7 per cent) spent 45 days or more submerged.

The two longest submerged patrols lasted for 54 and 55 days respectively, an average of 13 and 15 hours per day being spent in submerged operations.

The HERRING (Dec-Feb 1942) on her second patrol (58 days duration) with presumably about 70 men and officers aboard, spent 54 consecutive days submerged in reconnaissance in Atlantic waters for an average of slightly less than 13 hours each day. But little information is available concerning the state of the habitability of the ship during this patrol. A noticeable increase of headaches was observed among the personnel. "It was an exhausting experience to all concerned on the basis of: (1) length of time submerged on station, (2) bad weather and (3) lack of opportunity for offensive action"--on the basis of which it was decided that "future patrols in this area will be of 40 days duration." Those interested in the relation between personnel endurance and efficiency and length of patrol should review this patrol report.

On the GROUPER's first patrol a total of 55 days, averaging 15 hours per day, were spent submerged. "This would have been impossible without excellent air conditioning system." Thirty-eight sick days were incurred on this patrol but none were due to fault in habitability. Fourteen men were treated for headaches. The SHAD (No. 7) after a 51 day patrol in 1944 commented: "Submerged operations for about 14 1/2 hours a day for 30 continuous days gives the vessel a severe test of habitability and generally it was found not wanting."

On the first two patrols of the PICKEREL (made in December of 1941 and January of 1942) 51 consecutive days were spent in submerged operations--a total of 689 hours (surfaced for 541 hours), concerning which the commanding officer stated: "Living conditions were not good because of the 74 men aboard. Bunking space was at a premium. The carbon dioxide content on all day dives reached 2.5 to 3 per cent causing headaches. Humidity was excessive near the equator. The mattresses were sweaty and mildewed. The patrol lasted (No. 2) too long and excessive fatigue was noticeable. Nervous tension and eye strain appeared in the officers. The entire crew deteriorated in health because of the long confinement." The commanding officer of the SAURY (No. 2, February and March 1942) after a tropical patrol reported: "It was noticeable that the crew was in a poorer physical condition than on the preceding patrol; one reason, perhaps, is the carrying over and the cumulative effect of so much submerged time. Another is failure of the air conditioning. The boat has been much hotter and all hands perspired profusely with resultant decrease of efficiency."

The commanding officer of the S-42 (No. 1) in May 1942 observed: "In tropical waters of the enemy the crew of a twenty year old 'S' class submarine not equipped with air conditioning are subject to very severe physical and mental stress. Ninety per cent of the crew never see the topside at all and are submerged over 13 hours every day. This results in serious loss of efficiency. Thirty day patrols under such conditions are too long and should not exceed 21 days from base to base and 14 days between patrols."

MEANING OF "TIME SUBMERGED"

Early in the War the amount of time spent submerged was reported in terms of "hours." Later it came to be expressed in "days." In presenting the above figures on the basis of "days" the reasoning of the commanding officer of the SEARAVEN (No. 11) has been followed: "With regard to the entry 'Days submerged' in paragraph (S), only those days were counted on which we were submerged from morning to evening twilight. No instructions are available defining what constitutes a day submerged. Several of our days had only 1-2 hours of surface running and we seldom dived before sunrise." With due consideration for variations in length of daylight with latitude, submerged "day" has been taken to mean about 16 hours--the average figure derived from 18 reports in which the exact durations of the dives were stated.

According to the BATFISH (No. 2): "Submerged days indicate the total time submerged divided by 13 hours." BLUEFISH (No. 1) and CERO (No. 4): "submerged days are half days." BRILL (No. 1): "This figure includes only those days upon which we dived at dawn with the intention of remaining submerged all day."

It appears that S-boats operating in the Aleutian and Kurile Island areas were submerged a greater part of the 24 hours, exact duration of dives on 6 reports averaging about 18 hours. The PUFFER (No. 1) with about 73 men aboard spent a total of 38 hours submerged, the longest known dive made by a United States submarine during war-time. The HARDER (No. 2) on one occasion was forced by anti-submarine activity to remain submerged for 58 out of 66 hours. GUNNEL, on her first patrol, on one occasion was submerged for 36 hours with the exception

of two breaks totaling one hour and 34 minutes. PADDLE, on her seventh patrol was submerged for 21 hours. The average length of the dives made by the HADDO (No. 2) were 18 hours and 20 minutes.

SUBMERGED OPERATIONS AND LIMITING VALUES OF OXYGEN AND CARBON DIOXIDE

Before submerging, whenever circumstances permitted, most commanding officers followed the practice of thoroughly ventilating the ship so that the contained air at the onset of the dive was as pure and fresh as possible. According to the Bureau of Construction and Repair Manual (1934, Article 2701) under such circumstances the limiting value of 17 per cent oxygen and 3 per cent carbon dioxide will not be reached until the expiration of a period of hours (x) calculated by the following formula: $x = 0.04 \frac{C}{N}$ where C equals net space of the submarine in cubic feet and N equals the number of men in the crew. C and N for various classes of vessels are given in the following table together with the corresponding values of x for each class:

Table 24

Submarine	Approximate Net Air Space (Cu. Ft.) (C)	Complement (N)	Time in Hours (x)
S-3 to S-41	21,700	43	20
Narwhal, Nautilus	69,930	87	30
Argonaut	67,270	87	30
Dolphin (SS169)	40,175	58	27
Cachalot (SS170)	27,230	44	24

According to the Manual, if time submerged under ordinary operating conditions is less than the period listed in the last column above, oxygen or compressed air replenishment and carbon dioxide purification should not be necessary. However, if it is predicted that the time of submergence will be greater in any case than the period listed in the last column above, air purification with carbon dioxide absorbent should be resorted to immediately. Oxygen replenishment should be resorted to at the end of the period indicated for the respective vessel.

The Bureau of Medicine and Surgery has placed the limiting value of 17 per cent oxygen and 3 per cent carbon dioxide for the contained air aboard submarines. The symptoms consequent to the depletion of air or oxygen and the accumulation of carbon dioxide are well known to all submariners.

In a number of instances, recorded values of carbon dioxide and oxygen content of the air following prolonged submergence, are available and are presented in the following table (Table 25) together with pertinent explanatory data.

Table 25.--RECORDED LEVELS OF OXYGEN AND CARBON DIOXIDE ON SUBMERGED OPERATIONS AND RELATED SYMPTOMS.

Submarine	Patrol No.	Season	Area	Regulated Smoking	Complement	X	Submerged	CO_2	Comments
							Hours	Percent	
Puffer	1	Fall	Tropical	-------	*73	22	38	(*)	Excessive in evasive action. CO_2 absorbent and oxygen used.
Permit	4	Spring	Tropical	-------	111	15	22.5	2.5	CO_2 2.5% at end 16 hr. CO_2 absorbent and oxygen used; evasive action.
Permit	1	Winter	Tropical	-------	*73	22	16	1-2	CO_2 diminished to 1.5% toward end of patrol at end all day dives.
Spearfish	8	Fall	Empire	-------	*73	22	22	(*)	Air very foul on surfacing after silent running. Oxygen used.
Barbel	1	Summer	Empire	-------	*80	20	21	3	At end 16 hr. on surfacing after evasive action all hands exhausted. CO_2 absorbent used.
Barb	8	Sp-Sum	Kurile	Yes	*80	20	19.8	3	----------
S-41	6	Spring	Kurile	-------	*55	15.8	19	(*)	Breathing difficult on surfacing. CO_2 and oxygen used.
Trigger	5	Spring	Empire	-------	*78	21	19	3.5	No ill effects observed after prolonged silent running. CO_2 absorbent and oxygen used.
Bream	3	Fall	Tropical	-------	84	19	18.6	2.5	At end 17 hr. 20 min. of evasive action, oxygen used.
Trout	3	Spring	Empire	-------	73	22	18	2	At end of 16 hr., CO_2 absorbent used.
S-33	7	Sp-Sum	Kurile	-------	55	15.8	18	3	At end of 17 hr., associated panting, headache, and coughing.
S-34	6	Spring	Kurile	Yes	*55	15.8	18	(*)	Breathing difficult after 16 hr. CO_2 absorbent used.
S-40	8	Sp-Sum	Kurile	-------	*55	15.8	17-18	2.5-3	Headaches associated with CO_2.
Lapon	1	Sp-Sum	Sea of Japan	-------	*73	22	17.3	2	Breathing forced end of the day. No absorbent used.
Lapon	6	Fall	Tropical	-------	78	21	17	1.5	Possible CO_2 poisoning of crew. CO_2 absorbent and oxygen used.
S-30	6	Spring	Aleutian	-------	55	15.8	17	(*)	Difficult breathing last 2-3 hr. of dive. CO_2 absorbent used; no oxygen.
Cabezon	1	Sp-Sum	Kurile	-------	89	18	17	(*)	Air "poor" on surfacing.
Steelhead	1	Spring	Empire	-------	75	21	17	3	Undetermined. Mass illness of crew cause.
Threadfin	1	Winter	Empire	-------	85	19	16-17	3	Excessive CO_2 on surfacing. CO_2 absorbent used.
Sailfish	7	Winter	Northern	Yes	*73	22	16-17	(*)	"Air pretty bad" on surfacing.
Piper	2	Spring	Okhotsk Sea	-------	96	17	16-17	3	"Oppressive air" on surfacing.
Segundo	4	Spring	Yellow Sea	-------	87	18	16-17	(*)	CO_2 excessive on surfacing. CO_2 absorbent and oxygen used.
Tuna	1	Winter	Empire	-------	73	22	16-17	(*)	Headache on all day dives.
Tuna	11	Summer	Empire	None	75	21	15	3	Average CO_2 on all day dives 2.5%.
Nautilus	5	Spring	Aleutian	Yes	205	14	17.5	3	CO_2 3% at end of 11.5 hr. CO_2 absorbent and oxygen used.
Nautilus	7	Winter	Tropical	Yes	181	15	16	2.1	CO_2 absorbent and oxygen used.
Nautilus	2	Fall	Makin	-------	186	15	12	1.5	Tolerance limits not reached. Used CO_2 absorbent and oxygen.
Pampanito	2	Sp-Sum	Empire	-------	86	19	16	(*)	Excessive CO_2 on surfacing. CO_2 absorbent used.
Queenfish	5	Summer	Tropical	-------	88	18	16	(*)	Excessive CO_2 on surfacing. CO_2 absorbent used.
Tirante	2	Sp-Sum	Yellow Sea	-------	98	16	16	2	Headaches and slight panting at end of dive. CO_2 absorbent used.
Archer Fish	1	Winter	Empire	-------	73	22	16	2	CO_2 excessive at end of dive.
Bonefish	7	Spring	Empire	-------	84	19	16	3	CO_2 absorbent and oxygen used.

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Table 25.--RECORDED LEVELS OF OXYGEN AND CARBON DIOXIDE ON SUBMERGED OPERATIONS AND RELATED SYMPTOMS-continued

Pickerel	2	Winter	Tropical	-------	74 : 22	16	2.5-3	Headaches probably associated with CO_2.
Gurnard	2	Summer	Tropical	-------	75 : 21	16	2	Excessive CO_2 at end of dive. CO_2 absorbent used.
Whale	11	Summer	Empire	-------	105 : 15	15-16	(*)	Headaches associated with CO_2.
Bluefish	5	Spring	Tropical	-------	*80 : 20	14-17	(*)	CO_2 absorbent used. No critical level of CO_2 reached at end of dive.
Cuttlefish	3	Summer	Empire	-------	78 : 21	14-16	(*)	No critical level CO_2 at end of dive. CO_2 absorbent used.
Searaven	3	Spring	Tropical	-------	*113 : 14	14	3	Possible CO_2 poisoning of 50% of crew.
Kingfish	8	Spring	Bonin	-------	*84 : 19	14	(*)	CO_2 excessive at end of dive. Evasive action.
Blenny	2	Winter	Tropical	-------	89 : 18	14	(*)	----------
Plaice	5	Spring	Kurile	Yes	80 : 20	13-16	2.5-3.5	Excessive CO_2 on surfacing. CO_2 absorbent and oxygen used.
Sea Devil	1	Fall	Empire	-------	*73 : 22	14-15	(*)	Probably excessive CO_2 end all day dives. CO_2 absorbent used.
Cod	2	Winter	Tropical	-------	73 : 22	12-13	1.5	Mass poisoning from carbon tetrachloride.
Pomfret	6	Summer	Yellow Sea	-------	122 : 13	12	(*)	CO_2 excessive after 12 hr. dive. CO_2 absorbent used.
Dace	5	Fall	Tropical	-------	165 : 9.7	10.5	(*)	10 1/2 hr. maximum time with excessive CO_2. CO_2 absorbent and oxygen used.
Narwhal	4	Spring	Attu	Yes	202 : 14	(*)	4	CO_2 4% at end of all day dives.
Seal	7	Summer	Empire	-------	*73 : 22	(*)	2.5	Levels after silent running and on surfacing.
S-40	8	Winter	Kurile	(†)	*55 : 15.6	18	2.5-3	CO_2 absorbent (15 lb. daily) spread, despite which CO_2 level rose as indicated. Headaches all day dives.
S-41	6	(†)	(†)	(†)	*55 : 15.6	19	(*)	"On average dives (19 hr.) one can absorbent great help. Oxygen released on two or three occasions when more than usual activity in progress."

NOTES:

Complement: When unknown presumed to be about 73 men and officers.

X: Period of hours after which limiting values of 17 percent oxygen and 3 percent carbon dioxide reached according to formula $X=.04 \frac{C \text{ (capacity)}}{N \text{ (no. men)}}$

Submerged time: When not specified, assumed to be about 16 hours.

*: Number uncertain or unknown.

†: Unknown.

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In addition to the list in Table 25, 41 other reports mentioned, generally without detail, alterations in the level of oxygen and carbon dioxide.

DISCUSSION

Some observations drawn from these 89 reports are of interest: Ten reports were concerned with actual or threatening unfavorable changes in carbon dioxide and oxygen levels experienced during prolonged periods of silent running. Fifteen reports were from tropical patrols, 28 involved patrols made in temperate waters, and 36 were reported following cold water operations.

FACTORS CAUSING EARLY UNFAVORABLE CHANGES IN OXYGEN AND CARBON DIOXIDE CONTENT OF AIR

Cold Water Operations.--It is apparent that cold weather operations are more frequently occasion for unfavorable change in the oxygen and carbon dioxide content of the atmosphere within the boat. This is due to a combination of several factors: (1) increased complement carried in war-time, (2) extended submerged periods necessary in Northern latitudes, especially in the Spring of the year, (3) the amount of activity upon the part of the crew and passengers (as Scouts in preparing to disembark), (4) and the fact that the boats being commonly cold and wet, the men, though they wear more clothing, must as the commanding officer of the PLAICE (No. 5) observed, expend more energy to keep warm. TUNA (No. 11) with a complement of approximately 75 men reported, at the end of a normal submerged day of 15 hours, a carbon dioxide concentration of 2.5 per cent; on one particularly rough day it rose to 3 per cent. The schedule which is followed aboard the ship, too, is important--such things as serving a cold noon meal and the evening meal after surfacing provides a hot meal without unduly heating the boat (KINGFISH No. 7).

PIPER (No. 2) because of the long days, at the end of which carbon dioxide levels approached 3 per cent, found it advisable, when low visibility permitted, to surface at mid-day and take a 5 minute suction through the boat. JACK (No. 8) by delaying dives as long as possible, and by spreading carbon dioxide absorbent each day, and by surfacing early each evening, succeeded in cutting off an hour and a half from what would have been 16 hour dives.

Control of Smoking.--The presence or absence of controlled smoking hours influences the content of oxygen and carbon dioxide in the air, too. NAUTILUS (No. 7) with a total of 181 persons aboard, reported a rise of carbon dioxide content from 0.5 to 1.0 per cent after the smoking lamp had been lit for 15 minutes. Several boats, especially on long Northern patrols routinely limited the smoking hours (BARB 8, NAUTILUS 5 and 7, SAILFISH 7, SHAD 1, PLAICE 5, S-34, No. 6). NARWHAL (No. 4) in carrying 202 individuals to Attu did not permit smoking, despite which the carbon dioxide concentration at the end of ordinary dives reached 4 per cent.

Accidental Egress of Carbon Dioxide.--On one occasion aboard the POGY (No. 3) a container of absorbent was used to allay a possible high concentration of carbon dioxide when a fire extinguisher was accidentally opened during an all day dive. Aboard the POMFRET (No. 6) a carbon dioxide fire extinguisher leaked into the freezing box. When the door of the icebox was opened the gas escaped throughout the boat, the carbon dioxide concentration in the after battery compartment having risen to 4 per cent at the time the boat surfaced.

Use of Carbon Dioxide Absorbent and Oxygen.--Oxygen replenishment with or without the use of compressed air was commonly used in conjunction with CO_2 absorbent to revitalize depleted air.

It appears that the period of time allowed by the Bureau of Construction and Repair Manual at the end of which limiting values of oxygen and carbon dioxide levels are reached are not always applicable to war-time operations. It appears that the time at which symptoms of intolerance may be evident does not necessarily follow the calculated time; indeed, in 22 out of 26 of the above reports, the actual limit of viability of the air ran from one to six hours less than the calculated figure. This is a point that commanding officers may well bear in mind and which many anticipated by the routine spreading of carbon dioxide absorbent early in the morning of the dive.

BONEFISH (No. 7) reported carbon dioxide concentration as 3 per cent on one occasion at the end of a 16 hour dive; by the use of oxygen and absorbent in two compartments it had dropped to 1 1/2 per cent within 1 1/2 hours. This practice was found to definitely improve the quality of the air toward the end of the dive (BLENNY 2, CACHALOT 2, COD 3, DACE 4, DRUM 5, 6, and 7, HALIBUT 1, HARDER 1, JACK 8, PLUNGER 10, RASHER 1, GURNARD 2, S-30, No. 6, S-41, No. 6, PAMPANITO 2, POMFRET 6, QUEENFISH 5). SAWFISH (No. 6) reported: "In long dives on station (16 hours average) air in the ship was greatly improved by pumping down with high pressure air compressors and reviving the air from the high pressure banks." THREADFIN (No. 1) in this regard reported that carbon dioxide concentration reached the normal limits during long dives of 16-17 hours duration and that the use of absorbent would be required daily during summer patrols in Empire waters.

SYMPTOMATOLOGY

It is difficult from patrol excerpts to gain a clear picture of the symptomatology associated with the reported levels of carbon dioxide accumulation and oxygen depletion. This is true for a number of reasons: (1) brevity and terminology of the reports; (2) the fact that both oxygen lack and carbon dioxide excess are concerned; and (3) no instrument was aboard for measurement of the oxygen content of the air and that used for measurement of carbon dioxide was unreliable; (4) it must not be forgotten that other factors as excessive temperature and humidity are often involved, in addition to increased pressure in the boat, excessive and prolonged fatigue and very often the psychological trauma of enemy anti-submarine measures.

Individuals perhaps develop a tolerance to high concentrations of carbon dioxide. TUNA (No. 11) reported that many men complained of headaches on all day dives and that these were probably due to low tolerance to carbon dioxide since their incidence decreased as the men became accustomed to the long dives. Again PLAICE (No. 5) observed that when the carbon dioxide concentration could be kept below 2.5 per cent, "the habitability was generally good." And TRIGGER (No. 5) "on ten occasions was forced to remain submerged for over 19 hours with carbon dioxide content of 3.5 per cent without ill effects on any hands." KINGFISH (No. 8) on a patrol in the vicinity of the Bonin Islands observed: "14 hour dives left us somewhat lacking in oxygen but this was not unduly felt." And the BARB (No. 8) one day submerged for 18 to 19 hours with carbon dioxide concentration of 3 per cent, "air not too oppressive." BONEFISH (No. 7): "One day submerged patrol was of 16 hours duration at the end of which time the carbon dioxide had risen to 3 per cent--fewer headaches on this than any other patrol." In a British investigation of the after effects of exposure to carbon dioxide, in connection with the loss of H.M. submarine Thetis, it was evident that marked individual variation in symptoms existed. In one experiment it is possible that acclimatization to the gas was demonstrated. ("After Effects of Exposure of Men to Carbon Dioxide," Alexander, W., Duff, P., Haldane, J.B.S., Ives, G., and Renton, D., LANCET, August 19, 1939, pp. 419-420, London, No. VIII, Vol. II).

LAPON (No. 6).--The NAUTILUS on her second patrol after exposure to 1.5 per cent carbon dioxide concentration over a 12 hour period observed: "No lowering of the health of the crew or passengers." The LAPON, on the other hand, reported quite a different experience with similar levels of carbon dioxide on her sixth patrol made in the Marianas (4 September to 31 October 1944) with approximately 78 men aboard (29 of 58 days were spent submerged).

Prior to 21 September the ship had been submerged daily generally from 0536 to 1840. "On 21 September submerged at 0500, contact was made at 0632, approach beginning at 0640 and broken off at 0650." At 1320 contact again; battle station manned at 1333; at 1421 rigged for depth charge with silent running, but continued tracking. At 1645, "not going to be able to clear before dark, so decided to hit out undetected and go after this cripple after dark. Gravity is well down." At 1758 LAPON was almost dead ahead of a patrol vessel. "At 1759 with a loud explosion like a depth charge, started to 265 feet. At 1807 continuing evasive action, at 2045 fire in radar. As passed 125 feet two sets of screws commenced closing fast; went back to 270 feet. Twelve men were vomiting and complaining of headaches. Carbon dioxide was only 1.5 per cent but put out three cans of CO_2 absorbent. Boat was very hot. At 2222 all clear, decided to try again--at 2245 surfaced in blinding rain and secured from silent running and depth charge." 22 September: "at 0238--radar contact. At 0350 closing for attack. At 0406 two hits in large tanker. 0415 opening out for reload. At 0425 secured from battle stations except for plotting parties. After 17 hours of constant tracking and approach, crew exhausted and many sick from either carbon dioxide poisoning or some other cause. Decided to pull ahead on target tracks for dawn submerged attack--. This was not a wise decision and ultimately led to losing the contact." By way of contrast the submarine, on 27 May submerged at 0541. Tracking started at 0555 and continued throughout the day with 23 heavy and close depth charges. Surfaced at 1845 without illness.

The ship continued her patrol with several brilliant attacks and two gun attacks. Little more need be said to describe the perilous situation which might well have existed had the LAPON at 0425 on 22 September been obliged to engage in a gun attack. Her crew was in no condition to fight. If carbon dioxide concentration was to blame it seems likely that the original reading of 1.5 per cent CO_2 was in error. It may be argued that these symptoms were due to causes other than carbon dioxide. Undoubtedly after 17 hours of constant strain, 8 1/2 of which were spent in silent running, dehydration and excessive temperature throughout the boat affected the men. As a matter of interest, it should be observed that if carbon dioxide was responsible, the men vomited while submerged. The British speculated as to the possibility of headaches and/or vomiting when breathing pure oxygen in the escape apparatus as being due to the sudden fall in carbon dioxide rather than to the rise in carbon dioxide breathed. Many submariners, after long dives, are known to have been nauseated and some to have vomited on exposure to fresh air. This point will be mentioned again in connection with certain other illness aboard submarines and in connection with the escape of survivors from U.S.S. TANG.

Symptomatology Reported at Concentration of 2 per cent CO_2

At a concentration of 2 per cent CO_2, TIRANTE (No. 2) after a 60 day patrol in the Yellow Sea from 20 May to 19 July 1945 (20 days of which were spent submerged) with 98 men, officers and prisoners aboard, reported that at the end of 16 hour all day dives the CO_2 concentrations reached about 2 per cent resulting in headaches and causing slight panting. Carbon dioxide absorbent spread out on various levels throughout the ship "without doubt relieved the situation to some extent."

LAPON (No. 1) on a 42 day patrol (17 June to 4 August 1943) in the Sea of Okhotsk, 23 days of which were submerged, reported that carbon dioxide concentration at the end of 17.3 hours dive was 2 per cent, "breathing being somewhat forced, but not markedly so." Carbon dioxide absorbent was not used. On three other patrols (GUNNEL 2, TROUT 3, NAUTILUS 7) CO_2 concentrations reached 2 to 2.1 per cent on all day dives without specific report of concurrent symptomatology. ARCHER FISH (No. 1) reported CO_2 concentration "up to nearly 2 per cent in all day dives" with health of crew good. Perusal of the ailments treated by the pharmacist's mate revealed that throughout the patrol (19 days of which were spent submerged) 36 men were treated for headaches.

Symptomatology Reported with Concentration of 2 to 3 per cent CO_2

PICKEREL (No. 2) with 74 men aboard on a patrol in the Davao Gulf in December and January of 1942 spent 390 hours submerged and 541 hours surfaced. After all day dives, CO_2 concentration of 2 1/2 to 3 per cent was reported as causing headaches. Habitability conditions were very poor (overcrowded, hot bunking and high humidity and temperature). Excessive fatigue, nervous tension, eye strain, and general deterioration in health was observed in the crew because of the long confinement.

The S-40 on her eighth patrol made in the vicinity of the Kurile Islands from 24 June to 31 July 1943 reported: "Immediately upon diving, one can of CO_2 absorbent (about 15 pounds) was spread in the forward battery, (no oxygen replenishment was made) bringing the CO_2 down to 2 1/2 to 3 per cent at the end of 17 to 18 hour dives. There were a few headaches believed to be due to CO_2 generated during the long all day dives."

PERMIT (No. 4) with 111 men aboard, after being submerged for 22 hours and 33 minutes, reported CO_2 concentration as being 2.5 per cent. During this time, in which the boat ran silent and was depth charged, the pressure was pumped down, 500 pounds of oxygen was released supplemented by air from the air banks. No comment concerning the health of the crew is available. BREAM on her third patrol was submerged on one occasion for a total of about 18 1/2 hours. At the end of 17 hours and 20 minutes, CO_2 concentration was reported as 2 1/2 per cent. Oxygen was bad in the boat, no comments are available concerning symptomatology, if any, associated with the carbon dioxide concentration.

Symptomatology at Concentration of 3 per cent CO_2

When the concentration reaches 3 per cent apparently symptomatology becomes more obvious. PIPER as noted on her second patrol with 96 men aboard in submerged operations for 9 days reported: "during the early part of the patrol CO_2 reached 3 per cent and the air became oppressive." The S-33 on her seventh patrol from 4 June to 2 July 1943, 15 days of which were spent submerged, in the Kurile Island region with 55 men aboard reported surfacing on 18 June at the end of 18 hours of submergence (diving while charging batteries on finishing rate) "with all hands groggy with headaches." Four days later after 7 hours of submergence, in spite of using a can of absorbent, CO_2 concentration was 3 per cent. At the end of 19 hours, upon surfacing all hands had headaches and were panting; about 1/3 of the crew were coughing.

PLAICE on her fifth patrol (26 April to 13 June, 9 days of which were submerged, in the Kurile Island area with 80 men aboard) recounted an experience typical of northern patrols. "The first dive made on 7 May lasted longer than expected with no CO_2 absorbent spread. At the end of 14 hours all hands had difficulty in breathing, CO_2 concentration at that time being 2.5 per cent. Eight hundred pounds oxygen bled into boat with slight relief. Upon surfacing two hours later carbon dioxide in conning tower 3.5 per cent. The next day, upon submergence, two cans of absorbent spread about the ship. Eight hours later fire control drill held. Thirteen hours after we had submerged CO_2 was 3 per cent (1610). At 1800 pulled 1/2 inch vacuum in boat, replenished air from fresh bank, and released 400 pounds of oxygen. Upon surfacing 16 hours after submergence, breathing of all hands was accelerated. On 17 May after a 16 hour dive despite the fact that CO_2 absorbent had been spread and oxygen bled into the boat, all hands panting badly. Breathing usually becoming difficult after 15 hours. On subsequent dives through use of CO_2 absorbent, compressed air, oxygen, and regulation of smoking, carbon dioxide content kept below 2.5 per cent at all times."

The NAUTILUS on her fifth patrol in transporting Army Scouts to Attu, carried 205 individuals (109 men in excess of crew) from 20 April until 11 May 1943 in heavy weather. On 5 May after 11 1/2 hours of submergence, with unlimited smoking and activity, CO_2 content was 3 per cent. Absorbent was spread, CO_2 content being immediately reduced to 1 1/2 per cent. At the end of 14 hours, oxygen was bled into the boat. The ship surfaced at the end of 17 hours and 21 minutes. Thereafter each day 4 cans absorbent and oxygen were used except for a two day period when all hands were requested to sleep and the smoking lamp was put out at 1400. On 7 May at the end of 13 hours, CO_2 was 3 per cent. "The lack of oxygen and high carbon dioxide were more noticeable today due to the fact that the Army Scouts were constantly on the move making ready for their disembarkation." To climb from the control room to the conning tower was worse than running a 100 yard dash. "On 9 May upon submerging ordered all hands to keep as quiet as possible, smoking was prohibited to conserve oxygen because we must be prepared to await indefinitely for favorable weather." "On the day preparations were made to land, CO_2 rose to 4 per cent and there was much panting. For any similar operations which must await weather conditions the ship's allowance of CO_2 absorbent and oxygen should be augmented. It is obvious that if CO_2 absorbent is to be used it should be opened early in the day to insure getting the most absorbent. Because of irritation to the nose and throat it must be handled with care." Again, it would appear obvious that no man can be expected to fight efficiently who for an undetermined time before he disembarks has been exposed to concentrations of carbon dioxide in the neighborhood of 4 per cent. In this particular case, berthing facilities were inadequate, the boat was cold, condensate was heavy. All of these factors when read in conjunction with the high levels of carbon dioxide at the end of the day make understandable the statement of the commanding officer: "delay from day to day had a marked effect on most of the Army Scouts, probably due to the fact that this was their first enemy action."

The BARBEL on her first patrol from 15 July to 21 August (13 days of which were spent submerged) reported that on the 8th of August all bridge personnel had been drenched since 2000 the day before. "Our battle efficiency was dropping." On 9 August: "We have been down now 16 hours; all hands are pretty well exhausted. Have spread CO_2 absorbent. The ship had us pretty well boxed in--. We were in pretty bad shape; CO_2 is 3 per cent, hydrogen is 3 per cent, the battery getting lower and all hands getting more exhausted. Surfaced at the end of 21 hours and 20 minutes, secured for battle stations, prepared a hot meal, the first in 26 hours."

CO_2 Concentrations in Excess of 3 per cent

Two reports made reference of CO_2 concentration of 3.5 per cent. Aboard the PLAICE (No. 5) at the end of a 16 hour dive without use of absorbent, CO_2 concentration in the conning tower reached 3.5 per cent. No information is available as to symptomatology. TRIGGER, on her fifth patrol reported that on two occasions she was forced to remain submerged over 19 hours at which time the CO_2 reached about 3.5 per cent, no ill effect of any kind being observed.

The NARWHAL on her fourth patrol carried 202 men (105 passengers) for 29 days from San Diego to Dutch Harbor. CO_2 concentration on long dives was reported as reaching 4 per cent. No smoking was permitted. No information is available as to the influence of the carbon dioxide on the physical status of the crew or passengers. As noted above, NAUTILUS (No. 5) under similar circumstances reported the concentration of carbon dioxide in the ship at the time of disembarkation of Army Scouts to have been 4 per cent.

Symptomatology Without Known Level of CO_2

In several instances, reports make no mention of a recorded level of carbon dioxide but do describe certain symptomatology. TUNA (No. 11) ascribed the many headaches following all day dives as probably due to low tolerance to carbon dioxide; SAILFISH, on her seventh patrol, reported the air as being "pretty bad" at the end of long all day dives; restriction of smoking and use of CO_2 absorbent did not prevent headaches. S-34 (No. 6): "Air remained good for 16 hours after which time breathing became slightly difficult." S-41 (No. 6): "poor habitability; on one occasion surfaced with breathing difficult--decided to use slower speeds which will require fewer periscope observations."

The SPEARFISH on her eighth patrol (25 August to 12 October 1943, 25 days of which were spent submerged) reported after having been submerged for 22 hours "surfaced at battle stations with all tubes ready; he was not in sight in the moonlight. The battery was about flat. The very foul air in spite of the oxygen replenishment had visibly affected all hands. Neither the ship nor the personnel were ready to search for and tackle the escorted damaged freighter. Decided to chase the convoy to the south. Will give us about 18 hours to recover our breath." Here again, the effects of CO_2, lack of oxygen, heat and humidity of silent running, can not be separated.

POLLACK, on her third patrol (30 April to 6 June 1942) reported an incident which may have been due in part to carbon dioxide toxicity. "On 23 May several men began to develop an ailment which was not diagnosed on board, with symptoms of nausea, loss of appetite, and in some cases, vomiting. Eleven were affected. The illness lasted about 4 days. The drinking water was shifted and the water was boiled. Food was inspected but no cause was found. The 16 hour daily dives may have been responsible as all cases disappeared after surface running was resumed."

BLUEFISH on her fifth patrol 7 May to 28 June 1944, 39 days of which were spent submerged with 52 men aboard reported a similar condition. "On 1 June submerged at 0449; at battle stations from 0835 to 1140, surfacing at 2153 (17 hours). For the next 10 days, routine dives lasted about 14 hours out of the 24. During this period there was a slight epidemic of nausea and headache, affecting 50 per cent of the crew, 5 men were confined to the bed. All hands drank of the water before and after this trouble without ill effects. Food may have been to blame but it is unlikely since the people who ate all meals felt as bad or good as did others. The long dives made necessary by conditions of the area materially caused the temperature of the boat to rise." No explanation was found for these complaints when investigated by the squadron medical officer. It may well be that they were on the basis of carbon tetrachloride or excessive copper salt content of the water. On the other hand, carbon dioxide accumulation may have been at fault.

The CUTTLEFISH (No. 3) with 20 men in excess of her complement, from 23 July to 20 September 1943, reported the "oxygen deficiency was prevalent and enervating in the latter half of all prolonged submerged periods, it being difficult to light a match. After an hour all hands were breathing heavily and rapidly." The S-34 (No. 6) reported after a patrol in the Kurile Island region that the air remained good for 16 hours after which time breathing became slightly difficult. The smoking lamp was lit once a day.

Careful attention was given, in reading these patrol reports, to detect evidence of the influence of carbon dioxide toxicity upon the performance of the fire control parties, and upon the performance of gun crews in surface engagements with the enemy. Although the importance of toxic levels of the gas in these respects can not be denied, nothing was found in the patrol reports to indicate that they were recognized if they did exist.

HABITABILITY OF FLEET TYPE SUBMARINES AND PREVAILING WEATHER CONDITIONS

The habitability of a submarine is often directly related to the prevailing conditions of weather. We have seen earlier the beneficial effects accruing from an occasional day on the surface or from prolonged surface running, especially when a larger percentage of the crew may be rotated through the sun lookout. With extended submerged operations, revitalization of the air by mid-day surfacing is productive of improved living conditions. Improvement of the general well being of the crew is commonly observed in the tranquil period subsequent to leaving the area and arrival at an advanced base, especially if weather conditions permit surface running with personnel topside. There is undoubtedly a direct relationship between personnel endurance and favorable conditions of patrolling (as the temperature of the air, water, and a favorable sea) and good ventilation and air conditioning and the amount of surface running. BARB (No. 7) noted at the end of a 55 day patrol that the ship's company showed but few signs of fatigue and appeared to have an indefinite limit of endurance under conditions experienced in the area. And (No. 11) that patrols carried out completely on the surface, while inherently decreasing the amount of sleep obtained, increased the general well being. We have seen, likewise, how in tropical waters, the injection temperature of the water may put a severe strain upon the capacity of the air conditioning and ventilating systems which, if not operated efficiently, may result in impaired habitability. CUTTLEFISH (No. 2) reported, after a tropical patrol, that the bridge of the submarine was the most uncomfortable spot on the ship due to excessive heat and glare.

Mention has been made, too, of the influence of rough seas on ventilation, especially if inboard ventilation is necessary while on the surface. Materiel defects subsequent to the sudden egress of water and spray into the main induction may lead to materiel defects of the electrical equipment in the maneuvering room and disabling of the ventilation supply blowers. Inability to use the auxiliary induction in the maneuvering room, except in the calmest of sea, is cause for considerable accumulation of heat in that compartment.

HABITABILITY AND FOUL WEATHER

Personnel on the bridge of a submarine are afforded but scant protection in rough seas. As noted elsewhere, men were not uncommonly washed overboard and thrown bodily about the bridge, sometimes sustaining painful injuries. For further details of bridge conditions in Northern waters, readers are directed to the section outlining the needs for adequate protective clothing from the cold and wetness.

Heavy seas sometimes necessitated prolonged periods of submergence. On one of the GREENLING's patrols weather conditions on station were subject to quick change; variable winds of force were encountered which often changed direction 90 degrees during the hour; 30 foot high waves caused the ship to roll 15 degrees while submerged at 120 feet. Noted the PLUNGER (No. 10): "Rough seas interfered with the rest of the crew." The GUARDFISH on several of her patrols encountered heavy weather with the seas on one occasion reaching a height of 50 feet. Through a 10 day period of bad weather the outboard ventilation had to be secured. At night during battery charges, sulfuric acid fumes in the living compartments were reported to have reached a concentration that was both disagreeable and detrimental to the general health. "It was a very depressing period, mentally and physically. The men had not been topside for 27 days; the officers and crew were half sick and worn out from the beating taken each night. Submerged for an all day dive to rest and freshen the crew who were worn out from the fight against the weather--rough weather caused as much worry as did the enemy."

COLD WEATHER OPERATIONS

In this series of patrols, 44 fleet type submarines in 50 reports commented concerning habitability while on cold weather patrol as follows: excellent 6; good 13; fair 20; poor 11.

Excellent Habitability Reports

With reference to excellent reports the following excerpts are considered as typical. BALAO (No. 8, Feb-Apr 1945) after a Yellow Sea patrol reported: "habitability excellent; condensate on the periscope eyepiece and all uncorked metal attached to the hull was a nuisance submerged, the air conditioning not being able to cope with humidity in this cold atmosphere." SHAD (No. 3, Mar-Apr 1943) after a patrol off the coast of Spain: "Habitability excellent; moisture content of the air not considered too high--although it did not prevent condensate within the ship." GUARDFISH (No. 11, Feb-Apr 1945) after a patrol off Bungo Suido: "Habitability excellent; one air conditioning unit ran while on station to reduce moisture."

SEGUNDO (No. 4, Apr-June 1945) after a Yellow Sea patrol: "Habitability excellent; noticeable absence of colds. While submerged near coast CO_2 content became excessive near the end of the day; whenever possible surfaced under conditions of low visibility to change the air." TREPANG (No. 5, June-July 1945) after a patrol off Honshu: "Most of the patrol was spent in weather with an average temperature of 50-60 degrees which made the inside of the boat ideal." CERO (No. 8, June-July 1945) after a patrol off Honshu: "boat dry and comfortable; condensate kept at minimum by use of air conditioning unit." POMPON (No. 6, July-Sep 1944) after a Kurile Island patrol (her first cold water patrol): "Habitability excellent; heater keeping the boat comfortable even with injection temperature of 30 degrees F."

TAUTOG (No. 9, Dec-Jan 1944): "All previous patrols were made in the tropics. A tremendous difference was experienced in this patrol (Honshu) with air temperature about 40 degrees F. at night. Air conditioning no problem. Personnel felt refreshed after sleeping; water consumption was greatly reduced making less operation of the stills necessary. A cold weather patrol is much less fatiguing than a warm climate one." It will be observed that in only one instance was excellent habitability reported from a patrol made in waters really "northern" and that off the Kurile Islands during July and September 1944 (POMPON 6).

Good to Poor Habitability Reports

By way of contrast, the following excerpts are illustrative of habitability reports varying from good to poor. TAUTOG's tenth and eleventh patrols made in February-May 1944 in the vicinity of the Kurile Islands were reported as follows: "Torpedo room very wet. Metal fittings throughout the ship sweated considerably. Air conditioning--but little good except to make the boat colder and was not used. Heaters had to be used sparingly to conserve the battery." SAND LANCE (No. 1, Feb-Mar 1944) another Kurile Island patrol: "With sea water at temperature of 27 degrees F., single hull portions of the boat were impossible to heat. There was ice constantly in the torpedo room bilges and pipes containing water such as shower drains were frozen solid." SCAMP (No. 1, March 1943) after an Aleutian patrol: "During a depth charge attack the boat gets like a wet ice house; brandy rationed 1 ounce per man after each attack; not to quiet the nerves but to try and stop people from shivering from the cold."

GOLET (No. 1, Mar-May 1944) after a Kurile Island run: "Habitability only fair due to the extreme cold; average temperature averaging about 28 degrees F., injection temperature 30 degrees F., seas force 4-5. A light coat of ice formed topside each night. Result, sweating in boat--about 50 per cent of the crew had colds." CACHALOT (No. 2, June-July 1942, Aleutians) reported: "Health definitely below standard. The sudden shift from a sub-tropical climate to cold--of the Aleutians, the necessity for keeping the main induction closed most of the time thereby sending a stream of cold air through the main living quarters, engine room, control room and conning tower, and the damp and crowded conditions with the necessity of hot

bunks all contributed to catching and spreading of colds. Ship was cold and damp. While submerged condensate was continuously dripping from the overhead and bulkheads. Heaters were sometimes used but the desire to conserve the battery while submerged and the high voltage during part of the battery charge precluded their constant use. Air conditioning plants ran about 2 hours each morning after diving, drying boat out somewhat. During last week of patrol 1/4 can of CO_2 absorbent spread out early in morning on diving which definitely improved quality of the air toward the end of dive."

DACE (No. 7, May-July 1945, Kuriles): "The conning tower is like an icebox; this is the only time (during depth charge) that I have ever sweated it out and been very cold at the same time." LAPON (No. 1, June-Aug 1943) during a Sea of Okhotsk patrol: "bottomed at 210 feet; boat very cold in late afternoon and torpedo rooms had much sweat; all hands under blankets." TRIGGER (No. 1, June-Aug 1942) Aleutians: "An unusual amount of condensate was present in the ship the entire patrol and as a result many personal and stowage lockers had to be abandoned. Heaters and air conditioning unit helped to alleviate the dampness." SUNFISH (No. 7, June-Aug 1944) Kurile Islands: "Almost entire patrol spent surfaced, extremely foggy. Boat generally cold and sweated profusely when submerged; submerged at 1053, surfaced at 2022, sweating heavily at 1220."

HALIBUT (No. 1, Aug-Sep 1944) Aleutians: "Air conditioning system was used daily to prevent sweating and CO_2 absorbent spread daily at beginning of dives; 1/2 can used each day, benefit gained by the procedure can not be praised too highly." APOGON (No. 5, Sep-Oct 1944) Kuriles: "Boat very chilly in rough foggy areas. Air conditioning unit was kept running which made boat few degrees colder; however, increase of coldness preferred to dampness, believe this factor was important in reduction of colds experienced on this patrol. Those who had them were able to shake them off in remarkably little time. General health excellent." CABRILLA (No. 7, Sep-Nov 1943): "Though boat generally cold and damp, at no time did personnel show signs of great discomfort even during days when air and water temperature below freezing. Except in the conning tower the temperature of the boat was seldom below 55 degrees F."

SNOOK (No. 8, Dec-Feb) Kuriles: "Habitability fair; recorded temperatures throughout boat averaged about 65 degrees at noon on all day dives with 50 degrees in the conning tower. Condensate with and without one air conditioning unit. Running, it resulted in boat being about 3 degrees cooler but much dryer. At the best, hull fittings sweated continuously and heavy moisture collected in the forward and after rooms." BANG (No. 5, Jan-Feb 1945) China Sea: "Health good in spite of poor habitability, especially in forward battery and torpedo room with much condensate in after battery and after torpedo room. Suggest after torpedo room be better insulated with an additional coat of insulation on the overhead and under linoleum on the deck." POGY (No. 1) reported that when the injection temperature of the water was down to 50 degrees F. or lower, it was too cold for men to remove their clothes to use ultraviolet lamp located in forward torpedo room.

Clothing, Heaters, Etc.

The above excerpts indicate the state of habitability and comfort that may be expected on northern and arctic patrols in fleet submarines. They also indicate, in particular, measures taken to combat the cold and dampness. Low temperature below decks required that woolen underwear and sweaters be worn at all times, which, because of the high humidity, submerged or surfaced, often felt damp and sticky (SEARAVEN 12, TILEFISH 4, BOWFIN 7, SUNFISH 7).

As indicated, varying reports were made concerning the use of heaters on this patrol. SWORDFISH (No. 2, May-June 1945) after a patrol off Honshu reported that while submerged in water with an injection temperature of 42 degrees F. heaters were not necessary, habitability being good with one air conditioning unit being used to keep moisture at a minimum. SEACAT (No. 2, Feb-Mar 1945) after a Yellow Sea patrol in water with injection temperature of 45-55 degrees F. reported that heaters were occasionally used. DOLPHIN (No. 3, Dec 1942) after an Aleutian patrol recommended that more heaters be provided for cold weather operations. SUNFISH (No. 10, Jan-Feb 1945) after a Kurile Island patrol reported extensive use of heaters necessary in area with injection temperature of 31 degrees F. PLAICE (No. 5, Apr-June 1945) after a Kurile Island patrol with average temperature of 34 degrees F. reported habitability generally good; heaters eliminated excess coldness although the boat remained cool. POMPON (No. 6, Jul-Sep 1944) after patrol in Kuriles, her first cold weather patrol, reported habitability as excellent, heaters keeping the boat comfortable even with average injection temperature of 30 degrees F. Similar reports considering heaters as beneficial and necessary were made by: TINOSA 11, May-June 1945, Japanese Sea; TRIGGER 1, Jul-Aug 1942, Aleutians; TRUTTA 1, Mar-May 1945, Yellow Sea; several reported (CACHALOT 2, June-July 1942, cold weather operations, TAUTOG 10, Feb-Mar 1944 and No. 11, Apr-May 1944, Kurile Island patrol) that although heaters were considered necessary, they were used sparingly in order to conserve the batteries.

Habitability and the Use of Air Conditioning on Cold Weather Operations

Twenty-one of these reports made no mention of the use of air conditioning units in reducing condensation and dampness. Commanding officers of three submarines (DOLPHIN 3, SKATE 5, and SCULPIN 7) preferred not to use air conditioning units for this purpose: "because boat already too cold," "too cold to run air conditioning unit, consequently air completely saturated and condensate on the hull fittings."

Of the 26 boats using the units, 10 returned unfavorable reports: "Every effort made to run air conditioning to prevent excessive moisture, but satisfactory adjustment could not be found. Running it part time submerged eliminated excessive moisture but attempt to run it on the surface promptly froze us, especially in the forward battery" (PLAICE No. 5). "Air conditioning system constantly used in spite of which the forward and after rooms were cold and damp at all times while submerged" (SALMON No. 7). "Improved operation of air conditioning unit needed in reducing condensation" (BOWFIN No. 9). "Air conditioning seemed unable to maintain a comfortable temperature with high injection temperature or comfortable humidity level with low injection temperature" (BALAO No. 9). "Air conditioning ran but didn't help torpedo rooms much" (DACE No. 7). "One air conditioning plant insufficient to keep the boat dry" (SHAD No. 2). "Two were run part of the time; torpedo room very cold, dropping very near injection temperature by end of long dive, but living compartments were comfortable" (PARCHE No. 5). "Air conditioning was not able to cope with the humidity in the cold atmosphere" (BALAO No. 8).

Sixteen reports commented favorably upon the use of air conditioning units in reducing condensate and dampness. "Air conditioning unit kept moisture down to a minimum of sweating" (TILEFISH No. 4). "Air conditioning reduced excessive dampness" (TRITON No. 4). "Operation of one air conditioning unit definitely reduced the amount of condensate" (SNOOK No. 8).

Use of CO_2 Absorbent on Cold Weather Operations

Due to extended periods of submergence, particularly in the spring, in northern waters, occasion often existed for the use of CO_2 absorbent and oxygen. Nine reports mentioned use of these adjuncts to improve habitability. "Average temperature was 34 degrees; sea conditions were excellent with fog and overcast 95 per cent of the time. Operating as we were in spring time in northern water, dives generally averaged 16 hours. The first dive lasted longer than expected. At the end of 14 hours all hands were breathing with difficulty; CO_2 level is 2 1/2 per cent. Eight hundred pounds of oxygen bled into the boat with slight relief. Upon surfacing two hours later CO_2 content was 3.5 per cent." "On submerged dives CO_2 absorbent spread at beginning of dive and smoking lamp was regulated. Whenever the pressure rose to 1 inch a 1/2 to 1/4 vacuum pulled and air from the fresh bank was bled into the boat. This combination kept the CO_2 content below 2.5 per cent all of the time" (PLAICE No. 5).

"Air in boat became poor when submerged 17 hours, getting progressively worse on successive dives" (CABEZON No. 1). "Air conditioning system used daily to prevent sweating and CO_2 absorbent spread daily at beginning of dive; 1/2 can used each day--benefit gained by this procedure can not be praised too highly" (HALIBUT No. 1). "Due to extended submerged operations at this time of the year in this water found it necessary to use a can of CO_2 absorbent each day to take care of excessive CO_2" (PAMPANITO No. 2). "Long submerged periods in northern latitudes resulted in a high percentage of CO_2 on submerged days. Most noted was 2 per cent at the end of a 17.3 hour dive. Breathing was somewhat forceful but not markedly so. Did not use CO_2 absorbent" (LAPON No. 1). "In June at 40N latitude days long, dives last 16 1/2 to 17 hours. This, with increased complement, made air pretty bad. Restricted smoking to 5 minutes every 2 hours. One day when depth charged, used oxygen and CO_2 absorbent but still some headaches" (SAILFISH No. 7).

Protective Measures for Submarine Personnel in Cold Weather Operations

At the request of the U.S.N. Tactical Publication Panel the following recommended protective measures for submarine personnel in cold weather operations were drawn up:

1. The following precautions apply to all personnel aboard ship but particularly to those working in exposed positions during very cold weather operations. Failure to exercise care in preparing for exposure to severe weather may result in considerable impairment of efficiency, physical discomfort, and perhaps injury.

(a) Because of the prevailing wetness of the outside world and the high humidity inside the submarine, all hands will require suitable and adequate clothing at all times. Clean dry woolens should be worn next to the skin. Two (2) wool or flannel shirts and trousers and one (1) Army Issue cotton or woolen comforter are strongly recommended for each member of the

crew for use or wear below decks. Shoes should be loose fitting and allow for one or two pair of wool socks.

Available protective clothing for bridge personnel includes: Winter Trousers and Winter Jacket (N-1), Winter Helmet (N-1 & 2), Rain Trousers and Parka Jacket (N-1), Sea Arctics (N-1) or Boots (N-1), Winter Scarf (N-1), and Winter Sweater (N-1). A Winter Parka Coat (N-1) is available for officers. Winter Face Mask (N-1) and Goggles (N-1) should be worn in extremely cold weather. Knitted helmets are invaluable in protecting the sides of the face and chin and preventing water from running down inside the parka. Long knitted scarves or mufflers and the pullover type of sweater with turtle neck are of great benefit in keeping the bridge watch warm. Gloves or mittens which separate the fore-finger from the rest of the hand quickly become cold and uncomfortable. Rubberized gloves and mittens lack pliability and safety, becoming slippery when wet and preventing a sure grip on sustaining stanchions and ladders. Felt inner soles add considerable warmth to foot wear - because they absorb moisture rapidly at least three (3) sets should be procured for each pair of boots. The Bureau of Medicine and Surgery has instituted study toward the improvement of protective clothing for submarine personnel particularly with reference to the development of a lined coverall type of exposure suit and waterproof hand and foot wear. Whatever combination of present available clothing is worn, a parka helmet with protection for the head and ears is essential. Above all, avoid tight fitting clothing which impairs the circulation of blood, the evaporation of perspiration, and is especially uncomfortable about the neck and shoulders.

(b) Tolerance time in subfreezing weather depends primarily upon rapid cooling of the hands and feet. Personnel who are dressed and who are to spend long hours on watch should restrain their activities to keep from perspiring before they get to their post. If the feet or other parts of the body perspire make certain that the clothing and body are dry before exposure to severe cold. Ice will form in damp clothing and damp portions of the body will freeze quickly. Inauguration of a rotating pool of protective clothing (especially of gloves and parkas) is recommended to insure an ample supply of dry and intact clothing for bridge personnel.

(c) On long clear days in the arctic, particularly if the wind is strong, personnel may become sunburned. Snow blindness caused by glare of the snow is a common affliction and may occur not only on bright days but on days of fog or overcast. Colored goggles (N-1) or sun glasses (N-1 Type 1) are as important for protection of the eyes in cold weather as in the tropics. All personnel participating in surface search where glare is present should wear the sun glasses. Those anticipating night lookout duty should be required to wear them whenever exposed to sunlight. The glasses are not designed for scanning the sun. Other important protective measures include the use of visor caps and lamp black or burnt cork applied under the eyes or over the cheek prominences to protect against the reflected rays of the sun, snow or ice on those occasions when sun glasses or goggles are removed.

(d) Exposure to low temperatures, especially in a strong wind, carries risk of frostbite, the parts most susceptible to this being the cheeks, nose, ears, chin, forehead, wrists, hands or feet. Frostbitten skin becomes whitish and stiff and the parts feel numb rather than painful. Exposure at ambient temperatures from -25 degrees F. to 30 degrees F. with prolonged deep respirations may result in undue exposure and subsequent damage to fragile lung tissue due to cold. Personnel should be instructed, if they inadvertently overexert under such circumstances and start breathing heavily, to put their head down and breathe the warm air from inside their clothing until the deep breathing stops.

(e) In sub-zero weather gasoline, etc., spilled on hands or clothing in a few minutes after contact will freeze the flesh. Exposed metal should not be touched without gloves. The moisture on the hands may freeze to the metal surface and result in painful tearing of the flesh. Metal tools may be insulated by wrapping the handles with tape or light line. Gloves should be further worn to prevent frostbite and prevent cuts or nicks of the skin or flesh going unnoticed because of numb hands.

(f) To prevent frostbite and to maintain the greatest efficiency, personnel working in exposed positions should be frequently relieved and allowed to go below for a rest period with hot coffee or soup and sandwiches. To promote efficiency and conserve stamina it may be necessary in especially foul weather to shorten the OOD and lookout watch to 3 or 2 hours or even 45 minutes.

2. The extended hours of daylight, especially in Spring time cold weather operations may result in protracted all day dives. Personnel expend considerable energy in keeping warm in the cooler than usual inside environmental temperature. For these two reasons, especially with increased complement, commanding officers, if an all day dive is planned, should anticipate the accumulation of excessive carbon dioxide. Spreading of carbon dioxide absorbent on the morning of such dives is recommended. Revitalization of the air by oxygen or compressed air replenishment may be necessary. It is considered highly expedient that a practical method be devised by BuShips for removal of carbon dioxide as it is evolved without resorting to the method in vogue of spreading the absorbent on bunks. A simple canister-blower or container in the air ducts or at the blower source would solve the problem.

3. If complement permits, few men as possible should be bunked in the forward and after torpedo rooms as they become especially cold, damp and uncomfortable in cold-weather operations. Intermittent operation of the air conditioning system will materially reduce the dampness but lower the temperature two or three degrees at the same time. If the use of fresh water is unlimited, an increased amount may be used per may per day because of the warmth and comfort derived from showers or sponge baths. The consumption of food may be expected to increase on cold weather operations. The amount of coffee drunk may be tripled.

POTABLE AND BATTERY WATER SUPPLY OF SUBMARINES

Aboard the fleet type submarines potable water is stored in four normal fresh water tanks and various emergency fresh water tanks distributed throughout the various compartments. The capacity of each normal fresh water tank is about 500 gallons; the normal potable water storage amounts to about 4,200 gallons. This does not include battery water. Submarines departed on patrols, having filled these tanks with fresh water from the tender on dock. "In one to three weeks, depending on the rate of water consumption, this water is diluted 50 to 90 per cent with the water distilled on board." Fleet type submarines are equipped with two electric vapor compression distilling units (Kleinschmidt still) with a common distillate collecting tank. The rated capacity of each still is about 750 gallons per day. New construction submarines are provided with 1,000 gallon per day evaporators. In the early days of the war some of our submarines were equipped with distillation units that were of inadequate capacity and subject to frequent failure when required to operate for long periods. The rated capacity of these units (later replaced by the Kleinschmidt unit) is not known. Variable ballast tanks located at or near the center of buoyancy of the vessel are designated as "auxiliary tanks." Some ships had two of these tanks; others had a third, with varying capacity, and these were sometimes used for the storage of fresh water. Fresh water storage in an auxiliary tank is no longer available on new construction submarines.

The available information concerning the amount of fresh water used and made on war patrols, though grossly incomplete, has been tabulated as follows for fleet and S-type submarines. The data will be of interest to medical officers.

Table 26.--FRESH WATER USED AND MADE ABOARD SUBMARINES

Submarine	Patrol Number	Area	Year	Complement	Duration	Amount Fresh Water Used (Gallons)	Amount Battery Water	Total Amount Fresh Water Used by Crew	Amount Per Man Per Day	Distilled Per Man Per Day (Gallons)	Type of Still	Condensate Used	Comments
Tautog	Pre-war	Midway	1941	*67	38	9,140	1,332	7,808	3.16	(*)	(*)	Yes	Rigid curtailment.
Tautog	1	Marshall	1941	*61	41	(*)	(*)	12,223	4.9	(*)	(*)	Yes	Patrol endurance limited by potable water capacity.
Triton	Pre-war	(*)	1941	*67	(*)	#454	(*)	*19,068	6.75	4.65	Non-electric	Yes	Non-electric still; showers out of commission.
Triton	2	Wake	1941	*67	42	#275	(*)	(*)	4.1	(*)	Non-electric	Yes	Non-electric still; rigid curtailment; figures apply last two weeks in area.
Argonaut	1	Midway	41-42	*90	44	#900	(*)	(*)	10.0	(*)	(*)	(*)	No water restrictions.
						#550	(*)	(*)	5.5	(*)	(*)	Yes	With water restrictions.
						#200	(*)	(*)	2.2	(*)	(*)	Yes	Use restricted to cooking, drinking, dishwashing.
Tambor	1	Wake	1941	59	35	#250	(*)	(*)	4.23	"125.0	(*)	Yes	Rigid economy. Lasted eight days.
Dolphin	1	Truk	41-42	(*)	47	(*)	(*)	(*)	5.0	4.5	(*)	No	Rigid restrictions.
Permit	1	Luzon	1941	(*)	9	#256 (all purposes)	(*)	(*)	(*)	(*)	(*)	(*)	Rigid restrictions.
Trout	1	Wake	1941	(*)	23	#230	150	(*)	(*)	(*)	(*)	Yes	Rigid restrictions.
Tuna	1	Empire	1942	(*)	55	(*)	(*)	(*)	5.2	(*)	(*)	Yes	Rigid restrictions.
Sargo	1	Indo China	1942	(*)	48	(*)	(*)	(*)	2.76	(*)	(*)	Yes	Used condensate.
Thresher	2	Marshall	1942	(*)	59	(*)	(*)	(*)	4.7	(*)	(*)	(*)	Restricted.
Tarpon	2	Tropics	1942	(*)	39	#300 (all purposes)	(*)	(*)	(*)	(*)	(*)	(*)	No comment.
Grampus	4	New Guinea	1942	(*)	54	#350	(*)	(*)	(*)	(*)	(*)	(*)	Vessel entirely self-supporting in potable and battery water.
Apogon	2	Formosa	1944	80	38	#200	(*)	(*)	2.5	(*)	Klein-schmidt	(*)	Conditions existing last two weeks patrol; fresh water excessively chlorinated.
S-38	8	Gilberts	1942	*51	31	3,275	(*)	(*)	(*)	(*)	(*)	(*)	No comment.
S-47	1	Rabaul	1942	*51	30	(*)	(*)	(*)	4.38	(*)	(*)	(*)	Rigid restrictions. Evaporator defective.
S-47	2	New Britain	1942	*51	27	(*)	(*)	(*)	3.0	(*)	(*)	(*)	No comment.
S-18	1	Aleutians	1942	*51	12	(*)	(*)	(*)	1.5	(*)	(*)	(*)	Average temperature in conning tower 22-32 degrees F.
S-18	2	Aleutians	1942	*51	21	(*)	(*)	(*)	1.9	(*)	(*)	(*)	Submerged 14 hours per day.
S-33	2	Aleutians	1942	50	37	(*)	(*)	(*)	2.2	(*)	(*)	(*)	No comment.
S-23	1	Aleutians	1942	*51	11	(*)	(*)	(*)	2.1	100-150	(*)	(*)	Ship self-supporting.

Legend: Total amount used for batteries includes: battery water, makeup engine cooling, torpedoes.
Total amount used by personnel: use of fresh water in cooking, dishwashing, personal needs, unless indicated otherwise.
* - Indicates approximate or unknown item, number or quantity.
# - Gallons per day.
" - Gallons per night.

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DISCUSSION

TAUTOG (Pre-War Patrol and No. 1).--The TAUTOG, after a 38 day patrol made in Oct-Dec of 1941 in the Midway Island area, reported that the average outside air temperature was 73 degrees F. The average temperature and humidity within the ship at the end of a dive was 86 degrees and 60 per cent respectively; 460.7 hours were spent submerged. It is estimated that 67 men were serving aboard. Of the 9,140 gallons of fresh water utilized, personnel used 7,806 gallons (cooking, drinking, dishwashing, and tooth washing). One thousand three hundred and thirty-two gallons were used for making water for the batteries, engine make-up and the torpedoes. All fresh water outlets were closed with the valve handles removed, pressure not being kept in the system unless it was actually in use. Water was turned on in the heads twice a day for washing of teeth. Under this regime 3.16 gallons of water were used per man per day. It was pointed out that more water than is generally accredited is used in the galley and scullery. An average of 83 gallons of condensate water was recovered daily. The amount of fresh water used on station per man per day averaged 4.43 gallons. "This amount was sufficient to keep on the borderline of cleanliness. However, considering the acne and other skin disorders, while this does not approach the minimum for existence it is below the minimum for reasonable comfort." At the end of her first patrol in the Marshalls area, the total amount of fresh water reported used by personnel was 12,223 gallons or 4.9 gallons per man per day. "Patrol endurance was limited by potable water capacity. Increased consumption was due to higher temperatures, longer submerged periods and shorter time on the surface for distilling." The average wet bulb temperature was 83.3 degrees, the average dry bulb temperature at the end of the day was 92.7 degrees. An average of 97 gallons of condensate water were recovered daily. No mention is made of fresh water consumption on her third patrol, but the situation must have been grim for the temperature in the ship during all day dives near the equator was excessive, the average being well over 95 degrees with humidity of 70 per cent. The average battery compartment temperature was 116 degrees. Ventilation and air conditioning were inadequate on this patrol.

TRITON (No. 1, 2).--The TRITON reported after a pre war patrol made in 1941 that 454 gallons of fresh water or 6.75 gallons per man were used per day. The ship's evaporator made 4.65 gallons per day. The majority of the water was used in cooking and washing dishes. On her second patrol, made in the Wake Island area, the "potable water situation was one of the chief causes of concern." The capacity and type of distilling installation on this class of submarine are inadequate. "Electric stills were requested. In last two weeks on the station by closing the wash room, potable water consumption was cut to 275 gallons per day, water being only used for battery, washing dishes, cooking, and drinking. Condensation, after chlorination, was used for laundry and battery purposes."

PERMIT (No. 1), TAMBOR (No. 1), ARGONAUT (No. 1).--The PERMIT on her first patrol which was of 41 days duration in a tropical area, rigidly curtailed the use of water after the first day. The average daily consumption for all purposes was 256 gallons. "There were numerous cases of prickly heat, a few cases of 'guam blisters' and three cases of fungus infections of the ears." On her first patrol made in the Wake Island area, the TAMBOR reported a similar state of affairs: "Managed to produce about 125 gallons of fresh water each night by rigid economy, which meant that no one had a bath. We kept the fresh water consumption to about 250 gallons per day. This condition lasted for 8 days. I considered that it would have been necessary to health to have left station for a full night--about once a week to make fresh water (running on all generators) and let everyone have a bath." Condensate water was not used on this patrol.

On the first patrol of the ARGONAUT (SS166) enroute to the area, no water restrictions were employed, 900 gallons of water being used a day (with a crew presumably of 90 men), about 10 gallons per man per day. Eventual establishment of water restrictions with showers every third day reduced the amount of water used per day to 550 gallons (about 5.5 gallons per man per day). Then the stills became defective and use of water was further curtailed to cooking, drinking, and use in the scullery, consumption thereby reduced to 200 gallons per day or about 2.2 gallons per man per day.

DOLPHIN (No. 1).--The first patrol of the DOLPHIN, made in the Truk area, lasted about 47 days; 30 consecutive all day dives, averaging 13.5 hours were made for a total of 405 hours. Air conditioning being defective, the average temperature was 97 degrees with relative humidity of 98 per cent. Before reaching the area the showers were closed; eventually the use of water was limited to washing the face and hands, under which condition 5 gallons per man per day were consumed (the still produced 4.5 gallons per man per day) "an absolute minimum figure." In the first week aboard, every man broke out with heat rash.

"Due to the high temperature and humidity of the boat during dives, an abnormal amount of water was drunk. Believe that a more or less unhealthy condition existed in that men were not able to bathe or launder for over a month. After working for several hours in a hot compartment, they merely wiped off the sweat and laid down in hot damp bunks."

TROUT (No. 1), TUNA (No. 1), PORPOISE (No. 2), NAUTILUS (No. 7).--The TROUT on her first patrol in the Wake Island area reported an even lower expenditure of fresh water; 150 gallons a day were used for cooking and in the scullery. The battery consumed 150 gallons per day. The scuttlebutts were secured; water for washing was taken out of the trim tanks. Water for drinking purposes was put out in a 10 gallon can, 80 gallons a day being used. Habitability on this patrol was reported as good. On the TUNA's first patrol the showers and drinking fountains were secured. Use of basins and spigots was not restricted, the crew being allowed unlimited sponge baths. Chlorinated condensate was used for washing clothes. Five and two tenths gallons of water per man per day were consumed. Sixteen men were treated for fungus infection of the skin. Habitability was reported as good. It was observed by high authority that "unnecessary restriction in the use of fresh water is of such high importance to morale that every effort should be made to allow its use in reasonable quantities."

Fresh water consumption as listed above was reported by the THRESHER (2-42), TARPON (2-42), SARGO (1-42) and GRAMPUS (4-42). PORPOISE's second patrol, as noted elsewhere, was terminated in part due to a lack of air conditioning. Health of the crew was described as "seriously affected". Concerning water supply it was noted: "Battery water is distilled with difficulty but the supply of potable water gradually dropped." The NAUTILUS on her seventh patrol (1943) with 181 men aboard observed that: "the combination of water loss through engine failure and the large number of passengers carried made the water situation acute at times."

ALBACORE (No. 1), GATO (No. 1), GROUPER (No. 1), AMBERJACK (No. 1).--The first patrol of the ALBACORE (1942) was made in tropical waters with an injection temperature of from 80 to 85 degrees. By using air conditioning units to offset the heat and the humidity while on station, the ship was kept relatively cool and comfortable, the health of the crew being excellent with but three days lost to illness. The following temperatures taken in September at about 1500 are indicative of the conditions on an all day dive. Minimum temperature 86 degrees in the crew's quarters; the maximum temperature was 90 degrees in the after engine room, maneuvering room, and after torpedo room; the average temperature was 88 degrees. The relative humidity was 76 per cent; the battery temperature was 103 degrees. The daily consumption of water, for all purposes, on this and two subsequent patrols, (1942 and 1943) varied from 420 to 495 gallons per day with an average of about 6.4 gallons per man per day.

On the first patrol of the GATO (1942) made in tropical waters, 29 consecutive days were spent submerged, averaging slightly less than 15 hours per day in sea waters of 81 degrees. The maximum temperature of the batteries reached 132 degrees. The maximum hydrogen content in the boat at the end of the dive, prior to surfacing was 0.6 per cent (average of about 0.3 per cent). Both air conditioning units were run continuously. The health of the crew was excellent, there being only two admissions to the sick list. On this patrol 33,000 gallons of water were made by the two evaporators. On the GROUPER's first patrol (1942) 55 days, averaging 15 hours per day, were spent submerged. On the next two patrols of this ship, about 6.7 gallons of water were used for all purposes per man per day. The AMBERJACK at the conclusion of her first patrol (1942) reported that "air conditioning made the ship quite comfortable during the entire stay on station, even though the temperature of the sea was from 85 to 86 degrees F. and the battery temperature stayed around 122 degrees. The fact that the air conditioning units were constantly in operation was believed to have prevented many colds. Twenty-five thousand eight hundred gallons of potable water were used. No restrictions were placed on washing clothes as ample water was available at all times in the form of condensate from the air cooling units. The water was clear, odorless, and less than half the output was used."

APOGON (No. 2), PLUNGER (No. 10) - Salting of Water Supply.--Prior to departure of the APOGON on her second patrol (15 January 1944) potable water was taken aboard which, for purposes of purification, had been previously chlorinated (free chlorine). Enroute to the area, because of its excessive chlorine content, part of this was dumped. Rough weather at Midway prevented replenishment of the supply of fresh water. Some of the remaining water was inadvertently re-distilled into the battery water, slightly contaminating two tanks. On 4 and 9 February, after watering the batteries (previously the water had apparently tasted satisfactorily) chlorine gas was detected and traced to the after battery. Sixty cells were unwatered and the contaminated water was dumped. On 24 February, and for the remaining two weeks of the patrol, it was necessary to secure the laundry and showers and limit the consumption of water for all purposes to 200 gallons per day (2.5 gallons per day per man). On 25 February only 1,800 gallons of potable and 900 gallons of battery water remained aboard. On 26 February considerable amounts of fresh water were lost due to a crack in the

exhaust muzzle. In making potable water (using the distillers with the by-pass open) further loss of water resulted when various gaskets carried away. Five hundred gallons of water were left at the end of the patrol. "The shortage of fresh water would have necessitated ending the patrol at the time it did." "The capacity of the water tanks is 4,000 gallons. This vessel does not have a third auxiliary tank which could be used to carry water. It is believed that fresh water consumption should be increased to at least 6,000 gallons." On her third patrol (May 1944) it was reported: "Limited capacity of fresh water levels of this class of submarine makes it imperative that stills be in first class operating condition prior to the starting of every patrol."

The PLUNGER (No. 10, 56 days duration, 27 days submerged) in March 1944 reported that: "Loss of the air conditioning plant (several depth charges) and its condensate reduced the amount of water available for baths. The fresh water scarcity was further aggravated by accidentally salting 600 gallons."

FRESH WATER ENDURANCE AND AUXILIARY TANKS

The SKIPJACK at the end of her fourth patrol in March 1942 reported that the potable water endurance was unlimited as long as the Kleinschmidt stills were operable. POLLACK (No. 3) in June 1942 reported that with two Kleinschmidt stills "have a capacity of 12,000 gallons of water plus the quantity in the tanks." (It would appear that auxiliary tanks were probably used for fresh water stowage.) SEAL in July 1942 (No. 3) reported: "Restricted the use of water but it was not a problem. Started with one and three auxiliary tanks filled."

SEAWOLF (No. 10, 1943) stated: "This is the tenth consecutive patrol in which the ship has left with No. 1, 2 and 3 auxiliary tanks filled with fresh water. In no case has salt water been taken into the auxiliary tanks." SARGO (No. 9, December 1943): "Carried fresh water in No. 1, 2 and 3 auxiliary tanks. No inconvenience in trimming experienced, and added water permitted use of showers and washing machines. In addition, collecting tank for air conditioning provided plentiful source of water."

PIPER (SS409, commissioned in August 1944) after her first patrol of 63 days duration, 26 of which were spent submerged, made in the Honshu area, observed: "The fresh water tank capacity is much too low for the number of men carried aboard (84). Should go back to using the three auxiliary tanks, using one for emergency fresh water and battery water." In June 1945, at the conclusion of her second patrol made in the Kurile Island area (49 days duration, 9 submerged days, 96 men aboard) it was reported "the cold climate created such a yen for basin baths that water hours had to be instituted." "Lack of condensate (probably resulting from cold weather operating area; one air conditioning unit was running all the time) for laundry and washing caused some inconvenience but clothing changes were at a minimum and equalized this." RAZORBACK (SS394, commissioned in April 1944) with 93 people aboard reported unsatisfactory performance of her stills. The number one unit was out of operation for 3 days. Twenty-six days before the end of the patrol it began to produce water unfit for battery consumption, the No. 1 distillator operating at excessive pressure the entire patrol. No mention was made of curtailment of fresh water because of these materiel defects.

SUMMARY

It is said that in one to three weeks, depending on the rate of water consumption, the water in the fresh water tanks is diluted 50 to 90 per cent with the water distilled on board. A modern submarine during a war patrol will consume an average of 1,000 gallons of fresh water per day for cooking, drinking, and engine water make up. In addition to this, the main storage batteries required about 500 gallons of water per week (Submarine School, U. S. Naval Submarine Base, New London, Conn., "Inst. Pamphlet Fleet Type Submarines," NavPers 16160, Restricted, 1945).

As observed (ARGONAUT) the average water consumption (unrestricted) before a patrol (off the dock) averaged from 8.6 to 10.8 gallons per man. Enroute to station, without water restrictions, 900 gallons per day (approximately 90 men aboard) or 10.0 gallons per man were used. When water was restricted to the extent that showers were curtailed to one every three days, 550 gallons of water were used per day, 5.5 gallons per man.

We have seen from the above reports (and the majority of these were made in 1941 and 1942) the extremes to which, with very rigorous restrictions, water consumption may be reduced, the lowest figures per day for fleet type submarines being reported by the ARGONAUT (No. 1, 2.2 gallons per man per day) and the APOGON (No. 2, 2.5 gallons per man per day). When the auxiliary tanks are used to augment the supply of potable water, together with the use of condensate (provided the stills function properly) present day submarines generally contemplate no fresh water problems. When condensate is neither saved nor utilized and when the auxiliary tanks are available, the capacity of the fresh water tanks in one instance (PIPER 1 and 2) has been reported as inadequate, particularly for prolonged patrols with an increased (war-time) complement.

In one instance (TAUTOG No. 1) patrol endurance was limited by the potable water capacity. On two other patrols (TAMBOR and APOGON No. 2) potable water capacity assumed considerable importance with regard to the duration of the patrols.

FRESH WATER CONSUMPTION ABOARD S-CLASS SUBMARINES

The available data concerning the production and use of fresh water aboard the "S" class of submarines is very limited. These submarines, with a crew of about 51 men, made patrols averaging about 27.8 days in length. As observed, the daily consumption of fresh water, particularly on patrols made in the Aleutian area, sometimes was reported as being amazingly low per man per day. Note should be made of the difference between the amount of water consumed per man per day on cold and hot weather operations. On two patrols (S-38, No. 8 and S-47, No. 3) the amount of fresh water consumed affected, in part, general patrol limitations.

The commanding officer of the S-21 (No. 1, December 1941 and January 1942, off Panama) reported that while running on one engine it was impossible to keep up with the consumption of fresh water--which had to be limited to the use of cooks, and mess attendants.

The S-23 (No. 1) in the first report of a war patrol made in the Alaskan area (17 Feb 1942) reported that 2.1 gallons of water per man per day were consumed. The ship evaporators could produce without difficulty 100-150 gallons per day "which is adequate, the ship being self-sustaining indefinitely in fresh potable water."

On the first patrol of the S-18 lasting 34 days with 14 hours per day being spent submerged, in the Aleutian area, 1.5 gallons of water per man per day were consumed. On the second patrol, in the same area, the average temperature in the conning tower varied between 22 and 32 degrees and ice collected on the boat up to two inches or more in thickness. An average of 1.9 gallons per man per day was consumed.

A Kleinschmidt type of still was installed at the end of the fifth patrol of the S-18. The S-33 (No. 2) on a 37 day patrol in the Aleutians, with 50 men aboard, consumed an average of 2.2 gallons per man per day. Living conditions aboard on this patrol were poor. The S-47 made her first patrol (30 days duration, 19 of which were spent submerged, average length 13.8 hours) in the Rabaul area in 1942 with air conditioning. Habitability was poor; the temperature in the boat averaged about 96 degrees with relative humidity of 100 per cent. An average of 4.38 gallons of fresh water was consumed. The evaporators were putting out brakish water. The strictest economy had to be practiced to reach port with the available supply of fresh water. On her second patrol, made 15 days later, in the New Britain area (27 days in length, 16 days submerged, average of 13 to 16 hours) habitability conditions were again poor when submerged. The average daily consumption of water was 3 gallons per man.

The S-38's eighth patrol (Gilbert Island area, 31 days duration) was likewise made without air conditioning. "In all day dives the humidity approached that of a tank full of saturated steam. Habitability is bad but we can take it." Three thousand two hundred and seventy-five gallons of drinking water were consumed (61.8 gallons per man or approximately 2 gallons per day). Among other factors the amount of drinking water consumed was felt to have limited the duration of the patrol.

The S-28 (No. 1) after a 40 day Aleutian patrol in May to June 1942 reported that "limited capacity for making water with the Clarkson Boiler made rigid limitation of water necessary" one third of the crew had scabies. The S-30 making her fourth patrol in August to September 1942 (32 days duration) in the Aleutians without a Kleinschmidt still reported: "fresh water offered no problem; laundry was not permitted." A Kleinschmidt still was installed at the end of her fifth patrol in October 1942. Such a still was installed on the S-28 in October to November 1942 between her third and fourth patrols. The S-34 (No. 2) June 1942, reported that water was no problem with Kleinschmidt still.

The S-31 (No. 7) in July 1943, after a 21 day patrol in the New Hebrides, reported that with 3 days of cruising left with 600 gallons of potable water available, the Kleinschmidt still ceased to function. Habitability was fair with temperature in the control room rarely dropping below 100 degrees. S-47 on her third patrol spent 19 of 28 days submerged in the Solomons Island area (July-September 1942). She reported habitability as fair, "with the usual incidence of heat rash. Because of the unreliable evaporators severe water rationing was necessary. No showers from 27 August to 22 September; only in exceptional cases was water used for baths. A period of 26 days without a bath is not particularly healthy." The fresh water situation was a factor limiting the duration of the patrol. Because of inability to make potable water, salt showers were rigged on the S-42 on her first patrol.

USE OF AIR CONDITIONING CONDENSATE WATER ABOARD SUBMARINES

The available data concerning the accumulation and use of condensate water from the air conditioning units aboard submarines on war patrols is presented in the following table (Table 27).

Table 27.--AMOUNT OF CONDENSATE WATER PRODUCED AND USED ABOARD SUBMARINES

Submarine	Patrol Number	Date	Area	Duration	Submerged	Complement	Outside Air Temperature	Average Ship Temperature	Humidity (Percent)	Air Conditioning	Amount Condensate Per Day (Gallons)	Gallons Per Man Per Day	Comments
Drum	1	1942	Spring Temperate	56	(*)	*67	Temperate	(*)	(*)	Satisfactory	50	*0.74	Probably had two four-ton cooling units.
Tautog	Pre-war	Oct. to Dec. 1941	Midway	38	480.7 hours	*67	73 degrees F.	75 degrees (Wet) 86 degrees (Dry)	60	Satisfactory	83	1.27	Used for bathing and laundry. Definitely unpleasant to use; pronounced odor. One unit ran continuously; the other part time. Probably two four-ton units.
Tautog	1	1941-1942	Marshall	41	(*)	*67	Tropical	83.3 degrees (Wet) 92.7 degrees (Dry)	(*)	(*)	97	1.45	Increased production of condensate associated with higher temperature and longer dives.
Drum	5	Spring 1943	Truk	50	(*)	*67-70	Tropical	(*)	(*)	Satisfactory	150-200	2.61	With crew of 70, condensate would amount to 2.5 gals. per man per day if an average of 175 gals. was produced per day.
Drum	6	Summer 1943	Bismarck Sea	49	32	*67-70	Tropical	(*)	(*)	Satisfactory	200	2.98	With crew of 70, condensate would amount to 2.8 gals. per man per day. CO_2 absorbent used each all day dive.
Snapper	7	Summer 1943	Marianas	44	29	*67-70	Tropical	(*)	(*)	Satisfactory	300	4.48	With crew of 70, condensate would amount to 4.2 gals. per man per day. Probably had 2 four-ton units.
Trout	8	Spring 1943	Empire	43	(*)	*67-70	Temperate	(*)	(*)	Satisfactory	150-200	2.61	With crew of 70, condensate would amount to 2.5 gals. per man per day. Probably had 2 four-ton units.
Tambor	9	Winter 1944	China Sea	61	(*)	*67	Temperate	(*)	(*)	Satisfactory	300	4.48	"Twelve thousand gallons alone were obtained from the forward air conditioning unit."

Legend: * - Indicates approximate or unknown item, number or quantity.

DISCUSSION

TAUTOG (Pre-War and No. 1).--The TAUTOG on her 38 day pre-war patrol made off Midway Islands in October and December of 1941 accumulated some interesting data in regard to this subject. On this patrol 460.7 hours were spent submerged with presumably a crew of about 67. The average temperature of the outside air was about 73 degrees F. Daily temperature readings taken just prior to surfacing were as follows: wet bulb 75 degrees, dry bulb 86 degrees, with humidity of 65 per cent. The number two air conditioning unit was run continuously; the number one was run part time. Under these conditions an average of 83 gallons of condensate were recovered per day (1.27 gal/m/day) which was used for the batteries and washing clothes thus augmenting the available supply of fresh water. Each man was allowed a total of 4.43 gallons per day. On her first patrol of 41 days duration made in the Marshall Islands area with presumably the same size crew, the average wet bulb temperature was 83.3, the average dry bulb temperature at the end of a submerged day was 92.7. The humidity percentage is not known. Ninety-seven gallons of condensate were recovered daily, an average of 1.45 gal/man/day. Nothing is known about the battery temperature.

DRUM (No. 1, 5, 6), SNAPPER (No. 7).--The DRUM's first patrol was made in the spring of the year in cool water. It lasted 56 days, presumably a crew of about 76 was carried. The amount of time spent submerged is not known nor are special details with reference to the temperature and humidity. Air conditioning worked satisfactorily. Presumably the ship was equipped with two four-ton cooling units from which 50 gal/day of condensate water was collected. On the fifth patrol made in the Truk area in the spring, air conditioning kept the boat comfortable and dry. "During this patrol the air conditioning plant put out from 150-200 gallons of condensate per day" which was thrown away. Now, if one figures that the ship carried 67 men the average amount produced per man per day is 2.61 gallons; with a crew of 70 it would be 2.5 gallons. On the sixth patrol of 49 days in length, 32 days being spent submerged, "the air conditioning system produced 200 gallons of water per day" despite the fact that one can of CO_2 absorbent was spread during each all day dive. With a crew of 67 men, 2.98 gallons were produced per day; with crew of 70, 2.8 gallons were produced per day. The SNAPPER, on her seventh patrol (Marianas, 49 days duration, 29 days submerged) reported that approximately 300 gallons of condensate water were produced per day which would have provided an abundant supply of water for the laundry had the washing machines been functioning.

TROUT (No. 8), PIPER (No. 2).--On the TROUT's eighth patrol made in cooler waters (43 days in duration) it was reported: "a 75 gallon tank was installed in the crew washroom to which condensate draining from both air conditioning coils was piped - thus providing an additional 150-200 gallons of water daily for general use." By way of contrast to the amount of condensate produced on northern patrols, the experience of the PIPER (No. 2) is quoted. The patrol, lasting for 49 days (9 days submerged) was conducted in the Kurile Island area with 96 men aboard (April-June 1945). Air conditioning was satisfactory and was apparently operated in reduced capacity. With the increased complement and increased need of hot water for showers "lack of the condensate for laundry and washing caused some inconvenience."

USE OF CONDENSATE WATER, FURTHER COMMENTS CONCERNING

Other comments concerning condensate and its use aboard submarines on war patrols were as follows.

In 1942: NAUTILUS (No. 1) with a normal complement and two six-ton cooling units: "Ample water was available from the air conditioning for baths, laundry and scrubbing down." SARGO (No. 1) expending an average of 2.76 gallons fresh water per man per day used condensate water and the first distillate from the evaporators (generally containing high content of chloride ion) "for dishwashing and personal needs." TUNA (No. 1): "After adding chlorinated lime to the condensate water for purposes of sterilization used it for laundry purposes in the washing machine." ARGONAUT (No. 1) "used it to clean the paint, deck, and for the batteries." SWORDFISH (No. 3): "Installation of a 45 gallon tank to collect condensate water plus installation of the Kleinschmidt compressor are of unestimable value in improving living conditions on the ship by making fresh water adequate to meet the needs of personnel in keeping themselves, their clothes, and the ship clean."

AMBERJACK (No. 2): "No restrictions were placed on washing clothes as ample water was available at all times in the form of condensate from the air cooling coils--less than half the output was used--although a DC washing machine was used every day throughout the patrol. On this patrol on station the average battery cell temperature was 120 degrees F., the highest temperature being 134 degrees F. The sea temperature averaged between 85-86 degrees F." GATO (No. 2): "Condensate water was obtained from air cooling drains and used for washing clothes."

In 1943: SARGO (No. 9): "Collecting tanks for air condensate provided plentiful source of fresh water." SILVERSIDES (No. 3): "Recommend number one lube oil tank be made into fresh water tank for condensate. The tank capacity for lube oil, exclusive of the number one tank, is more than ample for the cruising radius. Some means of storing the condensate from the air cooling system is needed which could be used for washing and thus reduce the demands on the evaporators."

In 1944: PARCHE (No. 2): "Condensate from the air cooling unit provided more than ample water for laundry purposes." PLUNGER (No. 11): "Loss of the air cooling plant and the condensate water reduced the amount of water available for the batteries." KINGFISH (No. 9): "Condensate provided more than ample water for laundry and cleaning the decks and paint work."

In 1945: SEAPOACHER in January commented concerning provisions for utilizing air condensate: "Twenty-five gallon system designed by this vessel and installed--for using this water in the crew's head and shower resulted in a tremendous saving of water. This could be greatly improved by building two 100-gallon condensate drain tanks in the number two sanitary tank. The 1,200 gallon capacity of this tank is only half used on all day dives. Both air coolers would drain into either of these tanks and piping installed to utilize this fresh water for the crew's showers and laundry of clothing--including provisions for heating. The present fresh water lines would be retained for alternate use." THRESHER (No. 15) in April reported using condensate to make water for the batteries. Concerning the advantage accruing from the utilization of condensate the PIRANHA (No. 5) in July stated: "Condensate tank and shower arrangement installed at Midway were great morale builders during the hot weather." THORNBACK (No. 1, August): "Enough condensate was available to allow extensive use of the washing machine every day."

Source of Condensate

The source of the condensate, of course, is the water vapor present in the atmosphere within the submarine. This, in turn, is an accumulation of the water expended in the respirations of the men, and evaporated from their perspiration--and the steam from the galley. Without a doubt, considerable amounts of water vapor result from the battery cells when on charging, electrolysis of the water occurs, with the formation of oxygen and hydrogen. "The cooling of batteries produced by the battery ventilation system--does not provide sufficient cooling to prevent battery temperatures exceeding 130 degrees under all conditions of operation."

Characteristics of Condensate

TAUTOG on her pre-war patrol reported that the condensate had a pronounced odor and was definitely unpleasant to use. "Boiling appeared to remove the odor and it is probable that it would disappear had the water been permitted to stand for a while." AMBERJACK (No. 1) reported that the condensate water recovered was clean and odorless.

It appears, under normal surface conditions, that the taste is not objectionable. However, at the end of a 6 to 10 hour dive its taste and odor reflect the general staleness of the atmosphere. Others have described it as having a pronounced ammonical odor and flocculent precipitate. "Since this has not been reported in other classes of vessels with air conditioning, it is probably due to the unique arrangement in submarines whereby the heads are included in the air conditioned compartments." PERMIT (No. 4) reported that the condensate often became salty because of salt spray entering the ventilation system when running awash.

As noted, TUNA (No. 1) used the water for dishwashing, laundry, and personal needs after sterilization with chloride lime solution. TAMBOR (No. 1) stated: "Use of condensate from air conditioning coils other than for scrubbing-water or for battery water, if chemically satisfactory, is not considered good practice, except in emergency, as such water might contain germs or other viruses of a contagious nature which might have a deleterious effect on the health of the crew." DRUM (No. 5) thought the water chemically pure and advocated some sort of a filter to eliminate the odor so the water might be used.

Condensate Filters

Lt. Cdr. G. N. Schiff MC-V(S) USNR accompanied the TAMBOR on her ninth patrol (January to March 1944, China Sea) of 61 days duration, 28 of which were spent on station, to investigate the possibility of utilizing condensate water (SMO, USS HOLLAND conf ltr AS-A9-8(1) dtd 2 Aug 1944). Bacteriological examination conducted aboard, before and after filtration of the water, "revealed the presence of very few organisms", it being concluded that the water is fit for potability from this standpoint.

"Using a filter (glass wool, activated carbon, sand and Duolite C-2--an ion exchange resin) he found that the concentration of the soluble salts of copper, nickel and iron could be reduced to conform to existing standards for drinking water. The filtered condensate will meet the battery water standards except for the sometimes high chlorine (chloride ion) content. If a quantitative analysis for chlorine (a test used much aboard ships) is not successful, in an emergency, the water can be mixed with water from the stills so as to reduce the overall concentration and meet the standards of battery water." By use of the filter he concluded that sufficient condensate water can be purified chemically and bacteriologically to make 300 additional gallons daily available for drinking and general purpose use, if the water from the forward and after air condensate unit is realized. The filter designed will filter 12,000 gallons of condensate water from the forward air cooling unit, the average quantity produced during one patrol in temperate climate.

The commanding officer of the SHARK (No. 2, August 1944) reported upon the installation of a Schiff air conditioning water purifier as follows: "This was an excellent addition to the fresh water system. The charcoal purifier, together with the newly installed 30-gallon collecting tank with the heater, afforded excellent washing water for all hands throughout the patrol. The showers were open 48 out of 50 hours and yet the fresh water consumption was well below 500 gallons per day."

Current Bureau of Ships Directive Regarding Use of Condensate

BuShips (conf memo from BuShips, Section 5815, JMB/mg to 5805M, dtd 11 Oct 1945; BuShips ltr SS/S48-4(5815) of 25 June 1945 to ComSubPac, ComSubLant, ComdtNavy Yard, Portsmouth, N.H., Sup Ships, USN, Groton, Conn.) expressed the opinion that the present evaporating units aboard submarines (750 and 1,000 gallon rate) are capable of producing an entirely adequate supply of fresh water and are reliable in service. "It must be recognized that weight and space are very critical aboard submarines and the provision of an emergency source of potable and battery water which service experience has not indicated to be necessary is not acceptable." "It is considered that a tank of approximately 20 gallon capacity should, if space permits, be installed in the crew's wash room to collect" condensate water for use in the washing machine.

VARIOUS INSTANCES OF IMPAIRED POTABILITY OF SUBMARINE FRESH WATER SUPPLY

In these patrol reports various instances of impaired potability of the submarine fresh water supply have been observed.

Potability and the Lining of the Fresh Water Tanks

"--there were a number of vessels on which crews complained of the taste or odor of the fresh water. Almost invariably these complaints have arisen from vessels on which the lining of the fresh water tanks are either 'Metallic Brown' or 'White Plastic Paint.'" In contrast, "water from tanks lined with 'cement wash' is almost invariably free of objectionable odor and taste" (conf ltr from Force Medical Officer, SubForce, Pacific Fleet, 5 Nov 1945 to Research Division, BuMed).

TAUTOG (Pre-War), TRITON (No. 3), GUDGEON (No. 3), CERO (No. 5).--At the conclusion of the TAUTOG's pre-war patrol in 1941, it was reported: "Water from the ship's tanks was unpalatable for drinking in any but the calmest weather. When the ship had any appreciable motion, the water had a light brown color and dark brown taste from the metallic brown paint used in the lining. This condition is too well known throughout the submarine force to deserve comment--the normal explanation being that the paint is not properly dried before the tanks are filled. Recommend reverting to use of cement wash in fresh water tanks until another preservative acceptable to the forces afloat is developed." Commented ComSubPac: "Fresh water tanks should not be recoated with metallic brown except at regular overhaulings when at least two weeks drying with forced ventilation can be obtained."

In this respect other submarine commanding officers reported: TRITON (No. 3, 1942): "Metallic brown compartment paint for ship's fresh water tanks caused heavy discoloration and bad taste to the extent that, eventually, drinking water was drawn directly from the evaporators." GUDGEON (No. 3, Sep 1942): "Drinking water unsatisfactory--will be corrected by coating fresh water tanks with cement wash." CERO (No. 5, Aug 1944): "Water from the No. 1 and 2 fresh water tanks tastes strongly of 'Gelsinete' coat applied during the refit prior to the patrol--the water is bitter and unpalatable."

PERMIT (No. 9).--The PERMIT (No. 9) during a 63 day patrol in May-July 1943, reported an epidemic involving 40 per cent of the crew associated with food poisoning or water contamination, symptoms being nausea and vomiting (without diarrhea) lasting from

5 to 10 minutes. Approximately 8 days later and lasting for two days, a recurrence of symptoms was noticed affecting about 20 per cent of the crew. "In spite of the negligible time spent submerged, health of the crew, as a whole, was poor." In the careful report of the medical officer, Submarine Force, Pacific Fleet, 1943, it was stated: "An outbreak of stomach upset occurred on U.S.S. PERMIT as result of deterioration of the fresh water tank lining. This was composed of a phenolformaldehyde varnish which chipped off during depth charging and then deteriorated with a sticky gummy substance with a sweetish odor."

Contamination of Fresh Water Supply by Oil

The S-42 (No. 2, 1942, a 25 day tropical patrol) enjoyed fresh water the first week of the patrol. "Thereafter water from the No. 2 auxiliary tank had a light brown color, unpleasant odor and taste. Shifted to fresh water tanks but very soon this water also became unpleasant with many resulting headaches and stomach aches. As for myself, I could have vomited upon request any minute day or night for 10 weeks running. Several men gave up water altogether and drank only fruit juices." On 25 July: "three days before the patrol terminated, opened up No. 2 auxiliary manhole and found on top of the fresh water about one-half inch of fuel oil on the starboard side and about 4 inches on the port side."

The S-43 (No. 2, Aug 1942) on a 20 day tropical patrol had a similar experience: "Port evaporator out of commission and the small amount of water made with the starboard evaporator was rusty and barely palatable. Due to a leak in the bulkhead between No. 4 main engine and No. 2 auxiliary main, the fresh water in No. 2 auxiliary was contaminated with oil from No. 4 main ballast tank. Although there was an elimination of the usual symptoms of constipation, the water was oily, unpleasant to taste, and soap would not lather."

Excessive Chlorine Content of Fresh Water Supply

Reference has been made elsewhere (APOGON No. 2, 1944) of excessive chlorination of water taken aboard prior to departure upon patrol and its effect on battery water distilled aboard.

Sanitary Tanks and Contamination of Fresh Water Supply

Aboard some submarines, the No. 1 fresh water tank has a common bulkhead with No. 1 sanitary tank. A leak in this bulkhead (as in a severe depth charge) would result in fresh water contamination when pressure was applied to the sanitary tank to discharge its contents overboard. About one-fourth of the crew of the STURGEON (No. 7) for a period of 7 days were "affected with slight nausea and sickness similar to mild food poisoning. Fault with food or water was never definitely found." "There might be a leak in the bulkhead between No. 3 sanitary and No. 3 fresh water tank or through the deck from the crew's shower into the forward water tank, which was in use at the time--thereby contaminating the drinking water." A supply of water was taken for analysis (refitted by the SPERRY). The use of drinking water from the tank was discontinued. No further information concerning this hypothetical case of contamination of the drinking water from the sanitary tank is available.

SWORDFISH considered such a possibility in investigating the cause of acute gastro-intestinal distress among 90 per cent of her crew on one occasion on her fifth patrol. TUNNY (No. 8) reported flooding of the after battery well with water smelling strong of the sanitary tanks, resulting "probably from a cracked seam in the No. 2 sanitary tank."

No authenticated report of contamination of fresh water, in this way, is apparent from the patrol reports. It is a possibility, however, and one that the pharmacist's mate and medical officer should keep in mind if called upon to investigate the occurrence of unexplained illness aboard a submarine.

Miscellaneous

PARGO (No. 1, Oct 1943): "Two days after the tanks were filled, the drinking water was found to contain wrigglers. Large strainers were placed over the outlet at the scuttlebutt."

The RAY (No. 5, Aug 1944) reported: "The potable water filter definitely made the water unpalatable during the first week but the filter taste disappeared after that period."

TARPON (No. 11, Aug 1944) mentioned that "the drinking water began to take on a strong iron taste when it had not been running for some time before use."

IMPAIRMENT OF HABITABILITY CONSEQUENT TO COPPER CONTAMINATION OF POTABLE WATER ABOARD SUBMARINES

From time to time, before and throughout World War II, the crews of some submarines were afflicted with a distress or illness often ascribed to the presence of excessive amounts of copper salts in the fresh water made aboard the ship. Upon investigation by the Bureau of Ships, the matter was recently made the subject of special investigation carried out aboard the USS ICEFISH by two medical officers from the Naval Medical Research Institute (Lt. Cdr. Gerald J. Duffner (MC) USN and Lt. Cdr. Robert Hayter (MC) USN). Their detailed and well-conducted studies will be referred to later. Much of the technical information which follows has been taken from their report (NMRI Research Project X-588, Report No. 1, 30 January 1946, Confidential).

"Fleet type submarines are equipped with two electric vapor compression distillation units (Kleinschmidt still with a rated capacity of 750 gallons per day). A unit consists of four essential parts--a heat exchanger, a boiler, a vapor separator and a vapor compressor. Cold sea water, entering the bottom of the still, flows around the copper-nickel tubing (of the heat exchanger) and is boiling upon emergence from the upper end of the still. The vapor is led through a vapor separator into a compressor and then discharged into the tubing. On the way down through the tubing the vapor is gradually cooled by contact with the tubing walls. A part of the sea water flows out of the still separately as concentrated brine. The distilled water flows into the distillate collecting tank which is usually made of brass (ICEFISH's tank was made of stainless steel). Water is transferred from the distillate tank first to fresh water tanks No. 3 and 4 and is transferred again when necessary to tanks No. 1 and 2 and put on service." "In one to three weeks, depending on the rate of consumption, the water in the fresh water tanks is diluted 50 to 90 per cent by the water distilled on board."

Pre-War Reports of Excessive Copper Content of Fresh Water

Before the war began mention was made of excessive copper content in the supply of fresh water in two reports. The TAMBOR on her first patrol (really a pre-war patrol since it extended from 19 November to 23 December 1941) with 59 men aboard detected copper salts in the fresh water. "Source of copper probably is the copper line in the distilling system. Chemical analysis of the drinking water indicated that copper in excess of reasonable values was present." The TAUTOG on her pre-war patrol in 1941, in checking the water system (the water being unpalatable consequent to the "metallic brown paint" used in lining the tanks) discovered that "the vapor lines from all of the main evaporators and part of the lines from the battery water evaporators were made of copper, which is probably the explanation for abnormally high copper content of the water found in the water supply made aboard. This would not be normally discovered since these items are either lagged or painted. They will be replaced with copper-nickel pipe in case scheduled installation of the vapor compressor evaporators is delayed."

Early Distilling Units Aboard Submarines and Copper Contamination of Water

Some submarines in these early days of the war were equipped with distilling units (with copper coils) which derived their source of heat from the exhaust of the main engines. Excessive amounts of copper salts in the fresh water were associated with this type of still. The SARGO, at the end of her third patrol in May 1942, reported: "Potable and battery water endurance was satisfactory with regard to quantity--. Quality was poor due to the copper sulfate content of the water being so great that the water had a distinct metallic taste and the entire crew exhibited symptoms of minor copper salt poisoning. This condition could not help but lower the general efficiency of the ship as a fighting unit." On the 37th day of her fourth patrol (15 July) it was reported: "Evaporator output from the forward engine is unsatisfactory--(unfit for drinking) due to the copper sulfate content." "Evaporator so fouled that gives only 20 per cent rated capacity." "All fresh water is more or less contaminated, which indicates that the fresh water piping is actively corroded and will require extensive renovating in the next yard overhaul (carried out at end of sixth patrol)." "Health uniformly good. The Kleinschmidt still was a great help--and a second still will add to comfort."

As the war progressed complaints of this nature continued to be made. Although some of these were proven due to other causes, some were undoubtedly the result of excessive copper salt content of the water. It is believed that the true incidence of impaired potability of fresh water aboard submarines due to excessive copper content was much more frequent than the patrol reports indicate--the condition, in some cases, being almost taken for granted and as commonplace by submariners. The available data in these various reports are tabulated as follows (Table 28).

Table 28.--DATA CONCERNING MASS ILLNESS OCCURRING ABOARD SUBMARINES RELATED TO WATER, FOOD, OR USE OF CARBON TETRACHLORIDE

Submarine	No.	Date	Area	Duration	Submerged	Complement	Type of Evaporator	Copper in Water	Taste	Cigarette Tests	Onset	Duration	No. Men	Symptomatology: Nausea	Vomiting	Pain	Vomiting After Surfacing	Malaise	Comments
Tambor	1	Nov. - Dec. 1941	Wake	35	(*)	59	(*)	Yes, excessive	(*)	(*)	(*)	(*)	(*)	(*)	(*)	(*)	(*)	(*)	Source of copper probably the copper line in distilling system.
Tautog	Pre-war	Oct. - Dec. 1941	Sula Sea	38	*460.7	*73	Engine Exhaust	Abnormally high content	Metallic	Soap Test	Latter part patrol	(*)	(*)	(*) Yes	(*)	(*)	(*)	(*)	Abnormally high copper content in the fresh water distilled aboard; believed originated in vaper lines.
Sargo	3	Mar. - May 1942	Sula Sea	52	Average dive #13.8 #582.7	70	Engine Exhaust	Abnormal in CuSO4 content	Metallic	(*)	(*)	(*)	100 percent	Probably Drinking Water	(*)	(*)	(*)	Probably	Entire crew exhibited symptomatic minor copper salt poisoning; affected fighting efficiency of the ship.
Sargo	4	June - Aug. 1942	China Sea	57	#663.3	70	Engine Exhaust	Yes	Metallic	(*)	37th day	20	(*)	Probably on Drinking Water	(*)	(*)	(*)	(*)	CuSO4 content excessive; water from forward engine evaporator unfit for drinking.
Angler	5	Feb. - Apr. 1944	Philippines	55	26	*73	(*)	Yes	Metallic	Soap Cigarette Test	27th - 55th day	27	1/3 crew	Yes, on 1/3 Drinking Water	crew	(*)	Yes	(*)	Copper incriminated - "last week of patrol 1/3 crew vomiting."
Angler	6	May - 1944	Tropical	27	14	*73	Klein-schmidt 2.2-2.8 ppm	Yes	Metallic	Soap Cigarette Test	16th day	1-7 average 3 days	100 percent	Yes, 26 men	Yes, 48 men	Yes, 14 men	Yes, at onset	Yes, 38	Patrol terminated because of the illness on 26th day; violent onset; copper incriminated.
Pilotfish	1	May - July 1944	Marisas	49	8	*73	(*)	Yes	Metallic	(*)	(*)	(*)	(*)	No	No	No	No	(*)	Metallic taste of water and green crystals disappeared after use of duolite filter.
Redfin	2	Mar. - May 1944	Celebes Sea	44	18	*80	Klein-schmidt .00010 to .00054 ppm	Yes	Metallic	Soap Cigarette Test	(*)	(*)	100 percent	Yes, on Drinking Water	(*)	(*)	(*)	Probably	Numerous cases of nausea and vomiting; copper incriminated.
Redfin	3	May - July 1944	Sula Sea	49	24	*83	Klein-schmidt	Yes	Probably	(*)	(*)	(*)	50 percent	Yes, on Drinking Water	0	0	0	Probably	Glauconite filter in a scuttlebutt, crew's mess (water still produced nausea without vomiting); copper incriminated.
Hasher	5	July - Sept. 1944	Philippines	45	16	74	Probably Klein-schmidt	Yes	Metallic	Soap Test	(*)	(*)	(*)	0	No	No	No	No	Health excellent; pronounced blue color seen when soap added.
Dace	7	May - July 1946	Kurile	47	15	86	Probably Klein-schmidt	Probably	Metallic	(*)	(*)	(*)	(*)	Yes, on Drinking Water	0	0	0	0	"Fresh water developed a metallic taste causing slight nausea."
Kingfish	12	May - June 1945	Kurile	55	12	90	(*)	Probably	(*)	(*)	(*)	(*)	Many	Yes, on Drinking Water	Yes	Yes	(*)	Probably	Many complaints of nausea, vomiting and abdominal pain after drinking water distilled aboard over course of several patrols.
Apogon	7	May - July 1945	Kurile	48	31	*86	Klein-schmidt	Yes, by test	Yes	(*)	(*)	(*)	8	Yes, on Drinking Water	Yes	(*)	(*)	(*)	Fresh water barely palatable; tested and found contained CuSO4.
Apogon	8	Aug. - Sept. 1945	Marcus	25	12	88	Klein-schmidt	Yes	Yes	(*)	(*)	(*)	(*)	No	No	No	No	No	Analysis requested.
Icefish	1	Sept. - Nov. 1944	Formosa	66	34	*80	Klein-schmidt	Yes	Yes	Cigarette Soap Tests	7-14 days	Rest patrol	75 percent	Yes	Yes	Yes	Apparently Not	Yes	Copper incriminated by CO.
Icefish	2	Dec. - Jan. 1945	China Sea	43	16	*60	Klein-schmidt	Yes	Metallic	Cigarette Soap Tests	7-14 days	Rest patrol	75 percent	0	0	0	0	0	Coating of inside of lines in vicinity of distiller resulted in considerable improvement; metallic taste remained but no further illness from its source; copper incriminated.

Submarine	No.	Date	Area	Duration	Submerged	Complement	Type of Evaporator	Copper in Water	Taste	Cigarette Tests	Onset	Duration	No. Men	Symptomatology: Nausea	Vomiting	Pain	Vomiting After Surfacing	Malaise	Comments
Grampus	3	July - Aug. 1942	Philippines	54	#695.3 - 42 days	*73	Probably Engine Exhaust	Perhaps	(*)	(*)	14th - 35th days	5 days	50 per-cent	Yes	Yes	Yes	Yes	Yes	Five day episodes of nausea, vomiting and abdominal cramps occurred twice; "materially lowered efficiency of watch."
Grampus	4	Aug. - Nov. 1942	New Georgia	47	(*)	*73	(*)	Perhaps	(*)	(*)	(*)	2 days	25 per-cent	Yes	Yes	Probably	(*)	Probably	Two day episode illness on two separate occasions; white crystals found in water in silex bowl. "Seriously affected efficiency of ship."
Pollack	3	Apr. - June 1942	(*)	46	16 hour dives	*73	Kleinschmidt	(*)	(*)	(*)	25th day	4	11	Yes	Yes	Probably	(*)	Probably	Copper salts not mentioned by CO; could have been due to carbon tetrachloride.
Skipjack	3	Apr. - June 1942	China Sea	51	#530	*73	(*)	(*)	(*)	(*)	22	48 hours	75 per-cent	Yes	(*)	(*)	Yes	(*)	All complement wilted in 4 hours (running silent); 75 percent nauseated and lost appetite on surfacing; gradually wore off in 48 hour period; cause unknown.
Sturgeon	7	June - Aug. 1943	Empire	52	20	*73	(*)	(*)	(*)	(*)	21st day	7 days	1/4 crew	Slight	Yes	(*)	(*)	(*)	Similar to poisoning from food or water. Nothing definite found.
Bluefish	5	May - June 1944	Tropical	52	39	*73	Probably Kleinschmidt	(*)	(*)	(*)	25th day	1-3	50 per-cent	Yes	Yes	Probably	(*)	Yes	Believe water cause; not definite.
Razorback	2	June - Nov. 1945	Philippines	51	21	75	Kleinschmidt	(*)	(*)	(*)	(*)	(*)	(*)	Yes	Probably	Probably	(*)	Probably	Increasing number of mild and severe stomach upsets, headaches, constipation, and diarrhea. Cause unknown.
Swordfish	5	July - Sept. 1942	Tropical	56	(*)	*73	Kleinschmidt	.00046 to .0002	Yes	(*)	40th day	3 days	90 per-cent	Yes	Yes	Yes	(*)	Yes	Copper incriminated as cause; symptoms recurred on next patrol.
Swordfish	6	Oct. - Dec. 1942	Solomon	51	42	*73	Kleinschmidt	No record	Iodine	(*)	38th to 42nd day	4 days	30 to 100 per-cent	Yes	Yes	Yes	(*)	Yes	Increased symptoms associated with particularly bad lot of water. Said due to carbon tetrachloride.
Steelhead	1	Apr. - June 1945	Empire	48	30	*80	Kleinschmidt	(*)	(*)	(*)	22	14-18	100 per-cent	Yes	Yes	Yes	Yes	Yes	Violent onset; seriously impaired fighting efficiency of ship. Diarrhea present; cause undetermined.
Cod	2	Jan. - Mar. 1944	China Sea	63	45	(*)	Kleinschmidt	No	No	No	18th	25	95 per-cent	Yes	Yes	Yes	Yes	Probably	Proved due to carbon tetrachloride; additional symptoms, headache and dizziness.
Plaice	1	June - July 1944	Bonin Islands	52	18	*73	Probably Kleinschmidt	(*)	(*)	(*)	20	4-19	79 per-many cent	Yes, 1/3 crew	Yes	Yes	Probably	Yes	Thought to have been due to carbon tetrachloride poisoning. Violent onset; light diarrhea; one fever.
Blackfish	9	Sept. - Nov. 1944	Formosa	63	34	82	Kleinschmidt	(*)	(*)	(*)	18th	4-8	80 per-cent	Yes, 80 percent many	Yes	Yes	Yes	Yes	Proven due to carbon tetrachloride; diarrhea uncommon.
Baya	3	Feb. - Mar. 1945	China Sea	46	38	87	Kleinschmidt	No	No	No	31st	3	50 to 60 per-cent	Yes	Yes	Yes	Probably	Yes	Additional symptoms, dizziness and diarrhea; onset followed by jarring depth charge attack; possibly due to carbon tetrachloride.

Legend: * - Indicates approximate or unknown item, number or quantity.
- Indicates hours.

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Illness Aboard the Angler

The second patrol of the ANGLER, of 55 days duration, was made in the Philippines. "Half way through the patrol, fresh water contamination caused numerous cases of severe nausea. During the last week of the patrol, nausea was so pronounced that one-third of the officers and crew could not keep food on their stomachs." "No specific cause for fresh water contamination could be found; several samples were analyzed chemically and bacteriologically and were well within the prescribed limits. The fresh water tanks were scraped, cleaned, given a cement wash and flushed out."

Her next patrol, 3 May to 29 May 1944 (14 days of which were spent submerged) was made in the Sunda Straits. On the 16th day (19 May): "submerged at 0601; surfacing at 2010--the first few cases of nausea being observed. The next day, after a 14 hour and 48 minute dive, upon surfacing, several cases of nausea, especially among the lookouts were observed. At this time I felt it might be due to running silent and the attendant heat--although the heat was never excessive and the duration of silent running not long enough to have caused general discomfort." On the 21st of May, on surfacing after a 14 hour dive--"all officers are now afflicted with nausea and about 75 per cent of the crew." On 22 May: "Physical condition of officers and crew so bad that it is difficult to maintain a proper watch either surfaced or submerged. Lookouts, electricians, ship's cook, radar operators and auxiliary men being afflicted the most. Have tried the following remedies: (1) put the crew on fruit juice alone, no water; (2) held thorough field day in case the boat is contaminated in some unknown way; (3) exercised special supervision in cooking, dishwashing, etc." On 23 May: "Decided to remain submerged today since we do not have enough able bodied officers and men to maintain a proper surface watch." On 24 May a medical officer, Lt. James Bateman (MC) USN, reported aboard; the patrol was terminated two days later. "Health and habitability were limiting factors of patrol since all hands aboard were poisoned for some unknown reason."

This incident was made the subject of a Board of Investigation, 3 June 1944. Twenty-one days later the ship departed on her fourth patrol, the officers and crew having been given two weeks of rest and recuperation. Anconite filters on the scuttlebutts and the cold water tap in the officer's pantry were provided. "Health of all hands was excellent throughout the patrol. Water was much better than on any other submarine the commanding officer has served on." There is no evidence from the patrol reports that a recurrence of the above symptoms were experienced on this ship.

Drinking Water Aboard PILOTFISH (No. 1) and GATO (No. 2)

The first patrol of the PILOTFISH (16 May to 4 July 1944) was made in the Marianas and was of 49 days duration. "The drinking water had a slight metallic taste and small crystals of a green salt and rust were found in the water which had been left to stand. It was determined that the green crystals probably came from the distillers and the rust from the fresh water tank. A Duolite filter has been furnished by the senior medical officer of the Holland for use with the air conditioning condensate. It was connected directly to the scuttlebutt. Both the green crystals and rust with the metallic taste disappeared but small particles of the filter passed through the water." (Note has been made earlier of the similar observation in the fresh water.) The GATO on her second patrol (1942) observed: "Both distilling units were used every night while on the surface and sufficient water distilled to meet the requirements (450 gallons per day). Each unit operated 275 hours. During the first 25 hours of operation a bluish tinge was noticed in the water and upon return to base a sample will be analyzed."

Illness Aboard REDFIN (No. 2)

The second patrol of the REDFIN (19 March to 2 May 1944) was made in the Celebes Sea, 18 days of which were spent submerged. Habitability was excellent. "The fresh water made on board produced a nauseating effect, indicating the presence of a foreign matter. The water was tested for salt content and found suitable for use as battery water. When used with soap the water turns greenish blue indicating high copper content. If cigarettes are smoked immediately after taking a drink, the water has a noticeable sweetish taste. The first drink in the morning was always the hardest. There were numerous cases of nausea and vomiting. This defect in the water system is considered most serious as it greatly reduced the efficiency of the officers and crew. This is not a new problem to submarines. All the old timers who had to drink the water made in the exhaust heater evaporators remember the same taste." It is hard to take. On this patrol considerable anti-submarine activity was experienced. The endorsement to this patrol report observes: "The unpalatable condition of the fresh water supply is receiving intense study. Two sources of water contamination are being investigated: (1) Kleinschmidt still. (2) the brass transfer lines. Various samples of water analyzed show a copper content of from .00010 to .00034 per cent, nickel content of from .00014 to .00048 per cent and chloride content of from .00010 to .00020. ANGLER water did not show as much copper but the color reaction to soap was the same and there

were many cases of nausea. The whole fresh water system is being thoroughly flushed and cleaned. Instructions are being issued to keep the transfer lines filled at all times to reduce the copper oxidation."

The third patrol of the ship, made 24 days later, was carried out in the Sulu Sea (26 May to 14 July 1944); 24 days were spent submerged. "Prior to departure on this patrol a Glauconite Filter was installed in the scuttlebutt in the crew's mess. This did not appear to remove the impurity as the officers drank the water directly from the ship's line and never became sick. Water this patrol still caused a turnover of the stomach when it was drunk in the morning before eating but no sickness occurred. The cause is still unknown." No mention is made of the potability of the fresh water supply on the fourth patrol of this ship.

Illness Aboard the RASHER

On the RASHER's second patrol (19 December to 24 January 1944) of 37 days duration (24 days submerged) in the China Sea: "general symptoms of headache, nausea, sometimes backache, frequent urination and malaise were noted in about half of the crew at various times--with occasional fever not lasting more than 24 hours. Injuries of a trivial nature were followed by imflammatory changes out of proportion to the original injury. Submitted water samples of shore water from Australia for analysis. Debilitation and lowered efficiency among the crew was evident throughout the patrol even though the duration was comparatively short with few submerged days."

Her fifth patrol of 45 days duration (16 of which were spent submerged) was made in the Philippine Islands area with 74 men aboard from 22 July to 3 September 1944. Concerning the water supply, it was reported: "Fresh water had an unpleasant burning metallic taste suggesting copper. It showed a pronounced blue color when a small amount of soap was added and the surface tension appeared high judging from its tendency to foam. Samples from both the evaporators and the tank have been taken." Health was reported as being excellent on this patrol.

Drinking Water Aboard the DACE

The seventh patrol of the DACE, conducted in the Kurile Island area, lasted for 47 days (25 May to 10 July 1945) 15 of which were spent submerged. "Fresh water developed a metallic taste causing slight nausea." No other information is available.

Illness Aboard KINGFISH and APOGON

The twelfth patrol of the KINGFISH conducted in the Kurile Island area, lasted for 58 days (17 June to 14 August 1945) 12 of which were spent submerged: "Intend to give the fresh water tanks, drinking fountains and lines a thorough test this refit to determine the potability of fresh water on this ship. Many complaints from both officers and men have arisen throughout the patrol. The general complaint is one of nausea, sickness and stomach aches after drinking the water distilled aboard. This has occurred throughout several patrols and the cause never determined." Health is reported as excellent.

The seventh patrol of the APOGON (May and July 1945) was made in the Kurile Island area: "Fresh water was barely palatable. Eight men were complaining of feeling 'sick' at the stomach after drinking. It was impossible to run routine laboratory tests (refitted at Midway) but tested for, and found copper sulfate--in samples obtained from the still, fresh water tank and the scuttlebutt." At the end of the eighth and last patrol, terminated on 2 September 1945, it was reported: "The water has a slight metallic contamination; request that samples be taken for immediate testing."

Illness Aboard the ICEFISH and Investigation Thereof

The first patrol of the ICEFISH (commissioned 10 June 1944) made in the Formosa area, was of 66 days duration (9 September to 13 November 1944); 34 days were spent submerged. "Our fresh water still has copper or some other impurity which causes nausea and stomach discomfort. The commanding officer was one chronic patient--. An investigation will be made during the coming refit." Availability granted did not permit the undertaking of any remedial action. At the end of her second patrol, it was observed: "On the last patrol trouble was experienced with contamination of the fresh water with copper. It is believed that this is the result of verdigris forming around the copper and bronze fittings in the system, later washed into the ship's fresh water tanks when water is transferred to the tanks from the distillers. Lines were coated inside in the vicinity of the distillers during the last refit and resulted in considerable improvement. There is still a coppery taste in the water which is particularly noticeable when the water is warm. Improvement in the condition of the drinking water was marked and there was no further illness from this source."

Further information (Conf ltr CO, U.S.S. ICEFISH, SS367/S48, Serial 01510, 10 September 1945, to Chief, BuShips) reveals that the drinking water, in general, was unsatisfactory on all five patrols of the ship. This was first observed during a three week training period in the Panama area during July and August 1944, the first extended period in which the ship had been self-sustaining. Symptoms were observed then and thereafter in the first 7 days to two weeks, during which time interval, presumably, the contamination of the fresh water supply by water distilled aboard took place and finally reached a point conducive to symptomatology. Symptoms having appeared, persisted until fresh water was again obtained. It was observed that cutting down the consumption of fresh water (fruit juices, etc. were used when available) resulted in some alleviation of the condition. In general the water tasted musty, leaving a hint of metal or dirt in the mouth. All personnel who smoked noticed the disagreeable sweet taste of a cigarette after smoking. The first drink of water, upon rising, was reported as the worst. Some personnel were only nauseated, others complained of "gastritis", stomach pains or cramps with excessive gas and back pains. Some vomited after eating and drinking. Soapy water was of a greenish tint.

Dr. Duffner and Dr. Hayter, in their report (NMRI Research Project X-588, Report No. 1) observed: "It is of interest to note that the impure water did not produce symptoms in all of the crew members. In fact, when certain members of the crew were quite ill and complained of the water consumed, others failed to develop symptoms or notice any peculiarity in the drinking water. Some stated that they noticed no change in the taste of the water until it was called to their attention." "The investigation officers, on making a sea voyage aboard the ICEFISH, reported that the water distilled from the sea was clear and colorless but tasted flat and mildly astringent and turned a blue-green when soap was added to it. The distilled dock water did not possess these characteristics." It was learned, following chemical analysis that the water delivered at the crew's scuttlebutt contained approximately twice as much copper (8.18 parts per million) as did the water delivered at the distilling units (3.67 parts per million).

"There can be no question but that the distillate is definitely unpalatable and that its unpleasant taste is due to presence of a fairly high concentration of copper. It appears reasonably certain that the elements of copper and nickel are derived from the action of the compressor vapor and hot water on the metal tubes in the Kleinschmidt still."

The authors point out the symptoms of acute copper poisoning, and that the occurrence of chronic copper poisoning in man has not been established. "If we assume that the water on a submarine contains 8 ppm copper and a man in a hot climate consumed four liters of water a day, the daily copper intake then would be 32 mg. There is no evidence that this amount of copper ingested daily would produce any systemic effects--." "It is difficult to understand how drinking a glass of water containing a few miligrams of a copper salt can produce nausea and vomiting on a submarine. There are other factors which might lower the threshold at which water containing 8 ppm of copper would produce nausea; namely, tension, motion, high temperatures and humidity following long periods of submergence with 'silent running' and lastly a suspicion that the water is going to make one ill." It was concluded: "There is no evidence as yet which indicates that continued consumption of the drinking water aboard the ICEFISH has produced copper poisoning; the taste of the water, however, renders it undesirable for drinking purposes."

"The newest fleet type submarines are equipped with 1,000 gallon per day distillers, the surfaces of the copper nickel pipes of which are coated with a layer of tin." When units are placed on "all submarines remaining in full commission--copper contamination of the potable water on submarines should no longer be a problem." By the use of a special filter (Schiff filter, among others) it has been thus demonstrated that excessive amounts of metal salt may be removed from water, making it more palatable.

SUMMARY

It seems reasonably evident that on the above 18 patrols (completed by 12 submarines) contamination occurred of the fresh water supply by copper salts. Four of the patrol reports indicate that the effect of the metal on personnel was sufficient to seriously impair their efficiency and the efficiency of the ship (SARGO 3, ANGLER 2, RASHER 2, REDFIN 2); causing termination of a patrol in one instance (ANGLER 3). Of the remaining 13 patrols, symptoms of varying degrees were associated with the copper in 6 instances (REDFIN 3, DACE 7, KINGFISH 12, ICEFISH 1, 2, APOGON 7), and being apparently without effect as reported in 7 reports (TAUTOG, pre-war, TAMBOR 1, SARGO 4, PILOTFISH 1, GATO 2, RASHER 5, APOGON 8). It is said that similar difficulties with excessive copper content of the fresh water were experienced aboard the PUFFER (in first two patrols water had a bluish tinge when soap was placed in it; some nausea upon rising and after drinking fresh water) and the GROUPER, no information of which, however, appears in the patrol reports.

ILLNESS ASSOCIATED WITH THE USE OF CARBON TETRACHLORIDE ABOARD SUBMARINES

"Carbon tetrachloride, when allowed to vaporize in a closed area, is poisonous in concentrations in excess of one hundred (100) parts per million. When used on electric motor armatures as a cleansing spray, it is volatilized by the heat of the turning armature to produce phosgene, which is highly toxic in concentrations higher than one (1) part per million." "Recurring cases of unexplained illness aboard submarines in the early part of the war were the subject of considerable investigation. Many of these cases were found to be due to carbon tetrachloride. Poisoning from carbon tetrachloride is difficult to distinguish clinically from sub-acute phosgene poisoning, except that surfacing and airing the boat in the latter results in increased nausea and vomiting, while fresh air improves the characteristic nausea, vomiting and, at times, diarrhea of carbon tetrachloride. Incidence of such poison cases on submarines was of sufficient order as to have the use of the offending agent abolished by order of the Force Commander". (From Conf ltr Force Medical Officer, Submarine Force, Pacific Fleet, 5 November 1945 to Research Division, BuMed.)

It appears certain that the use or presence of volatilized carbon tetrachloride accounted for serious illness aboard 6 submarines as reported in the following 7 patrol reports. It should be observed that serious impairment of personnel efficiency resulted in all instances. This adverse effect was reflected in decreased battle efficiency (especially at night) on 4 patrols (BLACKFISH, STEELHEAD, BAYA, and COD).

SWORDFISH (No. 5 and 6)

SWORDFISH on her fifth and sixth patrols experienced episodes of illness originally felt to have been on the basis of excessive copper salt in the water but later apparently proved due to carbon tetrachloride.

The fifth patrol (27 July to 21 September 1942) was made in tropical waters. On 12 September, it was reported: "All officers and about 90 per cent of the crew have been suffering from acute and persistent stomach disorders for the past few days--with constant dull pains in pit of stomach, frequent vomiting and general debility. Temperature, pulse and respiration normal." "Surfaced at end of 13 hours and requested medical treatment by radio--." "Nothing was found to incriminate food. The forward sanitary tanks immediately adjacent to the No. 1 and 2 fresh water tanks were tested for leaks." On September 9: "all scuttlebutts secured--all water for cooking and drinking being drawn from one electric still." By the 17th of September: "disorder had practically run its course, with the majority of the crew remaining weak." The endorsement to the patrol report continues: "The malady which afflicted all hands toward the end of this patrol has been investigated with the following results: (a) The medical officer's report revealed that personnel were probably suffering from copper poisoning incurred from the use of water distilled on board, the copper content of which varied from .00046 to .00002 per cent; (b) the only probable source of copper has been found to be the elements of the vapor separator installed in copper nickel vapor piping from the main engine evaporator to the distillers. The machinery plans indicate the material of these elements to be brass, whereas the elements examined on the SWORDFISH and the SEAWOLF were found to be completely dezincified. The remaining metal was porous copper, which in some cases could be completely crumpled by hand pressure. New elements are being manufactured of brass and will be installed prior to the next patrol. In addition all fresh water tanks are being cleaned of rust and metallic brown paint and will be coated with two coats of cement wash."

On her next patrol (sixth) from 20 October to 9 December 1942, (51 days duration, 42 days submerged) conducted in the Solomons area, the commanding officer again reported an excessive amount of sickness due to stomach disorders. "Thirty per cent of those on board at some time on the cruise were sick enough to vomit while 100 per cent had aching stomachs at one time or another. From the 38th to the 42nd day of the patrol the greatest amount of the illness was seen with 20 people vomiting and two turned in. This particularly bad period occurred soon after a particularly bad tasting batch of water had been put into use which was believed to have been the cause. The taste of water was distinctly like iodine. Two men had cramps and abdominal pain and vomited for 5 days and had to be given intravenous feedings. One man had mild yellow jaundice and was turned in for 10 sick days."

The commanding officer at the end of the seventh patrol reported: "The stomach upsets experienced on the two previous patrols were attributed to drinking water. During the last refit the Senior Medical Officer of the Fulton advised that the malady must have resulted from the inhalation of carbon tetrachloride fumes. This liquid had been carried below decks for cleaning electrical equipment. All carbon tetrachloride was removed from the ship and nothing was done to the fresh water system. It now appears that the trouble has been remedied." In the number of patrols subsequently made by this ship, no further reference is made to similar incidents.

STEELHEAD (No. 1)

The STEELHEAD's first patrol of 48 days duration (21 April to 9 June 1943, 30 days being spent submerged) made in the Empire area, was handicapped "by an epidemic of stomach disorders which affected many of the officers and men, taking the fighting edge off the entire ship for a period of 18 days." The comments of the commanding officer as they appear in his patrol report are as follows: 13 May, 1940: "Pressure built up to about 4 inches during the day and carbon dioxide concentration reached close to 3 per cent. Shortly after surfacing there were 16 cases of violent nausea and vomiting--." 19 May: "Over half of the crew afflicted with stomach disorder and all the officers mildly affected, although pressure in the boat constantly kept below 1 inch and carbon dioxide concentration is below 2 1/2 per cent on surfacing." 20 May: "Many cases of nausea still aboard; cause still undetermined. Most of the cases occur immediately after surfacing when contact with fresh air is made. At one time the entire bridge watch, including the OOD, were regurgitating simultaneously." 24 May: "After long dives the entire bridge detail again taken with stomach trouble, and, in view of possible increased surface patrols in area during the night, decided to shift patrol line to eastward. Only one officer now capable of standing a thoroughly alert watch and 3 are turned in. The condition of the lookouts is little better, and unless the condition is improved by tomorrow consider further operations in this immediate area an unwarranted hazard." 25 May: "Upon surfacing half of the crew were no better; consequently decided to proceed to eastern edge of area awaiting improvement in the condition of all hands." "Gradually, one by one, the officers and men are returning and by 30 May, a sufficient number as to warrant a close-in patrol had recovered."

"Very few men reported being entirely recovered before we left the area. Three officers and men were turned in for 4 to 5 days and those who continued on their feet were fighting their stomachs most of the time. The real cause of the illness has not been determined. It was assumed to be due to carbon dioxide but there is a possibility that battery gases in the boat were a contributing factor." "The following points are considered of interest: (1) the illness developed after the submarine had been in her area for ten days, during which time submerged periods had averaged about 18 hours a day. (2) on the first day of the illness carbon dioxide concentration reached 3 per cent but the symptoms usually associated with high carbon dioxide concentration; namely, headaches, and difficulty in breathing, were not evidenced. (3) all hands were affected at various times; (4) personnel who went into the fresh air immediately after surfacing were the ones most seriously affected; (5) while nausea and diarrhea were present, which would indicate food poisoning, the commanding officer is of the opinion that food was not responsible for the sickness because the epidemic lasted so long and the diet was not changed throughout the episode and after the men recovered; (6) drinking water used at this stage of the patrol was made by the ship's electric stills; (7) personnel were completely recovered upon returning from the patrol."

No further mention is made in subsequent patrol reports from this submarine concerning the cause of this incident. It is presumed that it was likely due to the use of carbon tetrachloride.

COD (No. 2)

On the second patrol of the COD, made in the China Sea (from 11 Jan to 12 March 1944): "Shortly before surfacing on 28 January, after all day dive, various members of the crew were complaining of nausea, headache and dizziness. Carbon dioxide reading showed 1.5 per cent. Carbon dioxide absorbent had been in use since submerging. Since this was the first all day dive in several days it was felt that this might account for the headaches and nausea. Upon surfacing about half of the officers and crew were nauseated and many started to vomit. An hour after surfacing practically the entire crew exhibited some of the following symptoms: cramps, dizziness, nausea, vomiting, weak pulse and subnormal temperature. Approximately half of the crew recovered in the night's surface operations. After inspection, a partially used and improperly sealed, five-gallon can of carbon tetrachloride was found." On 30 January: "The officers and crew, nearly all of whom are still suffering from the effects of carbon tetrachloride or food poisoning, are performing their duties to the best of their ability." "Nothing seems to check it and each unsuccessful attempt to gain a suitable firing position makes the try more difficult." "--Removed to give the crew a chance to recover from their sickness and to try to forget a very sad night."

"Approximately half of the crew recovered in night surface operations and the remainder in the next two days. In some cases the illness lasted for 5 days. Since investigation of the food and water consumed in the previous two days caused no suspicion it is presumed that the lack of oxygen and carbon tetrachloride fumes was the reason for the illness."

Comments concerning this experience by higher authority were as follows: "The attack of illness clearly indicates that it had its origin in carbon tetrachloride fumes saturating the air. The saturation point was in all probability such so as not to bring about more serious effects and the rapid recovery indicates that the degree of poisoning was not sufficient to bring

about any serious complications." "The fact that 90 per cent of the officers and crew were suffering from this poisoning on 29 and 30 January was, in a great measure, undoubtedly responsible for the failure to develop an attack upon an important enemy convoy encountered."

PLAICE (No. 1)

The first patrol of the PLAICE was made (4 June to 25 July 1944) in the Bonin Islands area; 18 days were spent submerged. On 24 June, after about a 16 hour dive, 15 per cent of the crew came down with "upset" stomachs. On 25 June: "Submerged at 0419; surfaced at 1958. Those of the crew first incapacitated are still sick and another dozen are sick. The malady starting in on the officers." On June 27: "Submerged on about a 16 hour dive. Returning at two engine speed to original area. Half of the crew are still sick." On 28 June: "The first to get sick and the lighter cases are getting over the sickness while new ones are catching the 'bug.' At first believed food poisoning, but after careful survey of the symptoms and reaction have definitely decided we are having a full grown epidemic of intestinal influenza. Each case persists about 2 or 3 days at least and the disease spreads to more people each day." On 29 June: "Most of the cases are starting to recover." On 30 June: "All hands to battle stations--invalids would not be denied." On this day COD received 30 depth charges--submerged at 0402, sighted smoke at 1343, hit an enemy ship with torpedo at 1631, rigged for depth charges which were dropped from 1635 to 1830--surfaced at 1957 after an almost 16 hour dive. "Four officers and 3 men had relapses, probably due to the result of the day's excitement." On 12 July the last victim returned to duty.

The onset of this illness, in the commanding officer's opinion, was so explosive as to suggest food poisoning, although no particular item of food could be singled out. The average case lasted 4 or 8 days with the bad ones requiring bed rest and lasting 10 to 12 days. The main symptoms were the sudden onset of nausea, light diarrhea in most cases, vomiting in about 1/3 of the cases and fever in one case. The epidemic lasted for 19 days for a total of 60 cases with 480 sick days. The air conditioning plant worked well. The matter was investigated by the force medical officer. According to the endorsement: "The symptoms indicate the possibility of a gas poisoning such as might result from carbon tetrachloride fumes." No mention of a similar illness as occurring on subsequent patrols is made in the reports.

BLACKFISH (No. 9, 2, 5)

The ninth patrol of the BLACKFISH (25 Sep to 24 Nov 1944) of 63 days duration, 34 of which were spent submerged, was made in the Formosa area. On 21 October the commanding officer upon surfacing, after a 13 and a half hour dive noted: "For the last 8 days about half of the crew have been seriously ill upon surfacing. Tonight at least 70 of the 82 persons aboard are either vomiting or feeling ill. Have found no cause for the condition. Smoking in effect once per hour. It must be the air although the carbon dioxide test shows only one per cent." 22 October: "surfaced; crew sick as usual. This situation is assuming major proportions. Have investigated the Mk-18's, food and air. Have even spread carbon dioxide absorbent and bled in fresh air periodically. No improvement in condition of crew tonight." 23 October: "Situation of crew remained the same, at least 90 per cent sick with several serious cases." 24 October: "Surfaced with few men sick tonight." 25 October: "Crew with two exceptions seems to be recovering from whatever malady has affected them. Hope we are not bothered by this sickness again; battle efficiency has been practically zero, especially at night."

Other points with reference to this episode are as follows: The illness developed on the 14th day on the station, during which time the submarine had been submerged an average of about 13 hours daily. Fully 80 per cent of the crew were affected on the first day of the illness. Personnel who went into the fresh air immediately after surfacing were the ones most seriously affected. In fact, they dreaded surfacing because of the violent nausea, vomiting and upper abdominal pain. Carbon dioxide concentration on one occasion was reported to have been about 3 per cent. Personnel were completely recovered upon returning from patrol.

The writer was one of two medical officers investigating this illness upon the ship's return to Saipan. Thought was given to the possibility of it having been due to carbon tetrachloride but assurance was received that it had not been carried aboard. No personal search was made. "On return to port (to Midway) two nearly empty gallon cans of carbon tetrachloride which had loose lids were found aboard. It is believed that the sickness was caused by lead poisoning from this." It again emphasizes that a medical officer investigating such an episode must not only keep the possibility of carbon tetrachloride in mind but he must personally search for it. Personnel forget that it is carried aboard. In this case it was perhaps never actually used to clean the armatures. The lid of the can may very well have been jarred loose, from whatever cause, with consequent volatilization of the agent into the atmosphere.

It may be, too, that use of this cleaning agent explains the complaints occurring on the second patrol when, in the second week, 23 men complained of nausea, vomiting (2 men), flatus and mild diarrhea without fever and, on the fifth patrol, of the mild episode of DU (food poisoning) experienced in the sixth week.

BAYA (No. 3)

The BAYA's third patrol, from 10 February to 27 March 1945, was spent in the China Sea. It was 46 days in duration, 38 of which were spent submerged with 87 men aboard. On 21 March, the ship underwent a severe close depth charging. "As the ship rolled and worked on the bottom, there were loud creaks and groans heard throughout the boat." At about 1400 the next day (the 22nd) about 15 per cent of the crew were observed to be sick, suffering from dizziness, nausea and general abdominal discomfort. "Cause undetermined." On the 23rd: "At about 1400 (presumably at about the time the ship surfaced) about 20 to 25 per cent of the crew sick; symptoms as previously reported plus diarrhea and vomiting. The possibility of food poisoning has been ruled out as no single item of food was eaten by all affected." "Causative agent not determined. Believe whatever the etiology may be that it is related to the jarring depth charge attack on the 21st. Secured number 1 and 2 fresh water tanks to minimize possibility of contaminated water. Because of the fact that the afflicted officers and men suffered most during the end of the submerged run, it is suspected that there may have been a slight presence of stibine or arsine gas."

It seems likely, from the evidence available, that this is another case of symptomatology upon the basis of carbon tetrachloride. The possible relation to the depth charge attack of the day before is interesting.

MISCELLANEOUS

There were yet other patrol reports with details of illness, the cause for which can not, from the following data, be definitely ascertained. The case for food poisoning is not strong. It would appear that the symptoms experienced aboard the GRAMPUS may have been on the basis of contamination of the fresh water supply. "The similarity of the other cases to the classic symptoms of syndrome poison due to carbon tetrachloride, although it could not be definitely incriminating, was sufficiently great to conclude that they were also cleaning fluid in origin." (Conf ltr Force Medical Officer, Pacific Fleet, 5 Nov 1945, to Research Division, BuMed).

GRAMPUS (No. 3, 4)

GRAMPUS made her third patrol (8 July to 30 August 1942) in the Philippine area; 42 days were submerged for a total of 585.3 hours. On 25 July note was made: "For the past few days several complaints of nausea and loss of appetite (onset on 22 July, the 14th patrol day)--these symptoms lasted not longer than 5 days. On 16 August, submerged at 0530--surfaced at 2100 (15 1/2 hour dive)." "Late in the afternoon greater number of crew complained of feeling sick--one or two in bed--nausea, loss of appetite, vomiting and some abdominal cramps--50 per cent of the crew involved--symptoms lasted not longer than 5 days. During this time watches stood with materially lowered efficiency--." "Investigation of food and water was carried out."

On the fourth patrol, made in the New Georgia area: "On two occasions, the commanding officer, 3 officers and 15 to 20 of the crew were sick for 2 days with what seemed to be food poisoning--the illness was similar to that experienced last patrol. It is felt that the illness was caused by the water, as white crystals were found in the water in the silex bowl. Sickness seriously affected the efficiency of the boat and its recurrence is a matter of serious concern when special precautions were taken to prevent it." No information is available concerning the health of the crew on the succeeding patrols.

POLLACK (No. 3)

The area in which POLLACK's third patrol was made (46 days duration, 30 April to 16 June 1942) is not known; 16 hour dives were made. Two Kleinschmidt stills were carried aboard. "On 24 May (25th day of the patrol) several men began to develop an ailment which was not diagnosed on board. The symptoms were nausea, loss of appetite and vomiting in several cases. Eleven men were afflicted (8 men and 3 officers), two were turned in for a total of 3 sick days." "The illness lasted about 4 days. Water samples were taken for analysis. Drinking water tanks were shifted and the water boiled." Food inspected and no defects found. "The 16 hour dives may have been responsible, as all cases disappeared after day-time surface running was resumed."

It seems that this could have been upon the basis of excessive copper salts in the water; it could have been due to carbon tetrachloride, or even to excessive accumulation of CO_2 on long dives. No mention of similar incidents appears in the subsequent eight patrols made by the ship.

SKIPJACK (No. 3, 2, and 5)

SKIPJACK, on her third patrol made in April and June of 1942 in the China Sea, reported that habitability was satisfactory except when running silent. This condition lasted for about 4 hours on 6 May (22nd day of patrol), during which time about 39 depth charges were received. "Entire complement of officers and men 'wilted.' Upon surfacing that evening 75 per cent of the personnel were nauseated and had lost their appetites. Symptoms gradually wore off with the next 48 hours for the majority. In about 4 cases, including one officer, they persisted and continued to incapacitate the men for 5 days. Submerged for 530 hours." Similar symptoms were reported at the end of her second patrol when "most of the crew and all of the officers were nauseated and tired--lasted 2 days and cleared up and thought due either to water deficiencies or canned beef served at supper the night before." And on her fifth patrol: "between the 30-40th day of the patrol, 75 per cent of the complement became nauseated and lost their appetites for 1-10 days. Cause not definitely known but thought to be due to food or water. Since most of the men unaffected had just come aboard from the relief crew, while many of those sick had made all patrols since the war started, it may be that the latter group is simply a bit run down."

STURGEON (No. 7, 11)

The STURGEON on her seventh patrol reported: "Health of the crew excellent except for one week--from the 3rd to the 10th of July when about 1/4 of the officers and crew were afflicted with slight nausea and sickness similar to food poisoning. Nothing defective was found with the food or water." Here again the etiology of the disorder could have been copper salts in the fresh water, food poisoning or the use of carbon tetrachloride about the ship.

At the end of the eleventh patrol of this submarine it was reported: "During the last few days on station and enroute to Midway about a dozen cases of 'tired stomachs' occurred--probably induced by the long hours of submergence and lack of activity."

BLUEFISH (No. 5)

The fifth patrol of the BLUEFISH was made in tropical waters in May and June 1944. It lasted for 52 days, 39 of which were submerged (about 14 hours average dive). "From 1 June to 3 June (25th day of patrol) a slight epidemic of nausea and headache affected 50 of the officers and crew." Five men were laid up for a day, the remainder felt sick at the stomach and complained of headaches. Believe water caused the trouble; however, nothing is definite since we drank water out of the same tanks before and after the trouble and no ill effects were noted. Food may have been the cause, but it is improbable. Some people who ate all meals felt as bad or good as those who ate their meals during the period. Habitability was very good." Higher authority commented: "The reported nauseous condition during the period of 1 to 3 June has been investigated but the evidence available is too meager to allow finding the cause."

RAZORBACK (No. 2), SKATE (No. 2), SEADRAGON (No. 1 and 8)

RAZORBACK on her second patrol, terminated in January of 1945, commented upon "the increasing number of mild to severe stomach upsets, headaches, constipation and diarrhea. Could not be directly traced to food or water." "On this patrol difficulty was experienced with the one distilling unit which made water unfit for use in the batteries."

On the SKATE's second patrol, terminated in January of 1944 it was reported: "Health was generally good; practically every man and officer in the crew suffered from nausea and diarrhea at some time or another. Some cases were severe. Samples of water have been taken for chemical analysis."

On the SEADRAGON's first and eighth patrols "epidemics" of illness occurred which could have been due to the use of carbon tetrachloride but were considered more likely in the nature of "food poisoning."

IMPAIRMENT OF HABITABILITY BY OTHER NOXIOUS AGENTS

FORMATION OF HYDROGEN GAS ABOARD SUBMARINES

"A certain amount of hydrogen gas is given off from submarine batteries at all times. It is evolved during the discharge and standing of batteries as well as during the charging process when, as the charge becomes complete, hydrogen and oxygen are evolved as a result of the electrolysis of the water with the ratio of hydrogen to oxygen formation eventually becoming 2 to 1. Excessive gas formation is objectionable because of the highly inflammable and explosive nature of hydrogen." "The primary purpose of battery ventilation is to dilute the hydrogen to a concentration which is non-inflammable and non-explosive, so that under the most adverse operating conditions the concentration of the hydrogen under cover of any cell will never exceed 3 per cent." Present day submarines are equipped with hydrogen detectors and eliminators.

On one occasion on the SNAPPER (No. 4): "Decided this was a good night for an equalizing charge. Put in 2 1/2 hours and then vented at zero float for an hour before diving. Upon diving the boat was very hot; at 1630, upon lighting a cigarette, burned with a blue luminous flame. Started the hydrogen detector and also started testing with portable hydrogen detector, obtaining reading of about 4 per cent so at 1646 surfaced and started to ventilate the boat." Comment from higher authority concerning this incident is to the effect: "Due to the advanced age of the SNAPPER's batteries a hydrogen eliminator is being installed during the current overhaul."

On the third patrol of the SKIPJACK "battery gases on discharge were excessive. On three occasions just prior to surfacing, hydrogen content throughout the boat varied between 2.1 to 2.3 per cent."

CHLORINE GAS FORMATION ABOARD SUBMARINES

A few patrol reports mentioned the formation of chlorine gas under varying circumstances. It is not hard to imagine the extent to which the military efficiency of the submarine might be impaired under circumstances where excessive amounts of chlorine were formed.

Chlorine Gas and Flooding Torpedo Battery Compartments

In several instances, chlorine gas formation was reported following flooding of torpedo battery compartments, the following excerpts of which are typical: HAMMERHEAD (No. 4): "Battery compartment of torpedo flooded during attack, emitting chlorine gas into the boat." On her sixth patrol: "Battery compartment of torpedo flooded when the tube was being made ready with the formation of considerable amounts of chlorine." In both instances the remains of the torpedoes were jettisoned.

The TAUTOG on her seventh patrol: "Had a hot run torpedo in the tube. Four bow tubes had been made ready--decided not to fire. Outer doors closed--tube drained--went deep--when, after closing the outer doors, noises were heard in the No. 2 and 3 tubes. Both were found to have been flooded and were gurgling and hot. Handhold plates had cracked from which hot water, black smoke and chlorine gas issued forth."

The FLYING FISH, on her seventh patrol reported a hydrogen explosion followed by a battery insulation fire in the No. 6 torpedo tube. "No personnel injuries. Surfaced for 37 minutes to ventilate the boat and alleviate the concentration of hydrogen sulfide."

Chlorine Gas and Main Batteries

On the third patrol of the COBIA: "Chlorine in the main battery. Both batteries watered with water containing salt. While the batteries were on float, there was no indication of chlorine. About two hours later dove and immediately noticed the smell of chlorine in the boat. The concentration was not severe enough to cause discomfort."

The PETO on one patrol, while submerged, detected chlorine gas in the after battery compartment. The source of salt water was found to be coming from a leaky engine air induction and battery ventilation drain which interconnected. After surfacing and ventilating outboard it was discovered that 5 cells had received a small quantity of sea water. During war-time submerged operations, battery exhaust ventilation was inboard. The possible consequences of this casualty are made more dramatic by the knowledge that the ship, at the time, was under depth charge attack by 3 enemy destroyers overhead.

The STINGRAY (No. 1) reported: "in rigging for depth charge, all drains were closed including those for the battery ventilation ducts which normally drain to the CPO wash stand and thence into the sanitary tank. This procedure caused condensate to collect in the ducts and combine with sea water which leaked through the battery exhaust valve, drained into the after battery with the production of a small amount of chlorine. This was soon dissipated without ill effects."

On the fourth patrol of the S-41, "on diving, the outboard battery ventilation valve jammed in the open position. Water entered the battery ventilation trunk from whence it leaked past the hull flappers to the after battery ventilation system--. Enough water entered to contaminate 20 cells. Traces of chlorine were noticed and the after battery was sealed. After surfacing the compartment was entered by two officers wearing escape apparatus, engines started and the batteries ventilated by the resultant draught."

On the fourth patrol of the S-31, "while attempting to run in a heavy sea with the conning tower hatch closed and the main and auxiliary inductions open, sea water entered the forward battery compartment (via the auxiliary induction) draining into the forward battery well where it apparently mixed with some residual acid, chlorine gas being detected immediately."

Mention has been made earlier of the experience of the S-33 on her third patrol on which 18 and 19 hour all day dives with 55 persons aboard were being made. On one occasion upon surfacing: "All hands groggy with headaches, probably the result of 18 hours of submergence combined with diving while charging the batteries on the finishing rate. In spite of using a can of absorbent midway through the dive, carbon dioxide concentration reached 3 per cent at the end of 17 hours. All hands had headaches and were panting noticeably upon surfacing and about one-third of the crew were coughing." It may be that some of these symptoms were due to excessive fumes from the batteries. The GUARDFISH on one occasion, through a 10 day period of bad weather, had to secure her outboard ventilation: "On those nights, during the battery charge, the sulfuric acid fumes in the living compartments were reported to have reached a concentration that was both disagreeable and detrimental to the general health."

Chlorine Gas Aboard GRENADIER (No. 4) and PIRANHA (No. 1)

More serious experiences with chlorine gas were reported from two submarines during the war. The GRENADIER's fourth patrol, made in the Philippine Island area, from 13 Oct to 10 Dec 1942, lasted for 59 days. Salt water leaked into the after battery well with the formation of chlorine gas. The following notations appear in the patrol report concerning this: 12 Nov: "On the surface--fired again at 0035. At 0657 dove to make an approach--." and received 10 depth charges, 5 of which were close. At 0810 hit bottom; surfaced at 2010. "Noted that all hands were suffering from symptoms indicating chlorine gas with aching joints, pains in the throat and lungs, rasping cough, and some cases of vomiting. Located the chlorine in the battery well and flushed it out. Believe that salt water had leaked into the battery sump from the heads that overflowed due to faulty sea valves." On 14 Nov, it was observed: "The effects of the chlorine are beginning to wear off; however, we now have numerous cases of sore and swollen gums." "The experience was an unpleasant one. The efficiency of the whole ship's company was adversely affected for several days. The following symptoms were noted: 100 per cent had pains in the chest with each breath; 100 per cent had dry hacking coughs; 70 per cent complained of nausea and vomiting; 60 per cent had headaches lasting for 12 hours; 70 per cent complained of soreness of the gums and throat; 50 per cent complained of tiredness for several days." Concerning this episode higher authority observed: "Routine periodic flushing of battery sumps with fresh water and soda solution should be carried out in order to prevent the accumulation of acid which will generate chlorine gas on contact with salt water."

The PIRANHA's first patrol was made in the Formosa area, from 14 June to 8 August 1944 (54 days duration, 28 of which were spent submerged with 76 men aboard). On 18 July at 0357: "Just prior to surfacing it was noticed that everyone was coughing badly and that breathing was difficult. Pressure in the boat was pumped down and carbon dioxide in the air tested but did not exceed 2 per cent." "Upon surfacing at 1800 the entire complement was seen to be affected by coughing; nearly everyone complained of severe pains in the chest with breathing; nearly everyone had a headache. About one-third of the crew were nauseated, 9 of these were sick, most having a high temperature with chills. The pharmacist's mate was the first to go to bed. The only known cause for the sickness is the spirits (Tectyl) that had been used during the afternoon in cleaning torpedoes. There was no evidence of chlorine gas (tests for it having been carried out) although the batteries had been watered during the afternoon." "The next day about 50 per cent of the crew complained of aching and sore gums. Also about 50 per cent had slight throat irritation. Nearly 3 days went by before all hands were feeling normal. Assume that the poisoning came from the spirits used during the day in cleaning torpedoes although had been used previously without ill effects." The squadron medical officer (Sperry) noted: "In comparison with personnel of other submarines returning from similar patrols, PIRANHA's officers and men were noticeably below par physically upon arrival at Majuro, presumably because of the effect of the 3 day experience. Preliminary investigation of the cause--indicates that it was chlorine gas. A detailed report of this will be made separately."

MISCELLANEOUS

Arsine and Stibine.--In this series of reports, no evidence is found which would indicate that the formation of stibine and arsine in appreciable toxic quantities occurred during the charging of batteries. In a memorandum to BuMed (Memo Lt.Cdr. F.C. Houghten C-V(S) USNR, X-jhm, 5 Nov 1942, "Arsine and Stibine in Submarine Battery Losses," to Capt. E.W. Brown (MC) USN (Ret.)) it was stated: "Recently several cases of illness were reported on the submarine POMPANO with the suspicion that arsine and stibine may have been the cause. It should be pointed out, however, that the usual symptoms of jaundice and dark brown, discolored and rank smelling urine were not reported, shedding some doubt on the acceptance of arsine or stibine as the cause." No mention of this incidence is to be found in the patrol reports submitted by that ship.

As reported above, the BAYA (No. 3), in reporting upon 2 or 3 episodes of illness experienced aboard on her third patrol, commented: "Because of the fact that the afflicted officers and men suffered most during the end of the submerged run it is suspected that there may have been a slight presence of stibine or arsine gas." STEELHEAD (No. 1), too, suspected that perhaps the illness experienced by her crew might have been associated with the battery gases.

"A number of epidemics of arsine poisoning occurred in submerged British submarines in the first World War as a result of contamination of the electrolyte with traces of arsenic which lead to arsine formation by reaction with nascent hydrogen in the cell" (Conf ltr Chief, BuMed, Serial 1014, S38/SS (421118) (SC), 18 Nov 1942 to Chief BuShips, "Stibine and Arsine in Submarine Storage Batteries"). Readers interested in this subject should consult for full details of this illness: Dudley, S.F., "Arseniuretted Hydrogen Poisoning", J.R. Nav.Med. Ser. 1919, 5:239-248; and Dudley, S.F., "Toxemic Anemia from Arseniuretted Hydrogen Gas in Submarines", J. Indus.Hyg. 1919, 5:215-232.

HAZARD OF MERCURY VAPOR ABOARD SUBMARINES

There exists in the literature ("Collective Intoxication of Mercury Aboard a Submarine", Giorgis Jacobelli, Ann.Med.Nov. Colon 46:11-12, Nov-Dec 1940, 465-469) report of an illness occurring aboard an Italian submarine, apparently in the nature of fulminating mercury poisoning.

Aboard United States submarines "mercury used in some gyro compasses is open to the atmosphere and vaporization might possibly occur during normal operations, especially in warm climates." In addition, it is known that on several occasions (BILLFISH 2, DRAGONET 1, PIRANHA 1, SEADRAGON 1, WAHOO 6) mercury has been spilled from the gyros (severe storms, depth charge attacks) and from mercury-type electrical switches which have broken. "Because of the physical characteristics of the element, it is believed that any mercury spilled in a submarine would be very difficult to completely recover, and that a limited amount of free mercury may exist in some submarines for long periods. Although there have been no reports which would indicate that mercury vapor has been a source of illness to submarine personnel, it is believed that the mercury vapor tests suggested in the enclosure are appropriate." (NMRI conf memo to BuShips NH6-1/A11, EGH:jt, of 25 Feb 1946). (BuShips conf ltr to ComSubLant, Section 5815, C-SS482/S38(5815) C-SS484/A11 of 26 Mar 1946.)

On the SEADRAGON's first patrol, in a depth charge attack: "Considerable mercury was blown from pitometer log--on 26 January submerged at 0008, surfacing at 1945--with about one-third of the crew suffering from food poisoning believed caused by some beef served the night before. This epidemic lasted for 24 hours." No further details concerning it are available.

Reference has been made to the episode of chlorine gas intoxication aboard PIRANHA (No. 1). This had its onset on 18 July. It is stated in the patrol report: "Master gyro out of commission for 9 hours due to mercury being spilled into the bowl of the master gyro--." The date upon which this occurred is not known. In general the weather was good; from 20-22 July, a typhoon passed close by.

OTHER TOXIC AGENTS

The TUNNY on her seventh patrol, was severely bombed on 1 September with considerable resulting materiel damage. On 2 September, the ship submerged at 0520 and surfaced at 1856: "All hands had headaches from breathing oil fumes from the oil leaking into the boat from the No. 7 normal fuel oil tank."

Concerning habitability on her first patrol the HAMMERHEAD reported: "Habitability was excellent except for a short spell when a bottle of chlorox broke in the rough sea after surfacing. Habitability would have been rather poor if submerged. Advocate a special stowage locker for chlorox, if it is used, in the custody of one man."

During a depth charge attack, the pressure within the forward torpedo room of the HALIBUT built up to about 50 pounds. Air in the compartment was further impaired by the fumes from a broken bottle of chlorox and various toilet waters (crew's lockers).

On one occasion aboard the SEAL on her fifth patrol, "gas escaped from the forward air conditioning unit. On surfacing after this, several officers and men experienced severe headaches. This occurred after a period of silent running, so there may have been other contributing factors."

On one occasion in 1943, a case of near asphyxiation was absorbed aboard the SARGO. This class of submarine, at the time, was equipped with deck storage torpedo tubes, the only access to which, in addition to the below deck hatch, was a secured drainage vent. On submerging there was some accumulation of condensate and flood water in the tubes. Through the course of a long tropical patrol, hydrogen sulfide was generated within the tube due to the action of sea water on organic material. Detection of the gas was almost immediately apparent on opening the hatch. That its concentration within the confines of the tube might well have been lethal was convincingly demonstrated when, to retrieve the manila line stowed within, a crew member crawled into the tube and had to be subsequently rescued and treated for asphyxiation. Commenting upon this incident, ComSubPac directed: "In the future, care should be taken to thoroughly air out these tubes before entering them after long periods at sea."

FIRES ABOARD SUBMARINES

Fires occurred not infrequently aboard submarines. Some of these were minor and easily extinguished. A few, however, were or might have been accompanied by disastrous consequences.

BASS (No. 4)

The worst fire occurred aboard the BASS on her fourth patrol off the coast of Panama, on the 17th of August 1942. BASS made a routine morning dive at 0455. At 0535 fire broke out in the after battery compartment. The ship surfaced and the procedure for fire drill was carried out. "Twenty-six crew members trapped in the after compartments of the ship died of asphyxiation. They were apparently overcome by the gases of combustion which spread rapidly due to several low order explosions. Nearly all men dead were asleep at the time of the fire. The intense heat and the necessity of sealing off the battery compartment prevented rescue work through the ordinary means of entrance. Rescue work had to be carried out via the after torpedo room loading hatch and the escape hatch. Shortly after surfacing, two men in the after compartments were rescued. The remaining bodies, except one, were brought upon the deck from the sealed compartment. Attempts were made to revive them using artificial respiration, strychnine and free oxygen. The last body was removed at 1000. Increasing seas and heavy rain required that the bodies be taken below where artificial respiration was continued until rigor mortis became apparent. The bodies were placed in the forward crew's space. By the 18th, the odor from the dead was sickening; they were removed to a surface ship on this date."

"Rescue work was hampered in that all work had to be done using smoke masks, working in heavy smoke and the intense heat in the after torpedo rooms, by increasing seas and heavy rain and by the outbreak of a fire in the crew's galley." The Momsen lung was used for rescue work. Its use was made hazardous by the danger experienced of chance losing the mouth piece with the individual's attempt to turn his head or raise his head above the horizontal. The hands, moreover, could not be used to hold it in place while holding a stretcher. Sometimes the eye pieces of the goggles fell out, and it was difficult to keep the nose clamp secure, especially when the skin became wet.

"Due to the strenuous work, coupled with the gases and the injured men, the crew became quite exhausted. It was necessary to more or less double the watches."

S-35 (No. 5) - CONTROL ROOM FIRE

An equally serious fire occurred aboard the S-35 on her fifth patrol in the Aleutian area. On 21 December, consequent to break down of the insulation of the main power cables, fire broke out in the control room at 1830. Two compartments had to be very soon abandoned. Two fire extinguishers and some lungs--all the gear that existed aboard the ship for fighting the fire--were pressed into use. The carbon dioxide fire extinguishers were reported as ineffective in checking the fire. Attempts to enter the control room with the smoke lungs were not successful due to the fact that the fire had consumed the oxygen in the compartment. The lungs were subsequently charged with oxygen. The heavy smoke filled the boat. Over a three day period, extreme hardships were experienced. Twice the entire crew of 53 men, suffering from smoke, were driven topside and forced to remain there in the bitter weather with the heavy seas of a three day storm breaking over the bridge. The commanding officer

was nearly completely incapacitated as the result of painful injuries received on the bridge immediately preceding the casualty. On arrival in port the entire crew, upon examination, was found suffering from smoke, exposure and exhaustion. Four men were hospitalized.

COBIA (No. 4) - ENGINE ROOM FIRES

The fourth patrol of the COBIA was made off the Indo-China coast. On 21 February 1945, Desmond, motor machinist's mate first class, while securing the No. 1 engine from a charge, inadvertently closed the outboard exhaust on No. 2 engine which continued running, lifting the relief valve and filling the compartment with exhaust gases. The after engine room crew passed the word "fire" and secured the door between the two engine rooms. Desmond was overcome by the fumes. The engine was secured from the maneuvering room.

Remillard, a shipmate, entered the compartment without a smoke mask and secured the ventilation. He was overcome but was immediately removed by another shipmate, Kutzleb, who had covered his face with a wet rag before entering. He returned to the control room and hearing that Desmond was unaccounted for, grabbed an oxygen rescue breathing apparatus and started aft, adjusting the apparatus as he went. The engaging wheel broke off before the canister was pierced. Realizing the apparatus now furnished him no protection, but knowing that time was precious, Kutzleb continued using the mask. He crawled the length of the compartment to the throttle station looking for Desmond. Not finding him he closed the engine throttle and fought his way back out of the compartment.

In the meantime, the pharmacist's mate had begun artificial respiration on Desmond, who had been removed from the compartment. He was kept under oxygen all night. Kutzleb though nauseated and weak, rapidly recovered in the open air. The next day, because Desmond had shown no improvement, the boat reversed its course and proceeded at full speed for Exmouth and medical help.

The commanding officer stated further: "I have gone to some length in this account to emphasize the toxic, blinding and demoralizing effects of a smoke filled compartment, and the necessity for thorough and frequent instruction in the operation of the cumbersome Navy oxygen rescue breathing apparatus. Because of the weakened condition of both men, oxygen was administered to assist their breathing. Some form of an oxygen mask or tent would have been more efficient than the cloth and smoke mask that we used." Readers interested in other possible demoralizing effects of smoke should turn to the experiences reported by a survivor from the forward torpedo room of the TANG.

SARGO (No. 12), PILOTFISH (No. 4)

A crank case explosion occurred in the No. 2 main engine on the twelfth patrol of the SARGO (Oct to Dec 1944), setting rags and paintwork afire. The boat was filled with heavy smoke, necessitating abandoning the forward room. Personnel equipped with smoke masks extinguished the fire. There were no personnel casualties.

MANEUVERING ROOM FIRES

WAHOO (No. 4), SILVERSIDES (No. 8), SCAMP (No. 7), SEARAVEN (No. 3), SUNFISH (No. 1).--As noted elsewhere, use of the auxiliary induction in the maneuvering room in any but the calmest seas is accompanied by the hazard of water entering the auxiliary induction and flooding the main cubicle. WAHOO (Feb to April 1943) on her fourth patrol reported such an incident: "Several zero grounds were created which in turn started many small fires, making control stations untenable by a very caustic smoke. All forced ventilation was stopped. Cleared the maneuvering room of smoke in a hurry by taking a suction through the after torpedo room hatch."

On 2 January 1944, the SILVERSIDES (No. 8) dove at 1335. Fire broke out in the maneuvering room at 1337. Surfaced at 1359. "Fire about under control but the maneuvering room had become untenable except with rescue breathing apparatus. Ten carbon dioxide fire extinguishers had been used on the fire. The crew fighting it became nauseated and in several cases almost collapsed. Continued submergence was deemed unwise. The only damage was the burnt cork on the overhead. Believe that the cork became overheated while operating at full power and then when the ventilation was secured, upon diving, its temperature reached the ignition point and it burst into flames. The cork is very close to the bus bars and starting resistors. Some insulation with a higher ignition temperature is indicated." "Cubicle fires are probably the greatest materiel casualty an electrically driven submarine can suffer. It is recommended that a permanent shock-proof carbon dioxide system be installed that will quickly blanket and extinguish these fires. As a temporary expedient, more portable carbon dioxide fire extinguishers (carry about 12-50 pound size) should be carried." "The words 'fire in the maneuvering room' when heard in enemy controlled waters is a thrill, but definitely not a pleasant one."

The SCAMP on her seventh patrol (March and April 1944) had a similar experience. Upon one occasion, on sighting an enemy plane, she submerged. She was passing 40 feet when a bomb or depth charge landed on her port side. "A terrific explosion jarred the boat. All hands not holding on to something were knocked from their feet." At 330 feet: "Fire in the maneuvering room; all power lost. Thick toxic smoke filled the maneuvering and after torpedo rooms. All hands aft were sick. We went up and down three times and had started down the fourth time before power was regained. In the maneuvering room the situation was bad. All hands were violently ill. The angles which the boat had taken had not helped. An EM 2/c made three trips to the maneuvering room to rig it for the fourth time. Maneuvering room reported making 2/3 on starboard shaft--never received a happier report. THERE WAS NO CONFUSION. ALL HANDS DID THEIR JOBS WELL AND SILENTLY." This episode took place between 1423 and 1800. At 1755 ten more depth charges were received. Surfaced at 2103. Comment by higher authority was as follows: "--total loss of power combined with the dense nauseating phenolic smoke from the fire in the main control cubicle could readily have caused loss of the ship."

The SEARAVEN (No. 3) in April 1942, suffered a severe fire in her maneuvering room, as a result of which this, and the after torpedo room, had to be abandoned leaving the ship without power propulsion. The smoke in these compartments was very dense; oxygen masks had to be used to return to them.

SUNFISH (No. 1) on 15 December 1943, had a fire in her maneuvering room. The smoke was so thick that the source could not be immediately located. A suction was taken to clear the smoke and prevent the suffocation of men fighting the fire. Carbon dioxide extinguishers and oxygen masks were used. When the smoke cleared sufficiently, it was found that the cork over the starboard main motor resistor was flaming and smoking. The fire was impossible to extinguish quickly unless the cork could be cut away. The cork was inaccessible because the control cell was energized.

SPEARFISH in reporting a fire in her main control cubicle (9th patrol) stated: "Fire in the main control cubicle--lost all main power. The next few minutes seemed like years but our patrol saint was with us--."

TORPEDO BATTERY FIRES

PERMIT (No. 13), FLYING FISH (No. 7), BLUEGILL (No. 3), COD (No. 5).--Fires not uncommonly occurred in torpedo battery compartments. PERMIT (No. 13) reported: "With a fire in a torpedo battery compartment the smoke was heavy and acrid. Donned rescue breathing apparatus and loaded torpedo in tube. Smoke fumes caused 7 day long headaches; the odor from it was discernable over a period of 3 weeks." FLYING FISH (No. 7) reported a hydrogen explosion followed by a battery insulation fire in the No. 6 torpedo tube. "No personnel injuries. Surfaced for 37 minutes to ventilate the boat and alleviate the concentration of hydrogen sulfide."

On the third patrol of the BLUEGILL, two battery explosions in two Mark-18 torpedoes occurred with a serious battery fire following one of the explosions. "--in attempting to pull out the battery and salvage the fish the fire broke out and got ahead of personnel. Heavy smoke and fumes made the habitability in the after torpedo room and maneuvering room dangerous. Opened after torpedo room hatch, closed engine induction and pulled a suction with four engines while the flaming fish was loaded back into the tube and jettisoned by firing."

Similar experiences occurred aboard the HADDOCK (No. 11) (eye irritation associated with smoke), the SAILFISH (No. 12). COD (No. 5) in reporting such fire stated: "Readings were being taken after the completion of the charge on the Mk 18 torpedoes which were partially withdrawn from tubes 8 and 10. An explosion occurred in the torpedo in tube No. 8. The battery of this torpedo burned with a very hot fire which could not be extinguished with the carbon dioxide extinguishers. The after torpedo room was filled with a dense suffocating smoke. The smoke lungs were totally inadequate. This left our two rescue breathing apparatuses and our one shallow water diving mask which could be used and which thus permitted only three men to enter the torpedo room to fight the fire." "At this point the commanding officer would like to point out the inadequacy of the present submarine allowance of the rescue breathing apparatus. The old smoke type of canister, as everyone knows, is of no value whatever. At Pearl Harbor the ship attempted to draw four of the rescue breathers, but only two could be obtained (the ship's allowance). Thus, when this fire occurred only two rescue breathing apparatuses were available (one at each end of the ship) and only two men could work in the compartment, plus one other wearing a shallow water diving mask. At one time a smoke canister and lung were authorized for each compartment. It would seem to follow, therefore, that a rescue breathing apparatus should be authorized for each compartment on the ship. This change is recommended for submarine allowances."

MISCELLANEOUS

THRESHER (No. 5), DARTER (No. 4), GREENLING (No. 11), LAPON (No. 8).--THRESHER (No. 5) reported a waste basket fire, the result of spontaneous combustion when the chemical from a rescue breathing apparatus filler was dumped into a trash can with some old rags.

At the time the DARTER (No. 4) was grounded on a shoal, to destroy the confidential gear prior to abandoning the ship, three fires were started--one in the forward engine room, one in the radio shack and one in the officer's shower. "These made much smoke--which was kept down to some extent by running one blower continuously. More fires would have made destructive work below impossible. As it was, personnel had to go topside for air every few minutes. One man suffered a severe attack of heat exhaustion."

On the eleventh patrol of the GREENLING, a short circuit in the stern plane clutch solenoid caused a heavy cloud of black smoke to fill the after rooms. The fire was extinguished using two fire extinguishers. Rescue breathing apparatus proved invaluable in the heavy smoke. "Exertion and the fire raised the carbon dioxide in the boat to 2.5 but the use of absorbent lowered it to 2 per cent before we surfaced--the fire occurred at 1405, surfaced at 1807."

On the eighth patrol of the LAPON, following overhaul of the main engine, "the engine room requested permission to start the engine. When--it was started an air header box explosion occurred." The commanding officer on the bridge felt the blast of the explosion through the conning tower hatch and ordered "ALL STOP." The explosion had blown off all but two coverplates and filled the engine room with flame and smoke. Six men were in the compartment, 4 were burned about the face, arms and eyebrows. One man with his clothing afire had the presence of mind to jump into the forward engine room before rolling on the deck to extinguish the flames. One man was blown from the after room into the maneuvering room and men in the forward engine room were knocked to the deck. The after engine room was temporarily secured because of the fire. The compartment was entered with rescue breathers and it was determined that all personnel were clear. It was fortunate that no one was behind the engines.

SMOKING ABOARD SUBMARINES

We have observed earlier, in connection with prolonged periods of submergence on northern patrols, that several boats routinely limited the smoking hours and that the NAUTILUS on her seventh patrol, with a total of 181 persons aboard, reported a rise of carbon dioxide concentration from 0.5 to 1.0 per cent after the smoking lamp had been lit for 15 minutes.

NARWHAL (No. 4) observed that despite the fact that smoking was not permitted, carbon dioxide content, with 105 passengers aboard for a 29 day period, reached 4 per cent on long dives. SHAD (No. 1) as did SAILFISH (No. 7) on 16 to 17 hour dives during June, at 40 degrees north latitude, restricted smoking to 5 minutes every 2 hours. On the tenth patrol of the SAILFISH, the commanding officer observed: "Smoking lamp constantly lit and the crew did not abuse the privilege; on two occasions when the possibility was good of being kept down for a protracted period, carbon dioxide absorbent was used."

PERMIT (No. 10) observed concerning the problem of smoking aboard submarines: "No restrictions were placed on smoking. After explaining the plan and requesting the cooperation of the crew, an experimental policy of free smoking was instituted. The results were most gratifying. On many days of submerged patrols the commanding officer has never seen less smoking nor air better at the end of the day (15 days were spent submerged). It seems, therefore, that there is something about the words 'the smoking lamp is lit' that makes a man involuntarily reach for a cigarette whether he wants it or not."

Aboard the S-31 (No. 5) smoking lamp lit every two hours during submerged operations (dives averaged 12 1/2 hours daily); aboard the S-34 (No. 6) it was lit once each watch. Aboard the S-42 (No. 6) the smoking lamp was out most of the day because of frequent contacts.

"Aboard German submarines, because of the explosion danger (hydrogen) no smoking was permitted within the vessel at any time. This deprivation was one of the many which were accepted without complaint by the U-boat personnel as being of absolute necessity" (CICS Field Team Report XXX-61 F2-S-320-46, Confidential).

PRESSURE WITHIN THE BOAT

SAWFISH (No. 4), HAMMERHEAD (No. 1), SEAFOX (No. 1)

There is normally a rise in barometric pressure aboard a submerged submarine which may reach several inches of mercury in the course of the dive. This is due to the compression of the hull and to the egress of air from small air leaks (leaking valve) and venting the tanks inboard. Firing a torpedo may raise the pressure within the boat 1 inch. Commonly in the course of the dive, and often in conjunction with revitalization of the air supply and use of carbon dioxide absorbent, when the pressure rises above 1 inch, a one-half to one-fourth inch vacuum is pulled with the high pressure air compressor pumping the excess air into the air flasks.

SAWFISH on her fourth patrol reported "more headaches than usual, possibly due to the increase of normal pressure in the boat (seldom less than 3 inches at the end of an all day dive) caused by the use of air for ventilating the Mk-18 torpedoes." HAMMERHEAD (No. 1) reported that habitability was improved on all day dives by keeping the pressure down. "By securing the 200 pound air system and the high pressure air forward and aft--and not changing trim--the increase in pressure over a 15 hour dive was decreased during the latter part of the patrol to 0.7." SEAFOX (No. 1) reported that she was unable to pump down the pressure during all day dives because of the stench that was thereby emitted from the sanitary tanks. "The pressure, just before surfacing, generally was around 4 inches."

SCORPION (No. 1), S-42 (No. 1), PUFFER (No. 1)

The SCORPION (No. 1) on one occasion, while laying mines, was submerged for 16 1/2 hours, surfacing with a pressure of eight inches in the boat. The S-42 (No. 1), as has been stated elsewhere, underwent an exceedingly rugged experience following the successful torpedoing of an enemy cruiser on her first patrol. The ship, on that day, had submerged at 0441, torpedoes being fired at 0450. "Pressure built up very rapidly during the ensuing period of silent running (initiate at 0516)--by 0730 the barometer needle had stuck at 10." The ship surfaced at 1830 with "the men completely beaten down."

Reference has been made to the 38 hour ordeal which the PUFFER experienced on her first patrol. She submerged, on that occasion, at 0525, the anti-submarine attack beginning at 1110. Revitalization of the air was begun at 1825. The pressure in the boat built up to 12 inches.

SEAWOLF (No. 10), PINTADO (No. 2)

The SEAWOLF on her tenth patrol reported her crew at the battle station from 0825 until 1730, after which they were on depth charge alert until midnight. With the accumulation of 6 1/2 inches of pressure, the ship became most uncomfortable.

On the second patrol of the PINTADO, "while reloading the No. 5 tube, the torpedo securing strap under the deck caught on the safety stick as the torpedo moved forward, lifting the safety stick from its recess, and at the same time tripping the starting lever of the torpedo (2,500 pounds of air carried in its flask). A dense fog of exhaust fumes from the torpedo immediately filled the forward torpedo room and the forward battery. The gas was confined to this compartment by closing the bulkhead flappers and door. Communications were established with the forward torpedo room but it was difficult to hear due to the great noise and pressure in the compartment. No one was hurt--. Upon surfacing, the executive officer went on deck with a maul to open the torpedo room escape hatch. As the lower hatch in the trunk opened the officer was blown out of the hatch and up on the deck but was not injured except for a bruise on the arm."

HALIBUT (No. 10)

The HALIBUT, while on her tenth war patrol underwent a severe depth charge attack which lasted over a period of 5 hours. A chief torpedoman in describing what happened said: "During the attack about 15 men were in the forward torpedo room which was rigged for depth charging. As the result of 10 extremely close depth charges the high pressure lines (from the control room manifold) carrying about 2,500 pounds were broken. The 6 impulse tank drains were knocked open (in 4 of these tanks there was about 50 pounds of pressure each); the blow valve of the No. 1 sanitary tank in the forward battery compartment (carrying about 200 pounds of air) was ruptured as was the No. 1 air bank. All of the sea valves were knocked open and we could hear the water washing back and forth in the bilges. All of the men sitting on the deck plates, which were suddenly sprung, fell into the bilges, one man being hit across the back by one of the falling plates. One torpedo slipped forward from its suddenly insecured rack. The sides and doors of the lockers were blown out and there was a din of breaking

bottles. The fumes from a broken bottle of chlorox and various toilet waters was very much apparent. All of the lights, except the emergency lights, were shattered; bits of cork and dust were flying around making a regular fog." "The men ran aft to go into the control room because I thought we were beginning to leak but the door was secured and they had to come back. The pressure began to build up, we could feel it. I closed off all the impulse tank drains, master blow vent and the blow vent to the sanitary tank. I figured that there was about 25 pounds of pressure in the compartment by this time. We then closed the door leading into the forward battery. There was still air leaking so we secured all of the high pressure going to the separator; this stopped all of the big leaks. The pressure in the forward battery, according to the gauges in the control room, built up to about 50 pounds; that in the torpedo room probably was about 40 pounds. I think that there was an excess of hydrogen."

"Everyone was breathing fairly normal except there was panting from the heat which was pretty bad; there wasn't any drinking water and we had to drink out of the emergency tanks. Because of the difference in the pressure in the two compartments we very carefully cracked the hatch to the forward battery to equalize the pressure, doing it slowly until the pressure was about 40 pounds throughout. I warned the men about cracking their ears as we did this. Only one mess attendant had trouble. Everyone's voice changed. We had a dog in there with us--he didn't whimper or bark and lay curled up on one of the guy's laps. When we submerged, after several hours, I took the plug out of the bulkhead between the forward battery and the control room but the rushing air made too much noise. By opening up the trim line hose connection in the forward battery and by removing the bonnet of the valve going into the bilges of the forward torpedo room, the pressure was reduced but not completely. So those in the control room took a five-ton hydraulic jack and by using a force of about two and a half tons forced the hatch open into the control room. When it opened there was much fog." None of the men--nor the dog--apparently suffered physical injury as the result of this experience.

SHAD (No. 9), S-47 (No. 1), SAWFISH (No. 3), POLLACK (No. 5), PORPOISE (No. 2)

The fact that there is a normal increase in the pressure within a submarine on an all day dive is important not only from the standpoint of headaches but also from the ability of the individual member of the crew to successfully equalize this pressure within his middle ear. The following excerpt from the SHAD (No. 9) report is illustrative of the importance of this: "One seaman received from the relief crew at Midway burst his eardrum on the first occasion when pressure in the boat exceeded 1 inch. He said that he had never had a pressure test. One fireman was received from SubDiv 82 just prior to getting underway when it was found that he was totally deaf in one ear and was unable to adjust himself to the pressure differential existing between the engine and the after battery rooms."

S-47 (No. 1) reported that keeping the pressure below 2 inches helped in making the ship more comfortable. The commanding officer at the end of the third patrol of the SAWFISH observed that there had been more headaches than usual, possibly due to the increase of normal pressure in the boat--which was seldom less than 3 inches at the end of an all day dive caused by the use of air for ventilating the Mk-18 torpedoes while charging. He observed that the air on long dives on station could be greatly improved by pumping down with the high pressure air compressor and renewing and reviving the air from the high pressure banks.

On the fifth patrol of the POLLACK the navigator opened the hatch too soon and "went up with the pressure, cracking his head wide open on the overhead." On the second patrol of the PORPOISE it was reported: "The heat on dives was almost unbearable, the majority of the crew having severe headaches. Pressure in the boat was 6 inches of mercury on surfacing."

VARIOUS OTHER ASPECTS OF HABITABILITY ABOARD FLEET-TYPE SUBMARINES

LIGHTING AND INTERIOR DECORATION

Several important and highly interesting comments were made by commanding officers concerning lighting facilities aboard submarines.

On the sixth patrol of the DACE: "Misses in the first Salvo in the AK can be accounted for as a control error. The TDC selective switch was on 'Position Keeper' only and not 'Position Keeper and Angle Solve.' The operator inadvertently placed it in this position in the dark and did not use a flashlight to check. Luminous paint has now been added."

The commanding officer, probably in the conning tower, of the POMPON (No. 8) reported on one occasion: "SJ contact; took a look on the SD. Plane contact 6 miles--closing. Submerged. The captain almost fouled this one up. Having my red glasses on so long I had forgotten they were there. When I heard the SJ had a contact, I turned on the SD myself and naturally saw nothing and assumed the SD was not turned on. Luckily, the APP operator (probably in the radio shack) looked at the same time and sung out contact."

On the third patrol of the BURRFISH "on routine training dive learned a lesson in lighting. The control room red bulb over the diving station gave insufficient light for the diving watch (which had just come from the brilliant sunlight) to see the diving indicator--resulting in a rather spectacular 20 degree dive angle due to the stern planes not getting unlocked. Needless to say, white bulbs have replaced the red for day-time use."

On the first patrol of the HALIBUT "red lights were used for night illumination from the air lock door forward, using dark and light red bulbs. About two-thirds of the patrol passed before we noticed that the 'Christmas Tree' in the control room was destroying the effect of the red bulbs to a large degree. A resistance was devised, inserted in series with the TP-TR circuit connected with a spare switch on the IC board. This markedly reduced the glare from the indicator board. Marked reduction in eye strain among personnel in the control room was immediately apparent and dark adaptation of the lookouts materially increased. Believe this alteration should be included on every circuit on this and subsequent classes of boats."

GRAYBACK (No. 1) "used red lighting in the crew's space, maneuvering room, control room, conning tower, forward battery and the forward and after torpedo rooms at night." "A GE-Ruby 25-watt gave sufficient light and yet the eyes of personnel going topside were very quickly adjusted to night vision."

The commanding officer of the SEAL (No. 2) observed that in the conning tower, the COC must be dimmed to provide a place for the lookouts to accustom their eyes to the darkness and to keep the light from the bridge; yet, both places require localized light for necessary functions. "This is particularly important if the periscope is used on a night attack. All instruments and various indicator lights in the conning tower are especially too bright. This was partially solved by the use of makeshift dimmers and dimmed flashlights."

The commanding officer of the SUNFISH (No. 5) in December 1943, reported that the TDC night (black lighting) was excellent: "consider it desirable on all installations and dial faces in the control room and conning tower--this is especially applicable to sonar instrument faces, radar dials, gyro-repeaters and periscope bearing circles."

SKATE (No. 3) in March 1944 reported: "The Mare Island TDC lighting installed is considered equal to or better than the 'black lighting' now in use on several ships. It consists of numerous small shielded bulbs set into the face of the TDC panel between the various dials. The light is spread evenly over the face of the instrument by means of 'Lucite' rings or forms around each bulb." STINGRAY (No. 10) in May 1944 reported: "The Mare Island type of TDC black lighting recently installed is better than nothing."

On the seventh patrol of the POMPON, in diving with the conning tower hatch open, the pump room was completely flooded. THE EMERGENCY LIGHTING THROUGHOUT THE SHIP FAILED WHEN FLOODING SHORTENED THE JUNCTION BOX OF THIS CIRCUIT LOCATED IN THE PUMP ROOM.

At the conclusion of the HADDO's ninth patrol (July 1945) the commanding officer reported: "In a recent overhaul, much time and effort was spent in a project to improve the lighting and coloring in the control room, conning tower, and wardroom. To this end the assistance was enlisted of an interior decorator from the University of California, a color psychologist from the Naval Hospital at Mare Island and a lighting engineer from the Halophane Company. The results were most successful. Eye strain in each of the compartments was cut to a minimum. The cheerful and restful quality of the color scheme was greatly appreciated by all hands. It is most urgently recommended that an immediate study be made of lighting conditions and color effects aboard submarines. I have been told that such a study has been underway for some time. (BuMed Research Project X-380, Report No. 1, "Instrument Lighting and Low Level Illumination in Submarine Conning Towers" and various studies submitted by Norris and Elliott, Inc. for Columbia University concerning General Specifications for Color and Illumination Standards in Submarines--June 1945.) If so it would be of interest to those making the survey to see what the HADDO accomplished in 3 months."

In contrast, the commanding officer of the TRIGGER (No. 10) in November 1944 reported: "The varied color paint job installed at Hunter's Point, after exhaustive and extensive search by the University of California for psychological effect, still baffles the commanding officer who does not feel better or worse for the same."

OVERCROWDING AND THE HABITABILITY OF SUBMARINES IN WARTIME

Head facilities, accommodations for bunking, and the stowage of personal gear aboard fleet-type submarines were designed for a peacetime complement. As the war progressed, for various reasons the complement was increased without an adequate compensating increase in living facilities. Ordinarily the absence of privacy, the crowding, the lack of stowage space and the necessity for sharing bunks was regarded as the minor inconveniences of the submarine way of life.

OVERCROWDING AND INCREASE IN PERSONNEL WITH WARTIME OPERATIONS

Comments Made Concerning Overcrowding in 1942.--On her second patrol, the PICKEREL was submerged for 51 consecutive days with a crew of 68 men and 6 officers. "Living conditions," reported the commanding officer in his report of January 1942, "were not good."--"because of the number of men bunking space was at a premium." On the first patrol of the SEADRAGON, terminated in February of that year, because of excessive humidity and mildew, mattresses from 44 bunks had to be thrown over the side. At the end of her third patrol in August of 1942 she reported that the presence of 69 men aboard using 46 bunks made it necessary for a number of men to either remain awake or sleep on the deck. SCULPIN (No. 3) in April 1942 recommended the use of sponge rubber mattresses aboard submarines; at the end of the fourth patrol (July 1942) she stated: "Since the beginning of the war no facilities have been available for the fumigation or renovation of mattresses. The problem of keeping clean has been complicated by the fact that 90 per cent of the crew are using hot bunks--we have 36 bunks available for 62 men." In January of 1943, at the end of her sixth patrol, she reported: "Habitability was overcrowded. With 68 men occupying 48 bunks a variation of hot bunking was used in which three men, one from each section, are assigned to two bunks thus insuring that off-watch men will have a place to sleep. In many cases one man of such a trio prefers to sleep on the deck to sharing a bunk; which, of course, makes it fine for the other two." SEAL (No. 4) in October 1942 reported that "66 men with 58 bunks means hot bunking or deck sleeping."

On the fourth patrol of the GRAMPUS four additional military personnel were carried for a special mission. Concerning habitability on this occasion the commanding officer stated in November 1942: "The addition of four men seriously cramps the wardroom living space and their gear in the after torpedo seriously interfered with reloading."

Overcrowding in 1943.--The commanding officer of the PORPOISE (No. 5) reported in April of 1943: "having only 48 bunks for the men (66 men and 7 officers) made hot bunking necessary for practically the entire crew." This state of affairs existed on her sixth patrol made during the summer in equatorial waters. The commanding officer of the SNOOK (No. 1) in May 1943 reported habitability as good. He recommended (as he did at the end of the fourth patrol) rearrangement of the forward battery compartment to include a four-man bunk room in the location of the commanding officer's stateroom, with installation of a small single room for the commanding officer on the starboard side of that compartment. The TAUTOG (No. 7) reported in July 1943 that with conversion of the starboard stateroom into a bunk room, (eight bunks) eight officers were carried with comfort, none sleeping in the wardroom. TARPON (No. 8) in September 1943 reported that habitability was good with 54 bunks for 65 men and 6 bunks for 8 officers. The commanding officer of the GRAYBACK at the end of her eighth patrol in November 1943 reported: "The newly installed officer's bunk room provides better ventilation and better sleeping accommodations for 6 officers than did the two staterooms and wardroom bunks. Stowage facilities, however, are neither adequate, convenient, nor handy." Habitability was excellent on the succeeding patrol, "except for the necessity of 4 hot bunks."

Overcrowding in 1944 and 1945.--BURRFISH in March 1944 (No. 1) with a complement of 83, reported excellent habitability. There were 5 hot bunks. One officer slept in the forward torpedo room and two in the wardroom. PERMIT (No. 11) at about the same time reported habitability as excellent, except for crowded conditions. GAR in April 1944 (No. 11) reported that "the forward battery was not designed to carry 14 officers for an extended period of time." POLLACK (No. 9) in April 1944 reported it necessary to sleep 14 hot bunks. SEARAVEN (No. 11) in May 1944 had 64 bunks to accommodate 77 men--"there is no space for additional bunks; can not reduce the crew to 64."

The FLOUNDER (No. 1) in May of that year reported that "berthing conditions for the crew (70 men) can not be further extended. If 9 officers are to be carried, 2 more bunks are needed." TRIGGER, at the end of her tenth patrol, in November 1944, reported that the "new wardroom and stateroom arrangement is good, allowing 10 officers to eat and live comfortably." BESUGO, in the same month at the end of her first patrol reported habitability as having been fair: "the difficulties of having 76 men and 9 officers aboard a submarine are well known." KINGFISH (No. 9) in November 1944 with 75 men and 10 officers aboard reported living conditions as relatively good with only 5 men using hot bunks. SKATE (No. 6)

November 1944 requested the addition of more bunks in the officer's quarters. The BECUNA (No. 3) in March 1945 with a complement of 83, reported that bunking and head facilities were adequate, 9 men alternating in the use of 6 bunks.

KINGFISH (No. 11) in April 1945 reported: "Habitability was a matter of becoming accustomed to our eating and sleeping schedule. Once the system was begun, all hands found it possible for 92 persons to live just as comfortably as we used to with 75 aboard." The BLACKFIN at the end of her third patrol in April 1945 recommended 6 additional bunks be installed in the after battery compartment to alleviate the hot bunking. JALLAO (No. 3) in June 1945 reported berthing facilities inadequate--"plan to add 6 more bunks in the next refit." In July of that year, the commanding officer of the DENTUDA, at the end of her first patrol, reported habitability as good, "especially from the standpoint of 79 men and officers aboard a boat designed for 68 men and 8 officers."

Recommendation was made at the end of the third patrol of the DEVILFISH (July 1945) having carried 79 men and 11 officers aboard, that "with almost all submarines carrying more than 75 men on patrols it is felt that a study of the bunk arrangement is warranted. With some re-arrangement we are certain that more bunks can be fitted into the torpedo rooms." On her fourth patrol, in August, additional berthing space was provided by placing seven mattresses on canvas stretchers across 4 empty torpedo skids. REDFIN in July 1945 reported (No. 6) that 15 of her crew were required to hot bunk: "if two less torpedoes were carried forward on special and lifeguard missions, 6 of the crew could sleep on mattresses on these skids." RONQUIL on her fourth and fifth patrols (April and July 1945) reported sleeping accommodations crowded and recommended installation of more bunks.

The ARGONAUT on her first patrol (terminated in August 1945) with a total of 93 men and officers aboard, enjoyed excellent habitability. The commanding officer's stateroom plus 3 officer's bunkrooms proved "quite satisfactory; bunks were not used in the wardroom." "The disadvantage of hot bunking was minimized to some extent by separate day and night lookout sections." On the sixth patrol of the REDFIN concluded in July 1945, 15 of the crew were required to "hot bunk."

The first and second patrols of the TIRANTE were made with bunks for 77 men and 10 officers (using the wardroom). With a total of 98 people on her second patrol (terminated in July 1945) "on 16 hour all day dives--the carbon dioxide content in the boat reached about 2 per cent, resulting occasionally in headaches and causing slight panting. Carbon dioxide absorbent spread out at various locations throughout the ship on these all day dives without doubt relieved the situation to some extent. However, to provide for an efficient watch and maintenance bill, to get the most out of our complex and more numerous equipment, particularly in the gunnery, radio, radar and sonar fields, the vessel deserved to be maintained with its crew at its present strength."

The commanding officer of the ATULE (No. 4) in August 1945 observed: "A clean ship with proper handling of limited quarters by an efficient chief of the boat more than compensates for the hot bunking."

HABITABILITY AND ROUTINING OF TORPEDOES

The commanding officer of the GRAMPUS at the end of that ship's first patrol in April 1942 observed: "Habitability was satisfactory--the poorest item of design is the torpedo rooms--making torpedo overhaul very long and difficult and extremely uncomfortable for one-third of the ship's company that lives in these compartments."

Several other commanding officers reported concerning the unsettled living conditions in the torpedo rooms consequent to the routining of the torpedoes. TAUTOG (No. 7) in July 1942 stated: "The Mark 18 torpedo puts a strain on all hands. Until a few are fired the forward torpedo room is uninhabitable with bunks triced up in the wardroom passageway, gear constantly being shifted, racks always on the move and chain pulls constantly in operation. Only 4 men slept in the forward room at this time, causing 8 to hot bunk in the after room and crew's compartment."

SARGO in March 1944 (No. 10) stated: "Mark 18 torpedoes were used in the after room for the first time. Due to the increased amount of work in routining them, the after room was more or less in a state of upheaval approximately two days out of seven, on which days the bunks had to be taken down." FLYING FISH in April 1944 (No. 9) reported habitability as poor in the forward torpedo room. "The necessary considerable handling of electric torpedoes makes living conditions unsettled here until 4 or 5 fish have been fired. In the after room the upkeep is relatively simple due to the fewer number carried." SEADRAGON (No. 10) in May 1944: "Recharging of Mark 18 torpedoes is accompanied by the additional trouble of dismantling them with a loss of sleep for the after room watch personnel."

EFFECT OF OVERCROWDING ON OXYGEN AND CARBON DIOXIDE CONTENT OF THE AIR

Overcrowding is important for other reasons than the inconvenience which it causes to personnel. As the excerpt from the TIRANTE's second patrol illustrates, long periods of submergence with increased personnel necessarily result in more rapid utilization of the oxygen in the atmosphere and accumulation of carbon dioxide. THREADFIN (No. 1) February 1945, experienced similar conditions when, with 85 officers and men aboard, carbon dioxide concentrations reached the maximum limits during long dives: "It will require the use of carbon dioxide absorbent daily during summer patrols in the Empire area." PUFFER, in July 1945 at the end of her eighth patrol reported habitability as fair. "Failure of the booster blower in the control room (which made the forward part of the ship warm) coupled with the heat of the tropical water made for a very warm trip. On all day dives the air became bad at the end of the day due to the large complement (96 men)."

The HARDER at the end of her fifth patrol in July 1944 reported habitability as "not so good--this was caused, in part, by the lack of efficiency of the air conditioning, the consistently high battery temperatures, the high temperatures of the sea water and the presence of 89 men aboard. Their body heat and the greater use of oxygen necessitated frequent daytime surfacing whenever possible to change the air in the boat." The commanding officer of the CUTTLEFISH (No. 3) in September 1942 noted a similar relationship between, in part, the presence of 20 men more than the complement called for and habitability which was "excellent on surface running, fair on all day dives and miserable during silent running." The PICKEREL in January of 1942 (No. 2) reported that "with 68 men and officers aboard, carbon dioxide content on all day dives reached 1.5 to 3 per cent concentrations."

INFLUENCE OF OVERCROWDING UNDER NORMAL CONDITIONS ON HEALTH AND SANITATION

There are only a few recorded instances in which, in the opinion of the submarine commanding officer, these conditions, under normal operational conditions, adversely affected the health of personnel.

In July of 1942, at the end of her second patrol, the commanding officer of the CACHALOT observed: "The sudden shift from a subtropical climate to the cold damp climate of the Aleutians with the necessity of keeping the main induction closed most of the time thereby sending a stream of cold air through the main living quarters, and the damp and overcrowded conditions of the boat (hot bunking) all contributed to the catching and spreading of colds--almost the entire crew having colds at various times. Health was definitely below standard."

PORPOISE (April 1943) reported that this, her first patrol in tropical waters, since the installation of air conditioning made the ship comfortable and contributed greatly to cleanliness, stopping all rash and prickly heat.

POMFRET (No. 5): "Large number of fungus infections is attributed to the number of men using the limited washing facilities and general dampness of washroom while operating in semi-tropical water with an average inside temperature of 85 degrees F."

The commanding officer of the S-28 (No. 1) reported hot bunking necessary with 45 men aboard--"one-third of the crew had scabies; necessity for hot bunks believed to have accelerated spread of this rash; when it became known, personnel were segregated."

HABITABILITY OF SUBMARINES ENGAGED IN AIR/SEA RESCUE OPERATIONS

With air/sea rescue operations increasing toward the end of the war, submariners frequently found themselves faced with the necessity of providing, if not sharing, accommodations for sometimes large numbers of aviation personnel, often seriously wounded. Comments concerning habitability under these conditions are as follows.

BLACKFISH (No. 12) reported that "living and sleeping arrangements were a trifle crowded with 23 visitors aboard." She further recommended "furnishing lifeguard submarines with a few kits of toilet articles such as the Red Cross has, containing tooth brushes, plastic razors, shaving and dental cream, ditty bags and containing in addition a small supply of jungle green trousers and shirts and underwear." In this same line the commanding officer of the QUILLBACK (No. 1) commented: "Recommend a survivor's kit consisting of perhaps a Red Cross ditty bag and a reasonably small supply of standard clothing be furnished each submarine detailed primarily for lifeguard duty. The outfitting of survivors by the ship's force is no great hardship but as long as we are in the business it is considered necessary."

RAZORBACK (No. 4) suggested the "efficacy of submarine lifeguard duty would be increased by additional quarters for the survivors. Outfitting of survivors will soon be a problem. We were able to absorb the clothing and toilet requests (5 aviators rescued) of our aviators over the relatively short time we had them but we could not help but wonder how we could have handled a larger number for a longer period of time. A dozen or so survivor kits should be provided." Similar recommendations were made by SEADEVIL (No. 4).

The commanding officer of the DRAGONET (No. 2) faced with a bunking space shortage with 11 aviators aboard, recommended "that fewer torpedoes be carried in the racks and that additional bunks be built in their place to relieve badly overcrowded situations." The WHALE (No. 11) with 15 survivors aboard experienced, in general, good habitability except on all day dives when crowded conditions--made the boat uncomfortable and made necessary the use of carbon dioxide absorbent.

POMFRET, on her sixth patrol (August 1945) carrying 5 aviators and 30 prisoners in addition to her own crew reported habitability as good. "The use of carbon dioxide absorbent was necessary when submerged--." "If possible, suggest that 4 less torpedoes be carried so that the racks can be utilized as bunk space. One torpedo rack when provided with some form of mattress will provide a reasonably comfortable bunk for 2 men. A submarine with one or two B-29 crews aboard is, indeed, hard pressed to provide adequate sleeping facilities."

SAILFISH, 12 December 1944: "With 7 aviators in the wardroom and 5 crew men in the crew's quarters conditions were a bit crowded but by putting them on the watch schedule and hot bunking we had no trouble."

The TIGRONE, on her second patrol, established a record for the recovery of friendly aviators, picking up a total of 30 men, in 5 separate rescues, 16 being recovered in one rescue. These pickups took place from 25 May through 26 June. On 4 June: "Submerged all day to get much needed sleep and rest from the APR contacts. All hands pretty well pooped from lack of proper rest during the time the 28 aviators were being cared for--the dunkees being alloted all of the sleeping space possible because they all suffered a little from shock."

The SEADEVIL having recovered 3 pilots and 4 Japanese survivors on her third patrol reported that she intended to take about 6 folding cots along on the next patrol to alleviate the inevitable crowding. On the fourth patrol, having recovered 12 aviators and 3 prisoners she reported that "habitability reached the straining point with 106 aboard for 2 weeks."

THE EFFECT UPON THE HEALTH OF PERSONNEL AND HABITABILITY OF SUBMARINES CARRYING LARGE NUMBERS OF PASSENGERS

Throughout the war, on a number of occasions, the already heavily taxed living facilities of submarines on war patrols were further strained by the necessity of carrying large numbers of passengers. It is in this respect, particularly when used as troop transports, that this particular problem of submarine life may assume considerable importance.

MISCELLANEOUS

S-38's Third Patrol.--This submarine, on her third war patrol (area, Mandura Straits, from 22 Feb to 13 March 1942) with a crew of 38 aboard (air capacity for the crew estimated at 12 hours) recovered 52 survivors of a British ship, the Electra. These men had been in the warm water for about 24 hours, aboard rafts and in life jackets. Their ship had been lost by shell fire. It is said that a Japanese submarine went through the area after the ship went down, and apparently shot at the survivors in the water. When the S-38 came among them, the sailors were afraid that she was Japanese.

The crew of the S-38 prior to the recovery of the men, was tired. They had spent, prior to departure on the patrol, a non restful stay of 7 days in the bomb shelters at Soerabaja. On the patrol following an attack on a cruiser they had been pursued for 24 hours--at the end of which time "great fatigue was visible in all hands and particularly in the older men." "The presence of the Electra survivors and caring for their wounded proved a tremendous strain and resulted in all of us going over 24 hours without sleep. However we were glad to have them and tremendously impressed with the high spirits, calmness, and fortitude that these British sailors displayed in the face of their bad luck. Never will we forget the pluck of the youngster in the water who, realizing that there was still another raft full to be picked up and that we were having difficulty locating them in the dark sang out, 'Leave me, I can't make it, go get the rest.' Needless to say, we got him too."

The survivors were described as being severely fatigued and "stunned" when brought aboard. Fortunately, a British surgeon had luckily survived, unhurt, and was able to render considerable assistance. His task was made difficult by the fact that Asiatic Squadron submarines had not, at that time, been supplied with medical supplies. Some of the men were badly burned, some had shrapnel wounds. A bos'n mate had to be "sewed up" with thread from the crew's thread bag. One possible pneumonia case was given oxygen.

Habitability aboard the S-boat, with these men was very bad, particularly as applies to heat and humidity after 14 hour dives. There were 2 cases of heat prostration. The name of the above medical officer was thought to be Dr. Doormann. This ship did not carry a pharmacist's mate, nor was it equipped with air conditioning.

SARGO's Fourth Patrol.--The SARGO, on her fourth patrol (February 1942) while carrying 24 passengers (Army) experienced very uncomfortable habitability in the forward part of the ship, due to the fact that the forward air conditioning unit had to be used for purposes of refrigeration. The temperature of the supply air of the ventilation system ranged from 95 to 104 degrees during the entire patrol. Almost all personnel berthed forward, and those standing watch in the control room, developed heat rashes, in some cases covering the entire body, which materially increased their discomfort.

SWORDFISH's Second Patrol.--The SWORDFISH, on her second patrol (March 1942) carried 10 passengers from the Philippines for 2 days, transferring them to a motor tender. Among these were included President Quezon, his wife, two daughters and son. Two days later another party, including the High Commissioner to the Philippines was taken aboard and transported to Australia.

TROUT's Second Patrol.--The TROUT, on her second patrol (March 1942) took ammunition to Corregidor and returned with 20 tons of gold, silver and securities.

SEARAVEN's Third Patrol.--SEARAVEN on her third patrol (April 1942) recovered about 33 men from Timor. The following day, after a 14 hour dive, carbon dioxide throughout the boat was 3 per cent. "Air was most malodorous due to the malarial sweat of so many sick men--all had malaria and tropical fever; three were unconscious."

SNAPPER's Second Patrol.--The SNAPPER, on her second patrol (April 1942) carried stores to Corregidor. "Bataan Peninsula previously had surrendered and Jap guns were covering our position. Received 25 passengers" (later found had two deserters) who were carried to Australia.

SPEARFISH's Third Patrol.--On the third patrol of the SPEARFISH (May 1942) "27 passengers were taken aboard from Corregidor, including 12 nurses and 1 civilian wife. There were 2 unauthorized passengers--who assisted as part of the Corregidor working party in transferring baggage and apparently had stowed away."

TUNA's Third Patrol.--The TUNA on her third patrol (August 1942) landed Army personnel at Kuluk Bay. The men left the ship by rubber boats one of which "developed an air leak and capsized. The two men were rescued and retained aboard the submarine."

NAUTILUS's Fourth Patrol.--On her fourth patrol, the NAUTILUS (13 Dec to 4 Feb 1943) rescued 26 adult and 3 half-breed children from Bougainville. The CPO quarters, wardroom, commanding officer's stateroom, and one officer's stateroom were used by the women. The men hot bunked with the crew--"however, I am sure that most of them had the same bunk the entire time and that the NAUTILUS crew slept on the deck." This cruise, discussed elsewhere, was made especially arduous for the ship's company by the lack of adequate air conditioning in calm hot weather.

GATO's Fifth Patrol.--The commanding officer of the GATO in describing her fifth patrol (September to October 1943) stated: "To give the best medical picture of the patrol, it must be considered as a 78 day period interrupted after 23 days by 8 days of hurried repairs (performed mainly by the ship's force). During this repair period each man was given a 48 hour shore leave, which, it is feared, did not materially aid his health. In addition, during this period over 100 civilian and military passengers were carried at various times. These included Commandoes, Coast Watchers, Missionaries, Nuns, Chinese and Fijian women and children, most of whom were carried under crowded submerged conditions in the tropics. The general health deteriorated but it had been exceptionally good to start with; consequently it became very little if any poorer than normal submarine health. Signs of general sluggishness became apparent toward the last. These were manifested by such things as incorrect transmission of orders over the telephone, incorrect interpretation of the same, clumsy clearing of the bridge and overall slowness of motion. There were about 45 head colds, about a dozen of which were accompanied by sore throats."

On one occasion "Lt.--came aboard; he had assembled 41 souls and asked that we take as many as possible. The number was a shock but we decided that we could handle them. All of our passengers were 'troupers' and were quickly adopted by the ship's company. The adoption was reciprocal. Typical example: one ten-month old child would not sleep except in the arms of a bearded torpedoman; they made a weird picture on watch. Brief impressions of the GATO's incongruous family: (a) the children through a cycle of awe, apprehension, mischief and unwilling sleep; (b) the mother, distraught then trustful; (c) the Nuns benign and patient; (d) the soldiers, 'Haven't you some dirty job we can help you with?' and 'is there any beer in Brisbane?'; (e) the GATO's crew, clumsy, but enthusiastic nursemaids--."

DACE's Fifth Patrol.--The DACE, on her fifth patrol, with the rescued crew of the DARTER aboard, carried 165 men for a period of 11 days. Concerning this the commanding officer reported: "Living conditions became crowded but not to the extent imaginable--. Men were assigned to compartments and requested to remain there for the major part of the time. There was only time for two meals, but soup was available throughout the day. Although there was no room to spare and the quality and quantity of food declined in the last few days, believe that no one suffered any undue hardships. It could have been an intolerable situation, but the

conduct of the DARTER made it a pleasant cruise." "The maximum time submerged was 10 1/2 hours. Liberal use was made of carbon dioxide absorbent and oxygen in order to revitalize the air. On one occasion surfaced to air out the boat."

ANGLER's Sixth Patrol.--The chief pharmacist's mate of the ANGLER (No. 6) in describing the effect of overcrowding resulting from a total of 126 men carried aboard (the crew of BERGALL No. 2) stated: "We had them with us for 5 days of surface running. Ventilation, which was outboard, was adequate; running on 4 main engines drew a mighty draft through the ship. We didn't try to control smoking. Being low on fresh water, every one had to use the condensate water for bucket baths. There weren't enough bunks and men were always standing around waiting to get into a bunk to sleep. We weren't able to clean up the boat with the men standing around and it became, in a few days, a mess. We had plenty of food, having taken on some from another source. We fed the ship's company first because they had to take watches; we ran extra meals for the other men. The forced inactivity for the passengers was perhaps their chief complaint. About a day or so after they left us we had an outbreak of scabies and 'crabs' among our crew, having about 7 or 8 cases of each."

GUARDFISH's Eleventh Patrol.--The GUARDFISH on her eleventh patrol, with 73 men recovered from the ARS-15, for a 2 day period (27 Feb to 11 Apr 1945) described the habitability of the ship as having been "average."

COD's Sixth Patrol.--The COD on her sixth patrol (24 March to 29 May 1945) for a 4 day period carried 47 men and 8 officers, rescued from a grounded Dutch submarine. "Made preparations for bringing all hands aboard. Had two rubber boats, heaving lines, life rings, and rescue party topside; dry clothing, empty bunks, hot soup and coffee below. During rescue, lost a boarding party which BLENNY rescued after had spent 48 hours on a junk (5 men) during which time forced to use the food and water present aboard. Two men experienced ill feelings from change in diet with mild abdominal cramps and diarrhea." Conditions aboard the boat were described as crowded and hot; a periodic suction helped considerably.

ROCK's Sixth Patrol.--The ROCK, on her sixth patrol (May 1945) rescued 15 survivors from the SS Peter Sylvester, which had been torpedoed 32 days before in the Indian Ocean. These men had sailed some 1,600 miles in a 26 foot open lifeboat, their only navigation being a 3 inch boat compass. Although they had water they had run out of food, living the last 5 days before recovery on malted tablets. All hands were in a fair condition except for two men with "moderate ulcers." The men were transferred that same day at Exmouth Gulf.

HAMMERHEAD's Seventh Patrol.--HAMMERHEAD (No. 7) in August 1945, found that the addition of "20 newly recruited Filipino's to an already swollen complement did not help habitability any. One apparently slightly crazy had to be kept handcuffed for safety."

RESCUE OPERATIONS CARRIED OUT BY THE SEALION, QUEENFISH, PAMPANITO, AND BARB

The SEALION and the PAMPANITO, on 15 September 1944, recovered 124 men from the waters of the South China Sea. The BARB and the QUEENFISH, two days later, recovered an additional 32 men. There exists in the annals of submarine warfare no more moving story than the rescue of these 156 survivors, formerly Japanese prisoners of war, and the care given them by our submariners.

The commanding officer of the PAMPANITO (No. 3), P. E. Summers, USN, described incidents befalling that ship as follows: "At 1605 on 15 September 1944, a bridge lookout sighted some men on a raft, so we stood by small arms and closed to investigate. The men were covered with oil and filth and we could not make them out--black curly hair didn't look like Japs. They were shouting but we couldn't understand what they were saying except the words 'Pick Us Up Please.'" "Called the rescue party on deck and took them off the raft."

"The first problem was getting the men on board. In their weakened condition, and due to the fact that they were covered with heavy crude oil, the actual recovery was quite a task." "All of them were exhausted after 4 days on rafts and 3 years of imprisonment. Many had lashed themselves to the makeshift rafts, which were slick with grease, and had nothing on but life belts." "Many of the men could help themselves but the majority had to be lifted bodily on board." "Some of them were in very bad shape but with the excitement of the rescue they came alongside with a cheer for the 'Yanks' and many a curse for the Nips. It was quite a struggle to keep them on the rafts while we took them off one by one. They could not manage to secure a line to the rafts so we sent a man over the side who did the job. The survivors came tumbling aboard and then collapsed with their strength almost gone. A pitiful sight that none of us will ever forget."

"The next problem was to make an attempt to clean some of the oil off before sending them below and to treat their immediate medical needs. Several required hypo shots, but for the most part a little oil wiped from their eyes and mouths and a wet rag to cool their parched salt sore lips and throats and a strong Yanky hand to help them get below was sufficient. While still topside their clothing was cut away and they were given a diesel oil sponge bath to remove most of the heavy crude oil. Getting the weakened ones down the hatch was quite

a job, until in the middle of one recovery operation when three planes were sighted (turned out to be a false alarm), you should have seen them run for the hatch when the word 'Jap Planes' was passed."

"All hands turned to with a will and the men were cared for as quickly as possible. We had cleared the after torpedo room and after once getting them below, the main problem was to further examine them to determine the extent of their injuries and sickness. In this respect the tireless energy and sound professional knowledge of M. L. Demers, PhM 1/c was of the highest order. He quickly examined and treated every survivor and tirelessly and continuously tended their ailments for the next 3 days until a medical officer and a chief pharmacist's mate came aboard to take over the work he had started."

"All survivors, except 6 of the more seriously wounded, were berthed in the after torpedo room. This required ingenuity in devising bunks from torpedo racks and deck space, but with two in each bunk and three or four in each torpedo rack most of them made out better than you might imagine." "Water was their most acute need and they were given plenty in small quantities. Hot soup, tea, and broth followed and they were soon sleeping the sound sleep of thoroughly exhausted men." "One man died in the night after recovery, cause not being determined." "All men were infected to various extents with beriberi, scurvey, malaria, and other skin irritations. Two officers were assigned to manage the problems and a two-man nursemaid watch was kept in the after torpedo room in addition to the pharmacist's mate and two volunteer assistants (one ship's cook and one seaman) who were working continuously." "Each day a number of men were allowed to go to the engine rooms and to the forward torpedo rooms to stretch their legs and to allow the bed ridden ones to have a little more room and receive their treatments." "By this time we were getting a little low on medical supplies--quinine, bandages, tape, gauze, salves, alcohol and antiseptics and other equipment extensively used." "Rendezvous was made with a destroyer at sea, but after conference with a medical officer and on examination of the survivors, it was decided that the transfer at sea in a small boat was not the best policy and they were kept aboard."

"As the condition of the men improved they were given more staple food and their spirits and strength continued to rise in direct proportion." "It was a wonderful sight to see the survivors as they gained strength, began to tell stories, laugh and joke and appreciate the music, stare in wonder at the fresh bread and butter and become human beings again." "The survivors were anxious to do their own part and were soon standing short nursemaid watches, helping polish-up the compartment, and feeding the bed patients. By the time we arrived at Saipan they really were not such a bad looking lot after all--dressed in donated dungarees, khakies, socks, and some shoes. Everyone with a smile and a warm spot in his heart for the 'Bloody Yanks' who sank their ship but 'bloody well' came back again and picked them up."

The SEALION (No. 2) beginning at about 1840 on the 15th of September "recovered a total of 54 men--until darkness and space limits prohibited further rescues." Four of the survivors died aboard the SEALION and were buried at sea. The pharmacist's mate 1/c, P. J. Williams, USN, was commended by his commanding officer and by the squadron commander for the care which he gave the survivors under his care. The commanding officer of the SEALION stated, concerning the health of the crew: "Health was good until we arrived at Saipan with the survivors. Several men subsequently developed mild cases of catarrhal fever and there were 7 or 8 severe colds and sore throats scattered among the crew--probably the result of overcrowding, loss of sleep, and irregular meals and routine while the survivors were aboard."

The QUEENFISH (No. 1) on 18 September took aboard about 18 survivors. "Sea and wind began to pick up, making rescue work extremely arduous and hazardous. Only in a few cases were they able to assist in their recovery and officers and men on deck did yeoman service in lifting them bodily from the water. In one instance--plunged into the water to tow a raft back to the ship on which sat a survivor who was too weak to reach for a heaving line that had fallen at his feet." "The forward torpedo room was previously prepared for their living space, an arrangement which worked with a minimum of discomfort for our crew and a maximum of comfort for our passengers. An officer, and pharmacist's mate 1/c, H. Dixon, were in charge of a group who gave individual attention to each of the survivors as they were carried below."

The commanding officer of the BARB (No. 9) reported concerning these rescues (11 men were recovered): "Too much credit can not be given to the crew for their superior performance and willing effort in the production line we had formed from the deck party who picked them up, stripped them, and passed them on to the transportation gang to get them below, where they were received by the cleaners who removed the oil and grease, then on to the doctors and nurses for treatment, then to see the feeders and finally to the sleepers who carried them off and tucked them in their bunks." "We found that by taking over every single foot of space aboard, by sleeping three to a torpedo rack, etc., we could have accommodated 100."

"Upon arrival at Saipan the Fulton had made all preparations for taking care of us very efficiently. She had her relief crews standing by to decontaminate the boats and clean them thoroughly. She took all contaminated clothing and replaced them for us, giving each member of the crew a new suit of dungarees and shirts. All soiled blankets and mattress covers were replaced."

The following pharmacist's mates were aboard the submarines involved in these rescues: Demers, M.L., PhM1c, USN, USS PAMPANITO; Williams, P.J., PhM1c, USN, USS SEALION; Donnelly, William E., PhM1c, USN, USS BARB; Dixon, Harold, PhM1c, USN, USS QUEENFISH. Stated ComSubPac (third endorsement to ltr MedOfficer, USS Fulton, AS11/P2-5, 30 Sep 1944): "ComSubPac considers that the pharmacist's mates attached to the PAMPANITO, QUEENFISH, BARB, and SEALION were outstanding in their performance of duty. It was only through their knowledge of medicine, combined with their painstaking and conscientious attention to the surviving prisoners of war, that 152 of 157 rescued were brought through at all."

Through the courtesy of the U.S.A. 148th General Hospital (located at Saipan at that time) and Colonel R. G. Wadsworth and Captain W. H. Moorhead, who were responsible, in part, for the care of these men after they were removed from the submarines, further medical information concerning them was obtained. Upon hospitalization, all were found to be suffering from malnutrition, exhaustion, and exposure. One hundred per cent showed evidence of vitamin deficiency. All had some type of skin lesions which varied from severe ecthyma to minor abrasions and erosions. Five men had either scarring of the cornea or acute corneal ulcers, in one instance these were bilateral. Undoubtedly, exposure to the sun and oil had contributed to their development. Ten per cent of the men complained of a sticking sensation on swallowing beneath the manubrium, perhaps in the nature of an esophagitis associated with dehydration and the swallowing of salt water. Twenty per cent of the men recovered by the PAMPANITO and SEALION had an acute bronchitis, which it was stated developed within a few hours after their rescue. Of this group, 9 cases of acute broncho-pneumonia were evident upon X-ray examination. There was one open case of pulmonary tuberculosis.

One medical officer who met the submarines prior to their arrival at Saipan recommended that all ships of the Navy likely to recover survivors be provided with short, concise directions concerning the most suitable diet and special forms of treatment likely to be encountered. These conditions are: malnutrition, general and special forms of protein deficiency and vitamin deficiency, malaria, eye conditions from the salt water, and sun, deficiency states and fuel oil, skin conditions, especially infected wounds, sunburn and pustular lesions; general nursing care, as the best way to remove fuel oil, etc. (Ltr MedOfficer Paul V.W. Waldo, to BuMed, USS Curtiss, AK-4, 12 Dec 1944).

USE OF SUBMARINES AS TROOP TRANSPORTS

In this last war, on a few occasions, three of our largest submarines were used for the purpose of transporting scouts or raiders. Various features of habitability aboard these submarines, when so used, have been described elsewhere. Inasmuch as submarines may very well be used for similar operations in the future it is thought that interested personnel might profit from a report of the operations as they are available.

ARGONAUT's Second Patrol

The old ARGONAUT (SS166) on her second patrol, transported 114 Marines and 7 Marine Raider officers in addition to her own 8 officers and 91 men (a total of 220 men). "This is believed to be a record for people embarked on a submarine on an offensive mission." Prior to departure on this special mission (8 August to 26 August 1942) "it was decided to have only two meals a day, with soup and crackers at mid-day. The plan worked out very satisfactorily. It required from 3 to 3 1/2 hours to mess all hands for each meal. This meant that when the first mess sat down, the food for the last mess was just being prepared. The galley was in use 24 hours of the day, making it necessary to do the baking at night. As a consequence, the mess hall was extremely hot and uncomfortable. Two cases of heat prostration occurred among the galley force. If future operations of this sort are considered, serious consideration should be given to the installation of additional galley and washroom facilities. There is only one washroom for the crew; an additional one could be easily installed in the forward end of the mine stowage room."

"The ventilation and air conditioning systems installed are totally inadequate. The volume of air flowing through the new air cooler installed in the mess hall was so small that full advantage of the cooler was not utilized. A 'booster blower' installed in the supply line aft of the cooling unit would somewhat alleviate conditions. The entire subject of ventilation and air conditioning is being made the subject of separate correspondence."

"Health of the crew and of the Marines was very good, considering the poor habitability of the ship. There were 25 cases of heat rash developing enroute, 10 of which were very severe, and 8 cases of heat prostration. Humidity was very high every place except in the engine room. A contributing factor to the high humidity is the fact that when ventilating inboard, the battery ventilation exhausts into the control room."

"The wardroom had to be utilized as an operating room. The surgeon performed two operations under general anesthesia, one on a head wound and the other on an abdominal wound."

NAUTILUS's Second Patrol

The NAUTILUS (No. 2) participated in this mission with the ARGONAUT (8 Aug to 25 Aug 1942). She carried, in addition to her own crew of 78 men and 7 officers, 101 Marines. Concerning the habitability of the ship the commanding officer reported: "Spot air conditioning units were installed in the torpedo room to offset the effect of temperature and humidity of the warm sea water on increased personnel. These units were inadequate--. The temperature in the living spaces was 93 degrees F. with a relative humidity of 85 per cent on the hottest days with 90 per cent relative humidity and 91 degrees F. on the coolest days. Use of the air conditioning to decrease humidity brought but little improvement. The air supply in the forward torpedo room was poor. This compartment gained in personnel about 80 per cent. A suitable booster blower will solve the problem."

"Dives were sufficiently short so that limits of carbon dioxide concentration and oxygen were not reached. After 12 hours the carbon dioxide concentration reached 1.5 per cent throughout the ship. Fifteen hours would be a maximum without the use of absorbent, and about 16 hours for steps to add oxygen. An oxygen measuring device is being requested. The use of ventilation throughout the boat to clear out the old air and lower the temperature was of great value. Men were ordered topside whenever possible for exercise and fresh air. During this short trip to the operations area (8 days) no lowering of the health of the crew or passengers was seen. For longer trips, it is essential that air conditioning be improved."

"The majority of the crew were without sleep for some 70 hours; the gun crews seemed always ready in the hatch without sounding general quarters." "As usual, personnel endurance is a difficult item to estimate. The men seemed more tired after this operation than at any time during the first patrol. This was caused by a lack of sleep and the extreme heat of all day dives. Prickly heat was very much in evidence. Recommend that submarines be equipped with more air conditioning and that the entire bunk installations be modified."

NAUTILUS's Fifth Patrol

On the fifth patrol of the NAUTILUS, 109 Army Air Scouts were transported from Dutch Harbor for a landing on Attu (20 April to 25 May 1943). Because of heavy seas the men, who came aboard on 29 April could not be disembarked until 11 May. Comments taken from the patrol report concerning this period are as follows.

"On 5 May at 1700 (11 1/2 hours after submerging) the carbon dioxide concentration was discovered to be 3 per cent; the use of absorbent immediately brought it down to 1 1/2 per cent; oxygen was used at the end of about 14 hours, the ship surfaced at 1721. On the 7th of May the ship submerged at 0546. By 1913 the lack of oxygen and high carbon dioxide content was more noticeable due to the fact that the Army Scouts were continually on the move making ready for their disembarkation. To climb from the control room to the conning tower was worse than running a 100 yard dash. On 9 May, all hands while submerged, were ordered to keep as quiet as possible to conserve the oxygen, because we must be prepared to await indefinitely for favorable weather. By keeping quiet and ordering no smoking, no oxygen was used that day (surfaced at 2236). On 11 May at 0002 commenced giving Army Scouts a big steak dinner; at 0300 they were disembarked."

Concerning this mission the commanding officer observed: "From the military standpoint the ship can be used for a raid with only sufficient warning to remove the reload torpedoes. The addition of 109 men aboard presented several problems: (1) air purification; on each day 4 cans of carbon dioxide absorbent were used; oxygen was used except on 2 days. On these days all hands were required to sleep if possible and the smoking lamp was out at 1400. The ship's allowance of carbon dioxide absorbent and oxygen should be augmented for similar operations, which must await weather conditions. On the day preparations were made to leave the ship, the carbon dioxide concentration had risen to 4 per cent and there was much panting. It is evident that if absorbent is to be used it must be opened early in the dive to insure getting the most absorbent. Because of irritation to the nose and throat it must be handled with care. Without the use of absorbent the carbon dioxide content rose to 3 per cent in 2 1/2 hours (50,000 cu. air ft., 205 persons, unlimited smoking and moderate activity). (2) Berthing: there were no additional bunks. Each torpedo stowage skid was rigged and held three persons (36). Hot bunking by the watch squad (29). The remainder of the soldiers slept on mattresses on the torpedo room decks. On the Makin raid we had additional bunks. The method used this time was much better in that it improved circulation of air, allowed space for recreation in the large floor space in the torpedo room. In the event of a raid in the tropics, more air conditioning units would be required. Used cafeteria system to serve 194 rations; the total time required while on the surface was one hour. For all day dives the troops were messed by taking about 15 men from each living compartment at the same time to avoid any radical

change in time. The time necessary for messing under these conditions increased to about 2 hours. The ship's force of 3 cooks and 1 baker put in about 12 hours daily assisted by 2 cooks from the Army Scouts. For operations of a similar nature, additional metal trays and mess gear are recommended to facilitate messing. The small after sanitary tank, now used as a sludge tank for the after head, would fill after 4 hours of submergence which made unavailable half of the head facilities. Men walking forward and aft caused much operation of twin pumps. (3) Sweating of the hull and hull fittings with condensate on the cold parts of the hull had a high nuisance value. (4) Recommend steam heating plant be removed as it is of no value."

About 90 per cent of the crew had colds "more or less due to the sudden change in climate enroute to Dutch Harbor from Pearl Harbor." The commanding officer observed further: "The delay from day to day had marked effects on most of the Army Scouts--probably due to the fact that this was their first enemy action." In this respect, one can not help but wonder of the effect which the rough weather (seasickness) and excessive accumulations of carbon dioxide toward the end of all day dives, must have had upon the physical fitness and fighting efficiency of the Scouts.

NARWHAL's Fourth Patrol

The NARWHAL (No. 4) participated in this mission with the NAUTILUS, departing from San Diego, California with, in addition to her own crew of 99, 103 Army Scouts (total of 202 aboard) for 29 days. Comments made by the commanding officer concerning the operation are as follows: "Installed 120 additional wooden and canvas bunks." "The commanding officer moved to the conning tower; one extra bunk in the cabin provided accommodations for the troop commander and the Army Medico. The second in command used a spare bunk in the executive officer's stateroom. The other 3 officers used variations of the hot bunking system. The troops were much cramped for other than sleeping space. It is believed that the system used was good--(that is, the temporary installation of bunks augmented by mattresses on the forward and after torpedo room decks plus a modified hot bunk system for the regular crew). This system gives much needed deck space for bull sessions, cleaning of weapons, guns, etc."

"The Army cook worked with our commissary department and the troops expressed themselves well satisfied with submarine food. Meals were served almost constantly throughout the 24 hours. The Army personnel ate after the ship's company so as to interfere less with the normal change of watch. As a matter of interest the Army personnel consumed food in the ratio of 3:1 over the regular crew. One breakfast of beans required 15 cans to serve the crew and 43 to feed the troops. When fried eggs were served at one meal the Army consumed 42 dozen. One mess cook resigned after carrying 72 hot cakes to a table of soldiers."

"Sanitary needs could not be met at all times due to the doubling of the ship's members. During battery charges at meal time, hot water could not be kept in a completely sanitary condition due to continual use. An average of 170 men used 4 stools. There was no admission to the sick list as the result of this." "Carbon dioxide concentration on long dives reached 4 per cent. No smoking was permitted." "Habitability was good although the weather was cold and damp. All men had warm and foul weather clothing." During these operations, the weather was rough; two men were transferred at Dutch Harbor because of seasickness. In general, health was excellent.

It has been possible to gain access to Army records concerning these operations in which the NARWHAL participated (Unclassified Report of Composite Battalion, 7th Scout Company and 7th Reconnaissance Troops) from which the following comments were taken: "It was found that training was necessary to accustom men to life aboard the submarine." "The NARWHAL--completely revised our method of debarking from the boat. With the new method, the boats were inflated and pushed to the after part of the deck. Then, with the men sitting in them, the submarine would partially submerge, leaving the rubber boat afloat. This method proved much easier and cut the time of disembarking in half." "The light infantry pack had to be carried because of the impossibility of getting the Ruck sacks out of the submarine hatches in the time allotted by the submarine commander."

And from G3 Operations Report (A Synopsis of the Operation of Landing Force 51.4 In Landing on, Engagement in, and Occupation of Attu): "The need for realism can not be stressed too strongly in all phases of training, particularly that part which involves Navy function that is unfamiliar to Army personnel." "The long exhausting trip on a submarine from the United States undoubtedly affected that portion of the 7th Scout Company aboard. All troops suffered in physical condition as a result of the long transportation voyage."

NAUTILUS's Seventh Patrol

On her seventh patrol (8 Nov to 4 Dec 1943) the NAUTILUS landed Marines on Apamama. With her own crew of 70 men and 8 officers, she carried 181 men. Comments made in the patrol report concerning this operation are as follows.

"The health of the crew and the Marines was excellent. Food was satisfactory--moved Thanksgiving Day up to D-day, so that the Marines could have the traditional feast before leaving the ship. Used the cafeteria method--which proved highly satisfactory. Habitability was fair to good. During all day dives, smoking was prohibited except for a 15 minute period at noon. Carbon dioxide absorbent was spread in the morning upon submerging and the level rose to 2.1 per cent by the time we surfaced." (On one occasion during the 15 minute period in which the smoking lamp was lit the carbon dioxide content rose from 0.5 to 1 per cent.)

"To avoid large weight shifts the Marines were kept in the end compartments except during their meal hours. We carried 5 movies along and showed them in alternate torpedo rooms each night." "Wardroom berthing and messing arrangements were crowded but we satisfactorily took care of 17 officers." "Air conditioning for all of the ship is satisfactory except for the conning tower." "A combination of water loss through engine failure and the large number of passengers carried made the water situation acute at times."

"The Marines were stoic but they were unanimous in the attitude that they would much prefer a rubber boat or a hostile beach to their present predicament--it was certain that none of them would be hesitant about leaving the ship at landing time."

On 20 November (the ship having been shelled prior to the landings)--"The Marines seemed anxious to get off the submarine. They had determined that the torpedo rooms were not satisfactory sites for foxholes." In this operation two wounded men were returned to the ship, one of whom died and was buried at sea.

TRITON's Fourth Patrol

The TRITON, on her fourth patrol, from 26 to 30 August 1942 carried 24 Army passengers from Dutch Harbor to Adak. "Landing operations were begun at 2234 and completed at 2315. Troops were furnished with Kapok life jackets and fed sandwiches, soup, and coffee just before they embarked."

SANITATION FEATURES OF FLEET TYPE SUBMARINES

ABOARD SUBMARINES USED AS TROOP TRANSPORTS

In the preceding section, mention has been made of the desirability of increasing present head facilities when submarines are used as troop transports. On the NARWHAL (No. 4), an average of 170 men used 4 stools for 29 days. On NAUTILUS (No. 5) with the small after sanitary tank filling after 4 hours of submergence with 109 passengers aboard, men walking forward and aft caused much operation of the trim pumps.

LAUNDRY FACILITIES ABOARD FLEET-TYPE SUBMARINES

Light leather (or leatherette) bunk covers proved worthy in keeping mattress covers clean. A small leather bag attached to each bunk and designed to be used as a laundry bag became invaluable as a locker for clothing, toilet gear and books (NAUTILUS No. 1).

We have seen elsewhere the necessity for restricting the use of fresh water aboard submarines, and that this was compensated for by the use of condensate for bathing, and for use in the washing machines. This latter facility was very popular and much used by the men. A few criticisms concerning the machines are to be found in these patrol reports. TULLIBEE (No. 2, 1943) reported that "the washing machine motor was out of order the whole patrol." PORPOISE No. 4 (Jan 1943): "The washing machine, designed for household use, is not rugged enough to take care of the laundry for 69 men." SNAPPER (No. 7, Sep 1943): "The most desirable installation of the washing machines was largely defeated by the bulk and fragile construction of the equipment provided. Believe a Bendix machine would surmount both of these difficulties. Approximately 300 gallons per day of condensate water could provide an abundance of water for the laundry." GRAMPUS No. 1 (Aug 1942): "Could not use a washing machine due to the electrical load on the IC machine."

ROUTINE ABOARD THE SHIP

POGY required the cooks, mess cooks, and mess attendants to shower daily, the rest of the crew being allowed showers once a week. "Creosol was used on the deck of the shower rooms. The ultraviolet lamp was not used due to its location in the forward torpedo room, which, when the injection temperature of the water was down to 50 degrees F. or lower, was too cold for the men to remove their clothing."

CROAKER (No. 6) reported a high level of cleanliness with adequate clean laundry and mattress covers, berthing compartments swabbed daily and the bulkheads and overheads throughout the boat frequently washed. Heads and showers were disinfected daily.

On the first patrol of the SHAD the commanding officer observed: "Reveille of all hands took place at 0700 except on Sunday and two very rough days when turned to at 0800. Field days on Friday. Carried out material routine and cleaning--probably the best result of this daily work period was to provide a daily period of physical work which broke the normal routine of watches and sleep, preventing boredom and lassitude." CROAKER (No. 4) had field day every few days. SHAD (NO. 6) followed a "strict daily routine of reveille, breakfast, work in cleaning stations and group instructions by officers and leading men in specialties and submarine knowledge except for Sundays and after night attacks."

PLAICE (No. 6) held a weekly field day. "On Friday one compartment was selected and word was passed that it would be ready for inspection by 1130. The rest of the boat observed a normal routine. This enabled the commanding officer to completely inspect the boat once every 7 weeks and worked a hardship on no one." ATULE (No. 4) reported that "a clean ship with proper handling of limited quarters by an efficient chief of the boat more than compensates for the hot bunking--." BURRFISH (No. 5): "Required daily field days; a continually clean boat added to the comfort of all." On the FLOUNDER (No. 4): "Cleanliness of the boat was maintained at all times due to the friendly rivalry between the two torpedo rooms and also among the chiefs of the watch." BATFISH (No. 1) reported: "--repeated field days helped spend idle hours and enable us to live comfortably."

GARBAGE DISPOSAL

The S-30 (No. 4) having stowed garbage (and ruptured tin cans) in cotton sacks, threw it over the side. TUNA (No. 1) obtained burlap sacks for this purpose--"being less conspicuous than the debris, even though they do not sink rapidly. Moreover, they can be thrown completely clear of the main deck from the bridge keeping the main deck clear of refuse which might float off when submerged."

On one occasion aboard the SEAHORSE (No. 7): "While dumping garbage through gun access trunk, SJ picked up plane coming in fast. Submerged--since the same thing happened last night this time believe are after our STM or some of our CRS garbage cans. Some of latter, we have been forced to leave topside--. Will set clock ahead one hour tomorrow to prevent it happening again."

"The disposal of garbage is still a matter of concern to the commanding officer. It is difficult to keep the nonsinkable portions segregated, resulting in much work on it before dumping. Weights for sinking are scarce; therefore, most nonsinkable garbage and trash is kept aboard while on station." (S-37, No. 5).

SANITARY TANK-HEAD SYSTEM

On some submarines at the present, one head near the maneuvering room is emptied by blowing directly into the sea; the waste from the other heads, showers, etc., are accumulated in sanitary tanks. Aboard fleet-type submarines there are generally two of these tanks, with a capacity of roughly 350 to 900 gallons each. The contents of the tanks are received via drains from the showers, etc., and directly from the head seats by way of a hand operated flapper valve equipped with a counter-weight for automatic closing. At sea, the tanks are emptied upon surfacing and sometimes every few hours thereafter during the day, and upon rigging for diving. This is accomplished by admitting air until the pressure within the tank is from 10 to 12 pounds above that of the sea pressure, whereby it is emptied or "blown" of its contents. The physical act of blowing the tank produces, of course, some agitation and odor, which, for the most part, is ventilated outboard. Upon submerging until the pressure in the tank drops to normal, ventilation is inboard through a charcoal filter. When empty, the tanks are said to have been "blown dry"; actually, however, some 8 or so inches of residue commonly remains in the bottom of the tank.

Inadequate Size of Sanitary Tanks, Etc.

The commanding officer of the WHALE (No. 3) in April of 1943, stated that "the capacity of the No. 2 sanitary tank is inadequate (250 gallon capacity) for disposal of all of the vessel's wastes during the average all day long dive." STEELHEAD (No. 1) in June of 1943 made a similar observation. The commanding officer of the HADDOCK (No. 5) in August of 1943, observed: "In the Drum-class submarine the sanitary tank for the crew's wash room is not large enough, even with the most careful use of water and proper supervision. The originally designed No. 3 sanitary tank was modified at the time of construction into a lube oil tank. The boats now carry 15 men over the originally intended complement of 53 men. This fact together with the absence of the No. 3 tank places too heavy a strain on the capacity of the No. 2 sanitary tank. This tank ordinarily overflows at least 2 hours before surfacing every day. Recommend that No. 1 lube oil tank adjacent to No. 2 sanitary tank be modified into an overflow sanitary tank." The commanding officer of the LAPON (No. 3) in April of 1944 reported that "Installation of a large hopper under the officer's head was a source of great relief--all hands being convinced during an all day submergence."

HAWKBILL (No. 1) reported that during a depth charge attack a leaking valve in the No. 1 sanitary tank caused it to overflow and fill the boat with a most disagreeable odor.

Odors in Sanitary Tanks

Throughout the war numerous complaints were made by various commanding officers concerning the unpleasant odors associated with Portsmouth design of the head-sanitary tank system.

Said the commanding officer of the CREVALLE (No. 2) in February 1944, after a 60 day patrol: "Habitability was excellent with one exception--something should be done about the sanitary tank situation which stinks. All the heads, showers, sinks, and wash basins discharge to either of the two sanitary tanks. These are blown to sea at dawn and at dusk, the time interval being about the maximum possible. Both tanks are fitted with activated charcoal filters in the inboard ventilation BUT to discharge the water closet bowls, direct connection without benefit of a water trap is made between the tank and compartments and personnel will leave the bowl flappers open. Hence any liquid entering the tank forces an equivalent volume of highly flavored air from the tank up into the water closet compartment where it is picked up by the hull exhaust system and discharged to the forward engine room. To use the air conditioning, a certain amount of recirculation must take place. The aroma at times prevades the ship and in no way resembles the attar of roses. We have controlled matters to a limited extent by several times daily completely filling and then flushing the tanks out with considerable expenditure of high pressure air and then putting a few gallons of fuel oil in each tank daily to neutralize the Whangpo River effect as much as possible. However, like Chick Sale's men who failed to 'dig her deep', these tanks must now be cleaned or we can not be responsible for the consequence. A deodorant and sterilizing chemical should be supplied in addition as it is felt that the tanks are a fly breeding menace, as flies enter and leave the tank freely through the water closet bowls." He reiterated his complaint at the end of the fourth patrol that "the sanitary tanks continued to give off offensive odors despite the liberal use of creosote; the tanks should be thoroughly cleaned--a difficult task."

TILEFISH (No. 1) in May of 1944, reported that "at the beginning of the patrol the flushing valves to the heads began to leak, necessitating leaving the head flappers open during dives. This resulted in a constant bad odor in the boat. Several flushings of both tanks during the night and the use of deodorants did not eliminate the foul smell."

SEA ROBIN (No. 2) in April 1945 reported: "One of the major defects in design of present submarines is the system of heads and sanitary tanks. The alternate vacuum and lack of vacuum in the head space, caused by the suction from the engines when the engine room door is opened for the access of personnel, induces a flow of air in and out of the sanitary tanks. This foul air causes an unbearable stench in the vicinity of the head space which overpowers any disinfectant or deodorant." Similar complaints were made by the commanding officers of the REDFISH (No. 1), PLAICE (No. 5), STICKLEBACK (No. 1), ATULE (No. 1), PIPER (No. 1), SEACAT (No. 3), BERGALL (No. 1).

Another commanding officer (BATFISH No. 12) reported that inability to obtain replacement filters at Midway resulted in considerable unpleasantness after a few weeks at sea. PIRANHA (No. 3) reported: "special attention was paid to the two sanitary tanks. They were kept well supplied with creosote (1 1/2 to 2 gallons), and lye (10 cans to 1 1/2 gallons of water) once a week was put into dry tanks--this kept a particularly odious and odiferous situation under control."

Suggestions for Improvement

Different suggestions were offered to relieve the above highly disagreeable and unsatisfactory condition. First of all, frequent cleaning of the tanks is a help--but, as indicated, it is a difficult and disagreeable task. Secondly, the charcoal filters used in inboard ventilation have to be frequently replaced.

PLAICE (No. 6) suggested installation of a constant-flow disinfection system. TILEFISH (No. 1) and STICKLEBACK (No. 1) suggested a separate sanitary system or tank for the heads, as distinguished from the wash basins, showers, and scullery drains. "We seem to get several times the amount of odor as was the case in the older type of submarines on which heads were supplied with individual tanks." ATULE (No. 1) suggested dividing each sanitary tank into water tight compartments; one-half to be ventilated inboard for drainage of the sinks, wash bowl, showers, scuppers, etc., the other half to be sealed and provided with heads of the old design with an air chamber installed so that excreta could be blown or pumped into the sealed tank."

INSECT LIFE ABOARD SUBMARINES AND FUMIGATION

Flies.--While undergoing refit alongside a dock or tender there is no means by which flies may be kept from the interior of the boats, to which they are drawn especially during the loading of supplies. Once underway, they may be difficult to eliminate. As noted above, when the flapper valve of the stock is left open, for whatever reason, flies may readily gain access to the sanitary tanks.

Many submarines, starting on war patrols, commonly utilized the space available in secured deck hatches for the stowage of potatoes; DRUM (No. 8) observed that spoilage of the potatoes "provided a breeding place for flies."

Other Insect Life.--Routine physical examination of submarine crews will often times disclose the presence of a few cases of body lice. Their prevalence sometimes can be related to the general hygienic conditions aboard the ship and to overcrowding. It would appear reasonable to associate the prevalence of scabies to similar conditions and particularly to hot bunking.

Some ships were plagued by cockroaches, some had rats. Reported one commanding officer: "A grim battle was waged throughout the patrol between the crew and the cockroaches. On many times the decision was in doubt, especially when copra bugs--brought aboard on captured equipment from a sampan--reinforced the roaches. The anti-climax was a latent outbreak of 'crabs' among the crew."

Prisoners of war when recovered and brought aboard, were commonly stripped above deck and suffered clipping of their body hair. When taken below they were carefully inspected by the pharmacist's mate for evidence of insect life and venereal disease.

Fumigation.--In this series of reports, 25 submarines made 28 requests for fumigation during the refit on which the report was submitted. Three commanding officers (TRIGGER 10, ANGLER 7, and BONEFISH 7) associated their insect life with lengthy overhauls carried out in the San Francisco Bay area. "The ship was infested with bugs on leaving San Francisco (BONEFISH) which were eliminated by the use of DDT in Pearl Harbor" (SILVERSIDES 9).

One commanding officer stated: "Carboxide gas was not available during the past refit. Therefore, we put to sea with a family of roaches which had already made one patrol. It is hoped that the boat will receive a proper fumigation before it is necessary to qualify these unwelcome passengers." SHAD (No. 8) reported: "Had many cockroaches. No carboxide was available at Midway because (it was said) someone, somewhere had been badly poisoned on one of the boats." As far as is known (Preventive Medicine Division, BuMed) this fact can not be substantiated. It is true, however, that carboxide gas, as is any fumigant, is potentially dangerous unless all precautions, as fully outlined elsewhere, are followed. When used aboard submarines, it is particularly important that personnel descending into the engine room to start the ship's ventilation system be protected by a gas mask, and that the boat be well ventilated before personnel are permitted to return. Freon bombs were used in its place and were ineffective. PERCH, at the end of her fourth patrol, reported that the use of the Freon Aerosol Bomb had been very successful: "One bomb was used each week with a noticeable decrease of vermin, and with the final two applications the boat was completely clear of them." TRIGGER (No. 9) speculated upon the relationship between badly needed fumigation and the low state of the physical condition of the crew.

VARIOUS OTHER ASPECTS OF HABITABILITY ABOARD S-BOAT SUBMARINES

Many aspects of this subject have already been discussed elsewhere, as: life aboard this class of vessel in rough weather, the impairment of habitability (carbon dioxide accumulation and depletion of oxygen) on prolonged all day dives especially in cold weather operations, and the fresh water situation. Remarks concerning the ration aboard S-boats will be taken up elsewhere. Other aspects of living conditions, as mentioned by commanding officers were as follows.

In the first patrol report made from the Aleutian area, the S-23 No. 1 (7 Feb to 17 Feb 1942) reported having made patrol without heaters--all living compartments were cold and damp and personnel slept in their submarine clothing to keep warm. On the third patrol of the S-31 (July to August 1942) many colds were experienced; many of the men developed sore throats in the first 10 days, "believed transmitted through the mess gear, there being no facilities available for its disinfection." When submerged, all hands not on watch were allowed to sleep, a routine carried out on her fifth patrol except during short daily clean-up periods.

On the fourth patrol of the S-30 (August to September 1942) portable heads were used which were dumped at night; laundry was not permitted; garbage (and ruptured tin cans, etc.) were thrown overboard in cotton sacks; mess gear was cleaned with alcohol. Sweating throughout the boat was extremely annoying causing wet clothing, bunks, etc. The ship had no air conditioning; heaters were not used. The daily average temperature averaged above 64 degrees F. within the boat. Hot bunking was necessary.

"Living on an S-boat in these waters" reported the commanding officer of the S-34 (No. 3, September to October 1942, Aleutians) "is like living in a sewer--the boat is cold, wet and overcrowded. Standing watch on an S-boat bridge in cold weather is sheer hell; below deck it is but little better."

The commanding officer of the S-33 (No. 2, July to August 1942) reported: "The fact that only one head is available for 45 men is a contributory cause to the prevalence of headaches, constipation and colds." S-30, No. 8 in this respect reported: "the one head for the crew had an almost steady flow of customers."

On the fourth patrol of the S-28 (Dec 1942 to Jan 1943) made in the Aleutians, heaters kept the boat comfortable; extreme difficulty was experienced in the drying of clothes. Aboard the S-40 (No. 8, June to July 1943, Kurile) "the new heater drained the batteries too much and was not useful. The torpedo room became excessively cold and damp and sleeping was impossible in them after the first few all day dives."

"The habitability of the vessel (off Java) in the patrol area is best described by a spontaneous remark by one of the officers going on watch after two hours of sleep while submerged: 'One never really gets used to this living but I can tell the difference now between perspiration and a cockroach'" (S-37, No. 4).

THE SUBMARINE RATION

Recognition of the many inherent limitations and discomforts of life aboard submarines make special efforts to provide a good ration imperative. This is necessary for morale, health and personnel endurance. In general, the food served aboard submarines in World War II was excellent and well deserved the reputation which it came to have among other less elaborately fed branches of the Service.

The ration provided a submarine for a long cruise needs to fulfill certain requirements. It must have been selected to occupy a minimum of space, evidence excellent keeping qualities under sometimes adverse conditions of stowage, and a minimum of waste. From it a daily well-balanced menu incorporating a maximum of food value and variety should be easily prepared. In 286 patrol reports from fleet and S-type submarines the ration was specifically reported as being good or excellent. In many of these and other reports, critical comments were made with regard to the supplied ration which are worthy of note.

STOWAGE

S-boats.--Aboard the S-type of submarines limitation of food stowage space very definitely was one of the limiting factors of endurance. Observations made by commanding officers of S-boats in this respect are as follows: "This type of ship normally carries provisions for 31 days which should be regarded as the normal limit--that will offer a well balanced diet; this could probably be extended by the use of dehydrated and concentrated foods and vitamin tablets." "Ran out of vitamins on the second week; had a few dehydrated foods and a few special submarine items. In the last week the predominating items on the menu were canned ham, canned roast beef, canned corned feef, Vienna sausage, rice and corn bread. Canned milk ran out on the 30th day; white flour two days later." (S-33, No. 2, 45 men and 5 officers aboard, 37 day patrol, July-August 1942, Aleutians).

"This class of submarine does not permit sufficient stowage space for more than 30 days' supply of balanced rations. The patrol lasted for 36 days, the last 5 days we scraped for any remaining food." "In spite of the fact that we realized the patrol might extend beyond the 30 day period, and the care taken to conserve provisions--we consider ourselves lucky to have eaten so well." The estimated "25 days of personnel endurance is based solely on the stowage available to carry a well-balanced ration to cover this period. A 30 day patrol period is considered the maximum--for efficient performance of personnel in an S-class submarine" (S-32, No. 3, 36 day patrol, July-August 1942, Aleutians). "Very little reserve is left in this class of ship after 35 days on patrol. Provisions for all practical purposes are exhausted. The base of the icebox loomed very large during the last week. No one got malnutrition but there was a decided reduction in the quantity and variety of food" (S-28, No. 2, 34 day patrol, July-August 1942). "Fresh food lasted 12 of the 30 days--estimate the total quantity on board at the start of the patrol was 45 days" (S-38, No. 8, 31 day patrol, tropical, September-October 1942). "Three weeks fresh provisions were stretched out over four weeks; food for the fifth week came out of cans" (S-31, No. 3, 36 day Bering Sea patrol, July-August 1942, 51 men aboard). "Food was good, well prepared and palatable; a few staples had to be rationed on the return trip"--although no one went hungry (S-30, No. 4, 32 day Aleutian patrol, August-September 1942). "Stowage problem was limiting factor in providing of sufficient perishible food" (S-42, No. 6, 30 day patrol, 54 men). Aboard the S-34, No. 3, the commanding officer reported: "Ample food was carried; stowed everywhere, from the COC bilges to the torpedo loading hatch (excellent for bread stowage)."

Fleet-Type Submarines.--In general, it is believed that most fleet-type submarines departed on patrol with food supplies calculated to provide them with an endurance of from about 70 to 90 days. Anyone who has ever been aboard a submarine at the time supplies are being loaded has marveled at the ingenuity evidenced by the crew in making stowage space available. Literally every available inch of space was utilized. The iceboxes were crammed; potatoes stored in hatches; showers were piled high with crates of vegetables and fruit; cases of food were stacked in available corners sometimes in passageways and pushed under bunks and when this space was reduced, individual cans were tucked into every conceivable nook and cranny.

Specific remarks made by commanding officers concerning available stowage space for staple articles of food on this type of vessel were as follows. The commanding officer of the DOLPHIN, at the end of her first patrol in January 1942, 47 day patrol: "We had on board a sufficient supply of stores for 75 days. Stowage space for this quantity of provision is inadequate and prevents systematic arrangement of food. Proper stowage and access to all provisions is necessary to effect a continuously balanced diet."

During the third patrol of the PERMIT (39 day patrol, tropical, 30 Dec to 6 Feb 1942, 70 men aboard): "Ran short of food--with increase of 30 per cent over normally carried personnel. By stretching, the provisions lasted until 4 February when it was necessary to start using emergency rations. During the last 10 days the diet was poor and unbalanced due to the exhaustion of staples such as fresh meat, flour, sugar, and milk." At the end of her eleventh patrol (2 Jan to 18 March 1944, 76 day patrol, tropical), it was observed: "Food was adequate but" preparation of the "menu was difficult and certain specific shortages became onerous--toward the end of the patrol--definitely attributed to the fact that there is hardly sufficient stowage space on the ship--even using the after battery room and all passageway deck--to carry provisions for 78 men for a long patrol. After a long series of comparatively short patrols, commissary personnel had lost their knack of buying and stowing to utilize the space with the utmost efficiency." At the end of her thirteenth patrol (45 day, tropical) it was again reported: "Commissary stowage facilities are definitely inadequate; as usual, departed with passageways, showers, motor room, piled high with cases of food."

At the end of the first patrol of the FLOUNDER (May 1944) it was reported: "lack of stowage space for dry stores; converted log room and one shower stall for dry stores to reduce amount of random stowage throughout various compartments of the ship." At the end of the GATO's eleventh patrol (March 1945) it was observed: "About one-third of the dry stores room is now taken over by the SD mast. Our carrying capacity is greatly reduced--as noted by the reduction in the variety of meals the last two weeks of the patrol (54 day patrol, 78 men aboard, Yellow Sea). Some additional nooks and crannies throughout--will have to be found for storage prior to the next patrol." The SNAPPER at the end of her first patrol in 1942 commented upon the "excellent stowage rack table installed by Mare Island workers in the crew's mess hall."

SHORTAGE OF FOOD AND PATROL ENDURANCE

Despite the limited space available for the stowage of food aboard submarines, very rarely, comparatively speaking, was the supply depleted to the extent that men suffered or that the patrol was thereby terminated.

In the early days of the War, especially in the active war zone, it was difficult for submarines to obtain adequate food supplies. This was reflected, in a few instances, in unsatisfactory rations. On the first patrol of the SEADRAGON (30 Dec to 13 Feb 1942, 45 days, tropical): "inexperience in planning and procurement for such a long patrol made the diet unsatisfactory. Difficulty in obtaining food at Soerabaja prevented getting a full larder. Food had to be rationed. Much meat and flour had to be surveyed. Dietary deficiency was noticeable, especially in a large number of the crew with sore gums after about the third week. On one occasion, for a period of 24 hours, there were many cases of diarrhea." At the end of the first patrol of the SEA RAVEN (9 Dec to 19 Jan 1942, 41 days, tropical): "from 1 January to 13 January the food supply was low. The decision to remain on station was based on a 5 day supply of food." Shortage of provisions was a limiting factor to the duration of the fifth patrol of the STURGEON (4 Sep to 25 Oct 1942, 52 days, tropical). The third patrol of the CUTTLEFISH (23 July to 20 Sep 1942): "could not have been continued for more than 5 days longer without serious reduction in the efficiency, and health--due to the unbalanced ration."

As the War progressed, on occasion, deficiencies in the quantity and variety of food sometimes was reflected in monotonous diet. As will be seen, this was due to different factors--unusually long cruises, unexpected extension of the patrols, inexperience in loading and poor quality of food available before departure and refrigeration failure while on patrol.

The eighth patrol of the BLACKFISH, "an 80 day patrol", one of the longest made by any submarine during the war--was completed with the remarks: "It was very fortunate that we had taken on a 90 day supply of food (83 men aboard, made in the Ryukyu area)--by the 77th day choice and variety had disappeared and all food came out of cans. Planning menus was difficult"; 5 days of provisions were left at the end of the patrol. The eleventh patrol of the FLYING FISH, of 83 days duration (1 Aug to 22 Oct 1944, tropical) was concluded with a monotonous menu in the last week--due to "the length of the patrol and the quality of food available."

The STEELHEAD on her third patrol (12 Sep to 25 Nov 1943, 81 men, Bungo Suido)--"one of the longest made out of Pearl Harbor--ran low of coffee and sugar the last 10 days but otherwise the amount carried on board was sufficient." THRESHER on her fifteenth patrol (82 days, 31 Jan to 25 April 1945, tropical, 88 men aboard) was ordered onto a patrol station between Pearl Harbor from Saipan. The quantity of food was investigated and need for conservation was found should the patrol be long extended. On 13 April--the 71st day--"daily ration changed to two meals with soup at midnight. The change worked better than expected and did not affect morale. On 18 April the food stock had been reduced to the level that cabbage and asparagus were served for breakfast--fortunately orders to depart the area were received that morning."

On the fourth patrol of the HOE (4 April to 2 June 1944, 60 days, 61 men, China Sea) "food was entirely expended except for two cans of catsup--this was largely due to inexperience of the Commissary Officer and the unpalatable items carried." At the end of the fourth patrol of the PERCH (19 Dec to 15 Feb 1945, 59 days, China Sea) it was reported: "Food was poor--much canned food and 300 pounds of Australian beef were surveyed after a month at sea. If food standards are lowered much more the time on station will be definitely limited. Our reserve food on board will not inventory over 5 days this patrol in comparison to 15-25 days on previous patrols." At the end of the sixth patrol of the SALMON (1943, 53 day patrol) it was reported: "--estimate have 20 days of rations left--do not believe we could have served a balanced ration." On the ninth patrol of the TAMBOR (5 Jan to 5 March 1944, 61 days, China Sea) as a result of depth charging "all the fresh meat, vegetables and fruit had to be surveyed on 6 February--the diet from then on consisted of canned food. In view of the possibility of refrigeration failure it is necessary to carry a good reserve of canned food."

SEA OWL on her second patrol (11 Feb to 21 April 1945, 71 days, tropical, 86 men aboard): "Replenished food at Saipan only to the extent of fresh provisions--for the trip to Midway. Enroute specific shortages occurred. Food was rationed; the menu became fairly rugged in spots--but we were never hungry and the last meal was almost as good as the first." On the twelfth patrol of the SEARAVEN (15 Aug to 6 Oct 1944, 52 days, 74 men, Kuriles): "Food proved to be quite a problem toward the end of the patrol. Apparently the appetites of the crew increased inversely to the temperature--7 days of provisions left." At the end of the third patrol of the GRENADIER (13 July to 18 Sep 1942, tropical, 67 days) four days of provisions were reported "meaning a balanced ration. Our supply of fresh meat, flour, sugar, and canned juices was low. We could go three weeks longer on rice and canned meat and vegetables."

Sometimes food supplies were depleted consequent to flooding the store room--as on the TARPON (No. 1) when some "cereal and sugar were lost when water was taken down the hatch"; and aboard the PUFFER (No. 7) when "700 pounds of sugar was salted; teaching us the hard way not to put all of one thing in the same place. Issued ration cards for the small quantity of remaining brown sugar and learned to drink but not to like a new beverage--Navy issue coffee with brown sugar." A similar accident occurred aboard the POMFRET (No. 3).

SUPPLY OF VEGETABLES AND FRUIT CARRIED BY SUBMARINES

The quantity of fresh vegetables and fruit that can be carried aboard a submarine is limited, not only by the amount of available storage space, but by the available supply at refitting bases.

Inasmuch as the potato occupies a prominent place in the average American diet, submariners naturally wish to carry as large a supply as possible. It is said that the PUFFER (RAY 3) first made a "spud locker out of the trunk of the crew's mess hatch" for extra stowage space. At any rate, through use of this space RAY found that she could carry about 50 per cent more fresh potatoes; others found it would augment the supply to the extent that potatoes were available for the entire patrol; for two-thirds of the patrol (HAMMERHEAD 2); for an excess of 30 days (BURRFISH 3). HERRING on her seventh patrol "for the first time carried enough potatoes and onions to last practically the whole patrol;" as did ICEFISH (No. 3) and TILEFISH (No. 4). The GATO (No. 11) and PUFFER (No. 6) observed their capacity for carrying fresh potatoes was reduced by the addition of water tight hatches at the bottom of the access hatch. Sometimes the "supply of potatoes, as in the forward torpedo room, proved a breeding place for flies" (DRUM No. 8).

Canned, water packed, potatoes were frequently available and some submarines regarded them as "superior to regular fresh potatoes" (GUDGEON No. 1 and SNAPPER No. 1). Certainly, they must have been more convenient of use. GUDGEON goes on to say that rice is an excellent substitute for potatoes and was served frequently. CROAKER (No. 3) observed in this respect that "in the last two weeks when potatoes ran out, rice, spaghetti, macaroni, and increased consumption of bread and cake filled our need for starch."

Other fresh vegetables and fruit, as onions, tomatoes, lettuce, carrots, cabbage, apples, oranges, etc., are especially appreciated by the crews of operating submarines--especially in that they lend variety and interest to meals which, without them, become very monotonous. "About the 50th day fruit and fresh vegetables became the usual topic of conversation" (SARGO No. 5). The commanding officer of the STURGEON (No. 3) in February 1941 observed that "fresh provisions of an excellent and superior quality," should be made available for the crews of submarines on patrol--"the importance of this is hard to over estimate." "We had tomatoes for two weeks, onions and cabbage for four weeks, lettuce for three weeks and potatoes for five weeks (patrol lasted 46 days)." On the fourth patrol, lettuce was available for over four weeks. BALAO (No. 9) observed that fresh apples and oranges were especially welcome. BATFISH (No. 4): "Fresh fruit, apples, and oranges, still served after 40 days from Midway." On the ninth patrol of the TAMBOR fresh vegetables and fruit were carried to supply the need for the greater part of the patrol. On the second patrol of the LAPON, fresh fruit was available for 26 days (40 day patrol). POGY (No. 7, 50 day patrol) and SEARAVEN (No. 11, 49 day patrol) had fresh vegetables available for three weeks. "Loading icebox with fresh lettuce and tomatoes paid dividends for first two weeks of the patrol" (BLUEFISH No. 6). "Fresh provisions taken on at Tulagi were a great help. Lack of frozen foods was offset by an abundance of fresh fruit" (ALBACORE No. 8 and No. 10).

The commanding officer of the S-38, No. 2, reported: "A quantity of locally (Soerabaja) produced concentrated lime and lemon juice was carried and proved a delicious and refreshing drink. Since this product is fresh, it is considered to supply, in part, the vitamin deficiencies in our ration, due to the inability to stock sufficient fresh food for the entire patrol. Adoption of this beverage as standard by all submarines is recommended."

FRESH FROZEN FRUITS AND VEGETABLES

The advent of quick frozen fruits and vegetables was a boon to the submarine cook and crew. They are convenient, simple to prepare, cook with a minimum of waste, and can be easily stowed. Unfortunately, however, they require refrigeration, the amount of which space aboard a submarine is definitely limited.

Comments regarding this type of commodity were, on the whole, very enthusiastic--"quick frozen foods are excellent" (LAPON 6); "we need more quick frozen vegetables, especially fruit" (SARGO 12); "the value of such items as frozen strawberries, corn, beans, peaches, and vegetables can not be too strongly stressed" (BOWFIN 5, REDFISH 1); "fresh frozen fruits and vegetables should be stocked to the limit of the capacity" (SPEARFISH 12); "it is unfortunate that the space available restricts the amount of fresh frozen foods that can be taken aboard" (BANG 3, PINTADO 5); "even a small quantity enlivens an otherwise drab bill of fare" (ANGLER 5, BERGALL 4, CREVALLE 3, CROAKER 4, DRUM 6); "the variety of fresh provisions was limited but quick frozen foods helped and were greatly appreciated" (PARGO 4); "fresh frozen foods were a welcome relief from the regular diet" (REDFIN 4); "--worth their weight in gold toward the end of the patrol" (SEA DOG 3).

By institution of rationing, quick frozen strawberries, peaches, and peas were retained until the last three days of the patrol (FINBACK 3, 52 day patrol). By this means aboard the TIRANTE (No. 3, 60 day patrol) fresh frozen fruit and vegetables were made to last throughout the patrol--with a total of 98 people aboard. On the fourth patrol of the TILEFISH (47 days in length) they lasted for 30 days; aboard the PICUDA (No. 1, 52 days in length) there was a 6 day supply left and twice this amount of dry provisions "enabling the Chief Commissary Steward to feed 81 men and officers with despatch." On the third patrol of the PUFFER, "120 pounds of strawberries lasted without spoilage until the 49th day of the patrol--." Aboard the STURGEON (No. 11) "after a long period of evasion, the balance of frozen food had to be surveyed." The commanding officer of the PLAICE (No. 2 and 4) observed that frozen foods suffered a loss of flavor through long storage.

Unfortunately, and especially at advanced bases, it was not always possible to supply submarines departing on patrol or returning from a long cruise with fresh vegetables and frozen foods in adequate quantities. Several commanding officers (20) reported lack of or limited supply of this food, often the cause for considerable disappointment. "The absence of frozen foods was heavily felt--a great disappointment in view of all the correspondence during the past year regarding the desirability, benefit, etc., of supplying submarines on long patrols with frozen foods" (HADDOCK 1, September 1942); "A small selection and quantity of frozen foods were available--supply officers should be ordered to keep the stock of these items high at all times" (SNOOK 4, December 1943); "Another report of a submarine

lacking fresh frozen provisions. Highly recommend that the high priority assigned this type of food be rigidly enforced--that shore stations and tenders do without to such an extent that operating submarines may benefit" (C.O. Sq. 4, conclusion of POMPON's sixth patrol in September 1944); "Unable to see why there should not be an adequate supply of frozen vegetables and fruit at Pearl Harbor" (SPADEFISH 2, December 1944); "If at all possible 'stores' of quick frozen food should be kept on hand at Midway for submarines only. Beans, asparagus, peas, and strawberries are great morale builders on a long patrol" (TULLIBEE 2, November 1943); "Fresh vegetables issued in Guam are not sufficient to supply the chill box of a modern submarine--. These items are considered necessary and should be supplied" (LAPON 8, July 1945). Sometimes vegetables and fruits, if over ripe, spoiled quickly and had to be surveyed after a few weeks at sea (POMPON 9, WHALE 3, COBIA 1, HADDO 5). SILVERSIDES, departing from Pearl Harbor in July 1945, was unable to obtain fresh lettuce and vegetables before departing on her thirteenth patrol, 60 days duration.

"SPECIAL SUBMARINE FOODS"

Several different articles of food, often called "special submarine foods", were especially appreciated by submarine personnel because, like fresh and frozen vegetables and fruit, they served wonderfully to relieve the monotony of the regular diet; moreover, they provided "a maximum of food value, in a minimum of space with great keeping qualities and little waste" (GUDGEON No. 1).

Inasmuch as many submarines served only a lunch at the noon meal during submerged operation, canned luncheon meats were highly desirable (GUDGEON 1)--as canned ham, spiced meats, chicken, sausages, shrimp, oysters, crab, clams, and lobsters. "Our irreplaceable community stock of canned tuna, shrimp and crab disappeared during the last refit and was missed by all hands, particularly for the noon meal on all day dives" (CABRILLA No. 4). Canned bacon, too, rated high on the list. Other special foods included: sausage, cheese, peanut butter, pickels.

Aboard the S-38 (No. 3) and S-39 (No. 3) meat became unfit for consumption at the end of 4 days, due to improper freezing before delivery. "A quantity of the canned stew in use on the Dutch submarines was carried and proved a delicious and welcome addition to the menu. Development of a supply of this ration is strongly suggested as a means of adding to the food endurance, due to the high stowage efficiency of this food. Two varieties of this were carried: 'Hutspot me t lapstuk' (hodge-podge with thick flank) packed by H. Jenne & Company, Batavia in 1940 (plain stew with potato and green vegetables); and 'Snijboonen ment Worst en Aardappelen, gestooted met Bouillon, Boter in Vet' (sliced beans with sausage and potatoes, furnished with bouillon, bread and butter) packed by Tieleman & Dros at Leiden."

Fruit juices, of all kinds, were very much appreciated. "An ample supply of fruit juices is believed responsible for the marked decline in the number of bleeding gums among the crew" (SAURY No. 6). Aboard the GUITARRO (No. 5) an Australian brand of apple juice was especially liked. Other submarines (DACE 6, RATON 4, BATFISH 2) reported that the Australian variety of canned orange and fruit juices was "undrinkable" and "unfit for consumption", being "excessively bitter." Aboard the DRUM (No. 13) "several cases of low grade food poisoning without sick days were possibly due to "an American brand of prepared orange juice." "Tea shortage at Pearl Harbor caused great inroads in our fruit juice supply early in the patrol, with rationing during the latter part" (BARB No. 9). Coca cola was often times carried aboard and was a very popular drink (TREPANG No. 1). "Coca cola made with water and put in the cold room to 'ice up' was a delicious drink at any and all hours of the day" (DRUM 7). Aboard the SILVERSIDES (No. 1) coca cola, canned fruit juices and especially cider mixed in a syphon bottle was liked. "Ovaltine was by far the most popular beverage, hot or cold" (CABRILLA No. 6).

GUDGEON (No. 1) observed that Klim, powdered milk, made very good cocoa and chocolate milk and was satisfactory on cereal but was not recommended for use as whole milk for drinking. Stabilized cream, Avoset, was also very popular, though sometimes difficult to obtain in quantity and apt to turn sour (SEA POACHER 1, SPOT 3). "The absence of Avoset was keenly felt and precluded the serving of cereals and many desserts to which we had been accustomed" (TUNNY No. 3). Aboard the PARGO (No. 8) it was used to stabilize and enrich Klim--"and is a most desirable addition to the diet; it is hoped that this very useful item will remain available to submarines." Aboard the POGY (No. 8) "the mechanical cow was popular." "Powdered milk made available at all times--reduced consumption of coffee when used as cocoa" (SEAL No. 3).

ICECREAM

The number one item of food in relieving the monotony of the diet as far as most submariners were concerned was icecream, it being specifically mentioned in 23 reports. The TRIGGER on her ninth patrol (May 1944) had a homemade freezer, "which became as essential as any piece of gear except the air compressors." *WHALE on her fourth patrol requested a 10-gallon freezer.*

Many were the enthusiastic reports concerning this dish: "Adds an enjoyable variation *to the meals*"; "*The importance of icecream can not be over emphasized*" (ASPRO 2, 3); "at propitious intervals it supplemented a well balanced menu" (ATULE 4); "the icecream freezer is a most welcome addition" (BARB 7, April 1944); "generally found that near the end of the patrol icecream was the food that did not suffer with repetition" (BOWFIN 9); "served it three times a week" (BLUEGILL 1); "icecream machine was the saving grace this patrol" (GABILAN 2, GUITARRO 4); "unfortunately the motor of the freezer burned out on the 27th day (40 day patrol)--a bitter loss to all hands, especially since so much time was spent submerged" (JACK 5); "desserts improved 100 per cent over the last patrol by the icecream machine" (GUNNEL 2); "had icecream for dinner every day of the patrol" (HAWKBILL 2, JACK 3, BARB 9); "Icecream machine is by far best maintained and most popular machine aboard" (KINGFISH 9); "on long hot dives icecream is really appreciated and is easy to take" (POLLACK 4); "icecream freezer paid for itself many times over--it being estimated that one ton--was consumed during the patrol, cold weather not withstanding" (SEA CAT 2); "icecream was well liked despite the ice about us" (SNOOK 8); "failure of the icecream freezer was keenly felt" (WHALE 9).

On occasion, increase of the issued quantity of icecream powder was requested (BARB 8, 9, BLENNY 3). SEALION (No. 1) observed difficulty in cleaning the icecream freezer and made recommendations to better the situation.

DEHYDRATED FOODS

Dehydrated foods--potatoes, onions, eggs, etc.--in general, were not very enthusiastically received. "Dehydrated potatoes are palatable when mashed or french fried. They do not approach the fresh variety--." Powdered eggs are fine for cooking and baking but lack flavor when scrambled (GUDGEON No. 1); "dehydrated potatoes are not as palatable as the canned variety" (BURRFISH 1); "dried potatoes are peculiar and not appetizing" (HAMMERHEAD 2); "the dessicated variety of potatoes are not satisfactory" (COBIA 4); "dehydrated foods are inferior to those of a year ago" (BARBERO at end of her first patrol, October 1944).

SUBMARINE COOKS

Unless some care is taken in its preparation, the finest of food may prove unsatisfactory, especially on discerning patrols. Unsatisfactory preparation of food by inexperienced cooks was reported in 19 of these reports. "We had one inexperienced cook. Constant effort and the use of the Navy Cook Book was required on the part of the Commissary Officer to keep the food palatable. It is strongly recommended that each submarine be furnished with at least one experienced cook" (DARTER 1). "The inexperience of one cook's striker and one baker's striker was noticeable at times" (CARP No. 1, August 1945). "Only the best cooks obtainable should be assigned to the exacting cooking duties aboard a submarine, and between patrols it is believed that a brief course of instruction in diet and preparation of healthy menus should be given to all submarine cooks by a qualified medical officer" (SKIPJACK 5).

TUNNY (No. 1) recommended addition of a baker to the ship's complement in February 1943. The commanding officer of the SEA DOG (No. 1) pointed out that a cook with enthusiasm for his job can do much to improve the food situation. "Cooks are in a rut--they are born, not made" (DRUM 13). Food preparation was reported as poor on the sixth patrol of the GUNNEL--"three unimaginative cooks and the Navy Cook Book are a bad combination for even the hardest working commissary officer" (No. 6). "Supply of food was excellent; variety is a word most Navy cooks have never heard of" (CREVALLE 6). The baker on the first patrol of the MUSKALLUNGE was unsatisfactory--"took a month to teach him how to bake." "The proficiency of the average submarine cook these days leaves much to be desired. We have no baker" (ICEFISH No. 5, August 1945). "The practice that some ships followed while in the Bay area, of permitting the ship's cooks to take part-time work in the galley of the St. Francis Hotel was followed by this command and has paid ample dividends. This is the first good commissary department that we have had in 5 patrols" (PADDLE No. 8, July 1945). "Food was only fair, despite having sent cook to the St. Francis" (SAILFISH No. 11, September 1944). "Finally acquired a first class cook at Pearl Harbor" (ATULE No. 1, December 1944).

By and large, however, it is believed that most cooks and bakers aboard submarines performed their duty with satisfaction if not aplomb, for they were commended by their commanding officers in 47 of these reports: PERCH (No. 6) commended the bakers--"who are responsible for the particularly high morale around chow time." "The unsugn heroes

of these patrols are the cooks. Their's is a difficult task and one that is always well done" (GRENADIER No. 3). "The abundance of fresh bread, cakes, rolls and cookies provided by a conscientious cook went a long way toward making the BARBEL a fine ship" (No. 1). "The cooks and bakers made meals a pleasure" (BOARFISH 2). "Food was made very enjoyable by the excellent baking--an effort should be made to provide all submarines with a good baker for the morale factor--. This is the first time the commanding officer has had consistently good bread on a patrol--he appreciated it greatly" (BALAO 8).

SUBMARINE COMMISSARY PERSONNEL

In a number of these reports, poor or unsatisfactory food while on patrol was felt to be due, primarily, to lack of experience of members of the Commissary Department. "Food was lacking in variety--a deficiency which probably may be traced to the inexperience of commissary department personnel, the senior man of which is a ship's cook third class" (CAIMAN 1). "Improper preparation and lack of planning were contributing factors to the poor food--" (MUSKALLUNGE 2). "A rated member of the steward's branch is needed" (ROCK 4). "Food was excellent; having a commissary steward aboard is a great help" (GUITARRO 4). "Complete overhaul of the commissary department resulted in better food" (SAWFISH 8, SAILFISH 12). "Inexperience in planning and procurement for such a long patrol made the diet unsatisfactory" (SEADRAGON 1). "Quality of food good but ran out of several items due to carelessness in loading" (APOGON 7).

"Food lacked variety; provisioning for the next patrol will be undertaken with the assistance of more experienced base or tender personnel" (HERRING 6). In this regard the commanding officer at the end of the ASPRO's sixth patrol (a 50 day patrol concluded in February 1945) made some constructive suggestions worthy of note: "fresh frozen foods and Avoset ran out too early on the patrol because of the decision to load the refrigerator with an excessive amount of meat, at the expense of luxury foods. As a result we arrived in Saipan with a certain amount of meat but low in certain canned goods. There should no longer be the necessity to load to the hilt with the old staples, missing out on taking aboard the more desirable items of food that are available. At any rate, the Commissary Officer and steward should be furnished a sample list of provisions listing the items--with alternative and quantity--that are recommended to be carried by submarines on war patrols. There has never been anything published to guide the Commissary Officer, to the best of my knowledge, although unlimited information must be available. The only system has been the ordering of food carried on previous patrols, which system often goes amiss when certain items are not available. It is felt that this haphazard ordering of provisions could be eliminated by preparation of a standard provision list for submarines that would be mandatory on the part of submarines to follow. This list could be prepared with enough alternatives to give it enough flexibility to satisfy any boat."

On one submarine a commissary officer stated that he had had no previous experience as a commissary officer on any ship; that this was his first patrol. He stood a communication watch and the decoding task took up nearly all of the watch. He felt that he should spend at least an hour each day learning the boat; thus it will be seen that he had little time for other duties.

Aboard the PICUDA (No. 10) "feeding of 81 men and officers was accomplished with despatch by the chief commissary steward." "Food was excellent due to the energetic attention to duty of our commissary department" (PIRANHA 4). "The fact that the food was as good at the end as at the beginning of the patrol reflects most favorably upon the planning and supervision of the commissary officer and steward at the time food was loaded aboard, and upon the ability of the cooks" (SEAHORSE No. 6). Other such commendations were observed in some 9 reports.

MEAL ROUTINE

It is believed that most submarines on war patrols probably maintained the normal schedule for meals, with certain modifications; namely, a cold lunch at noon (1139), with breakfast (0715) before submerging, and the evening meal (1915) after surfacing and after ventilating the ship in order to avoid undue heating of the boat (KINGFISH 7).

Concerning this schedule observations of interest are as follows: "Light noon meals were tried during submerged days and during warm weather and were well received" (ASPRO 3). "Lunches were limited to soup and sandwiches with soup again at 1600 and the evening meal at 1930" (BILLFISH 1). "The noon meal during all day dives consisted of cold cuts, salads and two hot vegetables. A wider variety of sausage, preserved meats and cheese would have improved this meal" (BLENNY 1). "Cold lunches served while submerged become monotonous unless the cooks use variety and skill in their preparations" (DOLPHIN 1). "Although the weather was never too hot, light lunches of soup and sandwiches were well received" (PIRANHA 4). Other ships following this practice, and finding it satisfactory were: FLYING FISH 8, PORPOISE 6, THRESHER 2, HADDOCK 1, SHAD 2, SNAPPER 1, TARPON 2, S-34, No. 3.

Aboard the FLASHER (No. 1) meals were served at regular times with hot soup and crackers at midnight. DACE (No. 7) served soup at night on cold weather. Aboard the HADDOCK (No. 11) hot soup was served each afternoon in addition to the three regular meals. Many boats kept an open icebox (SILVERSIDES 1). On the PLUNGER (No. 1, 8) two meals were served a day--breakfast at 0730, and dinner at 1520. Aboard the PORPOISE (No. 6) supper was served before sunset during surface running to avoid "red light."

On some boats, the time for meals was shifted from the day to the night, as aboard the SPEARFISH (No. 1) where this plan "worked well." Aboard the S-47 (No. 1) breakfast was served after surfacing at night, dinner at 2330 and supper at 0400--a light cold meal permitted securing of the range several hours before diving, thus cooling off the after battery compartment. On the HERRING (No. 3) the heavy meal was served at midnight, breakfast at 0700 and a light supper at 1800--this plan "reducing the amount of cooking required while submerged to a minimum." On the SEARAVEN (No. 1) this routine was modified to the extent that the dinner meal was replaced by soup, a heavier meal proving unpopular. Aboard the SARGO (No. 1) breakfast was served at 1915, supper at 0330, with soup, cold meat, and coffee at 2315 and 1130. TRITON (No. 3) observed that the only advantage of this schedule was that the mid-day meal was thereby cooked while on the surface instead of submerged.

Other observations made concerning meals and their effects were as follows. The commanding officer of the ASPRO (No. 3) was of the opinion that serving a light lunch at noon "curbed the tendency to over eat from boredom with a beneficial effect on the crew." Aboard the CACHALOT (No. 1) food consumption was observed to fall off noticeably, the decline being most noticeable during the fourth week. "Appetites were considerably reduced after the beginning of the patrol" (GRAYBACK No. 1).

Others have observed a decline in appetites after prolonged periods of silent running. PARCHE (No. 5) observed that serving no meals during silent running left a great surplus of food. On the sixth patrol of the PLUNGER, food consumption was observed to increase with cold weather, a similar observation having been noticed on the twelfth patrol of the SEARAVEN made in the Kurile Islands area. Cold weather operations were observed by the TIRANTE to be accompanied by a marked increase in the consumption of coffee (tripled).

On the tenth patrol of the PLUNGER difficulty in the preparation of good bread was observed in rough seas and high humidity--the dough not rising well. More than one cook on a war patrol has experienced collapse of his cakes during depth charging attacks. On the GUNNEL (No. 6) the "cook was given permission to try out an idea. Instead of the usual one or two vegetables with meals, he prepared three or four as well as often two types of meat. This reduced waste--actually less food being used--and added variety." Aboard the GUDGEON (No. 1) "one cook did all the baking on every other night--keeping the temperature down in the boat on all day dives. On the days he didn't bake he stood lookout watches topside. The other two cooks alternated days cooking watches and lookout watches on the other days." "Fortunate in having aboard one chief commissary steward and two cooks. Thus one cook is available for baking, and it is strongly recommended that all boats of this class carry three cooks. Cooks stood lookout watch four hours every day" (HALIBUT No. 1).

MEAT

The one article of the submarine ration most commonly the subject for comment and criticism was meat--its quality and quantity.

There is no denying the fact that good meat is appreciated as an important part of the diet, by most all men. Aboard submarines there was nothing quite as satisfactory as a good piece of steak or beef. ATULE (No. 1) used "steaks and icecream at propitious intervals to supplement a well balanced menu." "A good steak occasionally is a big morale booster" (BILLFISH No. 1). Frozen poultry (turkey and chicken) went far, too, in adding variety to meals.

Australian Beef

Australian meat, particularly beef, was common cause for complaint. "Australian--beef is tough, stringy, and rubbery--despite the efforts of our cooks to prepare it in a satisfactory manner. Steak and hamburgers seemed to be most satisfactory. It is realized that this is not a new complaint but pains were taken to select the meat from that available and the results were far from satisfactory" (BOWFIN 5). "The beef was disgraceful. It is considered that a more thorough system of inspection and more care in selection of quality be employed by those having charge of supplying frozen meats to submarines on patrol. The limited storage space available makes it necessary that every piece of meat be usable in some manner." To this criticism (BONEFISH 3), higher authority replied: "The Australian beef issued was the best available at the time. It was nutritious and in good condition but is known to be tougher and more stringy than average U.S. beef. All U.S. beef available to this Task Group has been reserved for submarine issue."

Other complaints in this line were: "Australian beef continues to be--Australian beef" (BLUEFISH 6). "Australian choice cuts were tough, dry and stringy, necessitating a softening process which usually removed the flavor" (RAY 4). "300 pounds of Australian beef were surveyed after a month at sea--" (PERCH 4). "--better meat was available for the first time in three patrols--could appreciate these items after two refits in Fremantle" (ASPRO 6). Similar comments are present in the patrol reports of: CERO (No. 4), CAVALLA (No. 6), BLACKFISH (No. 6), GUITARRO (No. 2), HADDO (No. 6), HAWKBILL (No. 2), SWORDFISH (No. 5), THRESHER (No. 9), BATFISH (No. 5).

Percentage Issue of Boneless Beef

According to the commanding officer of the PUFFER (No. 3, April 1944): "Frozen beef comes in three varities--steak and roasting, stewing and boiling and chopped beef. Steak and roasting beef, though a bit tough, are satisfactory; stewing and boiling beef is not only tough and unpalatable but is 60 per cent waste and therefore wastes space in the icebox. Chopped beef is tough, stringy and unpalatable. Ordered only steaks and roasts and specifically requested that all the usual percentage of other types be eliminated. Ninety per cent of the hamburger, meat loaf and meat balls served were made by grinding trimmings from steak and roasting beef. Augmented the beef supply by 500 pounds of fresh beef loin boned prior to stowage in the icebox."

At about the same time SEARAVEN (No. 11, May 1944) observed that "submarines prior to patrol are provided with beef in the following proportions: roasts and steaks 70 per cent, 15 per cent hamburger, 15 per cent stewing and boiling meat. This is a satisfactory proportion, but since stewing and boiling meats are not considered worth the icebox space, it is generally left at the base, and other frozen items as shrimps, frozen foods and sausage are taken in quantity to fill the space."

The commanding officer of the CROAKER (No. 1, August 1944) recommended that "submarines going on patrol be excluded from the requirements of Article 1308 BuS&A which requires ships to draw 30 per cent of their meat in inferior quality. It is difficult enough to prepare satisfactory meals for 83 men and officers in a submarine galley when using standard grade products. It is understood that some submarines draw their inferior meat and immediately survey it." Higher authority observed: "It is believed that the presently followed percentages of meat issues are satisfactory and provide the necessary variety of meals. However, at no time should meat of inferior quality be issued submarines for use on war patrols. Various cuts of good meat are recommended."

SUNFISH (No. 4, September 1943) recommended that ground beef be removed from the mandatory items for submarines. "There is only one icebox in which must be stored various kinds of food which must be entered daily on two month patrols. Ground meat absorbs odors quickly and becomes unpalatable after a few weeks at sea. Arrangements should be made so submarines going on war patrols can increase the percentage of roasts and steaks but reduce the percentage of ground meat. It becomes the practice of tenders to store meat turned in by submarines returning from patrol and reissue these same meats when submarines draw stores for succeeding patrols. In most cases such meat, though not ready for survey, is becoming strong through handling--it certainly should not be reissued to submarines going out on 58 day patrols. Long periods of silent running with the refrigeration necessarily shut off results in occasional raising of the icebox temperature."

Lack of refrigeration space, as pointed out above, makes essential a minimum of waste in meat provided submarines. SWORDFISH (No. 5, September 1942) recommended "contractors be required to furnish pre-cut or boned meat or else the Navy establish their own butcher shop. Utilization of cold storage space is necessary. In preparing steaks for the mess, the cook removed 170 pounds of beef loin from which he obtained 70 pounds of edible meat from the bone." PUFFER (No. 3, April 1944) augmented the supply of frozen beef by 500 pounds of fresh beef loin boned prior to stowage, which kept well, the last being eaten on the 50th day. Recommendations were made for arrangements "whereby it can be supplied to all submarines." PUFFER (No. 9, August 1945) reported "about 15 pounds of steak meat in 1,500 pounds of beef." SEALION (No. 5) in April 1945 reported "much available space in the icebox taken up by unboned meat." SAURY (No. 5, December 1942) reported "boned meat as tough." WHALE (No. 6, February 1944) suggested "commercial cuts of roasts and steaks be made available--to supplement the use of boneless beef." SAND LANCE (No. 2, June 1944) observed "the greatest complaint about the food--is that a good deal of the meat is pretty well wrecked before we get it. Cuts are exactly the opposite of anything I have ever seen. A single cut will be a loin at one end and stew meat at the other." "In most cases meat required an inch of trimming to insure complete eradication of probable contamination, resulting in much waste" (MUSKALLUNGE No. 5, December 1944).

Lack of Variety

Another common cause for complaint was the scarcity of choice cuts and variety in meat, particularly at advanced bases or tender ships. Sometimes it was necessary for submarines departing on patrol to take an increased amount of stewing and boiling meat, or an excess or lack of pork, veal, etc. Frozen poultry--chicken and turkey--could sometimes not be supplied. In addition the special items, as canned luncheon meats, canned sea foods, etc., were scarce and difficult of procurement. "Food was adequate and well prepared. Departing from an advanced base precludes procurement of any of the more fancy items which provide variety. The only item we were unable to procure was a sufficient quantity of eggs. We had two cases on departure. They didn't last long. All in all, we ate good staple food prepared in as many different ways as possible, and were satisfied" (BOARFISH 3). "The advantages of leaving from a major base instead of an advanced base was evident by the food; the meat was of better quality, the quantity of frozen foods, fresh vegetables and fruit and the variety of canned foods was more satisfactory" (ROCK No. 4, November 1944). Difficulty in obtaining fresh and frozen fruits and vegetables, as mentioned earlier, persisted throughout the war. "Seriousness of the food problem probably somewhat more pronounced than usual, due to lack of fresh food in Guam" (BOWFIN 9, July 1945). The WHALE, at the end of her third patrol (April 1943) stated: "Obtaining proper provisions at Midway was a problem. --there were not enough dry stores, fresh fruit, vegetables and meat. Fifty per cent of the fresh food issued was unuseable. Meat was of poor quality, two-fifths being bone and fat. Cold storage eggs were not good; two cases were surveyed. Provisions were issued on pro-rated basis to the various activities on the island. Submarines have to resort to begging and borrowing."

Excessive Spoilage of Meat, Etc., on Patrols

Upon many occasions it was necessary for submarines to survey large amounts of meat and other produce while at sea. Not infrequently in silent running refrigeration had to be secured with heating of the icebox. Again, refrigeration failed due to materiel defects. Food, especially meat, spoiled quickly. Sometimes submarines were issued meat which had been removed from other submarines returning from patrols; again meat was issued which, having thawed out, was refrozen. Potatoes spoiled soon after delivery if they had been frozen or exposed to the weather. Such food had to be surveyed, seriously depleting the food stocks, and made food planning difficult and menus monotonous.

Aboard the BARBERO (No. 2) 1,200 pounds of meat were surveyed which had been frozen and thawed out. GUDGEON (No. 9) surveyed 1,200 pounds of meat--"believe thawed and refrozen prior to loading." Aboard the HADDO (No. 5) "the entire lot of potatoes spoiled two days after we had put to sea." HALIBUT (No. 5) surveyed 1,700 pounds of potatoes, 200 pounds of canned wheat flour and 100 pounds of rice found to contain weavils. Aboard the LAPON (No. 2) "having silent evasive period, allowed meat room temperature to increase to freezing--as a result, surveyed 150 pounds of frozen chicken and 200 pounds of beef." "Four hundred pounds of meat spoiled" (No. 3); 70 per cent of the yeast was useless (No. 4). "One thousand pounds of meat were surveyed" aboard the SAURY (No. 10). "Meat partially thawed had to be surveyed" (BLENNY, January 1945).

Blame for such casualties, as pointed out, often follows refrigeration failure. Again, "Quality of food was good but ran out of several items due to carelessness in loading" (APOGON 7); and "Closer supervision by the ship's officers of the variety of food taken aboard during the loading period will go far toward eliminating the unsatisfactory food situation as described--" (first endorsement to second patrol report of MUSKALLUNGE).

On the other hand, as pointed out by the commanding officer of the ASPRO (No. 6, February 1945): "the haphazard ordering of provisions should be eliminated by the preparation of a standard provision list for submarines that would be mandatory on their part to follow. This list could be prepared with enough alternatives to give it enough flexibility to satisfy any boat."

"Food (Australian origin) was poor" (BATFISH No. 5, December 1944)--"shipboard inspection of quality or quantity in the time allotted for loading stores could have corrected these deficiencies, and it is incumbent on the issuing agency to check and double check the food which they issue to operating submarines." "--at no time should meat of inferior quality be issued submarines for use on war patrols" (endorsement to CROAKER No. 1, August 1944).

In this line, squadron medical officers may well be more concerned with the food issued to submarines. According to the Manual of the Medical Department (Part III, Chapter 5A) "--the medical officer in carrying out his responsibility relative to food shall inspect, as to their quality, all fresh provisions issued an authorized mess." "This is the first patrol on which considerable quantities of fresh meat have not been lost through spoilage--attributed to the squadron medical officer--who inspected each piece of meat before it was put in the chill room" (SHAD No. 3). "The supply officer of the Fulton made a determined effort to

improve the selection of food available in Brisbane--and the addition of fowl and Avoset was appreciated" (SILVERSIDES No. 7). "Food was difficult--the untiring effort and cooperation of the commissary officer of the Aegir is commended" (POGY No. 8). One submarine (S-38, No. 2) reported that "fresh pork obtained at Soerabaja was tainted and a mild wholesale case of food poisoning resulted from its use before the trouble was located. Prohibition of use of tropical produced pork is strongly urged."

REFRIGERATION ODORS AND TASTE IN FOODS

Food, especially meat and butter, as indicated above, crowded into a small and often opened icebox as aboard a submarine, frequently absorbs various odors and becomes "strong." "Toward the end of the run, food began to acquire 'icebox' taste" (WHALE No. 7). At the end of the second patrol of the DOLPHIN, installation of a deck fan to circulate the air within the icebox was advised, as well as deck drains into the pump room bilges to remove the droppings from the meat. At the conclusion of the fourth patrol of the WAHOO in April 1943 it was reported: "Fresh meat, although kept at 20 degrees F. again acquired a most unpalatable taste early in the patrol. In spite of every effort to locate and remedy the cause, this condition has existed on every patrol. Ventilation was increased, a charcoal filter was installed, and the icebox was inspected by a medical officer without apparent benefit." TUNNY at about the same time (No. 2, April 1943) reported: "Objectionable icebox odor eliminated by careful observance of cleanliness, stowage and ventilation of the refrigeration spaces. In two refits, the spaces have been scrubbed with soap and water, wiped down with alcohol and aired out with a portable blower for two days. Meat and provisions have been stowed in such a manner as to allow the circulation of air. An electric fan was installed to provide circulation and temperature was maintained at a low level by limiting the frequency of opening the door to an absolute minimum."

The commanding officer of the SCULPIN (No. 6, January 1943) reported: "This was the first patrol made with virtually no spoilage of meat. An Ozonelite (trade name) produced from an Australian firm was adapted to the ship's AC supply (with a 110-210 volt transformer) and installed in the cold room, being operated one hour daily. The usual odor of an objectionable nature observed when the cooling room was opened disappeared. There was no discoloration of the meat. The Ozonelite was certainly of value but we carried less meat, to allow packing so that air circulated freely and the refrigeration plant functioned perfectly." "It is believed that the ozone machine installed in the cold room has minimized the formation of harmful bacteria" (CABRILLA No. 1).

In August of 1944 at the end of her tenth patrol the commanding officer of the SAURY observed: "The present arrangement of the icebox (altered when the magazines were changed for 4 and 5 inch stowage) is not satisfactory. Either arrangement of coils, shelves, and ventilation or a compromise of each is required to utilize the present refrigeration space. The excessive amount of meat spoilage (1,000 pounds) shows the necessity of an improvement. At no time during the patrol was the icebox out of commission--." On this patrol 17 cases of food poisoning occurred--believed due to prepared pie mix--chocolate pudding. SALMON (No. 11, November 1944) reported that the "new type of refrigeration space with the opening at the top has the disadvantage that the cooling coils are all near the top and the one provided fan is insufficient ventilation. One thousand pounds of meat and 300 pounds of frozen vegetables near the bottom spoiled." In this respect the commanding officer of the TRIGGER (No. 10) in November 1944, observed: "Feel that with the increase in personnel over designed complement which necessitates carrying of more food, that proper circulation is not obtained near the bottom of the icebox."

BUTTER, MILK, AND EGGS

As observed earlier, Avoset (stabilized cream) was very popular and was used in coffee, and on cereal and fruit. Its keeping qualities were not always too satisfactory and sometimes large amounts had to be discarded (SEA POACHER)--"eight gallons turned sour--recommend supply officer attempt to date stock received." "Three one-half gallon jugs of Avoset were spoiled when opened" (SPOT 3). Many boats used Avoset to fortify powdered milk.

HARDHEAD (No. 2) suggested "providing powdered milk in small containers to prevent spoilage." In June (BOWFIN 5) and August 1944 (RATON 4) reported "60-75 per cent of cases of Australian canned milk spoiled." "Ten cases of Ideal condensed milk soured, though stored in a cool place--the second successive patrol this has occurred."

Fresh eggs were a boon and much appreciated: "Eggs for breakfast were one of the most popular items served" (SHAD No. 2). "It was a distinct pleasure to have fresh eggs at the start and end of the patrol instead of the usual spam and dried egg omelet" (SCABBARDFISH No. 2). If available in quantity, enough eggs should be carried to last throughout the patrol. Like other commodities, especially at advanced bases, freshness of eggs was hard to guarantee. Powdered eggs were used with some success in cooking but generally they were not greeted with enthusiasm in taking the place of the "strictly fresh egg."

Difficulty was not uncommonly experienced in keeping butter sweet and palatable. "Eight cases of eggs and 100 pounds of rancid butter were surveyed--brought from the States" (RASHER 6). "Butter went bad after the first week" (CAVALLA 5); "after two weeks at sea found all the eggs rotten and all the butter rancid--a sorry state of affairs when we know that the food eaten on the tenders and at the bases is of the best." "Due to old age, eggs from Midway could not be served after the third week; butter became rancid shortly after the patrol began" (SEARAVEN No. 11, May 1944).

HOE (No. 6) experiencing rancid butter "despite excellent refrigeration, recommended that a separate butter locker be installed in the cool room." Aboard the BALAO (No. 9) "butter as usual became unpalatable. A special sealed wrapper should be provided for butter to prevent the absorption of all the odors in the refrigerator space." GUDGEON (No. 1) recommended "canned butter although its cost is high." Among the two items listed as unfit for human consumption by the SNOOK (No. 6) was Kraft canned butter--"contracts should be cancelled--no boats should be stocked with it." "Brookfield brand canned butter had a cod-liver oil like taste" (SNOOK No. 8). "Canned butter was used for the first time and found to have far superior qualities to fresh butter; tastes better, does not require refrigeration, providing more space in the icebox for other fresh foods" (S-28, No. 3).

MISCELLANEOUS COMMENTS

In some instances, spoilage of certain staple articles of food was experienced--particularly was the presence of weavils in rice, wheat flour, cereals, macaroni, noodles and cocoa described. "Poor variety of food--had to survey 1,200 pounds of potatoes, 100 pounds pork and 75 pounds of beef; worms in noodles and cocoa" (CAPITAINE No. 1, July 1945). Inferior canned foods were listed (BARB No. 8) as canned carrots, bologna, and salmon. As observed elsewhere, Australian orange juice was described as bitter; canned fruit was sometimes thought to have been canned green.

BANG (No. 2) reported that the 5 gallon cans used for packing graham crackers were too large for normal rate of consumption and that they became soggy. GUDGEON (No. 1) observed that "the ever present danger of oil contamination of flour when kept in other than regular stowage space makes the use of canned flour imperative." DACE (No. 6) reported that "it was impossible to get enough canned flour; bagged flour is unfit for patrol due to the lack of proper stowage facilities." Canned flour, potatoes, and dehydrated vegetables were described by the SNAPPER (No. 1) as being excellent. BARBERO (No. 2) surveyed 400 pounds of tinned flour (brought from the States) which was found to be caked, hard, and mildewed.

In 5 reports the yeast provided was described as being unsatisfactory. "--with failure of yeast supply--no bread for most of patrol" (ANGLER No. 2). Curiously enough, in only 2 instances in this series of reports was the Navy issue of coffee mentioned or criticized (ANGLER No. 7).

Aboard the DOLPHIN (No. 1) 1.5 pounds of meat were used per man per day. Total food consumed was 5.6 pounds per man per day--at end of her first 47 day patrol off Truk; 31 days were spent submerged. It was reported at the end of the first patrol of the ARGONAUT (SS 166): "The average cost of the daily ration on patrol was 65 cents. Thirteen pounds of coffee and 30 pounds of bread were used a day."

Aboard the ANGLER: "The crew was particular about the food that they ate; they ate all of the time and lots of food. They have been known to eat 60 dozen poached eggs for breakfast, averaging one case (30 dozen) eggs a day, so that they had to be rationed to once or twice a week so that they may have enough to last through the patrol."

SUMMARY

1. The ration provided submarines in World War II succeeded in meeting their somewhat specialized requirements, namely: ease of stowage, excellent keeping qualities, and ease of preparation in providing a well balanced daily menu incorporating a maximum of food value, variety and a minimum of waste.

2. More active participation of submarine squadron medical officers in the problem of supplying submarines with a satisfactory ration is indicated.

3. It is urgently recommended that this entire problem be re-studied in the less hurried atmosphere of peace time with a view toward constructing a master ration plan for the Submarine Service, sufficiently exact to be helpful as a guide, and, at the same time, flexible enough to allow for satisfying individual preferences.

4. The need for more thorough schooling and training of the entire team (commissary officer, commissary steward, cooks, bakers, and supply officers) is apparent and will go far toward eliminating some of the problems of the submarine ration.

5. The one single item of food most common cause for unfavorable comment by commanding officers of combat submarines was the quality and percentage issue of boned beef. A review of this situation with a view to possible corrective measures may be in order.

6. With reference to individual food items provided submarines the following points appear worthy of emphasis:

(a) The significance and importance of icecream in providing variety in the diets as well as nourishment is apparent. In addition, it rates high as a recognized morale builder aboard submarines.

(b) Submarines should be given a high priority in the obtaining of available supplies of frozen fruits and vegetables, the importance of which, in the submarine ration, has been amply demonstrated.

(c) Certain luxury foods (Avoset, canned luncheon meats, sea foods, Nescafe, jams, etc.) particularly when available in small pack size, are important in providing variety and enlivening what may otherwise be a monotonous diet.

7. The foregoing comments are intended not as a criticism of the commissary department of the submarines or the supplying organization but as suggestions designed to make more perfect an already smoothly functioning organization. In fact, from all information available, it is apparent that the submarines of World War II amply earned their reputation of being "the best feeding ships in the Navy."

SUBMARINE CLOTHING

MISCELLANEOUS

In general, the clothing requirements of submarines patrolling in warm or temperate climates were not complex. Officers above and below deck wore khaki or gray trousers and shirts with sleeves sometimes cut short. Some wore shorts. On special occasions, as when returning from patrol with colors flying, ties were worn by the OOD; otherwise, in forward areas, they were seldom seen. Enlisted men wore dungarees, sometimes abbreviated into shorts on tropical patrols. Leather sandals, available for wear with or without socks, were popular; being comfortable and cool. It would seem not unlikely by keeping the feet dry, they served to curb the hazards of fungus infections. The soles being free of special non-slip construction, became slippery, especially on greasy decks. They were sometimes, and especially if ill fitted, the cause of tripping on ladder rungs, hatch combings, etc., and painful lacerations and bruises. These wounds, often over the tibia, were inclined to resist healing and to become chronic sores. Another type of every day special footwear was the field shoe. This, a strong heavy shoe made of double tanned leather with treaded sole and heel, was popular with some; it became very comfortable with wear (SEAL No. 11). The CUTTLEFISH (No. 1) recommended, for purely psychological reasons, that felt slippers be obtained and issued to submarines for use during silent running in depth charge attacks. Officers and men wore regulation naval caps; many when topside were bareheaded. The baseball cap with attached visor, on some submarines, was extremely popular among the bridge watch. The THRESHER (No. 4) reported, after an early spring patrol in the Marshalls, that the intense heat and glare of the sun caused considerable discomfort to bridge personnel. This condition was alleviated by use of the inner fabricated section of the new type of steel helmet as a sun helmet, being extremely light, comfortable and affording good protection. Inasmuch as most submarines, particularly in the latter part of the war, had air conditioning, the above clothing worn with or without shorts and T-shirts, generally sufficed.

Goggles, Sunglasses, Etc.

The established allowance of special submarine clothing (January 1945) includes Goggles (N-2, 1 pr.). Lens settings for this all-purpose goggle, issued for protection against the wind, cold, glare, dust, and for dark adaptation, include: clear, polarized green with high light transmission, polarized green with low light transmission and red lenses for dark adaptation. The commanding officer of the BARB (No. 12) stated that these goggles at the darkest setting were worn on launching rockets. SEADRAGON (No. 4) recommended that at least 24 goggles for dark adaptation be issued each submarine. Sunglasses (N-1), fitted with colored glass lenses, have been replaced by Sunglasses (N-1, Type 1, CNO Navy Dept. Bull., 30 April 1945). These neutral, all plastic, polarized glasses transmit 12 per cent light and eliminate over 90 per cent of the surface glare from water in a calm sea. During moderately rough weather and hazy weather with dampness and much glare and even in highly humid weather, glasses tend to smear with fine salt spray or steam. In order to see, men, while on watch, commonly remove their glasses. Personnel exposed to sunlight by day fail to properly adapt to darkness at night and lose 50 per cent of their vision both in late twilight and night time. This damage

to dark adaptation is slow to recover. A few hour's exposure will result in retinal damage lasting for days, and a week's exposure may require a month for recovery. Eyestrain, headache, and "sunburned eye" with conjunctivitis, consequent to exposure to sunlight, were not uncommonly seen in submarine personnel returning from a cruise. The conjunctivitis may be accompanied by as much as a 25 per cent reduction in visual acuity. To reduce these symptoms and primarily to protect and maintain dark adaptation, all personnel participating in surface search where glare is present were directed to wear the new sunglasses. Those anticipating night lookout duty were required to wear them whenever exposed to sunlight. The glasses are not dark enough to look directly at the sun and they are not designed to be used by observers searching the area near the sun for aircraft. (Sun scanning instruments used included the Crossed Plastic Sun Scanner, a simple device which could be attached to the rim of ordinary sun goggles, the AO Polaroid variable Density Goggle and the Icaroscope). Being plastic, the glasses scratch easily and have to be protected from dirt. The protective case could be improved.

A "Special Lookout Training Program" has been outlined (BuMed News Ltr, Vol. 7, No. 7) which might well be adopted by submarine pharmacist's mates. In part, it stresses the importance of protective measures including the use of visor caps and lamp black or burnt cork applied under the eyesore over the area of the malar prominences to protect against the reflected rays of the sun on those occasions when sunglasses are removed. Binoculars in driving spray and rain, sometimes because of flooding and fogging, are practically useless. The SEARAVEN (No. 2) used a 6 inch by 12 inch celluloid shield which, when held before the eye, proved very useful to the lookout and the OOD in the driving rain and spray. It was worn suspended by a small line around the neck. HADDOCK (No. 6) found best insurance for good visibility in rain storms to be two flexible glass windshields on the bridges, hinged in place so as to be free to bend back upon submerging.

HEAVY AND COLD WEATHER CLOTHING

The subject of protective clothing and its improvement for submarines is important and should be studied in light of the requirements of the service and their satisfaction by the established allowance of special protective clothing. Special mention was made of these articles of apparel in 60 of the 1,393 war patrol reports studied (on 55 of which cold weather was experienced, 33 being in the Aleutian and Kurile Island areas). Thirteen commanding officers expressed satisfaction with the gear as issued; of the 47 who were dissatisfied, 21 considered the clothing completely unsatisfactory, 10 stated protection was adequate except for the feet and hands. Nine satisfactory reports were made in 1944 and 1945 in contrast to the 4 made in 1942 and 1943. Fourteen submarines in the first two years of the war, in contrast to 6 in 1944 and 1945, found the available winter and foul weather clothing completely unsuitable. Almost twice as many commanding officers found wearing apparel partially satisfactory in 1944 and 1945 (17) as compared with 1942 and 1943 (9).

The NAUTILUS (No. 5) in 1943, having patrolled off Attu in the vicinity of a hurricane, expressed satisfaction with the design of winter clothing, especially praising the rainproof parka. The SWORDFISH (1944) (No. 10), after experiencing 4 successive storms of cyclonic proportions, praised jungle cloth winter clothing and parka rain suits as being "superlative." The TAUTOG (No. 10), and the SEAL (No. 11), in the same year after winter and fall patrols off the Kurile Islands, expressed satisfaction with the provided winter clothing. The CABRILLA (No. 7) in May of 1945, following a Kurile Island patrol in water with an injection temperature of 28 degrees F. reported: "Except in the conning tower the temperature throughout the boat seldom fell below 55 degrees F. The heavy winter clothing used below decks, gave satisfactory protection. At no time did personnel show signs of great discomfort, even on days when the temperature fell below freezing." The SPADEFISH (No. 3), after a Yellow Sea patrol (average water temperature 35 degrees F.; air 17-35 degrees F.) in February of 1945, reported the bridge personnel to have suffered much discomfort from the icy wind and spray, but that their clothing was sufficient, the boat being comfortable most of the time. The SEADEVIL (No. 3) about the same time, following a patrol in the same area, reported cold weather clothing to be adequate for the average encountered temperature of 41 degrees F. The MUSKALLUNGE (No. 7) and the POMFRET (No. 6), at the close of the war, following Kurile Island and Yellow Sea patrols, expressed satisfaction with protective apparel: "That issued on the last patrol showed great improvement and can be said to be adequate in almost all respects."

Dissatisfaction with the available protective clothing was the rule. The majority of men putting it to test under combat conditions in cold weather patrols found it but little improved as the war continued. The THRESHER (No. 3) complained in April 1942, after returning from a patrol in Empire waters, that "the present foul weather clothing is inadequate and poor. Bridge personnel have to wear so many clothes that they are awkward in their movements." "We are still sadly lacking the proper clothing for patrols in this area" (S-32, No. 7).

Commented the TUNA (No. 1) in March 1942, after a patrol off Wake Island: "A satisfactory glove is needed. Those provided (leather, lined with flannel) became wet too quickly; mittens of some heavy water repellent fabric are suggested." The SUNFISH (No. 7) prior to a patrol begun in June 1944, examined all clothing available for issue and found only 3 items not available in 1942. The commanding officer of the SEA POACHER (No. 1) in January 1945, on returning from a China Sea patrol reported the winter clothing status completely unsatisfactory. Agreed the STERLET (No. 4) two months before the end of the war and after completing a patrol in the vicinity of the Kurile Islands: "All submarines operating in the polar circuit are unanimous in their condemnation of the two fingered split mitten. A straight mitten would be better."

Today, 8 months after the conclusion of the war with Japan, on return of the U.S.S. Midway from a 26 day experimental cruise in the Northwest Atlantic (200 miles from the Arctic Circle), designed to test equipment and technique under severe weather conditions, Rear Admiral J. H. Cassady, Commander of the Task Group, stated (N.Y. Times interview, 29 March 1946): "While airplanes and other mechanical gear were operable at least 90 per cent of the time, some of the clothing worn by personnel proved inadequate and recommendations were made particularly for improved protection of the face, hands, and feet."

Encountered Weather Conditions

The greater number of complaints were made by men returning from patrols in the vicinity of the Aleutian, Bonin and Kurile Islands and the Bering Sea, in which areas weather wields an important influence on the ability of the submarine and her crew to carry out their primary mission. The commanding officer of the S-28 (No. 4, Jan 1943, Aleutians) noted: "Weather was always a factor controlling operations, the wind and the sea practically always being in condition 5 or above." Heavy weather with fog, driving spray and rain and often mountainous seas were the rule. The S-23 (No. 2, summer of 1942) in the Akutan Pass, took 30 feet waves over the bridge at the rate of 5 every 30 seconds--the bridge being flooded solid 5 times in a minute. The SAND LANCE (No. 1, March 1944) patrolling in heavy ice floes off the Kurile Islands encountered snow, freezing water and two typhoons. Time and again the bridge watch was chest deep in water. The SPADEFISH (No. 3, Feb 1942, Aleutians) reported bridge personnel constantly drenched with salt water spray, hail and snow storms. Ice collected on the boat up to 2 inches or more in thickness and the average air temperature in the conning tower varied from 22 to 32 degrees F. Snow, sleet, rough seas, cold and drift ice were routine, there being a succession of storms. Fog and dampness were often excessive in these patrol areas. On her second patrol (late spring of 1942, Aleutians) the S-35 observed that visibility 90 per cent of the time did not exceed two miles; thick fog was frequently encountered day and night; and the SUNFISH (No. 7, winter 1945, Kurile Islands) noted: "Weather was foggy; submerged or surfaced, the clothing generally felt damp and sticky."

All hands aboard a submarine, whether it be a 20 year old S-boat or one of the newest of the fleet-type submarines, may expect to share the discomforts of the Arctic. The gun crews (SEA CAT No. 2, winter 1945, Yellow Sea) exposed on the open decks with the heavy seas breaking over them become thoroughly chilled in the cold air (38 degrees F.). The bridge watch, especially, experience the bitterness of heavy weather, being particularly exposed on the low, cut-down type of bridge. Without proper clothing it is impossible to keep the feet and hands warm and dry when taking spray or seas over the bridge with the air temperature below 30 degrees F. (S-34, No. 4; S-33, No. 5; SPADEFISH No. 3). Inadequate clothing in cold weather is not conducive to an alert bridge watch (BALAO No. 9, APOGON No. 6). Not uncommonly, in especially foul weather, the OOD and lookout watches have been shortened to 3 hours (S-34, No. 5, Aleutians) to promote efficiency and conserve stamina; to two hours (POLLACK No. 5)--it being impossible to endure more with any degree of vigilence; and even 45 minutes (SKIPJACK No. 10, Kurile Islands)--to keep the lookouts more or less comfortable. Lookouts (TAUTOG No. 10, Kurile Islands) have been stationed on the cigarette deck where, because of their increased comfort, they are more effective.

Again rough, cold water patrols are generally marked by an increased incidence of upper respiratory infections and topside injuries. The commanding officer of the S-32 (No. 8, spring 1943, Aleutians) observed on a patrol on which extremely severe Arctic weather was experienced markedly lowered resistance of the personnel with an increase in colds and coughs--the inside of the ship in that climate being likened to the inside of an igloo doused with continuous showers of freezing salt water. The S-31 (No. 3, summer 1942) observed, while patrolling in the Bering Sea, an epidemic of colds and sore throats, developing 10 days after the onset of the patrol. The S-34 (No. 5) on an Aleutian patrol on which the temperature remained between 33 and 42 degrees F., reported that the boat was constantly cold, that all of the bridge watches were wet. Colds were a major illness, 6 men and 2 officers being put to bed for 2 days each.

Many times, decision has been made to remain submerged to rest the crew and dry out their clothing because of topside conditions. "During the night, the bridge watch was pounded down to the deck by the heavy seas on an average of once every 15 minutes" (S-28, No. 4, winter Aleutian patrol). "Topside watch took a beating. Submerged--afraid might lose someone overboard because it is too cold to hold on and the footing with the ice is dangerous" (APOGON No. 6). Water is commonly taken through the conning tower hatch or main induction, sometimes resulting, as aboard the S-35 (No. 4, winter, Aleutian patrol), in an Arctic "slip stream" running, while on the surface, between the conning tower and the engine room. Generally on cold water patrols, the interiors of the boats were cold and damp (SEARAVEN No. 12, SKIPJACK No. 10, SUNFISH No. 7). Engine rooms when surfaced and running on all four engines, with induction open, were uncomfortably cold. Heaters had to be used sparingly to conserve the batteries. Metal fittings sweated continuously, making the torpedo rooms, especially, very wet. Air conditioning accomplished but little good, acting to make the boat colder than when it was not used. Others (TILEFISH No. 3) found that by using the air conditioning, they could keep the moisture at a minimum.

AVAILABLE PROTECTIVE CLOTHING

Undergarments, etc.--Because of prevailing wetness of the outside world and the high humidity inside the submarine, all hands on patrols in the Arctic Circuit commonly and constantly wore long woolen or flannel underwear, heavy and full length wool socks and sweaters (TILEFISH No. 3, SEARAVEN 12, SEAL 11, SUNFISH 7). The crew of the S-23, while making their first winter cruise in the winter of 1942, having no heaters aboard, slept in their submarine clothes to keep warm. In general, though bulky, this heavy winter clothing gave satisfactory protection while below decks. Some boats, after trial, strongly recommended the Army type of woolen shirt and trousers while others preferred a brown flannel shirt (similar to the CPO shirt). Each member of the crew of the STERLET (No. 4) had two pair of Army woolen trousers, two woolen shirts and one Army woolen quilt. Wool clothing was found to be especially good, doing away with the need for jackets and heavy sweaters while not actually topside. Army quilts were found to be invaluable and far superior in size, weight, and warmth to the regular Navy issue blanket. "Providing as much warmth as two blankets, one was all that anyone needed on the coldest night" (SNOOK No. 8). Being brown, the quilt showed the presence of dirt less noticeably than did the blankets. The long knitted scarves or mufflers and sweaters received from the American Red Cross, particularly the pullover type with the turtle neck, were especially appreciated and were of great benefit in keeping the bridge watch warm. Knitted helmets were invaluable in protecting the sides of the face and chin and preventing water from running down the inside of the parkas.

In addition to the above garments, the bridge watch of the S-23 (No. 1) while making a winter Aleutian patrol in 1942 wore dungarees, waterproof trousers and jumpers with a hood and face drawstring (Army rubberized parka and trousers), aviation helmets or leather or wool watch caps, leather gloves or mittens lined with wool, fabric overshoes or galoshes or knee length rubber boots with many pair of woolen or diving socks. A few boats on the Atlantic coast in 1940 and 1942 were issued jungle cloth trousers and jackets (with hoods) lined with cellular rubber (SNOOK No. 8, SEAROBIN No. 2). Others had a few suits of "submarine clothes" (Melton trousers and jackets). Standard gear for the PERMIT (No. 7) on a cold water patrol in the winter of 1943, consisted of jungle cloth jackets, trousers, and helmets, a rain suit (rubberized parka and trousers) and face masks. In 1944, in an autumnal patrol off the Kurile Islands, the crew of the TILEFISH (No. 3), in addition wore parka hoods and helmets with visors, rubber sea boots with felt inner soles, socks, and felt slippers, rubber gloves. Officers wore heavy alpaca lined, zipper closing, 3/4 length coats with parka hood. A few had fleece-lined leather flying hoods and slippers. By the winter of 1945, the crew of SNOOK (No. 8) had a few fleece-lined leather flying suits, and fur vests. As noted SUNFISH (No. 7) in 1943, 1944, and 1945 only three items appeared on the supply list of special protective clothes not available in 1942 (Sea boots, N-1; Mittens, waterproof, N-1; and coat, parka, winter, N-1).

The Established Allowance of Special Protective Clothing for Submarines

(CNO Ltr. Op-12/LL Serial 28 P12) as of 24 January 1945 was:

ONE STANDARD SEA OUTFIT (For 100 per cent attached personnel):

	Unit Price
ARCTICS, SEA, N-1; One pair Light weight, flexible, non-slip, 13 inch, 5 buckle, all rubber, fleece-lined; worn over shoes.	$ 3.18
COAT, PARKA, WINTER, N-1; One (officers only) Waterproof, alpaca lined, front opening, zipper closed, 3/4 length coat with hood.	15.44
GOGGLES, N-1; One pair All purpose, molded rubber-frame goggle with sponge rubber padding. Three interchangeable plastic lenses, clear, polarized, green and red.	1.67
HELMET, WINTER, N-1; One Jungle cloth (Heavy bedford cord or twill), flannel lined, neck shield and adjustable visor.	1.06
JACKET, PARKA, RAIN, N-2; One Pullover, waterproofed, snug fitting jacket with hood (face drawstring). Made of two sheets of cotton cloth laminated with layer of synthetic rubber or resin.	3.47
TROUSERS, RAIN, N-2; One Waterproofed, webbing suspenders, protected zipper fly.	2.95
JACKET, WINTER, N-1; One Jungle cloth, alpaca lined, front opening, water repellent. Worn under rain jacket, N-2.	6.98
TROUSERS, WINTER, N-1; One Jungle cloth, flannel lined, zipper fly, water repellent, webbing suspenders; worn under trousers, rain, N-2.	9.17
MASK, FACE, WINTER, N-1; One Wind and waterproofed, closely woven, cotton fabric, felt lined, flexible; neck shield, nose and mouth flaps.	0.89
MITTENS, WINTER, N-2; One pair All wool, one finger style, 10 1/2 inch; for use separately or under mittens, waterproof, N-1, or mittens, work, N-3.	0.90
SOCKS, WINTER, N-1; Three pair Seventy-five per cent wool, knee length.	1.17
MITTENS, WATERPROOF, N-1 Rubberized cashmerette, fleece-lined, poplin cuff, one finger style. Designed for wear over mitten, winter, N-2.	1.55
MITTENS, WORK, N-3 Tanned horsehide or cowhide, one finger style, unlined; for wear over mittens, winter, N-2, or C & S.S. five finger woolen gloves.	1.05

PLUS:

SWEATER, WINTER, N-1; One All wool, pullover, turtle neck type.	4.00
SANDALS, N-1; Two pair	

The Following Substitutions May be Made

BOOTS, SEA, N-1; One pair All rubber, watertight, flexible, non-slip soles; worn with two pair of felt inner soles and 1, 2 or 3 pair heavy woolen socks over which worn a heavy felt duffle sock. May be substituted for arctics, sea, N-1.	5.72
COAT, RAIN, N-2, and HAT, SOU'WESTER, N-2 May be substituted in lieu of jacket, parka, rain, N-2, and trousers, rain, N-2.	0.83
GLASSES, SUN, N-1 Regular spectacle type glasses, tinted glass lenses, plastic frames. CNO Navy Dept. Bull. 30 April 1945, replaced by sunglasses (N-1, Type 1).	0.90

	Unit Price $
SUNGLASSES, N-1 (Type 1) Neutral, all plastic polarized glasses. Not intended for sun searching.	
DRAWERS, WINTER, N-1	1.91
UNDERSHIRT, WINTER, N-1	2.47

CNO Ltr. (Op-50A/les Serial 0650-A (SC) JJ55-1 of 10 May 1945) authorized the addition of following articles for submarines for 100 per cent personnel attached:

ONE STANDARD SEA OUTFIT PLUS THE FOLLOWING:

SCARF, WINTER, N-1; One	1.55
SHOES, FIELD, N-1; Two pair Double tanned leather, heavy Klondike type with laces, non-slip soles and heels.	
COMFORTER, COTTON, ARMY ISSUE; One.	

Not included on the above lists but commonly issued is:

HELMET, WINTER, N-2 All wool, knitted helmet with front and back shield; used as alternate or under helmet, N-1.	1.75

RAIN CLOTHING

Bridge personnel of an operating submarine, in any climate, require protection against driving rain and salt water spray in which respect oilskins are generally regarded as worthless. The TUNA in 1942 (No. 1) suggested shortening the garment to prevent tripping or entanglement while clearing the bridge. It was further unsatisfactory in becoming sticky, odorous, stiff and cracking while in storage and wore out rapidly from the exceedingly hard usage given it by the lookouts and OOD. It was not wholly water repellent, becoming less so with age. Moreover, bulk complicated the carrying of sufficient numbers aboard. A plastic raincoat, such as the Koroseal or Pliofilm has been suggested for trial (SARGO No. 9).

The S-23 (No. 1) recommended that the Army rubberized trousers and parka jacket (with hood and face drawstring) be procured for all submarines in preference to the regular issue raincoat; it soon became apparent (RUNNER, SS 275, No. 1) that this was an excellent addition to foul weather gear. Fifteen commanding officers have especially commended desirable features of this all purpose garment (Rain Outfit N-2, parka, jacket and trousers) used from the tropics to arctic regions. The design is particularly well adapted to bridge use in that it does not impede progress down the hatch with clearing of the bridge (NAUTILUS No. 5). When worn over dungarees it is not sufficiently warm for a watch on a cold weather patrol. When worn with high rubber boots, over jungle cloth jackets and pants, some have reported it as "superlative." It is bulky and awkward to put on over the other clothing that the men must wear to keep dry and warm (S-23, No. 5). Two submarines (NAUTILUS No. 3 and S-23 No. 5) reported that the fabric became soaked through at the end of two hours of rain and spray, and was not completely water repellent.

PAMPANITO (No. 4) in December 1944, considered the type of foul weather clothing provided submarines to have been well tested and found to be very unsatisfactory during the long period of bad weather encountered. An adequate number of waterproof parkas and trousers, were aboard, most of them new. By the middle of the patrol they were all in very bad condition. The impregnating material came out of the cloth after 10 days in wet weather, when the cloth became flimsy, ripped frequently and leaked conspicuously. The fastenings around the neck, face, wrists, and ankles were found poorly designed, both as to durability and prevention of leakage. The suits required an excessive time to dry after being worn. Bulk somewhat complicates the storage and drying problem. A special submarine protective clothing board convened by ComSubPac concluded that this garment was unsatisfactory (ComSubPac conf ltr FF12-10(A)/JJ55, Serial 0637 to CNO, 26 March 1946), a conclusion recently substantiated by a NMRI representative on protective clothing field tests (Research Project No. X-189, Report No. 11) carried out in the North Atlantic.

JUNGLE CLOTH JACKETS AND TROUSERS

Jungle cloth trousers (heavy bedford cord or twill cloth) jackets and helmets worn under the rain parka and trousers for further protection against the cold and wetness, were comparatively successful except in the coldest of weather. The commanding officer of the SNOOK (No. 8), February 1945, in a comprehensive review of this problem of submarine winter clothing, stated that 10 of the lookouts and quartermasters preferred this combination of clothing. "If the jacket and trousers had been lined with alpaca (said to be superior as insulation to sheepskin or flannel) as were 8 of the 80 jackets and 1 pair of the 80 trousers issued us, they would have formed a satisfactory garment." Boats operating out of Portsmouth and New London in 1941 and 1942 were issued jungle cloth trousers and jackets (with hoods) lined with cellular rubber. This garment was reported to be completely wind and waterproof, warm and compact. It acted as a life preserver if the wearer went over the side. Ten suits issued to the FINBACK are said to have proven satisfactory in all weather. SNOOK and SEA-ROBIN requested that the garment be reissued to the Service. ComSubPac (April 1942, S-23 No. 1) recommended that 18 of these garments be furnished each type of fleet submarine.

COATS

The parka winter coat is available for officers. This three quarter length, alpaca lined coat, with attached hood, and zippered front, in a heavy driving rain or when the seas are shipped, is unsatisfactory, the front opening not being watertight. "When the alpaca lining becomes wet it is practically impossible to dry." The SNOOK (No. 8) found the coat shoddily built, buttons tearing out with chunks of the fabric after one or two uses, and the outer repellent covering easily torn when dried and cracked. The garment was recognized to be excellent for the occasional bridge kabitzer and for the conning tower and the COC watch. For the bridge watch, however, it did not afford sufficient protection. The shirt was too bulky. The SUNFISH (No. 7) concurred and recommended it be manufactured in pullover style similar to the present parka raincoat, with a vulcanized gusset at the neck front to bar water. An easier drying type of lining was further recommended. Fur vests worn in a few instances were reported as excellent, providing the necessary chest and back protection without bulk in the shoulders and arms. Sheepskin coats were said to be excessively bulky.

HEAD PROTECTION

As noted above, the head was commonly protected by an inner knitted helmet over which was worn a jungle cloth helmet with adjustable visor and neck shield. Others chose to wear wool watch caps, leather aviation helmets with Red Cross mufflers or scarves all covered by the hood of the parka rain jacket. The SEARAVEN (No. 12) after an autumnal patrol in northern waters reported fleece lined leather flying hoods to be invaluable and considered them requirements for cold weather submarine operations. All purpose goggles were worn as protection against the wind and cold and the sun. Commonly they were supplemented by a closely woven cotton fabric face mask, adapted to head movements, and without which it was difficult for a lookout to face the ever present biting wind, snow, hail and sleet storms in the Arctic Circuit. In general, face masks seem to have been well received and were reported to be of the greatest value. The POLLACK (No. 5) reported them uncomfortable and poorly tolerated. The S-23 satisfactorily employed a transparent mask, as worn by skiers, for face protection.

HAND AND FOOTWEAR

No items of submarine winter clothing were more bitterly criticized than were the mittens, gloves, and footwear. Footwear must be warm, waterproof, lightweight, flexible, designed to avoid clumsiness and to afford a firm grip on heaving ice-coated decks and ladder rungs. SKIPJACK's lookouts (No. 10) on a winter Kurile Island patrol, early discarded shoes because they were found to resemble iceboxes even when worn with arctics. The S-23 (No. 5) concluded that the fabric-covered overshoes or galoshes were inadequate, being neither waterproof nor warm, and recommended that they be replaced by a short rubber boot. Rubber sea boots with felt insert soles were available after the war had begun. The SUNFISH (No. 7) felt that they were too clumsy and heavy in comparison with the old style galoshes but admitted that they might have been given more exhaustive trial had the weather been colder. The SNOOK (No. 8) reported that they were not as bulky and cumbersome as they appeared and when worn with two pair of felt inner soles and socks (1, 2 or 3 pair) with an outer hair felt duffle sock, were quite warm, being the best piece of foul weather gear carried aboard. They are flexible, may be rolled up and stored in relatively small space and have non-slip heels and soles. The felt inner soles and socks soak up moisture and in a few days become

highly odorous. Instead of the usual one, at least 3 sets of these felt items should be issued with each pair of boots. SUNFISH recommended boots made of waterproof material similar to the present galoshes (rather than leather), fur lined and sufficiently high (16 inches) to come up well under the leg of the present rain or winter clothing trousers. HALIBUT (No. 3) advocated adopting a short, waterproofed fur or fleece lined boot. Others suggested felt *slippers to be worn inside the arctics.*

An adequate protective glove or mitten is the most important piece of foul weather gear. (Tolerance time in subfreezing weather depends primarily on rapid cooling of the hands and feet, particularly the fingers.) Twenty-two submarine commanding officers, on 23 cold water patrols, reported clothing issued to them for this purpose as completely inadequate. *The rubberized Waterproof Mitten (N-1) proved unpopular;* it was neither pliable nor safe, becoming slippery when wet and preventing a sure grip on sustaining stanchions and ladders (SKIPJACK No. 10, SNOOK No. 8).

The non-waterproof leather Work Mittens (N-3) *and the woolen Winter Mitten (N-2)* were received with but little more enthusiasm. They were "completely unsatisfactory" chiefly because of their lack of warmth and inability to shed water. "All gloves (and mittens), despite the application of Neatsfoot and water proofing salve, eventually became damp and uncomfortable" (POMFRET No. 5). "The leather mitten is not warm even when dry, and once it becomes wet (which it rapidly does on a flooded bridge) it stays soggy the rest of the watch and is practically useless as far as protection goes" (TAUTOG No. 11). "Leather mittens, if of the full palm design, when worn with the inner woolen mitten, would have been warm enough but never dry" (SNOOK No. 8).

Faults in design were cause for further grievous complaints. "All submarines operating in the polar circuit are universal in condemnation of the two fingered split mitten" (STERLET No. 4); "all three types - leather, woolen, and rubber mittens - are worthless since they separate the forefinger from the rest of the hand and effectively freeze it" (SNOOK No. 8). Furthermore, "the wrists and hands are inadequately protected; all available gloves and mittens quickly become filled with water. When the hands are raised, water is discharged up inside the sleeve of the parka jacket" (S-28, No. 5). Loss of gloves when momentarily removed from the hands, it was pointed out, might be prevented by securing them in some manner to the cuff of the parka or winter jacket.

SUNFISH (No. 7) *recommended a 5 fingered glove made of a good grade of horsehide,* with a waterproof lining (Koroseal or *some other similar material)* and a long folding gauntlet to be tucked up under the sleeve. When treated with wax, it was said to be waterproof for hours and to dry rapidly; an under-woolen glove was to be worn. SEARAVEN (No. 12), after trial, did not agree, reporting that the leather, with waxing, became stiff and unyielding. The SKIPJACK (No. 10) suggested a cowhide, two fingered mitten with a rubber lining between the cowhide and the inner wool lining. The POMFRET (No. 6) described a similar mitten differing in that it was to be one fingered. The SNOOK (No. 8) advised: "Procure a heavy woolen, whole handed mitten as worn by fishermen, large enough so that more than one pair can be worn at a time. This would solve the problem of winter and water tightness since a wet outer mitten that becomes frozen is the warmest covering there is; but primarily the forefinger must not be separated from the rest of the hand!" Others have suggested fur or fleece lined gloves.

The present standard allowance of gloves and mittens is woefully inadequate for a submarine on a cold water patrol. They are frequently lost and have to be replaced. Moreover, becoming wet, they must be dried. "Since it was found that the men could not be expected to care properly for them (gloves) we inaugurated a rotating pool as a result of which a sufficient number of dry gloves were available. At least 40 sets should be on hand--for the radar and sound watch, in the control room, also need special clothing" (SKIPJACK No. 10).

BODY PROTECTIVE CLOTHING, EXPOSURE SUIT

To sum up, a typical lookout on the bridge of a submarine making an Arctic patrol, commonly wore long woolen underwear (one or two pair), full length woolen socks (two or three pair), a flannel or wool shirt, a turtle neck sweater or fur vest, jungle cloth winter trousers and jackets, sea boots with felt inner soles and outer duffle socks, knitted helmet, winter helmet of jungle cloth, knitted muffler, face mask and goggles--all covered by parka trousers, and jacket with attached hood. Two pair of mittens or gloves completed his costume.

This collection of apparel harbored several defects. It was awkward and bulky when worn by men who, within 10 to 15 seconds were expected to clear the bridge of the submarine. As noted the THRESHER (No. 3): "Bridge personnel had to wear so much excessively bulky and cumbersome clothing that they were awkward in their movements." Added the SNOOK: "The time considered for getting rigged into this outfit was argument for dividing the lookouts

in three sections, each section standing a four hour watch." The TILEFISH (No. 3) observed: "Each time the--lookouts--took their turn in the conning tower they were required to remove most of their clothing; a pair of dungarees and a leather flying suit would certainly have simplified things."

Members of the bridge watch, in heavy weather, have not uncommonly been washed over the side. Some of these men were not recovered. The CABRILLA (No. 7) in reporting the loss of an officer in such a manner observed: "Though dressed in heavy winter clothing it is doubtful if he could have survived for more than 10 to 15 minutes in water at a temperature of 28 degrees F." His heavy clothing and arctics, must quickly have pulled him beneath the surface.

Diligent attention must always be given to prevent fouling of the conning tower hatch. The necessity for trim and well-tailored clothing, free of bulky pockets or flapping trousers, in this aspect was apparent one time on the RUNNER (No. 1, SS 476) when, on a drill dive, a lookout's coat caught on the hatch of the conning tower; what could have been major catastrophe was narrowly escaped. On the eleventh patrol of the GUARDFISH, as a lookout cleared the bridge, his leather mitten lodged in the bridge hatch-seat. The hatch could not be properly sealed and considerable amounts of water were taken into the conning tower. The need for well designed and trim clothing exists elsewhere than on the bridge, as in the engine rooms where the regular issue "submarine coat" is too bulky for practical use.

In rough and cold weather these boats, as observed earlier, are cold and damp and the problem of drying clothes is difficult (S-28, No. 4). Reported the SKIPJACK: "The pump room affording only limited space, was used constantly." The engine rooms, in these areas, were only slightly higher in temperature than the topside and were of little use in drying clothes.

The problem of stowage is very important. It is not practical for a submarine to carry a full load of this type of gear aboard unless it will be used. Ideally, all tenders and bases, regardless of their location, should carry adequate supplies of heavy winter clothing for submarine personnel (REDFISH No. 2).

Eight submarine commanding officers complained that they were issued or had aboard an inadequate quantity of foul weather clothing. The FLYING FISH (No. 5) after departure, discovering that she was not equipped with sufficient nor the correct kind of clothing for a cold water patrol, recommended that a stock of winter clothing be kept at advance bases (as Midway) and that a plan be put in action whereby submarines departing on patrols and drawing on their supply would again turn in the clothing on their return.

It has been said (commanding officer, Submarine Squadron 45, endorsement to patrol report No. 4, S-34) that no clothing would be absolutely adequate for the bridge watch when green seas are being continuously taken aboard and that it is doubtful if anything could be designed to withstand continual submergence. Investigation of the problem, with such an aim in mind, is warranted, however, and should proceed. So far, the three factors of bulkiness, dampness and warmth seem to be a combination that can not be coordinated to produce a satisfactory garment which, when worn with a reasonable amount of warm underclothing, will afford dryness, warmth and agility of movement in the most severe weather.

Many suggestions for a one-piece garment with a hood have been made by submariners. Nine commanding officers recommended the development of a one-piece garment; seven thought it should be a fleece, fur or mohair lined coverall, or "if a fur lined suit, boots included, is not available, recommend a complete coverall, including the hands and feet, such as has recently been advocated for life saving." The SEA POACHER (No. 1) recommended the development of a "fleece lined, waterproof, snap-fastened coverall suit with a zipper collar type of hood, to be worn with watertight aviation boots." The other essentials were flap pockets for lens paper and sunglasses, elastic wristlets to prevent water running down the sleeve while using the binoculars and the securing of waterproof full palm mittens or gloves to the sleeve of the coverall so that they might be pulled off quickly and not lost. Others thought the garment should be in the nature of a fleece lined parka and trousers. The SNOOK (No. 8), on a winter Kurile Island patrol, had available a few fleece lined leather flying suits, concerning which it was noted: "Nine lookouts preferred these when worn under parka rain clothing for dryness. After frequent dressings with Neatsfoot they became fairly soft and water repellent but they were excessively bulky and the fur collar was nothing but a wick around the neck. All agreed that they were the warmest things that we had aboard."

Exposure suits have been the subject of considerable investigation by the Bureau of Supplies, Bureau of Ships, Bureau of Aeronautics, Naval Medical Research Institute, and interested civilian commercial firms. Several types of suits have been studied, including the Army Quick-Donning Exposure Suit, and the Bureau of Aeronautics' Continuous Wear Exposure Suit (Mk 2) plus the Bureau of Ships' Combination Rain Suit - Exposure Suit.

The Continuous Wear Exposure Suit (Mk 2, designed and constructed by the Naval Medical Research Institute, Project No. X-189, Report No. 6) was intended to be worn by aviation personnel forced to abandon their aircraft, as protection from immersion in cold water and exposure to the wind while aboard their life rafts. It is made of impermeable

laminate material composed of two layers of nylon cloth with a waterproof coating between the layers. Nylon was used because of its high tensile strength, resistance to snags, deterioration and mildew. The form fitting, neatly tailored coverall is used for a basic design, completely enveloping the body to the neckline. Gussets, sealed in at the front and neck, bar the entrance of water into the suit. There is a watertight relief zipper. Gloves and socks are attached at the wrists and ankles. The suit is tailored to fit over a pilot wearing woolen underwear, anti-blackout suit, green aviation working trousers and intermediate leather flying jacket. The socks are to be worn over heavy woolen flying socks but under standard issue shoes or flying boots. The material from which the present suit is made is not permeable to water vapor and the development of a suit with this property of facilitating cooling when the wearer is overheated, awaits perfection of a material having the necessary physical characteristics. Unofficially, it is said that the Mk 2, nylon suit, when worn by aviators in the field with electrically heated boots and gloves in heated cockpits (U.S.S. Midway) was found satisfactory, with the exception of a few defects, as accumulation of water vapor, and minor design faults. The Army Quick-Donning Exposure Suit is quite similar in design and construction.

In August and September of 1945, newly developed submarine clothing (Naval Clothing Factory, Brooklyn) was tested aboard the U.S.S. SNAPPER off Eastern Long Island. Inasmuch as no cold or foul weather was encountered, tests were solely limited to the utility of the garments. Clothing consisted of a one-piece coverall suit with attached hood. The boots were specially designed. Leather, Neatsfoot treated, two-fingered mittens with gauntlets were worn. Constructive criticisms of the garment were made. Additional studies for waterproofing were proposed (Ltr Naval Clothing Depot, Brooklyn, JJ55 RD/TJS:gb, 14 Sep 1945 to Permanent Naval Uniform Board).

The combination Rain Suit - Exposure Suit is made of material very similar to the Navy rain parka. Watertight closure at the neck and wrists is achieved by drawstrings and straps. There is a gusset at the neck; the legs of the suit taper to form loose fitting socks over which boots or galoshes can be worn. Under working conditions, at moderate temperature, NMRI (Project X-189, Report No. 9) found the Rain Suit - Exposure Suit to be as comfortable as the Navy parka suit and suggested that of the two it seemed to be the most desirable type of rain clothing, since, in addition to functioning as rain clothing, it would also afford protection to men washed overboard into cold water. Field tests of these different articles of protective clothing have recently been conducted in the Northern Atlantic by a representative of the NMRI (Research Project No. X-189, Report No. 11). It is understood that the design of the Rain Suit - Exposure Suit was found to be good and that, fundamentally, it afforded excellent protection against wetness and immersion. Additional protective underclothing is required for warmth. The fabric of the present garment proved wholly unsatisfactory, quickly losing its water repelling quality and tearing easily.

FLYING GEAR

There are two types of available flight gear, that which is heated and that which is not. The latter, consisting of shearling jackets, trousers, boots, helmets, etc., are heavy and bulky. It has been observed that the temperature at which exposure in unheated flying clothing (over which an exposure suit was worn) can be tolerated for four hours or more is 20 degrees F. Young men sitting in a room at 0 degrees F. for two hours are afforded adequate protection by unheated flying clothing for two hours. Different parts of the body require different amounts of insulation. Clothing should be designed in accordance with these facts. In sub-freezing weather, the tolerance time depends primarily on the rapid cooling of the hands and feet, particularly of the fingers. Heated gloves and boots must be worn when the time of exposure exceeds the tolerance limits (NMRI Ltr NH6-1/A11/NMRI-134, 14 July 1945). Electrically heated flying suits best maintain the correct body temperature and will protect the wearer down to -20 degrees F. and at a lower temperature for shorter periods of time. This type of clothing is much lighter than the shearling suit. It would appear, for various reasons, that electrically heated clothing at the present time is not feasible for wear on the bridge of a submarine.

SUMMARY

Special protective submarine clothing to adequately serve its purpose, must satisfy several basic requirements. When properly clothed in the most severe weather, bridge personnel (and gun crews) should remain comfortably warm and dry to maintain a reasonably long and alert watch. Since tolerance time for exposure depends primarily upon the rapid cooling of the hands (particularly the fingers) and the feet, adequate protection of the hands and feet is fundamental. Design of the clothing must be practical, tailoring neat, with a minimum of bulk to facilitate rapid and easy clearance of the bridge and easy rapid drying qualities; permeability to water vapor is desirable. Cold weather gear developed by the Bureau

of Aeronautics and Bureau of Ships (NMRD) has very recently been put to test in the field. Review and investigation of the problem of adequate protective clothing for submarine personnel has recently been undertaken by the Bureau of Supplies and Accounts in collaboration with the Naval Medical Research Institute and Research Division, Bureau of Medicine and Surgery. Approach to the problem may be from the standpoint of:

1. Improvement of existing protection under limitations of existing garments. Recommendations in light of the available garments and needs of the Submarine Service, are summarized as follows:

(a) The following articles available in one Standard Sea Outfit for 100 per cent of the personnel attached appear satisfactory as to design, and quality: (1) Goggles, N-1; (2) Drawers, Winter, N-1; (3) Helmet, Winter, N-1; (4) Helmet, Winter, N-2; (5) Mask, Face, Winter, N-1; (6) Undershirt, Winter, N-1; (7) Shoes, Field, N-1; (8) Sandals, N-1; (9) Scarf, Winter, N-1; (10) Sweater, Winter, N-1; (11) Comforter, Cotton, Army Issue.

A special submarine Clothing Board convened by ComSubPac (ComSubPac FF12-10(A)/JJ55 Serial 0637, Conf ltr to CNO, 26 March 1945, Encl. A) recommended that one Helmet, Winter (N-1), and one Mask, Face, Winter (N-1) be included for 50 per cent rather than 100 per cent of the attached personnel.

(b) The following articles available in one standard Sea Outfit for 100 per cent of the personnel attached are either unsatisfactory or capable of improvement:

(1) Footwear.--This must incorporate warmth (fleece or fur lined) waterproofness, lightness, flexibility, unawkwardness, ease of attiring, and afford a firm grip. An arctic type of fleece lined boot with inner closed flap and buckle fastening and waterproof outer material seems to be most suitable footwear for topside personnel. Shearling lined leather aviation flying boots were liked for their warmth. The Sea Boot (N-1) was liked by some, found unsatisfactory by others because of its bulkiness. If issued, it should be accompanied by at least three pair of inner felt soles.

(2) Coat, Parka, Winter (N-1).--Investigation warranted. According to ComSubPac, is a desirable garment and 6 should be included. Others report present design unsatisfactory, not being watertight, too bulky for rapid bridge clearance. Said to be shoddily built; alpaca lining, when wet, difficult to dry. Recommendations made for procurement of pullover style with gusset at the neck. Available to officers only.

(3) Parka Rain Jacket and Trousers (N-2).--Design of pullover jacket with hood generally approved. Fastening around the neck, face, wrist, ankles and fly said to be poorly designed as to durability and waterproofness. With heavy weather, material deteriorates; garment leaks copiously, tears easily. ComSubPac recommended redesigning to provide light rubber lining. Recent field tests by NMRI representatives substantiate these criticisms.

(4) Winter Trousers and Jacket (N-2).--Generally well liked as to design and quality. Recommended that those provided submarines be lined with alpaca, felt, fur or cellular rubber. Recommend investigation of lining from the viewpoint of insulation, durability and drying qualities. Substitution of a 1/4 inch and 1/8 inch thick cellular Neoprene as a lining in the jacket and trousers is under investigation (S&A Conf Ltr JJ55-1(SCR), 19 April 1945 to Supply Officer, NSD, Brooklyn, N.Y.). Garment too bulky for below deck wear.

(5) Mittens, Waterproof (N-1).--Rubberized exterior surface unsatisfactory in that they are slippery, unflexible and dangerous. Recommend change in design to full mittens, gauntlet type with waterproof insert between inner and outer fabric. S&A has initiated development of waterproof Neoprene gauntlets as possible temporary solution to problem of wet slick hands; dipping woolen and buckskin mittens in Neoprene to effect waterproofness and warmth. Mittens, Winter (N-2) and Mittens, Work (N-3) - recommend change to full mitten type, and above investigation for waterproofing and increasing warmth.

(6) Socks, Winter (N-1).--ComSubPac recommended shortening to 16 inches to prevent bulk near the knee, and that three pair be included in winter outfit for 100 per cent personnel.

(7) Shirt, Flannel, Blue and Trousers, Blue.--Recommended authorizing of flannel shirt in lieu of undress jumper and issuing of shirt and trousers instead of selling them. ComSubPac recommends three be included for 100 per cent personnel attached.

(8) Many recommend Trousers, Melton Cloth (formerly submarine special clothing) as a desirable addition; two pair for 100 per cent personnel.

(9) Insure that an adequate stock of special submarine clothing for protection against the weather be available aboard tenders and bases in areas from which patrols originate. Indoctrinate submarine personnel in the proper wearing and care of special items of protective clothing.

2. Reasonable proof of the inadequacies of the several pieces of special submarine clothing exists. As the commanding officer of the SNOOK, Comdr. J. S. Walling, USN, indicated, we should stop trying to make a satisfactory submarine garment from individual unsatisfactory items. Production of improved garments in view of special need of the service should be investigated.

(a) As indicated above, need exists for the development of more satisfactory footwear, mittens or gloves and rain garments. It appears that the parka rain garment is satisfactory only in design and requires replacement.

(b) Great merit exists in the recommendations of various commanding officers for the design and manufacture of a one-piece garment for protection against the cold and rain. It is recommended that a similar garment be designed for use aboard submarines in the light of the need of the service and the adequacies and inadequacies of present exposure suits as recently revealed in field tests.

(c) For the time being it would appear that electrically heated gloves, boots, and suits, etc., are not practical for use of personnel on the bridge of a submarine.

Patrol Reports Containing Information Concerning Apparel Worn by Submariners

APOGON 6; BALAO 9; CABRILLA 7; CUTTLEFISH 1; DACE 7; FLYING FISH 5; HALIBUT 3; MUSKALLUNGE 7; NARWHAL 1, 4; NAUTILUS 3, 5; PERMIT 7; PIKE 6; PIPER 2; PIRANHA 5; PLAICE 5; POLLACK 5; POMFRET 5, 6; PAMPANITO 4; PORPOISE 4; QUEENFISH 2; RAZORBACK 3; REDFISH 2; RUNNER (SS 476) 1; SAND LANCE 1; SARGO 9; SEA CAT 2; SEADEVIL 3; SEADRAGON 4; SEAL 11; SEA POACHER 1; SEARAVEN 2, 12; SEAROBIN 2; SKIPJACK 10; SNOOK 8; SPADEFISH 3; SPOT 1; STERLET 4; SUNFISH 7; SWORDFISH 10; TAUTOG 10, 11; THRESHER 3, 4; TILEFISH 3; TROUT 2; TUNA 1; WAHOO 4; S-23, 1, 5; S-28, 4, 5; S-32, 6, 7, 8; S-33, 5; S-34, 3, 4, 5; S-31, 3.

Chapter 4

Personnel Performance in Submarine Warfare in World War II

In the preceding section we have considered in detail how the various components of habitability aboard a submarine may influence the performance of its crew. There exists an abundance of information in these patrol reports concerning other aspects of the performance of the human machine in submarine warfare. As the commanding officer of the SEA CAT (No. 3) observed: "in 600 odd patrols preceding this, but little has been left unsaid of submarine officers and enlisted men."

In this section it is proposed to discuss the reaction and the response of personnel to the various features of submarine warfare in terms of personnel endurance, performance, and morale.

With the beginning of World War II, little was known concerning the type of performance which might be expected, in view of the existing circumstances, from personnel aboard operating submarines. There quickly accumulated, from commanding officers of submarines returning from the active war zones, first hand information which could be applied to answering the various questions which then existed as: how long could a submarine crew be expected to remain on station in contact with the enemy; how long could they, under submerged operating conditions, be expected to turn in an efficient performance; how important was the matter of morale and response to enemy antisubmarine measures, etc.

Commanding officers continued to turn in comments upon individual response to operating conditions which changed somewhat as the War progressed, and accumulated experience, as we shall see, tended to modify some of the earlier impressions. In connection with this it should be remembered that men and women especially trained and equipped to evaluate human performance may utilize special and complicated tests designed for these purposes. They may contrast, compare and describe the scores or results against a vast background of previously accumulated information. Commanding officers of operating submarines, especially in the early days of hostilities, had none of these advantages. They reported upon the response of the human machine to the War as they saw it--and their comments were interesting indeed.

PERSONNEL PERFORMANCE AND ENDURANCE AS REPORTED IN THE EARLY DAYS AND MONTHS OF THE WAR AGAINST JAPAN

The life of submariners in the closing days of 1941 and the early months of 1942 was made harrowing by circumstances under which they operated. Some of our submarines were on operations, others were on hand at the beginning of the War and felt the initial strikes of the Japanese. The immediate effect upon personnel of these hectic and harrowing early days of combat is apparent from the following comments: "Everyone seemed under a strain the first few days of the war" (TAMBOR, 23 December 1941). "The first day of the war has been a busy and trying one for all hands. After the first impact had made itself felt all personnel settled down quickly to the task ahead" (PICKEREL, 29 December 1941). "The first five days were most trying, since a complete change of habits, both mental and physical was necessary and this caused some distress" (SARGO, 25 January 1942). "Spent 21 and 22 December in escape tactics;--as the crew was exhausted went to 100 feet and stood out to sea at low speed" (STINGRAY, 24 December 1941).

"Morale has been commendable in view of the great strain and the long working hours all hands were forced to endure from 10 December until the start of the patrol, there being but little time to relax. Much nervousness was shown in the first contact with the enemy but this decreased in subsequent encounters--" (SEADRAGON, 13 February 1942). "SEARAVEN left Manila on patrol during the strike and most of that time was spent underway, standing by in order to avoid air attacks. Consequently no one got ashore or to the tender to stock up on cigarettes, tobacco, etc., and hence, all ran low--about 10 days before the end of the patrol--the lack of which was felt acutely" (19 January 1942). "Serious casualties during the first five weeks of wartime operation put a definite strain on the physical endurance and morale of the engineering personnel--who were required to work long hours when off watch in hot engine rooms to keep the engines in repair and were tired out at the end of the patrol. In port it was necessary to work with the entire crew every day to make ready for the next patrol--this combined with a complete lack of recreational facilities ashore" (SKIPJACK, 14 January 1942).

The first patrol of the SEAL ended on 5 February 1942. "The strain and disturbance of rest due to frequent enemy contacts--showed some effect on the crew in general but lulls occurred which forestalled any material reduction in efficiency. Upon arrival in Soerabaja, Java, but very little outside assistance in repairs could be had due to the daily air raids which dissipated local facilities and necessitated diving during the forenoon until about 1400. On one occasion bombs landed about 300 yards away while submerged." "Approximately one-half of the crew had two days rest at Tjilatjap, Java; a second half were taken to Copeng but were recalled the next day due to the imminence of enemy action against Java; departed the following day on patrol." "The officers and crew were not in very good physical condition, not having had time to recover from the last patrol" DOLPHIN, July 1942).

Some of these early war patrol reports give evidence of serious and excessive personnel fatigue and depletion of efficiency. The second patrol of the PORPOISE, begun on 9 February 1942, was terminated on 30 March with these observations: "On 10 March the ship's company showed the effects of fatigue and heat to a marked degree. Reactions are slow, tempers short and nerves on edge with skin diseases of all types and general health poor. On 11 March, due to the extreme physical exhaustion of the crew and the nervous exhaustion of myself together with the approaching exhaustion of provisions, I decided to start south by the shortest route." The second patrol of the CUTTLEFISH, begun on 21 April, was terminated on 15 June 1942. It was observed: "Fatigue was very evident after 6 June; even the normally reliable officers and men were making mistakes--this is only natural considering that the two weeks prior to the start of the patrol and the 6 days at Midway were spent working shifts. Mental depression was generalized about the time we left the area--this was directly attributable to our being ordered out of the area just when all hands were in the highest of spirits convinced that our bad luck had run its course and that great things were in store for us" (Battle of Midway).

The commanding officer of the GRAYLING (No. 2) after a 52 day patrol reported: "Fatigue of personnel was a factor of endurance which caused ending this patrol. The monotony of a submerged patrol in waters where active antisubmarine forces are present is fatiguing to personnel. The strain of being depth charged wears off with rest and quiet but the individual definitely loses more and more of his reserve energy with successive attacks. It is believed that three weeks is the limit of the efficiency of such a patrol unless some change of pace or diversion is introduced." At the conclusion of the third patrol of the SCULPIN (13 March to 27 April 1942) it was reported: "The physical, and to a great extent the psychological, well being of men deteriorated at an accelerated rate. The manifestations were sleeplessness, chronic headaches, general lassitude, loss of appetite, marked decrease in mental alertness, emotional instability and increasing nervousness. Two key men so nearly approached complete nervous and physical collapse that it was necessary to put them on the sick list, relieved of all duty. Any radical change in the ship's course or speed, especially at night, caused a noticeable tension to develop." "--two serious casualties resulted from what, in normal times, could only be called sheer stupidity." "--the slightest physical ailment would affect the men out of all proportion and it was necessary therefore, to make free use of sedation."

The commanding officer of the GUDGEON reported at the end of her second patrol (22 February to 15 April 1942): "This cruise seemed to be more strenuous and tiring on the men. This may have been due to the long stretches of bad weather and to the fact that the men have been worked to their maximum efficiency and endurance since the ship was commissioned. After a month, most of the personnel were fatigued--toward the last part, men who were good key men--were noticed to make errors. Patrol ended by fatigue (zero endurance) and sickness of personnel." Similar reports of excessive fatigue and depletion of personnel endurance, during this period, are to be found in the following patrol reports: PICKEREL No. 1, 2, and 3; CUTTLEFISH No. 3; PERMIT No. 2, and 3; SARGO No. 3; ARGONAUT No. 1; GRAYBACK No. 3 (terminated patrol); and FLYING FISH No. 2.

As noted above, the commanding officer of the GRAYLING (No. 2) was of the opinion that personnel efficiency reached its limit after about three weeks when active anti-submarine measures were encountered. The commanding officer of the CUTTLEFISH (No. 3) observed excessive fatigue after the third week on station, particularly in those making their third patrol: "the patrol could not have been continued more than five days longer without serious reduction in efficiency--." The commanding officer of the PICKEREL (No. 1) considered 17 days about the proper length of time for operations made under constant strain, "21 days being considered too long"; and on the second patrol, after 51 consecutive days of submerged operations, "rest must be provided and the length of patrols reduced in this climate" (tropical). Concerning the first patrol of the PLUNGER (14 December 1941 to 4 February 1942, 18 days submerged) the commanding officer reported: "The patrol was terminated by operation orders but the officers and men were very tired and our limit of endurance was reached at the end of the 42nd day submerged--it is believed that the absolute limit of endurance due to fatigue of personnel is about 40 days on station (submerged operations). It is believed that 30 days submerged operations should be the maximum in tropical waters if full battle efficiency is to be maintained." The commanding officer of the THRESHER (No. 2) reported after his ship had been at sea 108 out of 129 days: "--we do not feel that we can continue 49 and 59 day patrols with 21 days in port as a steady affair or where enemy opposition is too active. --60 day patrols seem about the limit of an effective patrol."

The GRAYBACK (No. 1, terminated on 10 April 1942) after spending 29 days on station reported that "although personnel were undoubtedly tired--they--could have continued although possibly at reduced efficiency." Higher authority in commenting upon this patrol observed that one half of the period had been spent on station--"a gratifying increase over the usual one-third." At the end of the GAR's first patrol (2 February to 28 March 1942) higher authority observed: "Two months ago little was known as to the ability of personnel to stand up under the strain of a long and vigorous submarine patrol and, therefore, orders at the time the GAR left on this patrol called for her to return to base about the 55th day--which resulted in submarines leaving their stations between the 35th and 40th days. Since that time, observations on crews returning has led to the belief that longer patrols can be conducted and the length of patrols is being gradually extended. Present orders requiring submarines to leave station on the 45th day will be extended if personnel conditions justify it." At about the same time, it was observed in connection with the conclusion of the first patrol of the TUNA: "It has been demonstrated that personnel can remain at sea in this type of submarine to the limit of its fuel capacity."

GENERAL INFORMATION

Lack of space and time obviously prohibits specific reference to each report of personnel endurance, performance, and morale made by commanding officers under varying circumstances as the war progressed. Generalizations, however, can be made as follows.

LENGTH OF PATROLS, TIME SPENT IN AREA AND IN SUBMERGED OPERATIONS

The average duration of 1,386 of these patrols was about 48.18 days. Of the 178 patrols lasting for 60 days or more, 22 lasted 70 days or longer and 6 lasted for more than 80 days.

On 1,011 patrols an average of 26.7 days were spent in the area of operations. Of 198 patrols on which 35 days or more were spent on station, 28 spent 45 days or longer and 4 remained on station for 55 days or longer.

On 967 patrols an average of 16.31 days were spent submerged. Four hundred and seventy-four of these patrols spent 15 days or less submerged. Two hundred and thirty spent 25 days or more submerged, 45 spent more than 35 days submerged and 7 spent 45 or more submerged.

PERSONNEL ENDURANCE - MEANING OF THE TERM

Personnel endurance in paragraph (P) on war patrol reports was reported in terms of endurance remaining at the time the submarine left her area of operations. Obviously there are many existing factors influencing the duration of personnel endurance. Moreover, any estimate must in part reflect the personal standards of the commanding officers. These things being true, but little information of importance would result from a detailed statistical analysis of these collected figures. Suffice it to say at this point that in 173 patrols lasting 60 days or longer, personnel endurance was reported as follows: Indefinite or unknown in 28 instances, 15 reported it to have varied from not more than 5 to not less than 1 day. At the end of three patrols it was reported in terms of 0 days and on the remaining 127 patrols (with an average duration of 64.4 days) it was estimated to have been about 12.5 days at the time

the ship left her area. Nine submarines made two or more consecutive patrols of 60 days or more duration, after each of which personnel endurance was reported to have varied from 7 to 21 days.

On the other hand, personnel endurance was reported as "0" days after 25 patrols made by 21 fleet submarines throughout the war. Details of these patrols are presented in the following table (Table 29).

Table 29.--SUBMARINE PATROLS TERMINATED WITH ZERO DAYS PERSONNEL ENDURANCE

Submarine	Patrol Number	Area	Date	Total No. Days	Days on Station	Days Submerged	Personnel Endurance	Factor Terminating Patrol	Comments
Gudgeon	2	Tori Shima	Feb. --Apr. 1942	53	20	(*)	0	Yes	Terminated in part due to excessive fatigue and illness (60 sick days due to upper respiratory infections).
Herring	2	Atlantic	Dec. --Feb. 1942	58	54	54	0	No	Low personnel endurance due (1) length of time submerged on station; (2) bad weather; (3) lack of opportunity for offensive action.
Seadragon	1	Tropical	Dec. --Feb. 1942	46	(*)	(*)	0	No	All hands under considerable strain from 10 Dec. until start of patrol. Epidemic food poisoning on patrol (24 hours) involving 1/3 men.
Grenadier	3	Tropical	July- Sept. 1942	67	40	(*)	0	No	"0" days endurance does not mean crew in state of mental or physical collapse; no longer on toes and keen at sea long enough.
Gato	2	Aleutians	1942	50	(*)	(*)	0	Yes	Patrol terminated in part due to end of personnel endurance. "Poor habitability due to high humidity, cold water, long hours submerged, operations." Acute communicable disease resulted in 35 sick days in bed.
Greenling	*2*	*Tropical*	*July- Sept. 1942*	*(*)*	*(*)*	*(*)*	*0*	*Yes*	*"During last week or ten days on station, increasing personnel fatigue was primary cause of ending patrol." Twenty-nine sick days.*
Grayling	2	Kyushu	Mar. --May 1942	52	26	(*)	(*)	Yes	"Fatigue of personnel was a factor of endurance which ended this patrol."
Porpoise	2	Tropical	Feb. --Mar. 1942	38	(*)	(*)	(*)	Yes	No freon gas for air conditioning. "On 18 March due in part to extreme physical exhaustion"--all hands--"started south by shortest route." Patrol abandoned.
Grayback	3	Tropical	July- Sept. 1942	61	38	(*)	(*)	Yes	"Heavy taxation of crew and officers led the commanding officer to discontinue patrol a few days early."
Greenling	4	Aleutians	Dec. --Jan. 1943	(*)	(*)	(*)	0	Yes	"Universal amount of illness; personnel fatigue prominent on 40th day--became too great for additional effective patrol on station." Forty-three sick days.
Drum	6	Tropical	Mar. --May 1943	60	27	(*)	0	No	"Health excellent." Habitability good.
Drum	8	Tropical	June- July 1943	49	33	32	0	No	"Health below usual standards."
Nautilus	4	Tropical	Dec. --Feb. 1943	53	(*)	(*)	0	No	"Personnel endurance minus quantity at termination of patrol. Poor air conditioning; health and habitability factors very low."
Plunger	4	Tropical	Nov. --Jan. 1943	64	40	42	0	No	"Patrol terminated by operation orders but officers and men near limit endurance end of 42nd day submerged."
Pogy	2	Tropical	June- Aug. 1943	61	32	25	0	No	"Health excellent; 0 sick days; habitability satisfactory."
Angler	2	Tropical	Feb. --Apr. 1944	55	25	26	0	No	Excessive amount illness; copper sulfate contaminated fresh water.
Angler	3	Tropical	May - 1944	27	13	14	0	Yes	"Health and habitability were the limiting factors of this patrol," due to copper sulfate contaminated water.
Barbel	3	China Sea	Oct. --Dec. 1944	39	18	14	0	No	"Health and habitability excellent"; six day refueling period between patrols No. 2 and 3. "Patrol terminated by CTF orders but is felt that fighting efficiency all hands dropped--to zero day endurance factor."
Blackfish	6	Tropical	Mar. --May 1944	80	43	9	0	No	"Few actual illnesses"; habitability adequate; "efficiency of all hands decreased rapidly after the 50th day of patrol."
Crevalle	2	China Sea	Dec. --Feb. 1944	60	51	6	0	No	Habitability excellent; strenuous patrol; "minor evidence operational fatigue on return passage."
Picuda	2	China Sea	May - June 1944	56	28	12	0	No	"Air conditioning inadequate; temperatures varied between 95-110 degrees F. in forward battery--with deleterious effect on frequent all day dives."
Tinosa	5	Tropical	Jan. --Mar. 1944	66	33	(*)	0	No	Satisfactory habitability; strenuous patrol; "crew at battle stations nine hours one occasion; submerged, rest all hands."
Tinosa	7	China Sea	June- July 1944	54	32	23	0	No	Health and habitability excellent.
Sealion	8	Wake	Apr. --July 1945	66	38	9	0	No	Health excellent; habitability satisfactory, crowded. Morale good. Long arduous patrol without opportunity to inflict damage to the enemy or effect rescues.
Grouper	1	(*)	1942	56	(*)	56	0	Yes	"Fuel, torpedoes and provisions were available for much longer stay in area, but human endurance was lacking."
					"S" Boats				
S-32	4	Aleutians	Aug. --Sept. 1942	33	27	(*)	0	No	Commanding officer considered 30 day patrol maximum for efficient performance of personnel in "S" class submarine.
S-34	3	Aleutians	Sept.--Oct. 1942	37	22	(*)	0	No	Habitability poor, numerous colds, "personnel considered to have reached limits of efficiency after 31 days."

Table 29.--SUBMARINE PATROLS TERMINATED WITH ZERO DAYS PERSONNEL ENDURANCE-continued

Submarine	Patrol Number	Area	Date	Total No. Days	Days on Station	Days Submerged	Personnel Endurance	Factor Terminating Patrol	Comments
S-43	2	Tropical	July-Aug. 1942	31	(*)	20	0	(*)	Habitability poor with "personnel exhaustion due to high temperatures and humidity on all day dives."
S-34	4	Aleutians	Oct.-Nov. 1942	29	20	(*)	0	No	Habitability poor.
S-41	4	Tropical	Aug.-Sept. 1942	27	(*)	17	0	No	Average temperature submerged 93 degrees. Chlorine gas on one occasion.
S-41	5	Tropical	Sept.-Oct. 1942	42	(*)	(*)	0	No	"Numerous colds."
S-23	3	Aleutians	July-Aug. 1942	34	27	(*)	0	No	Health described as excellent.
S-28	2	Aleutians	July-Aug. 1942	34	(*)	(*)	0	No	Health excellent; habitability improved. "Very little reserve left in this class ship after 35 days on patrol."
S-18	2	Aleutians	Feb.-1942	21	(*)	(*)	0	No	Average air temperature conning tower 22-32 degrees F. One man had pneumonia.
S-33	3	Aleutians	Aug.-Sept. 1942	33	26	27	1	No	Fifty percent of crew had colds. Habitability poor.
S-33	4	Aleutians	Oct.-Nov. 1942	28	17	(*)	1	No	Numerous colds.
S-33	2	Aleutians	July-Aug. 1942	37	(*)	(*)	1	No	Health poor. Commanding officer considered period 30 days maximum for "S" boats. Patrol terminated by order of Task Force, personnel endurance would have in part done it otherwise.
S-18	7	Aleutians	Nov.-Dec. 1942	28	(*)	16	1	No	Did not terminate patrol.
S-34	7	Kurile	July-Aug. 1943	33	(*)	(*)	0	No	Habitability poor.
S-42	1	New Ireland	Apr.-May 1942	25	(*)	(*)	0	Yes	"In enemy controlled tropical waters without air conditioning, crew of a 20 year old "S" boat subjected to severe strain--with a serious loss of efficiency."

Legend: * = Indicates approximate or unknown item, number or quantity.

Four of the patrols referred to in the above table have already been discussed: GUDGEON No. 2, SEADRAGON No. 1, GRAYLING No. 2, and PORPOISE No. 2. Those patrols made by the GUDGEON, GRAYLING, and PORPOISE were terminated because of excessive personnel fatigue. We have noted elsewhere that lack of Freon Gas aboard the PORPOISE resulted in very poor habitability, responsible to a great degree for the excessive fatigue of personnel. Five other patrols, all made at about the same time in these early months of the war were terminated for the same reason. The second patrol of the GRAYBACK made in tropical theater of operations, was "discontinued--a few days early--because of the heavy taxation on the endurance of the crew and officers--." At the conclusion of the GROUPER's first patrol, of 56 days duration, note was made: "Fuel, torpedoes and provisions were available for a much longer stay in area, but human endurance was lacking."

On the GATO's second patrol poor habitability was encountered due to the high humidity, cold water, and long hours of submerged operations. Acute communicable diseases accounted for 35 sick days in bed; personnel endurance at the conclusion of the patrol, was calculated to have been zero days. On the second patrol of the GREENLING, the limit of effective personnel endurance had been reached on the 45th day; two days later an additional half-day of submerged operations in the area was considered to be ineffective in view of the prevalent fatigue among the crew. "During the last week or 10 days on station, increasing fatigue--was evidenced in many ways, even by the officers and leading men. The enemy measures encountered, the several periods of deep running with air conditioning plants shut off, and the fact that this was the second successive tropical patrol conducted during the hot season, all, no doubt, contributed to this condition." Following this report authorization was made for commanding officers to withdraw from station for a short rest on occasion to restore alertness. On the third patrol (40 days in length) the following note was made: "Reluctantly decided not to chase the convoy; personnel are tired and need rest. Some have had little or no sleep during the past 48 hours of operation." "While the patrol was of relatively short duration, fatigue was quite noticeable before leaving station in the case of some of the officers and nearly all of the men, about 50 per cent of whom were on their third consecutive patrol. Contrary to the experience on former patrols the men did not appear to recuperate during the quiet return passage." Thirty-nine days later the ship was underway on its fourth patrol on which it was observed: "Health of the crew was considerably worse than on any previous patrol. Fatigue became prominent on the 40th day and became increasingly worse thereafter until day-light surface running was resumed--and was too great for additional effective patrol on station. The universal amount of illness undoubtedly had its influence on inducing personnel fatigue."

The commanding officer of the GRENADIER stated, after this 67 day patrol, on which the health of the crew had been very good. "Zero days of personnel endurance--is not meant to carry the impression that the crew is in a state of mental or physical collapse or that their morale is low. It does mean that they are no longer on their toes and have been at sea long enough." Throughout the rest of these patrol reports, in general, the term "zero days", personnel endurance, has been employed with this meaning. Very rarely were the states of exhaustion and near collapse, described above in the opening months of the war, encountered as the hostilities proceeded.

PERSONNEL ENDURANCE AS THE WAR CONTINUED

It will be observed that the remaining patrols referred to in the above table were made by fleet type submarines during the years 1943, 1944, and 1945. Contamination of the fresh water supply with excessive amounts of copper sulfate, aboard the ANGLER, as described elsewhere, accounted for "zero days of personnel endurance" on her second patrol and terminated her third patrol. Inadequate air conditioning in part, was no doubt responsible for depleted endurance of the crew aboard the PICUDA on her second patrol.

PERSONNEL ENDURANCE AND TOTAL LENGTH OF PATROL

The relationship which exists between personnel endurance and total amount of time spent on the patrol is one of considerable interest and importance. It was observed, as the war progressed, that "personnel could remain at sea in the fleet type of submarine to the limit of its fuel capacity." This appears to have been borne out by the fact that on the termination of 127 patrols with an average duration of 64.4 days, personnel endurance was estimated to have been about 12.5 days. Only three patrols lasting 60 days or longer turned in a "zero day" score for personnel endurance.

At the conclusion of the seventh patrol of the BLACKFISH (a tropical cruise of 49 days duration) after about a two week overhaul, the submarine departed on her eighth patrol (1 March to 19 May 1944). In all, the patrol lasted for 80 days--"one of the longest made by any submarine during the war." Habitability, as far as can be learned, was apparently adequate if not good. There were a few cases of illness among the crew (several serious dermatological conditions, four venereal disease cases, etc.). Upon returning to port, with enough food left

for 5 days, the commanding officer reported: "A submarine should not be left on a patrol for too long a period. This was brought home to us by the fact that the efficiency of all hands decreased rapidly after the 50 day period. The lookouts, particularly, involuntarily slackened up as was shown by the two bombings from planes which came in from directly overhead. The last few dives were not smart at all. In spite of the morale boosting 'States-side' news, the boys were very tired."

Habitability aboard the CREVALLE, on her second patrol of 60 days duration, was described as excellent. Health of the crew was reported as good. At the conclusion of the patrol, made exciting and arduous by "daylight tracking and night surface attacks"--"minor evidence of operational fatigue considered perfectly normal under the circumstances, was observed on the return passage." The sixth patrol of the SEALION, "--long and arduous without opportunity to inflict damage on the enemy or effect air/sea rescues--was concluded with 'zero days' personnel endurance." The third patrol of the BARBEL (39 days duration) was separated from the previous 41 day patrol by a 6 day refueling and rearming period alongside a tender at Saipan. Habitability and health were reported as being good on the patrol that followed "--due to the comfortable weather and the number of days spent on the surface." The patrol was terminated by operation orders--but "it is felt that the fighting efficiency of all hands had dropped sufficiently to warrant a zero day endurance factor--" due to the length of the patrol which followed a 41 day long patrol without adequate facilities for recuperation of the crew.

At the end of the eleventh patrol of the FLYING FISH (October 1944) most of which was spent in tropical waters, the commanding officer commented: "No serious health injuries were observed but all hands were tired, both mentally and physically. I attribute this to four factors: (1) the tenth patrol was long (62 days); (2) the Australian refit or recuperation was cheering and enjoyable but I firmly believe that ordinary length refits in 'civilized' ports not only make the succeeding patrols a more difficult task but are detrimental to physical and mental health; (3) this patrol was of 83 days duration--true it was broken by one day at Seeadler and 3 at Woendi but the breaks were of more benefit to the ship materially than to her personnel; (4) coming in with a full load of torpedoes, e.g., the type and results of the patrol--morale reached a new low toward the end of the patrol. Announcement of our prospective trip to the West Coast was of course a tremendous morale booster and I count myself a lucky commanding officer to have been able to make the announcement." Personnel endurance was reported to be 2 days.

The commanding officer at the end of the ARGONAUT's (SS 166) first patrol in commenting on the impaired physical reaction and loss of stamina of the crew said: "This was evident at the end of the third week on the station and grew progressively worse as the patrol continued. Definite impairment of the fighting edge and reserve stamina to meet possible emergencies was lacking. Although conditions were never such at any time to jeopardize operations of the ship, the lack of sunshine and fresh air over so long a period was considered an important factor. It is recommended that the amount of time spent by any submarine on station be held to a maximum of 3 weeks."

PERSONNEL ENDURANCE AND DAYS SPENT IN OPERATIONS AREA

As noted above, the average number of days spent in the operations area on these patrols was about 26.7 days. A great many patrols spent considerably more time than this on area, four having remained on station for longer than 55 days. The BLUEGILL is believed to have spent the longest time on station--a total of 57 days. On this, her third patrol, three men were injured in a surface attack. On one occasion the after torpedo room and the maneuvering room were made uninhabitable for a short period of time following a hydrogen explosion in a torpedo, and the ship was severely depth charged twice. The pharmacist's mate on this patrol treated 33 men for fungus infections of the skin among many other ailments. There is no information available concerning the morale of the crew or their endurance other than it was estimated to have been 15 days presumably at the time the ship left the area. The first three patrols made by the CREVALLE averaged 60 days in length. At the end of the third cruise the commanding officer observed: "The strain of 47 days in the area (with consistently bad weather) only 6 of which were spent submerged, was beginning to tell on all hands by the time we had departed for home." On the second patrol of the HOE while in area a submerged patrol was maintained for about 60 per cent of the daylight hours--on the 50th day of the patrol a search off Wake Island was conducted. The commanding officer considered the length of submarine operations as excessive, "the officers and crew being definitely tired upon arrival at Midway on the 53rd day."

The commanding officer of the PERCH (No. 3) observed "signs of lassitude and ennui--as the seventh week on station rolled around." At the end of the eighth patrol made by the POLLACK: "All hands were pretty well tired out by the time we left station. Continually dodging patrol boats day and night had worn everyone down to a point where they need a rest--the officers in particular. It is believed that this (31 days in the area, 26 of which were submerged) is very nearly the maximum length of time that can be spent on station without operating at reduced efficiency." On the fourth patrol of the SEALION of 40 days duration, "noticeable decrease in efficiency and lack of the usual evidence of high spirits and enthusiasm was observed in the last two weeks on station, the officers and crew having only had a few hours of rest and relaxation since the last refit in September." A similar conclusion was drawn on the third patrol of the THRESHER: "though personnel endurance is hard to estimate it appears certain that the last week on patrol is decidedly harder on the crew than the earlier weeks." The fifth patrol of the REDFIN (26 October to 7 January 1945, China Sea, 46 days in area) was 75 days duration, 4 days of which had been spent alongside tenders at advanced bases. "Physical fatigue was apparent."

PERSONNEL ENDURANCE AND AMOUNT OF TIME SPENT SUBMERGED

As observed elsewhere, long periods of submergence may be made without adverse effect upon personnel endurance (GROUPER No. 1, 55 days, SHAD No. 7, 51 days). The HERRING on her second patrol (December to February 1942) probably spent the longest time submerged when, with a crew of about 70 men and officers, 54 consecutive days were spent submerged (slightly less than 13 hours a day) in reconnaissance in Atlantic waters; concerning the effects, it was reported: "Acuteness of personnel fell off sharply after 5 or 6 weeks--and the ability to have spent a day or so on the surface would have had a highly restorative effect. The nature of this type of patrol is hardly contributive to a high state of interest necessary to maintain morale. Personnel endurance in these operations has few features comparable with those encountered in the Pacific--. Facilities for rehabilitation are limited, the climate depressing, and repair and supply facilities of doubtful adequacy." Similar comments concerning the effects of reconnaissance on submarine personnel may be found in patrol reports of the RASHER (No. 3) and BLUEFISH (No. 5).

The commanding officer of the HAMMERHEAD (No. 2) in November 1944 after a 54 day patrol in the China Sea reported: "Health was excellent during 43 consecutive days submerged for a period of almost 14 hours. At the end of the 40th day--the crew showed their fatigue by lack of coordination and fatigue. Believe it would be well about midway in such a patrol to pull off into the center of the area for 2 days of surface running even though contacts would probably be missed. Recuperation of the crew during the 5 days of surface running south of the barrier was noticeable." At the end of her second patrol SAURY observed: "It is noticeable that the crew is in poorer physical condition than on the preceding patrol--one reason perhaps is the carrying over and cumulative effect of so much submerged time (37 day tropical patrol, amount of time submerged unknown) and air conditioning failure." At the end of the third patrol (62 days in length) it was reported: "After 30 days of submerged patrol (563.6 hours) a marked decline in efficiency of all hands was noted." On the tenth patrol of the SAURY, it was reported: "After 28 days submerged with 87 men aboard all hands feel the need for exercise and recreation." And on the fourth patrol of the DACE, "after spending 36 out of 37 days in the area submerged all hands were beginning to show the wear and tear which accompanies an active patrol."

EFFECT UPON PERSONNEL ENDURANCE OF EXTENDED SUBMARINE OPERATIONS AND SUCCESSIVE PATROLS

We have seen, in the early days of the war, the relationship between extended periods of operations, without adequate facilities for recuperation of the crew and refitting of the submarine, and personnel endurance.

On occasion, as the war progressed, prolonged and extensive operations were the subject for comment. The commanding officer of the HAMMERHEAD in August 1942 in commenting upon the tiredness of his crew at the end of the first patrol pointed out, "that in the last 130 days, this vessel has had 10 days in port in a non-operating status, 5 days of which were used as a loading period." Prior to leaving the States the vessel had undergone an extensive and strenuous training and outfitting period. "Since then we have made 230 dives, 120 torpedo approaches, and have fired 18 torpedoes plus 30 contact torpedoes. In the last 130 days the vessel has steamed over 21,000 miles." The commanding officer of the BLUEBACK at the end of that vessel's second patrol, April 1945, reported: "Personnel of this submarine have been on their toes and hitting the ball since she was commissioned on 28 August 1944--this period consisting of undiluted work and training over a 5 1/2 month period as well as a 61 day patrol. The termination of the second patrol 7 1/2 months since commissioning, is considered too long a period without adequate rehabilitation facilities

(the submarine refitted at Subic Bay) and is not recommended for future new submarines joining the force." The commanding officer of the SCULPIN, at the end of her sixth patrol, January 1943, reported the crew beginning to suffer from the cumulative strain of the past 13 months: "seventy-five per cent of the officers and 60 per cent of the men aboard have served continually since the beginning of hostilities. Another 15 per cent have served continuously on this and other submarines operating in the South Pacific. Of the 397 days involved, 276 (70 per cent) have been spent at sea on patrols, and an additional 24 days have been spent at sea in passage, making a total of 300 days, or 75 per cent of the time spent at sea"--in view of which the men were approaching near physical and nervous exhaustion. The remainder of the time had been spent in refit periods (averaging less than 18 days) during several of which the ship's crew did much of the work. The SEAWOLF (No. 7) with the same commanding officer aboard completed 7 patrols in one year without a yard overhaul.

At the conclusion of the SEALION's fourth patrol in January 1945 the commanding officer reported that "noticeable decrease in efficiency and the absence of the usual evidence of high spirits and enthusiasm had been observed in the last two weeks of the patrol." This was attributed, in part, to the fact that the officers and crew had been without rest since the last refit 99 days before, out of which time all hands had been ashore in Guam on one occasion for an average of about 4 hours per man. The FLYING FISH made 5 war patrols in 5 days short of one year.

PERSONNEL EFFICIENCY AND SUCCESSIVE PATROLS

The question of how long men might be expected to make consecutive submarine war patrols and continue to turn in a satisfactory performance was the subject of considerable interest through the war. This is a question to which there is no single answer.

EFFECT OF ONE TO FOUR SUCCESSIVE PATROLS

As we have seen, after the first impact of the war, all hands settled down rather quickly to the task ahead. At the end of the second patrol of the GUDGEON in April of 1942 it was reported: "the men who usually were bright and energetic on the last cruise were not so much this time." The commanding officer of the SILVERSIDES at the termination of the second patrol of that vessel in September of 1942 reported an absence of nervous tension in some men in whom it had been seen in the first patrol. The commanding officer of the GRAYLING (No. 4) reported that depth charging, silent running, and long hours of repair work noticeably accelerated fatigue and nervous tension and that for one-third of the officers and crew this was the fourth successive war patrol. During the fourth patrol of the HALIBUT in March of 1942: "Personnel were found to tire more easily on this patrol than on the 4 previous ones. This may have been caused by the higher temperatures encountered or the fact that many have completed their fourth patrol, or more probably by a combination of both these factors." The squadron commander in commenting upon the crew of the KINGFISH in November 1942 observed: "definite indication of operational fatigue among both officers and enlisted personnel--the greater majority of whom had completed 4 or more patrols on the ship." On the patrol, health had been somewhat below par, colds being prevalent. By way of contrast, the commanding officer of the SEARAVEN, at the end of the fifth patrol of that vessel in November 1942 reported that the nervous tension so noticeable in the first few months of the war was no longer seen. The commanding officer of the SPEARFISH (No. 5) at about the same time reported that "one or two of the 'old timers' were showing the strain of 11 months of operations and should be given a lay-off during the next patrol."

EFFECT OF FIVE SUCCESSIVE PATROLS

At the conclusion of the fifth patrol of the FINBACK in June of 1943 many of the crew completing their fifth war patrol were said to definitely show strain during anti-submarine measures. On her sixth "one of the most aggressive of patrols" it was further observed: "Noted that those people who were pretty well shaken up with depth charging received on the fifth patrol seemed to have recovered their confidence and cockiness--." "The system of relieving the ship's personnel during the last refit was the first real period of relaxation obtained during a refit since the war started." At the conclusion of the fifth patrol of the TAUTOG: "the old hands making all patrols definitely need a change." At the conclusion of the first patrol of the SUNFISH in January of 1943 it was reported that a few cases of nervousness during depth charging had been seen in some of the older men who had made previous patrols. At the end of her fourth patrol in September 1943, 29 men were aboard who had commissioned the ship and who have made 4 maximum length patrols. "Key men who have made 4 patrols are beginning to show signs of nervousness and are not as efficient as expected." Further comments along this line made at the end of her fifth patrol were to the effect that "five men who had made all patrols, naturally tired more easily than fresh men.

One case of nervousness in this group is due to the number of runs made without adequate rest." By the end of the fifth patrol of the POLLACK in February 1943, eight men had made 5 successive patrols although between the third and fourth patrols a 4 month Navy Yard overhaul had given them an extensive period for recuperation. On the fourth patrol of the FLYING FISH, terminated in February of 1943, there was considerable illness in the form of seasickness--"mostly affecting those officers and men who have made 3 or more patrols. Officers and men who had made all patrols complained repeatedly of inability to throw off their lethargy and they apparently needed an unusual amount of sleep and rest. No duller patrolling could possibly exist and there were few interruptions day to day."

EFFECT OF FIVE TO TEN SUCCESSIVE PATROLS

From December of 1943 to the conclusion of the fifth patrol of the SAWFISH, it was observed that "officers and men making their fourth and fifth consecutive patrols were beginning to show signs of weariness." The commanding officer of the PARCHE, in July of 1945 reported that several men aboard the ship who had made five and six continuous patrols showed evidence of fatigue. By way of contrast the commanding officer of the GRAYBACK, at the end of her sixth patrol in April of 1943 reported that "health was very good despite the fact that 50 per cent of the crew and officers were making their sixth consecutive war patrol, in addition to the long trip from New London, Conn., which began in December of 1941." The SEAHORSE departed on her sixth patrol with 8 men aboard who had made all of her patrols--these were "retained only because their physical condition warranted it, 11 others being transferred because they were badly in need of rest. Their performance of duty had been of the highest order but did not show the spirit and enthusiasm exhibited on previous patrols." At the conclusion of the seventh patrol of the TAMBOR, 15 men who had made 7 or 8 patrols were observed to show varying degrees of fatigue or staleness with some pallor, rapid soft pulse and low blood pressure. The HOE made her eighth patrol with 3 officers and 4 enlisted men aboard who had made all 8 patrols. The commanding officer of the PERMIT at the conclusion of that ship's ninth patrol in July of 1943 reported that "several of the crew serving aboard since the war began, having made 9 successive war patrols, are showing signs of needing prolonged rests." At the end of the tenth patrol of the GUDGEON in December of 1943 the "lessened strain of present day patrols as compared with those conducted early in the war render less urgent the need for transferring personnel for rest. Officers on this ship have served for 8 consecutive patrols and enlisted men for 10 patrols without apparent ill effects."

Regarding the effect of successive war patrols, the commanding officer of the ICEFISH (No. 4) observed: "Receipt of 'new blood' amongst officer personnel resulted in a general improvement in spirit and workmanship during this patrol, indicating that there is a limit of endurance, at least psychologically, and that shifting of personnel is conducive to a virile spirit. The executive officer has completed 12 patrols; several men had made 12 or more war patrols and are being recommended for extended rehabilitation duty."

The third patrol of the RASHER, although particularly outstanding, "was arduous and exhausting for all hands." "In a 6 or 7 day period there were only 6 occasions when as much as 6 hours lapsed between contacts. The OOD, radar and sound operators and members of the control parties were becoming mentally and physically exhausted. Two officers were unnerved to the point of being unreliable in their performance of duty and were setting a very bad example for the crew. This was the eighth patrol for one and the first for the other. Two enlisted men became obviously unreliable in performance of duty. Fortunately all hands began to become accustomed to the unnatural existence about this time and in a short time everyone with the exception of the two officers was again relaxed." On the sixth patrol of the FLYING FISH the numerous headaches complained of among the crew were found to be primarily among men who had a large number of patrols to their credit and a great deal of time aboard submarines. On the fourth patrol of the TINOSA, the commanding officer reported that several men making numerous patrols aboard other submarines prior to joining his command were showing signs of strain. Aboard the TREPANG, at the end of her second patrol in December of 1944, "due to the fact that the commanding officer and some of the officers and men are showing the strain of too many patrols they have made during this war, the commanding officer does not consider it advisable to return to Saipan for a reload unless conditions necessitated it." This same commanding officer observed at the end of HADDOCK's seventh patrol in November of 1943 (51 days duration): "Having made 4 short patrols on the HADDOCK and 4 long patrols on the SILVERSIDES it is the opinion of the commanding officer that short aggressive patrols, where considerable action is seen, take as much or more out of the officers and crew as do the long patrols."

PERSONNEL ENDURANCE ABOARD "S" CLASS SUBMARINES

The longest patrol made by an "S" class submarine lasted for 53 days (S-41, No. 8, Kurile Island area), although the average duration of patrols made by these submarines was about 27.8 days. They steamed an average of approximately 6,123 miles. The average time spent on station was about 16.5 days--the longest period of time spent in the area was 29 days.

As is to be expected and as indicated in Table 29, personnel endurance was reported in terms of "1 or 0" days more frequently in patrol reports from this type of vessel in 13 of the 85 patrol reports available for study. It will be observed that 10 of these patrols were carried out in the vicinity of the Aleutian or Kurile Islands; three were made in the tropics. We have already indicated elsewhere the limitations and status of living conditions aboard "S" boats.

In part, the patrol duration of "S" boats was governed by the amount of fuel and lube oil that could be carried, and fresh water consumption. It was particularly related to the amount of available stowage space for food. "Sufficient storage space was not provided for more than 30 days of balanced rations" (S-32, No. 3; S-42, No. 6; S-34, No. 2; S-28, No. 2); and "this type of submarine normally carried 31 days' provisions which should be regarded as the normal limit that will offer a well balanced diet (unless concentrated foods are carried) Although the patrol was terminated by operation orders, limitations of fuel, provisions and personnel would soon have done it. Personnel endurance is believed equal to that of fuel. Due to the monotony of the diet and crowded conditions morale deteriorated rapidly after the 30th day" (S-33, No. 2, 33 day Aleutian patrol). "The patrol was begun after 8 days at sea and 24 hours stay in Dutch Harbor; it is considered that the limit of effective endurance was reached after the 31st day" (S-34, No. 3, 37 day patrol). "At the end of 36 days--growing tension and restlessness was observed that probably would have soon resulted in marked decrease in personnel efficiency" (S-31, No. 3, Bering Sea patrol). "No estimate of personnel endurance can be given but the efficiency of the officers and crew had passed the peak and was definitely on the decline"--after the 34th day (S-18, No. 3). "In about 10 more days personnel fatigue would have caused us to return"--at the end of 20 days (S-35, No. 2, Aleutian patrol). "Noticeable falling off of mental acuity was apparent in the last 15 days" (S-28, No. 1, 40 day Aleutian patrol).

Personnel endurance aboard this class of submarine was greatly influenced by factors other than the natural limitations of the boats. "Very few enemy contacts are made by our submarines operating in Aleutian waters" (endorsement to the second patrol report of the S-28, August 1942). Lack of targets provided a noticeable deterioration in the morale of the crew of the S-18, No. 7: "So ends the last day on station of the most monotonous and disappointing patrol that I ever hope to experience--the third patrol of this vessel in the Southwest Pacific area; although on two previous patrols we had no sinkings to our credit, we had at least some form of excitement--this patrol we had nothing." "Morale was very high after the ship was promoted from anti-submarine training to legitimate submarine operations" (S-47, No. 7).

The influence of weather on the efficiency of personnel aboard "S" class of submarines must be considered too: "Patrols in the Aleutians being characterized by lost opportunities due to navigational difficulties and vagaries of climatic conditions" (endorsement to third patrol of the S-18). "The 'S' type of submarine is not very comfortable at the best, but in constantly rough seas and damp weather becomes very trying as far as morale is concerned" (S-31, No. 4). The S-18 at the end of her second patrol (Aleutians in February 1942) reported: "bridge personnel to have been constantly drenched by salt water spray, hail and snow storms. Ice collected on the boat up to 2 inches or more. Only a few times was the mess set up since the motion of the ship exacted far too high a toll of unattended china." And again on the S-28 (No. 4): "--during the night the bridge watch was pounded down to the deck by heavy seas on an average of once every 15 minutes. Decided to remain submerged to rest the crew." Weather was always present in the patrol area as a factor controlling operations. Wind and sea were practically always condition 5 or above (December to January 1943, Aleutian area). The S-23 (No. 2, summer of 1942) in the Akutan Pass, took 30 foot waves over the bridge at the rate of 5 every 30 seconds--the bridge being flooded solid 5 times in a minute. On her second patrol (late spring of 1942, in Aleutian area) the S-35 observed that visibility 90 per cent of the time did not exceed two miles, thick fog being encountered day and night.

Intensification of operating schedules for "S" class submarines from advanced bases made it necessary for the crews to do some of the refit work. This, in the absence of adequate facilities for recreation could not help, in some instances, but influence and affect the efficiency and morale of crews (S-32, No. 4).

WEATHER AND PERSONNEL ENDURANCE, ETC.

BENEFICIAL EFFECTS OF WEATHER

There undoubtedly exists a direct relationship between personnel endurance and favorable conditions of patrolling--as comfortable temperatures of the air and water, a favorable sea, the amount of surface running and adequate ventilation and air conditioning.

As we have seen elsewhere, revitalization of the air by surfacing at mid-day, even if for only a few minutes, is productive of improved living conditions and improves the general well being and morale of a submarine crew on extended submerged operations (DRUM 11, BARB 7). Again, as pointed out by numerous commanding officers, patrols carried out completely on the surface (provided there is not too much enemy aerial activity) while inherently decreasing the amount of sleep obtained, increase the general well being of the crew (FLASHER No. 2, FINBACK No. 4, SEAL No. 11, BARB No. 11, HARDER No. 3). It has been observed that short patrols with a great deal of surface running make for more normal living conditions (PINTADO No. 1) although the general strain on personnel may be increased over that experienced on longer and less active patrols (HADDOCK No. 7). Discomfort following prolonged surface operations may be experienced when submerged operations, over a period of time, again become necessary: "This was the first submerged patrol by the DRUM (No. 11) in a year. A few days passed before all hands had accepted the fact that the boat would not be as cool as when cruising on the surface."

The beneficial effects of sunlight and fresh air are especially apparent if the crew can be occasionally rotated through the sun lookout watch. Marked recuperation from strain and minor evidences of fatigue and ill health were often reported when, after leaving the area, the crew could be allowed to rest and appear topside on the tranquil journey home from the area (REDFISH No. 1, TILEFISH No. 6, BECUNA No. 1, GRENADIER No. 2, HAMMERHEAD No. 1, GURNARD No. 5, NAUTILUS No. 1). Medical officers should be aware and appreciative of the amount of recuperation that may take place in a crew during this period. The commanding officer of the GAR observed in this respect at the end of that ship's second patrol: "The factor of 5 days endurance remaining to personnel is based on observations made at the time of leaving the area of concentrated activities. It is realized, of course, that the rest obtained enroute to the base, plus the lower temperatures encountered, tends to create a false impression upon arrival at the base."

On the sixth patrol of the TILEFISH (2 August to 3 September 1945) "When weather permitted, idlers were allowed on deck for exercise, sun and salt-water bathing in the superstructure from the end of work hours at 1400 to sunset daily. This did marvels for the morale of the crew." On the fourth patrol of the BAYA swimming call was once held, whole on patrol, with PBY's acting as an anti-submarine patrol." Excessive amount of surface patrolling, on an unusually long patrol (68 days) resulted on the DARTER's second patrol in considerable fatigue and eye strain among the officers and lookouts. The commanding officer of the PERMIT (No. 1) reported noticeable reduction in the efficiency of the officers and crew, which was associated with excessive perspiration and lack of sunshine. Gradual but noticeable reduction in night vision on the part of the officers and lookouts was also reported on this patrol.

When fatigue is excessive among the crew, but little evidence of recuperation may be seen during the quiet return passageway (GREENLING No. 3, HOE No. 2, STURGEON No. 11, SEA DOG No. 2, FLYING FISH No. 1, GRAYBACK No. 1, PUFFER No. 2, and THRESHER No. 2 and 3), especially if two long patrols are made, separated by only a brief refit or refueling interval at an advanced base, or if excessive amounts of action are experienced in the last week on station (THRESHER No. 3).

UNTOWARD EFFECTS OF WEATHER ON PERSONNEL ENDURANCE AND PERFORMANCE

Special reference has been made elsewhere in connection with encountered weather conditions and submarine clothing requirements.

Description of Encountered Weather

On cold weather operations, snow, sleet and drift ice were often routine (SAND LANCE 1). On the PIPER's first patrol mountainous seas were encountered, the bridge was swamped by pooping seas with solid water to the lookout platform--almost drowning two officers. The SWORDFISH on her tenth patrol encountered 4 successive storms of cyclonic proportions. On one occasion, footing could not be maintained on the bridge. The topside watches sometimes became too cold to hold on and their footing was made dangerous by ice (APOGON 6). In heavy seas men topside were not uncommonly thrown about the bridge against the periscope shears, gyrocompass repeater, etc., often times sustaining painful injuries. A number of men aboard submarines were lost when washed over the sides. Sometimes in severe storms it was

necessary to lash the lookouts to their platforms as aboard the NAUTILUS (No. 5) when in a hurricane, lookouts were lashed to radio mast with airplane safety belts; aboard the TARPON, on her first patrol, a typhoon was encountered during which it was necessary to lash the OOD to the bridge.

Sometimes fog and rain with accompanying poor visibility made navigation and searching difficult, thereby decreasing the offensive power of the submarine (ANGLER 7). "In the rough and rolling seas, submerged patrols were ineffective; submerged attacks were considered hazardous when it was necessary to run at 2/3 and standard speeds to hold periscope depth. On the surface, maneuverability was limited, in that the course and speed had to be picked to fit the sea condition" (KINGFISH No. 10). Boats were often times delayed in reaching their areas because of encountered storms. Attempts to man battle stations for gun action in such weather were hazardous. On the second patrol of the ATULE, under such circumstances, the deck was covered with ice. "Men had trouble toting shells from the ready locker with wind of 25 to 30 knots, snow flurries and spray icing all over the topside." Emergency topside repairs must have been difficult and hazardous when on the patrol "it was necessary to surface in heavy snow squall to commence repairs on the No. 4 main engine" (ATULE No. 1). Men become thoroughly chilled under such conditions of weather (SEACAT No. 2). On the first patrol of the SPIKEFISH such foul weather was encountered (average daily temperature 20 degrees F.) that fully 50 per cent of the 30 days spent on station were unsuitable for operations at periscope depth. But men and submarines did fight in such weather. The SAILFISH on her tenth patrol in a typhoon sank a carrier in mountainous seas, high wind, and driving rain.

Effect of Heavy Weather on Personnel Efficiency

Heavy weather, as described above, especially on the low, cut-down type of bridge markedly affects the efficiency of the lookouts and bridge watches (ARCHER FISH 1, PICUDA 5, POLLACK 5)--"when they are exposed to the cold biting wind and bone chilling spray" (KINGFISH 10) with "the rain heavy and relentless, striking the men with almost bullet-like force" (WHALE No. 5 in typhoon weather). "Under such conditions it may be necessary to bring lookouts down from their usual station in the A-Frame (THRESHER No. 14), reducing their watch to a period of time compatible with promoting efficiency, vigilance, comfort, and conserving stamina." The commanding officer of the KINGFISH, in this respect, reported that decreased efficiency of lookouts--"was more apparent at the first of the patrol as all hands' physical condition was tuned up to the balmy weather of Guam."

"The question as to how do men fare who have to keep watch while exposed to intense cold--largely deals with mental and physical efficiency--." "On the bridge or weather-deck or in the control top of a ship in the Arctic a watch-keeper may remain immobilized up to 4 hours, unable to keep warm by exercise. During this time he is required to keep alert at some responsible, if not vital, task, the temperature being well below zero. Impeded by many layers of clothing, he faces a wind of high velocity with driving sleet or snow. Gradually the bulky clothing proves tiring and burdensome. The high wind makes hearing difficult and handicaps intercommunication. Lacrimation and smarting of the eyes impairs visual acuity. The pain of the intense cold produces a general sensation of distress which, as it continues, more and more dominates consciousness. In this way attention becomes distracted, the victim becomes slow and inaccurate in perception and performance. A mood of depression may supervene, though irritability is the commonest effect. Finger movement becomes clumsy, either through numbness from cold or because of the cumbersome Arctic handwear. Lastly, somnolence is common and may become overwhelming when the rating comes off watch and goes below. The northern twilight and the mist may combine with fatigue to produce visual illusions so that the lookout may mistake a breaking top for a bow wave or the wake of a periscope" (From Military Surgeon, Vol. 98, March 1946, No. 3, Problems of Naval Warfare Under Climatic Extremes, by Macdonald Critchley, M.D., FRCP, pp. 221-233).

It is thought that such condition may account for the following experience described on the eighth patrol of the BARB (21 May to 9 July 1944, 50 day patrol, 33 days on station, Kurile Island area). On 7 June: "dodging through ice drift--in a wonderland of 50-60 foot columns and pinnacles with seals basking on smaller chunks. Injection temperature 34 degrees F. Visibility 700-5,000 yards. Several arctic mirages. A 20-30 foot solid pack of ice was sighted at 5 to 6 thousand yards with a kaleidoscope of light being reflected off its sides. Maneuvered ship to parallel. After passing along its side for 20 minutes all hands on the bridge sighted the masts and funnels of 4 trawlers apparently icebound. Lookout reported smoke from one forward. Decided to close for gun shot. Upon closing, ice field backed away and trawlers disappeared. An unbelievable mirage. OOD said he must have been on patrol too long and requested a relief. New OOD arrived thinking we were a bit touched. A short while later he reported an ice field on the opposite bow. The Captain, now feeling like a grizzled Arctic veteran, who knew all about mirages, took a good look through his binoculars and ascertained it to be another mirage and so told the OOD who immediately wagered a quart of whiskey. Considering the present scarcity and to teach the OOD a lesson the bet was made

and we approached mirage confidently only to find that it was the real McCoy. Captain retired to the wardroom. A few minutes later a messenger reported 'twelve o'clock and all chronometers are round.' At this time the Captain decided to turn in and take stock of himself."

On tropical patrols, the bridge watch and lookouts may suffer from prolonged exposure to excessive heat and glare. Special protective helmets and caps with visors were sometimes worn for protection against glare and eye strain. In this respect, an experience recorded by the commanding officer of the SUNFISH, after returning from that ship's first patrol (52 days duration, 28 days on station) is of interest: "In retrospect, considerable difficulty was experienced in identifying ships and landmarks, blurry visions sighted through the periscope, islands seen at great distances, low land close by obscured, piloting difficulties, ships with mast, bridge and stacks and no hull, erratic ranges--I realize that I was the victim of one of the pranks of nature; an inferior mirage. The only method of defeating this pheonmena, when it is realized that such a condition prevails, is to try to sight the target in sufficient time to get ahead of them, then to wait or close until the large vision disappears and the smaller actual target comes into sight." In the patrol report the first mention of this phenomena appears on 10 December: "Began to sight what appeared to be stacks and smoke of many freighters along the shore north of Dai Saki. Upon closer investigation determined that these were tall trees with bare trunks, topped by foliage or branches, giving the appearance of stacks topped with smoke. A peculiar phenomenon was observed here. Waves similar to the heat waves seen on a paved road in a hot summer day were plainly visible along the surface of the water. This phenomenon enabled one to see trees as tall poles, apparently hundreds of feet in height when 6 or 8 miles from land--a mirage." On 12 December target's "deck line almost completely obscured by surface heat waves previously mentioned."

Effect of Foul Weather on Below-Deck Personnel

Continuous adverse weather took its toll in yet other ways. As the commanding officer of the APOGON (No. 6) reported: "--a succession of storms. Still pointing into heavy seas. If this keeps up we will be worn out and several days late in reaching the area. Several good ones have come down the hatch but fortunately have damaged no electrical equipment, all of which possible is covered with canvas. The control room and the conning tower have the appearance of a circus side-show. Rain squalls, hail and just nasty weather--. My kingdom for a mill pond. Gave up the ghost and submerged. Crew appreciated the comparative quietness and immediately asked for a movie. That we can do and will." "Topside watch continues to take a beating--submerged. Might lost somebody overboard."

On the first patrol of the BATFISH, a typhoon was encountered on the fifth consecutive day of which it was reported: "Crew holding up well but I'm afraid they will all be worn out by the time we reach our area. If it hasn't abated tomorrow will be forced to dive to routine torpedoes, water batteries, and rest the crew, particularly the lookouts." "One 55 degree roll cost us 7 blueberry pies and half of our victrola records--but I suspect a little salvage, as we had 'blueberry shortcake' the next meal. Our favorite records left are becoming monotonous." "Heavy weather did much to reduce the comforts within the boat" (DACE No. 6). "It was a case of hanging on 75 per cent of the time." "--sometimes we were tired from just holding on as the boat rolled heavily in the rough seas" (PLUNGER 10). When submerged in such mountainous seas to depth of 145 to 200 feet, the ship might roll 10 to 18 degrees (BARB 7, RAY 6, TRUTTA 1). On the first patrol of the DRAGONET the forward torpedo room was flooded and had to be abandoned. Her crew succeeded in bringing her through a typhoon--on one occasion the ship rolled 63 degrees to port, eventually settling down to a 20 degree port list.

"Foul weather was hard on personnel; OOD watches cut down to 2 hours--as it would have been impossible to endure more with any degree of vigilance." "All hands expressed indignation at being bodily thrown from bunks to bulkhead--. Surfacing at night with the seas and the reversal of course to head back toward the beach was a problem in seamanship. When ready to attempt it, we would pass the word below 'ready about' which would be a signal for all hands to get hold of something secure with one hand and hang on to something which might start coasting with the other. On one occasion rolled 56 degrees by the inclinometer" (POLLACK No. 5).

These continuous rough seas couldn't help but interfere with the rest of all hands. The GUARDFISH on one occasion reported: "Through a 10 day period of bad weather the outboard ventilation had to be secured." "It was a very depressing period mentally and physically. The men had not been on deck for 27 days, the officers and crew were half sick and worn out from the beating taken each night. Submerged for all day dives to rest and freshen the crew who were worn out from the fight against the weather--rough weather caused as much worry as did the enemy." On the tenth patrol of the TRIGGER, on one occasion, "secured fighting the war--commenced fighting the weather in earnest, seasickness affecting one-third of the crew and officers." "This cruise seemed to be more strenuous and tiring on the men--this may have been due, in part, to the long stretches of bad weather" (GUDGEON No. 2).

"Strain of 47 days in area with consistently bad weather, only 6 of which were spent submerged began to tell on all hands by the time we had departed for home" (CAVALLA No. 3). "Constant rough weather and harrassment by the enemy and radar equipped night planes produced noticeable fatigue in many of the officers and men" (CROAKER No. 3). "A 50 knot wind, blowing the spray from 20 to 40 feet seas, reduced visibility to 100 yards. Water poured over the bridge and down the hatch--all hands on the bridge were drenched for hours. A few colds were noted especially in the bridge personnel." As noted elsewhere, clothing on these patrols became damp and unpleasant; it was difficult to dry foul weather clothing; the boats were damp and cold from excessive condensate--factors which undoubtedly contributed to the increased incidence of acute respiratory disease reported on such patrols. BATFISH No. 1 in a typhoon 5 consecutive days; "one 55 degree roll caused a mess; since then we have cleaned up the ship and morale has improved."

PERSONNEL ENDURANCE AND AREA OF OPERATIONS

ATLANTIC AREA OF OPERATIONS

From the patrol reports on hand there is but little information concerning personnel endurance and performance during submarine operations in the Atlantic. The comments made by the commanding officer of the HERRING (No. 2) on the return of that ship from a prolonged submerged reconnaissance patrol have been referred to above. The first 5 patrols of the BARB were carried out in the Atlantic, comments concerning personnel performance and endurance being made as follows: "The feeling of futility engendered by numerous contacts which failed to develop into attacks was hard to overcome; the tendency was to become lax and the effect on morale was noticeable" (No. 3, 38 day patrol, 28 days on station). The fourth patrol, of 44 days duration (April to May 1943) was made off the coast of Norway where air temperatures varied from 18-28 degrees F. "Dives of 20 hours duration with short periods of surfacing to obtain a noon sun were--not unduly hard on personnel." They were made only for 9 days--had they been carried out over a longer period of time they "undoubtedly would have done so." Higher authority in commenting upon this patrol stated that a "routine--to keep efficiency at its highest" on similar patrols in high latitudes with long daylight hours should be carried out, diving as much as possible. The sixth patrol of this ship, of 60 days duration, was carried out in the China Sea at the conclusion of which the commanding officer observed: "It is quite apparent that patrols in this area are much less of a physical strain than are those made in the European theater."

TROPICAL VERSUS NORTHERN OPERATION AREAS

There can be no doubt that excess heat and humidity on tropical patrols with no or inadequate air conditioning and ventilation quickly and dangerously impair personnel endurance and efficiency. Ample illustration of the value, from a military sense, of air conditioning is only too apparent in several patrol reports, as PUFFER No. 1, PLUNGER No. 5, GUNNEL No. 6, PORPOISE No. 2, and S-42, No. 1.

The commanding officer of the PLUNGER (No. 4) was of the opinion that "30 days of submerged operations should be the maximum in tropical waters if full battle efficiency is to be maintained"--due to fatigue of personnel after 40 days of submerged operations on station.

The commanding officer of the TAUTOG, after her ninth patrol, observed: "All previous war patrols of the TAUTOG have been made in tropical waters. A tremendous difference was experienced on this patrol (49 days duration) with air temperatures about 40 degrees F. at night. Air conditioning was no problem. While submerged, personnel felt refreshed after sleeping. Water consumption was greatly reduced making still operation easier. A cold weather patrol is much less fatiguing than a warm climate run." At the end of the next patrol made in the Kurile Island area, impaired habitability due to excessive dampness and rough weather was encountered and it was observed: "Health, in general was good. A long patrol in Kurile Island weather at this time of the year would no doubt be difficult from a health standpoint." The commanding officer of the S-41 (No. 6) following an Aleutian patrol observed: "The limitations of 'S' class submarines are well known--however, the lasting fatigue common in the tropics was not apparent." Elsewhere, impaired features of habitability as reported by other fleet-type and "S" type submarines making Arctic patrols have been pointed out. As will be discussed in another section, cold weather operations are undoubtedly associated with a greater incidence of acute upper respiratory infections.

PERSONNEL ENDURANCE AND AMOUNT OF ACTIVITY ENCOUNTERED IN THE OPERATIONS AREA

EFFECT OF LACK OF OR LOST OPPORTUNITIES ON PERSONNEL ENDURANCE AND MORALE

Personnel endurance and morale are closely related; they often times become one and the same. This especially applies to the effect upon personnel of lack (or failure) of opportunity for aggressive action against the enemy.

In the early days of the war unreliable and unpredictable torpedo performance was the cause for much disappointment and bitterness upon the part of submarine crews returning from the war zones. "Unreliable torpedo performance can be most discouraging to the commanding officer, his control party and torpedo personnel--the entire approach party being desperate--" (TUNNY No. 1).

The commanding officer of the SILVERSIDES, at the end of that ship's fourth patrol in January of 1943 observed in this respect: "During the first 3 weeks of inactivity around Truk the monotony began to tell on people's nerves. But the success of the latter part of the patrol was like a tonic. It was remarkable to see the difference. As Mike Fenno said 'the best music in the world is the sound of your own torpedo explosions--when they are not prematures stuck in the tube'." The commanding officer of the NAUTILUS (No. 1) observed: "The sinking of a ship increases morale and thereby increases endurance."

On the ninth patrol of the STINGRAY: "As noted before, there tends to be a general decline in efficiency and general tension during the latter part of--a patrol in which no contacts are made." The commanding officer of the SUNFISH estimated remaining personnel endurance of his crew at the end of that submarine's third patrol to be "five days with no contacts, 20 days with contacts--." On the return trip of the THRESHER (second patrol) "everyone was generally well tired out and there were a few cases of very short tempers and nerves." Difficulty was acknowledged in judging the degree of loss of mental alertness and general tiredness. In part, it was felt that "the low ratio of very active days to routine fruitless patrolling may somewhat explain the general condition of the crew." The commanding officer of the TRIGGER (No. 3) reported: "--this reduced efficiency, however, depends entirely on the amount of activity" encountered. "A patrol in good weather with targets to shoot at at least once a week with success in attacks and without expected depth charges can be far longer than one in which any one of these features is missing."

Mention has been made earlier of the disinterest shown by submarine crews in reconnaissance. In this respect, HERRING (No. 2) observed: "the nature of this type of patrol is hardly contributive to the high state of interest necessary to maintain high morale." The commanding officer of the BLUEFISH (No. 5) reported that though morale was good, "it may be said that the crew was very little impressed with the importance of reconnaissance work." The commanding officer of the STINGRAY (No. 9) reported: "Morale was definitely at a low ebb. This is the second patrol in the last three spent in the Truk area in which there was no target sighted or opportunity to fire. Needless to say--this is the hardest and most exacting kind--" of a patrol and there "is a definite lowering of confidence in the ship and in myself, clearly demonstrated in the pessimistic attitude taken by most members of the crew when there is hope of making contact." Higher authority observed in respect to this statement: "STINGRAY was employed primarily to detect the movement of enemy units--such employment reduces attack opportunities--but demands the highest qualities of leadership on the part of the commanding officer and alert patience on the part of all hands--that opportunity for positive action may be amply handled when it arrives. The lack of contacts under such conditions is not a valid excuse for lowering of morale. --the services of the submarine being valuable in that she was filling a place in the submarine line."

It is interesting to note on reconnaissance activities that the opposite effect may sometimes be expected, namely: "The first week of reconnaissance patrolling was more exhaustive than the remainder of the patrol put together. It seemed that we were in continuous contact with the enemy, and practically, we were, as there were only 6 periods during the week when as much as 6 hours elapsed between contacts."

The commanding officer of the POMPANO upon that vessel's fifth patrol wrote: "There was a noticeable increasing tension among officers and men as time on station increased until the last week when we operated further off shore. This is believed due to lack of sinkings, a naturally trying area as to planes, patrols, fishing vessels, restricted waters, and capricious currents and our allergy to this area since our last patrol here."

On patrols characterized by lack of worthwhile contacts, disappointment and lost opportunities, poor topside performance was sometimes observed. On the third patrol of the STINGRAY it was reported that "many sailboats, some lighted, some dark, caused numerous false alarms and a constant effort was required to keep the lookouts from adopting an attitude that anything sighted was not 'just another fishing boat'." And the SPEARFISH returning from her fifth patrol reported: "During the latter part of the cruise the lookouts tended to become a

little stale since nothing had been sighted for 2 weeks." "Shifts in the patrol are, from the standpoint of morale, excellent. At least there is hope always before one that the next area will be more productive" (ICEFISH No. 4).

EFFECT OF SUSTAINED CONTACT WITH THE ENEMY ON PERSONNEL ENDURANCE

Some aspects of this topic were discussed in the beginning of this section. The effect of close and prolonged enemy contact upon submarine personnel in the opening and early days of war was described, particularly as reported on the first patrol of the PICKEREL, third patrol of the SCULPIN, and second patrol of the SEAL.

Note has been made of the arduous features of the second patrol of the NAUTILUS (overcrowding, inefficient air conditioning) on which "the majority of the crew were without sleep for some 70 hours and the gun crews seemed always ready in the hatch without sounding general quarters." On the first patrol of the PINTADO the "radar tracking party spent a strenuous week of almost continuous tracking at their stations for 20 hours a day. Most of the action was crowded into the space of one week. Torpedo and fire control performance was exceptional, turning in a remarkable performance--in 3 attacks 16 hits were obtained out of 16 torpedoes fired." "Only a mentally and a physically fit crew could have had the endurance to continue the series of engagements over this period with the little rest permitted." On this patrol, a total of 190 depth charges were received, truly a "baptism of fire" when, on one occasion, 48 were dropped in a 30 minute period. On the RASHER's fourth, a very successful patrol, "hardly a day was spent in the area without contact." The QUEENFISH on her second and first patrols sank 10 ships. SAWFISH, on her third patrol in one week made 6 attacks, all except one of which were made at night--as a result of which "all hands were pretty well tired out at the end of 9 days in the area." On the seventh patrol of the SAILFISH, over a 10 hour period, 61 depth charges were received--. "About 10 hours of this makes for a long day and all hands are a little fagged out with a few showing some signs of nervous strain."

The result of such prolonged and strenuous activity upon personnel endurance is readily seen from the following excerpts. On the fifth patrol of the HARDER, in one week a special mission was completed, 6 separate attacks against enemy ships were made, (sinking 5 destroyers) close inshore reconnaissance of an enemy fleet base was carried out; two days and two nights of bombing by enemy aircraft and 3 depth charge attacks, one of considerable violence, were experienced. "The patrol was begun with 20 new men and 2 new officers who responded well to constant training but personnel casualties were high. The 5 or 6 days of intensive combat was a fast pace for the inexperienced men and veterans of other patrols. Lack of sleep and rest contributed to worn nerves and jumpiness--fatigue of all hands approached a dangerous stage several times but the aggressiveness and desire to close with the enemy never varied."

At the conclusion of the third patrol of the SEAHORSE, it was reported: "On this patrol at the end of three and a half days of chase everyone was exhausted. The first two attacks were poorly executed, the third was more successful due to the fact that everyone jacked himself up for the last chance at them and that had to be successful. In the past two patrols have used every effort to keep the officers mentally and physically rested in order to be more efficient. It is our experience that tired officers make mistakes and do not have the proper amount of aggressiveness. One bright-eyed watch stander is superior to two tired OOD's regardless of the amount of experience."

The commanding officer of the PILOTFISH in reporting upon the first patrol made by that submarine stated: "We were fully cognizant of the hardships of continuous tracking for long periods, even before the patrol, but were slow in realizing when to shift to the 'second string'--with the result that the fire control party was nearly exhausted before we had a satisfactory system of watch established." SWORDFISH at the end of her second patrol reported the "long periods of being pursued showed in efficiency by jumpy and nervous men and officers during the next 3 or 4 days." The commanding officer of the SEAL (No. 2) observed that the "strain and disturbance of rest due to frequent enemy contacts--showed some effects upon the crew in general but lulls occurred which forestalled any material reduction in efficiency--successful action being the best tonic."

On occasion, however, it was necessary to take measures to rest personnel. On the SNAPPER's seventh patrol a destroyer was sunk with a "down the throat" shot. "Next day an approach was made on the same convoy but--the ship--was forced down with depth charges. SNAPPER abandoned pursuit due to failure of the bow planes and very definite fatigue of personnel who had been under considerable tension for 30 hours and unusual weather conditions (rain squalls giving false radar contacts)." On the first patrol of the HAWKBILL, "all hands, having been at their battle stations without rest or sleep for 18 hours, decided to spend the remainder of the afternoon submerged--the crew literally lay down in their tracks and went to sleep."

Contact was lost on the fifth patrol of the TINOSA, and it was "decided to wait till morning for another attack; crew at battle stations for 9 hours without any evening meal; we all need a rest and some food." The CERO on her first patrol after a 13 hour session at battle stations, "decided to relieve, feed and rest the crew--before going in to attack the transport." And the PERMIT, on her eleventh patrol, on one occasion "decided to spend the day submerged as all hands are exhausted after the very busy last few days and reactions are noticeably inferior." "Dove on one occasion," it was reported on the eighth patrol of the SHAD: "All hands turned in to rest from fatigue unmitigated by the sweetness of SHAD's success." On the eighth patrol of the GUARDFISH after 6 hours at battle stations, "everyone in the control room was beginning to show fatigue and the commanding officer had had no rest for over 50 hours. Under these conditions it was considered best to let him go." On the eighth patrol of the POLLACK "one attack was too long delayed--by the time the situation had begun to clarify itself--all hands were so exhausted that a second night offered little prospects of success." Similar episodes of excessive personnel fatigue are to be found in the following patrol reports: SKATE 3, SPEARFISH 3, TAUTOG 2, TREPANG 2, WAHOO 3.

As observed above, following the second patrol of the GREENLING, commanding officers were authorized to withdraw from station for a short rest on occasion to restore alertness of personnel. The commanding officer of the NAUTILUS (No. 1) considered it well, following close depth charging, to proceed to a quiet section of the area for a day or so to recuperate personnel. On the second patrol of the SAND LANCE, after a 4 day period of severe depth charging and bombing, it was observed: "If we are attacked again in the next 2 or 3 days we shall have to pull clear and give all hands a couple of days to settle their nerves." On the fourth patrol of the SHARK, after a 7 day full speed chase, "headed out to the northwest,--all hands exhausted and welcoming a period of inactivity." At the conclusion of the third patrol of the WAHOO, "an epic in submarine warfare--the crew had been under considerable strain for about 3 days and their resistance had been definitely lowered with health reported as 'fair'." By way of contrast on the fifth patrol "in 10 action packed days delivered 10 torpedo attacks in 8 different targets," with health of crew reported as "excellent."

SPECIAL STRAINS OF SUBMARINE WARFARE AND EFFECT ON PERSONNEL ENDURANCE AND PERFORMANCE

In this and other sections the more general aspects of life aboard submarines contributing to strain of personnel endurance have been discussed--the inherent features of the boat itself, the adequacy of provisions for rest and recuperation, the effects of weather, the length of the patrol, time spent in the area, submerged and surfaced, the area of operations (European, Pacific, Northern, Tropical) the operational strain of successive patrols, the lack of targets, lost opportunities, or conversely, the strain of sustained or prolonged contact with the enemy. There were yet other elements of submarine warfare whose effects were often and keenly felt by personnel and which can be mentioned only briefly in passing.

ERRATIC TORPEDO PERFORMANCE

Faulty and erratic torpedo performance was cause for much disappointment in the early days of the war. "Confidence in torpedo performance and explosions is a wonderful thing--a decided contrast to the old days of praying, crossing the fingers and just plain hoping" (SPEARFISH No. 10). "Close premature explosion--10 seconds after firing. The shock to the ship was great. --thought we had been hit. Two torpedo explosions followed--not observed from the bridge, mainly because all hands were suffering from the shock of the prematures" (HOE No. 4). The FLOUNDER, on her fifth patrol, had a harrowing experience with an erratic torpedo when--"suddenly one passed close under our stern and passed up our starboard side not 10, repeat 10 feet away. A few minutes later another torpedo broached on our port beam at a distance of 50 yards--a terrifying experience and one which no member of the FLOUNDER's crew from the commanding officer on down ever wants to repeat." On the tenth patrol of the PERMIT it was recorded: "Our first torpedo had just exploded and the ship was passing 80 feet when a Nip torpedo was heard through the hull coming up the port quarter and passing directly over the conning tower. There were some funny looks on the faces of people in the conning tower they tell me." On the eighth patrol of the POLLACK probably one of her own torpedoes ran erratic and exploded beneath her--with a "tremendous explosion which shook the POLLACK and literally lifted her out of the water. A great flow of light seen in the water all around the hull. Men were knocked off their feet in the after part of the ship." "Hot runs" in the torpedo tubes, with sometimes the torpedo half ejected from the submarine, sometimes occurred. As noted elsewhere, hydrogen and battery explosions in the torpedoes were not uncommon.

ENEMY TORPEDOES, MINES, RAMMING, ETC.

Enemy torpedoes were often the cause of considerable strain and stress--as on the QUILLBACK--"on three occasions the torpedo detecting device gave indication of torpedoes having been fired at the ship. A grim reminder that submarines performing lifeguard duty must ever be alert to avoid possible submarine attack." "Numerous patrol craft encountered from day to day in closing the coast, plus two torpedo wakes sighted at night kept everyone on their toes" (PAMPANITO No. 2). Enemy mines were frequently encountered and having been sighted and exploded made lookouts unusually observant (TREPANG No. 1). "A floating mine bounced disconcertingly off the port side of the ship--and was plainly heard by the bridge watch and the officers in the wardroom--with a jar that turned out a good percentage of the complement. It hit once near the stern and then bounced several times down the side, busily exploring limber holes with its horns" (ATULE No. 2). On the fourth patrol of the THRESHER in a depth charge attack and ensuing search--"a loud metallic banging and clanking was heard, apparently caused by a heavy grapnel striking the starboard side of the hull and moving slowly aft--causing some raised eyebrows, the commanding officer's being as high as any." On the fifth patrol of the SEAL: "A loud crash and bang was heard over the conning tower followed by a rumbling and scraping noise of a few seconds duration--the periscope went black and vibrated severely--at daylight a small quantity of uncooked rice and beans, unlike any found aboard, were discovered between the wooden deck of the cigarette deck and on the bridge--as well as a good supply of Jap bottom paint on the periscope."

EXPLODING ENEMY SHIPS

On occasion considerable strain followed the actual sinking of an enemy vessel. On the fifth patrol of the TUNNY, a tracked target was verified to be "a large I-class submarine"--on which "two hits were scored--and felt before could get the hatch closed. The flash was seen inside the conning tower--there was some doubt for a moment who had hit who. Went to 150 feet and circled area of attack. Her screws stopped immediately, followed by terrific crackling noises as if large volumes of air were escaping." "The most nerve wracking attack of the TUNNY's. Spent the day submerged to let the crew pull themselves back together. The reaction was worse than that following any depth charge. Passed out the grog and I took a double shot."

"After the torpedoes started hitting and the ships breaking up, the noise and shock below were equivalent or worse than the depth charge that followed" (LAPON No. 5). "One target, when hit, was so close that the sound man reported he could hear the water rushing into her hull." "In the breaking up of the enemy ship, various compartments reported pieces of metal striking the hull" (PADDLE No. 3). "The breaking up noises were terrific, increasing in both quantity and intensity all about us. Our course changes have put us practically under a sinking ship. The noise was strongest on the starboard quarter and from the conning tower seemed to be just outside and on the deck. The loudest we've ever heard. Fully expected the ship was breaking up right on the deck but the main deck clear of all shipping when we surfaced. Guess this running under a sinking ship works as far as shaking the escort goes. Frightening though" (BLUEGILL No. 3).

"The shock of the explosion of one sinking ship was so great that the submarine was knocked down 50 feet in depth; blue flame showed around the periscope and the after engine room hatch." "On way to periscope depth when loud ship explosions--almost overhead--our AP coming down to join us. The ship was obviously breaking up almost overhead and pieces of metal were dropping down hitting the hull forward and aft--. Ship above sunk at an estimated distance of not more than 1,000 yards from us and rocked us gently as it went down. All the breaking up noises audible through the hull produced much discomfort and worry to all hands" (GUITARRO No. 3). "Four torpedo hits with a tremendous explosion--with a tinkle of glass from shattered light bulbs in the conning tower--ship forced sideways and down. Personnel grabbed the nearest support to keep from being thrown off their feet. Cases of canned goods burst open in the torpedo room. Section of deck grating was ripped out of the superstructure." And again, "Three hits timed and observed followed by a stupendous earth shaking eruption. This far surpassed Hollywood and was one of the biggest explosions of the war. The rarefaction following the first pressure wave was breath taking. A high vacuum resulted in the boat. Personnel in the control room said that they felt as if they were being sucked up the hatch--those in the control room wearing shortened shirts not tucked in at the belt felt their shirts pulled up over their heads. On the bridge, air was wrenched from my lungs. Shrapnel flew around us. Those topside alternately ducked and gawked. The horizon was lighted as bright as day."

EXCESSIVE DEPTHS

On occasion, too, submarines were forced to excessive depths. The HADDOCK on her fourth patrol in a severe depth charge attack was forced down: "At 415 feet we heard cracking, crunching sounds in the conning tower and saw the chart desk break loose from the bulkhead. Cork bulged in and broke up as part of the starboard side came in about 4 inches. Ordered the conning tower abandoned. Experienced some tense moments when we could not close the lower hatch. All hands commenced breathing again when a few blows with a sledge hammer freed the latch and the hatch was closed."

ENEMY AERIAL ACTIVITY, ETC.

Many patrols were characterized by intensive enemy air coverage and but few surface contacts. In four patrols the FLYING FISH (No. 11) logged 235 aircraft contacts; the BARB on her ninth patrol logged 73 plane contacts. The HARDER's fourth patrol made 57 air contacts; sighted 112 planes, was forced to dive 33 times to avoid detection--but only bombed once. Bombing by "friendly" planes was not uncommon. For men worn out with activity on station, numerous aircraft contacts made enroute to the base did anything but relieve nervous tension (FLYING FISH No. 2). The second patrol of the DEVILFISH was terminated when she was hit by a Japanese suicide plane.

Intensive night aerial activity and radar-equipped enemy planes placed considerable strain on personnel, as on the eleventh patrol of the HADDOCK when at one time, the submarine was making two dives a night. One night she was forced to dive 5 times. The commanding officer of the CROAKER at the end of her third patrol reported: "continual rough weather and harassment by enemy radar-equipped night planes produced noticeable fatigue in many of the officers and men." "Most disconcerting anti-submarine measures during periods of bright moonlight are intensive night-flying operation of Japanese aviators." "Numerous plane contacts pursued us until relieved by two PBM's and 8 fighters--greatly relieved--we were pretty tired and must admit the arrival of the planes was a great lift to morale. The crew brightened up and began their usual wisecracks" (TRUTTA No. 1).

The commanding officer of the SAILFISH (No. 2) observed: "personnel showing strain from being down 4 nights running." "Much night aerial activity necessitated frequent night dives. The attendant nervous tension coupled with prevalent rough seas interfered materially with the sound sleep of the crew at night. A surprise night bombing on the fifth night in area was a distinct shock to the crew" (BLENNY No. 1).

Detection of enemy radar activity--"was far more nerve wracking than depth charges" (TILEFISH No. 1). "Picked up first enemy radar on the APA-ARR equipment. Incurious as it now seems, it soon became a nerve wracking menace. The operator's frantic shout of 'He has been trained on us for 10 minutes' caused many of the crew to spend their off watch time looking at the cathode ray indicator with an awesome respect that should have been saved for the death ray." "Trained on us was changed to 'steady signal.' But even so, for the rest of the patrol there remained the constant knot of spectators fascinated by the green electronic--of an enemy radar."

"No new anti-submarine measures were encountered. However, the tempo of Japanese anti-submarine measures has increased as much during the 4 and a half months that the PUFFER (No. 6) has been absent from Japanese controlled water as it had from the beginning of the war to that time. This increase in anti-submarine warfare was a distinct shock to every war experienced officer and man on board. As our capable baker put it: 'Things are getting tough'." A summary of anti-submarine measures encountered in this short 9 day on station patrol included: many contacts with day and night search planes, bombed twice by planes, sighted 11 escorts, radar-equipped planes, one floating mine, and Japanese submarines are operating in the operations area. "That PUFFER ran the gauntlet of these measures and returned without damage was due to the considerable element of luck plus efficient watch standing." On the fifth patrol of the TUNNY: "The note of the Terutsuki (class) echo-ranging signal was much louder and deeper than any other ever heard--sounded like the fog signal of the San Pedro breakwater light. Horrible!"

MATERIEL CASUALTIES, ENEMY ESCORT VESSELS, ETC.

Materiel casualties, especially consequent to aerial bombs and depth charges, were cause for hundreds of additional hours of work upon the part of submarine crews. The commanding officer of the GRAYLING (No. 4) reported that "depth charging, silent running and long hours of repair work noticeably accelerated fatigue and nervous tension." On the ninth patrol of the GUDGEON "the crew was kept so busy repairing vital machinery on the patrol that it was impossible for them to get the proper rest required for a successful patrol." On the twelfth patrol of the PLUNGER: "The combination of colds (approximately 70 per cent

of the crew having them), lack of sleep as a result of continual repairs to equipment and lifeguarding, resulted in a certain nervousness and irritability which fluctuated in intensity with the magnitude of the three items mentioned." On the seventh patrol of the PIKE "much effort and extra hardship was placed upon the officers and crew in having to contend continuously with leaking exhaust valves during diving hours."

Constant air coverage, numerous escort and patrol vessels, necessity of working close to enemy shore installations or conducting submerged patrols one or two miles off enemy held coast lines to intercept coast-hugging convoys imposed strain on all hands, especially when operating in confined water. On one occasion the TIRANTE (No. 1) was so close to the coast that "the smell of cattle from the beach was strong." On another, the SEALION (No. 1) "with but one fish left, closed to 500 yards in the fog to make sure of a hit." Other conditions sometimes contributing to strain were: operating in poorly charted areas (GRAMPUS No. 4), accidental flooding of the conning tower, control rooms or torpedo rooms, gun fire from enemy planes or shore installations, "friendly" surface craft, boarding and firing of captured enemy vessels (RATON No. 4).

SHALLOW WATER OPERATIONS

As the following patrol excerpts reveal, shallow water operations were another cause for strain and anxiety. "During a considerable portion of the patrol we operated in water from 60 to 150 feet deep. It was noticed that there was considerable tenseness in submerged watch standing by both officers and men--and that all hands welcomed deeper water when it came" (S-39, No. 3). The SKATE on her seventh patrol, in water so shallow that the fathometer would not register, successfully evaded anti-submarine vessel while running at a depth of about 63 feet. On her third patrol the BUGARA--"one of the outstanding gunnery patrols of the year"--bounced along the bottom in 10 fathoms of water while under attack by air--which situation, it was observed, was not conducive to good submarine nerves. The commanding officer of the CABRILLA at the end of her third patrol reported "quite a few of the old hands found shallow water patrolling hard on their nerves. This is probably a very potent factor to the endurance of any submarine crew although its effect can not be specifically ascribed." In the same area, personnel endurance was reckoned as being 10 days, and 30 days in an open area with deep water. The commanding officer of the GUDGEON at the end of her eleventh patrol made a similar observation, namely that "shallow water patrolling is no picnic and imposes a strain on all hands. Everyone behaved very well but showed evidence of relief as we headed for deep water."

The commanding officer of the BARB (Commander E. B. Fluckey), at the conclusion of her twelfth patrol in one of the finest pieces of descriptive writing found in these patrol reports, has very effectively recorded the existing tension on patrols such as the above and as completed by the BARB. On this patrol, ship and shore installations were struck, rockets were used successfully for the first time in submarine warfare, and a party of Commandoes were landed on enemy held territory. Said Captain Fluckey: "Set course for--to cool things off and give personnel a chance to relax. In spite of the fact that this attack (shallow water shore bombardment) was consummated without any close depth charges or bombs it has affected personnel more than any other." "Frankly"--the place--"seems to be permeated with an electric, nerve wracking claustrophobia. No one likes it. I believe that this is due to the shallow water, the proximity of mine fields and the obvious fact that our fish are not hitting even with the best set up." "After days of patiently waiting and observing, the undercurrent of expectant action that ran through the boat made one's spine tingle. Even our prisoner is swept away with it and asked to be permitted to join the party (Commando landing)." "Feel more proud and happy over what my lads have done than I would in sinking a hundred ships." On the second patrol of the SPADEFISH (concluded in December of 1944) "one of the outstanding patrols of the war to date"--"19 depth charges were received in 23 fathoms of water which didn't seem to be very much. The depth charge indicator looked like an electric sign on Broadway. A considerable amount of mud was found topside after surfacing--giving a pretty good indication of the depth and distance at which some charges went off."

MISCELLANEOUS

The COD, on her second patrol, "lost a boarding party--which spent 48 hours on a junk (5 men) and forced to use the food and water present aboard. Two men experienced ill feelings from the change in diet with mild abdominal cramps and diarrhea" (rescued by the BLENNY). On the fourth patrol of the RATON a sampan sank under a boarding party--"no loss of life but narrow escapes."

Illness.--On not a few occasions illness materially contributed to lowering of the efficiency and endurance of personnel. Note has been made, above, of the influence of upper respiratory infections upon personnel endurance aboard the PLUNGER on her twelfth patrol. As seen elsewhere, excessive amounts of copper salts in the fresh water supply of the ANGLER

was the cause of generalized illness on her first patrol, and terminated her second patrol. An epidemic of illness with nausea, loss of appetite, vomiting and some abdominal cramps involving 50 per cent of the crew of the GRAMPUS (No. 3), lasting three weeks, was responsible for a "noticeable lowering of the vitality of the crew." A similar epidemic involving 40 per cent of the crew on the ninth patrol of the PERMIT adversely affected their endurance. Another such episode occurred aboard the RASHER on her second patrol involving about half of the crew with consequent "debilitation and lowered efficiency--even though the patrol was of comparatively short duration and little occurred to cause either physical or mental exhaustion." And again, aboard the SKIPJACK--"appreciably reducing the efficiency of personnel for a short period during the middle of the patrol." It is quite possible that many of these cases, including the severe epidemic of illness which occurred aboard the STEELHEAD on her first patrol, were due to the use of carbon tetrachloride as described elsewhere.

SUBMARINE PERSONNEL AND DEPTH CHARGES

The importance of the depth charge as an effective anti-submarine weapon is well known--"it was the Japanese anti-submarine weapon." Its full effect as a physical force can only be appreciated by experienced men. It is inappropriate for one who has not accompanied a submarine on a war patrol to assume familiarity with the encountered hazards and especially to presume to describe the effect of a depth charge attack. And yet it is well that medical personnel should appreciate this force and its effect on men--for which reason the following details from patrol reports are presented as a descriptive background of conditions as they sometimes existed.

"Although some special depth charges of 1,000 pounds have been heard of, the usual type 2 Model 2 depth charge (Japanese) weighed about 350 pounds and had an explosive charge of about 230 pounds. Early in the war, depth charges were placed on practically every kind of ship that could carry them. It could always be expected that even the smallest and weakest patrol craft might carry depth charges. Fleet destroyers carried 30 depth charges. The Japanese frigates--could carry as many as 300 depth charges. The total number of charges carried on board the 167 foot Japanese PC boat was 36. Japanese aircraft carried standard bombs, modified for use as anti-submarine weapons. Smaller planes carried 150 pound bombs, and large ones carried 625 pound bombs. These bombs were equipped with delayed action time fuses set to cause them to explode after they had sunk to a predetermined depth. Fuse setting corresponded to either 80 feet, 150 feet or 250 feet depths. The 625 pound bomb was considered lethal at 60 feet. The smaller bomb had to make a direct hit." (Enemy Anti-Submarine Measures, Confidential, prepared for ComSubPac, Pearl Harbor, pp 12-13).

The total number of enemy depth charge attacks endured by our submarines from the Japanese is not known. Some received only a few; others, as so aptly described, were subject to a "rain of depth charges" (GUDGEON No. 6). "It is not the number but the quality of depth charges that counts" (BLUEGILL No. 2).

Submarines anticipating this form of enemy counter-measure, as when going in for an attack, "rigged for depth charging", which measure, in part, included closing of all internal sea and hull valves, opening the vents, closing down the ice machine, etc. When combined with "silent running" conditions, as when escorts were sighted, all running machinery except the main motors were secured--including the refrigeration, air recirculation and conditioning systems, bracket fans and battery blowers. The hydraulic plants, being secured, steering and operation of the bow and stern planes was shifted to hand. Bulkhead flappers were closed, intercompartment doors were left open or on latch. All unnecessary lights were turned off with emergency lights in effect. All personnel were required to remain where they were--to sit still or those off watch turned in. All hands refrained from making noise, sometimes men on watch went barefoot. "The first depth charge was quite close. The hunt is on and the hunted is running silent at 350 feet with the escort passing overhead--and the next few minutes are tense" (LAPON No. 3).

DESCRIPTION OF THE EXPLOSION

The hushed and expectant submarine crew often times could hear the splash of falling depth charges and aerial bombs as they struck the surface of the water. "In coming up--at 70 feet--I heard something I never want to hear repeated. Everyone in the conning tower distinctly heard the splash of the first bomb about 7 seconds before the explosion" (SAND LANCE No. 2). "The character of the depth charge was first a detonation click and then water rushing violently around the hull and through the superstructure and then 'bang'." (BLUEGILL No. 2, August 1944). "On almost all of the depth charges the familiar small detonation was followed by a large explosion and then the swishing and falling waters were very evident" (CABRILLA No. 4, April 1944). "As each charge went off there would be two pings on the hull--which sounded as though two small nuts had been dropped. Then after a period of one to two seconds the depth charge would be heard" (SALMON No. 1, February

1942). "As it appears to me now, the thud heard similar to that expected when a 100 pound weight is dropped on the hull, was the detonation of the charge. The explosion afterwards was the water either breaking surface from the effect of the explosion or the sound produced underneath due to the sudden outward pressure when the charge exploded" (FLYING FISH No. 2, September 1942). "--they proceeded to plaster the nearby area--with bombs. None of these were closer than one-half a mile but they really packed a wallop. Their noise and pressure waves were far more intense than that of depth charges or aerial bombs heard before--each made a distinct slap on striking the water before the explosion took place" (HARDER No. 2, October 1943). Others in describing the sound of depth charges exploding in the distance, have said they may sound like a child playing with a toy hammer, very mild and weak.

The PARGO (No. 4) described the tremendous explosion of a depth charge--which "rocked the boat with three separate and distinct pressure waves and with a sound effect of whoom--whoom--bo--oom." The commanding officer of the LAPON (No. 2, November 1943) in commenting upon the heavier depth charges, called "block busters" by the crew, stated: "The noise started out with a deep rumble similar to a freight train, building up until the vibration could be felt through the boat." GRENADIER (No. 1) at a depth of 35 feet when a bomb was dropped described the noise in the conning tower as about the same as when a 3 inch gun is fired. The concussion from depth charges exploding "practically on top" of the ICEFISH (No. 1) was "as great as that of a 5 inch gun going off alongside the pointer. These were deafening." CREVALLE (No. 3) described concussion so great from charges "landing practically on the deck" that "the ears were ringing." "The noise of the first depth charge was unexpectedly loud and stunning." (TARPON No. 2).

"The first depth charge practically took the earphones off the sound operator's head--he was deafened for the rest of the night" (TRITON No. 5). The SPADEFISH (No. 3) was depth charged when bottomed at 140 feet: "pressure waves--could be heard reverberating off the bottom for some seconds after the explosion--not a very pleasant sound. The boat would rock and roll as the waves went underneath." The commanding officer of the SUNFISH after shallow water depth charging (No. 8) reported: "the boat did a veritable shimmy--writhed and wiggled like an eel--must be the pressure waves going between us and the bottom."

The initial force and shock of close exploding depth charges and bombs was described in various terms. Not uncommonly the boats were knocked or thrust bodily downward through the water for a distance of 20 or 50 feet. Often all power was momentarily lost and with the boat out of control--"Kamikaze went roaring overhead and let go the works--we lost power on everything and shot to the surface with a 20 degree up angle, exposing 60 feet of the forecastle and putting the bow 20 feet in the air" (HAWKBILL No. 5). "Two bombs went off directly under the stern and blew the whole ship about 3 feet in the air" (SAND LANCE 3). Several commanding officers described sudden sideways motion: "the boat was thrown to port with a snap roll" (HAKE No. 5). REDFISH (No. 2): "Closest one of these is believed to have exploded a little above keel depth and gave the sensation of pushing the bow sideways to port." "Shaking the ship severely, giving her a quick snap roll, throwing most people off their feet" (RUNNER, SS 275, No. 1).

Others described: "swaying and heaving" (GUITARRO No. 3); "lurching", "ship jumped up and down in an alarming manner" (RAY No. 3). "In the depth charging, SCAMP shuddered like a leaf in a high wind" (No. 3). "Three depth charges--bounced the ship up and down on the bottom" (TULLIBEE No. 2). "In two close depth charge attacks the ship was shaken like an automobile when someone stands on the running board and jumps up and down" (PARGO No. 6). "HAWKBILL (No. 5) leaped, shuddered and shook like a startled colt." (SCABBARDFISH No. 1): "in a heavy depth charge the boat seemed to spring in and out." "He made 8 single runs using his fathometer and layed them deep in the mud around us--the old ship would hop from fox hole to fox hole as each one went off" (COBIA No. 5).

The commanding officer of the BAYA in describing a close depth charging received on that vessel's third patrol stated: "As the ship rolled and worked on the bottom, there were loud creaks and groans heard throughout the boat--CO wishes he had gone to Church last Sunday." "One aerial bomb was so close to the periscope that the two feet or so that was inside the boat whipped around like a willow rod" (BATFISH No. 3). Aboard the ICEFISH (No. 1), on one occasion, cordite fumes from a very close depth charge filled the conning tower. In the forward torpedo room of the BLUEGILL (No. 3) a hatch was lifted off its seat during an attack.

MATERIEL DAMAGE

Depth charges or bombs exploding in such proximity often times caused excessive and extensive battle damage. "Was so long after he had passed that I thought we were safe--then, as the old saying goes, 'all hell broke loose'. Sixteen depth charges came about one second apart. A definite thump on the hull was followed by a tremendous explosion--believe a depth charge bounced off our side. Lights were knocked out, sea valves opened, oxygen and acetylene flasks opened, glass in the bridge gyro-repeater was shattered and the breech of the 4 inch gun was split open" (BANG No. 3). Pieces of shrapnel from the exploding missiles were not uncommonly picked up from the deck of the submarine after such an experience.

"Great showers of cork and paint chippings. All normal lights were knocked out, light bulbs shattering like icicles on an autumn morning. Sometimes emergency lights went out" (SEAHORSE No. 7). "Much rattling of deck plates and loose gear flying around. The conning tower hatch fluttered like a check valve. The navigator calmly combing the light bulbs out of his hair as he peers through the gloom to see if the control room is still there. All stop--laying on the bottom and taking it. One close one blew the door between the engine rooms closed. Forward engine room reports a bad water leak. After engine room dogs the door down. After engine room reports a bad water leak. Forward engine room throws the locking bar across the door. Both rooms believe the other drowned."

"This last barrage lifted the conning tower hatch; ordered conning tower abandoned." "Bolts flew off the bulkheads, the TDC seemed to fly off the bulkhead and then back again, mercury from the auxiliary gyro sprayed all over the control room" (BREAM No. 5). "Gauge faces popped off." "The first pattern of depth charges caused the pointers of the gauges and electrical meters to hit their pegs." "Wrenches sent flying around;" "with breakage of the torpedo alcohol stowage tanks, the forward torpedo room crew was getting tight on the fumes;" "cases of canned goods were ripped open;" "porcelain water closet bowls were shattered, drawers were emptied of their contents;" "the shock opened the vents on the fuel oil tanks showering the torpedo room and crew's mess with fuel oil." "Two solid inches of fuel oil covered the deck in the crew's mess and sleeping quarters."

Main air lines were commonly ruptured, and the rush of escaping air added to the general din. "--the second one was as close to any block bursting variety as I wish to experience. It lifted the relief valve in the 200 pound air system, and control room personnel hit every valve on the high pressure manifold before they finally got to the right one" (PIRANHA No. 1). "A rain of depth charges which, in addition to other damage, rang all four bells and started all the pumps in the engine room."

A small fire in the maneuvering room resulted when some foreign material fell into the control cubicle;" "dense nauseating phenolic smoke from a fire in the main control cubicle" (SCAMP No. 7). The main induction sometimes was flooded, as on the seventh patrol of the KINGFISH "a very large bubble of air escaped from the induction and it could be plainly heard."

"With one blast overhead appeared to come in six inches." On the sixth patrol of the GUDGEON, the hull was actually dished in. The HALIBUT on her tenth patrol, "as the result of extremely severe and close depth charges, practically all of the hull from the bulkhead of the forward battery to the bow badly wrinkled." On the last patrol of the SALMON depth charging was of such intensity as to cave in the engine air induction piping. Deck grating was sometimes ripped out of the superstructure. In addition to these casualties, radio and radar gear was sometimes knocked out of commission. Fresh water, salt water and oil leaks of all kinds necessitated bucket brigades.

The above picture was aggrevated by the extreme discomfort incident to long periods of extended silent running--so well described elsewhere as it existed aboard the PUFFER on her first patrol. Extensive materiel damage incident to the depth charge necessitated long hours of work under these extremely harrowing and uncomfortable conditions. "The ship was a shambles of broken glass, smashed instruments; quantities of cork and dirt and hydraulic oil over everything. Things looked very grim--another such pattern could possibly have finished us--." "Hunter-Killer group remained in the vicinity all day long and after 16 hours SEAHORSE (No. 7) was able to surface and escape in a rain squall." "Submerged--gingerly--on the way to Guam--to lick our wounds." Heard and felt depth charges--not very close but ship and crew allergic. "After five days all repairs were completed and all tubes back in commission" (BLACKFIN No. 3).

PHYSICAL EFFECT ON PERSONNEL

The effect of this type of punishment on the crew could be measured in terms of physical and mental strain. "While depth charged in shoal water, the conning tower was doing a dance. By the time I got out of it--my face stung with flying cork and paint chips, my ears were deafened and my eyes were kept busy watching the gauges and manifold dance. On one blast the overhead appeared to come in six inches" (SEAWOLF No. 4). "Propellers were heard through the hull and before any action could be taken the first depth charge exploded within 100 feet of the hull. Men were bodily thrown about" (TAUTOG No. 4). "Just as the periscope was lowered, a tremendous explosion close aboard shook the ship violently. All hands were momentarily stunned by the suddenness of the shock. One man was thrown out of his bunk in the CPO quarters; another was knocked off his feet in the forward torpedo room" (TROUT No. 5). "All hands seemed to lose their footing" (SNAPPER No. 5). "The second bomb was very close; personnel in the conning tower and control room had the strange sensation of landing back on the deck but no recollection of having left it" (PARGO No. 4).

Others described forces of an intensity to send men reeling from their stations, against bulkhead fittings, as a result of which minor casualties were suffered (GUDGEON

No. 6). Aboard the HALIBUT (No. 10) in the forward torpedo room "all of the deck plates were dislodged, throwing personnel into the bilges, one being sure he was going through the boat." On the REDFISH (No. 2) a water-tight door jolted loose, hitting one man and practically severing his ear from his head. Aboard the CABRILLA (No. 4) a fire controlman suffered lacerations of the scalp when a blinker gun flew off its designated stowage in the conning tower bulkhead during a depth charge attack. Aboard the GUDGEON (No. 6) personnel were cut by broken glass. Others were injured in hand operations of the diving planes. In the fires which sometimes broke out men were burned (PIKE No. 6). Aboard the SCAMP (No. 7) thick smoke caused all hands to be violently ill; some men were overcome. "The total loss of power combined with the dense phenolic smoke from the fire in the main control cubicle could have caused loss of the ship--."

We have noted above, the loudness with which the concussion may strike the ears and that men complained of ringing of their ears with an especially loud and close blast. The commanding officer of the CREVALLE (No. 4) described a concussion so great that "personnel saw red for a fraction of a second." Aboard the GRAMPUS (No. 5) in a depth charge attack "all men in single hull compartments saw red." "The concussion suffered at times was so great that the men actually saw red for some time after an attack, this being due to minute retinal hemorrhage suffered from the concussion--" (Submarine Medicine in the Advanced Area--Some Practical Features, by Richard G. Burman, then Lieut., MC, V(G), USNR, 9 August 1944, Confidential).

Several commanding officers commented upon the "tooth shaking" qualities of the concussions: "Depth charges so close that they fairly knocked the teeth loose" (SWORDFISH No. 10). "A string of eight very close depth charges along the port side and high--they were enough to jar your fillings loose--." "Depth charges so close they made our teeth chatter" (FLYING FISH No. 10). "A tooth rattling explosion--at 200 feet" (PARGO No. 4). "Following a severe depth charging, 3 officers and firemen complained of sore mouths and gums--all 8 of whom are considerably older than the rest of the crew. Two men had fillings knocked out by the intensity of the depth charges" (REDFISH No. 2).

SUSPENSE

Probably that aspect of depth charging most difficult to bear is the terrific suspense, well described in the following: "Kamikaze drew off and commenced a deliberate and systematic search and approach and passed directly over the conning tower. The roar of his screws heard through the hull was a sound none of us will ever forget. We held our breaths but nothing happened." Eighteen minutes later: "He passed directly overhead the second time. Again nothing happened. We can not understand it--we can hear him pinging, even through the hull; he certainly has spotted us. Issued brandy to all hands--a great morale booster and nerve steadier" (HAWKBILL No. 5).

"Rigged ship for depth charging and silent running. Screw of one escort could be heard through the hull above us. A hush descended on all hands. At 185 feet and sinking slowly unable to maintain depth--we must blow. By blowing caught her at 190 feet. The escort also caught us. One escort is starting his run. Ordered full left rudder. He will pass to the starboard. First depth charge--close to starboard and at our depth. Several additional splashes heard but charges must have been set too deep and hit the bottom going off. Escort stopped! Stand by! Heard two side throwers going off, followed by two splashes. About 15 seconds later two close astern. Long scale pinging--escort has lost us."

"The most discouraging moment of the whole patrol--the realization that these fellows were returning seemed to eliminate practically all doubt, but that they were looking specifically for us with a pretty good idea where we were."

"They started going off 6 minutes after firing. There were only 8 charges dropped but the next hour was the most harrowing of my experience--. There were two sets of screws, one fast and one slow. They would ping and listen. I tried to put them astern; only to have them make a run across to our other bow, passing ahead or directly over. They stayed one on either bow most of the time and would turn and make their runs one to the other side. At one time the maneuvering room reported our port screw making a 'squeaking sound'. This turned out to be a slow speed escort passing overhead. On another occasion both vessels were milling about overhead and I thought surely they must be using a depth finder. And all of this was carried on in the utmost silence. Not a charge was dropped after the first two minute barrage. It is impossible to describe the tension attached to listening to the charges when you know the scoundrel is in good dropping position and does not drop--. Found myself wishing that some charges would be dropped so that we might speed in on the occasion and get away" (COD No. 5).

"The boat was absolutely quiet and though no one removed their shoes, people walked on tiptoe and talked in whispers. Drawing a glass of water from the wardroom spigot sounded like Niagara Falls. Heard a loud clanking noise as if a chain was being hauled across the boat. This made a terrific clatter lasting several seconds. Either they were dragging across us or the bridge was falling off. No attack developed after this so we sat tight."

"He--was very deliberate. He would ease out after an attack, take his time about getting set up for another and then come in fast--. If he wasn't satisfied with his run he wouldn't drop. We heard him pass over several times without dropping. Immediately following this he moved out and came in for a drop of 5 that made our teeth chatter. He then searched back and forth while we held our breath and presently he shoved off--apparently ran out of charges" (FLYING FISH No. 10).

"Four bombs--no damage except to baker's cakes--which fell; broke off attack and went all ahead, frantically heading out for deep water and submerged patrol zone. Doing broken field running through numerous sampans--. Well inside submerged patrol zone one hour and 15 minutes later everyone resumed breathing. Nothing to show for a strenuous evening's work except 10 wasted torpedoes and 8 'butterfly' stomachs. A bitter disappointment to everyone" (PIRANHA No. 2). "Number one escort rushed over us a little late without knowing it. The suspense of waiting after that until we were sure no more charges had been dropped is conducive to high blood pressure" (CREVALLE No. 1).

MENTAL REACTION

Self Possession and Why.--By and large the reaction of submarine crews to depth charging revealed an amazing amount of self possession. This was due, in great part, to the care taken in the selection of submarine personnel. It is related, undoubtedly, to the stamina, resiliency and aggressiveness of youth. Some of it, too, can be related to the fact that most men having been depth charge indoctrinated while in training in submarines knew what to expect before they ever started on their first war patrol. It was also due to the policy of rotating 25 per cent of the crew of a submarine returning from a war patrol to the relief crews.

The commanding officer of the S-47 (May 1942) in reporting upon her first patrol stated that one man became very nervous and nauseated but there was no evidence of panic and the efficient performance of duty under the extremely trying conditions is commendable. "No officer or man on board had ever heard a depth charge prior to this trip. Every submarine and every man going on a patrol should be subjected to this experience by having one of our destroyers drop a depth charge at a fairly close range."

"In the last two patrols have received a total of 203 depth charges and a total of 17 anti-submarine vessels have searched for us!" "The policy of rotating 25 per cent of the crew leads to all hands suffering less from nervous tension during counter-attacks than they did in earlier patrols--" (PUFFER No. 5).

"Noted that those people who were pretty well shaken up by depth charges received on the fourth patrol seemed to have recovered their confidence and cockiness." Attributed to the system of relieving ship's personnel during the refit (FINBACK No. 6).

It was due, too, to the confidence all hands had in their ships. "This vessel weathered its most severe depth charging to date like a veteran. Any weakness in construction would have been all too apparent. There was none" (BONEFISH No. 3). Received a total of 107 depth charges--and "although the effect was sobering the lads that day learned to love a boat that could take such punishment" (ARCHER FISH No. 3). Concerning the second patrol of the REDFISH, on which most vicious depth charging was encountered, it was said: "--ability to withstand and return safely to port is testimonial of the highest order of the materiel sturdiness of our submarines and the courage and valor of the officers and men."

By way of illustration of the effectiveness of indoctrination to enemy counter-attack measures the following excerpt from the first patrol report of the BLENNY is offered. "A surprise night bombing on the fifth night (November 1944) in the area was a distinct shock to the crew. It is believed that had the crew been thoroughly indoctrinated to expect enemy anti-submarine activity at night they would have taken the bombing as just another irritation to be expected."

By and large, this was the reaction of the majority of the men. "Depth charge attacks had little if any effect on personnel. They came to be expected and accepted as routine and to all appearances were ignored. The experience of the heavy grapnel banging against the ship's hull at 340 feet, however, caused some raised eyebrows, --the commanding officer's being as high as any" (THRESHER No. 4). The commanding officer of the SCAMP in summarizing the 6 patrols of that ship made to date (February 1944) observed that in spite of the severe depth charges, "only one man cracked up--this occurred during the first attack on the first patrol and involved a man who was a veteran of several war patrols on other vessels."

"During the ordeal not a man failed or lost his sense of humor for a moment. Everyone stuck to his job of keeping the ship tight and under control without any orders" (HAWKBILL No. 5). The TUNNY's fourth patrol was terminated by considerable hull damage incident to severe depth charging. "The efficient functioning of the entire crew during this very severe counter-attack--the cool headed teamwork probably saved the TUNNY from disaster." "The officers and crew were exceptionally capable--acting and reacting as though they were experienced war veterans, in spite of the fact that 54 men and 5 officers were experiencing

their first taste of submarine warfare--due to the confidence of the crew in themselves and in their boat" (SEA CAT No. 1). "The crew and officers performed like veterans, every one, and I have a tremendous amount of confidence and pride in them" (ICEFISH No. 1). "Under severe depth charging all hands performed their duties quietly, quickly and efficiently. Extensive battle damage was repaired promptly under trying conditions" (CREVALLE No. 3).

COMPENSATIONS

There were compensations, too, for the endured punishment, especially when successful attacks had been completed. "Target blew up and sank almost immediately. This gave all hands an especial boost inasmuch as this gent was the same one who had given us a working over--" (ALBACORE No. 10). "First of 39 depth charges--. Wow! What a lacing but what could lessen any of the joy and thrill of hearing those beautiful torpedo hits after so much disappointment and heartache. From the least to the highest, SHAD's confidence and morale is revitalized and renewed by the music of these wonderful explosions" (SHAD No. 7). "Spliced the main brace for the crew--most of whom had just received their worst depth charging and biggest thrill when the result of the attack was announced from the periscope" (BONEFISH No. 1).

Grim moments for all were lightened, on occasion, by the ability of someone in the crew to wisecrack. "About 10 hours of this makes a long day and all hands are a little fagged out with a few showing some signs of nervous strain; however, all hands took it pretty well with an occasional wisecrack to ease the strain" (SAILFISH No. 7). "As one sound operator expressed it--"There was pinging and screwing all around--when 5 or 6 ships passed over astern, some pinging, stopping and listening" (SPADEFISH No. 1).

"After the first charge we were Christians. One cussing motor machinist's mate trying to keep the warped engine room air induction closed was shut up by his helper saying, 'Don't you do any sinning around me just now.' The Christmas tree showed 3 deck hatches open" (SEAHORSE No. 7).

"On 28 September, when the ship was barely under control, following a severe depth charging, and as soon as the principal leak had been precariously plugged, a Fillipino mess attendant, who had been engaged for an hour or more in bailing to protect the forward battery, in all seriousness asked the executive officer: 'Now we go up and shoot destroyer, maybe?'" (SCULPIN No. 5).

The CHARR on her second patrol sank a cruiser; of the event it is recorded: "The TDC operator jumping up and down saying, 'Jeezy Beezy, we hit him, we hit him!' And the exec making a mad scramble for the ladder saying, 'I gotta get my depth charge shirt on'." (The depth charge shirt being one of these screaming Aloha shirts--Ship's Service, Pearl Harbor, 98 cents.) (CHARR No. 2).

With reference to the effect of depth charges upon the crew, the commanding officer of the PUFFER's fifth patrol reported: "To add to the growing list of classic remarks born on such occasions as this, one of our old timers in the control room came out with the following: 'Boy, them was close! I was so scared I smoked half a package of my own cigarettes before I knew what I was doing'."

"A photographer's mate assigned to the ship was told to attempt to get a picture of the expression on the faces of personnel during a depth charge attack--none were taken. His reasons (1) cameras made too much noise; (2) he was too busy" (SENNETT No. 3).

On the ninth patrol of the TRIGGER: "--0338 put up periscope--saw ship about 50 yards away--boiling across our bow, firing a machine gun--." "While waiting for his depth charges, fired 4 torpedoes--at which time 4 of the escorts very definitely had us. One had just attempted to ram. One was following him with depth charges and 2 more were lined up, one on each quarter. Two hits were heard at 0340. 0342 two more hits followed by a string of 27 depth charges, much threshing of screws and pinging from every bearing on the dial interspersed with depth charges. 0439 there were 6 very close depth charges. These did all the damage suffered by the ship. The feelings of all hands were summarized by the comments of Ck1c, who had made nine patrols: 'That sho is the most brutal man it has evah been mah misfortune to encountah!'--TRIGGER ran silent at 300 feet for 17 hours--most of the time silently dogged by 6 anti-submarine vessels. The most nerve wracking experience in the history of the vessel--a christianizing experience." "At 2010 surfaced with the forward torpedo room flooded to the floor plates and much materiel damage."

UNFAVORABLE REACTIONS

There was some reaction, of course, to what must have been terrifying experiences to even the most stalwart, best indoctrinated and disciplined of men.

"Much nervousness was shown in the first contact with the enemy but decreased on subsequent encounters though no one liked to hear the pinging of enemy sound patrols" (SEADRAGON No. 1). "The first patrol was made constantly under potential counter-measures. All personnel responded to their duties readily. The long hours of silent running made the younger men soon realize their responsibilities as submariners" (PARCHE No. 5). The commanding officer of the WHALE (No. 2) remarked concerning the "considerable sobering effects" of the first exploding depth charge felt when passing 160 feet. "For the second time this patrol, BLUEGILL (No. 3) received a severe depth charging and, comparatively, the other was a dummy run! The quartermaster's usual cryptic remark of 'missed' was noticeable by its absence." "These were hits! Block-busters! The close depth charging received after the first attack shook all hands somewhat, but the majority snapped back to normal quickly" (BANG No. 3).

EFFECT ON TEMPERS, APPETITE, AND REST

"The strain of depth charging wears off with rest and quiet but the individual definitely looses more and more of his reserve energy with each successive attack" (GRAYLING No. 2). "On several occasions when all was quiet and screws were more or less distant, terrific explosions were heard, rocking the boat and sending little chills of 'what the hell was that' up the spine." "We have gained a tremendous respect for aircraft bombs and depth charging" (SHAD No. 7).

"Depth charges, especially if accurate, have a decided effect on the temper--" (NAUTILUS No. 1). "On our return everyone was generally well tired out and there were a few cases of very short tempers and nerves" (THRESHER No. 2). "In the latter part of the patrol, health of the crew fell off considerably--. Many complained of upset stomachs and overall tired feeling. This reduction in efficiency was felt to be entirely due to the continued nervous strain and shock of depth charging, and entirely disappeared after a few days departure from the area and the entire crew able to get some fresh air and sunshine" (REDFISH No. 1).

"If we are attacked again in the next 2 to 3 days we shall have to pull clear and give all hands a couple of days to settle their nerves" (SAND LANCE No. 2). The commanding officer of the S-32 following the sixth patrol on which she sank two enemy submarines and one destroyer, reported: "It was noted that within a period of 24 hours following a depth charge attack several cases of mild gastric distress consisting of slight nauseating and cramp-like feelings developed. Rapid recovery without treatment followed."

ACCUMULATIVE EFFECT OF ENEMY COUNTER-ATTACKS

As noted elsewhere, some men could not help but show the strain of accumulated and successive war patrols. "Many of the men were visibly and literally shaken in depth charge attacks. The majority of these have not seen light for almost two months" (PLUNGER No. 1). "A few cases of nervousness were seen during the depth charge--on the part of some of the older men making previous patrols" (SUNFISH No. 1). The commanding officer of the CUTTLEFISH in commenting upon the state of his crew at the end of the ship's third patrol stated: "Fatigue was evident and prevalent after the third week on station, particularly in those making their third patrol. Several key men have to be left in due to obvious fatigue. Four or five men were obviously shaken but remained at their posts; at least three on their third patrol are badly in need of rest." Higher authority in commenting upon this patrol stated: "The morale of officers and men is high but it should be noted again as on the POMPANO that the nervous tension created during a depth charging has a more marked effect on the men who are making their third patrol than it does on those who are making their first or second." "There was a marked difference in the apparent effect of depth charging between the old and new men--the new men being nervous" (SKIPJACK No. 4). "Many of the crew completing their fifth patrol definitely showed strain during anti-submarine measures" (FINBACK No. 5). "A few old timers showed the strain of depth charging but they recover quickly" (POLLACK No. 6).

The FLYING FISH on her second patrol suffered severe depth charging with sufficient battle damage to force her to leave her area. "The official count, exclusive of charges dropped on false contacts, was 11 depth charges and at least two bombs on station." Concerning this the commanding officer reported: "Started up the normal operating machinery--continued to maneuver, keeping the destroyers astern and watched aircraft patrolling the area. Ordered No. 9 torpedo tube blown down and torpedo inspected for tightness. Very soon thereafter felt the ship jar and noticed a large slick directly astern. Informed by the after torpedo room that a nervous torpedoman had fired No. 7 torpedo by hand--instead of firing No. 9. While this information was coming through, a loud explosion occurred--I raised my periscope

again for a quick look and noted a plane had dropped a bomb directly astern in close proximity to the slick left by the torpedo." In the bombing that followed: "Personnel were knocked down. Before the turbulence from one charge would die down, it would be augmented by the turbulence from a succeeding charge." In the long period of ensuing silent running many suffered from the extreme heat, nervous tension and the physical exertion required to remain at constant station during the attack. "Following the last attack, morale was visibly affected. Key men started making mistakes and constant attention was necessary to see that instructions were carried out promptly and properly. The symptoms were noticeable following each attack. Men would quietly ask for a relief, shove off, lie down on the deck anywhere and remain there till their services were needed elsewhere. There was no indication of hysteria whatever and every individual did his duty to the limit of his endurance through each prolonged attack. Men quickly shed their shoes without orders on the first and last attack. While things were quiet overhead it was noticed that flashlights, wrenches and valves were moved with the greatest of caution and stealth. Movement of all hands was done with forethought and deliberation. Conversation was unconsciously carried on in whispers when there was a lull in an attack and it looked as though we were getting clear. Little food was eaten for about 18 hours after a particularly strenuous period. Aircraft contacts did not particularly lessen the tension on the return to Pearl Harbor and men made it evident by their looks and actions that surface cruising, at this time, was not particularly enjoyable. Nerves were noticeably on edge on returning from station."

MISCELLANEOUS

It seems reasonable to assume that men who are physically unwell for other causes than the strain of submarine existence may react unfavorably to the stress of depth charging--as on the fourth patrol of the SUNFISH when "one man was extremely nervous and overwrought during a heavy depth charge attack--the fact that he had severely injured his finger before may have been a contributing factor."

Some submarine crews were the proud possessors of mascots. Their reaction to the strain of depth charging attacks was interesting. The author knows of one little dog which made several successive patrols on a submarine, finally being given away to personnel ashore because she had obviously made too many patrols. Note has been made of the conduct of the dog in the forward torpedo room of the HALIBUT on her third patrol who, during that harrowing experience, except for a whimper or so, lay quiet in the lap of one of the men. And aboard the WHALE (No. 8): "--a very close string of 10--'walked' right up to us--about this time Betty, the dog (making her third war patrol) wet the first Lieutenant." The dog, Luau, of the crew of the SPADEFISH "was a bit perturbed by depth charges."

There were relatively few instances in which men suffered serious physical deterioration due to the strain of anti-submarine attacks and the accumulated heat and humidity endangered in long periods of "silent running." For a very complete analysis of such a situation the reader is referred to the section "Silent Running."

Men, on submarine war patrols, in very few instances, suffered acute mental breakdown. These will be discussed elsewhere (psychiatric casualties). Suffice it to say that through the war, not more than 53 such cases appear in these patrol reports which can be attributed, in the main, to the strain of depth charging and other measures of enemy counter-attacks.

MORALE AND SUBMARINE WARFARE

Everyone recognizes the importance of "morale" in the successful accomplishment of whatever man or men may undertake. As a highly important factor contributing to the success of submarine warfare in this last war, it had many components.

"The commanding officer, always proud of the teamwork and fighting spirit of the officers and crew, finds it difficult to express his feelings in words. Some call it morale or esprit de corps or the old 60 per cent but whatever it is, it pays off in hits" (SILVERSIDES No. 10). "It is a good feeling to know that you have good solid citizens down below while you are standing on the bridge at night, charging in at high speed to make an attack on a ruthless enemy" (RATON No. 1). "The man transferred at Midway--with a high fever--was reluctant to go--so much so that he gave way to tears. The healthy aggressive spirit he exemplified is his country's life insurance" (POMFRET No. 1).

MORALE AND SELF-ASSURANCE AND SENSE OF RESPONSIBILITY

A high state of interest and aggressive determination on the part of all hands, essential to the success of an operating submarine, basically stems from confidence and assurance--confidence in the fitness and training of self and fellows, demonstrated sturdiness of the ship's construction, effectiveness of ammunition and torpedo performance, and pride in the Force and its accomplishments. "Due to the confidence of the crew in themselves and in the boat the 60 day patrol passed without strain" (BLOWER No. 1). On the first patrol of the BLENNY while surfaced, the crew was badly shaken by a surprise night bombing; thereafter--"nervous tension was relieved--. We had attacked an air and surface escorted convoy and escaped without detection by either planes or surface escorts. Confidence had returned."

"The policy of rotation is a most important morale factor. An enthusiastic new hand--and most of them are--acts as a stimulating tonic. Everyone takes delight in demonstrating their knowledge and feels more keenly their responsibility" (TAUTOG No. 9). "--the spirit and confidence among the officers and crew of WHALE--undoubtedly was due to pride that she had already checked off 10 successful war patrols and 10 successful runs. Every officer and man felt responsible for maintaining this habit of success. The old hands quickly indoctrinated the new men. Since the effort to keep equipment working, to stand alert watches established a mutual faith among all hands--each man felt he must do his part to help maintain a habit of success many former WHALERS had started early in the war" (WHALE at the conclusion of her eleventh and last patrol).

On one occasion the commanding officer of the S-39 (No. 3) "explaining the hazards involved and possibility of capture, a volunteer was called for from the rated men aboard, to make a landing on the island of Chebia to contact a British party thought to be there--. Out of the 38 men aboard, there were 28 volunteers - which is an indication of the spirit and cooperation of the crew."

Higher authority, ComSubPac, in the endorsement to the fifth patrol of the RAZORBACK observed: "It is well known and no new principle in warfare, but in the war just completed we have been given a common demonstration of the truth best stated by Admiral Nelson that common effort and danger shared do, indeed, create a band of brothers."

MORALE AND SUCCESSFUL ACTION

There can be no doubt but that the greatest single factor contributing to a high state of morale was successful engagement with the enemy (BALAO 8). "There is no substitute for action to put everyone on his toes to make the new men realize what they are up against. Ten minutes of real action accomplishes what 10 weeks of 'talking about it' might fail to accomplish" (SKATE No. 1). "The words 'Radar contact, 16,000 yards' spread through the boat like wildfire and every man heads for his battle station with a gleam in his eye" (RASHER No. 4).

"As is well known--the best thing for morale is the sound of a torpedo hit. The words: 'Captain to the bridge--SJ radar contact--1,200 yards' are exhilarating and torpedo hits are a satisfying climax" (SUNFISH No. 3). "Anything less than a heavy explosion in the enemy does little to bolster morale" (BLUEFISH No. 5). "It took 5 to get a ship worth only one torpedo or a gun attack but we got her and the extras were worth their cost in the morale effect on the crew and myself to say nothing of ComSubDiv 162" (CAPELIN No. 1).

"--target blew up and sank almost immediately. This gave all hands an especial boost inasmuch as this gent was the very same one who had given us a working over--" (ALBACORE No. 10). "In four patrols CREVALLE has sunk or damaged an estimated 140,000 tons of Japanese shipping and morale is correspondingly high. The men are proud, confident and aggressive. They are the cream of the Submarine Navy." "This has been an excellent cruise--lots of damage to the enemy--including spectacular fire works--. Needless to say morale is soaring" (JACK No. 2). "--what could lessen the joy and thrill of hearing those wonderful torpedo hits after so much disappointment and heartache. From the least to the highest SHAD's confidence (No. 7) and morale is revitalized and renewed by the music of those wonderful explosions."

"Morale was excellent and improved noticeably in direct proportion to the number of targets expended. The effect of our first night surface radar attack was practically electrifying" (STURGEON No. 9). "As others have observed, a night surface attack is like a tonic especially when the depth charges can be watched from the surface" (SWORDFISH No. 10). "High speed surface approaches are very invigorating and are highly recommended as a morale builder" (PARGO No. 1). "--the final explosion with flames and showers of sparks--one hour and 8 minutes after the first hit--when we were 23 miles away--was quite a finale to the patrol. Allowed men to come up one at a time to take a look as we made our exit" (ATULE No. 1). "It was very truly a beautiful three hours of action with ships blowing up simultaneously all over the horizon" (TREPANG No. 2).

MORALE AND LACK OF ENEMY CONTACTS

Conversely, nothing so adversely affected the fighting spirit of submarine crews than monotonous days of patrolling with lack of or disappointing surface contacts. "A patrol which results in no materiel damage to the enemy does not--give a crew that 'lift' which comes with the certain knowledge of sinkings" (endorsement to third patrol report of APOGON). "Have had two contacts worthy of torpedo attack"--which could not be developed. "In spite of it all our morale is still quite satisfactory--although not nearly so high as it would be if we could get in a damned good scrap. It is no joy to anticipate a return to base with no damage having been inflicted on the enemy. This type of patrol is undoubtedly the toughest you can make. Once a patrol has been successfully completed for a new submarine she has half won the battle. All hands are surer of their footing and they have ceased to be a 'detail'--they are instead a fighting unit, a crew. The metamorphosis is largely psychological but the importance of it can not be over estimated. The one single factor which contributed most to our morale continues to be the execution of successful attacks" (BATFISH No. 1).

"This is my seventh patrol but the first 'zero run.' As I have heard from other submariners it is a distinct shock and a blow to morale. This is especially true in the case of a newly commissioned submarine who has strove for almost a year toward building a first class fighting machine. However, our spirit is the same as after losing an Army-Navy game--we'll get 'em the next time" (BUMPER No. 1).

"Although no targets were seen to sink, the morale and fighting spirit of the crew is still high--. 'No sightee, no sinkee'!" (BLUEGILL No. 4). "Morale definitely ebbs when you patrol enemy water for several weeks with nothing but aircraft contacts" (PARGO No. 4). "The crew was getting 'fish happy'. Patrolling for more than a day or two on station without hearing torpedoes explode caused a general let down in spirits" (RASHER No. 4). Personnel of the HARDER (No. 3) are attack-minded. They grow restless when targets are hard to find. "Nothing is more demoralizing, enervating or clock stopping than to go day after day without seeing smoke" (POLLACK No. 6). "Lack of offensive action is productive of a general feeling of disappointment" (RATON No. 8).

"The feeling of futility engendered by numerous contacts which failed to develop into attacks was hard to overcome; the tendency was to become lax and the effect on morale was noticeable" (BARB No. 3). "This was the first of many abortive approaches on junks before we finally got accustomed to the idea of 'untouchables' in the patrol area. Perhaps the worse feature of it is the inevitable 'familiarity breeds comtempt' effect on all hands, particularly the bridge and radar watch' (SEA OWL No. 1).

"This, our first gun fight, was a disappointment but the experience gained was very beneficial. It also acted as a good tonic for the entire crew, who, after an entire patrol without a single ship contact, were getting disgusted" (SCABBARDFISH No. 3). "The entire patrol was monotonous because of many days of inactivity--bombardment and rescue during the final days had a vitalizing effect on all hands" (SPIKEFISH No. 3). "Though we consider the morale of personnel on the ship as high, the noticeable lack of torpedo targets during this and the last patrol was keenly felt. If such lack of suitable targets continues, serious morale problems may arise in the submarine service" (BLUEGILL No. 5).

It was difficult, sometimes, for men on war patrols to appreciate that the "effect of the presence of our submarines in the Empire Areas was not measured alone by the tonnage sunk" (endorsement to APOGON No. 3 patrol). At the end of the SHAD's ninth patrol, her second straight patrol without tangible returns, it was observed: "In the earlier days of submarine warfare it was enough to let tonnage sunk or damaged speak for itself; but now with the paucity of targets and a great deal of just plain old routine--not entirely deprived of thrills either--the lethargy of long diving days, of rough sleepless nights and limited exercise must be mitigated by reiteration of the task to be done and by a clear portrayal of the part submarines are now playing in the great strategical and tactical plans." "On long patrols without the stimulus of enemy contacts the highest degree of leadership is required on the part of the commanding officer" (PERCH No. 4).

MORALE AND BATTLE SURFACE

As indicated above, "battle surface" proved in many instances to be a great tonic for discouraged submarine crews particularly when they had been on the "receiving end" from the enemy. With regard to this type of action it was pointed out by higher authority in the endorsement to the first patrol report of the SCORPION: "Execution of gun fights must be carried out only after careful consideration of the value of the target and the risk involved. Submarines at all times must maintain the military advantage, fire power and strategical advantage. Gun battles are always extremely exciting encounters and are definite morale builders on long and sometimes boring patrols."

"Gun action--of inestimable value in raising the spirit of all hands" (KINGFISH No. 12). "The 5 inch crew did some pretty good shooting which lifted the morale of the gunnery department after their let down of not being able to sink a mine yesterday" (PIPEFISH No. 6). HARDER (No. 2) "considered the gun battle from the start to be nothing more or nothing less than good gunnery exercise and morale builder for the crew--after having dodged this type of enemy patrol ship for the past 3 weeks on station the boys were glad to dish it out for a change."

"Night gun attacks contributed highly to morale as though the crew was able to subconsciously find an outlet for action" (SHAD No. 1). Concerning a 2 day period on the third patrol of the ASPRO in which the ship was "in almost constant contact with a convoy and at battle and tracking stations for long periods" it was reported: "We were tired but after the prolonged chase we would have enjoyed sinking the cripple with the deck gun." "Station for battle surface was sounded. As the gun crew assembled in the conning tower the mental alertness shown in the sparkling eyes and clear headed expression, the evident grim determination mingled with smiles of satisfaction, left a picture not soon to be forgotten--a picture that told the commanding officer that the fighting spirit was there and there to stay until our job is well done" (ALBACORE No. 9). Anyone who has not witnessed a submarine conduct a battle, surfaced with three 20 MM and a 4 inch gun in the morning twilight with a calm sea and in crisp and clear weather "just ain't lived." It was truly spectacular (WAHOO No. 4). Readers especially interested in this phase of submarine warfare should consult the last patrol report of the SALMON, and its endorsements, for an account of her epic gun contact with the enemy, and patrol reports of the WAHOO.

MORALE AND PERSONNEL CASUALTIES

Encounters with the enemy in this manner were not always without their more grim and tragic aspects. In a number of instances submariners were seriously or fatally wounded by enemy gun fire, either in gun attacks or by strafing--such losses were grave blows (SUNFISH No. 1), leaving heavy hearts (MUSKALLUNGE No. 7). On the first patrol of the SKATE, in an encounter with the Japanese off Wake Island, an officer was killed. On the next patrol--"all hands agreed to dedicate"--to his memory--"a large freighter which was sunk--the target blowing up with a tremendous explosion which sent fire and flames shooting into the air and plainly visible over 50 miles." In response to the death of an officer killed in an encounter with the enemy on the SCORPION's first patrol it was resolved: "--we are now 100 per cent on the firing line and all of us have now been given a personal grudge. Each ship of this division will dedicate one full torpedo next forward to Lt.-----." The story of the bravery and heroism of the men and the commanding officer, Howard W. Gilmore, who were killed by enemy gunfire on the GROWLER is one that all submariners will long remember. Six men on the ninth patrol of the PLUNGER were injured when strafed by a Japanese Zero plane. The "boat was made acutely strafing conscious thereafter."

MORALE AND AIR/SEA RESCUE OPERATIONS

Participation by submarines in air/sea rescue operations, particularly when successful, was often times a source of tremendous satisfaction for all hands. "Up until this patrol all of us considered furnishing lifeguard services the dullest of duty and somewhat below the dignity of a crew used to sinking ships. The results of this patrol have changed our viewpoint entirely. We now realize the importance and high morale factor in aiding those men who are striking at the heart of the Japanese homeland" (TREPANG No. 5).

"It might be added that the rescue did more for the morale of the crew than anything else could have done with the exception of sinking ships. Every officer and man is proud to have been of some help to those who are now the ball carriers" (BANG No. 6).

The BLUEFISH, on her seventh patrol, rescued 3 aviators; another, a fourth, gave his life that the others might live. Concerning this rescue it is stated: "The entire submarine service may feel a solemn pride in that, through the assistance of one of our ships, his brave sacrifice did not prove in vain." The commanding officer of the SEGUNDO, at the conclusion of the second patrol of that ship, stated concerning these operations: "--although you do everything you can there remains an empty feeling inside; so near and yet so far away." And on the fourth patrol of the TILEFISH: "Regret giving up the search for aviators and heading for home. The jubilation felt through the ship as the result of sinking the cruiser has been completely surpassed by failure to rescue the aviators."

Throughout the war, on many occasions, other single and mass rescues of aviators, prisoners of war, refugees, etc., were carried out by submarines. These constitute some of the most exciting passages in the history of submarines in this last war. Always, however, the devotion shown by submariners to others less fortunate surpasses the thrill of the rescue operations. "During lifeguard assignment the entire ship's personnel (GROWLER) showed an enthusiastic interest in the duty at hand. The aviation personnel rescued had to be protected from the well intentioned but overwhelming solicitude of the ship's company. Clothing,

cigarettes and toilet articles were produced in abundance to supply their needs; and always there were eager audiences seeking them to tell of their experiences. Though normally the accommodations are considered to be congested there seems to be always room for more."

Concerning the rescue of British and Australian prisoners of war the commanding officer of the BARB (No. 9) wrote. "There is little room for sentiment in submarine warfare but the measure of saving one Allied life against sinking a Jap ship is one which leaves no question once experienced."

Japanese prisoners of war, when recovered, were sometimes severely wounded and were ably and professionally treated by submarine pharmacist's mates. The affection which the crew developed for these prisoners was often times astonishing--especially to visitors boarding the ships while stopping off at advanced bases: "The principal morale factor was, of course, the knowledge of having accomplished damage to the enemy. Moreover, the excellent baking of our S1c and the perpetual amusement over our young prisoners highlighted the BALAO, hostless USO" (BALAO No. 8).

On one occasion on the ninth patrol of the SUNFISH the following occurred:"A Chinese junk came alongside. After we had trained our guns off them and they had gotten over being scared it was evident from their actions and gestures that they desired to stay alongside and that they were in distress. Finally we made out that they were hungry and had been blown far away from the China banks. The crew by this time was ready to give them the ship. They were provided with a sack of rice, dried beans, chocolate, canned meat, fruit, vegetables, salt, bread, cigarettes and matches (plus some ordinary clothing) amid much greatful bowing. When we cast off their line and started to back away they set up a wail of tears and made more gestures. It wasn't until we were cleared that I realized that their gestures were 'drinking' and that they had no water. We circled with them gesturing us back alongside while we scouted up a 5 gallon can and a 4 gallon jug and filled them--they shouted and danced so it did your heart good--suddenly we had to dive. When a plane was sighted--started trailing the junk which we had in tow. There was no question now of leaving--my crew would have mutinied I am sure if I had not planned to get the water and other gear aboard the junk. They were completely taken over by a 10 year old boy who materialized when we pointed the guns up into the air--. Surfaced and received royal welcome from the junk. Five men, one boy about 16, and the 10 year old, all holding up food and rubbing their stomachs--transferred all gear and water."

"At any time, day or night, upon sounding of the diving alarm, an observer in the after torpedo room would perceive a small agile form emerge from the depths of the torpedo racks, scamper forward and shut the bulkhead ventilation flapper with a thoroughly business-like snap. Then on that spot it would freeze, immobile, its face a study in attentive concentration. With the command, 'Open bulkhead flappers--recirculate', briskly alive once more, the figure slaps the flappers smartly open, scurries aft (its entire bearing fairly shouting of prideful accomplishment) and disappears into the shadows from where it came--our prisoner is no mere passenger" (SEA CAT No. 3).

OTHER OPERATIONAL FACTORS AND MORALE

There were other factors, operational, etc., which affected morale. As observed elsewhere, reconnaissance operations and laying of mines were not greatly cared for nor was shallow water patrolling. Prolonged periods of operations, especially if submerged, without adequate facilities for recuperation contributed to a "definite drop in eagerness of spirits" (BERGALL No. 4). We have seen elsewhere the debilitating effects, especially in terms of inadequate sleep and rest, of bad weather, poor or inadequate ventilation and air conditioning, and continual harrassment from the enemy in the form of depth charge attacks, extensive day and night aerial activity, bombing and gun fire from "friendly planes or ships." Prolonged surface operations and routines whereby all hands were rotated through the sun lookout aided morale and health (DARTER No. 2, TILEFISH No. 6, and DEVILFISH No. 4). "Owing to lots of contacts, good luck and limitation of anti-submarine measures, morale is at a high pitch" (FINBACK No. 5). "Lots of damage to the enemy including spectacular fire works, only two days submerged, no depth charges, good food including icecream almost every day, very little ship trouble and good weather--needless to say, morale is soaring" (JACK No. 2). "At the beginning of the patrol there was considerable dissatisfaction, particularly among the older hands on the boat, at having to go out again on the 'old boat'--due to the long leave and ensuing overhaul, the materiel difficulties experienced subsequent to starting the patrol and the casualties suffered enroute to station. After the first successful attack, however, general morale was considerably improved." (POLLACK No. 9).

OTHER FACTORS CONTRIBUTING TO MORALE ABOARD SUBMARINES

"In the 10 previous patrols--none were so conducted with such plain creature comforts as was afforded by little things on this run--e.g., icecream, record transcriptions, the conning tower and forward battery air conditioning units, fresh eggs, potatoes and fruit throughout the patrol, the abundance of fresh water, the sound movie projector--these are little things that have rendered submarining so much easier than those first patrols at the beginning of the war" (SHAD). Anyone who has attended welcoming ceremonies for submarines returning from a long patrol will long remember the relish with which the crates of oranges and apples were attacked by men hungry for fresh fruit.

Food

Next to successful contact with the enemy, the ration was probably the most important component of good "morale." And the submarine ration, by and large, was very good.

"In my opinion morale and patrol results are in direct ratio to the food served" (BATFISH No. 5). "A good steak occasionally is a big morale booster" (BILLFISH No. 3). "The quality of the food was one factor contributing to the high morale prevailing throughout the patrol" (CERO No. 7). "As a result of good food, excellent living conditions and health, morale was exceptional and all men were highly contented" (SPIKEFISH No. 2). The commanding officer of the PERCH (No. 6) commended the baker: "responsible for the particularly high morale around chow time. I consider it as vital to morale as cigarettes under certain conditions of stress and it can be frequently used when cigarettes can not." Aboard the CERO (No. 1) "at the beginning of the patrol each man was given a carton of chewing gum. Believe that its use had a marked effect in reducing the number of stomach and intestinal disorders usually observed during a war patrol." BLUEGILL (No. 1) listed short order breakfasts for all hands as among the "boosters." Many boats kept "open iceboxes."

Reading patrol reports one can not help but be impressed by the importance of good bakers and cooks. The providing of facilities whereby submariners were able to make their own icecream bore especially happy results: "Lack of icecream was a disappointment to all hands, especially when so much time was spent submerged--it is a big morale factor" (JACK No. 5). Also BLUEGILL No. 2, BOARFISH No. 1, and POMPON. "Food was excellent and well prepared. The abundance of fresh bread, pastry, cakes, rolls, and cookies provided by a conscientious cook went a long way toward making this a successful patrol." "The provision of a baker in the complement has done much to relieve the unavoidable monotony of pies and canned desserts." "Our icecream freezer was again one of the saving graces of the patrol and with experience our cook has been able to obtain excellent results." "I consider the efforts of the commissary department as contributing, in no small part, to the high morale of the crew."

Aboard S-class submarines, restriction of available storage space frequently led to a monotonous diet and deterioration of morale after 30 days (S-23, No. 2).

Some boats had dispensers for coca cola and root beer (TREPANG No. 1) which were popular. The commanding officer of the CABRILLA (No. 4) reported that "chewing gum is an excellent substitute for smoking during a depth charging and many prefer it."

Movies

In all, in 29 of these patrol reports, mention was made of the movies supplied to operating submarines. Some commanding officers considered them as "morale boosters," second in importance to successful sinking of ships. "Morale booster equipment No. 1 is the movie projector. The crew's response to the community-sing type of short subject is amazing."

Aboard the COBIA (No. 3) movies were shown each Sunday and Wednesday afternoons. ROCK (No. 4) gave a show twice a week. Aboard the HAMMERHEAD (No. 2) the 8 films were frequently shown in the first 4 days out and the last 4 days before reaching the Base--being especially "appreciated in the latter part of the cruise."

Other remarks concerning this beneficial effect were: "The 16 mm projector was enjoyed and contributed greatly to the recreation and well being of all hands" (ASPRO No. 6). "One of the finest and most popular means of entertainment is movies--definitely a tension relaxer and excellent for morale" (BAYA No. 3); "The movie projector with the 10 films--furnished much enjoyment for the men during the patrol" (CARP No. 1). "Motion pictures--and broadcast records afforded the crew--more leisure and recreation while on patrol than anything else carried for this purpose" (RAY 7). "After 8 months in commission the ship was finally able to procure its allowance of 10 movies which proved good morale boosters" (BOARFISH 3, Spring 1945). The following veteran submarines enjoyed their first movies aboard in the Fall and Winter of 1944--SEARAVEN on her 12th, HADDOCK and HALIBUT on their 10th, and the HAKE on her 7th patrol.

Concerning the available supply and selection of films, commanding officers had several suggestions to make. Seven requested an increase in quantity. ROCK (No. 4), SEA POACHER (No. 1), and STEELHEAD (No. 4) stated that they hadn't enough. BLUEGILL (No. 2) and HADDOCK (No. 10) considered that 5 features per patrol were inadequate. Stated SEAROBIN (No. 2): "We carried two 16 mm films--could get no more. The movies available are not evenly distributed. Some boats have as many as 10, others none. Believe that more effort should be extended in obtaining sufficient movies to supply all boats with at least 10 prior to going on patrol." "We could obtain none in Pearl Harbor; Midway gave us 3 films from the scant supply they had available. The value of having movies to break the monotony of long patrols is well worth the effort on somebody's part to make them available for all submarines" (SPADEFISH No. 2). "Movies are great for the morale. We swapped every chance we had. Before the patrol was over we managed to show 18 different programs at sea" (THORNBACK No. 1).

Concerning the available quality, the following comments were made: "It is hoped that the quality can be improved. A few pictures of good quality are sufficient for the entire patrol inasmuch as enjoyment can be obtained from seeing a good one several times" (RASHER No. 6). "--the available selection is very meager. The majority were third rate entertainment and usually an insult to one's intelligence. The commanding officer believes first rate movies should be available for a first rate audience" (RAY No. 7). "Acquisition of some late issue movies were very welcome" (BOARFISH No. 4).

Books, Magazines, Phonograph, Re-broadcast Records, Mail, Etc.

A plentiful supply of phonograph, re-broadcast records, books, magazines, games, and mail were all highly and equally important in passing the time and brightening the mental outlook of submarine crews.

SILVERSIDES (No. 1) early in the war recommended a completely new ship's library for each patrol, to be arranged by swapping. Paper back detective stories purchased by the welfare fund proved very popular. "Few new books were available. A book exchange run by tenders would permit the circulation of all books held by boats in the squadron" (BLENNY 2). "Through wearing out and loss, the ship's library shrank to a pitiful condition. None of the monthly shipments of books have reached this ship since commissioning and no activity around Subic was able or willing to supply us with books. The same condition existed with regard to magazines. We departed on patrol with no new reading material whatsoever" (BOARFISH 3). "Books issued this patrol were rated poor. The Armed Forces Edition contains a surprisingly large number of volumes which interested no one. Next time we'll pick our own" (THORNBACK 1). "There was an abundance of reading material which is ever welcome and should never be forgotten" (S-32, No. 5).

Concerning phonograph and re-broadcast records the following comments (from 9 patrol reports) were noted: "The record player is the best single item of amusement" (TROUT No. 2). "Transcription records are excellent and replaced the static filled short wave broadcast program. It is a fine addition to the many morale boosters" (BLUEGILL No. 2). "The special Armed Forces phonograph records were--enjoyed and the 50 carried were about the correct number to prevent too much repetition" (HAMMERHEAD No. 2). "We had to listen to the same Armed Forces phonograph records for another patrol in that no exchange library was available in Subic Bay" (BOARFISH No. 3). "The re-broadcast records for this patrol, the same records carried for the last two patrols, were all recorded in 1943 or 1944. Considerable time and effort was expended in trying to establish a suitable record library for this patrol but activities in the San Francisco, Guam, or Pearl Harbor areas had little to offer. The records are available if distribution can be directed to those who should receive priority" (RAY No. 7, June 1945).

Submarine personnel, especially those on long and boring cruises, became hungry for news of the world and the war. The commanding officer of the PERMIT in December 1941 after her first war patrol observed: "More current information is needed for morale." Concerning a similar request made by the GUDGEON at the end of her first patrol in February 1942, higher authority stated: "The amount of traffic handled on the few transmitters available at the Submarine Base (Pearl Harbor) precludes ComSubPac from sending press. Numerous high powered commercial stations can be copied by submarines on patrol. A list of these stations is being furnished all submarines." "Personnel can not be allowed use of the radio; 15 minutes of radio press around midnight is recommended." FINBACK (No. 1) in August 1942: "news should be available for morale. Provision of short wave radio sets would help this situation." And CUTTLEFISH (No. 2) about the same time advised condensed summaries of world news, particularly war news--"submarines on submerged patrols for long periods in distant areas are unable to copy press and lose all contact with the outside world." The commanding officer of the PIPER (No. 1) observed in March of 1945: "The daily news message could be more interesting."

Several submarines, being blessed with enterprising personnel, published their own paper. "The greatest morale factor is the paper published daily by our chief electrician's mate; Scabby Scuttlebutt--with daily editorials, jokes, acey ducey and cribbage tournaments and essay contests" (SCABBARDFISH No. 1). Aboard the GUDGEON (No. 10) the Gudgeonian proved a valuable asset to morale. The SARGO (No. 11) had her Daily Torpedo, and the TIGRONE (No. 3), the Tiger Rag. "Ship's daily paper was a huge success" (JACK No. 3). The BLUEGILL (No. 1) had a weekly newspaper--which published "scoops" when possible. Aboard the TAUTOG (No. 10) "the editor, a radioman second class, wrote up each day the biography of a different man in the crew which was not only of interest but served to make us better acquainted."

As in any branch of the Service, mail commanded a high priority. Every effort was made by responsible persons to have it on hand for submarines returning from war patrols. On the eighth patrol of the APOGON, 4 ammunition cans full of mail were received aboard from a plane--"the plane did an excellent job. Our morale went up 100 per cent." "Received mail--at sea (10 March)--our first since departure from Pearl Harbor on 16 December. It certainly was excellent morale medicine and was certainly worth all of the effort. Cigars were passed by two of the crew" (BLUEJACK No. 3). "Mail at sea--is certainly the genuine McCoy morale medicine" (BLUEJACK No. 4). At the conclusion of the seventh patrol of the SNOOK it was reported: "Immediately prior to departure from Saipan the mail bag was delivered and was full of official mail. The fact that there was no personal mail was a crushing blow to the spirits of the entire crew."

Unfavorable Effect of News and Broadcasts

Upon occasion untoward effects of mail were seen upon submarine personnel, particularly in regard to personal problems, especially when the man was about to depart upon a war patrol. In these patrol reports, on two occasions, mention was made of unfavorable effect upon the crew by news by radio: "On--received a news broadcast from San Francisco stating that the building program of United States submarines had been slowed down because submarine losses in the war had not been as high as had been anticipated. Such a statement had considerable effect on the personnel of a submarine patrolling in the heart of Japanese controlled waters" (RAY No. 5). "About 10 hours of this (61 depth charges) makes for a long day and all hands are a little fagged out--but took it pretty well with an occasional wisecrack to ease the strain. From news comments we learn that the Japanese are 'unable to cope with the submarine menace' we are sure glad to know it" (SAILFISH No. 7). Broadcasts from the enemy, particularly from Tokyo Rose sometimes provided considerable amusement, particularly when she described attacks which they had made, followed by "sure destruction" of the attacking submarine.

Other "Creature Comforts"

There were other "creature comforts", small in themselves, but which were highly appreciated by submarine crews; as vitamin capsules, sunlamps, etc. "The condensate tank and shower arrangement installed at Midway was a great morale builder during the hot weather" (PIRANHA No. 1). Everyone appreciated the presence of washing machines for the provision of clean clothing.

"Cigarettes, stationary, comfort kits and various pieces of wearing apparel donated to us by the Red Cross were very useful and greatly appreciated" (DACE No. 7). In this line, the wool, turtle-neck style of pullover sweater and the long woolen mufflers were much appreciated and cherished by members of the bridge watch on cold Arctic patrols. Sewing machines on many boats were popular and put to good use.

Much amusement and benefit to the ship's welfare fund was derived from "slot machines." The potential importance and need for one more morale booster, the supply of brandy and whiskey carried aboard submarines, could never be accurately determined at the time it was dispensed by the medical officer. Some brandy containers were supplied with plastic caps which were not particularly effective, with resulting evaporation and deterioration of the liquor. The quota per man--is not excessive and if available should be dispensed--and who would question its use to sometimes cheer an otherwise dismal day, as Christmas, when it sometimes found its way into the mince pie and egg nogs. "Issued one ounce of medicinal spirits to all hands, resulting in instant lift of morale. Four or 5 men obviously shaken remained at their posts" (CUTTLEFISH No. 3). "Brandy was rationed one ounce per man after each attack--not to quiet the nerves but to try and stop personnel from quivering from the cold" (SCAMP No. 1). "The most nerve racking attack of the TUNNY's career--sinking of enemy submarine--the reaction was worse than that following any depth charge. Passed out the grog and I took a double shot" (TUNNY No. 5).

"School of the Boat," Competetive Rivalry, Etc.

Being cognizant of the extreme importance of continual training, submarines on war patrols commonly held classes for the instruction of the men. "The school of the boat was perhaps the most effective way of relieving monotony. Interest, enthusiasm and pride of achievement were greatly in evidence among the officers and men" (BLUEGILL No. 1). "The principal means of usefully passing the time on the ship continued to be the qualification of new men" (TAUTOG No. 6).

Other commanding officers encouraged competetive rivalry among the crew to sharpen interest and performance. Aboard the BLUEGILL (No. 1) lookouts competed for sightings. Aboard the THORNBACK (No. 1) "Acey ducey and cribbage leagues were organized to keep up the morale and competetive spirit. We use a point system for grading our lookouts, weighing various objects according to their importance. The finest lookout wins a War Bond." Aboard the SARGO (No. 10): "Lookout contests with War Bonds as first, second, and third prizes--inspired greater interest and greater realization of the importance of the job. Spirit of rivalry between sections was used to encourage the keeping of a clean boat." "Probably the best result of the daily work period was to provide a daily period of physical work which broke the normal submerged routine of watches and sleep, preventing boredom and lassitude" (SHAD No. 1).

Holiday Celebrations Aboard Patrolling Submarines

Indirect reference has been made above to the enthusiasm for the service, and loyalty for a particular boat, commonly engendered in submariners. Men commonly protested attendance at sick bays, especially when stopping over at advance bases, because they feared being removed from the ship. Actually, decision to remove a man from an operating submarine, especially under such circumstances, should always be carefully considered by medical officers in view of not a few factors involved.

This loyalty and affection, of course, sprang from different sources, not the least of which was the spirit of comradery engendered by occasions such as follows. On the fourth patrol of the SEALION: "Held Christmas dinner in the crew's mess, the commanding officer officiating."

"Had some Christmas Eve spirit. The crew had decorated the crew's mess, making it look very festive. Ship's officers sang Christmas carols over the loud speaker and the crew's quartet rendered carols plus group singing. The final touch of Jingle Bells was rendered by the OOD, JOOD, and QM and two mess boys from the bridge over the IMC. It certainly made a big difference in morale, especially to the young fellows spending their first Christmas away from home." "Ushered in the New Year with appropriate ceremonies and all hands below deck making plenty of noise--the bridge detail singing 'Auld Lang Syne' and 'Show Me the Way to Go Home' plus myself blowing the ship's whistle and police whistle over the IMC" (HAMMERHEAD No. 3).

"On Christmas day enjoyed special recorded Christmas program and Armed Forces radio service and Noel Coward's movie 'In Which We Serve.' Santa Claus visited every member of the crew with a package through the services of the Honolulu Chapter of the Red Cross" (PUFFER No. 6). "On Christmas Eve the crew made a Christmas tree--a sawed off broom handle, decorated with medical appliances, medical cotton, green and pink file paper, paper clips, flash light bulbs, pasteboard wrapper, tinfoil, etc." (SEAWOLF No. 1). "On New Year's Eve--whistles, guns, flashes, splashes, tracer smoke, and No. 9 torpedo left the tube aimed at nothing in particular" (SNOOK No. 1).

The termination of hostilities, of course, was the biggest morale booster of all--"personnel factor was unlimited after the surrender" (ATULE No. 4). "Turned on the running lights and lighted the smoking lamp on the bridge. This was as much of a thrill as entering Tokyo Bay" (CAVALLA No. 6).

Mascots, Publicity, "New Construction," Etc.

Mascots were commonly carried aboard the boats--dogs, a cat now and then, occasionally a monkey, and once, for a very few days, even a very small and worried suckling pig. Concerning the dog, Luau, aboard the SPADEFISH, the commanding officer wrote: "dog contributed greatly to morale with ready playfulness for all hands--."

At the end of the fourth patrol of the TAUTOG in November 1942 the commanding officer wrote: "Believe morale--would be improved by good publicity. A firm belief that your work is actually helping to win the war must be maintained. Good publicity would maintain the confidence and spirit of the veterans and their folks back home." The commanding officer of the GUDGEON at the end of her seventh patrol in April 1943 suggested: "Submarine enlisted men need some form of recognition which they can show the folks back home, especially with the necessity for maintaining security. This would materially contribute to the continuance of high morale in the Submarine Service."

"New construction" with its promise of a generous amount of "State-side" leave were magic words to submarine crews. The announcement of a prospective "States-side" refit was often observed to booster morale. Mention has been made elsewhere of the facilities for rest and recuperation established for submarine personnel throughout the Pacific.

After a refit at Subic Bay the commanding officer of the BLUEGILL (No. 6) reported: "No malaria or venereal disease--despite the complete freedom of the crew at Subic Bay." "It is felt that this was a considerable morale booster. There has been no venereal disease on this ship in the past two years."

Church Services Held Aboard Submarines

Commonly before submarines departed on war patrols, Navy chaplains from other activities came aboard the boats and held services. On two occasions (BATFISH No. 1 and PERCH No. 7) Navy chaplains, as passengers, conducted services aboard the ships while underway. On the eighth patrol of the SHAD, while in port, a Protestant Chaplain held Christmas Services in the after room, while a Catholic Chaplain conducted them in the forward torpedo room.

A number of commanding officers either personally conducted or encouraged church services aboard their ships while on patrol. Aboard the ASPRO (No. 6): "Church services held every Sunday, conducted by Lt. (jg)--proved very popular and were well received by all hands." Aboard the HAMMERHEAD No. 1 and 2, church was held every Sunday, with usually from 15 to 20 of the crew attending. On the second, third and fourth patrols of the STERLET: "Divine Services were conducted by a licensed minister, a steward's mate, in the forward torpedo room--by request becoming part of the regular Sunday routine."

Services were held aboard the TREPANG (No. 1 and 2) concerning which the commanding officer stated: "There is a definite desire from a large percentage of our submarine crews to have weekly religious services. This has been amply proved by several submarines that had held Sunday Services. Knowing the help and comfort these Services provide for the men, the commanding officer recommends that all submarines give proper consideration to having a religious service of one form or another." This same officer wrote when aboard the HADDOCK (No. 6): "Realizing that we all have a feeling of need for strength outside our own to meet the emergencies of the present days, the commanding officer found the crew desirious of having a period set aside for devotional study. Therefore, the commanding officer conducted a church service every Sunday afternoon at which more than 1/3 of the ship's company joyfully attended. It is obvious that this has meant much to them as shown by their attitude and mode of thought." And on her seventh patrol: "In church services the average attendance is 24." "To dwell in Truth and Love is to dwell in calmness, poise and fearfulness of righteous thoughts. The men are gaining new confidence and have almost a complete lack of fear. The harmony existing through the whole boat is directly responsible for the success the HADDOCK continues to have."

The commanding officer of the HARDER (No. 4) observed that psychologically the presence of another submarine lessened the monotony of a normal cruise to station. Submariners were sometimes very conscious of their "lone wolf" status. When on patrols the spirit of all was bolstered by reminders that this was not necessarily so. "Visibility opened and closed like an accordian through which the sun could be sometimes seen. Nice to know that we are not alone in this foggy world." "The fact that help came had a profound effect upon the morale of the boat. We realize that our interests are important and we appreciate inexpressibly the care and attention we received" (TAMBOR No. 12, upon being met by a destroyer to discharge a man seriously wounded in a gun encounter with the enemy). A pharmacist's mate's morale, in part, is bolstered by knowing that the visiting medical officer is interested in his problems and ready to champion his cause, even if the doctor does nothing more than walk through the ship and talk to the crew. Morale aboard S-boats was considerably improved by the addition of a pharmacist's mate to their allowed complement.

PERSONNEL ENDURANCE AND PROVISIONS FOR REST AND RECUPERATION

This subject has been carefully analyzed by the Force Medical Officer, Capt. O. D. Yarbrough (MC) USN (The Submarine Rest and Recuperation Program, Serial Report No. 3, 5 Nov 1945, to Chief, Bureau of Medicine and Surgery, Research Division). "Owing to the enormous size of the operation areas and the large number of submarines in the force, it was necessary to establish a number of refitting points located in the following places: (1) Midway, (2) Majuro, (3) Guam-Saipan, (4) Milne Bay, (5) Manus, (6) Fremantle Area, (7) Brisbane Area, (8) Pearl Harbor, (9) Mare Island", and (10) Dutch Harbor. In general, there were two classes of refit periods--those carried out in "civilized ports" and those taking place at advanced bases.

The need for relief from the strain of patrolling was, of course, recognized before the war began. The following excerpts served to emphasize the need for adequate facilities for rest and recuperation. As when it was observed at the conclusion of the PERMIT's second patrol on 27 December 1941: "All the officers and men with few exceptions, and then only for a few hours, have been aboard this ship under the most trying circumstances since 8 December 1941. Opportunity to rest and relax in the sunshine is rapidly becoming important for the maintenance of good health, morale and efficiency." At the end of the STURGEON's first patrol on 25 December 1941: "--some means must be found to permit rest and relaxation at the end of a patrol. I know I need it right now and I feel sure the other officers and crew need it." The commanding officer of the SARGO, at the end of her third patrol in May of 1942 reported: "Since 8 December we have had 23 days in port--all hands are tired out and much in need of rest and relaxation." At the conclusion of the sixth patrol of the FINBACK in September of 1943 it was reported: "The system--whereby ship's personnel were relieved during the refit was the first real period of relaxation obtained during a refit since the war started--a good liberty port greatly raised the morale of the crew." The commanding officer of the BLUEBACK, at the end of her second patrol, pointed out that a 7 1/2 months' period had elapsed since her commissioning--"without adequate rehabilitation facilities (refitted at Subic Bay). This is not recommended for future new submarines joining the Force."

RECUPERATION FACILITIES IN ATLANTIC AND ALEUTIAN AREAS OF OPERATION

Inadequacy of refit and recuperation facilities in the European theater was reported by the commanding officer of the HERRING at the end of her first patrol. The commanding officer of the S-32 commented briefly concerning facilities available at Dutch Harbor at the end of the ship's fourth patrol in September 1942. The commanding officer of the BERGALL (No. 4) observed in April of 1945: "The officers and crew have been living aboard the ship continually for more than 3 months, with a one week rest period in over 4 months. This, plus the lack of fresh provisions to give a variety of food and limited recreation facilities in Subic, has resulted in a definite drop in eagerness of spirit." Similar comments were made by the commanding officer of the BLACKFIN in February of 1945.

FACILITIES AT MIDWAY

Concerning the facilities for recuperation and relaxation of submarine crews available at Midway the commanding officer of the BARB, at the end of her eighth patrol stated: "Recreation at Midway did much to put the ship's company in top physical shape which was reflected at sea in general alterness and constant cheerfulness in spite of the discomforts of the cold weather." The commanding officer of the RAZORBACK, at the conclusion of her fifth patrol, after refitting at Midway, observed: "Everyone seemed to be in a better physical shape than usual due to the well planned athletic program available for the crew plus the more than average interest of all officers in having a game or a swim daily." Concerning the spirit of that advanced base, the SEGUNDO observed at the end of her third patrol: "they appear to get a great kick out of meeting you there and it makes all hands feel good." The commanding officer of the GAR, having refitted at Midway, reported in that ship's tenth and eleventh patrol reports: "The rest period at Midway was not satisfactory"--due, apparently to the necessity for frequent shifting of berths of the crew while at the Rest Camp. And: "It is not felt that a rest period at Midway in the winter months is of any benefit to the general health of the crew."

FACILITIES AT GUAM - SAIPAN AREA

Most submariners were highly enthusiastic concerning the elaborate and well managed facilities provided at Camp Dealy on Guam. "The efficiency and alertness of lookouts, especially, during this patrol can be traced to the recreation period spent at Camp Dealy when all hands thoroughly enjoyed and benefited from a vigorous athletic program" (TRIGGER No. 11). At the conclusion of the fifth patrol of the PICUDA the health of the men and officers was reported to have been poor--"traced to the stay on Guam (December 1944) and the continuous inclement weather, lowering the resistance to infections, one case of 'yellow jaundice' and 13 cases of enteritis being directly traceable to Guam." The commanding officer of the ARCHER FISH at the conclusion of her fifth patrol reported that "there was a universally large number of infections of various sorts causing numerous sick days. It is possible that they were contacted in Saipan on a 2 day stop-over--almost all of the men affected had been swimming (over the side, alongside a tender) just prior to our departure."

REFITS IN BRISBANE, PERTH-FREMANTLE AREA

Concerning refits carried out in the Brisbane and Perth-Fremantle areas, the following comments were made: "The Perth-Fremantle area (BLUEBACK No. 4) is much

preferred over Subic Bay for recuperation. The commanding officer is inclined to agree with the consensus of opinion that tropical patrols should not be followed by tropical refits when conditions are such as to make this possible." The commanding officer of the FLYING FISH at the conclusion of her tenth patrol stated: "FLYING FISH was the second boat to refit at Majuro--and I suspect that from a health standpoint were much more ready for sea than before." At the end of next, the eleventh patrol, he observed in connection with the somewhat evident nervous and physical fatigue of the crew: "The Australian refit and recuperation was a change and enjoyable, but I firmly believe that the ordinary length of refits in 'civilized ports' not only make succeeding patrols a more difficult task but are detrimental to physical and mental health. The amount of rest and recuperation one individual gets from the refit period is largely up to the individual himself, but if it is possible to avoid dissipation why not do so rather than rely on the individual for self-control."

HONOLULU AREA

The facilities available in the Honolulu area, with the Royal Hawaiian Hotel at hand, were extremely adequate from almost every conceivable aspect and were much enjoyed. The commanding officer at the end of the SILVERSIDES' thirteenth patrol, in commending facilities in this area reported: "all hands enjoyed a ship's party at Kulumanu in the company of some 60 Waves," the lack of female companionship being almost universal at the major and minor refitting bases outside the "States."

BENEFICIAL EFFECTS OF MID-PATROL RECREATION

Several commanding officers commented upon the benefits occurring from brief periods of voyage repairs, refueling or reloading carried out at advanced bases. "The one day layover in Darwin (HAKE No. 5) giving us an opportunity for swimming and ball games did wonders," for a crew in whom prickly heat and debilitation was generalized due to "almost daily evasive action and/or attacks necessitating silent running with loss of air conditioning over a two week period." "The two day break in the patrol (RAY No. 5) while taking on a second load of torpedoes was most beneficial to health and morale." At the conclusion of the SPADEFISH's first patrol--on which a great deal of action in short periods was experienced, it was reported: "The two and a half days spent at Saipan did much to relieve the tension of all hands."

The commanding officer of the FLYING FISH (No. 1) was of the opinion, on the other hand that such breaks in a patrol were "far more beneficial to the ship materially than to the personnel." In contrast, the commanding officer of the BLUEFISH, at the conclusion of her sixth patrol, reported: "Had occasion to lay-over for two days for fuel--men fished, swam, washed clothing or just lay in the sun. We enjoyed the peaceful relaxation, yet when we went to sea all loose ends had been tied and everything was shipshape. It was a grand Ropeyarn Sunday. It was a distinct relief to be able to get underway calmly and with the confident feeling that everything was right in contrast to the confusion normally prevailing on most submarines on departing from a liberty port. My recommendation is to grant that extra day or two as a lay-over at the advanced bases rather than as an extension of the readiness for sea period at the refit base."

TENDER AND SHORE FACILITIES

For everyone serving with the Submarine Force at advanced bases there was a very real thrill connected with meeting submarines returning from patrol or merely stopping over for voyage repairs enroute to the patrol area. The submariners as indicated above, enjoyed these lay-overs equally as much. There was considerable that bases, tenders and their personnel could do to increase the enjoyment of their stay, brief though it was. One tender, the U.S.S. Orion, in particular, was commended by the commanding officer of several submarines as follows: "--the most outstanding thing to us and indicative of the high state of efficiency and discipline existing on the ship, was the performance of the laundry. In the first place they practically begged us to let them do our laundry. We were somewhat retiring about sending it for overnight service on account of having lost from one-third to one-half of it with regular service elsewhere lately. However, we consented and the ship, in addition to ours, took the laundry of 3 other submarines and had it all back the next morning. As far as we can ascertain, not as much as one sock was lost." The commanding officer of the BANG (No. 6) in this connection with the Orion noted the following facilities as worthy of note: "(1) one day laundry service, (2) recreation parties for the men arranged with an absolute minimum of effort on our part." The commanding officer of the POGY (No. 8) added to the list of friendly things done by this ship: Opening up the ship's service and barber shop for the submariners, providing them with movies--and "even offered to pay us."

Concerning a refit carried out by one of the other tenders, the commanding officer of the ICEFISH (No. 4) observed: "The officers and crew were very appreciative when they filed through the ship on an inspection tour to find the relief crew cooks and mess cooks in white, the tables set complete with new cloths and a delicious roast of beef being prepared in the galley for our returning men. It was an unexpected holiday for our cooks and very gratifying to all hands." "Free laundry, free haircuts, and free beer--all help boat morale" (BOARFISH No. 1).

Chapter 5

Training and Performance Record of Submarine Personnel Aboard Operating Submarines

There exists no other better illustration of the importance of adequate training and discipline of military personnel than aboard a submarine where the carelessness or ignorance on the part of one man may so effectively endanger the lives of all hands and jeopardize the mission of the ship.

Training of men for submarine duty, after they had successfully passed carefully prepared selective personnel tests, was carried out in submarine training activities, with training submarines, in relief crews and aboard operating submarines.

INTRODUCTION

On 19 December 1942, Admiral R. H. English, USN, in commenting upon the sixth patrol made by the S-18, observed: "As the war progresses, experienced personnel will become less in number aboard each submarine. Many new and inexperienced men will appear in submarine crews. It is, therefore, necessary that commanding officers be ever cognizant of this fact. They must direct their officers to assure that they and the petty officers are constantly training these men to guard against personnel errors causing materiel failure and subsequent early patrol termination."

The imperative need for continual training is only too apparent from the following statistics. The commanding officer of the GUDGEON (No. 11), in summarizing the calendar year of 1943, reported: "The 12 new officers reporting for duty represent a turnover of 150 per cent of the complement of 8; in the same period 98 new men reported aboard representing a turnover of 148 per cent of the complement of 66." The commanding officer of the RAZORBACK (June 1945) at the end of the ship's fourth patrol, reported that "in 3 refits the ship has absorbed 62 men of which only 13 had been on previous war patrols and only 10 of which were qualified. In the same period we have given relief crews 43 qualified men; of 16 returned to the general service, only 7 were necessary during the last 2 refits. This data indicates a high type of personnel in addition to steady improvement in the method of selection and training." "The allowed complement of 69 men now allotted fleet type submarines on war patrols should be revised upward. A review of recent patrol reports indicates that most boats now assign 25 men to a section. The many recent additions of new electronic gear have made this almost mandatory. More sonar and radar operating ratings are needed. Operators are sometimes as busy as a one man band, wearing phones for one piece of gear, looking at the PPI scope with another and warming up a third--" (TARPON No. 9, November 1943).

We have elsewhere referred to the statement made by the commanding officer of the SKATE (No. 1) that there is "no substitute for action to put everyone on his toes and to make new men realize what they are up against. Ten minutes of real action accomplishes what 10 weeks of 'talking about it' might fail to accomplish." Other observations along this line were: "The fact still remains--no amount of indoctrination and training will make seasoned submarine sailors. The only thing that will do this is to ride the boats" (PUFFER No. 6). "The efficiency of the crew began to improve noticeably shortly after the attack and depth charging while enroute to the area" (CABRILLA No. 1). "Long hours of silent running made the younger men soon realize their responsibilities as submariners" (PARCHE No. 5). "Quite

a few personnel casualties due to inexperience rather than neglect occurred during this patrol. Enthusiasm and youth are not a complete substitute for years of submarine training and experience" (SKIPJACK No. 9). "Performance of all personnel throughout--was most gratifying. The new men, green of course at the start, responded most satisfactorily to the intensive training given during the run to the area and the youngsters who at the first failed to spot a plane until it practically flew down the main induction and thought that good steering meant within 10 degrees of course, have returned as fire hardened, veteran trained submarine sailors. The Axis leaders should see the rock-like steadiness of these men in action--it would shorten the war" (CREVALLE No. 2). "The men received on the boat with patrols on other boats under their belts soon fitted into the routine and were old hands before we left on patrol" (ASPRO No. 6).

UNFAVORABLE PERFORMANCE REPORTS

In these patrol reports, upon occasion, unfavorable performance reports or suggestions for improvement of performance were sometimes observed. These have been collected and are presented as follows.

LOOKOUTS

With regard to the first patrol of the famous WAHOO higher authority commented: "On submarines--there is the necessity for continuous alertness and quick positive action immediately when a contact is made--a carrier not sighted until at a range of 11,000 yards--bears out the commanding officer's statement that a more alert watch could have been kept." "Training of lookouts is of the utmost importance and advantage should be taken of every opportunity to improve their efficiency. Desire to spot a plane, mast tip, periscope, torpedo wake, floating mine, dark object or anything out of the ordinary is always there, but the ability or 'know how' is often lacking" (ALBACORE No. 8).

Other comments made concerning lookout performance were as follows. "Lookouts almost without exception don't see as much or as quickly as officers or the QM. The lookouts are young, have more rest, a higher platform and a more restricted area of search." This indicates that observation is more closely linked to knowledge and responsibility than to visual acuity (SNOOK No. 2, July 1943). "Lookout reported a spot on the sun. OOD and JOOD observed spot and decided it was a plane. However, the QM who was on the high periscope reported the spot as a single engine, high wing monoplane and further stated that the plane had dove and was headed for the boat. OOD deeming discretion the better part of valor dove, the plane observed still being in the sun. Began to suspect that the plane was a planet. At 1745 so called aircraft disappeared with the setting of the sun; many faces red" (LAPON No. 3). "SD contact at 4 miles. OOD dove and sighted plane on leaving the bridge. Commanding officer sighted the plane, a B-25, passing abeam about one-half mile as the periscope ducked. Bridge watch was asleep on this one and am glad was a 'friendly plane'." (BOWFIN No. 8).

"Dove when port lookout reported an aircraft about 4 degrees elevation on the port beam just turning toward us. Although this lookout is an experienced man, having sighted aircraft on previous patrols, it is believed his contact was a seagull in the sun, especially since it is reported that he watched it wing over and head toward us within the space of a few seconds. For the few days of surface patrol it has been very tiring for watch officers (extremely cold; mountainous seas, everything on topside, including watch, covered with ice; temperature 23 degrees F.)--two hour period on the bridge is all that can be taken at a crack--and consequently they never get caught up on their sleep--" (SNOOK No. 8).

"In the past 2 patrols we have used every effort to keep the officers mentally and physically rested in order to be more efficient. Our experience is that tired officers make mistakes and do not have the proper amount of aggressiveness. One bright eyed watch stander is superior to two tired OOD's regardless of the amount of experience" (SEAHORSE No. 3).

"In a routine dive a lookout in the crow's nest failed to hear 'clear the bridge.' By the time that he was aware, from the sound of the vents, that the ship was diving, and had reached the hatch, it was closed. He dove over the side and was later recovered none the worse for his experience." On the second patrol of the TRUTTA "phosphorescent wakes created by fish darting here and there in the water produced a case of 'jitters' among the OOD and lookouts during the night."

On the third patrol of the STINGRAY "many sailboats, some lighted some dark, caused numerous false alarms and constant effort was required to keep the lookouts from adopting an attitude that anything sighted was not 'just another fishing boat'." "This was the first of many abortive approaches on junks before we finally got accustomed to the idea of 'untouchables' in the patrol area. Perhaps the worst feature of it is the inevitable 'familiarity breeds comtempt' effect on all hands, particularly the bridge and radar watch" (SEA OWL No. 2).

"Inability of the commanding officer and OOD to hear the lookout's warning regarding the approaching plane might have had serious results. A more positive means of communication, such as the lookout grabbing the arm of the OOD, is recommended for future use" (TULLIBEE No. 2).

On the ninth patrol of the SEAWOLF "seven contacts comprising 36 ships and 4 reported convoys not to mention many sampans were made." "It might be said that the abundance of targets operated to the ship's disadvantage in that visual contacts, issued positions and reported positions resulted in a failure to relentlessly pursue the 'sure thing'."

The commanding officer of the RASHER (No. 4) reported some interesting statistics concerning the efficiency of lookouts. On this patrol there were 110 aircraft contacts, of which 62 were made on the surface and 48 while submerged. "We were forced to dive to avoid 30 of the 62 contacts made while on the surface. Further breakdown revealed that 13 contacts were made by sight and SD radar simultaneously; 24 by sight only and 25 by SD radar only. Of the 24 made by sight only, on 7 occasions the plane was in such a position that it could have effectively bombed us and appeared to intend to if we had not sighted it and submerged immediately. On these occasions we were saved by our lookouts, quartermasters or OODs who had developed into excellent plane spotters. But there were 25 occasions when planes were not sighted by the bridge watch due to low clouds, high speeds, high winds, rain, etc., but were picked up by the SD radar. On 14 of these occasions, the rapidly closing range indicated that the plane was heading directly at us--."

GUNNERY

Gun "Flash".--The commanding officer of the TAUTOG, in April 1943, after the sixth patrol of that vessel reported: "The gun attack showed the inexperience of the TAUTOG crew; misfires caused confusion; many were taken by surprise and temporarily blinded by the flash." Several commanding officers, through the course of the war, reported similarly concerning the blinding effect of deck gun fire. POLLACK (No. 2) in April 1942, reported "blinding effect of night gun firing--attempted to obtain flashless powder in lieu of which submarines must arrange for a signal for the pointer to give before firing--such as blowing on a whistle in order that the gun crew may close their eyes just before the flash." "When firing the deck gun at night a signal must be given to mitigate the detrimental effect of the gun flash on night vision. A whistle signal is recommended. In battle surface the first blinding effect of the gun flash caused acute danger to our own ship by ramming" (TRITON No. 3, June 1942). "Fired 3 inch gun after dark with pointer blowing a police whistle just before firing as a signal to the rest of the crew to close their eyes to prevent blinding from the powder flash. Works well for bridge personnel" (STURGEON No. 6, January 1943). "The so-called flashless powder is neither flashless nor uniform in its intensity" (POGY No. 5, March 1944). "Pointer and trainer blinded by flash of 5 inch and tracers of 20 mm and 20 caliber--resulted in very inaccurate shooting" (GAR No. 12, July 1944).

"In battle surface--the after 40 mm partially blinded the 5 inch crew; the blast from the 5 inch trained well forward almost lifted the 40 mm crew out of their seats" (TIRANTE No. 1, April 1945). "The blinding effect of our own fire on a dark night rendered firing relatively inefficient--estimate 20 per cent of hits by 20 mm and .50 caliber" (BOWFIN No. 9, July 1945). On the twelfth patrol of the BARB, when rockets were used successfully for the first time in submarine warfare, goggles were worn when the rockets were launched.

SONAR AND RADAR OPERATIONS

On the fourth patrol of the GUARDFISH the following incident took place. "The convoy had not yet passed our position. The ascent to periscope depth was abruptly interrupted when a heretofore reliable sound operator announced that the destroyer had speeded up and was 'charging directly at us.' Deep submergence ordered. When no attack developed and the operator continued his somewhat melodramatic report it was apparent that they were unjustified. Started for periscope depth but critical time had been lost. Although the man is removed from that important post he is not condemned. The sound man must say what he thinks he hears and it is felt that the man's imagination was sharpened by fatigue or perhaps the strain of the recent days."

Aboard the PIKE (No. 6) "a destroyer was sighted at less than 200 yards--loud screws were heard passing overhead." "Apparently the sound operator gave no information to the commanding officer concerning the close proximity of the destroyer" which was, in part, "responsible for the precarious position in which PIKE found herself."

"Sound operator reported torpedo crossing bow from starboard to port. Turned right and increased speed. Although the sound operator is a very reliable man I seriously doubt that it was a torpedo" (PIPEFISH No. 1). "Took course--to head out to deep water. Sound gave another good 100 feet below us--so rigged out JB sound-head and ordered 150 feet. Somewhat disconcerted presently to find ourselves neatly, and gently--bottomed at 152 feet. JB sound heads sheared off. At this point our fathometer watch blandly offered soundings of over

100 feet. He's a normally reliable man but--it is possible through nervousness or tension--he was working on false echoes" (POMFRET No. 1). The RASHER, on her third patrol, experienced a particularly harrowing 18 day period of patrolling on which, on one occasion: "Sound reported weak echo ranging dead ahead--contact was not developed due to other sound and radar contacts close aboard in the next two hours--apparently porpoises as nothing was seen. The sound and radar operators were getting fuzzy about this time."

Aboard the NAUTILUS (No. 3) on one occasion the "OOD taking a routine periscope look called to the bridge--'torpedo sighted'--. The sound man became so excited upon hearing the torpedo so close that he did not continue to follow its bearing but held on to the stanchion thinking the explosion would occur momentarily--despite the fact that he was not an inexperienced man."

"All ready to surface when sound suddenly reported: 'Torpedo on port beam'--. We were at 42 feet and it seemed an eternity to get back down. Everybody aged 10 years. Later determined contact was probably not a torpedo but a sudden and loud fish noise" (LIONFISH No. 2). "--sound operator reported a torpedo bearing. A description of the sound heard indicated a torpedo but the duration of the contact seemed to have been too short to have been the real thing. An opportunity to hear a torpedo running should be afforded all sound personnel during their training period since defensive measures against enemy torpedoes are becoming more and more necessary" (GUARDFISH No. 11).

Concerning the third patrol made by the PADDLE, in connection with means of eliminating the many phantom targets and false contacts (actually bird or floating objects) it was observed, in part, that "there can be only one solution to this problem and that is the augmenting of the training program for the operators."

ERRORS MADE BY PERSONNEL ASSOCIATED WITH FIRING OF TORPEDOES

With regard to this problem the commanding officer of the SCAMP (No. 3) observed: "No amount of training can replace the actual firing of torpedoes." On her fourth patrol: "Fired 4 torpedoes--missed due most probably to the TDC operator dropping the target speed 2 knots without informing the commanding officer who was in the control room." Aboard the SALMON (No. 4) "failed to sink a valuable target, apparently due to personnel failure in operation of the TDC causing the torpedo to go out on the wrong gyro-angle and pass astern of the target--illustrating the need for constant training of the entire torpedo control party." "Miss of one torpedo was caused by fire control error--the TDC operator had 'halved' the intended speed of the target." "Previous use of the halving device made this an ironical and subconsciously applied error" (LIONFISH No. 2). "Gave TDC new set up. TDC operator got target bearing confused with DD bearing and set wrong bearing on TDC. This gave a large gyro angle--when error was discovered--target had zigged giving us a 180 angle on the bow--decided not to waste the torpedo. This was a hard one to miss after watching him for 10 hours and successfully avoiding his surface and air protection. It hurt to have a control error keep us from firing. We have all learned a lot from our initial contact with the enemy. This was the first time any of the officers on the ship except the Exec had made an attack on the enemy. There was undoubtedly quite a bit of buck fever and some tense nerves and things didn't run as smoothly as they could" (PIRANHA No. 1).

At the end of the ninth patrol of the TUNA it was observed: "The efficiency of the fire control party, when tracking and making surface attacks, was considerably reduced by the great handicap of lack of means of communication between the bridge and the conning tower other than by shouting" (No. 9, January 1944).

"Misses on the first salvo at the AK can be accounted for as a control error. The TDC selective switch was on 'Position Keeper' only and not 'Position Keeper and Angle Solver.' The operator inadvertently placed it in this position in the dark and didn't use a flashlight to check. Luminous paint has now been added" (DACE No. 1). On the fourth patrol of the SNAPPER personnel errors in firing were on the basis of: (1) one torpedo was fired on the "stand-by to fire" order; (2) the QM neglected to put on the white light. On the third patrol of the SARGO, personnel were responsible for "repeated casualties in torpedo fire." Errors were made by the TDC operator. On the seventh patrol of the SPEARFISH: "Opportunity to inflict irreparable damage upon the enemy was missed when the ship's fire control party failed to function properly. Because of deficiencies in the fire control organization, the target got by and SPEARFISH was forced to use unfavorable tracks and gyro angles. The range and speed problems were underestimated. The officer who should have kept the approach officer informed of the track and gyro angles failed to do so and the commanding officer failed to realize the situation until the target had gotten by." "Apparently, confusion in the fire control party in the early part of the patrol accounted for the apparent lack of smoothness and coordination in the fire control party" (TINOSA No. 1).

Aboard the FLYING FISH, on her second patrol, the following incident took place: "Started up normal operating machinery--continued to maneuver keeping the destroyers astern and watched aircraft patrolling the area. Ordered No. 9 torpedo tube blown down and

torpedo inspected for tightness. Very soon thereafter felt the ship jar and noticed a large slick directly astern. Informed by after torpedo room that a nervous torpedoman had fired No. 7 torpedo by hand with a full impulse charge, the outer door closed, instead of firing No. 9 torpedo. While this information was coming through, a loud explosion took place and I raised my periscope again for a quick look and noted a plane had dropped a bomb directly astern, in close proximity to the slick left by the partial impulse from the No. 7 impulse bottle."

On the eleventh patrol of the GATO in an attack: "Commenced reload aft--after torpedo room reports all tubes empty. Upon investigation found that the torpedoman between the tubes had hit the hand firing valve on No. 7 tube when he should have fired No. 8; consequently No. 7 and 8 torpedoes went out simultaneously."

On one occasion aboard the TARPON (No. 1) "when 20 degrees from firing bearing, a torpedoman in a hurry to stop a small leak in a tube fitting, fell against a solenoid and fired the No. 1 tube." On the fifth patrol of the PARCHE: "Five early explosions occurred from the bow tubes--the torpedoman had by mistake reset tubes No. 2 and 4 back to high power."

"Number one and two torpedoes were fired simultaneously because of personnel error. SEAHORSE (No. 3) directions call for the torpedoman stationed between the tubes to fire by hand at the same time the tube is fired electrically to avert misfire in case of electrical failure. Due to a change in personnel, this particular man was at this station for the first time. It was simply a case of 'buck fever'."

Aboard the ICEFISH (No. 4): "--while routining torpedoes and tubes, an inboard slug was fired from No. 9 tube." On the seventh patrol of the HERRING: "No torpedoes were fired due to misunderstanding between the bridge and engine room, resulting in a delay in starting the engines, the range becoming excessive. During the excitement of trying to increase the range (the target having been determined to be a submarine) no torpedo tubes were made ready."

"Inspected 3 remaining torpedoes and found all flooded--during the excitement of sinking the destroyer and depth charging had forgotten to drain the tubes" (RATON No. 4). On the tenth patrol of the SILVERSIDES: "Heard torpedo hit. Had raised periscope but was ducked due to the torpedoman being overly ambitious in holding the poppets open." On the first patrol of the PINTADO: "Periscope dipped momentarily, due to a large amount of water taken in through the poppet valves forward by an over enthusiastic torpedoman." "On this patrol most of the action was crowded into the space of one week--only a mentally and physically fit crew could have had the endurance to continue the series of engagements over this period with the little rest permitted--the torpedo and fire control performance was exceptionally noteworthy."

"In the midst of the battle--put a little distance between us and this hornet's nest, and dawn commencing to break. This decision was further prompted by the fact that the gyro setting gear on all tubes forward had been jammed when the torpedoman commenced matching gyro setters just as the last spindle in tube No. 5 was being engaged, thereby bending it and preventing it from being disengaged."

On the third patrol of the NAUTILUS: "At range of--fired 2 torpedoes. Neither took the gyro angle generated by the TDC but went out on zero gyro. It is believed that during the process of getting the tubes ready the new men in the torpedo room (only one torpedoman in the room had been in battle before) became excited and knocked against the handle which withdrew the spindle from the torpedoes."

"Upon checking reason for misses, discovered that angle indicated on forward gyro indicator read 358, 4, 12 degrees at the time of firing. The first one was correct with the TDC but the other two should have read differently. The torpedoman stationed at the gyro indicator stated that he thought the dials were matched at the time of firing--I am convinced that the misses were due to personnel error and that the pointers were not matched when we fired the last two torpedoes" (KINGFISH No. 2).

"--while returning from patrol (APOGON No. 3) torpedoes were on one occasion being routined in the after tubes. Impulse in tube No. 10 was bled down and the torpedoman was ready to check the firing circuit. A mental lapse on the part of the torpedoman in charge caused him to disconnect the interlock in tube No. 8, raise the ready to fire lever on tube 8 and trip the hand firing key on this tube which was in ready condition--e.g., accidentally fired No. 8 with the inner lock open and the muzzle door closed thinking he had fired No. 10. The torpedo forced against the outer door had a hot run in the tube." "The ship was stopped; inspection over the side showed the torpedo to be sticking 18 inches out of the tube. The war head was dented and scratched and looked as though it was slightly cracked. Torpedo officer went over the side and wired the exploder impeller to prevent rotation. The tube was then fired--."

On the fourth patrol of the CREVALLE, in the midst of an attack, following firing of a torpedo, because of flooding of the after torpedo room, it was necessary to broach in the middle of a convoy. "Flooding was stopped in the after room with the bilges about two-thirds full. This was purely a personnel casualty,--caused by opening of the after trim tank vent rather than the No. 10 torpedo tube vent. This caused the poppet valve to remain open with

resultant flooding. Personnel were slow in closing the emergency stop, but in the meantime the man at the vent manifold had realized his mistake and opened the No. 10 tube vent leaving it open. This closed the poppet but allowed flooding through the inboard vent. The outer door could not be closed as the gyro spindle was not fully retraced. Closing the vent stopped the flooding, merely jarring the gyro spindle allowed the outer door to close. Personnel responsible--became excited after the first error and did not think quickly and clearly enough." "The man responsible for the error has had four patrols on this ship and is an experienced and reliable petty officer. He is, however, showing strong tendencies toward nervousness and will be left in this time for a rest. The loss of a shot at such a valuable target was heart breaking to all hands--." In the ensuing counter-attack 58 depth charges were received.

FLOODING

One of the most serious casualties that may occur aboard a submarine is flooding of the conning tower and the control room.

On the first patrol of the RUNNER in a drill dive, the lookout's coat caught on the conning tower hatch. On the eighth patrol of the PETO an "over-anxious watch partially closed the dogs of the conning tower hatch before it had returned to its seat." On the ninth patrol of the SHAD a "close call was had in an emergency dive when the conning tower hatch dogs were in the extended position and the hatch could not be closed."

On the sixth patrol of the RAY: "The quartermaster closing the hatch started the wheel too soon--the wheel jamming hard against the weighted lock. His attention being centered on freeing the lock, he failed to realize the hatch was open. Attempts to close the hatch were futile, and he was washed away by the rush of water. The ship went to 80 feet before starting up--flooding two-thirds of the conning tower." On the eighth patrol of the SEAL, failure to close the conning tower hatch promptly flooded the pump room. This occurred 4 days after entering the area, necessitating withdrawal to sea for one week to effect repairs. While diving, when the conning tower hatch was closed, the latch failed to catch and the hatch flew open.

On the second patrol of the TRUTTA: "--as the fog suddenly lifted--inevitably many fishing vessels were nearly hit--. Made a quick dive. As the bridge was being cleared a set of keys fell on the conning tower hatch knife edge and the hatch could not be closed. Blew all main ballast immediately; caught ship at 35 feet and brought her up handsomely--cleared knife-edge and submerged. Quick action of all hands concerned prevented what could have been a serious flooding of the conning tower."

On the eighth patrol of the TUNNY the "JOOD leaned against the diving alarm for a perfect diving signal. Got vents closed and boat back on the surface. Helmsman pulled hatch closed when the water started in. No damage but--made Christians of the bridge watch."

DIVING AND SURFACING

The HARDER, on her fifth patrol, received 3 exploding depth charges on reaching 300 feet. "A new stern planesman, observing the plane indicator inoperative (with I.C. circuit de-energized for silent running) thought he had lost power on the planes and made a quick shift to the hand operator. Then he wrongly put the planes on dive instead of rise as we passed 300 feet. The ship took a 15 degree up angle and rose to 250 feet. This was strictly a personnel casualty which should never have occurred, but considering the noise and concussion of the depth charge at the moment--."

Another episode indicating the necessity for training occurred aboard the SEAL (No. 2). "When--on diving, the commanding officer ran up 'Emergency Ahead', the first time this spot on the engine room telegraphs had been used during his period aboard the SEAL. It was a new experience for the planesman also and the boat took a large down angle which we blew and backed out of at 120 feet. Tanks were not vented soon enough so that the boat partially broached and then made a normal dive."

On the sixth patrol of the KINGFISH, while patrolling in extremely dangerous navigational waters: "Escort opened fire. The first shot was directly overhead--cleared the bridge and intended to swing hard left--in the ensuing confusion of the lookouts and control party going below JOOD commenced to dive leaving the Captain and Exec on the bridge. Ordered vents closed and 'Blow all main ballast.' The controllerman hearing the vents operating shut down the engines--as the range was closing rapidly we decided to dive at 60 feet--a few moments later the DD passed directly astern and dropped 5 depth charges. Ordered (or rather begged) for 350 feet."

On the fourth patrol of the NAUTILUS (a patrol made harrowing by faulty air conditioning, large numbers of passengers, etc.): "We had immediately gone to battle stations--on sighting a submarine--and during the moment when a decision had to be made whether to attack the submarine on the surface, the commanding officer ordered a depth of 38 feet. The diving officer inadvertently flooded negative and we went to 60 feet before we caught it--by the time we got up to 38 feet radar had lost contact--."

Aboard the S-18 (No. 6), while enroute to her new station, "in starting the engines after a dive, the starboard main engine housing was cracked as the result of turning over with water in the cylinders--. Responsibility for this casualty rests entirely with personnel." On the fourth patrol of the HAMMERHEAD, on one occasion, an unfortunate incident occurred when the throttleman did not properly start No. 3 and 4 main engines on surfacing.

MISCELLANEOUS

On the eighth patrol of the RAY "in diving from 3 engine speed our SD watch was 'right on the ball' and left the SD mast up. Before it could be lowered the force of the water bent the mast sufficiently to wedge it in raised position."

Aboard the ROBALO (No. 1) in diving "the engine induction was flooded due to personnel error in carrying out the normal procedure of locking the valve closed upon diving."

Aboard the SPADEFISH (No. 2): "--escort opened fire with 40 mm. Ordered bridge cleared. The helmsman overheard the word that we would not dive, mistook it for the word 'dive' and put his annunciators on 'full' position--signaled to maneuvering to shift to battery and stop the engines. Before the error could be rectified we had slowed to 8 knots and the escort had closed to 970 yards."

"In coming alongside the dock at Midway when 'all engines back full' was ordered the man on the annunciators became confused and rang up 'ahead full'." (NARWHAL No. 1).

With reference to the fourth patrol of the RAZORBACK it was observed: "unreliability of TDM is ascribed, in part, to unfamiliarity of operating personnel with the gear." And with reference to the 8 patrols of the STURGEON: "Throughout the patrol was hampered by an inordinate number of casualties--much of the responsibility for which must be laid to the ship's company--who need further training in routine maintenance work and particularly in effecting repairs."

On the first patrol of the SUNFISH "two attacks failed because of personnel errors. In one instance depth control was lost although the sea was calm; in the second, failure to close a fire control switch--an old casualty which can only be cured by frequent drill and proper use of existing communication systems."

On the sixth patrol of the TARPON, a main ballast tank was ruptured when an inexperienced man from the relief crew on watch allowed the pressure in the tank to build up to an excessive limit. On the eighth patrol of this ship "the batteries were salted" as the result of negligence on the part of a watering electrician's mate.

During the third patrol of the SPEARFISH, on 27 April--"decided to--obtain some sleep since with one thing and another it has been impossible to obtain more than one hour uninterrupted sleep since 4 April and may have been the cause of apparent poor judgement which almost directed SPEARFISH into a submarine net."

On the first patrol (9 December 1941) of the STINGRAY the following incident occurred: "On the 21st I sighted a ship--my OOD and QM reported that they could make out her outlines. I could not and did not fire--. It is suggested that commanding officers be given rigid physical examinations every few months. I have had very good to excellent eyesight with the last physical examination in March of 1940--believe my eyesight has deteriorated since the last examination--because in several instances episodes as the above have taken place."

COMMENTS CONCERNING PRELIMINARY TRAINING OF MEN RECEIVED ABOARD SUBMARINES

Concerning the caliber of men reporting aboard submarines for duty from training schools the following comments, made through the course of the war, were observed.

The commanding officer of the TARPON (No. 8) observed in September of 1943: "The caliber of our new men seems to be improving. They were all good men for this patrol. Usually on each patrol we have found one or two men entirely unsuited for submarine duty." At the conclusion of the first patrol of the BLUEFISH in October of 1943 the commanding officer observed: "There certainly has been no evidence of any deterioration in the caliber of submarine personnel detailed to new construction. The crew was in all respects equal to the crew assigned to the GREENLING."

"The first patrol in only a little over 4 months since commissioning and with 44 totally inexperienced men in the crew; it is not considered that this crew is sufficiently trained to be called an experienced submarine crew" (BONEFISH No. 1). The commanding officer of the RASHER in November 1943 (No. 1) reported: "This the first patrol after the intensive period of commissioning and training--was the acid test and the performance of duty indicated that dilution of experienced personnel has not been extended too far and that the schedule of schooling and training is more than just satisfactory."

Observed the commanding officer of the TAUTOG (No. 9) in January of 1944: "The general attitude of the officers and men as we enter the third year of the war continues to be

excellent. The policy of rotation is a most important morale factor. Although the average experience of personnel is constantly being lowered--performance is not reduced. An enthusiastic new hand--and most of them are--acts as a stimulating tonic. Veterans take delight in demonstrating their knowledge and feel more keenly their responsibility."

With regard to the first patrol of the CROAKER, completed in August of 1944, it was observed: "The commanding officer is particularly impressed by the keenness of the youngsters received from the Submarine School. The selection and screening methods developed at the school are believed to be responsible for our receiving the type of young man we want and need in submarines. It is hoped that some system for improving the quality of steward's mates can be devised. In the new construction period, noticed that chief petty officers making several war patrols frequently lost their enthusiasm for returning to combat duty. The conditioning being brought about through contact with chief petty officers having little or no combat experience and established in shore duty in the New London area." Recommend consideration of establishing a policy whereby no chief petty officer will be assigned to shore duty or shore based duty in the submarine service in the United States until he has completed 6 war patrols. Such a policy, if widely publicized and adhered to, would do much to maintain the high state of morale which has always typified these key men in fighting submarines.

The commanding officer of the ROCK (No. 4) in November of 1944 pointed out the need for rated members of the stewards branch. He commended the present program of training at New London "but to realize its full worth the new boys should have the opportunity to work with more experienced men on board the ship." In December of 1944 the commanding officer of the ATULE at the end of her first patrol observed: "The system of selection--turns out exceptionally well trained men who are mentally quick, enthusiastic and possessed of a background of fundamentals enabling them to learn quickly. A far cry from the raw recruits we once found in relief crews. Their familiarity with lookout technique and procedures was particularly noticeable."

In January of 1945, after the first patrol of the SEA POACHER, the commanding officer reported that there were 30 men aboard under 21 years of age--"the greatest defect is the immaturity of a large percentage; they must be weaned and it is frequently a slow process. Loss by attrition and weeding out from the fitting out period to departure on war patrol accounted for 14." The commanding officer of the ROCK (No. 5), February 1945, commended the psychological research carried out by the medical department at New London and recommended that all replacements for submarines be submarine school graduates. He presented some interesting statistics involving the number of men qualified, temperamentally disqualified, and transferred in the 5 patrols that the boat had made. On her sixth patrol in May of 1945 he recommended "return to the system of refitting boats with own crews as being beneficial to boat and personnel."

Note has been made earlier of the remarks of the commanding officer of the RAZORBACK (No. 4) in June of 1945 concerning the "high type of personnel" supplied his ship indicating a "steady improvement in the methods of selection and training." At about the same time it was observed from the POMFRET (No. 5) "the non-rated men obtained prior to patrol were not up to the usual high standards of men previously obtained." The QUILLBACK in July of 1945 considered that of the various sources of personnel provided the ship, those men received from the training submarines in New London were, as a class, least adaptable to new methods and combat experience. At the close of the war, the commanding officer of the THORNBACK (No. 1) reported: "The type of men being supplied from the Submarine School seems to have greatly improved since the beginning of the war. Men, though young, are alert, interested, enthusiastic and clean cut."

The commanding officer of the ASPRO (No. 2) in March of 1944 observed that "the policy of transferring 25 per cent of a crew to the relief crew after each patrol with no men eligible for transfer until they have completed two patrols on the boat works a particular hardship on new submarines. Recommend that for new submarines it be less than 25 per cent."

TEMPERAMENTAL DISQUALIFICATION OF MEN FOR SUBMARINE DUTY

Men who, for one reason or another, proved unable to meet the demands of life aboard submarines were removed from the boats. Frequently the statement that they were temperamentally disqualified for further duty aboard submarines was made in their service records by their commanding officers.

But little information is available in the patrol reports concerning this subject. "Four men were not good submarine material" (TRIGGER No. 10); "two new men proved unsuitable" (TINOSA No. 4). "At Midway on the way out one man was transferred for chronic seasickness, another was temperamentally disqualified" (SUNFISH No. 9). "One man was temperamentally disqualified. We had nursed him along since the ship was commissioned, taking away his responsibilities one by one till he ended up as an oiler. Even at this simple job he nearly caused

a serious casualty to a main engine" (SEGUNDO No. 2). "Between the time of commissioning and the start of the patrol 11 men were detached--four being temperamentally disqualified" (LARGARTO No. 1). "Before the beginning of the patrol 4 men were removed; 3 were temperamentally disqualified and one was removed because of chronic insomnia" (FLOUNDER No. 1). "One officer is not fitted for submarine duty" (FLYING FISH No. 11).

In all, according to the patrol reports, 20 men were removed from submarines for this reason. Actually, the number of men temperamentally disqualified and not mentioned in the patrol reports must have been several times this figure. At the conclusion of the eleventh patrol of the POLLACK (September 1944) the commanding officer observed: "Performance of personnel was excellent except for 2 or 3 men. Increasing numbers of men that are unsuitable for the submarine service are being received from the relief crews and are cause for grave concern. Not only do they add a burden on the remainder of the crew but the time and effort spent in attempting to train them is lost. With the current heavy demand for new construction it is imperative that replacements be trained as rapidly as possible. The requisite amount of training can be only obtained in a certain minimum number of patrols. Each man who has to be disqualified occupies a billet which could have been filled by a man who would have benefited by his experience. It is felt that more could be done to eliminate these men from relief crews before they ever get to sea. Perhaps some sort of a psychological test would help to eliminate some of the more unstable ones. Boats should not be permitted to transfer undesirable men to relief crews without disqualifying them. Any man transferred before making less than 3 runs is certainly subject to question and the boat should be required to explain why he is being transferred if not disqualified."

EFFECT OF ILLNESS UPON PERSONNEL PERFORMANCE

Mass illness, as we have seen elsewhere, can not help but adversely affect performance aboard a submarine. As aboard the HALIBUT (No. 5) when "loss of depth control on one attack was most important in that it prevented firing at a carrier. The order to make ready the tubes had been given rather late. This was combined with personnel errors in hurriedly preparing all tubes--at this time nearly all the crew were handicapped by sickness from food poisoning."

Acute, chronic and disabling seasickness among submarine crews is very important in this respect. "Seasickness was very prevalent among the new men on the way to the area, making men in a few cases unfit for duty. Strongly recommend refit crew personnel be combed of men subject to chronic seasickness to avoid what could easily become a dangerous situation to a submarine on patrol" (SILVERSIDES No. 12).

However, the illness of one man in so closely an integrated a crew may produce considerable inconvenience. The commanding officer of the SHAD (No. 2) observed in this respect: "Decrease in the number of men in a crew on a long patrol--does not permit flexibility of the organization without loss of efficiency, when, through illness or accident, a man is placed on the binnacle list." Aboard the BOARFISH (No. 4) "loss of the services of a torpedoman (through an accident) put a strain on our organization--carrying only 74 men leaves no spares in case of sickness or disability." Aboard the HOE (No. 4): "Fired torpedo--unable to observe it through periscope due to depth control difficulties caused by improper operation of the poppet valves. This was due to the leading torpedoman injuring his back and resulting in loss of a man and shuffling of assignments."

Illness or the death of a commanding officer or an executive officer may be seriously felt. As aboard the BUMPER (No. 1) which left Panama on the 15th of March 1945, enroute to Pearl Harbor. On the 18th "transferred Lt. Comdr.--to the USS--for medical treatment with a diagnosis of a ruptured appendix with preliminary peritonitis. The attack was sudden, unusual and devastating. It was with heavy hearts that we saw him hoisted over the side, for his untiring devotion to the organization and training to make the ship a fighting unit has been without parallel in my experience." Sudden loss of the commanding officer of the HADDOCK on her eleventh patrol, while stopping over at Saipan, through a serious accident, was felt deeply by the crew. "The unfortunate illness of the commanding officer of the POMFRET necessitating her return to Saipan--the ability of the ship to carry on despite his illness and the spirit displayed by the commanding officer during an attack despite his physical condition reflects great credit on the POMFRET" (endorsement to her second patrol).

INSTANCES OF UNUSUAL AND COMMENDED PERSONNEL PERFORMANCE ABOARD SUBMARINES

There were, in these patrol reports, enumerable instances when performance of duty deserved and received considerable commendation.

LOOKOUTS AND RADAR AND SOUND OPERATORS

Good lookouts were invaluable as the following comments will testify: "During the period from 13 to 15 May--in which we were in contact with a convoy almost constantly and at battle and tracking stations for long periods--the crew stood to their tasks in a commendable fashion. The alertness and attention to duty of the lookouts has been particularly commendable. It is believed that the high standards maintained by a group of petty officers who had stood these watches for 3 patrols has been a dominant factor in eliciting the same high standard of performance from less experienced men. Alertness of the lookouts saved the ship from possible embarrassment by small patrol boats at least on 3 occasions and from aircraft on several others" (ASPRO No. 3).

The ATULE, on her second patrol, "established a record for mine destruction--sinking or detonating 21 mines on this patrol--which is indicative of the high state of lookout training and expert marksmanship."

"Radar contact was made with a small object dead ahead at 1500 yards. It was immediately sighted from the bridge. At 1200 yards it was discovered to be a low pinnacle sticking straight up out of the sea with white foam breaking around it--came within 400 yards of grounding on it as we reversed course. Special credit is due to--for his alert watch standing which undoubtedly prevented a grounding which might have been disasterous" (HARDER No. 5). On the third patrol of the RASHER, two unusual lookouts were commended who sighted puffs of smoke 15 miles away.

Note has been made on the eleventh patrol of the TRIGGER: "much aerial activity while tracking the convoy. Only part of the picture could be relayed to all hands below. Snatches of radar conversation, such as 'He's coming in, range 5400, bearing 040'. While the bridge could see that the plane would pass clear people below could not see that part of the picture and they are to be commended for their coolness and efficient fast dives when diving actually became necessary. The efficiency and alertness of the lookouts, especially during this patrol can be traced to the recreation period spent at Camp Dealy when all hands thoroughly enjoyed and benefited from a vigorous athletic program."

"Sighted two destroyers in a line abreast bearing 145 degrees--started closing. JP sound watch reported screws bearing 120 degrees. Could not see anything through the periscope. The bearing was dropping aft slowly. Our best soundman reported the screws sounded like those of a submerged submarine with the characteristic sound. I am convinced; put the screws astern and started opening out" (ANGLER No. 5).

Observed the commanding officer of the FLYING FISH (No. 2): "Too much credit can not be given to the sound operators who remained long hours on watch and methodically heard and regularly reported what and when they heard. Good sound operators are essential and they contributed appreciably toward successful evasion in each instance."

FIRE CONTROL

On the tenth patrol of the PERMIT (September 1943) "the highest percentage of hits today--89 per cent (16 hits) were recorded. In 2 hours, she sank 2 freighters, 1 tanker and damaged 1 cruiser--an outstanding patrol of the year!" The third patrol of the SEALION, concluded in December 1944, was a "history making patrol--on which 1 battleship was sunk and another damaged." "In 3 patrols the SEALION has the outstanding record of sinking 11 ships for 101,400 tons and damaging 1 battleship for 30,000 tons." The SAILFISH (No. 10) in January of 1944 sank a carrier in a typhoon--"the first known unassisted sinking of an enemy carrier by a submarine of this force."

The SENNETT's fourth was "a very daring, aggressive and outstanding patrol in very hazardous water. Once in a 72 1/2 hour period, 8 ships were contacted, all were brought under attack, and 4 were sunk. The second, third and fourth attacks were delivered within 2 minutes which resulted in 2 of the sinkings. After only 3 days in the area all torpedoes were exploded." The HAWKBILL, on her fourth patrol, made "two daring surface attacks in 17 fathoms of water on a minelayer--which speak extremely well for the efficiency of the fire control party of this veteran ship's crew." The REDFISH, on her second patrol "one of the outstanding patrols of the war"--sank 5 ships, including a carrier, and damaged another.

On the second patrol of the BLENNY: "To Cooper, E. R., TM1c, in charge of the after torpedo room had come the experience of one torpedoman's lifetime if not all submarine torpedomens' lifetimes. He fired the torpedo, dashed topside to man his gun action station at the 5 inch pointer and as he hit the deck he heard the commanding officer say--'10 seconds to go.' His eye was steady on the target as 2 of his fish scored hits."

GUNNERY

The BUGARA's third--"the most colorful--and the outstanding gunnery patrol of the year--in at least 52 gun attacks disposed of 57 small ships." The GUITARRO, on her second patrol, accounted for one of the shortest gun attacks on record when with "5 rounds of 4 inch H.C. she accounted for a 700 ton coastal freighter after dark at a mean range of 2600 yards (previously damaged by a torpedo)--a remarkable gun performance." "In 3 gun attacks sank 17 small craft" (TRUTTA No. 2).

The PLUNGER, on her sixth patrol, in a period of 65 hours was known to have sunk 3 ships, and probably 2 others, including a freighter with gun fire. In this outstanding patrol, "in battle surface there was no stopping the 3 inch although the gun had to be pushed back to battery by hand after the first 100 rounds. A muscular negro officer cook, James Thomas McGuire, the Tennessee boy who really had his heart in his work, worked his way up the ammunition line from the mess room to the gun as the less stalwart were relieved."

The GATO on her twelfth patrol "engaged in a gun battle with aircraft." The GRENADIER on her last patrol before being scuttled hit and killed the pilot of an enemy plane.

DIVING AND SHIP CONTROL

The commanding officer of the GRAYBACK in commenting upon that ship's ninth patrol observed: "innumerable dives had been made for aircraft contacts. After 5 attacks were made, high speed surface escapes were effected with one dive to 250 feet from 17 knots; the escort was close astern. All dives were smoothly and quickly made."

"The inevitable effect of a month of considerable surface operations made near enemy bases--was beginning to manifest itself at the end of the patrol--the dives were getting faster and faster every day." "The crew performed duties with an enthusiasm (and as the patrol progressed) capable manner. It must be admitted that each of the first few dives and approaches were an adventure. This was because new men had to be placed on stations they had never manned before. Enthusiasm and hard work soon overcame this. Now as the patrol ends the crew--is a smooth working, self confident, eager, fighting, unit whose morale and efficiency are definitely on the upgrade" (GATO No. 4).

"All hands rate a well done for their work on the morning of 27 July when a slip on anyone's part would have lost the boat. We were in a very close quarters and had to make a dive at full speed, firing as we went down. The training of the crew really paid off as everything went as smooth as a trim dive in Long Island Sound" (DACE No. 4).

DAMAGE CONTROL

The fourth patrol of the APOGON was "terminated early due to damage sustained by ramming from a Japanese freighter. The performance of the officers and crew in handling the ramming emergency was outstanding and highly commendable. Excellent ship handling and coordination undoubtedly saved the ship--." In this casualty, No. 1 periscope was sheared off, water entering the conning tower at about 30 gallons a minute. Two depth charges were dropped immediately after the collision with the submarine at a depth of about 62 feet. "The quiet, efficient and orderly manner in which orders were carried out and the general conduct of all hands during the grounding--was gratifying and a source of strength to the commanding officer" (ASPRO No. 5).

The ICEFISH on her first patrol was severely depth charged. "Only prompt and efficient damage control saved the ship. The crew and officers performed like veterans each and every one and I have a tremendous amount of confidence and pride in them."

"The commanding officer feels that most of the credit for the success of the patrol should be given to the magnificent effort of the crew in repairing damaged equipment. In case of air compressors, ship's personnel never stopped working" (TRIGGER No. 9).

Severe depth charging terminated the third patrol of the KINGFISH with severe internal and hull damage. "The courage, skill, and resourcefulness of the crew in successfully extricating this vessel from a most hazardous position is commended."

"During the depth charge the enlisted men responded to the emergency in a manner that makes it a pleasure to sail with them. Not enough praise can be given to their coolness under fire and willingness to do more than their share. Uniform excellence of performance of duty from top to bottom made it possible to penetrate to the very inner doors of the Japanese Empire. The performance of duty and intelligence displayed by all hands in restoring the shambles caused by the extremely close depth charges, in blowing the leaking ship off the bottom with the bilges and storeroom flooded, and then clearing the area with a 10 to 25 port list speaks for itself--these men though tired, continued to repair, replace, weld, jury rig, and do all in their power to restore the ship to its normal condition" (SEAHORSE No. 7).

MISCELLANEOUS

On the second patrol of the SAND LANCE "by virtue of hundreds of hours of extra work capable radar personnel kept the equipment in operation." The BANG, on her third patrol, on one occasion, took a green wave down the hatch--the crew being called upon to put in many extra man hours of repair work under trying conditions. "The electrical force are the unsung heroes of the submarine force."

The third patrol of the PAMPANITO was "marked by outstanding resourcefulness and ingenuity in the repair of a serious leak in the forward trim tank. One officer and man volunteered to go down in the forward trim tank during a dive to locate the leak." "The manhole cover didn't leak and we knew we could supply an ample amount of air with the 225 pound blower. Arranged a set of signals and pumped dry for a test. Manhole cover was removed and the men were put inside and the cover replaced. Removed the manhole cover from the after part of the forward trim tank in the forward torpedo room and attempted voice communication with the forward part of the trim tank. Dived slowly. A few very tense moments passed while we waited for word from the men in the tank: finally at 60 feet voice communication was established--."

OVER-ALL PERFORMANCE

The commanding officer of the SEA CAT, on returning from her first patrol, reported that the "officers and crew were exceptionally capable--personnel acted and reacted as though they were experienced war veterans in spite of the fact that 54 men and 5 officers were experiencing their first taste of submarine warfare. Due to the confidence of the crew in themselves and in their boat the 62 day patrol passed with no strain."

On the first patrol of the JALLAO--"a patrol characterized by splendid aggression and determination on which a cruiser was sunk and carrier attacked--of the 8 officers standing deck watches, only 1, a former chief torpedoman, had made any patrols prior to this." Aboard the RAY on her fifth patrol "despite the presence of 19 new men with the necessity for training and assimilating them, successfully carried out an attack 9 days after leaving port."

The first patrol of the ATULE was observed to be an "outstanding example of what a submarine can do on its first patrol with most of its officers and men still green to combat." The commanding officer of this submarine, in summarizing her record at the end of the fourth patrol observed: "We have not made headlines by our exploits but all 4 patrols have been successful; all attacks have been successful and all 7 ships have been sunk--of this we are proud. It proved that all hands were doing their stuff."

"Each officer and man feels the greatest pride in the TINOSA, all but one of whose patrols have been successful. Being at sea on the twelfth patrol when the Japanese surrendered unconditionally, it is felt that no war patrol in the ship's history was more successful."

The commanding officer of the PLUNGER in commenting on that ship's tenth patrol observed: "The commanding officer usually simply states that performance of the men was satisfactory in every respect. This is an understatement. It covers devotion to duty of a high order. It covers numerous instances which could be reiterated when Department Heads and all ratings have shown great resourcefulness and stamina in maintenance and repairs at sea. It covers personnel conduct during attacks and counter-attacks that has always been spotless. Most important of all, it includes active participation in the team and confidence in PLUNGER's ability to find the enemy and to hit him." Concerning this patrol it was observed: "all of the 10 war patrols have been successful--there is no better criteria for judging the ability of the commanding officers, the officers, and the crew than by the results so obtained."

On the fifth patrol of the COD, a seaman first class was lost overboard. Concerning his loss the commanding officer commented: "--was my lookout, shipmate, and friend. He died heroically in the line of duty in order to save his ship. The commanding officer derives no satisfaction from recording the events of the patrol nor from the meager damage inflicted on the enemy. The only satisfaction lies in recording the acts of heroism that were performed by--and by his shipmates at the time of the casualty."

The commanding officer of the SAND LANCE on that ship's first patrol wrote: "conduct of personnel was exemplary--without a doubt the greatest single asset of the United States Navy is the enlisted man." Concerning the superb performance turned in by his crew in a depth charge attack the commanding officer of the BREAM (No. 5) observed: "The commanding officer can only repeat something that has been said many times: 'Give us 50 Bluejackets and we'll try anything, anywhere'." Upon conclusion of the ninth patrol of the HADDO: "The officers and men are most deserving of praise from the commanding officer. Their aggressiveness toward the enemy, their cheerfulness during a patrol filled with anxious moments and continuous mental strain and their incessant efforts to keep the boat in top materiel condition--were inspirations to the commanding officer. The success of this patrol is theirs." "Although the dangers actually experienced were not great, the nature of the operations (in the Japanese Sea), off Korea--keyed the men to the highest pitch. Enthusiasm and eagerness to 'raise hell'

in Hirohito's back yard were shown by all hands. Performance of duty by every man was typical in good submariners" (TARPON No. 11).

No finer piece of descriptive and appreciative writing appears in these patrol reports than the following excerpt taken from the twelfth patrol of the BARB. "What words of praise can one give to such men as these. Men who, without the information available to the commanding officer, follow unhesitantly when in the vicinity of mine fields so long as there is the possibility of a target. Men who offer half a year's pay for the opportunity to land on a Japanese island, to blow up a Japanese train with a self-trained demolition team. Men who flinch not with the fathometer ticking off two fathoms beneath the keel. Men who shout that the destroyer is running away after we've thrown every punch we possess and are getting our ears flattened back. Men who will fight to the last bullet, and then want to start throwing the empty shell cases. These men are SUBMARINERS!" (Comdr. E. B. Fluckey, USN, August 1945).

PERSONNEL STATISTICS AND MISCELLANEOUS INFORMATION

STATISTICS

The total number of men carried aboard fleet submarines increased as the war progressed. From information available in patrol reports the following charts have been constructed. (Chart No. 1)

Number of Patrols Made by Submariners

In a few instances in 1944 and quite generally in 1945, commanding officers in patrol reports listed by name the officers and chief petty officers aboard with the number of patrols made by each. From Chart No. 1 it can be seen with reference to chief petty officers, that the number contained on the complement of submarines showed an increase in 1945 (6.79) as compared to 1944 (5.5). In 1945 these men had made an average of about 5.3 war patrols, each not necessarily successive.

The number of officers carried in 1944 and 1945, from the available information, did not greatly vary, averaging around 9 to 10 per submarine per patrol. On an average they had made about 4 war patrols each. The commanding and executive officers, as is to be expected, had generally made more war patrols; thus, in 1945 on 188 patrols, the average executive officer had made 6 and the average commanding officer had made about 7.5 war patrols. The commanding officer of the PADDLE at the end of her fifth patrol, was congratulated by ComSub Pac for having completed his 17th war patrol. Four officers and chief petty officers are known to have completed 16 war patrols and a comparatively large number of men made 12 or more war patrols.

In January of 1944 (conclusion of the tenth patrol) 7 men had made 10 consecutive patrols aboard the SAILFISH. At the conclusion of the tenth patrol of the GUDGEON (December 1943) some officers aboard are known to have made 8 and some of the crew had made 10 consecutive war patrols. On the ninth patrol of the JACK (concluded on 29 August 1945) the commanding officer made note on 27 July that in the 932 days that had elapsed since the commissioning of the ship, she had made 1,000 dives. Four men aboard (three CPO's and one MOMM) had made them all. Three officers and 4 enlisted men were aboard all 8 patrols made by the HOE (April 1945). At the conclusion of the TAMBOR's seventh patrol (June 1943) 15 men were aboard who had made 7 or 8 consecutive war patrols. Eight men were aboard the POLLACK at the end of her fifth patrol (February 1943) who had made 5 successive patrols. On the fifth patrol of the PUFFER (August 1944) 59 men had made at least 1 patrol, 14 had made 2, 12 had made 3, 27 had made 4, and 6 had made 5 patrols.

At New London, from the thousands of questionnaires returned after the war in connection with a survey conducted on submarine personnel, a random sample of 318 returns was tabulated. The maximum number of patrols made by one man was 14 in this group; the average number was 6.17 patrols per man.

Average Age of Submarine Personnel

The average age of officers aboard our submarines on war patrols was about 26.7 years, about 27 years for chief petty officers and about 22 years for the enlisted men. On the TIRANTE's first patrol (terminated in April 1945) the oldest officer, the commanding officer, was 31, the youngest 22; the oldest chief petty officer was 34.

Chart 1.--COMMISSIONED AND NON-COMMISSIONED OFFICERS ABOARD SUBMARINES IN 1944-1945, NUMBER AND AVERAGE NUMBER OF PATROLS

Year	Commissioned Officers		Commanding Officers	Executive Officers	Chief Petty Officers	
	Average Number	Average No. Patrols Made	Average No. Patrols Made	Average No. Patrols Made	Average Number	Average No. Patrols Made
1944	9.75	4.05	7.4	6.35	5.5	6.16
1945	9.68	4.10	7.5	6.19	6.79	5.28

Chart 2.--AVERAGE NUMBER OF PATROLS

Submarine	Patrol Number	Date	Officers	CPO	Crew	All
Sargo	11	May 1944	----------	-----	3.8	---
Searaven	11	May 1944	4.0	-----3.7------		3.9
Razorback	1	Oct. 1944	1.8	4.0	1.8	2.2
Blackfish	11	May 1945	4.0	5.0	3.0	4.0
Tirante	1	Aug. 1945	6.3	5.7	2.4	---

Chart 3.--MEN MAKING FIRST PATROL

Submarine	Patrol Number	Date	Officers	Men (Percent)	CPO
Harder	2	Oct. 1943	2	20	----
Ray	1	Dec. 1943	----------	60	----
Sailfish	11	Jan. 1944	----------	24	----
Burrfish	1	Mar. 1944	----------	53	----
Sailfish	11	Sept. 1944	----------	15	----
Razorback	1	Oct. 1944	5 out of 9	---------	2
Seacat	1	Dec. 1944	5	54	----
Sailfish	12	Dec. 1944	----------	16	----
Jallao	1	Dec. 1944	7 out of 8	---------	----
Springer	1	Mar. 1945	----------	30	----
Blackfish	11	May 1945	3	14	0
S-40	8	July 1943	----------	60	----

Chart 4.

Submarine	Patrol Number	Date	Number of Officers & Men	Average Age Officers	CPO	Crew	All
Sargo	11	May 1944	----------	------	--23.1----		---
Searaven	11	May 1944	8 officers; 77 men	27.8	--24.4----		---
Sailfish	11	Sept. 1944	72 men	------	---	23	---
Razorback	1	Oct. 1944	9 officers; 78 men	28.0	31.5	23	27.5
Sailfish	12	Dec. 1944	74 men	------	---	23	---
Parche	4	Feb. 1945	----------	------	---	21.9	---
Sealion	5	Apr. 1945	86 officers and men	28.0	28.0	22	23.0
Tirante	1	Apr. 1945	91 officers and men	26.0	28.0	23.2	25.7
Blackfish	11	May 1945	85 officers and men	25.0	25.0	21.0	23.6
Tirante	2	July 1945	92 officers and men	26.3	26.7	----	---
Pargo	8	Sept. 1945	81 officers and men	26	--24.0----		---
Cobia	3	Jan. 1945	----------	27	31.0	22.0	26.6
Cobia	4	Apr. 1945	----------	27.2	27.4	24.4	---
Rock	4	Nov. 1944	----------	------	---	----	22.3
AVERAGE				27.92	25.8	21.9	24.7

Time Spent in the Navy Submarine Force and on Individual Submarines

On the eleventh patrol of the SARGO (May 1944) the average sailor had served 2 years and 10 months in the Navy; 6 men had been aboard the ship less than 1 year; 16 men aboard had spent 4 or more years in the Navy. The ship had been in commission 5 years; only 9 men aboard were in the Navy when she was commissioned; none were aboard when that ceremony took place.

On the eleventh patrol of the SEARAVEN (May 1944) 5 of the 8 officers and 49 men of the crew belonged to the Naval Reserve. Officers had spent an average of 1.1 months in submarine relief crews, the men having spent about 4.2 months in these organizations. The officers had had an average of 15.3 years of education, the crew 11.0. On her twelfth patrol (October 1944) of the 72 men aboard, 62 had had war patrol experience only on the SEARAVEN; 11 men had made 1 to 7 patrols on other submarines--indicating that 85 per cent of the personnel were entirely SEARAVEN trained. On the eighth patrol of the S-40 (July 1943) "for 50 per cent of the crew it was the first time at sea."

On the tenth patrol of the SAILFISH (January 1944) 13 per cent of the crew had spent 6 years or more in the Navy; 58 per cent had spent less than 2 years; 24 per cent had never made a submarine war patrol; 23 per cent had made 1 patrol; 30 per cent had made 2 patrols; 24 per cent had made 4 or more--7 of whom had made 10 consecutive patrols aboard the SAILFISH. On the eleventh patrol (September 1944) 15 men were making their first patrol; 22 were making their first patrol aboard the SAILFISH. On her twelfth patrol (December 1944) 16 men were making their first submarine patrol, 19 making their first patrol aboard this submarine.

On the first patrol of the JALLAO--a patrol characterized by "splendid aggression and determination" and on which a carrier was attacked and a cruiser sunk--of 8 officers standing deck watches, only 1, a former chief torpedoman, had made any patrols prior to this. On the sixth patrol of the ANGLER, all officers but one were new to the job. The ARCHER FISH's first patrol was the first patrol for 50 per cent of the officers, crew, commanding officer and the ship.

MISCELLANEOUS

"At the time of the Japanese surrender there were 11 Naval Reserve officers in command of combat submarines and 22 in command of training submarines." "Aboard the BILLFISH, there were 8 Reserve officers and 1 regular--the commanding officer" (All Hands, BuNavPers Information Bulletin #346, January 1946). At the close of the war, aboard the RAZORBACK, 60 per cent of the officers and crew were members of the Naval Reserve.

The commanding officer of the SHAD, at the end of her first patrol in 1942, observed: "decrease in the number of men in the crew on a long patrol does not permit flexibility of the organization without a loss of efficiency when, through illness or accident, a man has to be placed on the binnacle list." ComSubPac Fleet Administration confidential letter, Serial 0870, of 20 April 1945, proposed increasing the complement to 72 men. The commanding officer of the DACE (No. 7, July 1945) was of the opinion that a minimum of 74 men was needed. On the seventh patrol of the PUFFER (April 1945) it was considered that the "83 men carried was an adequate number to stand watches and provide sufficient relief to enable manning of all equipment 24 hours a day without undue strain on anyone." At the end of her eighth patrol (July 1945) it was felt that "86 men aboard are excessive; our experience shows that from 78 to 80 men make a complete complement." At the end of her sixth patrol "75 men carried aboard found to be barely adequate for all watches; complement of 80 would be better."

A poll conducted aboard the GUNNEL at the end of her seventh patrol (December 1944) revealed 14.7 per cent of the crew would "rather stay in Australia, 73.5 per cent were glad to be going home but wished to return to Australia, and 1.0 per cent planned to return to Australia after the war."

BUMPER (No. 2) was the last submarine to fire a full load of torpedoes at the enemy. PIPER (No. 1) was the last submarine to return from the war.

The S-23 (No. 1) submitted the first report of a war patrol made in the Alaskan area.

During World War II, Naval medical officers did not commonly accompany submarines on war patrols. Lieut. Hiram Moe Green (MC) USN was aboard the WAHOO on her last patrol; at the time this report was underway (June 1946) he was listed as "missing in action since 1 November 1943." Lt. Comdr. George N. Schiff (MC) USNR accompanied the TAMBOR on her ninth patrol (January to March 1944) for the purpose of investigating the possibility of utilizing condensate water. Lieut. Richard G. Burman (MC) USNR accompanied a submarine (HADDO No. 5) on a war patrol. A fourth medical officer, Comdr. Francis X. Sommer (MC) USNR made a war patrol aboard an S-type submarine operating in Aleutian waters. Lt. Comdr. Walter B. Martin (DC) USN accompanied the SEA FOX on her first war patrol for the purpose of studying dental problems of submariners.

PERFORMANCE RECORD OF SUBMARINE PHARMACIST'S MATES

The pharmacist's mate aboard a submarine, whose training is akin to that of a skilled civilian first-aid man, is necessarily the medical officer, the dentist, the nurse and the chaplain.

A rigorous selection program seeks a pharmacist's mate from the general service who is a high school graduate, above average intelligence and is, as nearly as can be determined, an emotionally stable, psychiatrically and physically sound adult. His training, as carried out at the School for Submarine Pharmacist's Mates at New London and Pearl Harbor, is designed to produce a man who can diagnose and treat all of the more common illnesses, who can perform routine minor surgery and, in the absence of a medical officer, care for surgical emergencies which may arise.

To the average civilian and especially the civilian doctor such a program sounds impossible of achievement and echoes of charlatanism. Observant readers will have readily discerned the author's great and ill concealed pride in the accomplishments of the submarine pharmacist's mates. They were not only a credit to the scientific world of physicians; they were often, by all odds, the most valuable, and, at the same time the best liked men on the boats. Their performance record stands by and speaks for itself.

Throughout these many pages time and again special reference has been made of the performance of the pharmacist's mates while on patrol. Indeed they, with the cooks and bakers running a close second, were the most frequently commended ratings aboard the submarines. Many of them were especially commended by not only their commanding officers, but also by their division and squadron officers. Not a few were decorated. One submarine pharmacist's mate is known to have been decorated by the Australian government.

EXCERPTS FROM SUBMARINES PATROLLING WITHOUT PHARMACIST'S MATES

Early in the war the older "S" class of submarines did not carry pharmacist's mates. Because of their great interest and because they so well illustrate the value of the medical department's representatives aboard an operating submarine, comments in this regard are presented as follows: The S-38, on her third patrol, in the Mandura Straits, recovered some 52 survivors from a British ship, Electra, which had been sunk by Japanese shell fire some 24 hours before. The difficulties in caring for these men, some of whom had severe shrapnel wounds and burns, can be readily appreciated when it is explained that submarines of the Asiatic Fleet, at that time, were not provided with pharmacist's mates. Furthermore, they had no medical supplies nor a standard medical reference work. "Fortunately a British surgeon had survived uninjured and was able to render considerable assistance. His task was made difficult by a lack of medical supplies, especially by the lack of an anesthetic and antiseptics. A Bosun's Mate had to be sewed up with thread from the crew's thread bag."

Stated the commanding officer of the S-34 (No. 3): "The following ailments illustrate the need for a hospital corpsman--one infected finger, 21 colds, 2 sore ears, 2 toothaches, 10 cases of constipation, 4 men with 'cramps,' 1 boil and 2 sore throats." "The serious illness of one of the crew during this patrol again stresses the desirability of carrying a competent pharmacist's mate. This man ran a temperature of 105 degrees for 5 days. His symptoms failed to agree with any of these described in the medical compend. His sudden and complete recovery is considered more of a miracle than the result of treatment received" (S-45, No. 2). "I again reiterate that with patrol operations extending approximately a month the responsibility for the health of 46 officers and men without any adequate medical supplies or a pharmacist's mate is an entirely unnecessary mental hazard" (S-39, No. 5). The inconvenience and worry experienced by one commanding officer is only too well illustrated in the patrol report of the S-35 (No. 5) when a case of acute appendicitis occurred (proven at operation later) and which was eventually transferred at sea to a plane. On this same patrol the commanding officer was nearly incapacitated as the result of injuries received on the bridge. A serious fire occurred and the majority of the crew, when the submarine reached port, were suffering from exposure, smoke and exhaustion.

On the third patrol of the S-31, an epidemic of common colds and sore throats occurred; one man was turned in with a fever, a mess attendant was under treatment for a DU (chancroid) and the commanding officer received a serious chest injury from the explosion of a Mark X Emergency Identification Flare. Concerning the needs of the submarine it is stated: "It is believed that the longer patrols of the fleet-type submarine allowing them a pharmacist's mate is more than offset by the poor habitability of this type of ship. In this connection it is recommended that a pharmacist's mate be added to the complement of the Sail class submarines." On the fourth patrol, when the ship was still without a corpsman, one man was transferred at sea to a plane because of a severe laceration of the arm.

In the endorsement on the fourth patrol of the S-30, ComSubPac in October 1942 observed that the Bureau of Personnel had increased the allowance of the complement of the S-type submarines by one pharmacist's mate. At the end of the eighth patrol of the S-18, in January 1943, the commanding officer reported: "A pharmacist's mate was attached to the ship for the first time this patrol and proved a most welcome addition to the crew. His performance of duty was excellent and relieved the commanding officer of much concern and worry." At the conclusion of the fourth patrol of the S-28 on which a man was treated for acute appendicitis, at about the same time, it was observed: "The addition of a pharmacist's mate has been a valuable materiel and psychiatric addition."

Chapter 6

Submarines and Air/Sea Rescue Missions

The following table summarizes, by year, the number of rescues of downed airmen made by submarines in World War II, as observed in the available patrol reports.

Table 30

Year	Number of Submarines	Number of Rescues	Number Recovered
1942	2	2	7
1943	3	7	14
1944	25	62	117
1945	84	143	411
Totals	114	214	549

The following statistics (Navy Press Release 211, 22 August 1945) show the rescues performed by Pacific Fleet Submarines during the period 28 May to 15 August 1945.

Naval Personnel		Army Personnel	
U. S. Carrier Aviators	39	B-29 Aviators	80
British Carrier Aviators	8	Far Eastern Air Force Personnel	33
Naval Aviators Other than Carrier	35	Army Fighter Pilots	25
	82	Army Air Rescue Personnel	7
			145

Grand Total 227

These figures indicate, in part, the gradual development of what was to become the elaborate and highly integrated system of air/sea rescue, promoted by the ever increasing number of men being shot down in combat over the Pacific.

"First there were the 'Dumbo' planes (medium Navy and Army search craft) that frequently landed in heavy seas to pick up a downed pilot or crew." "Later air/sea rescue became more of a science, organization and integration being added to newly developed rescue devices such as the improved life rafts, the 'Gibson Girl', and the emergency kits." "Air/sea rescue today provides living proof--of the value of joint effort. It is doubtful if the war can offer any finer example of progressive results than this saga of cooperation between the military services. Born of war, its record of lives saved is an amazing tribute to organized efficiency" (Capt. Eddie Rickenbacher, Air/Sea Rescue Bulletin, Vol. II, No. 4, Dec. 1945, pp. 2). "By the end of the war the average time required for search and recovery of a downed airman had been materially reduced. Although some aviators still spent days adrift in the open sea, surviving airmen from an abandoned plane could expect rescue within 3 hours" (Navy Press Release, "Submarine Lifeguard League", 3 Nov 1945). "This record of progress and development offers hopeful promise for the future. Not only as an integral adjunct of Army-Navy operations but as an important peacetime safety factor for commercial air carriers" (Air/Sea Rescue Bulletin, Restricted, NAVCG 128, Vol. III, No. 1).

Our submarine force played a far more important role in air/sea rescue than is generally appreciated. "It was the advent of the large carrier strikes against Japan and B-29 operations from Marianas bases which proved the services of the Submarine Lifeguard League as a valuable arm of the supreme strategy in the war with the Japanese." "Submarines performing lifeguard duties became an integral part of all major air strikes performed by Army

and Navy staffs. During the last few months of the war with the massive strikes by superfortresses from Guam, Tinian and Saipan the majority of surviving Army personnel who had been forced to ditch their aircraft were recovered through the services of the submarines" (Navy Press Release "Submarine Lifeguard League", 3 Nov 1945). "The use of submarines for such tactics not only opened up new areas in aerial offensive strategy but heightened the morale of Army and Navy Air Force pilots." "The knowledge that a competent and courageous submarine crew was on call to assist gave the individual flyers incentive to press home attacks regardless of probable damage to their aircraft" (endorsement to GATO's tenth patrol report). "In the period just before the Japanese surrendered when targets were growing increasingly scarce, one-third of the Navy operational submarines were engaged in some kind of lifeguard duty on the bomber paths to the Japanese homeland and conquered areas" (Navy Press Release, "Submarine Lifeguard League", 3 Nov 1945).

In 1944, 25 submarines in 62 different rescues recovered 117 aviation personnel. Through 1945 to the close of the war, 84 submarines in 143 different rescues recovered 411 men. Thus, it will be seen that 114 submarines from April 1942 through August of 1945 recovered a total of 549 airmen in 214 separate rescues (2.56 men per rescue). Six of these were Japanese (BONEFISH No. 7, POMFRET No. 4, TIRANTE No. 5) becoming prisoners of war, which patrol reports should be consulted by those interested in the behavior of the Japanese POW. Nine allied aviators were dead on recovery and were buried at sea. Two men died, aboard the submarines TIGRONE No. 2 and ICEFISH No. 4. Of the total number of airmen recovered, 532 were restored to the allied forces.

Instances of extraordinary heroism of officers and men of the Pacific Submarine Force during search of the vast expanses of enemy water in quest of perhaps a single pilot or air crewman are commonplace in the official records of these operations. It is with pride that the next few pages of this narration are given over to some of the more spectacular of these exploits, free though they may be of strictly medical information.

PATROL REPORT DATA

The SEARAVEN was apparently the first American submarine in World War II to rescue aviators. While on her third patrol on 18 April 1942 she recovered 33 Australians from the island of Timor in a hazardous 2 day rescue. Two pilots shot down over the island a day before, one of whom had an infected shrapnel wound, were included in this group. The rescue was accomplished with crude equipment and under the most adverse conditions; the men, some of whom were unconscious, being carried aboard in the face of breaking oars, anchors carrying away and beaching of the boat. In the same year and about the same time the PORPOISE (No. 3) rescued 5 airmen, the crew of an Army plane which a week before had made a crashed landing on the island of Jau in the Solomons, during the Guadalcanal operations.

The SKATE on her first war patrol in 1943 was the first submarine to be specifically assigned to an air/sea rescue operation, being utilized as a stand-by submerged submarine at Wake, to help direct the aviators of an attacking task force and to rescue any that might be shot down. In 5 separate rescues, 6 airmen were recovered, 2 within 2 miles of the island. This rescue "one of the more dramatic episodes of the war" was made at the cost of a life of a submarine officer, fatally wounded when the submarine was strafed by a Japanese Zero which dove suddenly out of a nearby cloud. In addition the submarine was bombed 3 times, strafed again and fired upon from the shore 3 times. In the same year the GRAYBACK, on her fifth patrol rescued 6 aviators who had bailed out of a B-26 bomber. Three of these men were in need of medical attention, one having a dislocated shoulder, and another had a fever, possibly malarial in origin. PhM 1/c Roby had only a few days before successfully removed the appendix of one of the crewmen of the submarine. PLUNGER on her ninth patrol in 1943 rescued one aviator.

The TIGRONE (No. 2) established an all time record for the recovery of friendly aviators when in 5 rescues she picked up a total of 30 men. The first man was recovered off the eastern coast of Honshu on 25 May 1945 with severe lacerations and second degree burns; on the 28th of May, 5 more were recovered, all in good condition 18 minutes after their plane had crashed. On 29 May, 16 men were rescued, 2 of whom were seriously injured, one with severe head and body injury, the second with a possible fracture of the back and skull. One man of this group died about 6 1/2 hours after recovery and was buried at sea on 30 May. On the afternoon of the same day, 7 survivors of an Army bomber were rescued who had been clinging to a life raft buffetted in tremendous sea with waves at least 30 feet from trough to crest. One of these had a bullet wound of the foot, a second had a fractured clavicle. The problems which confronted CPhM D. J. Percifield during this 6 day period must have been at times overwhelming. On 1 June a medical officer from a destroyer boarded the submarine; on the same day the survivors were transferred at Iwo Jima. Three days later the commanding officer, Comdr. Hiram Cassidy, USN, wrote: "Submerged all day to get much needed rest from APR contacts. All hands are pretty well pooped from lack of rest during all the

time the aviators were being cared for;--the dunkees were allotted all the sleeping space possible because they all suffered a little from shock." The 30th aviator was rescued on 26 June in good condition, having been in the water only a few minutes. Captain Cassidy recommended on the basis of these experiences that future rescue operations should provide for at least one doctor riding in a centrally located submarine so that he could be shifted from each boat as required. ComSubPac commented upon the persistence, rare judgement, and fine navigation demonstrated by the commanding officer of the submarine in this rescue which "established a record which will be a source of pride to the Submarine Force."

The exploits of the famous TANG (No. 2) in her remarkable recovery of 22 aviators in 7 different pick-ups over a 2 day period in April 1944 close to the reef and enemy gun installations at Truk were given nation-wide publicity. All interested in air/sea rescue should read Captain R. H. O'Kane's USN account of these recoveries, made possible "by virtue of remarkable cooperation with the aircraft of U. S. striking forces," by the submarine "seizing the initiative and her willingness to proceed from point to point within enemy gun range to expeditiously rescue personnel of downed aircraft. One rescue was carried out as the submarine gunners neutralized a shore gun on a nearby reef."

The RAY (No. 7) in 11 days of lifeguarding in 2 rescues picked up 20 aviators under adverse conditions, in shoal enemy water, from a downed B-29 and PBM. Three of the 10 men rescued from the superfortress were stretcher cases (shrapnel wounds and possible fractures). Nine days later 10 men were recovered at night from 2 rafts lashed together. While in close proximity to rocks and shoals, the submarine put a line over to the rafts. Great difficulty was experienced in getting a lee for the raft, heavy seas were washing over the deck, sweeping one man of the rescue party over the side. The survivors were exhausted having spent 12 hours in the cold rough water; one being so weary that he was almost lost when his raft overturned in the seas.

The famous WHALE on her last and eleventh consecutive successful patrol rescued 15 aviators in 9 different pickups. "This rescue is evidence of the confidence aviators had in their ultimate rescue by submarines if forced to abandon their planes at sea. One pilot giving aerial cover to a fellow aviator downed 80 miles up the Bungo Suido radioed the WHALE that he would continue circling his friend until the 'Dumbo' reached the scene or until his tanks ran dry. He asked the WHALE to stand by for him while he ditched. Patiently, the submarine waited and 90 minutes later, with a search aircraft on its way to pick up the pilot in the water, the protecting pilot quit his vigil and ditched 300 yards off the WHALE's starboard bow." Seven of the WHALE s 15 survivors were in good condition; of the remaining 8 one had a dislocated shoulder. Resistance upon the part of the patient made reduction of the dislocated shoulder necessary under ether anesthesia. The remaining men having been aboard life rafts for 2 days were suffering from various degrees of exposure. For the 11 days during which the submarines carried 105 men, crowded conditions made the boat uncomfortable--"15 to 16 hour dives were extremely hard on all hands to the point of being dangerous." The pharmacist's mate on this patrol distinguished himself in the care which he gave the aviators.

The 19 submarines recovering 10 or more aviation personnel accounted for almost half of the total men recovered. Each of the 214 rescues incorporated points of interest and suggestions for the development and improvement of air/sea rescues which in many cases proved invaluable. These patrol reports should be consulted by those interested in the technical aspects of this field. Details of each rescue can not be given here. Submarines and patrol numbers on which the rescues were made have been listed and appended.

Comment must be made concerning a few rescues which, in addition to those mentioned above, will long be remembered by submariners. For sheer bravery and magnificience the rescues effected by the HARDER, the POMFRET and the ASPRO are outstanding.

The commanding officer of the HARDER recorded on the ship's eleventh patrol report: "--finally sighted (the aviator) on the northwest tip of the second island (Woleai). Battle surface stations manned, ship flooded down, and maneuvered into a spot about 1500 yards off the beach. White water was breaking over the shoal only 20 yards in front of the ship and the fathometer had ceased to function--backed off to make the approach from another angle." "The aviator who had been standing on the beach was now observed to fall and lie there outstretched in the sand. His collapse was undoubtedly due mainly to physical exhaustion but also to the disappointment in seeing his chance of rescue fading away. Moved in again until the torpedo room reported 'bottom scraping forward.' Three volunteers dove over the side and commenced pushing and towing the rubber boat toward the beach. A line was played out from the submarine in order to pull it back from the beach. Meanwhile one of the planes had dropped another rubber boat to the stranded aviator who got in it and commenced feebly paddling it to sea against the tide." "The two men wading through the surf toward the aviator both in breakers now most of the time and their feet and legs badly cut by the coral reef, after about one-half hour by swimming and wading reached the aviator whose raft had meanwhile drifted farther away. By this time he was thoroughly exhausted. They put him in the raft and by alternately pushing and swimming headed back toward their rubber boat from which a line led to the

submarine about 500 yards away. Meanwhile a float plane--taxied over the line to the raft and it parted. Entire rescue party now stranded--another volunteer swimmer dove over the side and finally managed to swim a line to the three men standing just in-shore of the heavy breakers. This line was made fast to the raft and little by little the four men were pulled through the breakers and back to the ship. Throughout the entire rescue the cooperation of the aviators was superb. They kept up a continuous pounding of the island by bombs and flew in low to strafe the Japs and divert their attention from the rescue. In spite of this, Jap snipers concealed in trees along the beach commenced shooting at the ship and the rescue party and bullets whined over the bridge uncomfortably close." For a very detailed and interesting account of this rescue see: Navy Department Press and Radio Release, "U. S. Submarine HARDER, Now Overdue on Patrol, Performed Daring Rescue of Aviator," as of 24 February 1945.

Concerning the seventh patrol of the ASPRO on which 2 Army aviators, forced to abandon their plane were recovered, ComSubPac wrote: "One of these rescues occurring only a few days before the Japanese capitulation is particularly noteworthy in that to accomplish it the ASPRO entered far into the confined waters of Tokyo Bay." The aviator who had parachuted from his crippled fighter a few moments later climbed into a wooden power boat dropped by a circling "Dumbo." "Five minutes later 4 Jap Zeros darted out of the clouds and made strafing attacks on him as he began moving toward the surfaced ASPRO, grazing his left shoulder, cutting up both life rings and cutting holes in his boat fore and aft. Both of these planes were finally shot down by covering 'Privateers' but not before they had released their bombs which fortunately for the ASPRO narrowly missed her on both occasions when she dove." "In spite of this close and nerve wracking bombing the ASPRO, fighting ship that she is, surfaced and by her tenacity and courage succeeded in rescuing the pilot and escaping to less confined waters." "In the first attack the submarine was able to score 20 mm hits in the wing of a 'Pete' before diving." Full details of the rescue are available in Navy Department Press and Radio Release, "Submarine and Airplane Fight off Jap Pilots Time After Time to Rescue Downed Pilot in Tokyo Bay," 20 September 1945.

For sheer thrills the periscope rescues conducted by the STINGRAY (No. 11) and the FINBACK (No. 10) made within a few months of one another were outstanding. Noted FINBACK concerning the rescue of one of the 5 aviators she returned to port: "--pilot hooked on and we headed out away from the beach. He had one arm around the periscope and the other around the life raft with a bailing bucket bringing up the rear. Finally got under way towing the pilot in the boat; 2/3 speed filled the boat and then he was in the water again. Finally came up to 38 feet (from 55 feet) to keep him out of the water until at a range of 5 miles from the beach we planed up and opened the hatch." The STINGRAY in an equally brilliant rescue off Guam "saved 5 aviators in spite of enemy contact and gun fire--." The periscope method of rescue was resorted to when an aviator had to be picked up close to the enemy beach and at a spot under enemy fire. "The aviator, in a rubber boat, ducking the Ack-Ack, sighted the periscope and waved - holding up his left hand which showed a deep cut across the palm." "Four attempts were made to get him to understand"--the submarine finally running into his raft with her periscope until he hung on "towed him for one hour during which time he frantically signaled for us to let him up. His hand was badly cut and it must have been tough going hanging on to the bitter end of his line with one hand while bumping along over the white caps making two knots." He was towed for over 2 miles while the ship was kept submerged by the fire from shore batteries. This aviator, it was later learned, had bailed out of his plane at 14,000 feet falling upside down in his parachute for 12,000 feet. In a state of moderate shock, when rescued it seems likely that the difficulty of his pickup may have been on the basis of mental confusion.

The PETO on her tenth patrol "brilliantly performed her alternate mission of life-guarding. In the face of air and coastal opposition and by penetrating suspected mine fields she had the satisfaction of recovering 12 aviators in 4 well conducted rescues." On 23 July at 1557 one aviator, wounded by gun shot, in both legs was taken aboard. At 1714 the same date in a lightning rescue in 35 fathoms of water, as 3 shells whined overhead and landed a thousand yards away a second rescue was effected. "--four miles from land where people could be seen on the beach and a passing train stopped on a trestle for a ringside seat." One week later while searching for a downed aviator--"learned that a 'Dumbo' who had found his position had landed, and picked him up but had been damaged in landing and could not take off. This was unfortunate because we now had 9 survivors instead of 1--but luckily 'Jukebox 24' was on hand. He dropped his boat and all 9 survivors got in and started the long haul to us. We went 6 1/2 miles into the restricted area up to the 100 fathom curve. They went first on power, then sailed when the engine stopped, then rowed when the sails were ineffective, then got the motor going and finally reached us. We just stuck our nose over the 100 fathom curve to pick them up, and found 50 fathoms"--"at 1700, 9 tired but happy survivors climbed out of 'Jukebox's lifeboat'."

The GATO on her twelfth patrol reported: "Our 'Dumbo' led us to a point 5 miles from Kyushu. Went on 4 engines, everything blown up, bridge 20 mm and 40 mm mounted. Our 'Dumbo' has reported bandits in the area." "At 1057 a float type 'Zeke' entered the scene--'Dumbo' saw him and we both opened up simultaneously - our 20 and 40 mm tracers were hitting him but he still kept on coming--headed down on us--and saw 2 bombs released from his belly." "Put the rudder hard left, yelled 'Take her down' and proceeded to carry out my orders--bombs exploding starboard and astern." Surfaced. "Zeke pulled out of his dive, climbed to 1,000 feet, and did a nice wing over us for a strafing run. Dove at 1059. Surfaced at 1125. Heading for survivor. At 1239 our friend 'Zeke' returned for more of same. Dove. Surfaced 1400; at 1456 picked up survivor who crashed yesterday. "Apparently jumped at 500 feet at air speed 240 miles per hour. 'Dumbo' had dropped him a 7 man raft and he was fixed for 30 days. As we were only 12 miles from the beach he thought we were Japs, and covered the raft with his blue blanket and lowered the sail, trying to make himself inconspicuous. Later he said when he saw us getting closer he resigned himself to fate, took a drink out of his canteen, and waited for the machine gun bullets."

As noted by others the great success of air/sea rescue depended upon close cooperation between air, surface and under sea craft. The above reports barely begin to indicate the extent of this unification of effort. The TIGRONE on her third patrol rescued a P-51 pilot who bailed out nearby: "He had arranged his bailing out (4 miles from the beach) with our cover--who had no opportunity to inform us, before we saw him float down out of the clouds surrounded by a roaring circle of his squadron mates. While we were running to him someone reported a Jap nearby. We never felt safer in Apra Harbor--the sky was full of B-29s and P-51s."

The experience of the JALLAO on her third patrol is testimony to the fact that a "submarine engaged in rescue work close to an enemy base is in a precarious position, subject to air attack with men on deck, while dead in the water. Too high praise can not be given to those who successfully carry out this important mission." Following a raid on Marcus Island this submarine recovered 5 wounded aviators: "--1425--commenced rescue operations"--"by 1440 had received 2 men aboard but 2 of the most seriously wounded were still on the raft, when a shell from Marcus Island landed 500 yards ahead of the port bow. Four more landed with errors of 25 feet to 75 yards spaced about 30 seconds apart during the remainder of the operations. Believed condition of the 3 men on the raft was such that 2 of them might not have survived a longer stay in the water and warranted continuing the operations in lieu of diving and returning later. Although seriously wounded and suffering from great shock no more than suppressed groans were heard from the last 3 while being man-handled below, as the tactual situation would imply. With their help we were able to get all below and dove at 1443."

Lack of space prevents further description of rescue operations in detail. Some however deserve brief mention. Especially hazardous were rescues made often but a few thousand yards or so from enemy held territory, frequently near populated areas, commonly in shoal and dangerous waters and sometimes in the face of strafing enemy planes (ASPRO 6, CERO 8, CHUB 1, GAR 11, MINGO 5, PERCH 7, QUILLBACK 1, SCABBARDFISH 5, and STERLET 2). Two submarines (POMFRET 4 and GABILAN 6) in effecting two rescues, steamed into the very approaches of Tokyo Bay.

The first of numerous rescues of aviators from B-29's was carried out by the SPEARFISH (No. 12) on 19 December 1944, when 7 aviators were recovered off Iwo Jima. The BLACKFISH on her twelfth patrol recovered the entire crew (6 men) from a ditched B-25. The SEADEVIL (No. 4) recovered the entire crew of a ditched PBM (11 men) and the pilot of a downed P-47. BLUEFISH (No. 7) rescued 3 aviators "the crewmen bailing out 100 yards abeam the submarine." "Two men were recovered alive and uninjured. The third man to leave the plane, the pilot, was dead when recovered 4 minutes later of drowning, shock, and shrapnel wounds. Despite his severe wounds he had managed to remain airborne over an hour to bring his crew to safety." The submariners in performing the final ceremonies for this pilot must have experienced that feeling of comradeship in arms that sometimes comes to men sharing common dangers.

Lives were saved many times and again and again by this magnificent spirit of heroism. Five survivors from a B-25 forced to land in a sea, conditions 4 to 5, though in the water only a few minutes were suffering from minor injuries and shock, owed their lives to the members of the rescue party who went over the side of the submarine, to bring them safely aboard. On the GUAVINA's sixth patrol, "Bluejackets with lines about their waists swam through oil slicks, and the tangled wreckage of a B-25 bomber in the South China Sea to reach 3 aviators endeavoring to extricate themselves from the sinking plane." The efficient work of the rescue party of the TILEFISH (No. 5) recovered a wounded aviator who spent less than 3 minutes in the water. The renowned SAILFISH (No. 12) probably set a record for efficiency when she recovered the crew of a downed plane at the rate of one man every 11 minutes until 20 were recovered. BLUEFISH (No. 8) 7 hours after arrival on station made what was probably the quickest rescue on record; 4 minutes after the plane crash landed alongside, the pilot and 2 crewmen were safe aboard. The PINTADO repeated this record when one day on her fifth patrol "12 parachutes blossomed out in a row--" from a damaged B-29 which crossed her

bow and exploded one mile ahead. The entire crew was rescued within a 45 minute period. The grateful crewmen of the B-29 "Blackjack 13" remembered their lifesaver in a unique way. They christened their next superfortress the U.S.S. PINTADO and adopted the submarine's battle flag insignia as their own. The BULLHEAD (No. 1) reported the kindness shown by our Allies to 3 severely wounded pilots. The plane, in a low skip bombing run, was damaged and set on fire by one of its own bombs and forced down inside a blind bombing zone in 12 fathoms of water. "The aviators were taken aboard two junks near the scene of the crash which was marked by a column of high black smoke. When the submarine arrived the Chinese tried to hide the fliers until they knew we were friends." BULLHEAD obtained most graphic motion pictures of this rescue which well demonstrate the physical plight of the downed "zoomies," two of whom were unconscious when taken aboard the submarine.

MEDICAL AND SURVIVAL DATA

Of the 543 American or Allied aviators who were recovered, 284 (about 52 per cent) were uninjured and did not require medical treatment. The remaining 259 survivors (48 per cent) required some kind of medical care; about 157 (29 per cent) are believed to have been treated for shock alone, 83 (15 per cent) were injured, 49 (9 per cent) of these having sustained serious wounds. In short about 18 per cent of the total number of aviators recovered were seriously in need of medical care, commonly due to a combination of shock, exposure, and injuries.

Deaths Aboard Submarines

As noted, two of these aviators died after recovery, 9 were probably dead when taken from the water (CABRILLA 8, BLUEFISH 7, PIKEFISH 1 and 5, and SEA FOX 4). The cause of death in two instances is unknown (insufficient data); 5 were likely due to drowning; 3 were consequent to multiple wounds.

Between 25 and 30 May 1945 the TIGRONE (No. 2) recovered 29 aviators in 4 separate rescues. Nineteen of these were presumed to have been in fair condition; 5 are known to have suffered from shock and immersion, having been washed overboard from their boat a number of times during the night before they were rescued. A sixth man had a bullet wound of the foot, a seventh had a fractured clavicle. One aviator recovered from a raft two hours after he had bailed out of his burning plane had a deep laceration of the leg and second degree burns about the face and neck. Two pilots were severely injured when their plane nosed into a wave while attempting a take off, one sustaining a possible fracture of the skull and vertebra, and second was barely alive, suffering severe head wounds and deep lacerations of the arm inflicted by the port propeller of the plane which tore through the pilot's cockpit in the take off. This man died aboard the TIGRONE approximately 6 hours later, being buried at sea the next morning.

The ICEFISH on her fourth patrol in a rescue effected 3000 yards off the enemy's shore, brought 6 men aboard, in a force 3 sea, from 2 rubber rafts on which they had spent 24 hours. Three of the men were completely exhausted, 3 were stretcher cases. The commanding officer commended CPhM Hager, formerly with the Marines on Guadalcanal, for his "superb treatment of the injured under difficult conditions. Working steadily for 2 days without sleep he cared for 3 men with minor lacerations, sprains and bruises." The tail gunner had sustained severe lacerations of the legs and back; the engineer had a compound fractured rib. The radioman died approximately 14 hours later consequent to multiple shrapnel wounds, shock and internal injuries. Three days after recovery the wounded were transferred to Subic Bay.

Primary Injuries

The following table lists those primary injuries and allied conditions seen most commonly and reported in injured aviators:

Table 31

Aviation Personnel Recovered	548
American and Allied Personnel Recovered	542
Japanese Personnel Recovered (Aviators)	6
Aviators Dead on Recovery	9
Aviators Died after Recovery	2

Table 31 (continued)

Aviation Personnel (American and Allied) Not Treated	283
Treated for Exhaustion (diag. #2526-2527)	157
Treated for DU (injuries severe, diag. #2518)	16
Treated for Wounds, lacerated (diag. #2563)	12
Treated for Wounds, fragment (diag. #2584)	11
Treated for Contusions, multiple (diag. #2512)	11
Treated for Injuries, multiple extreme (diag. #2542)	10
Treated for Fractures, simple (diag. #2531)	8
Treated for Dislocations (diag. #2520)	4
Treated for Wounds, gun shot (diag. #2576)	3
Treated for Burns (diag. #2508)	5
Treated for Seasickness (diag. #2151)	3
Treated for Fractures, compound (diag. #2529)	3
Treated for Submersion, non-fatal (diag. #2554)	3
Treated for Fever DU (diag. #1309)	1
Treated for Intracranial injury (diag. #2543)	1
Treated for Drowning, fatal (diag. #2521)	5
Treated for Wounds, multiple, fatal (diag. #2564)	3
Killed in action, cause unknown (diag. #2545)	3
Total Number	542

Traumatic Injuries

There was one simple fracture each of the ankle, femur, patella, arm, and two of the clavicle. One fracture of the rib was compounded as were two fractures of the leg. There were 10 DU fractures including 3 of the skull, and one each of the ankle, tibia, and fibula, hip, shoulder, femur, arm, and nose. Nineteen men were wounded by enemy flak, fragments from bursting shells or bullets. In two instances (ICEFISH 4, and BLUEFISH 7) these wounds were contributory causes of death. Inasmuch as men with wounds the result of enemy action not infrequently sustained additional injuries in landing planes or bailing out of their planes, one can not clearly differentiate the cause of injury in all instances.

Of the 82 men moderately and seriously injured, it appears clear, however, that the majority were injured at the time their plane was landed or abandoned. As observed by others, the survivor rate is higher among those who ditch their planes as compared to those who bailed out (Air/Sea Rescue Bulletin, Restricted, NAVCG 128, Vol. III, No. 1).

Of the 8 men who were burned it is likely that only in 3 instances were the burns sufficiently severe to justify the primary diagnosis. In one instance friction burns were caused by the shrouds of the parachute; in 3 other instances burns were sustained as the pilots bailed from or otherwise tried to clear their burning planes.

One of the 4 reported dislocations resulted as the aviator parachuted from the plane, either as the result of hitting the bomb bay door or severe jolt of the opening parachute. A second, a dislocated knee, occurred when a plane was ditched. One patient being resistive required reduction of a dislocated shoulder under ether anesthesia.

As is to be expected, the majority of wounds were in the nature of lacerations, fractures, abrasions, contusions, and sprains, apparently most commonly sustained in water landings. The death of one pilot as already noted resulted from multiple lacerations about the head when the propeller was forced back into the cockpit in an attempted water take off. One deep scalp injury resulted when, in making a water landing, a machine gun bounced off the head of an aviator sitting in the rear seat of the dive bomber. Occasionally, minor injuries were sustained in bailing out of the plane as in the case of one aviator, his chute failing to open, was forced to climb back in and regain control of the plane. On his final successful attempt at bailing out he sustained bruises on striking the tail.

In only two instances was note made of secondary infection of wounds. Survivors from the Indianapolis observed that wounds did not become actively infected and after 48 hours were covered with a tough protective exudate or slough which relieved pain and offered some protection (Ltr of Medical officer, L. L. Haynes, Comdr. (MC) USN, U.S.S. Indianapolis, NavMed HF-33, (1943) dtd 26 November 1945). One man when recovered from a tropical island had a secondary infected shrapnel wound. Another aviator, recovered from similar surroundings, developed a severe fever aboard the submarine, possibly due to malarial parasites.

A point in relation to the above data should be emphasized. The commanding officer and the pharmacist's mate of a submarine on lifeguard should realize and anticipate that about 50 per cent of the men recovered will require medical care. The greater number of these will be suffering from shock consequent to over exertion and over exposure. Sixteen per cent of the aviators may be wounded, about 10 per cent gravely so with severe superimposed secondary shock. In the face of this the pharmacist's mate must have been adequately prepared. He must not only have sufficient quantities of medical supplies, such as plasma, splints, etc., aboard but he must have been adequately and thoroughly trained.

Survival Data

"The survival of an air crew member whose aircraft falls over water depends on a number of factors - successful exit from his aircraft, a successful search by rescuing parties, survival in the sea or in a dinghy until rescue is effected and medical treatment received after rescue."

"Ditching" versus "Bailing Out".--"Once he has left his aircraft the flier who has ditched is in a far more advantageous position than one who has bailed out. He has multi-placed life rafts, more easily seen from the air than the individual dinghy. The aircraft if it floats, or the oil film it leaves when it sinks aids detection from the air. Supplies of food, water, flares and a dinghy radio may be available. He has the companionship and help of his fellow crew members, while the men who bail out of a heavy bomber are likely to be scattered along a track 10 miles in length. In the Eighth Air Force, of 2,130 B-17 air crew members who ditched their craft 1,169 were rescued - a survival rate of 51 per cent. From March of 1943 to March of 1945, only 67 out of 354, or 19 per cent of the men who bailed out of this type aircraft during the same period survived" (Air/Sea Rescue Bulletin, Restricted, NAVCG 128, Vol. III, No. 1). Unfortunately data as available in the patrol reports prevents the preparation of comparative figures. Without a doubt, however, the truth of the statement would apply to this group of aviators rescued by submarines.

Time Spent in the Water.--Of the 539 airmen recovered alive by submarines through the war, 41 per cent (212) were recovered within the first 3 hours; 55 per cent (285) spent 6 or less hours in the water; 66 per cent (343) were aboard the submarines in 12 hours or less; 82 per cent (423) had been recovered within 24 hours or less. Note has already been made of many rescues in which the aviators spent but a very few minutes in the water, indeed 23 per cent (118) spent less than an hour while 16 per cent (81) of the aviators spent less than 30 minutes in the water.

As is to be expected, the majority of the men (348 or 67 per cent) were recovered from life rafts or boats. Of this number 82 per cent were recovered within 24 hours. Ninety-five per cent of those on rafts spent 4 days or less on this type of craft. The chances of recovery and survival after the fourth day drop sharply, thus only 15 of the total number of men recovered had spent more than 4 days aboard rafts before rescue. The longest time spent by a survivor on a raft was 21 days (aviation personnel).

Twenty-four per cent (122) survivors were recovered from the water wearing life belts. Ninety-one per cent of those so recovered had spent 6 hours or less in the water after which the survival chance drops quickly.

Fifteen men were recovered from enemy held territory or islands on which they had spent from 10 hours to 5 days.

As is to be expected only a small number (1 per cent or 6) of men were recovered swimming without life belts or a raft. Three of these spent an hour or less in the water. The TUNNY (No. 5) recovered a Japanese Zero pilot (19 years old) who shot down at 0710 on 31 March 1944 was recovered by the submarine at 0557 on 1 April having spent approximately 27 hours swimming in the water without a life belt or raft. Other than for exhaustion and severe sun burns he was in a fair physical condition, being apparently recovered 2 days later.

"The main factor determining the duration of life of an individual immersed in the sea is the water temperature. It is unusual for men to survive for more than 20 to 30 minutes in water of a temperature of 39-41 degrees F. (temperature of the North Sea during winter months). In water below 15 degrees C. a fatal degree of body cooling begins to occur within an hour or so. Under the high degree of air/sea rescue efficiency existing in the European theater in 1944 the mortality rate was 42 per cent among 163 men immersed for 10 minutes or more in water ranging from 40-60 degrees F. (average temperature 56.5 degrees F.). Of 103 men rescued 60 per cent were immersed for more than 30 minutes; if immersion had occurred in the winter months very few would have survived. For 870 ditched airmen who had dinghies the survival rate was 82 per cent while for 136 men immersed in the water the survival rate was 48 per cent" (Air/Sea Rescue Bulletin, NAVCG 128, Vol. III, No. 1).

A few survivors were recovered in this series of reports south of the Equator in the Solomon Island area. Many were recovered from the waters off the Japanese home island. None were reported as recovered from the colder water of the Aleutians or the Kurile Islands. Unfortunately survival figures comparable to those given above for airmen rescued in the European theater are not available. Undoubtedly, however, the survival rate was higher among the Pacific group due to the higher water temperature.

"In studies made of 10 normal (uninjured) subjects immersed in sea water of 62 degrees F. the rate of fall of the oral temperature averaged 0.1 degree F. per minute, for 25.5 minutes. When removed from water and dried in the wind their temperatures fell farther. Hence prolonged immersion even in tropical or temperate waters can be serious since thermal equilibrium can be attained in water at 90 degrees only by shivering and the warmest ocean

water is only about 84 degrees F." (Survivors from the Indianapolis stated that 18 hours after entering the water all became severely chilled. The chill lasted about an hour and was followed by a high fever and delerium). "Assuming the water soaked survivor boards his raft quickly his condition if not protected remains still serious. Evaporation of water from his wet clothing may cause as great a loss of body heat as takes place during immersion. Shock supervenes rapidly. The struggling aviator may die as the result of shock or unconsciousness with subsequent drowning." "It may be that death after immersion is circulatory in nature. It often appears after the warming up process. In a study done in the European theater electro-cardiographic tracings obtained on 3 of 10 rescued airmen showed abnormalities. One had a transient prolonged PR - interval, two had auricular fibrillation, observed 6 and 11 hours after rescue and returning to normal in 17 to 18 hours respectively."

Shock and Exposure.--Of the 539 aviators recovered alive by submarines, 53 per cent were apparently in good physical condition. Approximately 47 per cent were in a condition of shock, generally the result of over exertion over exposure and injuries. Twenty-nine per cent suffered from primary shock subsequent to over exertion and exposure.

Shock and Injuries Associated with Leaving the Plane and Landing.--As already noticed, injuries may be sustained in leaving the plane. On one occasion an aviator, his parachute becoming entangled had to return and steady his plane before making the second attempt to leave, when he sustained bodily injuries on striking the external surface of the plane. The STINGRAY (No. 11) experienced difficulty in the carrying out of periscope rescue of an aviator previously briefed in this type of procedure. Some of this difficulty undoubtedly resulted from the aviator's physical and mental condition. He had bailed out at 14,000 feet, falling upside down in his parachute for an estimated 12,000 feet before the parachute opened. For 3 hours he swam in a Mae West close to the enemy held beach, handicapped by a severely lacerated palm. Climbing into a life raft, 4 more hours passed before he was taken aboard the submarine.

The commanding officer of the GATO (No. 12) made some interesting observations with regard to bailing out at low altitudes. One survivor left his plane at 500 feet at an air speed of 240 mph. Pulling his rip cord as he jumped his chute opened just as he hit the water. "He is small and the high speed of his plane did not cause his shroud to break when the chute opened." He was the last of 6 to jump. The others were heavier by 30 pounds, jumped at a speed of 240 mph or more, and at about 2,000 feet. If they delayed in pulling their rip cords it would have been too late. Had they pulled them before their bodies lost their high lateral speeds, the shock of the opening chute would have broken their necks and their shrouds.

One aviator who bailed out of his plane had difficulty in clearing his parachute and ended up in the water with his life jacket collapsed, without a rubber boat and tangled up in his parachute. Within 5 minutes he was aboard the submarine half drowned and unconscious. Within a few more minutes he would have certainly drowned. Two men who bailed out "clung to their life raft, both exhausted from the few minutes (about 10) in the water in their heavy clothing and miscellaneous apparatus."

Wounds were many times sustained when the planes made water landings. In other instances the actual shock of the landing was reflected in the airmen's chance for survival. One pilot in the water less than 3 minutes and with superficial wounds was observed to have difficulty in keeping afloat and was given treatment for shock aboard the submarine. Another in the water only a few minutes, struggling weakly apparently overcome by shock, gasoline and oil fumes and by the water he had swallowed, had to be pulled aboard the submarine. Twelve uninjured survivors from a B-25, on rafts for not more than 45 minutes, were observed to show evidence of slight shock and nervousness.

Another survivor aboard a raft for 25 minutes, when rescued was described as being "quite tired." One sole survivor of a B-29 fell out of the plane when it exploded in mid air. He was picked up uninjured and wearing a life jacket from a calm sea in a slick of oil, oxygen bottles and debris 15 minutes later "in a state of exhaustion and shock." On another occasion crewmen from the submarine fastening lines about their waist plunged into the sea (conditions 4 to 5), to reach 3 aviators trying to extricate themselves from the tangled wreckage of a B-25. Though they were in the water no longer than 10 minutes all 3 upon recovery were treated for shock. The occupants of a burning SB2c which landed 400 yards off the port bow of one submarine were aboard 5 minutes later. The pilot was in a state of moderate shock having swallowed considerable sea water. The radioman was unconscious from shock and submersion.

Hazards After Landing.--Once in the water the airman faces additional hazards. As noted earlier very few survivors without life jackets were recovered and most of these were within an hour. Two were recovered after having swum 2 or 3 hours without life belts. Note has already been made of the physical condition of a Japanese recovered after swimming for 21 hours without a life belt. One aviator swimming for an hour without a life ring (condition of sea unknown) was so exhausted that crewmen had to be sent out to him with a life ring; another swimming about 7 minutes without a jacket was exhausted and had to be recovered in a similar manner.

Survival in Life Belts, Jackets.--Airmen wearing life belts fare better. Of the 122 recovered, only 10 had spent more than 10 hours in the water, the great majority having been immersed for less than an hour. One of the survivors recovered by the TANG who had swum for at least an hour with only a jacket before a raft was thrown to him could hardly make it on being taken aboard the submarine. One man hanging for 5 hours to a swamped boat was completely exhausted when rescued; a second, swimming in the water about 4 hours, was so exhausted that crewmen had to swim out and get him; a third in the water for 4 hours, two of which he was without a raft, was exhausted and ill from swallowing salt water and green sea marker dye. A survivor from a B-25 recovered after 2 hours of swimming was stated as being "unsteady" when taken aboard the submarine.

Unless the sea is dead calm, survivors trying to sleep in life jackets with occasional swells breaking over their heads, are apt to have their mouths and nostrils filled with sea water. A medical officer, survivor of the Indianapolis, spoke of mechanical sinusitis consequent to such exposure (ltr of Medical officer L. L. Haynes, Comdr. (MC) USN, U.S.S. Indianapolis, NavMed HF-33 (1943), dtd 26 November 1945). Submarine commanding officers have frequently mentioned sickness incidental to swallowing gasoline and fuel oil. Indianapolis survivors spoke of the intense photophobia, severe ocular pains and headaches, resulting from the glare of the sun. The commanding officer of the SAILFISH (No. 8) described painful sunburn suffered by an aviator adrift 4 1/2 days in a rubber boat who had lost his sunshade when the boat upset. A type of sun helmet made of rubberized cloth with a built in and transparent eye shield has been described to be used by survivors to cover their heads and face thus protecting them from the intermittent dousing of salt water and fuel oil in the mouth, eyes, and nostrils.

Survival in Rafts.--Those fortunate enough to take to the water in rafts or to have a raft shortly dropped fared the best. However, they faced not only the cold rough seas with periodic dunking but also seasickness. The rough sea, rain, wind and the shallow rafts all conspired to keep their bodies continually wet. Crowded and cramped quarters could be depended upon to interrupt sleep. Their bodies sometimes wet for days, developed salt water sores. The development of "immersion foot" though never described was not impossible.

Inasmuch as 82 survivors were recovered from rafts within 24 hours, lack of food and water was not a major problem. In general, their physical condition aside from previously received injuries may be expected to be better than that of men swimming without support. A significant number of survivors spending a variable period aboard their raft were described as suffering from exposure due to the vicissitudes as described above, in addition to the sometimes terrifying experience with the enemy which they underwent before rescue. The following anecdotes are illustrative of some experiences shared by airmen aboard rafts for variable periods of time.

Note has been made earlier of the physical condition and the exhaustion experienced by the aviator recovered by the HARDER. All the survivors from a B-29 after 20 hours on a raft and suffering shock and exposure were administered a tot of brandy upon recovery. Five men aboard one raft for 24 hours were in need of treatment when recovered--the night before rescue they had been washed overboard from the raft several times. Three aviators adrift on rafts for 24 hours, 3,000 yards off the enemy coast in a force 3 sea had to be lifted aboard the submarine so complete was their exhaustion. Thirteen men having spent 18 hours on the raft were recovered in a fairly good condition showing no evidence of excessive nervousness or complete exhaustion but all extremely weary of their cramped existence on the confined rubber boat which "fortunately did not prevent alert watch standing." Ten other survivors aboard 2 life rafts lashed together for 12 hours in cold rough water were all exhausted and suffering from the cold and salt water sickness. One survivor was so exhausted that he was almost lost during the rescue when the seas overturned his raft. Two Marine pilots spending 36 hours in the water aboard 2 Goodyears lashed together were recovered at approximately 2108 on 8 April. On 9 April at approximately 0500 "one man underwent an anti-climax of shock and exposure." The expert administration of blood plasma by a pharmacist's mate proved great relief in 1/2 hour.

Fifteen survivors recovered by the WHALE (No. 11) spent from 5 minutes to 48 hours aboard rafts. "Two cases of immersion developed in men who had been in the water for 40 hours, necessitating 5 days of bed rest." Comments of the WHALE's commanding officer are worthy of consideration: "The survivors when picked up were much weaker than we expected them to be and more important, they were weaker than they expected themselves to be."

Another aviator spending 7 hours aboard a raft in a calm sea with a moderate swell, demonstrated a hazard to which all survivors are exposed, namely, confusion. "He was sick from a combination of seasickness and shock for several hours and so weak that he could hardly pick up the flotation gear dropped near him by the 'Dumbo.' He had looked at the 'Gibson Girl' dropped to him but found it too complicated and decided he would figure it out

tomorrow. He was unable to find a corner reflector in his gear." Luckily and quite by chance he was contacted by the submarine when the radar, at 3,000 yards picked him up dead ahead. Concerning his condition a commanding officer said, "he was outwardly cool, calm, and collected."

Another aviator was recovered having spent 12 hours aboard a raft. "He was uninjured but weak and had to be carried below. He would not let go the flag pole with the red flag until we were about to carry him below." Again, an aviator having bailed out of his plane "landed about one mile from an enemy held beach and avoided capture by shooting a couple of Nips who had put out in a small boat to pick him up. The first night the boat upset and he lost his food, water and sunshade. When recovered about 5 1/2 days later his physical condition other than for a badly sunburned and swollen face was described as good." The tenth survivor from a B-29 was located, after a 15 hour search, a hundred miles away from the spot where the plane landed. He was described upon recovering as a consequence of lack of food and water as "very weak and a little sore."

An aviator recovered from a raft by TRUTTA (No. 2) told the following story. On the first of June, 1945, he parachuted from his plane. On hitting the water and while getting out of his parachute and inflating his raft he swallowed considerable salt water and was nauseated and vomited for 24 hours. When rescued at 1100 on 7 June 1945, 6 days later, he had been without food for 48 hours and without water for 15 hours. Throughout his stay on the raft he was sitting constantly in water never being able to get his clothes dried out, the rough sea making bailing futile. Constant immersion produced several salt water sores on the lower part of his back and hips with a generalized rash around his waist. The night before his recovery he had ridden out a typhoon of 14 hours' duration--"mountainous waves 40 to 50 feet high, wind at least 100 knots, visibility 5 to 100 yards and barometer at 14 points." He had been washed overboard 4 times, salt water ruining his remaining food, his first aid kit, and all except a pint of the water. When recovered he was suffering from exhaustion and mild shock, being mildly irrational and very restless for 18 hours. At the end of 48 hours he was up and about eating regular meals. An Army sargeant spent the longest time in this series adrift a raft for 23 days with "the only apparent sign of exhaustion being a weight loss of 40 pounds."

One of the first survivors of the war to be rescued by a submarine spent 4 days on his raft off Wake Island. Of his rescue Captain McKinney wrote: "He was so anxious to get aboard that he completely forgot his rehearsed 'Dr. Livingston I presume' and left his prized false teeth behind in his shoes on the raft. To show how water conscious he was he held up his half pint of water and exclaimed 'How are you fixed for water?'." Three others downed for 2 hours were recovered sitting very comfortably in their rafts. "They could have looked no more comfortable or satisfied had they been out there fishing," 6 miles off Japanese held Angour Island. The BECUNA, on her first patrol, rescued a Japanese soldier from Wake Island who had been at sea in a boat for 30 days. No information is available concerning his physical condition. On the third patrol of the COBIA one Korean rescued from a raft on which he had spent 40 days was severaly dehydrated, craving water. He lived but was restrained in his bunk for 2 days.

The PIPEFISH No. 5 noted concerning the recovery of one uninjured survivor 11 hours after he had bailed out of a B-29: "we noticed something which turned out to be a raft and there was someone in it but that he was covered over with a rubber sheet. He had no idea that we were near. One of the men called out: 'Say, Mac, what are you doing.' Mac came out from under that sheet in a hurry!"

Miscellaneous Survival Notes

Perusal of these patrol reports revealed some points of interest made with reference to a problem commonly shared by the rescued and the lifeguard submarine. Elaboration of these is thought justified.

As already noted injuries are not uncommonly associated with the process of bailing out. Dislocation of the shoulder in one instance may have followed a sudden jerk of the opening parachute. Friction burns associated with the shrouds of the parachute are mentioned. Difficulty in releasing the parachute after entering the water was sometimes described, in one instance the aviator, being wounded and in shock, was apparently unable to release the parachute which pulled him rapidly over the water. Though rescued within 8 minutes he was dead as a result of drowning, shock and enemy wounds. An accident similar to this may have accounted for another death (PIPEFISH No. 5).

In a few instances, discomfort, distress, and perhaps death may have been the result of faulty equipment or lack of ability to properly use the equipment. One aviator was recovered in a state of exhaustion having clung for 5 hours to a partially swamped boat (CHARR No. 1). A second was in a similar physical condition, having clung to a partially inflated life raft for 16 1/2 hours (SEA FOX No. 4). The PIPEFISH (No. 5) recovered 5 men alive and well who bailed out from a ditched B-29, 4 more were discovered dead, 3 of whom after 6 to 7 hours in the water showed no evidence of injury, death apparently being due to shock or drowning. A

fourth was presumably dead for the same reason, his boat being inflated and parachute hanging down in the water. The TIGRONE (No. 2) reported concerning the rescue of 7 Army personnel from a life boat: "Two were seriously wounded. Rescue was doubly difficult because of the apparent helplessness of the group and the long swell which was running. Three parachutes leading off the boats' port beam acted as a most effective sea anchor, preventing our holding the boat alongside. They were at a loss as to how to handle the lines and could not cast loose the parachute. They had been washed overboard many times but had managed to always climb back aboard. Knowing the condition of the sea during the night and seeing how the boat was held beam on to the sea it is a wonder any of them survived." An officer from the submarine was placed aboard to cast off the parachute, rig the lines properly and help the survivors when the TIGRONE came alongside.

PLAICE (No. 5) in reporting the rescue of 5 survivors from their ditched plane stated that with the impact of the ditching the life raft door jammed and the rafts could not be released. The plane shortly sank, leaving the men with only life jackets.

An aviator recovered by the SAWFISH (No. 8) after 4 1/2 days adrift in a rubber boat without food or water, stated that after the first night his boat upset and he lost all of his food and water and his sun helmet. Another submarine, PIPEFISH (No. 5) having recovered 8 aviators after a long and grueling search, observed that they were without flashlights or pyrotechnics, making an effective search after dark practically nil.

SEADEVIL (No. 2) recovered the entire crew of a PBM who had been aboard life rafts for 24 hours. The last one recovered after an additional 15 hour search had drifted away from the group. HAMMERHEAD (No. 7) recovered an aviator from a raft that had drifted and sailed approximately 300 miles from the position at which his B-24 had been ditched 5 days before. This raft was sighted 2,000 yards away in the moonlight by an alert lookout. The aviator said that when he took to his completely equipped raft, he weighed 145 pounds. He promptly had set sail for Australia. Eleven days later when rescued he had to be awakened from a sound sleep, being no worse from his experience and still weighing 145 pounds.

HARDHEAD (No. 2) enroute to station, unexpectedly recovered an aviator adrift on a small life raft for 7 days when the lookout first sighted "something white" adrift at a distance of about 1,500 yards. Others have observed that the bright yellow color chosen as a standard color for dinghies and life rafts may not be the ideal color under all circumstances (Air/Sea Rescue Bulletin, NAVCG 128, Vol. III, No. 1). Yellow when detected from a great distance is invariably described as white when seen against a blue sea and is likely to be confused with white caps or spray. Since the sea in the Pacific is generally blue the importance of this valid observation is emphasized. One submarine recovered the sole survivor of a B-29 (which exploded in mid air) from a calm sea in a slick of oil debris and oxygen bottles. Despite the fact that he was wearing a life jacket he was not seen until the submarine was 100 yards away. Another commanding officer stated that an aviator was seen to bail out of his plane passing 100 yards abeam of the submarine. After he landed he disappeared from view and despite the fact that 8 people on the bridge were searching for him he was not seen until his shouts were heard.

PIPEFISH (No. 5) stated that the red smoke from a bomb released by one survivor, attracting the searchers, was very effective. GATO (No. 10) had a tragic and disheartening experience. About 1625 on 4 August report was received of a plane downed 25 miles away from her position. Two green rockets were fired by the ship and were answered in turn it was thought by a red rocket. The ship fired the third green rocket and it was thought that a second red rocket was fired by the survivor in return. However, the weather was overcast and hazy, the red rocket appeared very dim and the aviator could not be found although it is not unlikely at one time he was within reach of recovery. On another occasion "dye marker placed in the water was sighted by a lifeguard submarine before the raft itself was spotted and before any position report had been received."

In this series of reports the shark hazards were mentioned only once and that by the SCABBARDFISH (No. 4). "--another officer was hauled aboard wearing only a Mae West since the time he ditched--with a 10 foot shark running close second--so close in fact that we now keep a rifle in the conning tower at all times." On another occasion the body of an aviator estimated to have been in the water about 7 days was recovered only after sharks had been driven away by rifle shots.

MECHANICS OF SURVIVOR RECOVERY

Once the survivor has been sighted and approached difficulty was sometimes experienced in bringing him aboard. The commanding officer of the POMFRET (No. 4) observed concerning the difficulty in recovering an unwilling prisoner from the water: "I never before realized how hard it is to put a submarine alongside a man who insists on swimming away." In this respect, it must be borne in mind that a submarine, when dead in the water, makes a good target for enemy torpedoes. Again, the ease with which survivors may be brought aboard depends to a great degree upon the state of the weather, other conditions of operations and, not a little, upon the handling of the submarine.

The most spectacular type of recovery, that by periscope, has practical limitations. It was used for pick-ups close to enemy beaches at a spot under enemy fire. "It required previous briefing, cooperation from the aviator and extremely expert submerged movement and ship handling." As observed in these reports, it was only twice used successfully in this past war.

Heroic rescues have already been described in which exhausted aviators swimming with or without the use of life belts were brought alongside by crewmen who had gone over the side for them. In more than one instance the rescuer has returned to the submarine as exhausted as the aviator. It is a method of rescue that must be many times used, recovery being otherwise impossible--and even then it isn't always successful.

Aboard the GATO (No. 10) in rescuing 2 airmen from a downed Helldiver: "Lt.--taken aboard after considerable difficulty due to a rough sea." "Besides being injured he was fagged out attempting to keep himself and his back seat man afloat. Two of our rescue parties went over the side but he slipped out of their hands and was not seen again. Lt.--said that he had a badly lacerated scalp and possibly a skull fracture and appeared to die as he held him."

Rescue parties should include men who are strong and excellent swimmers. If temperatures permit, they should be clad only in shorts and always leave the ship with a line around their waist. While topside, caution must be observed. Members of rescue parties in rough seas have been swept from the deck of the submarine. In cold weather operations it is imperative that all hands topside be warmly dressed. In the past, men topside for some reason or another, have been swept overboard and, clad in heavy foul weather clothing, have disappeared beneath the surface. For this reason, if available, all hands under such conditions of weather, should be clad in the one-piece exposure suit which not only protects from the cold but has flotation properties.

Lifting the Survivor Aboard

Once the survivor has been brought alongside, considerable difficulty will sometimes be experienced in hoisting him to the deck. SEA FOX (No. 4) in reporting upon the recovery of 2 aviators who had been swimming for 16 hours in Mae Wests reported: "our 'box-car' hand and foot grips on each side of the sea ladder were very effective in helping to bring the weakened aviators aboard." THREADFIN (No. 3) confronted with the task of getting 2 seriously injured men aboard--both of whom were stretcher cases--lifted the raft and the men aboard off a bow plane. WHALE (No. 11) in reporting upon the recovery of 7 aviators from a raft observed that she had tried to use her bow planes for the same purpose but found that the sea was too rough to put a man on them.

QUEENFISH (No. 4) in recovering 3 downed aviators who had spent 81 hours on a raft reported: "Our strong armed coxswain did valiant work in hanging over the side to assist the men as the rafts careened alongside in the swells--during which one raft filled with water." "One prisoner had to be hoisted bodily aboard, in shock, after the seas had inflicted terrific punishment, banging him under and alongside the ship."

"Flooding-down", Cargo Net

One of the most common and apparently most efficacious ways of bringing wounded survivors aboard submarines was that as used by the WHALE, when, "after flooding the after group, 2 men practically paddled their rubber boat onto the deck--between the conning tower and the after gun mount." This trick has been used by many other commanding officers and is especially applicable to the recovery of wounded men, even in a fairly rough sea. BALAO (No. 11) pointed out that the small and light rafts may be easily capsized by the wash of the submarine screws.

RAY (No. 7) reported great difficulty in getting a lee for the raft with the heavy seas breaking over the deck. SHARK (No. 2) commented: "The next time we pick up anyone in a rough sea we are going to have a cargo net we can rig."

Recommendations for Improvement of Available Methods

Concerning the problem of bringing severely wounded aboard from rafts, TIGRONE (No. 2) suggested: "We need some type of a more rigid stretcher with attached bridle and davit socket located so as to permit swinging the hatch davit over the side for lifting personnel from rafts and boats. A cargo net rigged over the side is a good idea when attempting to take personnel from one of the plane dropped lifeboats. It is a good idea to place some capable person in the boat to make it secure and to aid in the disembarking of personnel." And the RONQUIL (No. 4) after experiencing difficulty in hoisting aboard and lowering below 3 critically injured men (2 with multiple fractures) recommended a "zipper type of web jacket or some other type of suitable equipment for the lowering of injured men through hatches--be furnished boats during lifeguard duty."

Caution prevents indiscriminate opening of hatches while at sea. Sometimes the crew's mess hatch was used to lower survivors below decks. Sometimes one of the torpedo room hatches was used. In each, the narrow inner hatch prevents the lowering of men on the Stokes basket stretcher which, aboard submarines, may only be taken through the torpedo loading hatches. There exists a need, then, as described, for either a jacket which can be quickly applied or a rigid or semi-rigid stretcher, no wider than a man's shoulders, for use aboard submarines.

A simply constructed, easily applied and light weight rigid stretcher was designed by Lt. Cdr. M. T. Friedell (MC) USNR and placed aboard some submarines (PETO No. 9). The Naval Medical Research Institute has perfected a similar but semi-rigid stretcher (litter, canvas, semi-rigid, NMRI Model "A", S6-691, 1, $29.00) which appears in the Medical Commissioning Outfit for Submarines as of 21 September 1945. Unfortunately, very few submarines operating in the war zone had this type of stretcher aboard and it was not utilized in lifeguard operations as far as is known. However, it is felt that neither stretcher (Stokes, NMRI, or the Friedell) adequately supplies the needs of submarines--as outlined by TIGRONE above. Particularly, do submarines require some type of stretcher which can advantageously be used to transport injured men from one submarine to another while at sea.

Transfer of Wounded Men at Sea

Sometimes, at sea, it was necessary to transfer aviators from one submarine to another. Sometimes, due to military exigencies, it was necessary to make such transfers on the same day the man was recovered. Commanding officers should bear in mind, in this respect, as pointed out by QUEENFISH, that the transfer, if made under difficulties, may prove harrowing and difficult for men not sufficiently or yet recovered from their late ordeal. Her 13 aviators, who had spent 81 hours on a raft, showed no ill effects beyond extreme weariness. "We felt that transfer by small boat at sea to another submarine, although no serious ailments had been incurred, would interrupt the primary treatment which they needed at this time--namely sleep and rest."

Bow to Bow Transfers, Swimming

Transfer at sea can be very simple, as when 2 submarines (POMPON and RAY) while underway and maneuvering to keep their sterns apart, swung their bows together until they almost touched, enabling 10 airmen to quickly step from one ship to the other. Another submarine (SPADEFISH No. 1) found that the transfer of a prisoner of war was most easily effected by having him swim, with a life jacket, the short distance between the two boats. Or again, transfer was effected by passing a heavy line to the other submarine and towing the aviator across in his life belt--a quick method when only one or two men need to be transferred.

Life Raft

In a rough sea, or when wounded men are involved, transfer may be laborious and involve many anxious moments. "Anyone who had manipulated a rubber life raft in a rough sea knows the difficulties of conveying survivors by such a method." It has been done "using a raft and 3 men, with the patient on a Stokes litter lying crosswise in the gun wales in the center of the raft. One man on either end paddles and the third keeps the survivor from being dumped into the sea." GABILAN (No. 6) took 2 aviators from the STERLET in a heavy sea in a rubber boat using 4 men--"they hardly get wet." "This was the simplest and most expeditious operation yet. The same day we received 3 from the TORO the same way. The seas were extremely rough and several times we were certain they would not make it." "Transferred wounded gun pointer to--via rubber boat. Fortunately it was the calmest day we had. If the sea had been the normal force 3 to 4 which we had experienced 90 per cent of the time, transfer would have been impossible without further injury to the patient" (BOWFIN No. 2).

Sometimes the rubber life raft, controlled by heavy lines, was guided by one submarine as it was towed to the other (WHALE No. 11). One submarine transferred 5 survivors, one with a compound fracture, by rubber boat secured with light lines and bridle at both ends and hauled back and forth between the submarines, flooded down to take the men aboard. The transfer required about 1 hour and a quarter.

On one occasion the PETO "received Lt.--from the TRUTTA by rubber life raft." Transfer was accomplished by TRUTTA casting him adrift in the raft and PETO making an approach and picking him up. This was surprisingly easy in heavy seas although the passenger was half under water in his raft. POMFRET (No. 6) faced with the transfer of 5 men at sea, 1 of whom was unconscious with a concussion and a probable skull fracture, recommended: "that submarines carry a 6 man rubber life raft as used by the B-25's rather than the 3 man size since the latter is too small for the proper handling of stretcher cases when transfer at sea is necessary."

On one occasion RUNNER (No. 1) received 15 survivors from GABILAN in sea conditions 3. Three rubber boats were lashed together making it possible to send 7 men on the first trip, 6 on the second, and 2 in the last. STERLET (No. 3) recommended a small fast runabout for picking up fliers downed in restricted areas.

Recently, as the result of experience gained by all branches of the service in rescuing survivors, there has appeared: "Handbook of Survival in Water", Restricted, NavPers 16046, produced for CNO by Standards and Curriculum Division Training, BuPers, April 1946. Chapter 6 of the handbook, "Shipboard Rescue of Survivors", should be consulted by all interested in this particular phase of rescue work.

CARE OF SURVIVORS ABOARD THE SUBMARINES

Once having been safely brought aboard the submarine and taken below the aviators fared very well indeed.

As observed above, of the 539 airmen rescued alive, only 2 died aboard submarines while under the care of pharmacist's mates. This gratifying fact is in accordance with experience elsewhere: "In actual practice the mortality after rescue of men immersed in the English Channel and the North Sea was low. Of 103 rescued after immersion for 10 minutes or more, only 3 died."

A few comments made by commanding officers with respect to the facilities which they were able to offer their "Zoomie" friends are worthy of notice.

Medical Officers Aboard Lifeguard Submarines

The experienced commanding officers of the TIGRONE (No. 2) and DRAGONET (No. 2) observed: "There should be at least one doctor riding a centrally located submarine--so that he might be shifted around from each boat as required." It is the writer's opinion that in another emergency doctors may well be placed aboard selected submarines in the Lifeguard League. The presence of a doctor would have been a comfort in those instances (few it is admitted) when survivors were so seriously injured that transfer at sea was either impossible or unwise (POMFRET 6, THREADFIN 3) and the submarines headed, on all 4 engines, for the nearest source of more experienced medical care.

Medical Supplies

With especial reference to seriously wounded and shocked survivors, the commanding officer of the GATO (No. 12) recommended that submarines assigned lifeguard duty be allotted additional supplies of blood plasma--beyond the usual 4 or 6 packages which they usually carried. Indeed, serious consideration should be given to increasing certain strategic medical supplies on such submarines. There exists no reason why, with excellent refrigeration aboard submarines, whole blood should not be carried. Pharmacist's mates should be briefed, as to the hazards associated with exposure and especially of the nature and treatment of the circulatory disturbances that may be encountered. Quite commonly it is believed, brandy or whiskey was administered as a stimulant to survivors although only in 3 instances was this specifically mentioned.

RONQUIL (No. 4) recommended after her experience of caring for 10 survivors from a B-29, 2 of whom had fractured legs, "the addition of traction splints to the medical allowance would save a great deal of improvisation as was necessary in this case." This was an experience not uncommonly shared by other submarines. Certainly they should always have at least 2 Thomas traction splints available. PLAICE (No. 6) recovered 5 survivors, who after 5 hours in life jackets, had crawled into a small Higgins boat. One of the men on ditching his plane dislocated his knee. "Some type of immobilizing splint was needed badly--none was available in the first aid supplies of the Higgins boat. Fellow survivors could do little more than soak his limb in salt water."

On the fourth patrol of the BESUGO, a badly burned Japanese survivor was recovered. Second and third degree burns covered over 60 per cent of his body surface. He was in severe shock and completely covered with fuel oil. The fact that PhM G. A. Heibel brought him back alive is no doubt due as much to his good sense as to his judicious use of morphine and some 750 cc. of plasma. Because of difficulties encountered in administering the plasma he also used serum albumin. On the fourth day with the use of a dampened sheet, a 6 foot length of hose taken from the escape trunk, and a flask of aviation oxygen this form of treatment was started. At the end of 19 days his results were adjudged excellent. Apparatus is needed aboard submarines for the quick and convenient administration of oxygen.

Berthing and Clothing of Survivors

The addition of 15 or 30 aviators to an already overburdened berthing situation with 5 or 15 of the crew sharing "hot bunks" sometimes deprived the crew of needed sleep and rest. As stated by POMFRET: "submarines with 1 or 2 B-29 crews on board are indeed hard pressed to provide adequate sleeping facilities, often badly needed by the survivors." As we have seen, rescue operations were not uncommonly carried out under prolonged and hazardous conditions. Often times the ship, in addition to lifeguarding, carried out her primary mission; that of sinking ships. Not infrequently the addition of aviators and prisoners of war to the normal complement, on submerged days, made air purification necessary.

To alleviate the conditions which sometimes existed: "If possible suggest that 4 less torpedoes be carried so that the racks can be utilized as bunk space. One torpedo rack when provided with some form of mattress will provide a reasonably comfortable bunk for 2 men" (POMFRET No. 6). The commanding officer of the BLENNY (No. 2) suggested air mattresses with the view of their use in the torpedo skids as the torpedoes are emptied. And added the RAZORBACK: "The efficacy of lifeguard duty would be increased by the addition of quarters for the survivors. Advise setting aside of a certain number of submarines for lifeguard duty which would carry less torpedoes providing adequate living quarters for the aviators."

"Outfitting the survivors will soon become a problem. We were able to absorb clothing and toilet requirements of our aviators for the relatively short time we had them aboard but we could not help but wonder how we could have handled a larger number or for a longer period of time. A dozen or so survivor kits should be provided." Another submarine commanding officer (BLACKFISH 12) added in this respect: "--supply a few kits of toilet articles (Red Cross) containing tooth brushes, a plastic razor, shaving and dental cream and a ditty bag. In addition, a small supply of jungle green trousers and shirts and underwear would help." QUILLFISH (No. 1) recommended survivor kits consisting of a Red Cross ditty bag and a reasonable supply of standard clothing be furnished each submarine detailed to lifeguard duty. SEADEVIL (No. 4) recommended that lifeguarding submarines be issued a small stock of emergency issue clothing for the use of survivors as outlined in SecNav letter, EXOS:OOBR/T-Tn, 6 December 1944.

AIR/SEA RESCUE OPERATIONS AND THE SUBMARINES

Before drawing a few conclusions and suggestions from all that has been covered, opportunity is taken to point out once more the true magnificence displayed by all service units concerned in air/sea rescues in this last war. Speaking for the Submarine Force in this respect some would admit that lifeguarding was often a disappointing and dull business, particularly those on veteran submarines long accustomed to a diet of redder meat. They were often bored and restless, as expressed by PETO (No. 11): "Lost all SD contact at 16 miles--we guess the raid (Marcus) is over although we saw no bombs dropped nor were the Zoomies inclined to give us any dope. The least they could do would be to say 'hello.' I guess the only time we get attention from those boys is when they get into trouble. We certainly hope that none of these people get into trouble but the monotony is weighing us down." But the "Fly Fly" boys on that submarine's next patrol were witness to as brilliant a piece of rescue work as took place during the war. The crew of submarines, once they got into the spirit of life rescue were as enthusiastic as anyone--when they saw with their own eyes the results of the combined efforts of the patient and monotonous waiting: "The look on Lt.--face when we picked him up more than made up for the 57 fruitless days we had lifeguarded" (HADDOCK 13). "Our aviator--had been in the water 14 hours but was in an excellent condition and was very glad to be alive. Replacement of clothing was no problem except for size 13 shoes. It might be added that this rescue did more for the morale of the crew than anything else could have done with the exception of sinking a ship. Every officer and man is proud to have been of some help to those who are now the ball carriers." The commanding officer of the SPEARFISH, the first submarine to rescue personnel from a ditched B-29, in describing the effect of the rescue on the morale of the crew stated: "Every man aboard is as excited and happy as a newly made father at being able to save our countrymen."

And the aviators were grateful. They, if permitted, made themselves useful in ever so many ways. The HARDER, once her aviator had recovered from the effects of his ordeal, noted: "--has proven himself a valuable addition--the first week he performed nearly 3/4 of all the decoding and for the remainder of the patrol stood submerged and surface watch." And as the BALAO commented: "Transferred our aviator friends to the PETO--. The 'Zoomies' didn't want to go and we didn't want to loose them. Guess submarines didn't get all of the best of the lads."

The pharmacist's mate of the BATFISH (No. 7) was suddenly confronted with 3 Army aviators recovered from a B-17. After swimming for some 3 to 4 hours they had managed to crawl aboard a life raft from which they were recovered 17 hours later. All 3 had numerous lacerations and bruises and were suffering from shock and exposure. One had a fractured ankle and a lacerated finger tendon. A second had a deep 8 inch laceration of the leg, a third

had a sprained back. On the second patrol of the GUAVINA, 12 Army aviators were rescued in 3 separate pick-ups. One of these was so badly injured that the patrol was terminated. ChPhM Risner aboard the BLUEBACK (No. 1) in approaching Saipan was suddenly confronted with 4 wounded Army aviators. One had multiple lacerations and fractures of the femur, tibia and fibula. The second and third were suffering from moderate injuries. His work in caring for these men seen an hour or so later by a medical officer was "excellent and worthy of special notice."

The pharmacist's mate on the first patrol of the BULLHEAD did an excellent job in caring for the 3 aviators recovered from a Chinese junk. All were seriously wounded and in shock, only one being conscious when taken aboard. The commanding officer wrote: "The pharmacist's mate is concerned about internal injuries"; believe we can handle them unless infection sets in, "and they did and successfully too." Three of the 6 aviators rescued by the ICEFISH (No. 4) were stretcher cases. One died a few hours after recovery. ChPhM Hager was especially commended by his commanding officer for "his superb job in treating the injured under difficult conditions." Again ChPhM R. M. Sharp of the JALLAO (No. 3) was commended for the care which he gave to 5 aviators rescued following a raid on Marcus Islands. All, seriously injured, had been on rafts for 81 hours and were in great shock. Three had multiple contusions, abrasions, lacerations, and shrapnel wounds. "A fourth had in addition a possible fracture of the tibia and fibula." A fifth had a severe head injury and cerebral concussion. Two days later the services of a medical officer were made available.

ChPhM Drayton on the sixth patrol of the PICUDA among 6 survivors from a B-29 treated 1 patient for a severe laceration and exhaustion and a second with a compound fracture of the leg. Pharmacist's mates aboard the PIKEFISH No. 1 and 5 were confronted with the identification, preparation of reports, and burial of 6 aviators dead upon recovery. POMFRET (No. 6) rescued all 5 members of a ditched B-25. One was unconscious, probably from a skull fracture and was vomiting blood, being in such a critical condition that the submarine "headed South--transfer at sea unless by plane not being considered advisable." A second had suffered a shattered patella. For the care given these men, ChPhM P. W. Wood was commended by his commanding officer.

RAY (No. 7) (20 aviators recovered in 2 pick-ups) had 3 stretcher cases (fractures and shrapnel wounds) and 7 cases of exhaustion, from men adrift on a raft for 12 hours in cold rough water. ChPhM Polling who cared for the men was commended by his commanding officer. ChPhM P. E. Lister aboard the RONQUIL (No. 4) out of 10 aviators rescued was confronted with one vertebral dislocation and 2 leg fractures, 1 man having a fracture both above and below the knee. His care of these men was especially outstanding. SCABBARDFISH (No. 4) rescued 5 aviators; one adrift on a life raft for 24 hours with a compound fracture of the leg was in shock from loss of blood. ChPhM P. D. Byork was commended by his commanding officer and division commander and given credit for saving this man's life by his judicious use of plasma and other anti-shock measures.

One of the three Marine pilots rescued by the SEADEVIL (No. 3) some 8 hours after rescue "underwent an anti-climax of shock and exposure" for which he was expertly treated by PhM 2/c Valenzuela who was commended by his commanding officer. ChPhM Williams aboard the SEALION (No. 5) is especially deserving of notice for his treatment of Sergeant B. R. Grier, U.S. Army, recovered by that submarine from a raft on which he had been adrift 23 days. The commanding officer of the SPEARFISH (No. 12) commended ChPhM E. P. Chaput for his treatment of 7 aviators recovered from a ditched B-29, all of whom were suffering from shock and exposure having been on rafts for about 20 hours, 2 having severe lacerations of their buttocks and leg.

Pharmacist's mate R. L. Wood on the STINGRAY's brilliant parachute rescue (No. 11) was commended by his division commander for care given to the 5 aviators rescued on that patrol, all of whom were suffering from lacerations, shock and salt water sickness. THREADFIN (No. 2) through the capable services of her pharmacist's mate undoubtedly saved the life of an aviator who, having trouble in clearing his plane, ended up in the water with his life jacket collapsed, without a rubber boat and tangled up in his parachute. "Had he been in the water a few minutes longer he certainly would have drowned. Artificial respiration and the removal of large quantities of salt water from his stomach was a great help." On the succeeding patrol, ChPhM Olmstead again demonstrated his ability in caring for 3 aviators, 2 of whom were stretcher cases. One he diagnosed as possibly having a broken back, the other had serious internal injuries. They were seen approximately one hour later by a medical officer from a destroyer who concurred in his diagnosis. One was in such a seriously shocked condition that transfer to the destroyer at sea was not felt indicated.

TRUTTA (No. 2) rescued an aviator from a life raft on which he had been adrift for 6 days having ridden out a typhoon the night before rescue. The commanding officer commended ChPhM Serafin for "his personal and continuous watch over the pilot over a period of 6 days, until he had fully recovered from the physical and mental shock of his ordeal."

SUMMARY

During World War II, 110 U. S. submarines in 200 separate pick-ups recovered a total of 542 American and Allied airmen downed in Pacific waters in operations extending from Tokyo Bay to the Solomon Islands. It appears that once having left their aircraft, fliers who ditched were in a far more advantageous position than those who bailed out of their planes. Eighty-two per cent of the men recovered were picked up within 24 hours; 16 per cent of the airmen spent less than 30 minutes in the water. The chance for survival of men aboard life rafts or boats dropped sharply after the fourth day. Ninety-one per cent of those wearing life jackets spent 6 hours or less in the water following which the possibility of their recovery became negligible. Very few men swimming without life jackets were recovered after one hour in the water. Two hundred and fifty-nine of the survivors (48 per cent) required medical care, essentially for exhaustion and primary shock consequent to over-exertion and over-exposure. Ten per cent of the airmen were suffering severe wounds with severe secondary shock. It appears that secondary infection of wounds is not a source for great concern. Two per cent (11) of the aviators were either dead on or died shortly after recovery. Study of the details concerning these rescues available in submarine war patrol reports suggests:

1. Submarines designated for "The Lifeguard League" should, if possible, be especially prepared and equipped for such duty.

(a) If this country again finds itself at war serious consideration should be given to placing medical officers aboard key submarines in "The Lifeguard League."

(b) Pharmacist's mates aboard these submarines should receive additional training in the furnishing of quick and efficient emergency medical care to comparatively large numbers of survivors in a short time.

(1) All survivors should be assumed to be exhausted and treated initially as victims of over-exposure and over-exertion. Pharmacist's mates must be adept in recognizing the signs of incipient circulatory collapse and skilled in the administration of intravenous fluids, blood plasma and whole blood.

(2) A significant number of survivors will require skilled emergency care for major injuries, particularly for fractures of the long bones, dislocations and shrapnel and incised wounds. Corpsmen must be proficient in the application and improvisation of splints.

(c) Prior to departure, the submarine pharmacist's mate with a medical officer should check his medical supplies against the commissioning list which is inadequate for this type of duty with respect to: 4 packages of albumin are inadequate, should be at least doubled; serum albumin could be advantageously included as could be whole blood and tetanus toxoid; penicillin is not supplied, there should be at least 800,000 units aboard; present allowance calls for 12 basswood and 2 wire mesh splints which must be supplemented with traction splints (as 3 Thomas leg splints and 1 Jones arm splint); additional hot water bottles; current allowance of 6 cotton elastic bandages should be increased to at least 12; there should be available freshly sterilized vaseline gauze, rubber gloves and a small surgical emergency tray. Equipment for easy administration of oxygen should be provided all submarines.

(d) Provisions for increasing bunking space aboard the submarine should be made before departure. Fewer torpedoes may be carried with extra mattresses to convert the torpedo stowage racks into extra bunking space. An adequate number of survivor kits (capable of caring for the needs of 20 to 30 men) should be available to each lifeguard submarine. Potential need for air purifying chemicals should be anticipated.

(e) Members of the rescue crew should be carefully picked and trained. They should be stalwart, strong and good swimmers. In cold weather they should wear exposure suits. They must be familiar with and capable of improvising available methods for the recovery and transfer of injured and exhausted men from open boats, rafts, and water, for hoisting them aboard the submarine, and lowering them below decks with a maximum of safety and a minimum of handling. "In effecting the rescue of survivors, rescue personnel should keep in mind any previously obtained information in regard to the physical condition of the survivors."[2]

2. Special investigation and study is indicated with regard to some pieces of standard life saving equipment.

(a) The present stretcher (NMRI Semi-Rigid Canvas Litter available in the medical commissioning outfits of submarines[3]) should be investigated under trial operations in all kinds of weather as to its suitability for: ease and quickness of application to wounded and exhausted men in the sea or aboard open rafts or boats; comfort when applied to survivors for prolonged periods; adaptability when used to hoist injured men aboard the submarine, to lower them below through the narrow inner hatches, and for intra-compartmental transpor-

tation. Definite need exists for the improvement of available means to transfer injured men at sea, in inclement weather, from one submarine to another or to surface craft or planes. If the NMRI litter does not meet these needs a stretcher or piece of equipment should be developed which does.

(b) Kapok life jackets currently used should be modified to include the following (available in the new Mark 2 pneumatic life vest[3]): a whistle and a one cell life preserver light so placed that when the jacket is donned the light is held upright and furnishes the maximum visibility thereby facilitating rescue at night. Hoist straps should be applied to the jackets, facilitating the securing of lines from rescue craft and the hoisting of survivors aboard. Sun helmets made of rubberized cloth with built in transparent plastic eye shields when folded form a compact and neat package which could be secured in a pocket of the Kapok jacket. By completely covering the head and face they protect against the sun and keep the salt water and fuel oil out of the nose and mouth of the survivor.[4]

(c) "Life rafts and boats should be equipped with heaving lines and a ring buoy or small rigid float with a painter attached."[2] Emergency supplies (water, food, first aid, radio, etc.) should be contained in water-proof and floatable containers, easily secured against loss with over turning and flooding of the raft. First aid supplies should include a splint easily applied by untrained personnel.

(d) "Bright yellow has been chosen as a standard color for life rafts and life vests. Though it can be detected from a great distance it has been described as 'white' when seen against a blue sea and may easily be confused with white caps or spray."[2] This appears to be a valid observation substantiated by others and should be widely disseminated, especially since there must necessarily be a time lag before the color of life saving equipment may be improved.

(e) Indianapolis survivors recommended the development of a large emergency flare for night use. The efficacy of the available colored smoke bombs for daylight use should be investigated in all weather conditions. In hazy weather it may be that the red flare is not seen to an advantage.

3. All potential survivors should be briefed in the knowledge that:

(a) A survivor's life may one day depend upon careful and routine inspections for deficiencies and defects of life saving equipment.

(b) The careless loss of emergency supplies with the sudden over turn of a life craft may prove disasterous.

(c) Survivors should remain if possible as a unit. Life rafts should be lashed together, life jackets can be tied to one another by their strings to prevent drifting away should the occupants fall asleep.

(d) The green dye sea marker can sometimes be detected at a greater distance by a searching surface craft than can the survivors.

(e) The old trick of remaining afloat with the aid of air filled garments works and should be kept in mind by survivors swimming without life jackets.

(f) Their existence may depend to no small degree on their familiarity with rigging and using the life saving equipment particularly when stunned and shocked following bailing out of or ditching their plane.

References

1. U.S.N. BuMed, Medical Commissioning Outfit for Submarines, 9-21-45.
2. Air/Sea Rescue Bulletin, January 1946, Volume III, No. 1.
3. BuAer Technical Order 90-45.
4. Letter, Medical Officer, U.S.S. Indianapolis, NavMed HF-33 (1943) as of 26 Nov 1945.

Table 32

Submarines Recovering Aviation Personnel on Air/Sea Rescue Operations

Submarine	Patrol Number	Number Personnel	Submarine	Patrol Number	Number Personnel
ARCHER FISH	3	1	QUEENFISH	4	13
ARGONAUT	1	1	QUILLBACK	1	1
ASPRO	6	4	ROCK	5	1
ASPRO	7	2	RAY	6	1
BALAO	6	3	RAY	7	20
BALAO	10	4	RAZORBACK	4	5
BANG	6	1	RONQUIL	4	10
BASHAW	3	1	SAILFISH	12	12
BATFISH	7	3	SAURY	11	1
BOWFIN	7	2	SAWFISH	8	1
BOWFIN	9	1	SAWFISH	9	1
BERGALL	4	4	SCABBARDFISH	4	5
BLACKFISH	12	6	SCABBARDFISH	5	7
BLUEBACK	1	4	SEADEVIL	3	3
BLUEFISH	7	3	SEADEVIL	4	12
BLUEFISH	8	7	SEA DOG	3	1
BONEFISH	7	*2	SEA FOX	2	1
BREAM	6	6	SEA FOX	4	11
BULLHEAD	1	3	SEALION	5	1
CABRILLA	8	7	SEA OWL	3	6
CERO	8	3	SEARAVEN	3	2
CHARR	1	1	SEARAVEN	10	3
CHARR	2	1	SEAROBIN	2	1
CHUB		3	SEAROBIN	3	1
COBIA		7	SEAWOLF	13	2
DRAGONET	2	4	SHARK (SS 314)	2	2
DRAGONET	3	1	SILVERSIDES	13	2
FINBACK	10	5	SKATE	1	6
GABILAN	6	17	SNOOK	7	1
GAR	11	8	SPEARFISH	12	7
GRAYBACK	5	6	SPIKEFISH	3	1
GUARDFISH	11	2	SPRINGER	3	9
GUAVINA	2	12	STEELHEAD	7	1
GUAVINA	6	5	STERLET	2	6
HACKLEBACK	2	1	STERLET	5	2
HADDO	7	1	STINGRAY	11	5
HADDOCK	13	1	STURGEON	10	3
HAMMERHEAD	7	1	TANG	2	22
HARDER	4	1	TENCH	1	2
HARDHEAD	2	1	THREADFIN	2	1
ICEFISH	4	6	THREADFIN	3	3
JACK	8	1	TIGRONE	2	30
JALLAO	3	5	TIGRONE	3	1
KINGFISH	11	4	TILEFISH	5	1
KRAKEN	1	1	TINOSA	11	10
MINGO	5	16	TIRANTE	1	*2
PERCH	7	2	TORO	1	3
PETO	10	12	TORO	2	6
PINTADO	5	12	TREPANG	5	10
PIPEFISH	1	3	TRIGGER	10	1
PIPEFISH	5	12	TRUTTA	2	1
PLAICE	6	5	TUNNY	5	*1
POGY	9	10	TUNNY	8	3
POMFRET	4	*3	WHALE	11	15
POMFRET	6	5			
PORPOISE	3	5			

* One Japanese

Chapter 7

Experiences of Survivors from Submarines Lost During World War II

In comparison to the number of submarines lost in World War II the number of known survivors is very small. An effort has been made to contact these men as they have appeared at the Bureau of Naval Personnel in Washington, D.C. To date, men from the U.S.S. GRENADIER, U.S.S. TANG, and the U.S.S. PERCH have been interviewed. Information is available concerning survivors from the U.S.S. S-44, and U.S.S. SCULPIN. It is understood that there are existing survivors from the U.S.S. TULLIBEE and the U.S.S. FLIER.

LOSS OF THE U.S.S. PERCH

The following account of the loss of the PERCH was obtained from the Confidential account, "Enemy Anti-Submarine Measures", prepared for Commander Submarines Pacific, and in a personal interview with Lt. Cdr. Jacob J. Vandergrift, Jr., USN, survivor, as of 5 April 1946.

"PERCH was lost in early March 1942. Prior to her loss she had been operating in the Java Sea. She was commanded by Lt. Cdr. D. A. Hurt. On 27 February the battle of the Java Sea had occurred, ending all organized Allied surface resistance in the East Indies. On 28 February the Japanese landed on Java.

"PERCH, while making a night surface attack on 25 February had taken a shell hit in the conning tower fairwater. The antenna trunk had been ruptured, the standard compass flooded and miscellaneous minor damage had been sustained. After repairs to the antenna trunk, a message was sent to Commander Submarines Asiatic Fleet telling him that radio reception was all right but transmission was doubtful. On the night of 28 February she received a message directing all submarines to disregard assigned areas and to attack the Japanese convoy at the landing point.

"About an hour and a half after surfacing, on the night of 1 March 1942, she was steaming on a westerly course, approximately 12 miles northwest of Soerabaja, when she sighted 2 Jap destroyers. PERCH dove and the destroyers passed well clear astern, but after going on for 4 or 5 miles suddenly turned and came back toward the submarine position. It was a bright moonlight night with good periscope vision, and one of the destroyers was maneuvering itself with a good position for PERCH to attack with stern tubes. When the range was down to 600 yards, the destroyer suddenly changed course, presenting a zero angle on the bow coming in at high speed. Hurt ordered 180 feet, thinking he had 200 feet of water under him.

"With PERCH going down at 100 feet, the destroyer came over and dropped a string of depth charges. PERCH had hit bottom at 147 feet of water with the motors still turning over. There was no damage from the depth charges or from the accidental bottoming. The destroyer returned.

"On the second run 4 depth charges were dropped. Maximum damage and shock was in the motor room and engine room. All motor field relays were tripped and were re-set. Power was lost on one shaft. Ninety per cent of the engine room gages were broken. Hull ventilation supply stop valve was frozen closed. The high pressure air bank in the after battery was leaking badly. No. 5 main ballast vents were frozen closed. The engine air induction inboard stops were frozen closed. Both batteries showed a full ground. The hull was compressed in the after battery for about 6 feet by 1 foot to a depth of 2 1/2 inches. The crew's toilet bowl was shattered.

"The third string of charges came while PERCH was still in the mud with motors stopped. The maximum damage and shock was amidships. The hull exhaust duct section in the control room flooded, soaking the fire control panel. The battery exhaust valve apparently opened and reseated. Several depth gages were broken. The conning tower was compressed to a depth of 2 inches over an area about 3 feet by 1 foot. No. 2 periscope was frozen; No. 1 periscope would raise but required 4 men to turn it. The engine room hatch, conning tower hatch and conning tower door gaskets were crimped and leaking steadily. The air conditioning water supply flange cracked at the weld and leaked badly.

"Shortly thereafter they got the PERCH out of the mud and commenced evasion tactics. In about 2 hours they managed to shake the destroyers. It was found out later that loss of air and oil had convinced the enemy that the submarine had been destroyed and they broke off the attack because of that. All the depth charges were being set shallow and were going off above. Japanese depth charges were manufactured for a limited number of settings and would not detonate if they bottomed before making their set depth; therefore, against a submarine on the bottom the charges had to be set shallow. On the other hand PERCH had to lie on the bottom and take it. She could not attempt evasion. Most submariners concede that it is psychologically harder to take a severe depth charging when lying helplessly on the bottom than it is when trying to evade."

"At 0300 PERCH surfaced. All the antenna insulators were broken. An armful of fragments of depth charges were picked up on deck. Both periscope windows were broken and both periscopes flooded. The blinker light was compressed flat. No. 1 main engine ran away on starting, No. 4 main engine camshaft was broken. No. 2 main engine was put on battery charge. No. 3 main engine was put on propulsion and the PERCH was headed for the position of the Japanese landing, still going in to attack.

"About an hour later, about 2 hours before dawn, 2 enemy destroyers were sighted, PERCH dove for the bottom. Hurt figured that he had a better chance on the bottom because, to operate submerged in the condition he was in, the noisy trim pumps had to be operated constantly. On the bottom he could stop all machinery and lie quietly. Unfortunately PERCH had been sighted.

"The destroyers were on top of the submarine almost immediately. The first string of charges did no additional damage. PERCH was on the bottom in 200 feet of water. Efforts to move her off the bottom were unsuccessful. The second attack was bad. The air conditioning circulating water supply flange crack increased. The flange studs elongated under the shock. The same thing happened on the suction and discharge lines of the high pressure air compressor circulation water lines. No. 1 main ballast vent was damaged or the tank was cracked for it was impossible to blow the tank. Air could be heard passing up alongside the hull when blowing but the tanks would not hold air. There were many leaks in circulating water line and in various high pressure air lines. Toilet bowls in the maneuvering room and after battery were shattered. The antenna trunk leaked.

"The third string of 5 charges was laid directly overhead from stern to bow. The bow planes, then on 20 degree rise, were rigged in by force of the explosion, burning up the bow plane rigging panel. The JK sound head was out of commission. Torpedoes No. 1 and No. 2 made hot runs in the tube.

"The next run was also close. The support studs on the bow plane tilting motor elongated and the shim dropped out. Bow planes were operated by hand from then on. The officer's toilet bowl was shattered and thrust out into the passageway.

"The final run of 3 charges was the most severe of all. This was about at 0830 on the morning of 2 March. The depth gage suddenly changed from 200 to 228 feet. For an area 6 feet by 2 1/2 feet the hull in the officer's state room was compressed 1 1/2 inches. The after battery had one cracked cell, the forward battery had 19 cracked cells. All the electric alarm system and telephone circuits were out due to cables being out when instruments were flung off the bulkheads. The engine room decks supporting stanchions between the overhead and the deck, were broken at the hull weld. No. 1 and No. 4 air banks were empty from leaks. Due to air shortage, no attempts were made to get off the bottom until night. After this attack the destroyers steamed away, confident of a kill.

"During the day damage to one of the main motors was isolated returning power to both shafts. Bilges were kept pumped down to avoid grounding electrical machinery. Forward and after trim and No. 2 auxiliary were pumped dry.

"At 2100 on 2 March they surfaced after about an hour of trying. The main vents wouldn't hold air and emergency vents had to be closed. The barometer in the boat was broken and no one knew what the pressure was. There was a 240 volt ground on both batteries. By going ahead and astern at maximum power on both shafts, PERCH was finally broken from the mud.

"After successively trying all engines, they finally got one on the line and got underway making 5 knots. One auxiliary engine was charging batteries. Fifty per cent of the holding-down studs on No. 3 main engine had snapped. The engine vibrated so badly that the head covers raised one inch. There were numerous short circuits caused by spray from salt water leaks

under pressure. Strips a quarter of an inch square in cross section had been cut from the gaskets of the conning tower and escape trunk doors by the explosive force, squeezing the gasket between the door and the knife edge. Many gaskets were badly crimped. Port reduction gear casing was cracked and lost lube oil constantly. The steering gear was badly damaged. With 'left rudder', the rudder could be moved only with difficulty but upon reaching the amidships position, it would suddenly snap over against the stops on the starboard side. No. 2 main ballast tank was leaking badly. They were unable to elevate the gun and the sights were shattered. The hull leaks were so bad on the surface that both trim and drain pumps were required at full capacity to keep the water down in the bilges.

"Hurt decided he would have to make a trim dive before sunrise; therefore, about 0400 on 3 March they made a running dive. In spite of every effort to make the ship light, and catch a trim by flooding in, she was found very heavy on the dive. She went down to 60 feet before the descent could be checked. Conning tower and engine room hatches failed to seat and leaked copiously. The diving officer started blowing as soon as they were under. By the time they were back on the surface, water in the engine room bilges was up to the generators. After surfacing it was only possible to expose the forward half of the deck."

"It was discovered that the conning tower hatch was so badly twisted that there was a 3/8 inch opening that could not be closed. They tried to adjust the dogs on the hatch, handicapped by darkened ship. While they were busy on the hatch the officer of the deck reported 3 Japanese destroyers in sight.

"The nearest Jap opened fire with one gun. The first shell was 300 yards short. The next one was on in deflection and still short. None of the tubes could be fired. The gun was out of commission. It was obvious that the ship could not dive. Hurt ordered abandon ship and scuttled. All the men got in the water safely. PERCH went down very quickly with the conning tower hatch open." (Confidential, "Enemy Anti-Submarine Measures", ComSubPac, pp. 36-43.)

(As Related by Lt. Cdr. Jacob J. Vandergrift, Jr., USN, on 5 April 1946)

For about a year prior to the beginning of World War II the PERCH had been in the Manila area. Lt. Vandergrift reported aboard in May of 1941. The onset of the first patrol on 10 December 1941, was made during the bombing of Cavite and was conducted in the Philippine-Hongkong area, the ship putting in at Darwin, Australia, at the end of 42 days. On this patrol air conditioning was practically non-existent due to malfunctioning of the system and lack of Freon gas. Conditions of habitability were especially bad upon diving when temperatures of 120 degrees F. were not uncommon after charging the batteries at high speed on the surface.

The second patrol began on 3 February 1942, when the PERCH left Australia with Lt. Cdr. David A. Hurt as the commanding officer (later killed in a hunting accident in the United States after his liberation from a Japanese POW camp). There were 54 men and 5 officers aboard; (2 men, a CMM and ChPhM James Deives, later received commissions). The submarine was operating in the Java Sea.

On 24 February in making a surface attack on a transport, PERCH was hit in the forward superstructure by a 3 inch enemy shell. No one was injured but there was extensive radio damage. On 1 March she was ordered into shallow coastal waters to attack a Japanese convoy in the process of landing on Java. On the night of 1 March (at about 2100) PERCH began an attack on 2 destroyers when one of the vessels sighted her and started to ram. The Captain ordered 180 feet--as the submarine was at about periscope depth, 6 depth charges were received. She bottomed at 135 feet in the mud, and was subsequently closely and severely depth charged. After about 3 hours, having blown herself out of the mud, she surfaced (0300) in the moonlight but within 45 minutes was forced to again submerge by the enemy destroyers. During this interval when on the surface, armfuls of shrapnel from depth charge casings were recovered from the deck.

The submarine remained submerged at 200 feet all that day (2 March) being intermittently depth charged when picked up by the Japanese sound operators. This counter-attack which PERCH experienced has been described in official reports (ComSubPac, confidential, "Enemy Anti-Submarine Measures", pp. 29-43). It was very severe and close. The hull was compressed in the after battery and many of the hatches were crimped and leaking badly. All hands weathered this ordeal amazingly well. The extreme heat and discomfort while submerged contributed to a loggy and slowed-down reaction.

About noon while the Japanese were in the midst of a run, PERCH attempted to get off the bottom, apparently blowing up much fuel and oil. At any rate, the Japanese soon departed at about 1200. From then until 2100, the crew was busy getting the ship in running order again. Vandergrift had the cooks prepare a hearty breakfast. The submarine surfaced (2100) with her decks awash. One engine was finally got on the line and they got underway making about 6 knots. It being dark with the moon not yet up, as many repairs as possible were undertaken on the surface. During this 5 hour period the men worked furiously. The running engines were lubricated by hand--several men being unable to tolerate the heat in the engine spaces would

come up on deck, recover and return to their work. At about 0330 on 3 March a test dive was made; the submarine, despite all that could be done, "hit 60 feet in 30 seconds," following which she was surfaced once more and with her decks awash.

Soon thereafter a Japanese task force (2 cruisers and 3 destroyers) was sighted, one destroyer opening fire upon the submarine, defenseless with her tubes and gun out of commission. The Captain ordered abandon ship. All the men came topside. The First Lieutenant went aft and broke the inner locks on the after tubes--the same was done on the forward tubes. The diving alarm was sounded, the vents opened--the First Lieutenant fighting his way up the conning tower against the rising water. The men on deck literally felt the ship (which was going ahead 1/3 on her batteries) go out from under them--PERCH going down in about 3 minutes at a distance of 100 yards from the survivors. As the destroyer passed over the spot where the submarine had disappeared from the surface, the men in the water heard and felt an underwater explosion, which injured no one.

All the men upon leaving the ship, were equipped with life jackets; many had taken "lungs" in addition to flash lights. Vandergrift pinned his "lung" to his trousers, enabling him to float with his feet up without difficulty. The flashlights, immediately grounded in the water and could not be extinguished. When the underwater explosion was heard, thinking the Japanese were attacking, flashlights were ordered extinguished--which was done by dropping them to the bottom. The destroyer circled, stopped some 100 yards away from the survivors and turned on her search light. Two boats were lowered and the men were taken aboard. About half of the men swam to the destroyer, going up her sides on ropes--Vandergrift described his ascent wearing the "lung" and life jacket. At no time were they attacked. As a matter of fact, the Japanese made a special effort to recover every individual. They were in the water for about an hour. One man who could not swim had no difficulty. The sun was just coming up when they got aboard the destroyer.

They were soon transferred to a captured Dutch Hospital Ship. For the next 6 days, each man had a bunk with clean sheets and received one bowl of rice a day. Upon arrival in Macassar City, they were sent to a captured Army Post, where they occupied very confined quarters. After a few days their diet improved to the point where they were eating bread, sardines, etc. About 1 April of 1942, all of the officers and 3 radiomen were sent by merchant ship to Yokohama. After a slight delay (Doolittle's Raid) they arrived at the Ofuna questioning camp about 25 April. There living conditions and treatment were bad. From July 1 to 15, Vandergrift, because of dysentery, was a patient at the Yokosuka Naval Hospital where he received comparatively good treatment, gaining about 15 to 20 pounds in 2 weeks. Then he was sent to a Prisoner of War camp at Zentsuji where he remained until 20 June 1945, being then transferred to a POW camp high in the mountains at Rokuroski with 2 other officers from the PERCH. Most of the enlisted men remained at Macassar City; some were later sent to Japan. Fifty-three of the men and officers from the PERCH were returned to the States at the conclusion of the War. The pharmacist (about 43 years of age) and 5 enlisted men--all older men, 4 being chief petty officers--died in POW camps of pellagra and malnutrition. Vandergrift at the time he departed on the patrol weighed 190 pounds. At the time of his release he weighed 130 pounds.

LOSS OF THE U.S.S. GRENADIER

The following information concerning the loss of the U.S.S. GRENADIER has been obtained from two sources: Confidential, "Enemy Anti-Submarine Measures," prepared for Commander Submarines Pacific, and from an interview with Lt. Cdr. Alfred Toulon, USN, engineering officer aboard the GRENADIER at the time she was lost.

"GRENADIER was patrolling in Malacca Straits under command of Lt. Cdr. J. A. Fitzgerald, early in the morning of 21 April 1943. At 8 o'clock that morning, she had still about 15 minutes to go to obtain a desired position on a convoy's track when the lookouts reported, 'Plane on the port quarter.' Fitzgerald not wishing to be deceived by a bird or a false alarm, turned around and identified the object as a plane. He therefore ordered the ship submerged.

"A few seconds later as they were passing 120 feet, the executive officer remarked to the Captain, 'We ought to be safe now as we are between 120 and 130 feet.' With that, there was sound and fury like 2 express trains colliding immediately overhead. Later investigation showed that a bomb had exploded near the maneuvering room after torpedo room bulkhead. In the conning tower the first effect was loss of all power and lights. The ship keeled over from 10 to 15 degrees and continued down towards the bottom.

"There was some difficulty establishing communication with the after compartments. Then the word came through 'Fire in the maneuvering room.' So I set the boat down on the bottom in 267 feet of water. The fire in the maneuvering room could not be immediately controlled. Fitzgerald ordered the compartment sealed. In about half an hour the compartment was opened again and entered using 'lungs' and respirators. The fire was in the hull insulation cork, cables, stores and cleaning rags. The main motor cables had been cut by the hull movement and arcing and sparks from the resulting short circuit had caused the fire.

"When they got the fire out they found the maneuvering room pretty much of a wreck. Two men had been overcome by smoke. Many of the men appeared to be dazed. Fitzgerald passed the word over the public address system, 'Steady men. We're O.K. Everything is all right.'

"There were numerous leaks in the maneuvering room. The maneuvering room induction valve had been knocked off its seat permitting about a 2 inch stream of water to pour in. The hard patch above the main motor controller had broken loose and there was a spray of salt water coming down through the vast maze of vital electrical apparatus. Short circuits and grounds were causing many little fires to break out."

"It was immediately necessary to form a bucket brigade between the maneuvering room and the forward torpedo room in order to keep the water level down below the main motors. Many men lost consciousness from heat prostration and physical exhaustion. Eventually a jury rig was established between the main battery and a drain pump, which permitted putting the drain pump on the motor room bilge. The bucket line could be secured.

"Investigation showed that the bomb had apparently exploded near the maneuvering room--after torpedo room bulkhead. The door between these two compartments was sprung and could not be completely closed. On the starboard forward end of the after torpedo room the hull was dished in from 4 to 6 inches. The after tubes had been forced to port, apparently bending the main shafts. All the hull frames in the maneuvering room and the after torpedo room were badly bent inward. The strong back in the after torpedo room loading hatch was bent.

"The after torpedo loading hatch was damaged, permitting a shower of water to spray into the torpedo room. Later, on the surface, Fitzgerald found that about two-fifths of the gasket in that hatch was badly cut up. The hatch itself was elliptical in shape to the extent that he could put his hand between the knife edge and the hatch cover.

"All hydraulic lines to the tubes, vents, and steering mechanisms in the after torpedo room were broken. Many of the gages in the after room were knocked out of position. In the maneuvering room the control gage was twisted out of shape. Deck plates and supporting frames were warped. In the engine room, hydraulic lines to the main vents were broken, minor damage extended all the way to the forward battery where dishes and victrola records were broken.

"The radio transmitter was knocked off its foundation but was later put back in commission. The insulators in the antenna trunk were later found to be broken. The SJ radar appeared to be all right but could not be tested.

"They worked all day trying to regain propulsion. The electricians exerted every effort to protect the electrical installments from the shower of salt water falling from the maneuvering room overhead. Intermittent electrical fires broke out during the day. The fires and the leaks were constantly undoing the work that had been accomplished toward main propulsion repairs. At 2130 they surfaced. Lt. H. B. Sherry, the diving officer, brought her up on an even keel. On the surface there was a chance of restoring the electrical machinery without the handicap of so many leaks. The ship was cleared of smoke by turning over the main engine. Finally by jury rigs it was possible to get the contact levers into the second stage of resistance. Approximately 2750 amps were required to turn the shaft as against a normal 450. Finally the engineering officer, Lt. Toulon, and the electricians reported to Fitzgerald on the bridge that everything possible had been done to establish propulsion; they knew of nothing further that could be done, and they had not been successful.

"The 3 inch gun was reported out of commission. GRENADIER could neither fight nor run away. The chief yeoman, Robert W. Palmer, in his statement says, 'The morale was high due to the excellent skipper.' They attempted to rig sail, intending to work in closer to the beach where the crew could be disembarked and the ship blown up. This attempt was soon abandoned as futile. At 5 or 6 o'clock in the morning a coded message was sent giving the condition of the ship and notice of intentions to abandon GRENADIER.

"The confidential papers were destroyed. The radar and radio equipment was destroyed. The TDC and the sound gear were smashed. While these preparations were in progress the approaching dawn disclosed 2 ships in sight. A single engine plane came over and attacked; but GRENADIER was not yet helpless. Withholding his fire until the position angle was about 65 degrees, Fitzgerald opened up with 2, 20 mm and 2, 30 caliber machine guns. The plane was hit. It pulled up sharply and changed course to the left to obtain position to make a run up GRENADIER's port side. The plane dropped its bomb. It exploded in the water about 200 yards from the GRENADIER. Later it was learned that the pilot of the plane died that night as a result of his wounds and a crash landing bringing his plane in.

"As the patrol craft approached, the crew of GRENADIER with their life jackets were lined up the forecastle. The sick and the non-swimmers were assigned to rubber life boats. The chief of the boat, W. C. Withrow, was below manning the vents. Fitzgerald gave the order to abandon ship. All except he and Withrow jumped over the side. The chief opened the vents. GRENADIER commenced sinking by the stern. Fitzgerald and Withrow went over the side.

"The Japs circled the GRENADIER taking pictures. Lt. Hardy clung to a mattress and read to the crew from a Reader's Digest. They waited for the Japs to come, pick them up and send them to torture and starvation." (Confidential, ComSubPac, "Enemy Anti-Submarine Measures", pp. 44-49).

(As Related by Lt. Cdr. Alfred Toulon, Jr., USN, 7 February 1946)

Lt. Cdr. Toulon was aboard the GRENADIER on its fifth patrol after which the ship returned to Australia, refitting at Perth. The sixth and last patrol began on 20 March, 1943. During the night of 20 April, while in the Andamon Sea, the ship drew fire from enemy surface ships. On the morning of the 21st, while patrolling in the Malacca Straits, the submarine surfaced. At about 0800 an enemy plane forced the GRENADIER to submerge, scoring a direct bomb hit over the forward part of the after torpedo room when the ship was at about 100 feet. Lt. Toulon, having just come off watch, was in his bunk. Being somewhat tense in the knowledge that the enemy knew of their presence in the area, on hearing the order to "Standby to dive," he ran to the control room. When the bomb struck "the boat kinda went out from under me." He did not lose his footing. With the concussion he was conscious of a dull pain in both ears.

The ship sustained serious materiel damage. A propeller shaft was bent and the control panel in the maneuvering room was damaged beyond repair, throwing the electrical equipment throughout the ship out of commission. With salt water coming through the auxiliary induction, fire broke out in the maneuvering room. In the after torpedo room, bunks and torpedoes were thrown about wildly. The hull, though intact, was caved in at the point of the bomb impact. Beyond a few superficial lacerations and bruises, there were no personnel casualties. It is thought that escaping fuel oil convinced the enemy that the ship was destroyed, no further bombs or depth charges being dropped.

Not wishing to blow to the surface, the ship shortly bottomed in about 265 feet of water. Because of the overpowering and acrid smoke from the maneuvering room (the fire lasted about an hour) that compartment was shut off. Inasmuch as rescue breathing apparatus was not available, escape lungs were used by personnel working in the compartment. When put to this use the lungs are reported to be clumsy; difficulty was experienced in keeping the mouth-piece in place. A bucket brigade was set up, carrying water from the maneuvering room forward to the forward torpedo room. Inasmuch as the forward batteries were still intact, a jury rig was set up, whereby it was hoped to start the auxiliaries.

During the 16 hours spent submerged, atmospheric conditions became trying for the 8 officers and 68 men aboard. Emergency lighting was functioning. The air conditioning and ventilating systems were not working. The fire in addition to creating irritative smoke, had consumed some of the available oxygen from the atmosphere. About 8 cans of carbon dioxide absorbent were spread out in the after battery; oxygen was bled into the boat. Men were encouraged to lie down. Despite these measures, the ship became very hot and humid and headaches were common. There was no evidence of hysteria; those at work were spurred on by the confidence of the commanding officer's "Let's get out of here." As time went by it became apparent that the ship could not be gotten underway. Destruction of equipment was carried out. On surfacing it was hoped that the currents would carry the helpless submarine toward a nearby island. The ship surfaced about 2130.

With the morning, an enemy plane made a run on the boat dropping a bomb short of the ship. It was later learned that probably the 20 mm crew had fatally wounded the pilot of the plane. Enemy surface craft being spotted, the vents were opened and the submarine was scuttled at approximately 0930 on 22 April. There being an insufficient number of life jackets available for all hands, mattress covers were inflated with air prior to abandoning the ship. One rubber life raft was available, in addition, for some 4 men who could not swim. After about an hour in the water, the entire complement was recovered by a converted enemy merchant ship and was taken to Penang, in the Malay States.

At Penang the men were imprisoned as a group in an old English school. The first 5 days they were without food, after which they received a diet consisting, in general, of 2 bowls of rice twice a day. Interrogation was frequent; treatment was harsh. Questioning commonly ended with beatings and insensibility. After about a week, the commanding officer and 3 men were removed. One radar man was sent to Java where he was interrogated by the Nazis from whom he received exceedingly harsh treatment. Lt. Toulon states that after about 2 weeks, there was an onset of edema. Everyone while at Penang had dengue fever. Toulon personally lost from about 160 pounds to 100 pounds in weight within the first 3 months; during his imprisonment he never weighed over 120 pounds. He had recurrent amoebic dysentery and describes edema of the ankles, thighs and scrotum. The throat was continually dry; the gums were sore and he states that about 50 per cent of the men had swelling and enlargement of the maxillary lymph nodes. Scabies and other types of skin diseases were common. As far as he knows, no one had malaria or tuberculosis.

On 6 August 1943, after a period of about 4 months, the men were taken to Singapore where they were put to work building a road. Their diet was very meager. Not being considered prisoners of war, they received no compensation. While at Singapore, Toulon compiled a sort of a medical record of all the men. He states that shortly after the submarine had departed from Perth, 3 men developed a urethral discharge, diagnosed by the medical officer at Exmouth Gulf as gonorrhea. Enroute to the area, these men were treated with sulfonamide drugs. At the time the ship was scuttled, each man took some of the medication with him; all were relieved of this by the Japanese. Two of the men were said to have cured themselves spontaneously without further treatment. The third apparently developed complications, probably a periurethral abscess. Treatment was refused by the Japanese despite his great discomfort. In desperation he manually caused the abscess to rupture and drain. This man later developed visual difficulties. Toulon feared that it might be a gonorrheal conjunctivitis but was assured by an imprisoned doctor that it was not. This man, for a month or so, complained of inability to see; but eventually recovered. Other men, including Toulon, experienced visual impairments.

On 21 September, 71 of the men were taken to Japan. Fifty-two were sent to Fukuoka; 29, including the pharmacist's mate (PhM 1/c J. J. McBeath) and Toulon were sent to Ofuna where they remained for a year and through the severe winter of 1943. They were then sent to a camp near Tokyo. In February of 1945, they were removed to a camp on the coast opposite Tokyo where they remained until 6 September 1945, the date of their release.

Of the 76 men taken prisoner, 4 died. One of these was a Filipino. All 4 death reports carried the causes of death as lobar pneumonia and beriberi. Toulon is of the opinion they more likely died as the result of malnutrition and beatings. Prior to release from their prison camp, Toulon received a laceration of the forehead and cheek when struck by soap, dropped from B-29's. During imprisonment his teeth stood up remarkably well in view of the fact that for a year he was without a toothbrush and despite the poor diet. Upon examination only a few minor caries were discovered. Men while being beaten frequently suffered chipping of the enamel of their teeth until they learned to grit their teeth. In Christmas of 1945 each man received one-half of a Red Cross parcel; at Easter 5 men were supplied with 2 parcels. At Christmas of 1944 each man received one parcel.

LOSS OF THE U.S.S. S-44

The following information was obtained from Ernest Arthur Duva, CTM, USN, when interviewed on 1 October 1945, by Lt. W. A. Palmer, USNR.

"My name is Ernest Arthur Duva, CTM, USN. I was serving aboard the U.S.S. S-44, when that ship was lost 7 October 1943. At that time we were about 10 miles off Arito (Araido To) Island, Kurile Islands. At 1800, I was relieved as J.O.O.W. by Stromsoe. I had supper, then retired to the forward battery compartment where I was quartered. I turned in and was awakened by the one blast on the diving alarm which was our pre-arranged signal for a night surface attack. I immediately jumped out of my bunk, put on my shoes and proceeded to the C.O.C. (control room), my battle station. I made a note of the time which was 2030. The gun crews were scrambling up the conning tower ladders to man the deck and 20 mm guns and shortly thereafter the 4 inch gun commenced firing. I overheard Mr. Quinn, the executive, asking some of the lookouts what the target was, and one of them replied he didn't know but it was something big. By this time the target was firing at us. I could hear the captain shouting orders to the gun crew and helmsman. Finally I heard 'Gun crew below, stand by to dive.' The first shell hit the conning tower just as the men were coming through it on the way below. CM 1/c Moss was hit but managed to get down the ladder and forward. The next shell struck the control room. Meanwhile, numerous 20 mm shells were hitting the pressure hull of the submarine. By the time the Captain got to the control room from the bridge, the water was rising above the C.O.C. floor plates. Evidently there was damage in the forward battery room that I didn't have knowledge of, as I noticed the Captain go forward, apparently to inspect some damage in that compartment. We managed to get the trim pump started on the C.O.C. bilges.

"Water kept rising higher. Then all of a sudden from the forward battery room came the voice of the Captain ordering 'Abandon Ship!' The diving officer, Mr. Stephenson, ordered main vents shut. By this time all hands were proceeding to the torpedo room. I left my station, picked up a life jacket of the Kapok type, and went into the torpedo room. There was some more water coming into the forward battery compartment, and already a considerable amount in there, but I couldn't see where it was coming in. When I stepped into the torpedo room, quite a few of the men were assembled there. Velebny had the hatch undogged but couldn't raise it. Mr. Quinn tried and finally was able to open it. When the hatch opened, some light filtered in from the target's searchlight.

"The target proved to be a destroyer about 300 yards on our port beam. The submarine was afloat, the attempts to dive having been stopped when abandon ship was ordered. The destroyer was still laying machine gun fire across the deck and, consequently, no one

was making any particular effort to get up the ladder. About this time, a heavy shell hit the torpedo room, knocking most of us off our feet. I don't know whether anyone was killed or injured by this hit. The submarine was pitching and heavy seas were coming down the hatch. At times it seemed as though the bow would never rise again. I went up on deck and waved my arms at the destroyer, hoping they would stop firing. Luckily I was not hit--they kept right on firing. The searchlight was right on us. Heavy seas hit me at this time and knocked me under the deck gun where I stayed. The firing was continuous and the 20 mm and machine gun fire was hitting the superstructure and pressure hull. Whitemore came up after I did. He jumped overboard but was washed back on board and lay beside me under the gun. Several other men came up on deck and jumped overboard. I saw Stromsoe lying by the torpedo room hatch. He was bleeding about the head and I realized he had been hit. His hand was moving up and down. I saw a couple of other men come out of the hatch. In all, I saw about 8 come up onto the deck--Green, Ellis, Carrier, Stromsoe, Whitemore, myself and a couple more I can't identify. All of us either jumped or were washed overboard. The ship was sinking very fast. I climbed to the 20 mm platform and just as I got there the platform was awash. Seas knocked me overboard on the starboard side. Her nose went down and the stern came up. She made her last dive sinking very quickly by the bow. I felt no suction or explosion, although I was practically over the spot where she went down.

"The searchlight on the destroyer went out about a minute after the ship sank. I couldn't see the destroyer but I heard voices in the water asking for assistance. I heard Whitemore ask, whom we later believed to be Ellis, if he had a life jacket. Ellis replied in the negative. Whitemore then yelled my name and asked if I had one. I told him I did. I couldn't see him but heard him swimming toward me. He finally reached me and hung onto the jacket with one hand and swam with the other.

"We thought the destroyer had left the scene. About 20 to 25 minutes later, we saw a silhouette of a ship and started yelling. The current and tide were drifting us down towards this ship. The ship turned on her searchlight but trained it on an object on the opposite beam from us. The light stayed trained on this object for 3 or 4 minutes and then started sweeping. Apparently the object, whatever it was, sank from sight. Finally the light trained on Whitemore and I. During this time I could hear other voices in the water yelling for help. A small boat was lowered and rowed over to us. Whitemore climbed into the small boat while I grabbed a life ring and was pulled aboard. As soon as we were aboard the small boat, the searchlight on the destroyer went out. No attempt was made by the small boat to pick up any other survivors. It returned directly to the destroyer, about 300 yards away. When we were picked up by the small boat, I couldn't hear any other voices in the water.

"I am certain that the destroyer didn't pick up any other survivors. As soon as we got on board the destroyer got underway. They were apparently afraid there was another submarine about as they questioned Whitemore and me about it. We steamed directly to a big port, I believe it was Paramashiro, which took us about 2 1/2 hours to reach. Whitemore and I kept together all the time. We stayed in this port the rest of the night of the 7th, and the following day.

"On the morning of the 9th, they took us to a seaplane tender which in turn took us to Honshu, about 36 hours. There we were put on a train and were taken to Ofuna. We stayed in Ofuna until 30 September 1944. We were then taken to Omari and stayed there until 3 October 1944. Then we were taken to Ashio labor camp. We were liberated from this camp on 4 September 1945.

"The temperature of the water at the time the submarine went down was 47 degrees F. I know because I was keeping the water injection log. The seas were very rough. The Japs expressed surprise that Whitemore and I had survived in the water as long as we did. There were no other ships in the area as far as I could tell. I feel certain that the others who got out drowned. I don't believe they had a chance in the world to survive.

"The rubber life raft was never launched and I didn't see any debris in the water that would keep a man afloat."

LOSS OF THE U.S.S. SCULPIN

The following account of the loss of the SCULPIN has been taken from a speech made by Vice Admiral Charles A. Lockwood, Jr., USN, before the American Society of Naval Engineers at Washington, D.C., 5 April 1946.

"The SCULPIN was also lost under very tragic circumstances as we learned after the war. She attacked a convoy northeast of Truk on 19 November 1943, just the day before the Marines began the bloody battle of Tarawa. SCULPIN was part of the covering force for this operation and the wolf pack leader (Captain John Cromwell) embarked in her, of necessity, had been given an outline of the general plan of the operation. The attack on the convoy failed and during the ensuing depth charge counter-attacks which lasted about 5 hours, a particularly close string of 18 charges threw SCULPIN out of control and she went down deep."

"The hull was distorted, outboard valves were leaking badly, the torpedo tube doors were jammed and so much water had been taken into the hull that high speed was required to maintain depth control. Use of high speed, of course, made tracking an easy matter for the DD. Added to these troubles was the fact that the battery was almost exhausted and the depth was too great to permit lying on bottom.

"After some discussion as to the best course to pursue, the commanding officer, Cdr. Fred Connaway, decided to surface and fight it out with his 3 inch gun, 2, 20 mm and what 50 calibers they could rig. It was a last desperate chance, as he must have known, and the ensuing engagement with the DD 'Yokohama' soon reduced the topsides and C.T. to shambles. After Cdr. Connaway, Lt. Allen, and Lt. Defrens, with most of the men on deck had been killed, Lt. Brown, the senior ship's officer remaining, ordered the ship scuttled.

"Captain John Cromwell, when informed that the ship was being abandoned, said, 'I can't go with you; I know too much,' and was last seen seated in the control room. Ensign Fiedler also preferred death to capture and is said to have been last seen in the wardroom playing solitaire.

"And so the old SCULPIN, whom you may remember as having been the ship which located the SQUALUS when she sank off Portsmouth in 1938, went down with colors flying and engines running. The lads in the water say her last dive was as pretty as any she had ever made.

"The Japs picked up 42 passengers, threw one overboard who was wounded, tried to throw over another who was vomiting from having swallowed too much salt water and took the remainder to Truk.

"The sequel to this story was written 2 weeks later just before midnight on 3 December when the SAILFISH, which was originally the SQUALUS, picked up 4 radar pips, 2 large and 2 small, on a northwesterly course while patrolling about 200 miles southeast of Tokyo Bay; and eventually sank a Japanese carrier, the Chugo. Not until the end of the war did we learn, to our sorrow, that this flat top had on board 21 prisoners from the SCULPIN, 20 of whom went down with her."

LOSS OF THE U.S.S. TANG

The following information concerning the loss of the TANG has been compiled from the official report of the fifth patrol of the vessel as written by the commanding officer, Cdr. Richard O'Kane, USN; from a personal interview with Lt. Cdr. (then Lt.) Lawrence Savadkin, USNR; from personal correspondence with 2 other survivors Hayes Oliver Trukke, TM.1c, USNR and Pete Narowanski, former TM 3c, USNR; and from an account written by Lt. Harry J. Flanagan, USN. The quotation attributed to Clayton Oliver Decker, former MM 3c, USNR was taken from a news interview given in Guam at the time the men were returned from Japanese prisoner of war camps.

The fifth patrol of the TANG began on 24 September 1944, on her departure from Pearl Harbor. It was conducted in the waters off Formosa, ending on 24 October 1944, when the ship was lost. The available patrol record was written from memory by the commanding officer. Concerning the patrol, ComSubPac stated: "It was one of the great submarine cruises of all times. In four precisely executed attacks (22 out of 24 torpedo hits) 13 enemy ships were destroyed. The total tonnage sunk was 107,324 tons. It was the tragic result of one of the unavoidable risks of submarine warfare that this gallant ship would be struck when one of her own torpedoes, and that, the last one to be fired, made an erratic run."

"On 24 October 1944 (time is not definite) we fired our 24th and last torpedo--at the foremast of crippled target. Rang up emergency speed as the last torpedo broached and curved sharply to the left. Completed part of a fish tail maneuver in a futile attempt to clear the torpedo. It struck abreast of the after torpedo room with a violent explosion. The tops were blown off the only regular ballast tanks aft and the after three compartments flooded instantly. The TANG sank by the stern much as you would drop a pendulum suspended in a horizontal position. There was insufficient time to carry out the last order to close the hatch. One consolation for those of us washed off into the water was to see the explosion of the 23rd torpedo and observe our last target settling by the stern. Those who escaped in the morning were greeted by the transport's bow sticking sharply out of the water a thousand yards away." "Cdr. O'Kane, without a Mae West, swam from 0200 to 1000 when, with the others, he was taken from the water."

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[1] The TANG was recently awarded its second "Presidential Unit Citation" for "heroic services during the fourth and fifth patrols against Japanese shipping." Cdr. O'Kane has recently been awarded the "Congressional Medal of Honor" by President Truman.

Lt. Cdr. Lawrence Savadkin, USNR, interviewed on 7 February 1946, related the following details concerning his most interesting "free escape" from the conning tower of the submarine at a probable depth of from 50 to 60 feet.

Lt. Savadkin reported aboard the TANG in July of 1944, making the fourth patrol of the ship. On the 24th of October 1944, at approximately 0200, as the 24th and last torpedo was fired, someone yelled: "Let's head for the barn." The words were hardly spoken when those on the bridge saw the torpedo "broach and curve sharply--." It struck abreast of the after torpedo room with a violent explosion.

Shortly before the explosion there were 8 men on the bridge--the commanding officer (Cdr. Richard H. O'Kane), the OOD (Lt. Heubek), the quartermaster, a boatswain's mate (Liebold, the captain's "extra set of eyes"), and 4 other lookouts. They were joined by a radar technician (Floyd Muriel Caverly). In the conning tower there were 9 individuals--the executive officer, 2 radar men, the helmsman, a recorder, 2 plotters, Lt. Savadkin and the soundman (Bergman). Lt. Savadkin was standing at the TDC, near the after bulkhead, about opposite the soundman. In the precipitous plunge of the stern to rest on the bottom, personnel in the conning tower and on the bridge fell aft with the steep angle. There being insufficient time to close the hatch, an immense rush of water quickly flooded the conning tower. Personnel in the control room succeeded in closing the lower conning tower hatch; although, it had been jammed in the explosion and leaked badly.

Three of the 9 officers and men on the bridge (Capt. O'Kane, Liebold and Caverly) washed off into the water. They were able to swim throughout the night and were picked up 8 hours later. Nothing is known of the fate of the 6 other men except that the OOD is said to have been unable to swim. The lookouts, with the sudden lunge of the stern to the bottom, conceivably may have been thrown violently backward against the periscope shears; conceivably, too, their chances of having been thrown clear of the submarine or of having extricated themselves may have been hindered by the half encircling guard rail about the lookout platforms.

Lt. Savadkin described the events which befell him as follows: "With the explosion of the torpedo, the boat seemed to bounce up and down. I didn't lose my footing. For a short time thereafter we had communication with the bridge. I heard the order to close the hatch and the Skipper wanted to know if we had any propulsion. I started forward to look at the pit log which I remember seeing--. Then the lights went out. The conning tower filled almost immediately with water. One man is said to have fractured his arm in falling through the open hatch into the control room. I was hanging on, leaning against the No. 2 periscope shaft--which was down. Confusion was great at this time. With the sudden downward angle of the boat, men and loose gear were bumping and falling by me with the rush of water. I apparently rose up along the periscope shaft--things then quieted down. I observed that my nose and mouth were out of the water--in an air bubble in the overhead of the conning tower where the No. 2 'scope' goes through and where there is an indenture between the cork and the hull. I remained there in the quietness with my nose and mouth cramped up against the cork to breathe. I thought that I had better figure out what else I should do--wanted to know where I was. For some reason I thought the boat was upside down--I had a fear of going up the periscope well and being caught in the pump room. I ducked out and began to feel around, treading water all the time. Then I seemed to rise and come up into a real big bubble with my whole head and face out of the water. I felt around and found the engine order telegraph and knew that I was in the forward end of the conning tower. The air must have been trapped between the hatch and the forward bulkhead. I thought that I'd better get out--felt around and located the ladder, the trunk circling the top of the ladder at the hatch. I figured that I might hit into another air bubble. I went through the hatch which opens up underneath the cowling on the bridge where air was trapped under the cowling. In popping out of the water I must have made a noise for there was a voice calling 'Who is it?' I said, 'Mr. Savadkin. Who are you?' 'Bergman.' He was the soundman who had been opposite the TDC in the conning tower. He said: 'Do you know where we are?' 'I think we are under the bridge.' 'What are you going to do?' I told him that I thought we'd better get out of here and try to get to the surface. He said could he come with me. 'Sure.' 'How?' I told him to hold on--and I ducked down under the cowling with him holding my legs, but as soon as I pushed down, he let loose. I didn't see him again. I think he must have been confused, although his voice sounded normal."

Lt. Savadkin is of the opinion that, at this time, the bridge of the submarine was approximately 50 to 60 feet below the surface of the water. "I began to swim up, using both hands as hard as I could--." "The whole idea was to get up--". "I wanted air and lots of it--." "I had no sensation of being under pressure--but I thought about letting the air out and knew that as I came up I would have to force the air out. So I heaved it out--all at once--and then just as I thought I'd have to swallow some salt water, I burst out on the surface and began swimming." "I was dressed in long trousers, shirt, scivvies, and socks--the leather 'go-aheads' which I had on must have come off; and somewhere I lost my watch." "I could see the bow of the boat sticking out of the water ahead to about the windlass which is just forward of the hatch (the

hatch to the forward torpedo room thus being under water). I tried swimming for it, to hold on and collect my wits, but the current was too much for me. So I began to float. Then, so I would have more energy, I took off my shirt and trousers and socks, tying them around my waist. Then I began to get cold and began to shiver uncontrollably." "The water wasn't very rough--so that I could float and get only an occasional one over my face--but when I began to shiver, I swallowed water. I felt alone--screamed bloody murder--no answer--I got the impression that I was the only person who had gotten off the boat." "I remembered the trick of using your trousers for a life belt--blowing them up--had to refill them about every 15 minutes or so, but it worked. I lay on my back and stomach. I knew there was an island about 10 miles away and I knew that we were near the China coast. Thought if I could stay afloat until daylight I could make it--tried to swim west, using the stars, but I didn't know enough about them. When it began to be light I could see the China coast, and tried to swim for it; but the current swung me around in circles." Japanese patrols were running close by dropping depth charges occasionally. Having felt the explosion of the first one, he anticipated the others by floating and arching his back out of the water as they exploded. "When I saw the escorts, at first I avoided them but then I decided that they had better see me--so I yelled--splashed water--and they picked me up"--about 10 o'clock in the morning.

Events as they befell those men still alive and occupying the unflooded portions of the ship appear to have been as follows:

"In the explosion--which was described as very violent, whipping the boat, breaking high pressure air lines, lifting deck plates--numerous personnel as far forward as the control room sustained broken limbs and other injuries." "The immediate result to the ship was to blow the top off the only regular ballast tanks aft and to immediately flood the after 3 compartments, from which no one escaped. Even the forward engine room was half flooded before the after door could be secured. When the survivors from here and the after battery reached the mess room they found water already above the eye-port in the door to the control room. Testing the bulkhead flapper and finding that water had not yet reached this high, they opened the door, letting the water rush past them as they proceeded through the control room and the forward torpedo room." "Personnel in the control room succeeded in closing the conning tower hatch but it had been sprung in the explosion and leaked badly." Lt. Enis is said to have been bleeding about the head, apparently having been flung against some solid surface with the blast. "One man (signalman Arcardy) who had fallen from the conning tower into the control room sustained a broken arm. Another man in the control room had a broken leg. During this time all secret and confidential publications were destroyed (under the directions of the communications officer, Lt. (jg) Enis) first by burning in the control room and then in the forward battery compartment as the control room flooded. This latter seems unfortunate since a great deal of smoke entered the forward torpedo room" (Cdr. O'Kane).

One survivor, in describing what occurred in the forward torpedo room, stated: "There were only 2 torpedoes left and they were in tubes 5 and 6 forward. The forward torpedo room was my battle station and I never left it from the time we started firing till I escaped after we were sunk. We fired the last two fish on the surface and approximately 45 seconds later the sub shook with a hit aft. We knew we'd been severely hit but didn't know where or what damage had been caused. I was watching the pitometer log and we lost our forward motion in a few seconds. The boat took on a slight angle as the stern seemed to drop to the bottom. The bow was still buoyant and sticking out of the water leaving the sub at a very steep angle." "All loose gear fell to the forward battery bulkhead and the men held on to anything in reach. Almost immediately after the stern struck bottom I heard air rushing through the main ballast tank blowers and knew the men in the control room were trying to blow us to the surface. Quite a bit of the after part of the sub was apparently flooded by this time, but it didn't budge. We closed the watertight door between the forward room and the forward battery so we could secure our compartment. The man on the phones could not contact any other compartment, although he tried continually. The lights remained on and we also put on our emergency lights. The bow plane rigging and tilting motor began running and burning even though the fire controlman tried to stop it. It burned completely out in about 10 minutes. There were about 10 men in the forward room, consisting of the torpedoman, reload crew, 1 fire controlman and our torpedo officer, Lt. Flanagan. Weekly, CTM, in charge of the forward room, made his way up into the escape trunk, opening the lower hatch."

"Since it was quite possible the conning tower might be flooded and we were sure the after torpedo room was, that left only the forward torpedo room for escape purposes; therefore, we couldn't escape without waiting for everyone left alive to get to the forward room." (Lt. Savadkin states that the survivors discussed the possibility of leaving the ship through the empty forward tubes but decided against it because of the depth charges which could be heard and because they feared the bow would be shelled). "Fifteen minutes later a group of about 15 men made their way into the forward room. When we opened the door there was such

a difference in air pressure between the compartments that it literally blew the men into the forward room and when it had equalized there was quite an increase in pressure." These men had come from the control room and before leaving had pulled No. 2 main ballast tank vent handle and the angle had reduced some. A machinist's mate (Decker) is quoted as having said in a news interview: "I was in the control room and fortunately near vent No. 2. It was apparent that the ship must be leveled off before the mechanical lungs could be used through the escape trunk. Hydraulic power no longer existing, I finally succeeded in turning the vent with my bare hands. Slowly we sank until the ship sank and rested on the bottom at 30 fathoms." Lt. Savadkin, while swimming about, saw the bow sink out of sight, probably within a 15 to 30 minute period after he reached the surface.

"The conning tower was flooded but secured from the control room by a hatch, but quite a stream of water was flowing into the control room. After a few minutes this water reached the lighting motor generators but our emergency lights, coming direct from the batteries, kept on. The pressure difference between the compartments meant that the air lines to the forward room had been broken when we were hit. We checked and there was no high pressure (200 pounds) air to the forward room. About 45 minutes after our sinking, the second party of men came into the forward battery. Realizing there was a great pressure difference in the two compartments, a negro mess cook and I tried to get them to open the door only a little till the pressure equalized gradually but the men in the forward battery thought we were trying to keep them out. Since they apparently didn't understand our signals they forced the door open and it struck the negro in the face. His lips were smashed, nose pushed over to one side and eyes closed. When the air stopped coming in there was quite a decided increase in pressure again. This group of men consisted of about 20 who had been trapped in the after battery. Two were wounded; one with a broken leg and the other with a broken arm. PhM 1c Larson (making his first patrol on the TANG) stayed with them, attempting to make them as comfortable as possible, using the emergency first aid supplies in the compartment.

"We found out from these men that the boat was flooded up to the forward engine room and water was coming into it. There were about 45 men in the torpedo room now and the angle of the boat had lessened quite a bit. We were secured in the forward room and knew the boat would never run again but were confident we could escape.

"Lungs were passed to everyone and strapped on. Instructions on how to use them were given. Over half of the men didn't seem to remember how to use one. Life jackets were distributed and those who didn't get them were instructed to use their lungs as such when they reached the surface. At this time Jap patrol boats evidently picked us up again and dropped about 10 depth charges which shook us severely but did no real damage. Everything came to a dead standstill until they had left and there was no danger of them picking up our sounds.

"One officer decided that there might be a chance to blow the boat to the surface, thereby making it much easier and quicker for everyone to escape. He was going to lead a party of 6 men back to the control room to see what they could do. When they started to open the watertight door to the forward battery, a terrific blast of black smoke came into the forward room. Although the door had only been cracked for a second the smoke completely filled the compartment and the lights became only dim glows. Almost immediately some of the men began to gag. They were instructed to take a few breaths through their Momsen lungs when the irritation became too severe. (Lungs were put on when the smoke started to burn our throats. We were able to breathe through them without inflating them--Narowanski). The smoke was evidently from a battery fire because it smelled like burnt rubber. This smoke did more to kill the men who didn't get out than any other thing. The smoke in the forward battery left us trapped in the forward room, so plans were made to effect our escape."

"The men lay on the bunks discussing ways and means of survival. They knew or had a good idea of the depth of the water and that they were only about 10 miles from the Formosa coast." "In general, it would appear that there was some argument, there being different ideas as to how to operate the escape trunk and what to do next" (Lt. Savadkin). "Commencing at about 6 o'clock 4 parties left the ship, but only with difficulty as the pressure at 180 feet made numerous returns to the torpedo room necessary to revive prostrated men" (Cdr. O'Kane).

"Lt. Enis, CTM Balanger, and TM 1c Fluker were to attempt the first escape. They went up into the escape trunk and we handed them a rubber life boat they were going to try to get to the surface. They were to rig the trunk, escape and the last man out was to signal by tapping when he'd left; then I would pull down on a lever in the overhead which would close the door and then drain the trunk for another party. (With rupture of the air lines they were lacking the required pressure to blow the trunk down.) After waiting about 40 minutes with no signal whatever, I closed it anyway and drained the trunk. We knew there were men in it before it was drained, but decided to find out from them what had gone wrong. Lt. Enis had escaped but the other men were still in the trunk. A difference in opinion among them as to how the trunk operated caused the delay and after it was finally rigged, they had difficulty

getting the life buoy attached to its reel of line. Lt. Enis wouldn't wait for them to rig the life buoy and dove out the hatch, and right after this I closed the door from below locking it and making it impossible for the others to escape. (Lt. Enis, apparently believing that protection should be provided the survivors is said to have left the trunk wearing a lung and armed with a 'couple of pistols and a bayonet' and presumably some ammunition--Lt. Savadkin.)

"Fluker came down into the forward room stating he didn't care to attempt it again. They also decided not to attempt to take the life boat to the surface--because it was too bulky and heavy. Lt. Flanagan and MM Decker went into the trunk to make a total of 4 men. Then they decided to try 5 men so another Ensign entered the compartment. The same arrangements were made for rigging and draining. After about 40 minutes we began to worry about them having been unable to signal and I listened close to the hatch. I could distinctly hear moaning but nothing else. Balanger, Weekly, and Decker had escaped. The Ensign was in a stupor as we took him down and Flanagan had been pinned to the trunk bulkhead by the line attached to the buoy. He was cut loose and lowered to the deck and wrapped in blankets. The Ensign said he would not attempt another escape but that there was no reason why every other man in the compartment shouldn't escape. Japanese ships patrolling the area began dropping charges within a one mile radius so we stopped operations till they secured.

"I led the next escape consisting of TM Narowanski, TM Flucker, a MM I didn't know, and myself. We had cut the buoy line to get Flanagan down and not knowing it had also been secured outside the trunk, we took a life ring with us to use as a buoy. This ring had been taken off a Jap ship on a past patrol. I had no difficulty flooding the trunk to equalize the pressure, but when I tried to open the door it was apparently stuck but finally swung open. When I attempted to charge my lung from the manifold I found there wasn't any oxygen. This worried the other men even though I explained they could blow the lungs up with their own air and it served the purpose. I felt very exhausted--like I couldn't get any oxygen into my lungs and began to get dizzy, so I knew I had better get out while I could. It took me about 15 minutes to rig the trunk including preparing the life ring as a buoy. I would have let the ring go to the surface and then gone up the line, but I was so near passing out that I went up with it. The other men in the trunk would have escaped if they had only stepped out the hatch. They didn't want to try and escape without oxygen, although I explained how they could. TM Narowanski remained in the trunk after it was drained and had the men below turn on the remaining oxygen valve, then he led the next escape. I was the only one to leave in the group I was in.

"I took the life ring that had been attached to the line and stepped out the hatch. I started rapidly to the surface holding onto the ring. I had no difficulty breathing through the lung other than for the pressure. After about 20 feet the line began jerking so, Narowanski attempted to slow me down and I lost my lung. I blew air out all the way to the surface trying to equalize the expanding air the way the lung would have done. Upon reaching the surface I was very exhausted and sick and vomited for about a half hour.

"After floating around a few minutes I heard MM Decker calling me. He was hanging on the life buoy about 50 yards away. He cut the line and we tied the two together. The only other person he had seen was Balanger and he had been unable to reach him before the tide carried him from sight. We could easily see the coast of Lormosci, also the masts of two ships which had sunk and the bow of our last target only about a mile from us. The tide was never constant or we would have attempted swimming to the nearest ship. We were unable to do anything else but hang onto the buoy and wait for someone else to come to the surface.

"In about 45 minutes Lt. Flanagan, MM Da Silva, TM Narowanski reached the surface at about 3 minute intervals. They were all very exhausted but all right otherwise.

"We could see two destroyers slowly sweeping the water between us and the coast and realized they were either trying to find us or pick up survivors of their own ships sunk the night before. One of them finally spotted us after two hours and came by within a hundred yards, dropping a buoy then sweeping around in a circle. At this time PhM Larson came to the surface and I swam over and pulled him to us, as he was evidently unable to keep his head out of the water. Five minutes later the negro who had gotten his face smashed by the watertight door came to the surface but over 50 feet away. I don't think he had a lung on and after struggling a few seconds he drowned, floating off with his head still visible but under the surface. I had to hold Larson's head out of the water because he seemed to be in a stupor. He kept gasping as if he couldn't breathe and couldn't understand anything." "After 9 men had arrived on the surface, it was apparent that something had gone wrong. Five stayed afloat. We reached the surface at dawn about 5 o'clock a.m. and were picked up around 10:15" (Narowanski).

"The Jap destroyer made a circle then dispatched a pulling boat to get us. Larson stopped breathing before we reached the destroyer and while the Japs were tieing us up on deck, I saw some of them attempting to revive him by slapping and kicking him; but he never moved and we didn't see him or his body again. From then on we were prisoners of the Japs.

Cdr. O'Kane and 3 others who had survived were already aboard. Except for cuts and bruises, we were all right only very exhausted." "The DE that picked up all 9 survivors was one of the 4 that were rescuing Japanese troops and personnel. When we realized that our clubbing and kicking was being administered by the burned and mutilated survivors of our own handiwork, we found we could take it with less prejudice" (Cdr. O'Kane).

DESCRIPTION OF EXISTING CONDITIONS, ETC.

"The regular lights in the forward room remained on for about 5 minutes after the stern settled to the bottom. The emergency lights were already turned on and supplied the only lights we had from then on. They varied in brightness and even went out for a second a few times. By the time I made my escape the emergency lights were quite dim and with the smoke it was almost dark in the compartment.

"The heat and humidity increased gradually all the time I was below. Air pressure let into the forward room by opening the watertight door between compartments caused it to get hotter. At the last, the lower portion of the bulkhead between the compartments was so hot that the paint was peeling off. Undoubtedly the forward battery was on fire as no one had thrown the disconnecting switch. Air pressure from the battery compartment kept coming into the forward room and there was no way to stop it. The sinks in the officer's quarters drain into No. 1 sanitary tank as does the sink in the forward room. The air was coming from drains in the battery compartment down into the sanitary tank and then out through the sink into forward rooms. There were 2 valves on the one-way checks in the line, but even using wooden plugs provided in the depth charge kits wouldn't stop the air flow.

"The smoke that had been let into the compartment by only cracking the watertight door for a second, completely filled the forward room making breathing very difficult and causing everyone to cough and gag. A few of the men seemed to be actually choking to death on it even though they were told to take a few breaths into their Momsen lungs when they felt the tendency to cough, since the lung will act as a smoke lung and oxygen purifier to some extent. The smoke smelled like it came partially from burning rubber and was one of the greatest factors in delaying the escapes.

"The CO_2 wasn't too noticeable because of the amount of smoke in the air. Towards the last we considered using the CO_2 absorbent, which is in every compartment of a submarine; but decided it would be impracticable as the large number of men in the compartment left no place to spread it out. Since the usefulness of CO_2 absorbent depends on the amount of surface that is exposed to the air and keeping it dry, we couldn't use it even though it would have helped under ordinary conditions. Oxygen was bled into the room several times and did seem to relieve the feeling of suffocation.

"During the first hour, after all the men had reached the forward room, everyone seemed confident that we would eventually escape." "The conversation of the men at first was about our chances of escape and if we did, what we would do then. We knew from the last radar bearings that we were only 10 miles from the coast of Formosa and possibly stood a chance of reaching it." ("In general, most of the men were excited, scared and didn't know what to do"--Narowanski).

"After the difficulty met in trying the first escapes and the smoke entering the compartment, all the former enthusiasm died down and many of the men did not care whether they escaped or not. No one was hysterical or disorderly at any time but the men refused to keep quiet and stop talking even when enemy ships passed very close to us. A majority of the men, even those with several patrols, had never been properly trained in the use of the Momsen lung or operation of the escape trunk. They, therefore, didn't have any self confidence in their ability to escape, causing a general feeling of defeat among them. The constantly increasing pressure, smoke, and heat seemed to affect everyone's thinking." "The men did not mill about in the room but 'sacked out'--except those who wanted to escape and they worked for themselves." "One officer, a graduate of the Submarine School at New London where he is said to have made the 100 foot escape, apparently became discouraged after entering the trunk the first time. At any rate he made no further attempt to leave the ship, returning to the forward compartment--saying that there was no reason, however, why everyone in the boat shouldn't escape. Others demonstrated similar distrust or disinterest in using the escape facilities" (Lt. Savadkin and Trukke). "Toward the last conversation seemed to be mostly about their families and loved ones."

"Since I had only been on the TANG one patrol, I only knew the names of the men I had been directly connected with. There were about 10 men in the forward room when we were hit. The party that arrived from the control room contained about 10 men and the last bunch to arrive from the after battery and the forward engine room had about 15 men. I think that about 45 men were in the forward room at one time." ("There were about 40 to 50 men in the torpedo room; the names I can't recall as I was on the boat for just twenty some days"--Narowanski). "Arcardy, signalman from the conning tower, had a broken arm and one of the

men from the control room had a broken leg. The pharmacist's mate, 'Doc' Larson, spent his time trying to help these men in every possible way he could under the conditions."

"Weekly, CTM, in charge of the forward room, made his way up into the escape trunk opening the lower hatch." "Lt. Enis, though wounded by several deep cuts on the head, took charge and led the first escape. I explained the use of the Momsen lung and operation of the escape trunk, operating the device until my escape." "Our plans for escaping were for one man who was qualified in the procedure to take three who were not, into the trunk with him and all 4 escape when the trunk was rigged. This system would have worked under better conditions if there had been enough men who had had the necessary training. After the first two attempts there were very few men left who cared to try an escape although they knew what was going to happen to them below."

"All the lungs had been checked, aired out, counted and restowed in the forward room, conning tower and after torpedo room during overhaul in Pearl Harbor. There were enough lungs for every man in the crew and 10 per cent more--this was regulation for all submarines. The lungs were in good condition." ("Every man had a lung"--Narowanski.)

"There were two attempts made before the first escape and after that at least one person left the trunk on every attempt." ("About two attempts were made before the actual escape was successful. As far as I know 4 groups of men made attempts to escape. It seemed to take a long time to get the first escape started, but under the conditions a minute was just like an hour. The rigging of the escape trunk was held up at times when depth charges were dropped on and around us."--Narowanski.) "Not all men attempted to escape, and after 2 hours over half of the men did not even care to attempt it."

"The difficulties met seemed to stem from the fact that although everyone had read how to escape, not one had actually went through the motions. If the men had just made an escape from a regulation escape trunk in 10 or 20 feet of water during their training, many more would be alive today. Differences of opinion among the first men attempting escapes wasted valuable minutes. The men weren't sure of escape procedure and were afraid they would make a mistake that would be fatal to the men below. Escape procedure is very simple on paper but somewhat different where everyone's life depends on it. One of the major difficulties encountered was the lack of proper means of communication between the men in the trunk and the men below. We didn't know what was going on or what troubles they had." ("Escaping could have been speeded up had there been some other kind of communication between the escape trunk and the torpedo room. The system of tapping on the bulkhead gave our position to the enemy."--Narowanski.)

"The compression of the air as the water flooded the trunk caused a great amount of heat. When the water was above the door, it left a very small air space and everyone had difficulty in getting their breath. The pressure made the voices very high and almost inaudible. All these combined to create a certain amount of panic in everyone." ("I was conscious of the pressure at all times, in the trunk and torpedo room too."--Narowanski.)

"It was decided to carry some food in our pockets if possible. I still had a can of soup in my pocket when we were taken aboard the destroyer. Although they took it away from me after the rescue, they returned it several hours later, opened, and all 9 of us ate it."

"I was dressed in dungaree pants, undershirt and sandals. I had my ring and life belt secured to me. The sandals came off on the way to the surface." ("I was dressed in bathing trunks."--Narowanski.) "I used a nose clip but the lung was not equipped with goggles." ("I used the nose clip but the goggles were unnecessary."--Narowanski.)

"I tried to hold myself back as much as possible but the lung and life ring accelerated my ascent." "I felt at ease using the lung and knew it would work after I tested it under the water before leaving the trunk. I had made a 100 foot escape before. In places where the underwater currents move you around some as they did us, I think it would be better to have the lung more firmly secured to your chest."

"I must have been on the surface within 3 minutes after leaving the trunk." "I started rapidly to the surface holding onto the life ring. I had no difficulty breathing through the lung other than the pressure. After about 20 feet the line began jerking so, that Narowanski attempted to slow me down and I lost my lung, so I blew the air out all the way to the surface trying to equalize the expanding air the way the lung would have done." "On reaching the surface I was very exhausted and sick at my stomach which caused me to vomit for about half an hour." ("As I reached the surface, my physical condition was a series of dry heaves and I was very weak. I did not hold myself back while making the ascent. There was no discomfort in using the lung."--Narowanski.)

"The water must have been about 45 degrees F. because it seemed only pleasantly cool at first. After an hour, though, we were very chilled." ("The water was cold; I was unable to determine the temperature of it."--Narowanski.) Lt. Savadkin described, after a period of time in the water, the onset of uncontrollable shivering.

"The men were all very exhausted from conditions in the submarine and from the ascent. We were all sick to our stomachs. PhM Larson was practically unconscious when he surfaced and seemed unable to keep his head out of the water. His condition grew worse until

he stopped breathing. A negro mess cook surfaced right after Larson but had lost the line coming up and was at least 50 feet away from us. I don't think he had his lung on when he came up and he drowned while we watched him, floating away with his head just under the surface of the water. None of us could possibly have reached him." ("I do not recall anything unusual in the physical condition of the other men on reaching the surface except for 2 men that came up after the 5 of us were on the surface. They were complaining of being unable to breathe before they drowned."--Narowanski.) (Identified in later correspondence as Larson and the negro.)

"I think it is possible--that the others--could have lost their mouthpieces, then held their breaths, which would cause their lungs to rupture. Even if they did reach the surface, they were too weak to swim and keep from swallowing salt water." ("In my opinion, the other 8 men could have met the same fate as the 2 we saw drown--some men might have lost their lungs and some were too excited to come up slowly. Some missed the buoy line and were stuck in the superstructure of the submarine."--Narowanski.)

According to Cdr. O'Kane: "At the time the last party escaped, the forward battery fire had reached such intensity that paint on the bulkheads on the forward torpedo room was scorching and running down. Considerable pressure had built up in the forward battery making it difficult to secure the after torpedo door sufficiently tight to prevent acrid smoke from seeping by the gasket. It is felt that this gasket blew out either due to pressure or an ensuing battery explosion and that the remaining persons were asphyxiated." According to Trukke: "The smoke undoubtedly killed every man in the compartment not long after the Japs picked us up. Some men were nearly unconscious when I left. The smoke made you cough and the coughing just caused more irritation in your lungs and throat." "Even if conditions in the room hadn't gotten any worse than when I was last there, I'd say the men left below were all dead or unconscious from pressure, lack of oxygen or the smoke in the air within an hour after the last 2 men escaped." "I agree that the men remaining in the forward torpedo room were asphyxiated from the smoke in the forward battery" (Narowanski). "It is possible that others may have left the compartment. Japanese patrol boats continued to search the area throughout the day; but no others are known to have been recovered dead or alive" (Lt. Savadkin).

According to Cdr. O'Kane: "Of those 13 men who escaped, 5 were able to cling to the buoy until picked up; 3 others reached the surface but were unable to hang on or breathe, so floated off and were drowned. The other 5 were not seen after leaving the trunk. Of 9 officers and men on the bridge, 3 were able to swim throughout the night and were picked up 8 hours later. One officer escaped from the flooded conning tower and remained afloat until rescued with the aid of his trousers converted to a life belt."

The following individuals survived the loss of the TANG:

Commander Richard O'Kane, USN
Chapel Hill, North Carolina
c/o Dr. E. G. Groves

Lt. Cdr. Lawrence Savadkin, USNR
Submarine Base, New London, Conn.

Hayes Oliver Trukke, former TM 1c, USNR
10222 S. Hildreth, South Gate, California.

Pete Narowanski, former TM 3c, USNR
17 Woodland Avenue, Dundalk 22, Maryland

Jesse Borges DaSilva, former MM 3c, USN
1118 West 89th Street, Los Angeles, California.

Lt. Harry J. Flanagan, USN
Submarine Base, New London, Conn.

Clayton Oliver Decker, former MM 3c, USNR
1037 Beech Street, East Paulo Alto, California.

Floyd Muriel Caverly, RT 1c, USNR
1831 Sunnydale Avenue, San Francisco, California.

William Rudolph Leibold, CBM, USN
2920 South Mansfield, Los Angeles, California.

SUMMARY OF ESCAPES MADE FROM FORWARD TORPEDO ROOM

Commencing at about 0600, 24 October 1944, 4 parties are known to have left the forward torpedo room. As far as can be determined these parties consisted of:

First party (3 men):

Lt. (jg) Enis	First to escape; not seen again.
CTM Balanger	Entered second party.
TM 1c Fluker	Entered third party.

Second party (5 men):

Lt. Flanagan	Became exhausted; entered fourth party.
MM Decker	Second to escape. Lived.
CTM Balanger	Third to escape; reached surface and seen to drown.
CTM Weekly	Left trunk; not seen again.
Ensign	Removed in "stupor" from trunk; preferred not to try again.

Third party (4 men):

TM Trukke	Fourth to escape; arrived on surface without a lung. Lived.
TM Narowanski	Entered fourth party.
TM Fluker	Would not try after this, his second attempt.
Unknown MM	Would not try after this, his first attempt.

Fourth party (5 men):

Lt. Flanagan	Second attempt; fifth to escape. Lived.
MM DaSilva	Sixth to escape. Lived.
TM Narowanski	Seventh to escape. Lived.
PhM Larson	Eighth to escape. Died in arms of shipmates. Possible air embolism.
Negro cook or mess att.	Ninth to escape; seen to drown. Probably not wearing a lung when arrived on the surface.

According to TRUKKE's account 9 men were known to have left the trunk: 1 was not seen again (Lt. (jg) Enis); 2 drowned on reaching the surface (Balanger and negro mess attendant or cook); 1 died soon after reaching the surface (PhM Larson); 5 lived (Decker, Trukke, DaSilva, Narowanski and Lt. Flanagan). A tenth, CTM Weekly, presumably left the trunk and was not seen again.

According to Cdr. O'Kane's official report: "Of those 13 men who escaped, 5 were able to cling to the buoy until picked up; 3 others reached the surface but were unable to hang on or breathe and floated off and were drowned. The other 5 were not seen after leaving the trunk." Indicating that 3 other men not described by Trukke must have left the trunk but were not seen again.

If 13 men escaped or left the forward torpedo room and if there were 45 men there at one time, approximately 32 men were left in the compartment and were most likely asphyxiated. Of these it is known that 2 were seriously wounded (one with a broken arm and another with a broken leg). Trukke states that some of these men were almost unconscious at the time he left the compartment.

Of the 9 men in the conning tower, 7 drowned with no details known about them. One, a soundman (Bergman) contacted Lt. Savadkin but eventually drowned. Lt. Savadkin was the only one to escape from this compartment and live.

Of the 9 men on the bridge, 3 were able to swim throughout the night and were picked up 8 hours later. (Cdr. O'Kane, RT Caverly, CBM Leibold).

The practical lessons concerning submarine escape that may be learned from the experiences related above appear to be as follows:

1. The submarine escape "lung" and standard escape gear appear to have well accounted for themselves under practical trial in war time. All of the lungs had been checked, aired out, counted and restowed prior to departure of the submarine from Pearl Harbor. There were enough for every man in the crew and 10 per cent more.

2. Provision must be made for vocal communication between the escape trunks and adjacent compartments by sound-powered telephones. Under strain and in confusion, signals by hammer are not effective. Moreover, as in this case, they may lead to increased enemy anti-submarine activity. One of the major difficulties encountered was this lack of proper

means of communication between those in the escape trunk and those below in the torpedo room.

3. A redesign of the oxygen supply for the escape trunk is apparently needed, for on this and other representative submarines subsequently examined, the oxygen flask for charging the "lung" was in the adjacent compartment with the charging manifold in the escape trunk. The valve governing the flow of oxygen was, thus, in the compartment below and could not be operated by men in the trunk once they were locked inside.

4. In similar manner, the emergency lights were controlled from below instead of being turned on from within the trunk.

5. To aid submarine personnel, it should be pointed out and emphasized that in the absence of oxygen, compressed air may be safely used; and in the absence of compressed air, the "lung" may be safely filled with the individual's own breath.

6. It should be clearly pointed out that in the absence of a "lung" or in the event of its loss, "free escape" from considerable depths is not only feasible but was done with success by 2 men from this submarine, and by several Germans from a disabled submarine at an equal or even greater depths during this war. The author believes that at least all officers should be required to demonstrate their ability to make a "free escape" from the 100 foot lock in the Escape Training Tank.

7. It is urged that the 100 foot escape with the "lung" be made mandatory, for, as noted in this episode, confidence engendered by having successfully made this escape is of great value.

8. All personnel should be given additional instruction in the operation of submarine escape trunks and compartments. It is felt that perhaps intensive training of submarine officers in the procedure of submarine escape, the use of the "lung" and the operation of the escape trunk would have resulted, in this case, in more positive and adequate leadership under the encountered conditions of stress. Differences of opinion among the first men attempting escape wasted valuable minutes. The men were not sure of escape procedure and were afraid they would make a mistake that would be fatal to those below. Escape procedure is very simple on paper, but somewhat different where every man's life depends on it.

9. There apparently is room for improvement in the harness of the "lung" (in order that it may be held more firmly to the body) and in the mouthpiece (so that it will be less easily lost).

10. Ample evidence exists of the extreme toxic qualities of smoke from fires aboard submarines. This is particularly true of battery fires. It is recommended that all personnel be more thoroughly indoctrinated in the dangers and mitigation of the effects of this smoke.

11. In this connection, more thorough dissemination of the facts concerning the effect of increased atmospheric pressure, oxygen lack, carbon dioxide increase, and the effects of toxic gases other than smoke is definitely indicated.

12. Wide dissemination of the events as they occurred aboard this submarine is recommended as being of value to the entire submarine service.

This brief review of the lessons to be learned from this tragic episode is not intended to detract in the least from the remarkable display of courage, judgement, and resourcefulness in the face of almost insurmountable odds.

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