PHOTOGRAPH THIS SHEET

UNANNOUNCED

AD-A954 244

DTIC ACCESSION NUMBER

LEVEL

1

INVENTORY

ADTIC Rub-G-104

DOCUMENT IDENTIFICATION

1955

DISTRIBUTION STATEMENT A
Approved for public release;
Distribution Unlimited

DISTRIBUTION STATEMENT

ACCESSION FOR	
NTIS GRA&I	☒
DTIC TAB	☐
UNANNOUNCED	☐
JUSTIFICATION	
BY	
DISTRIBUTION /	
AVAILABILITY CODES	
DIST	AVAIL AND/OR SPECIAL
A-1	23 GW

DISTRIBUTION STAMP

UNANNOUNCED

Copy available to DTIC does not permit fully legible reproduction

DTIC
ELECTE
S MAY 15 1985 D
D

DATE ACCESSIONED

DATE RETURNED

85 5 14 156

DATE RECEIVED IN DTIC

REGISTERED OR CERTIFIED NO.

PHOTOGRAPH THIS SHEET AND RETURN TO DTIC-DDAC

DTIC FORM 70A DEC 83

DOCUMENT PROCESSING SHEET

PREVIOUS EDITION MAY BE USED UNTIL STOCK IS EXHAUSTED.

REPRODUCED AT GOVERNMENT EXPENSE

DISCLAIMER NOTICE

THIS DOCUMENT IS BEST QUALITY PRACTICABLE. THE COPY FURNISHED TO DTIC CONTAINED A SIGNIFICANT NUMBER OF PAGES WHICH DO NOT REPRODUCE LEGIBLY.

AD-A954 244

AIRMEN AGAINST THE SEA

An Analysis of
Sea Survival Experiences

ADTIC Publication G-104

Arctic, Desert, Tropic Information Center

Research Studies Institute

Air University

85 4 19 053

DEPARTMENT OF THE AIR FORCE
HEADQUARTERS AIR UNIVERSITY
MAXWELL AIR FORCE BASE AL 36112-5001

REPLY TO ATTN OF: AU/PA

SUBJECT: Security & Policy Review

TO: HQ AU/LDE

The attached paper/article titled: Airmen Against the Sea; An Ar[illegible] of Sea Survival Experience, is approved for release IAW AFR190-1.

Alan J Rod

ALAN J. ROD, GS-12
Deputy Director
Public Affairs

ADTIC Publication G-104

AIRMEN
AGAINST THE SEA

An Analysis of
Sea Survival Experiences

by
GEORGE ALBERT LLANO, PH. D.
Research and Editorial Specialist
Arctic, Desert, Tropic Information Center

1955

Arctic, Desert, Tropic Information Center
Research Studies Institute
Maxwell Air Force Base
Alabama

The contents of this publication are the views of its author and are not to be construed as carrying any official sanction of the Department of the Air Force or of the Air University.

Preface

AIRMEN AGAINST THE SEA is the fourth in a series of ADTIC studies to determine how military personnel survived under emergency conditions in various parts of the world. Its predecessors, "999 SURVIVED," "SUN, SAND AND SURVIVAL," and "DOWN IN THE NORTH," dealt with survival respectively in the Southwest Pacific Tropics, in the African Deserts, and in the Arctic. This study concerns survival at sea and, like its predecessors, employs the topical approach. It is not a water survival manual, but is a factual report of what happened to men who bailed out or ditched at sea, and whose only refuge for days on end was a rubber liferaft.

Under such topical headings as bailout versus ditching, survival equipment, the liferaft, food, hazards, injuries, morale, and many others, the experiences of the survivors themselves are emphasized. The result is a new and fresh insight into the problems of survival at sea which will be of interest to all those who fly over water, and of particular value to those concerned directly with rescue operations, with water survival training, and with the development of survival materiel.

Dr. George A. Llano, project officer for this study, has had first-hand knowledge of survival at sea. He survived for 2 days on a liferaft in the Straits of Florida, and during World War II was engaged in field-testing sea survival equipment and liferafts for the USAF Air Proving Ground Command. Dr. Llano consulted numerous sources in compiling factual information on the actions and activities of successful survivors. Two sources, particularly noteworthy because of the volume and quality of their information, deserve special mention. Through the courtesy of Captain A. J. Hesford and Commander Clement Vaughn of the Air Search and Rescue Agency, United States Coast Guard, there was made available a large number of personal narratives and other official Agency reports and correspondence dealing with survival and rescue problems during World War II. Mr. William H. Lane, Acting Chief, Division of Insurance, Office of the Comptroller, Maritime Administration, United States Department of Commerce, made available the detailed records of lifeboat and liferaft survival episodes following maritime disasters.

Members of the ADTIC staff who contributed materially to the final production of this study and are deserving of special recognition are Dr. Oliver L. Austin, Jr., Senior Research and Editorial Specialist, Dr. Frederick K. Morris, Chief, Tropic Branch, and Mr. William H. Allen, Research and Editorial Specialist.

PAUL H. NESBITT
Chief, Arctic, Desert, Tropic Information Center

CONTENTS

CHAPTER I

THE EPISODES

Page

Sources of Material iv
Scope of the Study 2
Geographical Coverage 2
Duration of Water Survivals 4
Time and Diminishing Returns 6

CHAPTER II

THE EMERGENCY

Bailout Versus Ditching 7
Reasons for Bailout 8
Bailout Hazards 8
Nature of the Landing 9
Bailout Landings 9
Ditching Landings 10
Sinking Suction 12
The Aircraft Factor 12
Weather Factors 13
The Human Factor 13

CHAPTER III

THE EQUIPMENT

SURVIVAL EQUIPMENT

The Mae West 14
Improper Procedures 15
CO_2 Cylinders 16
Oral Valves 16
Fit 16
The Liferaft 16
Malfunctions and Errors 17
Inflation Difficulties 18
Boarding 18
Buoyancy 19
Balance Troubles 19
Liferaft Accessories 21
Sea Anchors 21
Paddles and Oars 22
Sails 23
Lines, Lashings, and Knots 23
Clothing 24
Headgear 24
Goggles 24
Body Clothing 24
Gloves 25
Footgear 25
G-Suits 26
Antiexposure Suits 26
Improvised Clothing 26
First Aid Kits 27

RESCUE EQUIPMENT

Visual Signals 27
Sea Marker 27
Mirrors 29
Smoke Signals 30
Flagging and Splashing 31
Flashlights and Lighters 31
Tracer Signals 32
Flares 32
Very Signals 33
Miscellaneous 33
Audio Signals 34
Shouts and Whistles 34
Electronic Devices 34
The Gibson Girl 35
Success and Failure 35
Stowage 35
Malfunctions 36
Homing 36
Radar Aids 37
Walter 37
Target 37

AIRDROP EQUIPMENT

Airdrop Kits 38
Airborne Lifeboats 38
The Drop 38
Boarding and Operating 39
Equipment 40

SURVIVOR ANALYSIS AND COMMENTS

Signal Aid Deficiencies 41
Equipment Losses 42
Water Spoilage 43
Corrosion 43
Loss of Buoyancy 44

CHAPTER IV

THE ENVIRONMENT

DRINKING WATER

Raft Water Supplies 46
Desalting Kits 47
Solar Stills 48

Page

Rationing 48
Compliance with Instructions 48
Methods of Issuing Water 50
Other Sources of Water 50
Rain 51
Miscellaneous Water Substitutes 51
Fish Juices 52
Urine 52
Fresh Water Dilution 52
Salt Water Drinking 53
Reducing Water Needs 54

FOOD
Raft Food Supplies 55
Rationing 55
Instructions 55
Practices 56
Survivors' Attitudes Toward Food 56
Physical Efforts of Rationing 58
Food from the Sea 58
Foraging Instructions 58
Foraging Equipment 59
Improvised Fishing Gear 60
Accidental Catches 60
Sea Birds 61
Hunting Methods 61
Miscellaneous Foods 61
Palatability of Wildlife 62
Significance of Foraging 63
Tobacco and Alcohol 63
Tobacco 63
Alcohol 64

ANIMAL HAZARDS
Sharks 64
Kinds of Sharks 64
Distribution 64
Feeding Habits 65
Likelihood of Attack 66
Sharks and Liferafts 68
Anti-Shark Measures 70
Sound 71
Color 71
Odor 72
Anti-Shark Weapons 72
Summary 73
Miscellaneous Animals 74
Whales and Porpoises 74
Large Fish 74
Poisonous Fish 75
Birds 75
Reptiles 76
Invertebrates 76

THE SEA AND THE SURVIVOR
Keeping Afloat 76
Swimming 76
Some Case Histories 77
Sailing and Navigating 78
Sailing 78
Raft Drift 79
Raft Navigation 79
Obstacles to Navigation 81

CHAPTER V

THE INDIVIDUAL

Page

PHYSICAL ASPECTS
Presurvival Injuries 83
Combat Injuries 83
Bailout Injuries 83
Ditching Injuries 84
Liferaft Health Hazards 85
Comfort and Rest 85
Raft Drumming 86
Sanitation 87
Injuries From the Liferaft 87
Seasickness 88
Exposure 88
Cold 89
Heat 90
Wetness 91
Miscellaneous Aches and Pains 91
Treatment of Injuries 92

MENTAL ASPECTS
Presurvival Attitude 93
Shock 93
Morale 94
Discipline 96
Irrationality 97
Hallucinations 97

CHAPTER VI

THE RESCUE

Shore Landings 99
Ship Pickup 99
Aircraft Pickup 100

SEARCH PROBLEMS
Coordination of Search and Rescue 100
Coordination Difficulties 101
Planning and Procedure 102
Orbiting Difficulties 103
Communication Problems 104
Environmental Handicaps 105
Physiological Handicaps 105
False Alarms 106

CHAPTER VII

SURVIVAL MANUALS AND TRAINING

Survivors' Comments 107
Instructions 108
Manuals 108
Survivor Narratives 109

CHAPTER VIII

DEVELOPMENT OF WATER SURVIVAL CONCEPTS

1913 to 1920 110
1921 to 1927 111
1928 to 1934 111
1935 to 1941 112
1942 to 1946 112
1947 to 1954 113

Chapter I

THE EPISODES

"THE SHIP was negligently checked out . . . and was without emergency food or water. Overhead search failed to see us." This remark, from one of the earliest of the personal narratives of an airman on the sea, was made in 1918 by C. R. Gannon, pilot of a Curtiss flying boat, who was forced to ditch his aircraft upon water three times within 4 months.

The great speed of aircraft and their more direct routings have reduced greatly the time spent in crossing oceans, but mastery of the airways has not severed man's contacts with the sea. In time of air disaster at sea, speed is in itself a disadvantage, for it compresses the course of events, widens the area of action, and calls for elaborate, time-consuming search when urgency is paramount.

The likelihood of a forced descent at sea must be reckoned as a hazard on all overwater flights. The risk is increased by the abrupt transition from air to water—from one unpredictable medium to another. The swiftness of a forced landing at sea leaves little time for orderly procedure, and nothing short of the reflex action of trained personnel and the use of reliable automatic equipment can effect a successful change from airman to seaman.

Much of what we know about saving life at sea comes from the experience of seafaring peoples. The scientific study of sea survival received its strongest impetus from the farflung use of airpower over the sea, especially during World War II. The development of the Ferrying Command in 1941, and later the Air Transport Command, extended routes of travel across all the major oceans. In addition, many combat actions took place wholly or partly over water. Both emphasized the need for survival techniques, methods of search, and means of rescue.

During World War II transport or combat aircraft crossed the Atlantic on the average one every 13 minutes, the broader Pacific one every 1½ hours. In one year more than a billion pounds of high priority passengers, mail, and cargo were carried by air to war theaters around the globe. This rapid expansion of air travel was matched by a corresponding rise of inflight emergencies. The global extent of World War II and the variety of aircraft further complicated the problems of survival and rescue.

Improvising and borrowing freely from all sources, the Air Force met some of the sea emergencies during the early part of World War II and learned rapidly by experience. As the prevention of casualties and the rescue of downed fliers became increasingly important to improve morale among flying crews, the need to develop sound doctrines and practices for air-sea emergencies was recognized.

Among the agencies established by the Air Force to study problems of survival and rescue was the Arctic, Desert, Tropic Information Center. This organization fulfilled a valuable function by gathering information and preparing survival manuals and information bulletins which were widely used for training and guidance. But the emphasis was strongest on techniques for survival on land. AIRMEN AGAINST THE SEA examines the information supplied by the airmen who survived at sea.

Sources of Material

The material for this report was gathered from 175 different sources. Most of these are United States Air Force and Navy records; the remainder are chiefly reports of the Canadian, British, New

Zealand and Australian Air Forces. Japanese survival accounts are lacking, but German reports have furnished several instructive incidents. Much of the material was in Service publications. Of special interest were the records of the Sea Squatters' Club, an informal group organized and supported by the Walter Kidde Co. of Belleville, New Jersey, who kindly made its records available for the study. Correspondence with members of the Club brought out more valuable information.

The Air Force accident records were found to give explicit details of aircraft malfunction, but little of the human aspects of survival. The Air Rescue Service reports emphasize operational problems of search missions. Medical records give clinical facts but not the conditions of the mind. The reports made by personnel of submarines, destroyers, and other vessels are the most thorough. The most complete and detailed series of questionnaires are those in the Air-Sea Rescue report, Navaer 10-44 (1941).

The most valuable and informative material was found in the firsthand accounts written by the survivors themselves. The value of personal narratives lies in their sincerity and their expression of personal feelings. They contain much information that could not be brought out by a questionnaire. The brevity of these narratives was frequently tantalizing, especially when they suggested harrowing experiences. Where they touched on such a desperate measure as cannibalism, the survivors obviously did not wish to recall past events. The accounts often indicate physical and mental deterioration not always correlated with the length of the survival period. Many airmen revealed fears that a little knowledge of biology could have relieved.

Because interrogation reports are second hand they do not tell as complete a story as when survivors write their own narratives. The collected reports of men from the same aircraft or from the same theater are an excellent means of comparing experiences and evaluating the natural human error which so often meant the difference between loss and recovery.

The reports on pickups by submarine and other branches of the Naval Service were complete and coherent because ship's personnel were in daily contact with the survivors aboard ship. When too much time elapsed between rescue and interrogation, important details were forgotten and valuable retrospective analysis was often lost. Incomplete case histories are not entirely valueless for they provide isolated facts which become significant through accumulation. Their value is high if we assume that those who lived to report achieved success by doing the right things. But failure is not always the result of ignorance or mistakes; the odds against survival were often too high.

From the narratives the survivors can be sorted into two main groups. First were those who didn't foresee the emergency, lacked plan or practice, and were full of despair. Their accounts have a nightmare quality, and their stories reflect an absence of imagination and effort. The second group were "planners"; they had planned for eventualities by checking all equipment, some even making up personal kits, by frequent drills, and by regard for their crews. Anger at the limitations and malfunction of equipment and at the *snafu* of rescue operations which delayed pickup colors their reports. They came back with ideas for improving survival gear, and demanding more knowledge on how to survive.

The reports tell of concrete things such as equipment and food—or the lack of them, and they tell what the men did. But the emotions which grew out of the survival incidents are more difficult to grasp, and are but scantily recorded. To convey something of personal reactions, excerpts are quoted frequently from the survival narratives.

Scope of the Study

Most of the survival incidents considered in this report occurred between 1940 and 1946. The postwar period contained fewer water incidents. A few are from the Korean outbreak, when the Air Rescue Service recorded 9,680 rescue missions but made only 218 water pickups, all notable for their short duration. The most recent incident cited occurred 24 January 1955. A comparison of overwater emergencies between 1913 and 1954, exclusive of World War II, is given in Figure 4, page 110.

GEOGRAPHICAL COVERAGE. Most of the cases are from the theaters of World War II and the main air routes of ocean travel. Forty-four percent of the incidents, many of long duration, occurred in the West Pacific. Twenty-five percent occurred in the North Sea and English Channel; most of these were short but provided much information. The remainder happened in the South

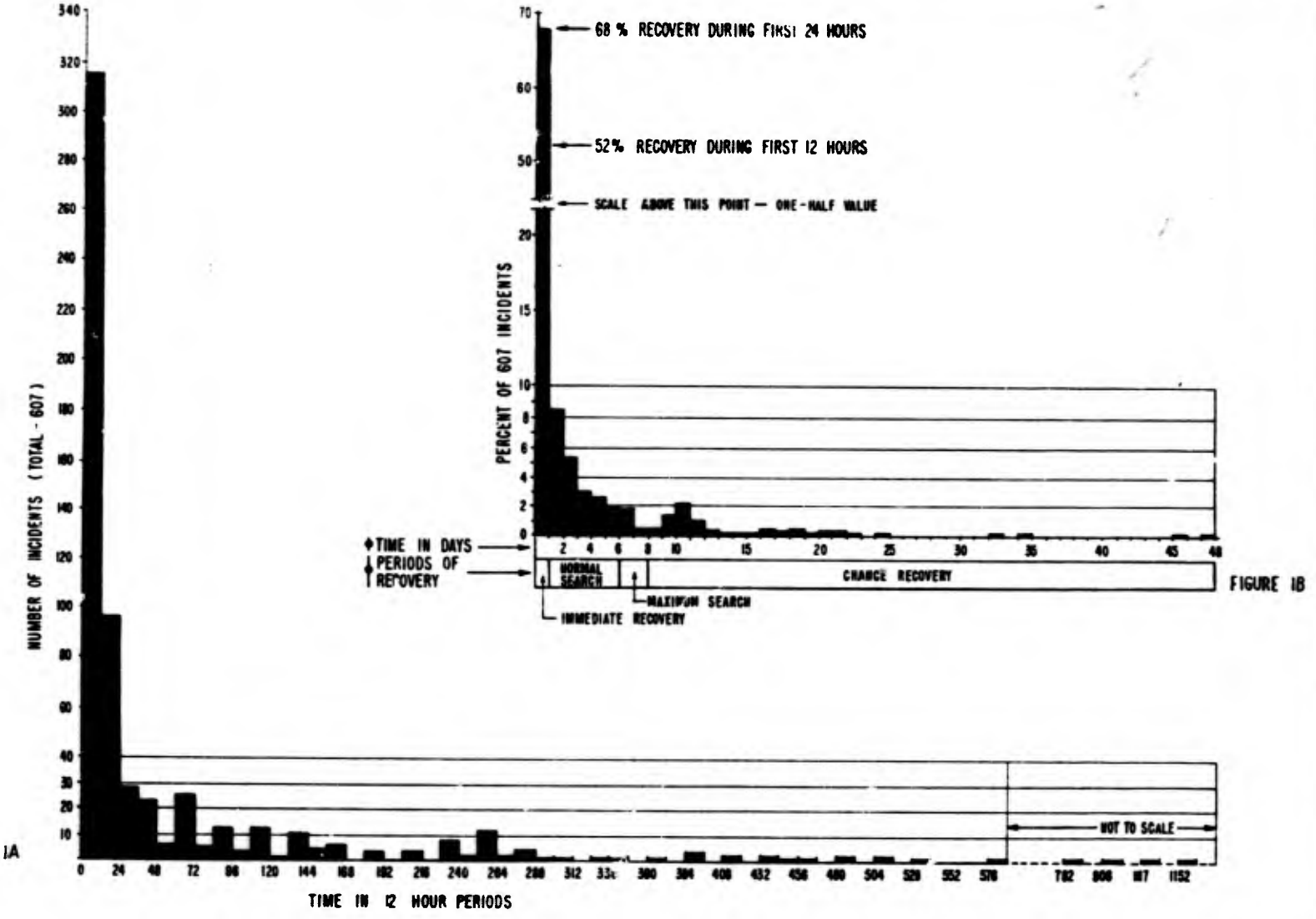

FIGURE 1A

FIGURE 1B

Atlantic Ocean, the Caribbean Sea, the Mediterranean Sea, and the Indian Ocean. Arctic records from the Aleutian Theater and from the ferrying route between the United States and Europe, via Greenland and Iceland, account for less than 9 percent of the total. Seventy percent of the incidents took place in tropic or subtropic waters; the rest were from cold temperate oceans.

Duration of Water Survivals

Survival is the "preservation of one's own life under conditions of immediate peril." Duration of water survival is the time interval between entering the water and final rescue. This study considers the events between ditching and pickup. It reviews some of the incidents preceding this stage only as they influence survival and rescue.

To show the duration of water survivals graphically, an analysis was made of 607 incidents selected on the basis of completeness of information on times of entering the water and rescue. These incidents were reported by one or more survivors of single- or multiple-engine aircraft disasters, and include crews of fighter, bomber, reconnaissance, training, and transport aircraft. In comparison with the many other narratives screened for other information but which were less exact in their reporting of time, the 607 sample appears to be typical. It includes records from all theaters and all climates. The durations range from 5 minutes to 48 days, and average approximately 55 hours.

The statistical information derived from the analysis of the 607 sample is presented as 3 bar graphs:

Figure 1A shows the distribution of the 607 recoveries numerically in 12-hour intervals. Figure 1B gives the percentages recovered each successive day. The first vertical bar of Figure 1B shows that 52 percent of the survivors were rescued during the first 12 hours and that 68 percent of those recovered were saved during the first 24 hours.

Figure 2 shows the number of recoveries made

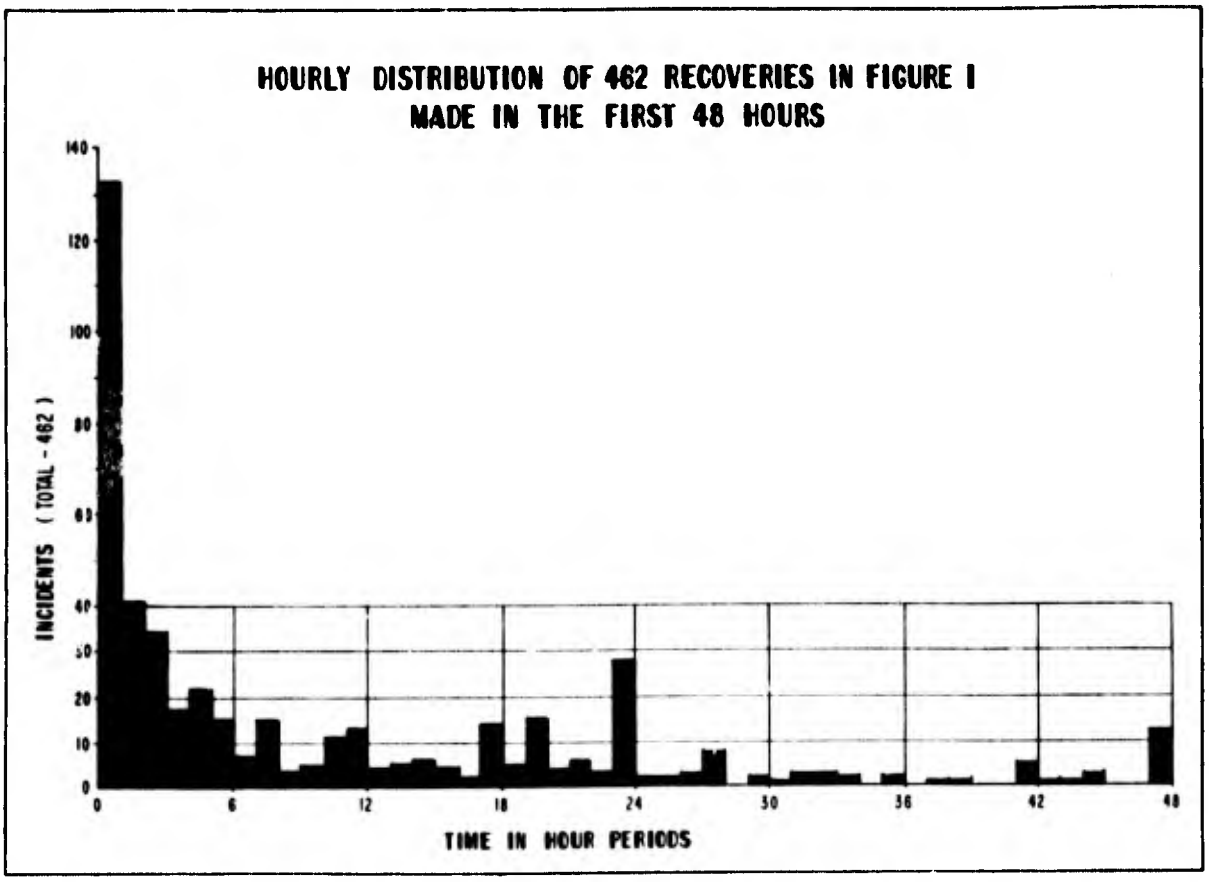

Figure 2

PROGRESSIVE ASPECTS
OF
SURVIVAL AT SEA

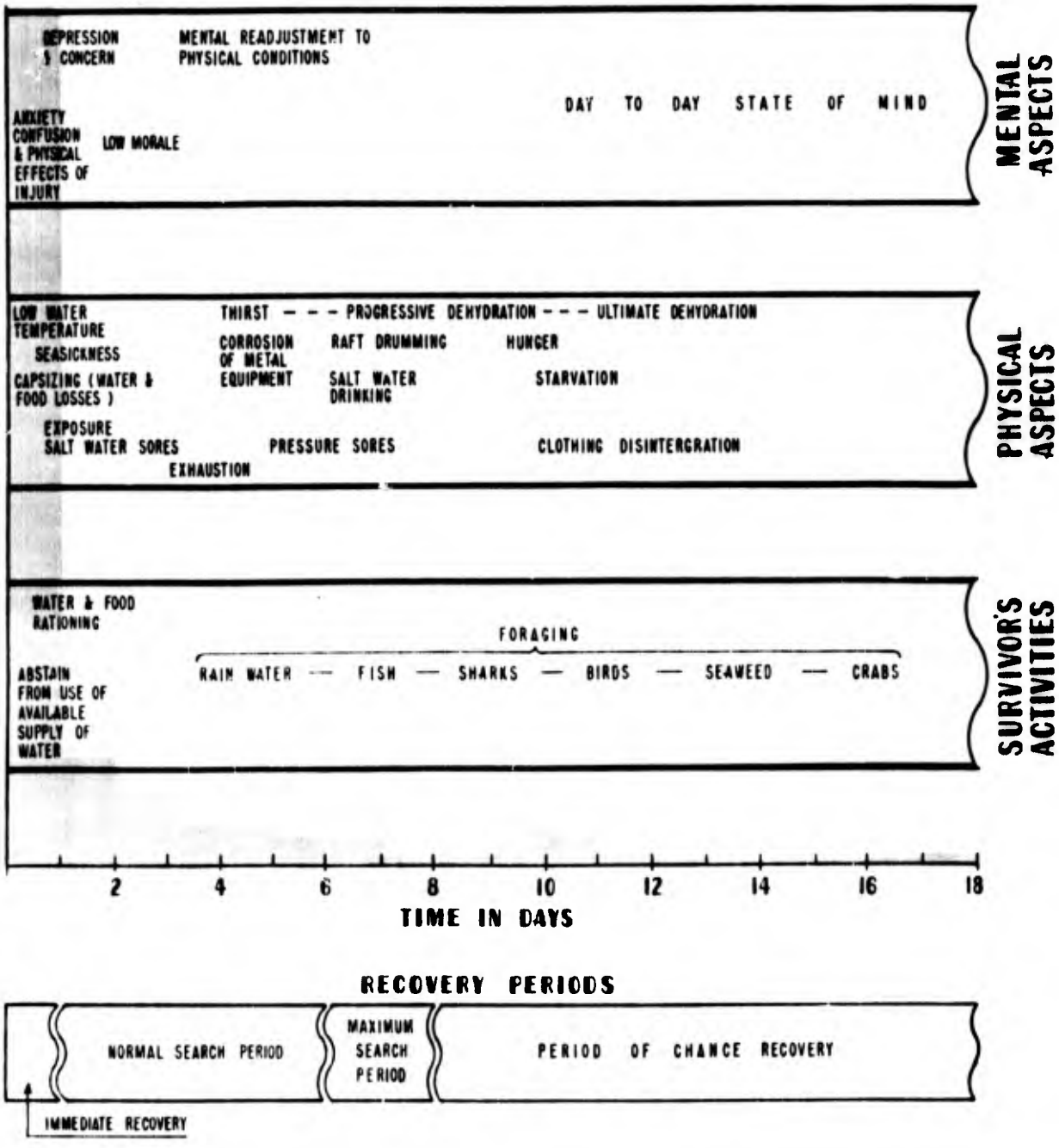

Figure 3

each hour of the first 48 hours of search. Probably the high achievement of 133 men saved, or 28 percent in the first hour, reflects the immediate presence of rescue facilities. The peaks at 24 and 48 hours are probably caused by inaccurate reports of time. An individual or group that had been in the water anywhere from say 21 to 26 or 27 hours would quite likely report the period loosely as "a day," which would be interpreted as 24 hours. Likewise, 48 hours might be given for a period which may have been more or less than 2 full days. Similar loose estimates of time may account for the lesser peaks at 12, 18, 20, 28, and 42 hours.

The three graphs show that the overwhelming majority of recoveries were made within the first 24-hour interval, which may be called for convenience the "period of immediate recovery." In the interval between the 2nd and 5th days, called here the "period of normal search," 19.5 percent of the men were recovered. Extending the search to the 8th day through the "period of maximum search" adds a further 4 percent of recovery. The remaining 8.5 percent were recovered in from 8 to 48 days, termed the "period of chance recovery."

The 48-day survival interval is the maximum only for the 607 sample. It should not be construed as the limit of human endurance at sea, although it may approach the limit of endurance on a flexible rubber raft. The longest sea survival recorded during World War II was the case of Poon Lim who drifted 133 days on a rigid merchant ship raft.

TIME AND DIMINISHING RETURNS. As indicated in Figures 1B and 2, the chances of recovery diminish rapidly with time.

Figure 3 shows that with diminishing time, survivors are exposed to an accumulation of unusual conditions, from within and without. Not the least of these is the confinement of the raft, which limits the individual to inactivity within the boundaries of a rubber platform. A water survival is characterized by a philosophy of waiting, wishing, and watching in a restricted physical environment. To increase his chances of survival the individual must first of all make a mental and physical readjustment. Secondly, he must be self-reliant and learn to forage from the sea.

THE EMERGENCY

AN INFLIGHT EMERGENCY is an event that compels the men aboard an aircraft to abandon it, either by bailing out or by ditching. The 2,500 case histories screened in preparing this analysis cover inflight emergencies for about 1,600 aircraft, or approximately 35 percent of the 4,000 to 5,000 ditchings during World War II. Many include the survival of more than one person, but rarely of more than one crew.

To determine the major causes of inflight emergencies and their relative frequencies a representative sample from the records of incidents for the period 1943 to 1945 was selected and analyzed. The results of the analysis showed:

Combat damage	45 percent
Engine or other mechanical failure	19 percent
Fuel exhaustion	17 percent
Navigational errors	7 percent
Failure of instruments	4 percent
Weather	3 percent
Failure of radio	3 percent
Miscellaneous—turbulence, collision, lightning	2 percent
	100 percent

Bailout Versus Ditching

When there was a choice, the primary reason for ditching at sea rather than crashing or bailing out over land was to avoid capture and internment. Crews of damaged aircraft over northwestern Europe made every effort to reach the English Channel. The desire to reach the sea was even more intense in the war against the Japanese who seemed determined to kill rather than to capture survivors. An official report of the USS HORNET states "Undoubtedly, the rescue service afforded at Palau and Woleai was the greatest single factor contributing to the high morale of the squadron. Pilots are apprehensive of landings in enemy territory and of falling into enemy hands."

In the Pacific Theater, battle-damaged aircraft were always headed out to sea to avoid capture or strafing and to get outside the barrier reefs. An emergency descent at sea was preferred to crashing on land, as search aircraft had better visibility on the sea than in forests or mountains, and liferafts could be seen more easily and were more likely to be spotted if near wreckage or oil film.

In two Pacific incidents men who bailed out over land immediately turned to the sea for safety. An Australian flying officer landed in the jungle at 0900 about 2 miles from a Jap strip. He walked a mile to the beach and launched his dinghy about 1515. At 1550 he was picked up by a DUMBO of the Second Emergency Rescue Squadron and returned to his base at 1710. A sergeant who came to earth inland on a Pacific island launched his dinghy in a river and in 2½ hours floated down to the coast. He forced the dinghy through the breakers and was picked up at sea 3 days later.

In abandoning aircraft the question was: "To bail out or to ditch?" The answer was not easy to decide even though the type of aircraft favored ditching. Such was the situation in the mass landing of 16 F4Us, which ran out of gas on a training flight off the Atlantic coast. Although the F4U was rated a good ditcher, and floated long enough to permit an unhurried exit, it rarely gave time to inflate the liferaft and to step into it dry from the wing. All of the 14 who chose to ditch were rescued. The only man lost was one of the two who chose to bail.

In extremely cold water the chances of sur-

vival are always better in ditching than in bailout. Survivors who bailed out over the English Channel repeatedly cautioned: "Bail out over water only when ditching is absolutely impossible." Crews of multiplace aircraft had larger rafts and more complete kits, but it was impossible to keep dry in rafts, and unless rescue was prompt, the effects of wind chill proved as fatal as immersion.

The Korean outbreak was remarkable for the small numbers (about 2 percent) of ditchings and bailouts over water. The pilots decided to come down over land largely to avoid exposure to the known low temperatures of the seas around Korea.

Crews of multiplace aircraft also preferred ditching to bailout because in so doing they remained together and were not scattered over miles of seascape. Companionship made the going easier. As one B-24 pilot in the Celebes action said: "We landed on water in preference to bailout so as to be picked up together." The conditions tabulated below are those under which ditching was always preferred to bailout:

a. When there were injured aboard, or passengers inexperienced in the use of a parachute.
b. When men were hampered by fouled parachutes, straps, clothing, or through malfunction of the canopy or exits.
c. When there was a shortage of parachutes, or when the parachute was damaged.
d. When there was fear either of jumping, or of not clearing the aircraft.
e. When the aircraft could be ditched close to shore or in sheltered waters, or when vessels stood by to assist in the rescue.
f. When there was no choice in the matter.

A summary of rescues in the New Guinea region from July to December 1944 affords some significant comparisons. Out of 53 ditchings, 43 or 81 percent were completely successful, in the remaining 10 one or more crew members died. In the 27 bailouts reported during the same period, only 9, or 33⅓ percent, were rescued. Of the 307 persons involved in these water emergencies, 224 or 73 percent were recovered.

A similar analysis for the Mariannas area during a 6 months period in 1945 shows 67 ditchings and only 16 bailouts. The recovery rate for ditchings was 98 percent, for bailouts 94 percent. The official report further states: "This unit cooperated with B-29 Wings in developing ditching procedures. As a result, the loss of B-29 crews shrank to a very low figure, although the number of B-29's operating in the area increased tremendously."

In the European Theater during August 1943, the survival rate was 57 out of a known 354 bailouts—or a 16 percent recovery.

REASONS FOR BAILOUT. Although most fliers preferred to take their chances with a hopelessly damage aircraft rather than hit the silk, certain conditions compelled the crew to abandon the plane in the air. These were:

a. When there was not sufficient time or altitude to bring the aircraft under control.
b. When there was fire, smoke, danger of explosion from hung bombs, a heavy fuel load, or gasoline fumes.
c. When surface vision was obscured.
d. When the ditching characteristics of the aircraft were known to be bad.
e. When fuel was exhausted or when the aircraft was out of control.

BAILOUT HAZARDS. Some of the many difficulties in bailout are illustrated by the experience of a P-38 pilot. He filled his pockets with gear, then jettisoned the canopy and stood up. The slipstream blew his goggles off and sat him down. He tried again, feet first, and as he was swept away his left arm was gashed. In preparation for the dunking he drew his knife but lost it in the shock of impact. He deflated his chute, but while trying to inflate his lifecraft in the choppy seas he tangled in the risers. The CO_2 toggle release was hard to pull and as the soaked chute and seat pack began to sink him, he abandoned everything by unhooking the static line. His Mae West had inflated properly but he had to unload his crammed pockets before he was even fairly safe. He gave up trying to unloosen his heavy boots.

In multiplace aircraft parachute discipline was imperative. As one commander put it to his crew: "As last man out, I don't want to have to wait around while you're scrambling around hunting chutes." Lack of chute discipline was a common source of trouble. Often when under stress of G-forces or swift descent, the crew could not get out of the aircraft, much less put on their parachutes. The sole survivor of a crew of 13 in a PB4Y that went into a violent spin at 6,500 feet had his chute on and dragged himself by force through the open hatch.

Failure to clear the damaged aircraft accounted for 75 percent of AAF deaths after bailout. Most of these fatalities were caused by striking or being struck by the aircraft, or by jumping when too low. In combat when the flier risked strafing, he bailed out as low as safety permitted. At low altitudes there was always danger that the chute might not open in time. One lucky marine pilot survived a 2,000 foot plunge into the ocean when his parachute deployed only partly. He was knocked unconscious by the impact. "I came to under water, green all around me. Wondering where I was, I pulled the life jacket valve and shot up." He suffered a broken pelvis, two badly sprained ankles, and was a mass of bruises from head to foot, but he lived.

Most parachute falls in World War II were made at about 6,000 feet. With the advent of jets, extreme altitude bailouts have become fairly common. Opening parachutes at altitudes between 30,000 and 40,00 feet has not been recommended because of the extreme cold, the risk of anoxia, and the strong shock when the chute inflates. To avoid these risks, flying personnel have been advised to fall free to below 20,000 feet. As this involves the risk of losing consciousness and subsequent inability to open the chute, pilots are apparently still faced with the decision of how far to freefall. An F2H-3 pilot who leaped at 32,000 feet explained: "Some may question my reasons for opening the chute so soon at extreme altitude, as the general policy seemed to be a freefall to a warmer altitude with sufficient oxygen as soon as possible; doing this by either counting or holding your breath as long as possible. I discussed this policy with the flight surgeon. He felt that on bailout with no oxygen, it would be better to open your chute while still conscious, taking your chances on anoxia and frostbite rather than chance anoxia during a freefall which might probably prove fatal in the event that you passed out prior to pulling the rip cord. I agreed. This is why I opened my chute when I did without oxygen."

Depending on the speed of the aircraft, more or less shock is felt when the parachute opens. Loose equipment such as sheath knives, sidearms, flashlights were often shaken out and lost, and heavy articles tore through the leg pockets of the flying suit. A violent shock stripped off a pilot's wristwatch, identification bracelet, boots, and ring-setting, and partially blacked him out. Those who wired gear to their chute harness found this unwise.

Improperly adjusted parachutes caused painful strap burns and bruises, chiefly on thighs, shoulders and face. The loss of men last seen struggling with inflated Mae Wests is attributed partly to badly fitted chutes. One fighter pilot suffered a bad scare when, as he rolled out of the cockpit, he slipped through the loose harness, which fortunately caught on his feet. He managed to pull the ripcord, and landed in the water with a twisted knee and some strap burns.

Nature of the Landing

The method of abandoning the aircraft largely determined the nature of the survivor's contact with water, starting a series of events so swift that men could not always recall the sequence of their conscious or reflex actions. Time was the critical factor, especially just before and just after abandoning the aircraft. Survivors repeatedly stressed three basic rules:

1. Don't get excited.
2. Take time in leaving the aircraft.
3. Take all available gear, including what may rise from the sinking aircraft.

BAILOUT LANDINGS. Once clear of the airplane and coming down with opened chute, the flier's next concern was for injury or deep immersion on dunking. Most men went down to 5 to 10 feet when they hit. Many misjudged the distance to the water, released the chute sling too soon, and were injured, dazed, or knocked out by their fall. The shock of a hard landing deprived the flier of the initiative, and was undoubtedly responsible for the loss of some who had bailed out safely. Others hit the water before they could get their chutes off. "We counted 9 chutes in the air and most of us hit the water before we could get the chutes off. This was due to our difficulty in judging the distance to the water."

Those who rode their chutes into the water were often dragged by the windblown canopy unless they had freed their leg straps for quick removal. Those who lived through this ordeal told how the leg straps forced their heads under water and made release almost impossible. One flier in this predicament was saved by the prompt action of a destroyer commander who placed his ship across the path of the wind to collapse the chute. Even the quick release harness that frees

the parachute when a plate is struck sharply is not foolproof. Some survivors reported difficulty in forcing the release mechanism when under water.

When the chute is not promptly disengaged, the risers foul arms and legs, which hampers even the best swimmers and provokes momentary panic. Uncollapsed chutes caught by the wind drag the flier, gagging on salt water, half drowned and helpless until he can release the tension on his harness and get clear. One man told how after hitting the water his chute planed him on his chest until he was able to release it. "I had a terrible fear of the chute because I knew it could enmesh and drown me. Every time I relaxed I drifted into it."

In the first moments after entering the water, the flier's life vest might fail to inflate. The drag of clothing and gear or the struggle to retrieve a seat pack always prove exhausting. One unlucky flier reported finding his seat cushion carefully tacked down.

Some pilots regained consciousness unhampered in the water with no recollection of what happened after they landed, and usually without their liferafts. Others landed and released their chutes safely, but without retaining their pararafts, which blew away with the harness and the chute.

The danger of losing equipment was always greatest at night. "It was dark when I landed on the water, *but despite that fact* [italics added] I secured all my gear and finally succeeded in removing and inflating the raft and painstakingly worked myself aboard, being careful all the while not to capsize the raft and run the risk of losing it in the dark."

DITCHING LANDINGS. In most ditchings the moment of impact dominates all following events. "Just before we hit I rang the alarm. I never heard that bell. There was an ear-splitting racket as the tail of the fuselage smacked the top of a wave, then a grinding, grating, thunderous crash when the nose hit one of those mountains of sea full-force. The whole cockpit seemed to explode. Abruptly the tumult ended and there was nothing but the gurgle of water. It had been like riding an eggshell into a concrete wall, then dropping to earth, a sodden mass of waste."

When multi-engine planes went down, especially aircraft with large crews or many passengers, all persons took part in preparation for ditching. Pilot and copilot fastened safety belts and shoulder-harness to avoid crashing into the instrument board or through the plexiglass. Loose articles that might become projectiles in the sudden stop were thrown out. Extra bombs or gas were jettisoned, and all exits were opened. The crew braced themselves to resist the shock of impact and the dragging deceleration forces. Pulled or closed chutes were used for padding. Plans provided for each man to leave through an assigned exit, and for each to take a preassigned part of survival gear. Perfection in this orderly procedure was rarely achieved because of physical injuries received in ditching, structural damage to the aircraft on impact, fire or explosion on landing, high, swamping seas, and attendant disorganization or panic.

Large planes often flooded quickly when they ditched. The inrushing water either covered the equipment laid out for salvage or, as in B-25's and 26's, washed it into the tail where it could not be recovered. Even amphibians landing on rough seas flooded in almost no time. In a PB4Y ditching made without power: "Besides the sudden deceleration, the most noteworthy fact was the fast rush of water into the cockpit and flight deck. Almost the second the nose dug in, the water was above the pilot's shoulders and by the time safety belts and shoulder harness were off the water was level with the top escape hatch. In less than a minute the 13 members of the crews were in or hanging on to the only liferaft salvaged, a 7-man raft."

Equipment stored in the wings or fuselage and released on ditching was often all that the crew had if the aircraft was abandoned hastily or sank at once. Many crews salvaged equipment that rose to the surface, but too often they failed to save anything in their haste to get away.

Crews well-trained in ditching drills cleared the aircraft swiftly, even with injured men. The survivors of a B-24, ditched in heavy seas after a typhoon stated "the crew of the SS Doran standing by saw us hit the water. A big wave came up; next thing, they saw us all in liferafts. It wasn't easy."

Through many interrogations the ditching characteristics of each type of aircraft were determined. The B-17 was generally conceded to have good ditching characteristics. Of 112 ditched

B-17's, 76 percent floated for more than 1 minute, and 53 percent for more than 5 minutes. Crews were rarely trapped.

The B-24 was considered a bad ditcher. In 41 ditchings involving 400 personnel, 140 or 35 percent were lost, either killed on impact or by failure to leave the aircraft before it sank. An analysis of 10 B-24 water landings made in 1944 disclosed that in normal landings, with wheels up and bomb bay closed, an average of 1 man was killed per crash. This was generally attributed to lack of safety belts or of proper bracing, but the greatest hazard was the collapse of number 6 bulkhead, which was frequently crushed by the weight of the ball turret and pinned down any of the crew braced or thrown against it.

The B-25 and B-26 were feared for their high landing speeds and their tendency to sink rapidly when ditched. Often extra equipment kept in the rear fuselage could not be retrieved because the inrushing water wedged it into the tail section.

The floating time of single-place aircraft was always short; usually they sank almost at once. Under the best of sea conditions, fighter aircraft hit hard, frequently slewed, cart-wheeled on one wing, or nosed over while the pilot hung upside down, helpless until he could release his safety belt and swim upward. Pilots of single-engine planes reported canopies wouldn't jettison, locked by the force of the impact or by rusted rivets, and released only after the aircraft was submerged. They were encumbered by a parachute and liferaft, whose bulk might foul in the aircraft or whose weight might sink the pilot before the liferaft could be inflated. In this dilemma, some wore their chute harness as they left the cockpit, while others hoped to salvage their gear from the wing or while in the water.

In 366 single-engine ditchings, 175 men took their chute and raft with them. Trapped air gave the packs about 5 minutes of buoyancy—enough to permit 168 of the 175 men to inflate their rafts. Of the 191 who chose to salvage equipment after leaving the cockpit, 63 succeeded. Of the 128 who lost their liferaft equipment, 3 were without life vests.

Men who wore their gear had trouble leaving the cockpit when the leg straps were unsnapped, when the chute harness was fastened loosely, or when the chute became wedged in the bucket seat. The buckles and strap loops fouled on narrow projections. Often feet were jammed or caught in twisting out of the cockpit. "My feet jammed in the bent rudder controls, and I found myself barefooted, having jerked myself out of a pair of heavy field type service shoes." A long belt knife caught edgewise and held one pilot in his seat. Canteens became stuck on the edge of the cockpit; rawhide revolver lanyards tangled on knobs.

In one incident, the pilot emerged from the cockpit under water, but was held to the aircraft by the canopy which slid forward over his dangling leg straps. By kicking and hauling he managed to break loose just as the pressure on his eardrums became unbearable. When surfaced, he was so exhausted it took him about 1 hour to open and inflate his dinghy. Some pilots of single-engine aircraft used oxygen under water to clear the cockpit and release the liferaft.

Reports on the ditching of jet planes show that the impact is severe, and that escape from the cockpit is difficult. "Contact with the water the second time was most severe. My crash helmet and inner liner came off and hit the gun sight. My wrist watch came off and hit the instrument panel. The plane nosed over. I lost consciousness. When I came to I was under water and it was very dark, I must have been approximately 40 to 50 feet under, because after approximately 10 good strokes upward and still about 10 feet from the surface I saw a bright yellow glow above me. I knew there was a fire on the surface and headed for the edge of it. On the surface I swam about 15 yards, then stopped and pulled the CO_2 bottles on My Mae West but nothing happened. I inflated the Mae West with just enough air to keep me afloat."

Studies of many ditchings under widely different climate and weather conditions show that very commonly the men are injured and dazed when they reach the water. Usually the water revived them, but all felt exhausted and found that their limbs were slow to respond. Rickenbacker noted that his companions were badly shaken and slow to get out.

Men in the water before boarding liferafts were especially attracted to the wing and tail surfaces, which provided the only visible handholds to keep from drifting away. This practice was dangerous in any but the calmest sea, for the violent slapping of the wings and tail of large air-

craft in a heavy sea often knocked men unconscious and upset liferafts. "The wing [B-29] would lift out of the water and slap down again with great force. The raft seemed inclined to go under it when it lifted from the water."

SINKING SUCTION. Although many pilots made successful exits from flooded cockpits after submersion, most crewmen feared being dragged down by the suction of the sinking aircraft. This fear provoked panic in leaving the aircraft and prevented the last minute salvage of items needed for survival. Flying personnel were repeatedly told to expect no appreciable suction when their aircraft sank, and to make every effort to retrieve equipment while time permitted. In spite of this instruction and reports of experience, one pilot stated that "the crew spilled out of the plane like Keystone cops out of a patrol wagon." Three B-29 survivors reported the curious experience of being "sucked upward" and out of their aircraft through a break in the fuselage.

The derelict airframe offered some very real dangers. Men were sometimes trapped in the fuselage, but unless they were completely immobile, or held in the wreckage, they could swim surfaceward through any exit before the aircraft had sunk very far. Time and again crew members, even though poor swimmers, were able to shoot upward from depths of 30 to 40 feet simply by inflating the life vest. They had to be careful to avoid jagged metal that might rip, pierce, or snap clothing or equipment. Pilots of fighter craft were especially concerned to avoid entanglement as the plane dove under nose first or rolled sideways.

With time running out, fighter pilots had to remember to disconnect the oxygen system, the mike, G-suit and heated suit conections, and tighten or unfasten the safety and shoulder straps. Shoulder or chute harness frequently caught on the canopy. Sometimes the parachute was fouled and precious time—and often the dinghy too—was lost in cutting the risers. A Spitfire pilot came to under water, held in his seat by the mike cord and safety strap. He released these but his chute had caught on the fairing behind his seat. When he finally wriggled loose the color of the deepening water had changed from light green to black and the luminous instrument dials were shining clearly.

Fighter pilots frequently admitted that they hesitated too long in their decision, lost power and control, and had to crash without regard for the attitude of their craft to the seas. Last-minute safety adjustments for proper bracing were underestimated or forgotten. The resulting injuries or the generally dazed condition which followed a poorly prepared ditching made a proper exit almost impossible. After the successful ditching of the plane carrying General Twining, the survivors lacked food for 7 days. The emergency stores were in care of one man, who was so dazed by the impact he had to be helped out, and he forgot the food.

THE AIRCRAFT FACTOR. In designing aircraft, little thought was given to the possibility of a water landing, and land planes tended to break up and sink after their first impact on the sea. Only 17 of 29 men aboard a C-46 managed to clear the craft when it ditched. It sank in about 1 minute, carrying 12 men still trapped inside. But 14 C-47 Troop Carrier units, each with 24 men, ditched on D-day and proved that with complete discipline and quick timing, large groups could be cleared safely out of transport aircraft.

Few designers made provision for the effects of deceleration in a water-landing, although studies of land crashes had shown the need of safety belts to withstand a force of at least 8 G's. Bailout exits were provided through floor hatches, and when water closed them the crew had to chop their way through plexiglass windows or domes. Mechanical latches, operated from inside the aircraft, sometimes jammed and failed to discharge the liferaft. Often floating equipment failed to work, and some was mishandled and lost.

Conflicting theories confused the problem of ditching, chiefly because of lack of knowledge of how each type of aircraft should be handled in ditching. No one could be sure how long each airplane would float, or whether the sinking hulk would suck men down. Above all, men did not know what *not* to do.

The British soon recognized the floating qualities of their large aircraft. They developed a training system that lessened impact injuries and helped crews to leave the aircraft safely. The training evolved a sound technique for ditching, even at night. By November 1943 British Air Sea records showed over 30 percent rescued of all crews dropped into the water. During the same 2

years nearly 50 percent of some heavy bomber crews were saved, and at times 70 percent.

American recovery from the same seas during the first half of 1942 was only 6 percent, but experience and training brought improvement. From March 1943 through March 1944, 1,169 men were saved out of a total of 2,130 ditched—a recovery of 55 percent. The improvement in American rescue figures was largely due to training and practice. An important influence was the establishment of the Personal Equipment Officer—a "survival salesman" born out of the moment's needs "in a hell of a hurry." The active participation of American units in the British Air/Sea Rescue Service also added to the gains in rescue and survival.

WEATHER FACTORS. Wind, swell, and waves are the most important outside forces to be considered when ditching. Land-trained pilots coming down over rough water saw only a confused network of breaking seas in which the combined effects of wind, wave, and swell could not be resolved quickly. The old rule was that ditching, like landing, should be made upwind, but usually the swell system and not the wind is the governing force. The development of downwind and parallel-swell landings increased the safety factor greatly and gave the crew a better chance to escape from the aircraft.

Although amphibious aircraft can land at sea to effect rescues, the risks are many and often led to failure. Many open sea rescue attempts by amphibians during World War II failed, some of them disastrously. An official report on the subject, dated 26 September 1945, states:

"From reading hundreds of Air-Sea Rescue reports, it becomes increasingly evident that in many cases off-shore landings were unnecessary and not the best thing to effect rescue. In all too many cases the offshore landing resulted in disaster for the would-be rescuer and a great delay in the rescue of the original survivors."

Visibility is more important in ditching than in bailout. Water landings on moonless nights are risky, even with the aid of flares and searchlights from stand-by vessels. Carrier pilots preferred reflections of winglights to the more glaring landing lights or flares. "If at all possible, give yourself an hour of daylight when ditching late in the day with possible gas failure early in the night. That much time is needed to assemble all men, rafts, and to dress wounds or injuries. By assuming a particular time for ditching, we were able to send a message to base giving our exact position. It took us about 10 minutes to get all hands into liferafts and paddle away from the aircraft, which sank in about 15 minutes. In 20 minutes it was so dark that we had to dress our wounds by flashlight. Emergency rations became entangled in the plane and were cut away and lost."

THE HUMAN FACTOR. The human factor plays an important role in all inflight emergencies. A minor error can start a chain of swift events which may end in disaster. Consider the rattled pilot who detonated his IFF when he meant to turn it on. His home base gave him a bearing which would have brought him in safely, but he ran out of gas because he couldn't transfer fuel from the drop tanks. He ditched, but with a loose safety strap so that on impact he suffered a broken jaw and contusions. Too dazed to use his liferaft, he lay in the water supported only by a Mae West; yet he lived.

American aircrews took most of their training over land, and were taught to bail out in an emergency. The lack of ditching drill was a serious defect, revealed early in World War II.

Land-based airmen rarely had the opportunity to gain a sailor's knowledge of the sea that most pilots of carrier-based aircraft did. Carrier-based pilots had to find and land upon a moving airstrip —feats that often led to survival experiences. Not only did they have some firsthand knowledge gained from shipboard life, many had seen accidental ditchings during take-offs or landings and had studied them critically for clues to right or wrong techniques that they might need should they ever have to dunk.

When able to ditch within the perimeter of a task force, carrier aircrews often felt that they "had it made," and in the midst of ships and picket escorts eager and willing to pick them up, some overconfident fliers did not inflate their liferafts. But even within this zone of ready help, darkness, sudden squalls, high seas, and the urgencies of battle often delayed rescue, even by 4 to 11 days. During the extraordinary Navy ditching in which 100 aircraft were in the water after the carrier strike on 20 June 1944, despite immediate and prolonged search by ships and amphibious aircraft, 25 percent of the aircrews were lost.

Chapter III

THE EQUIPMENT

THEORETICALLY, survivors had at their disposal a wide variety of equipment to meet survival needs. Most of the equipment was contained in the accessory kits of liferafts which were standard issue to individuals or aircraft. Most aircraft also carried supplemental equipment in various implement and sustenance kits and the crews often had some personally-owned things with them. When they first went down, orbiting wingmates frequently dropped additional survival gear to the man in the water, and on later contacts search aircraft dropped disaster kits and other needed equipment.

An individual's chances for survival in most situations depended almost entirely on his ability to retrieve and retain his gear. They were also influenced by such other factors as missing equipment, defective or malfunctioning equipment, or equipment which the survivors had never been taught to operate and did not know how to use at the moment of need.

Men in liferafts or floating in Mae Wests found it impossible to recover dropped kits because of seasickness, injuries, weakness, or rough seas. In many instances, airdrops were released too far away to be seen or recovered by personnel sitting low in the water. Of those who succeeded in keeping or retrieving survival equipment after ditching or bailout, 90 percent lost some or all of it in the first upset. In many incidents survivors had little more than the garments on their backs and the contents of their pockets. Bulky things crammed into pockets at the last minute became heavy, interfered with swimming, and were often jettisoned. Interrogation reports repeatedly express the advice of rescued men: "He says that the greatest lesson he learned was that every pilot should make frequent and thorough inspection of his emergency gear to make sure that everything is in working order and nothing is missing."

SURVIVAL EQUIPMENT

The Mae West

Unquestionably the most valuable single piece of overwater equipment issued to aircrews and the one most often used was the pneumatic jacket-type life preserver or vest popularly dubbed the "Mae West." Worn under the parachute, it was inflated by separate toggle levers which released carbon dioxide gas (CO_2) stored in two small cylinders, one for each buoyancy chamber. The vest could also be inflated by mouth.

The early models of the Mae West were not too satisfactory, for they tended to creep up and lower the wearer in the water, and needed constant adjustment. Complaints noted most frequently in interrogations, some as late as 1945, were: No support under the arms, for the back or the neck; a tendency to push the abdomen up and the head down, or to roll the wearer over backwards. Later models held the wearer a little higher, more erect, and provided some neck support, so that a man could rest more easily, and even sleep for short periods during immersion.

Mae Wests were a handicap when boarding liferafts, when attempting to duck under water to avoid being seen or strafed, when diving from a raft to retrieve sinking equipment, or when trying to swim below burning gasoline on the sea's surface. At all other times they were indispensable.

Notwithstanding its obvious value, the Mae West was a much criticized item of personal equipment. Many crewmen disliked wearing the vest

on duty because it was hot and hampered their movements. Although most aircraft commanders made the wearing of both Mae West and parachute compulsory, some crew members disregarded the orders.

A very small percentage of those who went into the sea without life vests lived to regret it. The narratives show plainly that to be in the water or over it without a life vest is to court disaster. Occasionally men trusted their swimming abilities more than their Mae Wests, and discarded their best surety of staying afloat. One overconfident pilot who removed his vest in a lake ditching drowned a half mile from shore.

The vest not only kept men afloat, but helped them escape from sinking chutes, tangled chute harnesses, and sinking aircraft, and brought them to the surface from depths as low as 40 feet. In one upside-down night bailout, a pilot hit the water hard and went deep before he regained consciousness. Dizzy and confused as to which way was up, he solved the problem by inflating his Mae West, which brought him bouncing to the surface at once.

Incidents of men in difficulties under water reaching the surface only with the aid of their life vest abound in the narratives. Typical of many is the case of the airman who freed himself of his fouled chute and an obstinate seat buckle 15 feet under water. By pulling along the antenna wire and pushing against the aircraft as it sank past him, he rose to a few feet of the surface, where the weight of his chute pack held him until he pulled his CO_2 lanyards and was lifted to the surface.

Many reports tell of men who drowned in uninflated life vests. In one accident in which 7 of a 12-man crew drowned, 5 were found wearing uninflated vests in working condition.

Some of the many complaints of malfunction resulted from damage to vests during combat or in severe ditchings or hurried exits from the aircraft. Men who tried to re-enter or climb up on the aircraft often ripped their vests on jagged metal. Others punctured the vests trying to ride floating belly tanks or other wreckage. A few cut their vests when cutting themselves free from their chute or other entanglement. The impact of ditching frequently tore off the Mae West—in one disaster 7 of an 11-man crew lost their vests in this manner.

A distressing number of reported malfunctions, however, were the result of ignorance of how to use the equipment which could have been avoided by adequate training, or of inexcusable carelessness, or failure to inspect the vests regularly to make sure they were functional and undamaged. In some theaters men were urged to give their Mae Wests 24-hour inflation tests for leaks at regular intervals.

IMPROPER PROCEDURES. Flight crews were often careless in handling their life vests. Some had a habit of winding or tying the loose ends of the pull lanyard around the cylinder top to keep it from snagging or discharging accidentally while in flight. Although this practice was condemned, instances of it are reported as late as 1945. "The cord on both CO_2 cylinders had been looped over the containers and I was deprived the use of my life vest. I had been warned of the danger months before by my squadron safety officer."

Another careless act committed by a number of survivors was to inflate the vest before unbuckling the parachute chest strap. "Before the crash, I had not been able to shed my chute because I could not afford the use of my two hands. Later when in the water I inflated my Mae West and nearly suffocated because of the pressure on my chest. Through assistance of the navigator, I unfastened my chute harness and kicked off my heavy flying boots and hung onto the raft for about an hour, exhausted and in bad shape from too much salt water."

Ignorance of the equipment led to difficulties: "I found the little pull-cord wrapped around the carbon dioxide inflating device—backwards. The tighter I pulled, the tighter the valves closed. A little matter of inspection on my part would have spared me a lot of difficulty."

When cylinder top caps were left loose, the release plunger could not pierce the cylinder seal. Even when properly threaded, the pin failed to puncture the seal.

When they had time, men often loaded themselves down with more gear than the life vest would support. Possibly the record "Mal Function" in this respect was the pilot who stepped into the water wearing his inflated Mae West, a back-pad kit, a carbine, and a large shoulder-type canteen. On top of the back-pad he had attached an extra Mae West. On a web belt around his waist he carried a .38 caliber pistol, a small pouch of

ammunition, two first aid kits and a smaller canteen. His pockets contained loose .38 caliber and carbine ball and tracer ammunition, several small cans of food, and three Very pistol shells, and he had thrust the large aircraft Very signaling pistol inside of his shirt. After a short struggle in the water with his 1-man liferaft, he found that it would not inflate so he abandoned it in favor of one a wingmate had dropped and which had inflated on impact with the water. Halfway to the second raft he had to jettison the carbine, pistol, shoulder canteen, pack-pad and Very pistol. He inflated the second Mae West and hung to it until rested. Finally he reached the inflated raft but was unable to board it because of the weight of his waterlogged clothing. This time he abandoned everything but his clothing. When picked up a half hour later he was too weak to climb up the boarding net.

CO_2 CYLINDERS. Carbon dioxide cylinders were so criticized that many fliers had little confidence in them. There was no way of testing them. Weighing will not show whether or not a CO_2 cylinder is operative because the gas in the charge is so light. Through accidental discharge and failure to inspect and replace used tubes, many men found themselves unable to inflate their vests automatically. Some carried spare cylinders, but in an emergency the unprepared had to inflate the vest by blowing through the oral valves—often exhausting work.

ORAL VALVES. Failure to close the oral valves was a frequent cause of trouble. The valves were often left open during flight to prevent pressure against the chest when the air in the bladders expanded with altitude. In moments of nervousness, men fiddled unconsciously with the valve, and sometimes left one or both open so that on inflation the released gas escaped before the dazed flyer saw his error.

Sometimes the threads of the valve stem were blocked, as with camouflage paint or string, which made it impossible to tighten the valve cap. One insistent raft survivor tried vainly for 2 days to inflate his Mae West before he found the trouble.

FIT. Badly fitted Mae Wests proved dangerous. A loosely adjusted crotch strap allows the Mae West to rise into the wearer's face or over his head. When the straps at the neck are too stiff, they force the head down, hold the stomach too high, and allow the head and shoulders to sag back; when too slack, the wearer rides too low in the water and can even swim out of the vest. One man, irritated by the difficulty of trying to stay comfortable in a Mae West that persistently rolled him sideways, abandoned it and had to tread water for 20 hours before he was picked up.

Sometimes men put Mae Wests on backward. On inflation the wearer felt a strong compression on his abdomen and an upward choking pressure under his chin that rendered him helpless in the water. Men lived to report this error only because other crew members helped to release them.

Men generally failed to appreciate the importance of proper fit and blamed most of their troubles on improperly filled gas cylinders. Unless the wearer was badly overloaded with personal equipment and unable to swim, one of the two air chambers was enough for safe buoyancy. With Mae Wests properly fitted and fully inflated, groups of men survived as much as 3 days in the water, often by tying themselves together. Some survivors gained higher buoyancy by sitting in their waist adjustment straps. Many managed to stay afloat long periods with badly damaged vests.

Nonswimmers with damaged or improperly inflated vests were susceptible to panic. Sometimes they refused to leave the plane and take to the raft. One such lucky survivor was so aroused by his ordeal that he took swimming lessons—16 months later.

The Liferaft

A liferaft is essential for a water survival of any duration. It serves as a platform not only for the man, but for his provisions and gear, and allows him relief from total exhaustion. Although there are authentic records of men who survived immersions from 20 to 35 hours without Mae Wests or liferafts, and up to 3 days with only a Mae West, most of the fatalities that occurred during this stage of survival were of men without rafts.

A report of the 13th Air Force made in 1944 on 870 ditched crews states that 82 percent of those using liferafts were recovered, only 48 percent of those without rafts.

Combat aircraft liferafts were normally released from inside the fuselage by a hand release which ejected the raft from outside compartments located in the wings or fuselage and automatically

inflated it. To prevent loss the liferafts were held to the airframe by lines strong enough to hold the raft at the surface, weak enough to break and release it if the aircraft sank. Spare liferafts were sometimes carried in the rear fuselage of combat planes when transporting large groups.

Liferafts on transports were usually placed near the rear cargo hatch and manhandled out when needed. All transport personnel felt strongly that cargo and survival gear should be kept separate, but pilots feared that jammed or inoperative hatches of large aircraft would prevent the use of any rafts stored in the waist. For this reason, even though the larger rafts were more comfortable, they preferred to have 1-man liferafts (MK I, or C-1, later replaced by the C-2), available as well. In the early B-29 actions crews were also given 1-man dinghies after multiplace liferafts proved useless in bailouts.

Each liferaft had a rated passenger-carrying capacity, which was considerably lower than its actual capacity. The A-3, which replaced a whole series of earlier type liferafts, was rated to carry from 2 to 7 men. One A-3 was issued to flights with crews of 3 to 5, two to crews of 6 to 12, and three to craft carrying 12 to 15 men.

With the exception of 8th Air Force personnel who occasionally used the round British rafts, the standard liferaft issued to American forces was rectangular and had inflatable seats which also served as bulkheads. The success of Pacific castaways in sailing liferafts to friendly havens was one of the deciding factors favoring the rectangular liferaft, which proved more maneuverable than the circular type, but was less stable and more easily capsized. To reduce upsets, later models had stabilizing pockets which worked with varying efficiency because survivors did not always understand how they operated.

One narrative relates the good fortune of a pilot who salvaged an outrigger canoe. When he encountered rough seas the constant bailing required to keep afloat forced him back into his rubber raft.

All liferafts contained accessory kits including water and food rations, first aid kit, fishing kit, signaling equipment, hand pump, plugs, sea anchor, waterproof sheet, bailer, compass, literature, and wood or aluminum paddles.

MALFUNCTIONS AND ERRORS. Theoretically, all flying crews were supposed to have had some familiarity with liferafts and their equipment. The following comments based on personal narratives show what actually happened in most instances.

Releases often failed to eject the liferafts out of their compartments, and rafts had to be dragged out forcibly by hand. When malfunctioning releases were improperly safety-wired or fouled, they often damaged the raft when it was pulled out. The B-24 had no mechanism for releasing rafts from the flight deck, so when the men in the waist were killed or incapacitated, the rafts were unobtainable. In 10 B-24 ditchings, the inside manual release was used only 5 times, release was effected from outside 3 times, and 2 rafts were recovered only after they floated free of their own accord. A similar analysis of B-25 ditchings showed that only half the rafts were released by hand from inside the aircraft.

The inaccessibility of releases was criticized in all types of aircraft. Large rafts carried in the waist were difficult to remove from the rear fuselage in all but moderate seas, especially when the raft case was coated with oil or blood. The wet, slippery case was too bulky to grasp, had too few handles, and often could not be pushed out against the rush of incoming water. The 105-pound E-5 raft kit issued to B-29 aircraft was often left in the waist for this reason. "The large liferaft in back of the aircraft was too difficult to move out by hand." "There was great difficulty in pushing the liferafts through the waist hatch in the dark and inflating them; three men jumped out in Mae Wests and were lost in the darkness." Where there was a choice, the large rafts were usually abandoned in favor of smaller rafts.

From the force of impact or through confusion, large rafts were sometimes inflated accidentally in the fuselage. It was impossible to get an inflated raft through the door, and in one desperate incident the raft was knifed, pushed out, and then abandoned.

Single-engine crews had similar difficulties getting 1-man rafts out of their crowded cockpits. Sometimes the hood jammed, and to get out the pilot had to leave both chute and raft behind. Sometimes the raft fell into the bottom of the cockpit and could not be retrieved. Men also abandoned liferafts when they could not extricate them from their tight-fitting covers, or because they were unable to find the safety wire holding the release toggle.

Some men lost their rafts by thoughtlessly throwing them overboard free. Unless securely attached to the aircraft or held firmly by hand, rafts drifted away before the survivors could get into them. When large rafts were held insecurely, or the raft lanyard broke before the inflated raft itself was in hand, wind and waves took rafts downwind outstripping the fastest swimmer. Survivor reports frequently echo the warning: "Don't inflate liferafts until all are close by, otherwise rafts may blow away." Seven who survived a Pacific ditching in January 1955 reported: "One of the rafts blew away before we could inflate it, so we piled into the remaining raft."

If launched on the windward side, the waves and wind forced raft and occupants against the aircraft in spite of frantic and often uncoordinated efforts to paddle away. Consequently they fouled on antenna and tail assemblies, and many were damaged or capsized when whipped and banged by the wings.

Sometimes the line holding the liferaft to the raft compartment failed to snap at the tested breaking point, and had to be cut or broken by hand. Men often injured themselves in the process. A jammed knot held one liferaft so tightly to a door that the men had to jettison the door and drag it into the raft. Many times the liferaft or the paddles were bound with twine which could not be undone with water-softened fingernails or gloved hands, and lacking a knife, men chewed the twine apart with their teeth. Sometimes the peripheral guard line caught across the middle and constricted the raft into an hourglass shape when it inflated.

The lack of familiarity with simple details of raft operations was apparent in the many night emergencies in which survivors had to wait for daylight to read the printed instructions.

INFLATION DIFFICULTIES. The inflation mechanism was a frequent cause of trouble. Most failures were attributable to improper gage of safety wire, inability to find the safety pin especially at night, and to sudden breakage of the release cable on the first tug. In one incident the crew crushed the casting with a pistol butt and forced the pin with the pistol barrel; in another the pilot opened the valve with his teeth.

Faulty plunger pins which failed to pierce the seal of the gas cylinder were reported early in World War II. Liferafts with CO_2 cylinders rolled improperly inside the raft had to be laboriously unrolled before the gas release handle could be reached. Greasy valve knobs could not be turned with wet hands.

Many fliers did not know how to operate the CO_2 release. When the gas was turned on, frost sometimes collected on the valve exterior and was mistaken for a malfunction. When tugging at the CO_2 ring, the whole assembly was apt to come loose, especially when men pulled the toggle free by bracing their feet against the raft. The release mechanism was often damaged or the CO_2 cylinder tore loose when liferafts were dropped without proper containers to persons in the water. The metal CO_2 cylinder always sagged down under water where it was hard to find. When the crew bailed out, the 1-man pararafts often tore loose on impact and were lost. Frequently the men were unable to remove them from their containers.

If the automatic filling device failed, crews were forced to use plunger-type hand pumps or concertina-type bellows to inflate the raft. Hand pumps were sometimes tied to the raft for immediate use; often they fell overboard and hung unnoticed until found by accident. Hand pumps were criticized as too weak to withstand constant use. Pumps made of plastic or metal were often cracked or flattened, while the cloth of the bellows pumps deteriorated rapidly. In several instances deflation pumps used by inspection crews were substituted in error for the inflation pump in the liferaft.

After several unsatisfactory reports from pilots in 1944, a general inspection revealed 11 of 30 dinghies damaged because of improper packing. It was found that when the CO_2 cylinder lay on top of the raft pack, the constant movement by the pilot while in flight caused the metal connection to chafe a hole in the raft fabric. As recently as 1955: 'Friction caused by a CO_2 bottle punctured a hole in the bottom."

BOARDING. The problem of entering the liferaft depended on the condition of the man and of the seas. "My rubber raft was of the small, 1-man pack type that is an integral part of the seat type parachute. Once in the water, it took me about 5 minutes to unpack and inflate the raft. It was dark when I landed. I dumped my heavy, water-soaked chute in and painstakingly worked myself aboard, being careful all the while not to capsize and run the risk of losing it in the dark. Com-

pletely exhausted, I lay athwartships for almost 5 minutes. Then I worked myself farther into the liferaft."

Almost all narratives refer to the struggle required in boarding liferafts. Wounded, injured, or exhausted crewmen succeeded only with help from others. "The pilot had broken his back. We had trouble getting him into the raft. Fortunately, he survived." Many were too encumbered by flying clothes, shoes, jungle kits, and other emergency equipment to hoist themselves in, even in smooth seas. They were further hindered by the inflated Mae West which fended them off the slick, rounded buoyancy chambers, or impeded by pockets jammed with excess gear. Many had to deflate one or both sides of their Mae West before they could crawl in, or they had to jettison shoes, outer flying clothing, chute harness, and attached equipment. But this was easier said than done, for to remove a heavy jacket they had to take off both the chute harness and Mae West. To unlace high shoes they had to bring their feet up against the buoyant pressure of the Mae West.

Usually the effort expended in just keeping afloat, or in inflating or securing the liferaft exhausted them so completely that they just hung on at the side until rested. Many recommended inflating the raft after crawling in, and some partly deflated the raft before they could get in.

Most British and some American dinghies had short rope ladders which were of little use when they floated on the surface. American types had as an additional boarding aid a lifeline secured around the raft periphery. In 549 rescue reports 3 percent credited the peripheral line as the most important aid in their survival. "When my gunner inflated the raft, the wind and swells drifted him and the raft away from the plane. I had to swim about 20 yards; exhausted and hardly able to exert myself further I lunged desperately and barely grasped the gunnel line."

BUOYANCY. Once in the liferaft, especially if overloaded, survivors usually had to top off the chambers. Men were often too exhausted to do this. One related that as "he laid in the raft he could hear air escaping and was so tired that he merely lay with his head at the other end of the liferaft so as to avoid hearing it, feeling with his toes every once in a while to see if the raft was still fully inflated."

In multiplace liferafts, the bulkhead seats and the patch connecting the metal carbon dioxide bottle to the raft leaked along the cemented seams and required constant attention.

Few men knew how buoyant a liferaft is, even when awash, and so spent much time bailing unnecessarily. Even bailing was not clearly understood, judging from the number of times the statement "Personnel should be briefed on bailing buckets" appears in the interrogations. One man landing in a calm sea with a 4-knot wind filled his liferaft with water "for ballast to avoid tipping over."

Damage to the liferaft deck was as serious as damage to buoyancy chambers. Men sometimes unthinkingly jumped from the aircraft into and through the raft bottom. Flak and machine gun bullets caused most of the damage to buoyancy chambers, but much of it was also due to deterioration from age, heat, and humidity, or from fraying of badly packed and carelessly inspected equipment. Many of the liferafts available from 1942 to 1943 were of poor quality. The principal faults were structural—inadequate cementing of seams, patches, and seats—complicated by deterioration and gross-mishandling by aircrews who found them suitable substitutes for bed rolls, mattresses, seats, and tables.

Survivors thought that the dorsal fin of a shark could cut a raft, and feared damage from the persistent rubbing or butting of sharks, but only one instance of serious shark damage was reported. The shark made 18 cuts and tears, 5 of them in the buoyancy chambers, but the raft remained afloat.

Improperly sheathed belt knives often damaged rafts. Holes were plugged with anything handy—gum, socks, bandages, handkerchiefs, the thumb, and many times with .45 ammunition—until the accessory kit could be opened and the wooden or rubber plugs and Schrader patches applied. A crew rescued as recently as 1955 stated: "There being no repair kit, fingers and wooden plugs from oar handles were used to plug the raft for 56 hours." To prevent loss, some tied the plugs to the raft. Some men refused to insert plugs for fear of "making the hole bigger." Pinhole leaks or crease leaks were difficult to locate or repair, and necessitated constant topping by pump or mouth. A number of reports state that rafts deflated for no apparent reason.

BALANCE TROUBLES. Balance was extremely important because the rectangular liferaft was a

distressingly precarious platform in heavy breaking seas and high winds. To guard against capsizing, men had to avoid unnecessary movements and use their hands for nothing except to hold on to the raft. Anything held in the hands was always lost if the raft upset. One lone rider explained: "It was pretty hard to patch up with the first aid kit. Every time I reached for something, I was in danger of rolling into the water."

Capsizing was dreaded because of the great danger of losing raft, comrades, and equipment in rough seas or at night. "It was a night-long battle to keep the liferaft balanced without being able to see in the darkness from which way the next large wave would engulf us." One survivor experienced five upsets on the first night. "Almost immediately after we settled down the raft capsized for the first of many times and we lost a sail and the mirror." Another man recorded being upset 16 times during the course of a 20-day survival.

A most perilous moment was when the raft was lifted to a wave's apex just as the crest broke, either flooding it or tumbling it down into the trough in a welter of water. Winds of 25 knots or more exerting unexpected pressure against the sides or the exposed undersurface veered the raft to leeward or flipped it over on its back.

Being flexible and without keels, rafts were very difficult to balance when the weight of the occupants was irregularly distributed. As three men in one raft found out (from THE RAFT, Henry Holt and Company, Inc., by permission):

"[The rain] drove down violently, in solid masses. We couldn't bail for the moment, but huddled together in one side with our backs to the wind and rain, holding the life preservers over our heads with both hands. We found, too late this time, that it didn't pay to sit together with our weight all on one side. The lighter side was in the air; a wave struck the under edge and the next instant we were in the water, the raft flying through the air over our heads."

In the resulting confusion of men thrashing in the sea, the empty raft often was blown down wind with the lightness of a kite. In General Twining's estimation "capturing a light rubber raft skimming before the wind and sliding down the slopes of mountain-like waves is a job for a seagoing cowboy."

When there were several rafts in a group, survivors in their desire to stay together tied one raft behind the other. When under tow all rafts suffered strain at the point of attachment. This was eased somewhat by the use of sea anchors, but the occupants naturally feared damaging the raft just the same. Because of this stress and because rafts in tow might capsize and endanger other rafts, men preferred to lash them side by side, and discovered that they thereby gained stability.

A most comfortable ride was afforded by lashing two 1-man rafts on either side of a 2-man raft as outriggers:

"In the rough seas our 2-man liferaft capsized twice before we could get aboard and once afterwards. We preferred to ride all three in the same raft, cramped as it was, rather than run the risk of being separated in the rough seas. We finally increased the stability of our craft by lashing the 1-man raft alongside and cutting away the seats in the 2-man so that we could get down on the bottom and keep our center of gravity low. We then rode the swells and did not capsize."

In one incident involving 13 men in two 7-man rafts, capsizing was controlled by lashing the rafts together, but in spite of this four of the occupants were knocked overboard by the force of the waves striking the raft. Flabby rafts with bad leaks gave less support:

"A little while after boarding our raft, we noticed it was becoming deflated. We searched in vain for the leak, and a very dangerous and awkward condition developed when we found that one side could not be kept inflated. When it seemed that the raft might founder, one man was transferred to the other raft, with great difficuly. For additional safety, I tied the rafts together, broadside, so as to support the bad side of our raft."

Balance in 1-man liferafts was always a problem, especially in rough seas. Some survivors mounted them astride with "some comfort." On many occasions men in 1-man or 2-man liferafts fell out when they leaned too far backward, and there was always the risk of losing the raft when they did:

"I was becalmed for about 15 minutes and enjoyed a great relief. Then my raft was capsized in a sudden gust of wind that threw me out all rolled up in the chute cloth. I swallowed much salt water. Fortunately my raft had not drifted off."

General Arnold himself noted (in GLOBAL MISSION) how often 8 men or more ended up in one 4-man liferaft and without equipment. In overcrowded liferafts survivors had to sit or drape themselves over the thwarts as best they could. In high seas, a "water watch" was maintained to warn when large waves threatened, so the crew could brace themselves and avoid capsizing.

Survivors discovered that a raft awash was relatively stable, sluggish in drift, and easier to climb into than an empty, fully inflated one, especially in rough seas. Even in cold weather, men deliberately filled or refrained from bailing their rafts in order to gain some stability in heavy, breaking waves. In this fashion the crew of a ditched B-24 rode out a hurricane for 3 days before making land on the Irish coast, and an Air Force lieutenant outlived a 100-knot typhoon in the Pacific in which the rescue submarine was reported to have rolled 10 degrees 200 feet below the surface.

Stabilizing pockets attached to the underside of some rafts were a hinderance in paddling. Survivors mentioned that they almost fell overboard when trying to clear them. One survivor reached shore after paddling against the tide for 57 hours with stabilizing pockets down. Sails, sea anchors, and paddles were also used at various times to control stability.

Liferaft Accessories

SEA ANCHORS. The sea anchor, sometimes called drift anchor or drogue, is one of the most important pieces of liferaft equipment. Used properly it holds the craft headed into the wind, checks drift, and provides the best and often the only available means of steadying the craft in a seaway to prevent broaching and capsizing.

Survivors usually put their sea anchor overboard immediately on entering the raft to hold it as close as possible to their reported ditching position, or to remain near the aircraft to salvage any gear that might wash out of the sinking fuselage. They used sea anchors to increase their chances of detection from the air by controlling raft drift away from patches of sea marker dye. They used them to hold the raft offshore when drifting onto an enemy-held beach when paddling would have drawn enemy fire, when driving onto a rough, breaking lee shore or reef during the day, or when approaching a strange landfall during darkness. One survivor had to take down his corner radar reflector of open mesh wire because the wind drove his dinghy toward a Japanese island against the drag of his sea anchor.

But the sea anchor's chief function, and the use to which it was most often put, is to hold the raft headed into the wind and steady it in rough weather. In a heavy swell the anchor brakes the tendency of the raft to roll, broach, and pitch as it descends into a trough, and dampens its corkscrew movements in choppy seas. While a sea anchor slows drift, it does not stop it, and its power to hold a raft in one place was greatly exaggerated and overemphasized in the early training manuals. Survivors who found out too late the potential usefulness of sea anchors suffered needless hardships and losses.

The sea anchors supplied with each raft were supposedly designed for optimum efficiency with the size and type of raft to which they were issued. Those for the 1-man liferaft were criticized as being too small to control drifting or to prevent capsizing. The larger ones issued with 7-man rafts were more effective, but even these often permitted rafts to turn broadside in heavy swells. No sea anchor could hold a raft so that it would not ship water in short, choppy seas.

When no sea anchor was found in the raft, as happened occasionally, or the one provided was lost when lines parted, which occurred frequently, castaways improvised them from the materials at hand. Liferaft covers or cases were the most common, "and by far the best 'ready made' substitute." The personnel parachute and the smaller chute of the emergency radio were found excellent. Ponchos, paulins, deflated Mae Wests, and extra liferafts, usually the 1-man raft, proved less satisfactory. Rafts awash used as sea anchors caused too much drag and the subsequent jerking motion was hard on both rafts and on the occupants.

When sea anchors would not sink enough to make sufficient drag, men tried weighting them down with seat packs, rolled up leather jackets, water cans, and in several cases with .45 pistols. One survivor ran a line through the opening handles of his three tins of candy rations to string them overboard for a sea anchor, and complained bitterly when the tins pulled open and his rations were lost.

Sea anchors had to be adjusted according to the wind and sea conditions and the weight of the raft. Too heavy a drag, such as a personnel chute, intensified the stresses on the raft in high winds. Describing how his raft sank in 6-to 8-foot waves during a 10-knot wind 7½ hours after he put his chute over the side as a drift anchor, one man stated "The parachute jerked the raft about and eventually pulled the handle off. This may have weakened the raft and may have been a factor in causing it to deflate."

To ease the spasmodic movements of the raft dragging against the sea, survivors generally lengthened the sea anchor line until by trial and error they found the proper length. One pilot eliminated the jerking of his conventional type sea anchor by securing the elastic bungee cords from his parachute across a loop in the sea anchor line. When the raft pulled against the anchor the spring of the elastic eased the strain and made the motion easier. The elastics didn't last long but while they lasted they gave him real comfort. Fearing the strain might tear out the rubber loop attachment, he had wisely attached the anchor to the peripheral lifeline of the raft, so that when the bungee cord broke, the loop merely straightened out again and did no damage to the raft.

The number of incidents in which castaways did not use a sea anchor when they should have and could have, or who used one improperly, shows that quite a few of the men had no idea of the anchor's purpose or how one operates. Some even tied sponge rubber or kapok torn out of seat cushions to the anchor so that it floated and gave little if any drag. Those who used their sea anchors to bail with or for lashings showed how little they appreciated its value. Probably the outstanding lubber was the pilot who ditched his plane in a lagoon, got into his raft, and when he had drifted about 50 feet put out both his sea anchor and chute to stop the drift. Deciding to go back to the plane, he started paddling with chute and anchor still overside. It took him a solid half hour of hard labor to cover the 50 feet.

Apparently very few survivors realized the possibility of using their sea anchor for kedging by throwing the anchor ahead of the raft and pulling it through the water to move the raft forward. This is exhausting labor, but a few men used the technique to recover comrades or equipment lost overboard when they had no paddles.

PADDLES AND OARS. Larger rafts were usually supplied with two or more aluminum or wooden oars, small ones with hand "glove" paddles. These were often the survivor's only means of propelling or steering the raft. Only by paddling or rowing could men on rafts hope to make shore against wind or current, or beat off rocky coasts or reefs.

Rowing and paddling rubber rafts is difficult and exhausting work, for the craft are not designed for ease of propulsion. Though it may mean the difference between life and death, making headway by paddling a raft even in calm weather requires a great deal of effort, and is almost impossible against a wind of any force: "The two dinky paddles were very inadequate. It was impossible to paddle a 1-man raft against a light wind and this was a 15-knot wind." Paddles and oars were useless when rafts were tied together, which gave stability at the cost of mobility.

The effort of paddling always exhausted and depressed the men; it took "lots of energy with little results." Survivors in weakened conditions recommended that others avoid paddling to conserve their strength. On the 15th day of their 34-day drift, Dixon, Pastula, and Aldrich used shoes for paddles and, with 15-minute rests between half-hour stints of heartbreaking effort, managed to make an estimated 100 miles in 18 hours. The next day adverse winds blew them back the entire distance.

As a rule the men preferred oars to paddles, though those unaccustomed to it found rowing "awkward." Inexperienced paddlers complained of "circling" and of the difficulty of maintaining a straight course. The light aluminum or wooden paddles were found more suitable for steering than for propelling. The early type of glove-paddle proved a particularly ineffective device which could be used neither for propulsion nor for steering under sail.

Metal paddles were always serviceable, even when damaged, but sank if they were dropped overboard. Wooden paddles and oars broke or split easily, and were lost just as easily when washed out of the raft in an unguarded moment.

When they needed paddles, survivors had to have them quickly. Consequently the practice of tying paddles in the bottom of the raft for packing and storage was bitterly criticised. When they had no knives, men often had to chew the tie-lines apart. "Pack oars on top of kit where they can be found easily, instead of the bottom." "As I cannot swim, the liferaft drifted away before they could break out oars and paddle to me." One raft-rider who was being machine-gunned from shore stopped trying to dig out the paddles, pulled off his shoes and used them as oars to hold his own against the tide until he drifted out of range. Other men in similar predicaments used their hands, water tins, bailing buckets, or empty signal equipment cases for paddles.

SAILS. In all raft assemblies the paulin and poncho were designed so they could be used as sails with an oar or paddle for a mast. When men lost their oars, it was impossible to set sails. Most survivors, however, found that they gained propulsion from the wind striking their bodies or the raft's freeboard.

All survivors who were able to use sails did so with pleasure, for sailing, as they expressed it, gave them "a psychological lift," even when they were not on course or didn't know where they were going. They seemed to feel that wherever they were headed, at least they were moving and on their way, making progress without effort or physical exertion.

LINES, LASHINGS, AND KNOTS. Ropes and lines are basic essentials at sea. Without lines, survivors were helpless to lash, repair, or improvise gear. Most liferaft kits contained spare lines, a 10, 25, or 50-foot hank of 75-pound test cotton line.

The spare line was used most frequently to stream a jury sea anchor when the original anchor was lost. This appears in many reports, and always happened during high seas or a sudden squall when the anchor was most needed. One survivor reported his sea anchor line parted in 15- to 20-foot swells with a 7- to 10-knot wind. When the line on the raft sea anchor was too short to allow the anchor to function properly in high winds and seas, the spare line was vital for lengthening it.

Extra lines were also needed to lash rafts together. The constant jerking of rafts tied to one another or riding to a sea anchor weakened lines rapidly and often tore out the grommet, rubber loop, or oarlock to which the line was attached. There were many complaints that the 75-pound test line was not strong enough. "More line of greater length and heavier than 75 pounds strength is needed. At least 100 feet is necessary to lash three liftrafts, to secure gear, and for streaming the sea anchor."

The substitution of 500-pound nylon cord for the 75-pound line reduced the danger of parting lines, but contributed little to overall raft safety because the points of attachment on the rafts were not strengthened correspondingly. Consequently, the 500-pound line holding two or more rafts in tow or side by side frequently tore the attachments loose. When this took place at night or during a squall, men had trouble coming together again.

When lashed side by side, survivors feared that their rafts would break down. As the rafts rose and fell at different intervals in the uneven seas, they knocked, rubbed, and chafed together. The tug of the lines frayed the rubberized fabric loops and pulled continuously at the cemented joints and seams. To prevent this the men tried to hold the rafts apart with their hands, feet or paddles, which took much effort and unbalanced the rafts. Some lengthened their lines and found that two rafts lashed 10 feet apart rode with less strain than when held with 5-foot lines. They found it wise whenever rafts were lashed together to detail one man to look out for collisions, chafings, or line partings. When heavily loaded liferafts were lashed together, the oarlocks and other points of attachment were reported torn off in 10 to 14 hours.

Shorter pieces of line, string, cord, or wire were invaluable for rigging a rudder or sail, for repairing and improvising various gear, and above all for lashing equipment to the raft. The snap fasteners on the raft compartment flaps were untrustworthy, and men who lost gear when they failed to hold in an upset recommended the use of lace fasteners.

One 20-day survivor who capsized on the first day had lashed every article in place and lost nothing. While congratulating himself on his good fortune with a swig of water, he lost his unfastened canteen cap overboard. While capsizing caused almost all losses of equipment, two accounts report that rations were "blown out of the raft."

The airman's best source of extra cord was the shroud lines of his parachute, which could be unraveled for longer pieces of lighter line for fishing or for lashing. Some men ripped off pieces of their clothing for the purpose.

Survivors found that a good knowledge of knots and skill in tying them was very handy in their raft life. The unskilled lost gear they tied down with knots that wouldn't hold or came untied, and spent hours picking at badly tied knots swollen so tight by dampness that they resisted all efforts of their raw and cracking fingers. Those who could not tie a bowline or any of the standard bends or hitches found the square or reef knot the simplest and safest knot for holding sea anchors, and the easiest to tie. The granny knot was responsible for many losses in both liferaft and personal equipment. "The Gibson girl radio was supposed to be tied to me. I didn't pre-flight test the fastenings to the radio because I was sure it was tied properly—

but the rope had only a slip knot which left the radio floating about a hundred yards away when we needed it most."

Failure to use easily loosened hitches when making sheets and stays fast cost survivors their sails. Their clumsy knots hardened and jammed, and in sudden gusts the paulin sails tore or carried away before they could be freed.

Clothing

HEADGEAR. In the aircraft fliers usually wore baseball caps, fatigue caps, the brimless flight or overseas cap, the regulation service cap with visor, or helmets of leather or cloth. In most warm water survival incidents the men were without headgear, having either left it in the aircraft or lost it after abandoning ship. Baseball, fatigue, and service caps were lost more often than the flight cap which is easily jammed down on the head, or the tight-fitting helmets held in place by a chinstrap. Men frequently discarded their headgear in the water when they found it hindered their swimming. Some thought the outing would be short and discarded their headgear in the raft while waiting for rescue, —and regretted the lack of it later. Those who had headgear found it indispensable for general comfort and, in the absence of other shade, a survivor's only defense from sunstroke or heat exhaustion. As Rickenbacker said of his fedora, "My hat—my wonderful old hat."

GOGGLES. Men found flying goggles indispensable during ditching to protect the eyes from plexiglass splinters, flames, smoke, oil, or gasoline. However, they generally discarded their goggles in the water when waves slapped them awry, wet them, and made them useless. Whether in the water or on a raft, salt accumulated on the lenses and hampered vision, and the protection that goggles gave from spray and salt water was more than offset by their unbearable pressure on sore and sunburned noses. Lightweight sunglasses were found to be more comfortable on the face than flying goggles, and more efficient against glare.

BODY CLOTHING. Body clothing worn on flights over water varied widely in material, type, and in the number of garments. Crews operating in cold or temperate regions dressed more consistently and were always better clothed than crews in warmer climates. They usually wore two-piece woolen uniforms over woolen underwear, frequently with woolen sweaters, jackets, and scarves under heavy leather, fleece-lined flying clothing. Because they rarely felt any need to shed their dress in flight, even on low altitude missions during warm spells, cold weather crews were more suitably dressed to meet the rigors of a wet-cold survival when they abandoned the aircraft than were crews in the tropics. This was not true of men equipped with electrically heated flying suits, which absorb water readily and become heavy without offering protection from cold.

Bulky clothing proved an encumbrance in the water, but the difficulty of undoing buttons, zippers, or laces with numbed fingers, and the overpowering desire to get into liferafts were so great that few took the time to shed it. Moreover, the many layers of clothing trapped air, provided buoyancy, and gave protection from cold. Swimmers found it hard to ease the constriction of shrunken knotted woolen ties and buttoned collars.

Men in woolen clothing kept relatively warm even when soaked. Some wished they had cotton underwear or socks that would dry out more quickly, but none reported any injury from the chafing of salt-impregnated woolen cloth against the skin. "I was wet most of the time. My double-sole wool socks could be wrung out and felt fairly comfortable when put on again." "The cold wind might have been less chilling had we worn winter underwear. There was little to conserve our body's warmth."

Crews operating in the tropics and subtropics showed more freedom of choice in the clothes they wore on flights—which consistently was the least possible. Except when on high altitude missions, they flew in light clothing best adapted to the scalding heat of low altitudes. "Dropping down to less than 1,000 feet over the Indian Ocean and flying there for hours in the steaming heat of the torrid monsoon weather we really suffered from that heat. No one who has not experienced it can have any idea of the physical suffering from the heat alone."

Many fliers wore one-piece flying coveralls, sometimes with, more often without other clothing underneath. Pilots preferred those of nylon, as did the enlisted men when they could get them in place of the regular issue of heavier herringbone twill cotton. Flying coveralls are light in weight and cool, but they have many disadvantages. In the water they are heavy and hamper swimming. They are hard to take off in a raft and, when re-

moved for rinsing or drying leave the whole body exposed to the sun. Worn constantly in a sitting position, coveralls tend to creep upward, binding in the crotch and across the back and exposing ankles and wrists. "The other enlisted man and myself wore one-piece fatigue uniforms; the two officers wore regulation suntan trousers and shirts. The fatigue uniforms shrank most uncomfortably when the sun came out. I was forced to unbutton mine." Survivors with one-piece suits, especially those of herringbone twill, invariably had salt water sores where the tight, salt-encrusted cloth rubbed against the skin.

Because it lacks a drop seat, the whole flight suit has to be lowered below the knees for defecating, hobbling the wearer so that he cannot balance the raft properly or recover easily if it capsizes. As flight suits have only two small breast pockets and no waist pockets, men tended to overload the large leg pockets with survival gear which they had to jettison in order to swim.

Two-piece clothing was more suitable for raft life. Fliers usually wore shirt and trousers of khaki or herringbone twill, with or without cotton underclothes. They frequently shed jackets, coats, shirts, undershirts, and even trousers prior to takeoff or early in flight, and when the emergency came they usually overlooked and left behind any clothes they were not actually wearing. In General Twining's narrative "W—— was burned actually black. He was wearing just his shorts and shirt when we ditched. It's hot flying those latitudes."

Men who wore two-piece clothing often discarded part or all of it in the water. Usually trousers went first; garments worn under the Mae West could not be removed as easily, but swimmers without Mae Wests frequently shed their shirts, shoes, and socks as well, not only because they hampered swimming, but in an unconscious reaction to normal bathing habits. This thoughtlessness left them unprepared for the ordeal of a warm water survival.

Clothing was usually the survivor's only protection from sun or cold in the tropics, and men often regretted they had worn light clothing on a mission or had discarded it when abandoning the aircraft. Rickenbacker remarked: "We started with nothing. But knowing that a man can live a long time without food or water, I was more concerned over the shortage of clothing." Men felt the elements particularly in the neck, which neither headgear nor body clothing protected adequately, and the sensitive nape was burned by day and chilled by night. "It is a mistake to get rid of one's clothes, except shoes."

As the Pacific operations moved northward to higher latitudes, fliers began to wear heavier clothing, usually a mixture of woolens and cottons. Survivors off Okinawa wearing light summer jackets, light wool or khaki trousers, or one-piece flying suits of "very, very thin nylon" experienced much discomfort during the "terrible cold of night. Cold presented the greatest obstacle to our survival. Had we been at sea for a longer period, food might have become a more important need, although appetite and thirst, in my experience, were overcome by the desire for warmth."

GLOVES. Fliers usually removed or lost their heavy flying gloves during ditching or bailout, and in cold weather had to thrust their bare hands into pockets, under clothing, or under their armpits for warmth. Light flying gloves gave protection from cutting metal during ditchings, but men often removed them before bailing out so they could manipulate chute fittings and work the liferaft loose from its case more easily. Wet gloves were slippery and difficult to work in. There are references to both shrunken and stretched gloves.

Survivors who retained their gloves found them invaluable for protecting their raw or water-soaked hands while working in the raft and against sunburn. In several incidents, raft occupants used gloves for socks to shield the tender skin of their feet from sunburn.

FOOTGEAR. Fliers showed the widest choice in their selection of footgear. Because of the likelihood that there would be much walking if they had to come down, and because it was standard and available, most crews wore the government-issue, ankle-high leather shoe. It was a very serviceable shoe and, in contrast to low-cut shoes, less likely to be lost during bailout. In the Pacific theater, the sturdier Marine boot or infantry boot was frequently substituted for the G.I. shoe; both boots and G.I. shoes were unwieldy and inflexible.

Survivors were unanimous in their complaints that high leather boots are too heavy and tend "to hold one down in the water." It was often impossible for swimmers to unlace or unstrap boots, especially in rough seas. Some suggested wearing heavy shoes loose in the aircraft so they could be kicked off more easily, and preferred low shoes for this

reason. Others recommended tying the shoes to the Mae West before entering the water.

The other extreme of choice in shoes was exhibited by men, mostly in the Ferrying and Transport Commands, who favored low shoes or the light, ankle-high "chukker" boot. Some went into battle wearing rubber-soled shoes or moccasins. The selection was in line with the expressed preference for a lightweight but sturdy shoe.

Except in cold weather, survivors usually removed their shoes in the raft during the day if they had socks, and put them on again at night for warmth. They did this partly in the hope of avoiding immersion foot, but many kept their shoes off at all times for fear of chafing a hole through the raft fabric, or so they could swim back more easily if they upset. Shoes were also used for paddling, to bail with, to catch and store rain water, to urinate in, and as bludgeons to drive off sharks. Discipline was enforced on one occasion by the threat of a heavy boot.

G-SUITS. Fighter pilots quickly learned that the G- or antiblackout suit is excellent for increasing buoyancy. The leg bladders when unzippered can be inflated orally through the connecting hose. The suit supported the swimmer in a horizontal position and kept his head above water without the need of continually treading water. To prevent the air from escaping, cloth or the hand were used as a plug. "I decided if I was not picked up that I could use my G-suit and life-jacket for flotation gear and swim to the beach before dawn."

ANTIEXPOSURE SUITS. Antiexposure suits, sometimes called "immersion suits" or "exposure suits" or "survival suits,"were a flier's only guarantee of a reasonable chance for survival in cold waters. The loose-fitting, rubberized coveralls were designed to inclose the outer clothing and keep the wearer dry. In multiplace aircraft the exposure suit could be donned in flight. For greater safety, single-engine pilots were urged to don theirs before flight, but because of heat and discomfort many preferred to carry the suits in the cockpit. Even crews of amphibious planes forced to descend into rough seas asked for the suits: "Exposure suits would have been very helpful since we were taking in seas and all were soaked and cold." Air trapped within the rubber fabric make the exposure suit balloon out when worn in the water. This keeps the survivor from sinking but makes swimming very difficult. Torn or leaky exposure suits are worse than useless. They become waterlogged quickly and make it hard for a man to stay afloat even with a life vest. The weight of the water in the leaky suits impedes rescue operations.

IMPROVISED CLOTHING. The only men able to improvise clothing to any extent were those who managed to save their parachutes. This was not easy after bailout because the water-soaked canopy became so heavy it often had to be abandoned. Crews of single-engine aircraft retained their chutes more often than did multi-engine crews, who from habit left their parachutes in the aircraft. Survivors in cold waters showed less initiative in salvaging chutes than those in warm areas. Some abandoned their chutes because they feared the white canopy would reveal their position to the enemy. When only one chute was available, it was always shared.

All raft occupants, especially those in one-piece coveralls, learned early the necessity of covering ankles, wrists, neck, throat, and face from the sun even when clothed or shielded by paulins or sails. They wrapped strips of chute cloth puttee-fashion around legs, feet, wrists, and forearms, as bandages over the hands, or as a turban around the head, or bandanna-fashion over the head or under the eyes. They draped pieces of chute cloth under their hats (those who had them) and over the neck and face, leaving the eyes exposed. Men with raw or tender hands devised shoemaker's palms tied around the wrist which left the fingers free but covered the upper and lower surfaces of the hands. These devices gave men relief not only from the sun and glare but also from salt sting.

Underclothing devised from chute cloth eased itching, sore buttocks and kept chafed buttocks and thighs from sticking to the hot, tacky rubber fabric. Men with insufficient clothing used parachute cloth as a blanket; a few made togas by cutting slits in the canopy for the head and arms.

Survivors agreed to a man that the parachute was an extremely valuable piece of equipment for raft comfort, especially at night or during squalls. "About 2300 my raft capsized. During the struggle I lost my parachute blanket and I was in misery the rest of the night. It was then that I realized how much warmth the chute had provided."

Rubberized, waterproof navigational charts were used for head coverings or as scarves to protect the neck and throat from drenchings or sunburn. One

survivor cut away the raft seat for greater comfort, and used the rubber fabric to make a long visor which he inserted under his flying helmet. Others used their undershirts for head covering. Even swimmers with most of their bodies under water experienced heat distress and were severely burned by surface glare. They improvised shorts, shirts, trousers, and in one instance a blanket into head coverings to protect their head, neck, throat, face, and especially their eyes.

First Aid Kits

Each aircraft, depending on the type, carried from 1 to 6 aeronautic first aid kits. Smaller medical kits were taped to the shoulder straps of parachutes, and it was not unusual for individuals to add extra first aid items to their personal gear. In addition, all survival kits and liferafts were supposed to contain at least one or more first aid kits, but they were sometimes missing from liferafts. In one incident the survivors were officially notified by a printed pink slip in the right compartment that the kit was *"Not in Stock."*

The size of the medical kit determined its contents, but all contained certain basic items, such as roll or triangular bandages which could also be used for compresses or tourniquets, and adhesive tape or safety pins for fastening them. Morphine tartrate syrettes were scattered throughout all kits. Tannic acid jelly, boric acid ointment, crystalline sulfanilamide, or sulfathiazol, sulfadiazine, atabrine, halazone and salt tablets, iodine applicators, and ammonia inhalants were generally provided. Later, scopolamine seasickness pills, benzedrine sulfate to ward of sleep, and four tubes of a titanium pigment ointment for protection against sunburn were issued to each raft. Most contained a tube of butyn sulfate for eye treatment, and Navy kits also included an eye-dressing package.

In the haste of bailout or the confusion of ditching, rarely were all the available first aid kits recovered. The incident in which six kits were brought together in one raft was exceptional. Men who bailed out with pararafts attached to their parachutes usually retained both the parachute and raft medical kits. In ditchings survivors often abandoned the chute and the aircraft kits. The liferaft kits and other large kits in assemblages of survival gear were the most useful as they contained a larger and more varied supply of medical necessities.

Personnel were, on the whole, well indoctrinated in the contents of the kits and their use, also in methods of resuscitation and improvising splints. However, both first aid training and the first aid kits were developed primarily for the needs of survival on land rather than at sea.

Kits were rarely dry when retrieved—even the plastic "flasks" in which some were packed often sprung and leaked—and once opened could seldom be kept dry on a raft. In one way this was of little consequence because the bandages were just as useful, but wet adhesive wouldn't stick, and all pills, tablets (especially salt tablets), ointments, and lotions soon either dissolved or became water-spoiled. Iodine applicators were frequently broken.

Survivors found use for most of the contents of their kits. Many were glad of the sulfa drugs and bandages, but the various ointments and the morphine received their most appreciative comments. They usually read and obeyed the printed instructions, but as time passed many experimented freely with their medications, and used morphine, sulfa, quinine, iodine, and halazone for purposes other than those they were intended for.

RESCUE EQUIPMENT

Visual Signals

SEA MARKER. Of the many dyes and metallic powders tried out at various times for marking the sea, the most successful proved to be fluorescein, a water-soluble, orange powder. When released in the sea it colors the water orange, with a highly visible, light green, fluorescent cast. A most desirable feature is its fast dispersion power; a half can spreads almost instantaneously into a slick about 150 feet in diameter, which lasts an hour or more in calm weather. Rough seas soon stream it into a long streak, and may disperse it in 20 minutes.

Packed under the nomenclature Sea Marker, it was first issued to liferafts, and shortly afterwards was added to the life vest equipment. One branch of the service issued it as a liquid in a small dispenser like a beer can, but it was more often provided in powder form in cans or packets, of which one or more were issued to each raft, according to size. Survivors commonly called it "slick powder," "sea dye," or "marker dye," and showed great faith in it as a daytime recognition signal.

Its range of visibility is most effective to aircraft at altitudes in excess of 900 feet, and its effectiveness increases with altitude to about 8,000 feet. One man swimming in a calm sea with swells 80 feet between crests was sighted by a search aircraft flying at 1,000 feet and 2 miles away, 3 hours after he had put out the dye. Under normal weather conditions aircraft at 1,000 feet often sighted dye at 5 miles; under optimum conditions dye was spotted 7 miles away from 2,000 feet. The narratives contain many incidents in which dye was spotted several miles away under difficulties. In one, despite a 500-foot ceiling and half-mile visibility in very bad weather, dye was sighted at 2 miles. In another under a 3/10ths cloud cover with a 20-knot surface wind and 8-foot waves, a spotter sighted dye 3 miles away.

Survivors were instructed to save their dye to release under the most favorable conditions, and only when there was some chance of its being seen. In most incidents men broke out the dye immediately after entering the raft, often when there was no evidence of aircraft in the vicinity. This wasteful practice stemmed from a misunderstanding of the dye's properties. Many survivors thought the dye would form a permanent trail behind their rafts which would enable surface ships or aircraft to track them down. "Early in the morning we began to put out marker dye which would streak the ocean a brilliant yellow as we drifted."

The opposite school of thought is exemplified by cautious survivors who did not use their sea marker for fear the waves would dissipate it before it could be seen. Overcaution often resulted in failure, followed by a general lowering of spirits. In one case survivors sighted a search PBM the first day, but held off using their dye "for a good try," and then had to spend 2 more days at sea before they had another chance.

Men habitually wasted sea marker by putting it out in a desperate attempt to contact aircraft flying so high they couldn't be seen. They also wasted it in heavy fogs, during storms with high winds and waves, and in solid overcasts. Under some conditions extenuating circumstances left the survivor little choice. A group of B-29 survivors floating in the sea in Mae Wests had dye as their only means of signaling. "The first three were flying quite high, at about 8,000 feet. We were spotted by the next two, which to me seemed quite remarkable."

In calm water survivors often sped up the dye's dispersion by stirring the water with paddles or hands; swimmers did likewise: "The marker didn't spread very fast, so I swam and kicked it around, which left a good trail." Two men on a raft in the Inland Sea of Japan established their position effectively by drailing dye marker in a figure-of-eight. Once the dye was spread, survivors tried to keep the raft within it by paddling.

Survivors pleaded for a better way of dispensing dye marker. Under most circumstances the escaping powder penetrated clothing, stained hands, face, and hair, and eventually contaminated food and water stores. To avoid the inevitable messiness, some survivors tied their sea marker to the sea anchor, which they reported as "most effective when winds were over 12 knots." Others dipped the packet overside, then let it drain off the gunwales into the sea.

Malfunctions were rare, but the dye containers were sometimes difficult to open. The release tab on the pockets frequently tore off, and the packet had to be cut with a knife or ripped apart with the teeth. Swimmers had to use both hands to open the packet, and even when supported by Mae Wests, were momentarily ducked in their efforts. When the dye packet was carried between the Mae West and the body it was difficult to reach when the vest was inflated. Some complained of "caked" powder which left no mark when dropped in the water. Those aware of the dissipating effects of rapid drift or high winds wanted a solid sea marker in a gauze bag which could be hung over the gunwales.

The principal loss of dye stores came from soaking by the almost constant slopping of waves. In bailing water out of the raft, survivors couldn't help throwing out dye which made an effective but wasteful trail, whether they wished to or not. However, this method of dispensing dye was used purposely to avoid detection by five men in a 7-man raft lying a half mile off enemy installations. "We added dye to the wash in the raft, then dipped it out into the sea at intervals." Their rescuers reported sighting a 'yellow raft with a green bottom."

In many cases liferafts would never have been noticed had it not been for the passive but telltale discolorations of fluorescein. One rescue re-

port states that the search plane was attracted to an "oil slick" from 3,500 feet; closer examination showed the slick to be dye marker with a yellow object in the center, which at 200 feet was seen to be a dinghy with a man in it.

Rescuers were highly impressed by the effectiveness of the marker dye, especially in tropic searches. "How very noticeable in tropical waters green dye is." However, unverified reports of dye were a frequent source of false rumors which led to many needless searches. Oil slicks, patches of seaweed, and changes of light intensity with depth were often mistaken for dye, especially in the tropics. One flight at 1,000 feet sighted a discoloration at 5 miles 'but as there were many shadows on the water that looked similar, we continued on course. At 3 miles we became aware of green dye, but saw no rafts until we noticed a tiny dot which became two 7-man liferafts lashed together, with two men attempting to wave attention with a coat on an oar." In a search incident off Florida the survivors stated that the PBM search crew "could hardly distinguish our sea marker because we looked like a patch of seaweed." Under certain light conditions in an English Channel search the rescuers reported difficulty in maintaining contact with the survivors because of the lack of contrast between the green slick and the sunlit waters.

In rough seas high speed rescue launches and other small craft coursing for reported raft survivors frequently made their first contact by following down a sea marker trail. Lifeguard submarines also often sighted dye marker before seeing the raft. One submarine using a high periscope spotted dye at 2,500 yards; another reported sighting dye in 30- to 40-foot waves.

Sea marker was more easily detected from the decks of larger vessels. A merchant vessel reported spotting a survivor in dye at 1 mile, while a destroyer picked up a man sighted in dye at 4,000 yards. Shipboard personnel maintained it is impossible to identify dye at a distance, and that dye is most effective after the general location of the survivor is determined. Aircraft personnel were equally emphatic in their belief that since it can be seen so much more easily than a raft, the greatest value of dye is its visibility. Both air and surface searchers agreed that a raft, even though painted bright yellow, is a most difficult target to find. Although visible for a short distance in calm water, a man in a lifejacket is practically impossible to spot in a moderate sea. Sighting a man's head in the sea, even when buoyed by a Mae West, was considered hopeless without the aid of dye marker.

MIRRORS. Reflected sunlight was recognized early as an effective means of signaling from rafts. The first mirrors were round or square plates of ferrotype tin which deteriorated rapidly under exposure to salt water. To remedy this, the metal was silvered or chromium-plated and coated with a film of oil or light grease. However, after the protective film was removed, the surface still corroded quickly. Both the round and square early mirrors were unwieldy to aim, though men learned to sight through two fingers held in a V.

About 1943 the metal mirrors were replaced with mirrors of corrosion-resistant, unbreakable, tempered glass. These mirrors, which are rectangular in shape and have a simple peephole or sighting cross in the center, soon became standard Air Corps issue. Shortly afterward the Navy introduced the Learned tempered glass mirror, which had a sighting device for night signaling consisting of a red button on the back which reflected orange-red when a searchlight was flashed on it, and had a tested visibility of 2 miles. The narratives examined give no evidence that this night feature was ever used in a survival situation, though several reported the red sighting button damaged or lost. All glass mirrors bore instructions on the reverse side and were fitted with lanyards that could be looped around the neck. One was placed in each liferaft and later on each Mae West.

Survivors found the peephole-type mirror simple to operate and very accurate with a little practice. The less desirable, older types provoked derrogatory comments, the mildest of which was "Bum mirror!" In spite of the lanyard, mirrors were often lost, which gave rise to the inevitable request to issue more than one to a raft. Most survivors complained that it was difficult to operate any mirror from a rocking raft, and all wished that they had taken the opportunity to practice sighting one. Under optimum conditions, tempered glass mirrors reflect a beam of 7,000,000 candlepower within 90 degrees of the sun and of 4,000,000 candlepower within 130 degrees of the sun. Mirrors are useless at night and ineffective in cloudy, rainy, or overcast weather.

Raft survivors considered the mirror "abso-

lutely necessary" for signaling and "most valuable for tracking rescue." Swimmers voted it "most useful for free-floating men, after dye." In CAVU weather it often made contacts successfully after tracers, flares, and smoke signals had failed. It was effective against sea glare and whitecaps. In report after report rescue craft state how much a flashing mirror helped them find a liferaft on the sea, even when dye was used. The mirror was especially useful for signaling vessels and aircraft homing on the emergency transmitter, and it was often used to maintain contact with orbiting aircraft, especially after dye had been expended or drifted off.

Mirrors attracted ships easily from distances of from 2 to 3 miles and in one instance from 4 to 5 miles. Although aircraft are smaller targets and more difficult to sight on, altitude made it easier for them to see mirror flashes at greater distances. The highest mirror contact recorded was made on two P-51's flying at 16,000 feet. Contacts were made easily at altitudes up to 6,000 feet, and not uncommonly at 10,000 feet from distances of 9 to 15 miles, but only under most favorable weather conditions. One PBM search pilot reported that "the flash of a mirror caught his eye from a distance of 20 miles." Another pilot on a routine transport flight at 10,000 feet was sufficiently annoyed by the light flashed on his face from 9 miles away to investigate its origin.

When flashed accurately and continuously, the mirror signal distracted fighter aircraft during strafing runs on enemy installations, but to attract the attention of aircraft or vessels passing by and not keeping a sharp lookout, survivors sometimes had to flash their mirrors for some time. One man played his mirror for an hour on a passing ship before he succeeded in turning it toward him. A 4-day survival off Natal was terminated when the survivors succeeded in drawing the attention of a Pan-American flight passing at 8,000 feet. According to the pilot's report, when the copilot walked aft during a rest period, one of the passengers, an Army nurse, stopped him to ask what the green discoloration and flickering lights on the water meant!

Survivors without mirrors improvised makeshifts by opening and flattening water and ration tins. In 1952 an RAF pilot who ditched at night in the Gulf of Oman without signal aids contacted a passing aircraft at dawn with his 3-inch-square tin ration box; the rescuer reported a "faint flashing object" and then an "additional series of flashes." Some survivors tried unsuccessfully to use flashlight reflectors as heliographs. After all regular signaling devices failed, the crew of a derelict PBM broke out a spare 2-foot sheet of aluminum and contacted an aircraft which thought the flash was an Aldis lamp signal from a surface ship.

SMOKE SIGNALS. Early in World War II the Army HC white smoke hand grenade was adapted for liferaft use by adding a wingnut clamp for fastening it to an oar or paddle. The grenade burned for 3½ minutes and had to be held to leeward because its zinc chloride smoke is toxic. The two smoke grenades supplied to rafts were replaced late in 1944 by improved smoke hand signals which burned for approximately 18 seconds and were small enough to be carried conveniently in a life vest pocket; eight were issued per raft. These signals burned with a distinctive orange smoke for daytime use and with a red flare for night signaling. The Thirteenth Air Force experimented with a smoke grenade to fit a .45-caliber pistol. When fired, its white phosphorous smoke rose up high enough to be seen from 10 miles.

Smoke signals have the advantage of being usable in cloudy, overcast weather, and even in rain. In one incident, rescuers reported seeing smoke 5 to 8 miles away in a slight haze with seven-tenths overcast through scattered showers which partly screened the rafts from view.

High winds disperse smoke quickly and reduce its effectiveness. Rescuers often complained of the difficulty of recognizing white smoke against a sea of whitecaps. White smoke was found to have a relatively short range of visibility, especially when it streamed low over the water.

Most of the complaints of the HC white smoke grenade centered on its wingnut clamp, which was frequently missing or fitted so loosely that it was easily lost. In some cases the clamp wouldn't fit over the paddle handle, or burned off so the grenade had to be lashed to the paddle. It was often reported unserviceable after wetting, and when operating properly the canister burned with a yellow heat and gave off sparks.

The hand distress smoke signal was better waterproofed and safely held in hand, but men were sometimes unable to remove the top seal to operate it. Its waterproofing was ineffective and was

criticized by both survivors and rescuers. "We picked up one Navy and nine Army aviators. Not one pyrotechnic was in serviceable condition. All were made in cardboard holders and needed only to be dampened to be made useless. It is our opinion that the one thing which aviators need most is a foolproof smoke signal." Four survivors of a B-29 reconnaissance flight in 1952 reported making contact with a passing vessel by waving a sea anchor after "the smoke signals failed."

Smoke signals survivors used at extreme ranges of 25 to 30 miles proved ineffective. Most were sighted at from 6 to 8 miles and rarely from above 1,500 feet, although both the white and orange smoke had a tested visibility range of 10 miles. A DUMBO sighted smoke under the extreme conditions of a rough sea and low overcast at 8 miles. A following PBM reported sighting the same signal but "not until overhead." When overtaken unawares by low, fast-flying aircraft, survivors could not set off a smoke signal in time to be seen, and often were not sighted until the rescue craft approached on another leg of the search pattern. Smoke signals were used occasionally to establish the final contact when the approaching aircraft was seen or heard homing in on the Gibson girl.

Rescuers, especially on ships, regarded smoke signals as the most effective manner of signaling from rafts. "It is clear that smoke or pyrotechnics will attract attention, while dye or similar surface indications will be overlooked."

FLAGGING AND SPLASHING. Although almost all survivors greeted approaching rescue craft by waving clothing or paulins by hand or tied to oars, there is little evidence that flagging was effective for making the primary contact. In some instances it served to verify the presence of life to low-flying search planes; more rarely it served to contact a surface vessel. The farthest sighting reported was a waving yellow poncho spotted by a destroyer 3 to 4 miles away on a very clear day. In this incident the survivor failed to use his mirror.

While the chances of sighting flagging signals at night are remote, they led successfully to two night rescues. After a bailout landing, one of a crew of 11 kept his chute open. When a destroyer swung its searchlight in his direction, he let the chute billow out and was the first of the eight survivors to be picked up. A submarine on night patrol sighted a survivor's sail of chute-cloth as he drifted asleep in the moon's path.

Flagging was often the only way survivors could attract amphibian aircraft after they landed on the water. There are innumerable cases of taxiing aircraft unable to close in on the survivor because of high waves. Engine noises make shouting useless. "We landed in 18 foot swells and could not see the raft. We spotted the men only when one held up an oar." Even greater difficulty was encountered in picking up swimmers, many of whom feared that their rescuers would give up before sighting them again.

Letter signals made from cut strips of cloth were impractical on rafts. However, one survivor used this method for air contact from an ice floe. Another pilot in a dinghy failed to attract rescuers with sea marker dye when three aircraft flew by him at 0715, then at 0900 flashed his mirror unsuccessfully at a B-29 low over the water. Finally, after firing his flares, he landed near a native village, and next morning decoyed an aircraft over the beach by using the native children to spell out "OK."

Splashing was usually accidental, but whether intentional or not, it served on several occasions when the sea was calm to attract attention from the air. When one survivor stood up to wave his paulin at a passing aircraft, he lost his balance and fell overboard. The splash he made was duly logged as the recognition signal. The sole survivor of a B-29 ditching was sighted by his splashing as he tried to board his raft. Another rescue crew reported their attention was drawn to a group of swimmers, who were unaware of the aircraft, not by their plainly visible sea marker but by their splashing as they thrashed the water white to keep off sharks. Eleven days of hardship for three survivors with no signal devices was ended by a dragging lifejacket they had streamed overboard some days before as a "navigational aid." The crew of a plane on submarine patrol detected the small white wake from 1,800 feet and thought it was a periscope plume. Not until they had dropped much lower did they recognize the raft and three men.

FLASHLIGHTS AND LIGHTERS. Except for a hand-energized, waterproof flashlight subsequently withdrawn from regular issue, all issue flashlights were battery-operated. The commonest in use was a small 1-cell lamp originally issued with a safety

pin for attachment. These lights were so frequently torn, jerked, or scraped loose when men left the aircraft that 3 feet of cotton lanyard were added as an additional safeguard. Later, liferafts were supplied with 1-cell floating lights, and 2-cell lights were added to the drop kits. Some survivors also carried commercial flashlights, of which the most popular was the clip-pencil type. Commercial flashlights were not waterproof, and most survivors found them useless after the first ducking.

Because of many unhappy experiences with them, most survivors had a low opinion of flashlights. Even waterproofed batteries were corroded, shorted, or exhausted by high humidity in storage. Pilferage was a common complaint. "Four of our six flashlights had no batteries, and yet we inspected them only 2 days previous to our ditching."

Nevertheless the Mae West lights enabled many crews to come together in the darkness, and raft lights guided surface ships to a number of rafts. Although 1-cell lights were supposedly visible for 2 miles, the farthest sighting reported was 1 mile. "There was some kind of a boat [a standby crash boat] a few miles away. I blew my whistle but never could attract their attention either by my whistle or flashlight." In most cases flashlights were first seen at between 100 and 200 yards.

Passing ships sometimes failed to recognize survivors' lights. "The destroyer personnel observed the light but thought it a reflection from the moon." Another survivor skirted offshore breakers, headed seaward, and sent blinker code to a cruiser which refused to approach for fear that it was being decoyed by a Jap suicide boat. A destroyer showed the same hesitancy, but the survivor finally convinced an LCI which held him in its spotlight for closer scrutiny.

Although pencil flashlights were relatively useless, they were used in some incidents to signal successfully up to about 200 yards. One survivor who had thoughtfully disassembled and separately rewrapped the parts of his pen light as insurance against wetting contacted a passing ship by holding the bulb to the battery in his hand. Ripley's *Believe It or Not* exaggerated this incident into: "A midget light no larger than a walnut, yet so powerful that it projects a beam of light visible for 60 miles, is now equipment for liferafts."

Cigarette lighters are at best last ditch devices for signaling, but men frequently reported trying to contact both surface ships and aircraft with them. The only success reported was by a crew that had bailed out over the South American jungle and floated down a river for 8 days. On the last night they encountered the monthly river steamer charging around a bend. The clanging engine drowned their shouts. In desperation one man pulled out his cigarette lighter, which responded on the first snap.

TRACER SIGNALS. Cartridge ball tracer ammunition for signaling was available in .38 and .45 calibers. Survivors described the .45-caliber tracers, which were marked with a slight cross indented on a red painted nose, as "orange red, about the size of golf balls." According to specification these tracers have a range of 1,300 feet, but most survivors estimated their maximum range at about 400 feet. Some remarked they were invisible in daylight, while others reported them "easily visible by day."

Fliers were so partial to tracer signals that some of them carried excess amounts which they had to jettison the moment they hit the water. One glider pilot understandably found it difficult to pull himself out of the water, even with assistance, with some 300 rounds of .45 tracers on his person.

No defects in tracer were reported. A few pilots failed inexplicably to use the tracers in their possession. Others had their tracers mixed with other ammunition, which made their signals erratic. Most complaints involved weapon malfunctions. The .45 automatic frequently jammed, while the cylinder barrel of the .38 revolver sometimes swung open. "I then drew out my .38 which had five rounds in the chamber. I had fired three rounds at ships 200 yards astern when the revolving chamber swung open and the remaining two rounds slipped into the water." The destroyer report affirmed that the tracers helped them get a fix on this survivor.

Most tracer contacts were made between survivors, especially swimmers, and surface ships at distances between 400 and 1,000 yards. Survivors frequently fired at low-flying aircraft, but there is no evidence they ever succeeded in attracting their attention by this means. In two incidents fighter pilots showed survivors the position of drop kits and rafts on the water by firing pistol tracers in the desired direction.

FLARES. The most common hand-held pyrotechnic signal for use by water survivors was a 6-

inch flare which fired two stars about 50 feet into the air. A later model shot two stars about 100 feet high. Their effective visibility in daylight was estimated at about 3 miles, at night a maximum of 12 to 15 miles. The later Mae Wests were fitted with two of these flares; rafts generally had four to six, depending on the type.

Most survivors expressed a desire for longer burning signals. They often stated that the hand-held flare was of doubtful value in daylight, and all found it easily water-damaged. The greatest source of trouble was age, which could have been avoided by proper inspection. Outdated pyrotechnics were not dependable; they had ignition difficulties and reduced burning periods. Swimmers had trouble using their hands to operate the signal, and frequently added the comment "inadequate." "I inflated the Mae West orally, took out a flare and jerked one end, but it would not work. I took hold of the other end, pulled the ring down, cracked the seal, rolled it off, gave a pull and the wire broke." In cold weather survivors found it almost impossible to peel off the protective tape with numbed fingers.

The practice recommended for night signaling at first was to fire flares at set intervals, but only those who ditched near surface ships did so as a rule. Most survivors hoarded their flares until they heard or sighted aircraft or surface vessels. Rescuers emphasized that flares fired at an angle are not as effective as those fired straight up. One survivor noted: "I fired the flare into the wind. Don't do this, as the flare came blowing back down almost into the raft." Aircraft were successfully contacted by flares in daylight at altitudes of 1,600 feet and approximately a half mile away.

In 1953 a downed pilot contacted a helicopter in heavy fog when only the undercarriage was visible by firing a hand-held flare. Successful night contacts were made with aircraft flying at 5,000 feet and 2 to 3 miles distant. Surface contacts at night under clear conditions were made easily with vessels up to 8 miles away.

VERY SIGNALS. Most raft supplies included either a Very pistol or a more compact hand percussion pyrotechnic projector for firing a distress shell at first 75, later 200 feet into the air. The distress signals resemble 10-gage shotgun shells and fire a 7-second red light visible at sea an estimated 8 miles. Pilots frequently removed the pistol carried in aircraft cockpits for use in rafts; they usually thrust it under their jackets or into the leg pockets of their flight suits, and not infrequently lost it.

Survivors regarded the Very signal as the "best visual signal to determine a man's position." Nevertheless they reported it as "not very effective in daylight" and thought its night efficiency would be increased if it could be fired 200 to 300 feet higher and would burn for at least 10 seconds.

In rough seas swimmers found the hand percussion projector almost impossible to operate; the pistol grip type gave less trouble. Failure to realize that the signal pistol can be loaded or unloaded while at halfcock gave survivors anxious moments and many reported that the pistol trigger would not pull. "I had some trouble with the safety on my Very pistol as I never fired it before." In some instances the projectile did not clear the barrel. "When Smith fired a flare the shell was not projected but burned in the barrel. Smith held it up. We were seen and picked up."

Very stars were identified at night by aircraft 2 to 3 miles away, but most aircraft contacts were made at shorter distances. "I'd say that a pilot in a raft shouldn't fire his Very stars until a plane is close enough so that he can see its lights. At least I figured I fired most of mine too soon." General Twining, using the Very pistol retrieved from his aircraft, purposely held off firing his first signal during a day attempt until the search craft came directly overhead. Then he fired three shells in quick succession in front, at the side, and finally at the rear of the aircraft. The last shot was seen, but the search plane subsequently lost contact in a squall. The same procedure with another search plane later in the day brought about rescue.

Very lights were used more successfully to contact surface vessels at night. A number of sightings were reported from 5 to 10 miles away. A submarine sighted a Very star 18 miles off and picked up the survivor. One man reported using his Very star on a destroyer "at a great distance; I chose the moment when their searchlight was turned toward us to make certain we would be seen."

MISCELLANEOUS. One of the most unusual ways in which one survivor contacted rescuers was with a sonobuoy. The pilot was unable to orient himself after a night carrier takeoff and flew into the water. A sonobuoy broke loose from the bombrack and came to the surface. The signal it emitted was picked up by a plane overhead

which relayed the information to the carrier. The carrier checked all airborne aircraft, found that one would not answer, and ordered the escorting destroyer to search near the sonobuoy, where it recovered the 3-man crew.

The yellow kite or white balloon used in raising the antenna of the Gibson girl occasionally brought about rescue. In one instance a ship sighted the balloon 10 miles away.

Carrier pigeons were used, primarily by the RAF, to relay distress signals, usually the estimated position after a ditching. They never achieved much success. Although in a few rare cases reports carried by pigeons did initiate successful searches, there was a general lack of enthusiasm for their services. One search was ended when the observer of a search plane caught "the glint of sun on one of the pigeon containers." The pigeons, released previously, had failed to arrive at their lofts.

The Air Corps attempted to use pigeons for carrying emergency and rescue messages in the Caribbean area. However, this was soon discontinued because the crews had little confidence in the pigeons, often refused to accept them, and frequently failed to use them when in distress.

Audio Signals

SHOUTS AND WHISTLES. Though sounds carry far over water under ideal conditions, they are easily distorted and deadened by the wind. Shouting and whistle signals were effective in summoning rescue only at comparatively short ranges. Most contacts by these means were made at less than 200 yards. A few reports claim success at ranges up to a mile, the longest being the narrative of a group drifting off the Irish Coast, whose spokesman said: "The next day I learned that the patrolman along the beach had heard my whistle from a distance of around 6 miles by water and 11 miles by land. The strong wind blowing toward him had helped and yet it seemed impossible that any of us could have mustered enough strength to make ourselves heard more than 2 feet."

Shouting at the right moment saved many men who would otherwise not have been noticed in the water. "He landed one-half mile from the submarine in a life vest. The BLUEFISH sailed past at full speed about 100 yards from him. Despite eight lookouts on the bridge, he was spotted only when his shouts attracted their attention." Shouting, however, is exhausting, and few men can make their voices heard as far as they can make the blast of a whistle carry with far less exertion.

The whistles in liferaft kits and attached to life vests saved many lives. They were of greatest value when the visibility was bad, as at night or in a heavy fog, and in well frequented waters such as the English Channel and the North Sea where the fishing boat and convoy traffic was usually heavy. They were used less in the compartively lonely Pacific, though carrier pilots found them invaluable when they ditched at night in the midst of a task force.

Comments on the whistle varied with the survivor's success in signaling with it. Men whom it failed were quick to discount its value, as did two survivors who managed to contact a distant submarine with a flare at 0100. The vessel passed close by them in the darkness without seeing or hearing them, though both men shouted and blew their whistles. Another survivor, trying to ride out 20-foot waves in a 30-knot gale, failed to clear the water out of his whistle in time to signal a destroyer going by 400 yards to leeward of him.

Those who succeeded in making themselves heard were loud in their praises of the whistle. One man credits it as his salvation when he was heard and rescued in a heavy fog. Another pilot was being passed by a destroyer at dawn when a blast from his whistle was heard on board and the vessel came about and picked him up.

Electronic Devices

Survivors were keenly aware of the value of electronic devices as rescue aids, yet in the 546 incidents cited in Table 3 (page 41), only 2 percent of the items listed as contributing most to rescue involved electronic communications. Table 4 (page 42) credits electronic devices with only 12 percent of the contacts in 136 search incidents.

The most common method was direct air to ground transmission on appropriate VHF channels with station ships, lifeguard submarines, rescue aircraft, or land communication centers. Voice communication between airborne aircraft, especially fighter aircraft, was a frequent means of reporting an emergency. Voice radio assisted accompanying aircraft to orbit over the ditching position while relaying the location to assisting craft, and to direct surface rescuers to survivors

when sea conditions lowered surface visibility. Tactical aircraft had prescribed emergency channels and also used the common Mayday code over the 500 kilocycle International Distress channel.

Emergency Identification Friend or Foe (IFF) equipment proved especially valuable in locating missing aircraft. The importance of radio homing devices is emphasized by the fact that missing aircraft in 93 incidents were located by radio search from direction finder stations.

Electronic devices were valued because they were operative during periods of bad visibility in overcasts, heavy fogs, or at night. They were most useful when they provided a definite fix, and when there was no time lapse between the established fix and final ditching or bailout. Search efforts were seriously compromised when aircraft continued in flight before ditching. It was not unusual for a communication center to receive half a dozen positions, or for reported positions to be 15 to 70 miles in error. In one unusual situation the crew of a B-17 with a disabled communications system used the emergency raft transmitter to send out a series of distress calls while still airborne. As they flew some distance beyond the last fix they reported, and then left the emergency radio transmitter in the aircraft when they ditched, the survivors were lucky indeed to be found.

THE GIBSON GIRL. Throughout World War II the standard electronic device for transmitting distress calls from a liferaft was the radio transmitter nicknamed the Victory or, more popularly, the Gibson girl. This hand-cranked set was designed to transmit code automatically or manually and to light a lamp for night signaling. It operated only on 500 kilocycles with a 1000-cycle tone modulation, the international distress frequency guarded by vessels, aircraft, and shore stations. It had a maximum range of 300 miles at sea, depending on atmospheric conditions. Using less than the entire 300 feet of antenna reduced the transmitting range correspondingly. When the signals were strong enough cross bearings could be coordinated to fix the position of the distress radio, and rescue craft equipped with RDF could home on them.

The transmitter would not operate unless the antenna was raised, either by means of a collapsible box kite or a balloon. The box kite could not be flown in winds below 7 mph. The balloon was lifted with hydrogen gas produced by immersing a chemical generator in the sea. The transmitter was portable, weighed about 40 pounds, was packed in a waterproof, buoyant container, and was issued to all aircraft on overwater flights except fighters. Sets were dropped to survivors by means of a small chute.

About 1945 the range of the Gibson girl was increased to a maximum of 1,500 miles by using the long range H/F transmitting wavelength of 8280 kilocycles. RDF homing could be done only on the 500 kilocycle frequency, and a mechanism automatically switched the operating frequency from 8280 to 500 kilocycles every 40 seconds.

Success and Failure. The first rescue of a downed aircraft crew brought about by an emergency raft radio was made off the British Coast in May 1943. By July the Gibson Girl had effected eight more rescues. Although the British model was the prototype, American crews used American-made equipment with consistently greater success.

The limited range of the early Gibson girl was ample for the restricted waters of the North Sea and English Channel, for the network of communication centers concentrated on the adjoining shores assured efficient monitoring and quick reporting of distress signals and bearings. Air traffic was so heavy that distress signals were often reported by aircraft; in one instance 21 aircraft reported strong signals from a distress radio 80 miles away. Distress signals were also relayed by the spotter aircraft which regularly patrolled the sea lanes. Most transmissions were received at short distances, rarely more than 200 miles.

Somewhat similar conditions prevailed in the Caribbean and Mediterranean Seas, but in the Atlantic and Pacific Oceans the Gibson girl did not give as good results. As officially stated in January 1945: "There is an apparent inconsistency in the reports on use of the Gibson girl in the Pacific Area as compared with its record in the European and Mediterranean Theatres." As time went on it became apparent that, among other things, the radio transmitter was not being fully utilized. Some survivors in the Pacific refrained from using it for fear of attracting Jap planes, but the evidence shows many other reasons for the failure, chief among which were improper stowage, inadequate training or briefing, and lack of ditching drill.

Stowage. Because the Gibson girl was carried loose in aircraft, it was frequently overlooked

during ditching, especially at night. In transport aircraft it was often impossible to find when stowed improperly or mixed with the general cargo. Tactical crews left it behind for no apparent reason. The British Air/Sea Rescue Service estimated that only about 5 percent of the downed crews took them into the raft with them. American surveys from various theaters were almost as low. In 16 B-24 ditchings the Gibson girl was retrieved in only 6; only 2 of these sets were used, and 1 was lost before it could be put to use. In 85 B-17 survival incidents, only 9 crews took the radio from the aircraft. In 10 B-25 ditchings, Gibson girls were taken out in only 3. Random study of the narratives reveals many emergencies in which aircrews unknowingly jettisoned their radio equipment. Often they threw it hurriedly into the water, and it drifted off before they could recover it.

Malfunctions. Raising the antenna with the box kite gave rise to many complaints. Lack of wind was the chief cause of failure, but men had difficulties even when wind force was above 7 mph. "The antenna wire could not be flown even in the 10 mph wind." Some of the difficulty arose from the limited space within the liferaft, which was sometimes overcome by using two rafts. Even under suitable wind conditions most survivors had difficulty raising the kite more than 50 feet, and rarely were able to make it reach the prescribed 300 feet. By tying an inflated balloon to the kite a few managed to raise the antenna to about 120 feet. In winds above 15 knots the kite often broke loose. After repeated dunkings, the kite became waterlogged, unwieldy, and useless.

The erratic motion of the raft in rough seas made generating gas for the balloon difficult. Many survivors reported that they had to expend two generators to make enough hydrogen to lift one balloon. "We tried to get the balloons to fill up but the stuff when placed in the water would not give off gas to fill the balloons." Failure to comply with the gas generating instructions led to accidents. "When we thought the balloon was big enough, the navigator plugged up the canister to conserve the gas. In a short time it blew up, showering everybody with glass." When the balloon was improperly inflated "it would not lift clear of the water but kept bouncing back." Properly inflated balloons were frequently forced down by high winds.

Another source of trouble was "seizing" or binding of the crank handle, which was reported to occur in various instances after about 1 hour of operation. The failure was usually preceded by a lowering of the power output, indicated by the dimming of the neon pilot light. Some survivors abandoned their sets as inoperative when the pilot light failed to glow, usually because the crank-handle was turned too slowly. One account gave a backache from cranking as the reason for abandoning the Gibson girl, and in many cases seasickness, wounds, and exhaustion prevented men from operating it properly.

The night signal lamp run on the current generated by the set was normally worn on the head, miner's style. It made primary contacts with surface vessels in several incidents, and was used successfully in a few cases with search aircraft at night. The headlight cord was a source of annoyance because it easily fouled around the arm while cranking. Undoubtedly transmission was ineffective in many instances because of structural defects. The most common was shorting when the mechanism became wet. One group of survivors reported that they used their Gibson girl for 8 days, but were finally sighted by a chance B-24 attracted by a flare.

Homing. Despite the shortcomings of the Gibson girl, survivors had great faith in it. In one 1945 incident, the survivors succeeded after many trials in raising the antenna and operating the set, an SCR 578-B. Fourteen stations obtained bearings on the signal at distances of 600 to 870 miles and, although the distress call was improperly spaced, interpreted the V7 signal correctly as an SOS.

A downed PBM-5 crew had trouble raising the antenna, but finally 4 hours after ditching managed to send out a signal which was received about 250 miles away. The rescue plane homed in easily on the strong, continuous signal from 150 miles, sighted smoke at 6 to 8 miles, dye at 2 miles, and picked up the survivors successfully 10 hours after they ditched. In another search the rescue aircraft left its base without knowing the exact location of the survivors. It picked up the SOS 203 miles away at 800 feet altitude, and finally secured a bearing at 157 miles, 5 hours after setting out.

Surface ships frequently received distress calls but were unable to determine their origin without proper RDF equipment. An American destroyer

in this predicament relayed the distress signal to a land base and received the last known position reported by the aircraft, which enabled it to locate the survivors 9 hours after their ditching.

RADAR AIDS. To facilitate air search, and especially to provide 1-man rafts with some means for electronic detection, the Services began to investigate radar.

Walter. The first device was a portable battery-operated set called Walter, originally designed by the British for use on 1-man rafts. A modified version was adopted by the Air Force, which operated on 176 megacycles with a battery life of 18 hours. The device was triggered by the ASE radar set and had a tested surface range of 5 to 6 miles and up to 20 miles with airborne detection equipment. Walter was distributed in 1945 in relatively limited quantities, and there are no references to it in the narratives examined.

Target. A second radar aid device was added to both Air Corps and Navy survival equipment early in 1945. The basic model adopted by both branches of the Service bore the nomenclature Radar Reflector Target, but survivors referred to it as the Corner Reflector Target, Corner Radar Reflector, Corner, Target, or "Emily." Target was a lightweight, collapsible device of wire mesh and rods made of monel metal to resist salt water corrosion. It opened like an umbrella into three reflecting planes intersecting at right angles to deflect radar energy, which, when intercepted by appropriate receiving equipment, registered a blip. It had a tested range of from 2 to 18 miles. Two types were available, one for single-place rafts and one for multiplace rafts.

The first use of a Target Reflector noted in the narratives occurred in the Pacific in May 1945, when a PBM-5 on routine flight picked up an unknown blip at 4 miles 3½ hours after the survivor took to his liferaft. In June 1945 a similar radar signal was received by a search DUMBO at 3 miles, but the radar operator did not recognize it. As the aircraft continued on course the survivor had to use a mirror to effect his rescue.

An official report from the Pacific Theater in October states: "Very few Corner Reflectors have been seen in this area." Again, "Corner Reflectors are seldom used although the value of this equipment is well proved." In another rescue report the first contact was made by a flare sighted at 20 miles, then confirmed by Corner blip at 8 miles. A B-29 crew was rescued by a surface vessel directed by a Navy search plane which first intercepted their Corner signal 10 miles away at 1,000 feet altitude.

The mast height of most surface vessels limited their radar search to about 5 miles; a few had a range of 8 to 10 miles. The farthest radar contact made by a submarine was 2 miles; the visibility was poor, and though the survivors in an airborne lifeboat fired some 40 flares, the pickup submarine succeeded in locating them only by obtaining a radar fix on the DUMBO orbiting 200 feet above them; even then the submarine crew did not see the survivors until they were within about 500 yards of them.

The assembly of the Target always gave some trouble; many found it impossible to rig the device at night. "I worked with the screen for about an hour but had difficulty in erecting the reflector properly in the darkness. I finally got one triangle stretched out and kept it rotating over my head until I was tired." Apparently survivors often held the target in their hands; one reported holding his screen up for 7 hours. During high winds men were sometimes forced to take down the device for fear it would blow away.

Survivors quickly recognized the limitations of the Radar Reflector Target. Many suggested incorporating a radar "window" in the Gibson girl balloon to increase the range of radar search, and one man tried attaching an aluminum oar blade to the Gibson girl box kite to act as a radar reflector.

AIRDROP EQUIPMENT

From the beginning of World War II it was apparent to units operating over water that it was essential to provide immediate emergency assistance to their downed crews. The most direct and obvious method was by airdrop. Before airdrop kits became standardized, units developed a series of kits made locally from readily obtainable materials and containing basic items survivors might need until rescue was assured.

The 8th Air Force obtained a number of ideas from the drop kits developed by the RAF, and modified several of the British devices to meet American needs. The Thornaby Bag and the Bircham Barrel were essentially containers for free-fall drops of food, water, and first aid and

signal equipment. The more elaborate Lysander Rescue Outfit and Lindholme Gear consisted of series of containers dropped in train and connected by floating ropes. The two latter kits included a large raft which automatically inflated on impact, greater supplies of food, water, and other survival gear, and warm clothing essential for cold water survival. Another valuable contribution by British Air/Sea Rescue was the airborne lifeboat, propelled by twin engines or sails, and containing substantially larger stores of food, water, and other emergency equipment. The airborne lifeboat was carried by specially modified heavy bombers and dropped by parachute. By 1942 the airborne lifeboat was in operational use in the European Theater. The first United States aircrew was successfully rescued by a British designed and dropped airborne lifeboat in July 1943.

Because of the close coordination and overlapping air and sea activities in the Pacific Theater, Navy and Air Corps survivors had access to airdrop kits developed by each of the Services. The standard Air Force kit, the E-11, was an emergency sustenance kit with food, water, first aid and signal equipment sufficient for six men; it was designed for parachute drop. The three types of Navy Shipwreck Kits were basically similar; in addition the Navy had separate ration and signal kits. To meet the particular needs of carrier operations, the Navy developed Multiple Assembly Kits consisting of a raft and shipwreck kits dropped in train from modified TBF or TBM aircraft. The most elaborate was the AR-10, a 275-pound, 10-man pneumatic raft, with 60 pounds of fuel and two 88-pound shipwreck kits. A 225-pound, 9-horsepower outboard motor and a simple mainsail were provided for power.

The Navy AR-10 and the Air Force lifeboat were found to be the best solution to long overwater and cold water survivals. Although the American airborne lifeboat was not put into operation until the middle of 1945, it was used extensively as rescue support for B-29 overwater bombing missions from Pacific bases against Japan.

Airdrop Kits

Fighter crews who sighted survivors often made impromptu airdrops of liferafts, emergency and personal kits to help them. Although they usually dropped much more than the survivors needed, little of it was recoverable. Most of the gear thrown out on the spur of the moment was not intended for use in water drops, and much of it was broken by the impact or spoiled by salt water. Rafts were often unusable because of lost CO_2 bottles, shattered fittings, or ripped fabric. Hand pumps were frequently crushed, and stored accessories broke loose and sank. It was not uncommon for survivors to receive six or more raft drops and yet be without a liferaft. Air and surface search crews repeatedly complained of their inability to determine the number of men involved in a survival when the sea was littered with airdrops.

Survivors recovered drops only with great effort. "Rafts fell near us but we made no attempt to secure them because of the heavy sea." Survivors in rafts usually recovered downwind drops more easily than upwind ones. One group of British survivors recorded that it took them 5 hours to reach Lindholme Gear dropped 1,000 yards away from them. Survivors repeatedly suggested that "when dropping equipment, try to hit the raft. Chances are you will not actually strike it." Swimmers experienced the greatest difficulty; from their low position in the water they were often unable to see supplies floating near them.

Airborne Lifeboats

The 15 incidents analyzed here represent a very small sample of the airborne lifeboat's actual use, but are the only adequately detailed accounts available. Eight of them concern the Air Force A-1 model, six the British MK-1, and one the Navy AR-10. The principal difficulties encountered by survivors in the first two types are given in condensed form in Tables 1 and 2. As Table 2 is based on the reports of the first six operational drops of the MK-1, its later performance cannot be judged thereby.

THE DROP. Improper launching of airborne lifeboats decreased their usefulness. Lifeboats dropped upwind or too far from the survivors were difficult and even impossible to reach. Although the MK-1 and A-1 were designed to be self-righting and self-bailing, the engines and stores were often flooded. Airborne lifeboats dropped at proper altitudes with full parachutes suffered less damage than the AR-10 which was dropped free. Only one lifeboat was reported damaged in landing, but the waterproof cover of

TABLE 1

SURVIVOR REPORTS ON AMERICAN AIRBORNE LIFEBOAT, TYPE A–1

Drop	*Boarding and Operating*	*Equipment*	*Success*
1. No comment.	Air-cooled engine hard to start. Air-cooled engine overheats.	Adequate.	Dutch pilot rescued 50 miles later by surface vessel.
2. 150 yards short; mechanism to actuate life rings and sea anchors failed.	No data.	No data.	A–1 lost. (1-man drop.)
3. Keel split, centerboard and propeller shaft damaged.	Impossible to start engine; set up mast with difficulty.	Food and water used.	A–1 used. Group picked up by surface vessel.
4. Satisfactory	Took ½ hour to climb in overside; injured man could not start engine.	Water, first aid kit used.	A–1 used; 6-man group picked up by surface vessel.
5. Clearing chute from lifeboat exhausting work.	Could make no headway from enemy shore with engine; inexperience with sails rendered them useless.	Food and water used.	A–1 used; 8-man group picked up by surface vessel.
6. Satisfactory.	Unable to operate; seasick; native swam from shore and paddled boat in.	No comment.	A–1 used; group reached shore.
7. Clearing chute from lifeboat exhausting work.	Engine started; could not operate the still.	Could not find fresh water.	A–1 used; group rescued by surface vessel.
8. Drifted off at angle.	2½ hours to board; engines hard to start; used sea anchor at night; did not use Gibson girl for fear of Jap planes homing in; contacted DUMBO at daybreak on transmitter.	Welcomed change into dry clothing; Used food, water, first aid and signal equipment.	A–1 used. Group of 11 picked up 24 hours later by submarine.

the AR-10 was split, and the drive shaft and operation levers of its outboard were bent.

Survivors complained most frequently of the failure of the automatic mechanisms to shoot out lifelines and sea anchors or to release the parachutes. Survivors who neglected to clear these lines before starting the engines invariably fouled the propellors. Dropping a lifeboat to a single survivor whom a large raft would have served equally well sometimes deprived large groups of the airborne lifeboats.

BOARDING AND OPERATING. Boarding lifeboats was more difficult from the water than from liferafts, especially for the injured or exhausted. For the latter the tasks of clearing lines and starting balky engines was slow, hard work. It took great effort to turn over an outboard motor which had not been run in months, especially if it was water-soaked. Though the protected stationary engines of the airborne lifeboat were an improvement, the rescue services still felt and stated officially: "There is need for a reliable, droppable lifeboat with engines that are positive."

Although some crews attempted to keep their craft shipshape, few realized that an orderly boat is easier to handle and that work is a strong antidote to boredom. One reason for this was that few survivors had any experience in handling small boats. Men found stepping the mast and setting sail a problem. Handling sail was also strange, and in many instances survivors used both engines and sails when sails alone would have served and saved fuel for later emergencies. Men inexperienced in sailing found it difficult to hold a set course, to come about, to steer in following seas, or to reef. Yet several whose sails or sea anchors carried away improvised serviceable jury rigs from oars, clothes, and other available gear to hold the bow into the waves and keep the lifeboat from broaching.

Men who did not keep things shipshape allowed loose clothing to wash out over the deck, which blocked sluices and cancelled the lifeboat's self-bailing feature. They lost stores or subjected them to water damage by failing to reseal hatches after taking out supplies. Crews who tried to sail at night instead of laying to a sea anchor until daylight always had trouble. Equipment was more likely to be lost or damaged at night, especially when men were unfamiliar with it.

TABLE 2

SURVIVOR REPORTS ON BRITISH AIRBORNE LIFEBOAT, MK–1

Drop	*Boarding and Operating*	*Equipment*	*Success*
1. Forward self-righting chamber not inflated; drogue and line rockets failed.	Injured laid on uninflated chamber concealing forward hatch; rudder difficult to ship; mast difficult to set up; pin sheared, propellor lost; engines useless; hatches left open underway.	Instruction manual overlooked.	1st operational use; by British crew; rescued by surface vessel in 10 hours. May 1943.
2. Self-righting chambers failed to inflate; drogue, line rockets and chute releases failed; landed 20 yards upwind.	Ship underway in 20 minutes; plugs changed once.	Read instruction manual aloud.	British crew rescued by surface vessel in 5 hours. July 1943.
3. Chambers, line and drogue rockets, and automatic chute releases functioned.	Engine flooded; instructions illegible; engine never used; stepping mast difficult; no use found for patent log.	Read instruction manual individually; donned waterproof jackets; smoked cigarettes, ate chocolate.	American B–17 crew rescued by surface vessel in 5 hours. July 1943.
4. Chambers, line and drogue rockets, and automatic chute releases functioned.	Engines difficult to start, overheated due to poor water circulation; tiller damaged in heavy seas.	Read instruction manual and engine starting directions; used rations; water tins damaged.	American B–17 crew rescued by surface vessel in 12 hours. July 1943.
5. Chambers, line and drogue rockets, and automatic chute releases functioned.	Ship underway quickly.	Read instruction manual and engine starting directions; clothing supply short; ate food; needed no water.	American crew rescued by surface vessel in 20 hours. Traveled 100 miles. July 1943.
6. Chambers, line and drogue rockets, and automatic chute releases functioned.	Rudder shipped with difficulty; mast stepped easily; engines started quickly. In storm, hatches left open, tiller carried away, boat brought about by additional drogue of mast and mainsail; lost drogues and engine power; offset starboard list by flooding port hatches; pumped dry in 6 hours; then used log and waterproof suit for drogue.	Read instruction manual; clothing and first aid kit watersoaked; waterproof clothing leaked. Rationed to 1 tin of milk, 1 tin of water, and 9 Horlick tablets per day per man.	British crew rescued by surface vessel in 65 hours. July 1943.

One group of survivors reported making 122 miles in 3 days in their airborne lifeboat. Most were picked up within 100 miles by surface vessels. Radio contact was extremely important: "The boat's color made it very difficult to see us. I believe it would be purely accidental if such a boat were spotted without knowing where to look."

EQUIPMENT. In most incidents the first item of equipment searched for and used by survivors was the "book of words." The instruction booklet in each airborne lifeboat showed where the equipment was stowed and how to operate it. This was important because in many cases survivors had no previous familiarity with lifeboat gear. The majority started engines, set sails, and made an inventory of the stores 'by the book."

In cold water areas the tinned condensed milk proved to be the most popular food item; in warm areas survivors showed more concern for water. In one narrative the survivors suggested that the fresh water supplies should be more prominently labeled for immediate availability.

SURVIVOR ANALYSIS AND COMMENTS

The experiences of survivors during the Korean outbreak revealed difficulties highly reminiscent of the troubles reported by World War II survivors. The general pattern of survivor reaction was similar to that shown by survivors in the ETO. However, water recoveries in Korea were often made minutes after the emergency was reported and rarely more than 48 hours later because of the efficiency of Air-Sea Rescue opera-

tions and the wide use of helicopters and SA-16 aircraft.

Because rescue marked the end of uncertainty and their release from hardship, survivors tended to stress this phase of survival rather than the earlier ones. Open ocean survivors measured their chances for recovery entirely by their success in signaling. "In flying over water, emphasis should be put on signaling devices and not on survival gear such as food and water." But the difference between life and death was often stated simply in terms of a flare, a piece of string, or a handful of malted milk tablets.

To appraise survivor opinion of survival and rescue equipment, 546 Air-Sea Rescue Reports (Form Navaer-1941) covering the 1945 rescue operations in the Pacific between 15° and 35° North Latitude were analyzed. The resulting data are listed in Table 3.

TABLE 3

SURVIVOR EVALUATION OF ITEMS
(based on 546 Incidents)*

Column A — CONTRIBUTING MOST TO SURVIVAL		Column B — CONTRIBUTING MOST TO RESCUE	
Item	*Number of Incidents*	*Item*	*Number of Incidents*
Mae West	287 F	Stand-by Ship	209 V/A
Raft	212 F	Sea Marker Dye	100 V/A
Swimming	13 F	Orbiting Aircraft	46 V/A
Parachute	13	DUMBO Pick-Up	35 V/A
Rations	8	Mirror Signals	34 V/A
Aircraft	4 F	Smoke Signals	25 V/A
Shoulder Straps	3	Submarine Pick-Up	20 V/A
Empty Belly Tanks	2 F	Light Signals	16 V/A
Good Ditching Procedures	2	Correct Fix	13 E
A Sense of Humor	2	Liferaft	12 V/A
		Very Signals	11 V/A
		Landing on Reef	8 L
		Tracer Signals	6 V/A
		Flare Signals	5 V/A
		Whistle Signal	1 V/A
		Tied to Fish Stake	1 M
		Guard Raft Line	1 M
		Paddles	1 M
		Oil Slick of Aircraft	1 V/A
		Sonobouy	1 E

*F	Flotation	95 percent
V/A	Visual Aids	95 percent
E	Electronics	2.6 percent
L	Landfalls	1.5 percent
M	Miscellaneous	.5 percent

Ninety-five percent of the 10 items listed in Column A of Table 3 as "Contributing Most to Survival" are means of keeping afloat. The figures show the Mae West and the liferaft to be practically mandatory equipment. Although survivors did not grade the value of the accessory raft equipment, the narratives demonstrate the usefulness of other emergency gear. The principal accessories contributing to safety and well-being in a raft are the inflation pump, the bailing cup or bucket, and the sea anchor.

The appraisal does not consider raft accessory shortages which were officially reported as late as 1945 to have reached "serious proportions." Thus "We had no survival equipment in the liferafts; it just wasn't there!" Again: "The fact that our raft equipment was obsolete and short of rations was criminal."

Signal Aid Deficiencies

Both survivors and rescuers were conscious of the fact that it is extremely difficult to sight an object the size of a liferaft even on a smooth sea without some additional way to attract attention. Survivors looked upon the standard day and night signal aids as real lifesavers. The introduction of electronic devices, of which the Gibson girl and Target had the widest use, were in General Twining's opinion most essential. "Without some such device, the chance of seeing the tiny dot of a raft in the hills and valleys of the sea are about equal to the chances of finding a collar button in a ploughed field, even when passing overhead."

Raft signals were not always needed after ditching or bailout near standby rescue vessels. Crews frequently made their primary contact by radio while still airborne. Some hesitated to use signal aids in fear of contacting the enemy; the inability of others to recognize passing aircraft, vessels, or submarines as friendly robbed them of opportunities for an early pickup.

Survivors usually broke out signals whenever there was a chance of being sighted. Table 3 shows visual and audio signals contributed most to final rescue in 95 percent of 546 cases. To obtain a more realistic evaluation of the various signaling methods employed, the records of the 13th Emergency Group for one quarter of 1944 were scanned to determine how this rescue unit located survivors. The findings from the 136 accounts that stated the method are listed in Table 4.

Table 4 shows the contact to have been made visually in 88 percent of the incidents, by means of electronic aids in only 12 percent.

To determine the percentage of success of the various signaling devices, narratives in which

TABLE 4

HOW RESCUERS SPOTTED SURVIVORS IN 136 INCIDENTS

Method	*Number of Incidents*
Orbiting	53 (visual)
Mirror Flashes	20 (visual)
Raft Sighted (Color)	16 (visual)
Sea Marker Dye	14 (visual)
Radioed Position	13 (electronic)
Pyrotechnics	8 (visual)
Aircraft Sighted	5 (visual)
Emergency IFF	3 (electronic)
Mae West (Color)	2 (visual)
Flagged	1 (visual)
Gibson Girl	1 (electronic)

signal aids were listed as on hand and used were surveyed. This selection was then checked against the accompanying rescue reports, which tell how the rescuers were attracted to the survivors. The results of this analysis are given in Table 5. Although the limitations stated in the footnote to Table 5 restrict their interpretation, these data do provide information of comparative value when properly evaluated. For example, the success of sea marker dye, 60.9 percent, clearly shows that dye is of paramount value. Though the success of the whistle, 6.9 percent, shows it to be only about one-tenth as effective as sea marker, the survivors considered it desirable because it is easily carried and operated, its sound carries farther than shouting under some wind conditions, and blowing it is less disturbing emotionally and less exhausting physically than shouting. Though shouting appears to be 100 percent effective, it is ordinarily of little use. It was mentioned only five times, and in each of these five cases the rescuers were close at hand.

Equipment Losses

Because all losses of gear were disastrous, survivors put great emphasis on the need to tie down all equipment. Complete losses of provisions, water, and first aid kits in raft upsets were not unusual, and often occurred at the first capsizing while the survivor was examining or checking the contents of his kits. The range of losses was considerable. A partial survey of several hundred narratives shows that heavy articles such as backpad kits, pyrotechnics, sidearms, rations, and water supplies were lost most frequently.

Men wanted more raft pouches for small items; all complained of the poor closure of existing pouches. There were requests for a vest-type kit, and those with previous survival experiences devised their own vests and filled them with small articles.

In upsets men often made frantic efforts to empty their pockets to keep from sinking. Experienced survivors advised others to tie down all gear promptly, and to divide their equipment when they had more than one raft to avoid total loss

TABLE 5

SUCCESS OF SIGNAL EQUIPMENT*

Equipment	*When Used*	*Number of Times Used*	*Times Successful*	*Percent Successful*	*Survivor's Comments*
Sea Marker	by day	330	201	60.9	Wanted more
Mirror	by day	210	32	15.2	Desirable
Smoke	by day	110	46	41.8	Wanted more
Flagging	by day	30	30	100.0	None
Arm Signals	by day	4	4	100.0	None
Splashing	by day	4	4	100.0	None
Very Signals	by night	135	32	23.7	Wanted more
Flares	by night	37	13	35.1	Wanted more
Flashlights	by night	127	22	17.3	Desirable
Tracer	by night	130	21	16.2	Wanted more
Whistle	at all times	145	10	6.9	Desirable
Shouting	at all times	5	5	100.0	None
Radar Reflector Target	at all times	20	5	25.0	Desirable
Gibson Girl Radio	at all times	12	4	33.3	Desirable

*The figures in this table reflect only the frequency of success of equipment when equipment was available and used. A high percentage does not necessarily indicate that a given piece of equipment is superior to another under equal conditions.

through capsizing. They usually stored loose equipment in shirt pockets, seldom in water-shrunk pants pockets where they were difficult to remove. Those with foresight replaced land survival items with extra rations of water or other items more desirable for survival at sea.

Losses were sometimes due to negligence in a last minute switch of aircraft which did not give the crews a chance to check their liferaft equipment. But for the most part the usefulness of emergency equipment was compromised by improper packing (cracked hand pumps and broken paddles) or by improper storage (mildewed fabrics, cracked bailing buckets, gummed rubber items, corroded or rusted metal goods)

Water Spoilage

The grievance expressed most commonly in all narratives was that equipment was inadequately waterproofed. Of the 65 or more basic items in liferaft accessory kits, about two-thirds were susceptible to salt water damage. Water and food were, with few exceptions, relatively well packaged, but signaling equipment was not, and suffered the most from water damage.

Flashlight batteries were reported corroded and "dead"; so-called "waterproofed" lights often filled with salt water and shorted. "I signaled with my water-filled flashlight and the hands aboard saw the dull red glow." There were complaints of lights that worked for only 2 hours or that failed to work after immersion of 12 or more hours. Survivors requested that flashlights be packed in vacuum tins.

Parachute signal flares, fusee signal flares, smoke signals, and the cartridges for Very pistols or hand projectors were all made of heavy carton paper more or less waxed to keep out water. Because pyrotechnics were so important for long distance signaling, their repeated failure to fire depressed survivors greatly. Very cartridges swelled when wet so they would not fit into the breech unless part of the outer layer was peeled off; many misfired. During the latter part of World War II Very cartridges were effectively waterproofed in tight cellophane wrappings which, however, were so hard to remove that "I was unable to use my Very's pistol to show my location to the taxiing DUMBO hunting for me because I had dropped my knife and I could not remove the slick cellophane wrapping off the Very cartridge with wet hands. I finally ate it off." White smoke hand grenades were also reported useless after wetting. The failure of tracer ammunition was blamed on the lack of suitable watertight containers.

Electronics equipment was generally better waterproofed than most raft items, but there were frequent complaints of salt water grounding out emergency radios. The most common cause of radio transmission failure was the inability of survivors to raise the aerial when the kite was waterlogged.

Waxed K ration cartons disintegrated readily and only the tinned food escaped salt water damage. After the tins were opened, salt water and sea dye made the contents inedible even when stored in pliofilm bags. After a dye packet was opened the dye penetrated every nook and cranny of the raft.

Inadequate waterproofing of the raft repair kit ruined the sandpaper, but sandpaper was of no use when the rubber cement tube was empty or dry. "Waterproofed" matches lasted about 12 hours. "I have found on numerous occasions that the supposedly waterproof bakelite match container with compass lid had been either broken or the matches wet, if intact." Salvaged flight folders, logs, diaries, and toilet paper turned to pulp when wet.

Condoms received universal approval as watertight containers. One desk-bound interrogation officer described them as "a makeshift though somewhat indelicate device to fit flashlights, medicine, wallets, watches, cigarettes, and gear of all kinds, and when knotted provided excellent waterproofing." But even condoms were not proof against salt water damage.

Corrosion

Many survivor reports refer to equipment found damaged by rust. Knives, fishhooks, compasses, and tins often rusted in storage. Corrosion was greatly accelerated in liferafts, where everything came in contact with salt water. Knives made of untreated metal, especially the so-called "shark knives" made from files or other tempered steels, were particularly prone to rust. Even the stainless steel in the Boy Scout clasp knife and in the fishing kit gutting knife lasted a relatively short time. Although these knives were sharp at first, after a few hours exposure to salt water the metal edge crumpled so it would not cut a light line.

Knives were a tremendous psychological aid in warm water survivals, and very useful in ditching, after bailout, and in the daily chores of raft housekeeping. They were used again and again to cut loose risers and chutes. "If any misunderstanding should occur between you and your chute, a knife is the only compromising authority." Men who had to cut their way clear when fouled in aircraft were especially thankful for their knives. Knives were lost most often when they were worn without a lanyard, or when held in the teeth or hands while swimming.

The galvanized wire of the collapsible dip net oxidized readily and weakened the cloth. Lead sinkers also oxidized and flaked, reducing their weight. All watches "froze", even the "waterproof" ones, and leather wrist bands rotted so the watch was eventually lost. Steel mirrors were coated with oil which had to be removed before they could be used effectively; men often licked the oil off. Stainless steel mirrors were reported badly corroded in 2 to 3 days. Few compasses lasted through a survival experience of any length. All were easily waterlogged, and the needles often rusted or stuck in position.

Sidearms, both the .45 and .38 calibers, were reported rusted and useless in 3 to 4 days, even though stored in waterproof rubber or pliofilm bags. For lack of something better to occupy their time, most survivors field-stripped their guns daily and oiled them either with oil saved for the purpose in a discarded Mae West gas cylinder, or with coconut oil, bird fat, fish oil, or with oil rubbed from their noses or from behind their ears. Rusty guns usually fired as long as the working parts were loose, and one survivor claimed that an occasional shot seemed to free the barrel of corrosion: "As for my gun (.45 automatic) the rapidity of the corrosion effect of the salt water was appalling. I kept the cartridges in my shoe and attempted to keep the gun usable by frequently working the slide. For raids in the Central Pacific I think a canteen on the gun belt would have been much more sensible." One raft castaway kept his .45 in its holster lashed to raft deck where it was always submerged in salt water. Complete submersion apparently reduced oxidation; after 13 days exposure to salt water the piece was workable, and was completely serviceable after the pitted barrel was replaced.

Unless in fear of shark attacks or capture, most survivors had little use for sidearms. Some used them for shooting birds or fish, but their greatest value was for signaling with tracer ammunition.

Loss of Buoyancy

Apprehension of the raft's buoyancy is expressed in many of the narratives. Men worried most about it during the first 24 hours, but usually became more confident as they grew accustomed to the craft. They were uneasy during squalls and storms, and felt the greatest anxiety after dark when they feared they could not detect damage and make repairs in time. The many survivors who outlasted hurricanes and typhoons or who sustained raft damage from strafings or shark attacks show that free-floating rafts, even with perforations and slits in the buoyancy chambers, were capable of withstanding severe sea conditions if holes were plugged and the chambers properly topped off.

Most raft damage was incurred not during the drifting phase of survival, but resulted from battle, careless maintenance or storage, or collision with the aircraft during ditching. Men who retrieved rafts after impromptu airdrops often found them useless because the metal fittings were torn off where they joined the fabric. Those who survived strafings found repairs were always possible, and showed no indication they considered their situation hopeless.

In four reported cases attacks by sharks or other large fish collapsed rafts completely. Lashing rafts together gave survivors real cause for concern. Two or more rafts, especially when overloaded, wore against each other, and the continuous seasawing of the lashings weakened the cemented joints and caused slow leaks that were hard to locate or to repair.

Most survivors felt that their heavy shoes would damage the fabric, but there is no evidence that shoes worn in the raft did it any harm. Fishhooks and the jagged edges of opened ration tins are mentioned as accidentally causing tears or punctures. "Then somebody discovered a fishhook lying on the bottom of the raft, and somebody else discovered a leak. There was no doubt that the raft was getting soft. It was beginning to buckle in the center." Knives were the worst offenders, and most survivors were partial to large belt knives. Survivors' sheath knives, unlike sailors'

blunt-pointed general utility knives, were usually sharpened to a fine point for defense against shark attacks. The point invariably wore through the leather sheath, and every time the survivor moved, the blade slid past the sheath and pierced the raft. Knives were often used carelessly, especially against sharks, with damage to the raft. One raft occupant, tortured by the constant rubbing of a shark underneath his raft, stabbed at the animal through the raft deck.

Chapter IV

THE ENVIRONMENT

DRINKING WATER

OF all the elements needed to maintain human life at sea, fresh water was most apt to be in short supply. Survivors felt the lack of water keenly when they were exposed to high temperatures, and when the survival period was of long duration. Narratives of short survivals generally express less discomfort. Survivors exposed to low temperatures relegated drinking water to a position of secondary importance: "Very few survivors indicated any real discomfort from thirst, even after 3 to 4 days, but all complained of great discomfort from cold and exposure" (Ditching Reports, Japanese Theater). "Appetite and thirst, in my experience, were overcome by the desire for warmth" (from an ETO narrative).

The data show a wide divergence of survivor opinion and practice in the use of water stores. Apparent throughout them are the varying views of the Services which led to a lack of agreement on uniform water ration practices during World War II. The emergency issue was limited, and intended only to maintain life until rescue was accomplished. This compromise failed to maintain the physical efficiency survivors needed to assist in their own rescue and did not allow for the long periods at sea without water.

Raft Water Supplies

To prevent spoilage, all emergency water for storage in liferafts was pasteurized and stored in metal containers with screw caps which could be removed or resealed by hand. These were stored in an accessory kit tied inside the raft. The containers were commonly regarded as pint cans and are referred to as such in this report, but they never contained a full 16 ounces. The cylindrical Navy emergency water tins held 12 ounces, the flat Air Force tins 14 ounces. Because full cans sink when dropped overboard, all water cans were filled only to a waterline marked on the outside of the tin. The airspace made them buoyant and prevented the containers from bursting when the water froze under low temperatures in flight. Survivors unaware of this provision often complained that the water in their emergency cans had evaporated, or that their stores had been tampered with or were improperly filled.

The cans were so bulky and heavy they had to be distributed within the liferaft pack with due regard to other items of survival equipment. Raft water supplies were limited not only by space within the raft, but by the capacity of the compartment in the wings or fuselage of the aircraft where the survival gear was stowed.

The amount of water supplied to liferafts varied with the rated occupant capacity of the raft. Single-place liferafts had only one can of emergency water while multiplace rafts were stocked with at least one can per man. Depending on the branch of service, the largest rafts carried either 7 or 14 cans of water. Vinylite storage bags and large rubberized sheets for collecting rainwater were included in all raft equipment.

The number of water cans assigned to each raft was reduced when sea water desalting kits were developed. These increased the potential water supply without adding size or weight to the raft equipment. Some rafts were stocked with one or more solar stills. However, desalting kits were not a standard issue until May 1944, and the two most efficient distilling kits were not available until mid-1945.

In many instances, men on overwater flights

took the precaution of carrying at least one and often two 24- or 32-ounce canteens suspended from their belts. Sustenance kits carried in the waist of multi-engine aircraft generally held a more generous ration of water and, sometimes, cans of tomato juice. Crews were occasionally able to salvage from the aircraft canned fruit juices, water breakers, thermos bottles or jugs carried for in-flight use.

All too frequently, however, survivors found themselves without the water supplies they expected to have on hand. Those who had canteens often discovered to their chagrin that they had failed to refill them before takeoff, or that they had neglected to screw the caps securely after drinking in flight. The narratives of B-29 crews frequently mention the loss of personal canteens during or after bailout. Because screw-cap containers were often contaminated, many narratives recommended that all water stores should be sealed. Salt water also entered through the air vents of aircraft water breakers salvaged in ditching operations.

Aside from the repeated complaint that cans were not brimful as expected, a few show the water cans in their equipment were empty. In most cases this could have been avoided by adequate preflight inspection. Cans were found to be rusted out, or empty from leakage caused by damage through careless handling or packing.

A major cause of water loss from careless maintenance was failure to secure the accessory equipment to the raft's deck properly in packaging. In such cases the heavy container, as well as all the water, were often lost when the liferaft was unavoidably or accidentally inflated upside down.

When they had to board the raft upside down, as happened not infrequently, survivors were unable to get at their water supplies. "For two days I lay on my inverted liferaft; it was too rough to attempt to right it. On the third day I was too weak."

Loss of raft water supplies through accident or carelessness was a common occurrence, and usually happened during the first 24 hours. By far the greatest cause of loss was capsizing. In one 11-day episode, the raft capsized four times the first night. This cost the three men 8 of their 11-can water supply; of the remaining 3, one was filled with salt water.

Capsizing losses were often increased by the survivors' failure to make all gear fast and to keep it fast at all times. Ignorance of a liferaft's lack of stability in a rough sea led to injudicious actions. The most foolish were to display the contents of the accessory kit, mainly out of curiosity, and to take inventory at inappropriate times. Again and again at such times men lost not only their water but all their gear when the raft upset. The fear of capsizing also provoked raft occupants to such extreme measure as using the accessory kit as a sea anchor, and in at least a dozen incidents water stores were lost when the water cans were used to weight the sea anchor down.

After survivors were located by air search, they were usually supplied by airdrop until they could be rescued. Because water was of chief interest in airdrops, survivors asked that in large drops of gear it be packed so as to be immediately available. In many instances the cans were punctured or ruptured on hitting the sea.

DESALTING KITS. Survivors called the sea water desalting kits "water makers," or "Permutit kits" after the name of the company stamped on each can. These kits, which remove salt from sea water chemically by ion exchange, consist of a vinylite bag with a filter base and six briquettes of silver aluminum silicates packed in a metal container about the size of one flat tin of emergency water. Each briquette, when kneaded with 15 ounces of salt water, produces an equal amount of potable water, and is then discarded. Thus each unit supplies the equivalent of six cans of emergency water. The weight ratio of the kit to the water it produces is 1 to 10.

Desalting kits were issued during the last 2 years of World War II, and the narratives mention them frequently, usually without comment, which would leave one to believe they worked satisfactorily. However, some dissatisfaction was expressed. First attempts to use them often resulted in brackish water because of insufficient kneading. The instructions recommend 45 minutes, but one user claimed that after 2½ hours the water still tasted salty. This usually happened when the men tried to use the same briquette to purify more than 1 pint of sea water.

The survivors' usual practice was to drink a little, then add more sea water. A few tried to drink the water from the top of the bag instead of through the filter as prescribed in the instructions. One survivor who lost his spare briquettes when his raft upset used the remaining briquette several

times. When rescued he was delirious and suffering from the effects of drinking salt water.

Several survivors remarked that the time it took to produce drinkable water with the desalting kit made little difference because it gave them something to do. Some complained the kits produced too little water, others deplored its odor. Because survivors commonly tied the filled desalting kit overside to keep it cool, it was often the only water saved after capsizing.

SOLAR STILLS. As solar distillation kits were not made a part of standard liferaft equipment until late in 1945, the narratives contain almost no references to them, and the few at hand are largely noncommittal. One man did say he considered his "water distiller" impractical, and as he feared it might puncture his raft, he jettisoned it. The type still he had cannot be determined from the account.

The idea of converting solar energy into distilled water under liferaft conditions was first tried out with the Delano-type solar still prior to 1943. This was a noncollapsible unit with a distilling efficiency of about 30 percent, which could produce a maximum of 5 ounces of water a day in favorable weather. As each Delano still had to be hand held, a man could operate only one at a time.

With the development of collapsible solar stills it was possible to obtain more practical water yields. One unit of the cylindrical type LL-1 yielded an average of about 24 ounces of water a day. The LL-1 had an efficiency of about 52 percent in the middle of the day, which dropped to about 38 percent during the morning and afternoon. Because of its construction and shape it was fussy to operate and the water it distilled was frequently contaminated with salt.

The spherical still now in use, LL-2, yields about 32 ounces per day. It is simple to operate, has a noontime efficiency of about 90 percent, and of about 50 percent in the early morning and late afternoon. All stills dependent on solar energy are useless under cloudy conditions or in areas of low temperature.

Rationing

Throughout World War II the instructions to air crews on overwater flights stressed the need to conserve their water stores. In the early days the basic rule was to use no water during the first 48 hours of survival. This overly strict rationing worked severe hardships on all survivors. Seasickness and too strict rationing were largely responsible for the poor physical condition of most of the men rescued even within the first 5 days.

Field studies late in the war, concurrent with the development of desalting kits and solar stills, led to a re-evaluation of water rationing to maintain survivors at peak strength as long as possible. Aircrews were advised to drink all the water possible before leaving on missions. Except in cold weather, men were advised to conserve body water by avoiding unnecessary action, by removing or unbuttoning clothing to expose the body to the breeze, and by keeping the clothes wet during hot days. Crews were still told, however, to drink no water the first 24 hours unless they were wounded or overpowered by thirst, on the assumption that so doing avoided loss of body fluids through the flow of dilute urine and from seasickness.

After the first day they were advised to limit their water intake to 1 pint a day if the supply was limited. When supplies were plentiful, they were encouraged to drink at least 1¼ pints a day or more. When the raft supplies were reduced to 10 ounces, water was to be used sparingly, and only to moisten the mouth in rationed sips. After a limited regime, if the supply was increased it was suggested that survivors drink their fill slowly over the course of 1 hour, but on the following day, to adhere again to a ration of 1 pint daily.

Under this more liberal ration scheme, it was felt that men could maintain themselves in good order for the first 5 and most important days. Although a rapid decline might set in after the 5th day, at the end of 10 days crews would probably be better and certainly no worse off than those under more severe rationing.

COMPLIANCE WITH INSTRUCTIONS. In most of the incidents, the men tried to comply with the rationing instructions. "I had purposely kept from eating or drinking the first 24 hours as we had been instructed to do this. Besides, *I felt no real thirst* [italics added] and chewed gum constantly which kept my mouth moist."

Most survivors interpreted their instructions too rigidly and rationed themselves as strictly as they could. These extreme measures were encouraged by a variety of circumstances. First, most survivors were shocked by the inadequacy of water rations after they took stock of their situation. Secondly, most took a dim view of the possibilities for quick recovery. Finally, all had been thoroughly

impressed with the constantly repeated dictum that an individual can live for 30 days without food if water is available. This aphorism, which applies only to fasting under confined conditions when water is plentiful, was the basis for most survivors' attitudes toward their supplies of drinking water.

With little or no comprehension of the daily amount necessary to retain physical efficiency, most survivors maintained such severe water rationing practices they reduced their chances of survival. Although in many narratives the men speak of the strong temptation to drink all their water at one time, most carried their self-denial to the point where they might even have died with water in hand. Failure to understand the physiological function of water is shown by the many instances of men rinsing their mouth out and ejecting the water back into their canteens.

Although survivors were doubtless aware of the need to drink water in order to maintain life, they usually drank to satisfy the sensation of thirst. Sometimes they used their water to rinse out the taste of vomit, salt water, gasoline or sea dye from the mouth, to control "cotton mouth," or to ease furry and swollen tongues. Several men stated that they drank to relieve tension, or to take their minds off the seriousness of the situation. After an especially severe shark attack which left the survivor's raft awash, the individual expressed himself as "terribly depressed." While in this mood he drank all his water supply, which he credits with reviving his spirits. Finally, there is one record that proves that even among castaways there are individualists; this man stated that he drank water "to pass the time."

The survivors gave a number of different reasons for not using the water they had at hand (see group B in Table 6). Those who abstained for at least 24 and often 48 hours reflect in large part a desire to comply with their instructions. They usually spoke of being thirsty within that time, and when men who had water (groups A and B, Table 6) failed to drink during the first 72 hours, it was usually because of seasickness When seasickness was uncontrollable or recurred during rough weather, many made no attempt to use water, and left their supplies untouched as long as 3 or 4 days. In one incident, survivors were picked up after 3½ days of almost constant seasickness. During this time, the crew of 13 had consumed only 1½ pints of water. In other cases, after periods of retching and dry heaves, men tried to overcome nausea by sipping water, and some brought it under control within 6 to 12 hours.

Thirst was also less evident during low temperatures. In cold weather men went from 12 to 80 hours without touching their water supplies, largely, they said, because they were not thirsty. Survivors in the tropics rarely took water during the cool of the night.

Other things kept men from drinking during the early stages of survival. Some complained of rust in the canned stores, others refer to the "stale"

TABLE 6

USE OF WATER IN 113 SURVIVAL INCIDENTS

	Number of Incidents	*Percent of Incidents*	*Number of Men Involved*	*Remarks*
GROUP A Had emergency water but did not use it	35	31	154	Minimum time without water—½ hour. Maximum time without water—48 hours. (Mean time without water—13.6 hours.)
GROUP B Had emergency water and used it	63	56	226	Elapsed time before water was first used: at will, 7%; 1-8 hours, 15%; 12 hours, 9%; 24 hours, 41%; 48 hours, 19%; 72 hours, 9%. (Maximum duration of one 14-oz. can of water—9 days.)
GROUP C Had no water	15	13	63	Minimum time without water—1½ hours. Maximum time without water—8 days. (Mean time without water—48.8 hours.)

taste of canned water. The water "made" with desalting kits they sometimes considered "undrinkable." A few men found rainwater tasteless, and described rainwater contaminated by salt as "brackish." They often dissolved Charms (see p. 55) in rainwater to make it more palatable. Chewing gum and hard candy seemed to give a higher degree of mouth comfort than did drinking water. Almost half the men who expressed themselves on the subject had decided to hold their rations in reserve for at least 24 or 48 hours, or until rescue was in sight. Usually when rescue was imminent or the prospect of reaching land favorable, men drank up all their supplies at once. The only others who ever drank all their remaining water with no concern for the future were those who had given up all hope. When men drank at will, they often finished off their water allowance quickly: "Our two cans of water were gone in two swallows."

On the 5th day of an 11-day ordeal, three men "made a ritual of our last drink of water. Bill complained constantly of thirst, and talked a lot about a pet theory he had that the best place for storing water is inside the body. 'It doesn't do much good to hold water in a container," he'd say. 'A doctor told me once you couldn't do better than store it inside yourself.' " (from SURVIVOR, by Paul H. Madden and Peter Martin, Bruce Publishing Co., 1944).

METHODS OF ISSUING WATER. As a rule, when there was more than one survivor in a raft, the water supplies were placed in charge of one man who issued it in accordance with majority opinion. However, a few reports show that one person, usually a man of senior rank, was sometimes given the responsibility of determining the daily water issue. In rare instances water cans were divided among the raft occupants to use at their own discretion.

Most remarkable in connection with the allotment of water is the absence of any evidence of contention. By common consent when there were wounded on board, they received the first and often the larger part of the water available.

Water was usually handed around in the container, and each man drank his share. The amount to be take at a time varied from a "sip" to a "swallow" and was probably not more than from ½ to 2 ounces of water. In many instances men stated that they merely moistened their lips.

It was customary among large groups to measure out the daily ration of water. In extreme circumstances the smallest container available was used, and there are references to a "capful" of water because the water was doled out in the caps used to seal water cans or canteens. This was hardly more than the amount taken to moisten lips. When large canteen cups were used they were usually scored to a measured depth to regulate the water issue. In some cases men used empty Very shells which hold about 3 ounces when full. Water drunk from the desalting kits was more easily measured out since the plastic bag is clearly marked in equal units.

In response to what they termed "meal thirst," men generally drank their water allowances after meals, especially if they ate chocolate or other thirst-provoking foods: "Next day [after 24 hours] we decided to try some of the liferaft rations. We ate some stuff, I believe it was called 'pemlican.' It was peanuts and bacon or something and it made us thirsty." In the absence of food, they rationed their water according to the amount available to morning, noon, and night allowances, or just morning and night. If the last water allowance came too early in the day, survivors found they suffered from thirst at sundown. To avoid this and still hold to the planned allowances, they moved the last water issue to about 1600. When the air temperature dropped after darkness, thirst seemed less pronounced.

Other Sources of Water

Men on short water rations during an extended survival period usually experimented with some substitute for water. The great increase in ocean survival incidents during World War II brought on a number of suggestions of allaying thirst at sea. These included salt water enemas, the use of urine and the juice expressed from the flesh of fish, and drinking salt water in moderate quantities or diluted with fresh water.

Popular notions such as these have been tried many times and have never proved successful, but it has not always been possible to discredit them. This is particularly true of salt water drinking, which as recently as 1952 was again put forward as a reliable means of satisfying the human requirements for water. The fact still remains, however, that under survival conditions at sea, unless means for chemically or physically separating the salts

from sea water are at hand, *the only safe fluid to drink is rain.*

RAIN. As a rule, rain is not a dependable source of water. The probability of rain in many parts of the ocean during any 10-day period is less than fair. Innumerable records among the survival narratives speak of dry spells which lasted anywhere from 8 to 14 days. The most pathetic of these are the ones from the South Pacific, where rain squalls are a common phenomenon—but so often at a distance. "It was annoying and disheartening to see rain squalls build up all around and no rain."

When there was some hope for rain, the men on rafts usually made plans to build up their reserve supplies. The simplest method and the one most often used was to spread paulins, ponchos, or sails to catch the rain. These sheets were difficult to handle in the high winds and rough seas that usually accompany a squall. Spray sometimes contaminated the water before it could be transferred to closed containers, and much water was wasted in washing excess salts from the sheet before the water was free enough of salt to be drinkable. The water which gathered inside of the raft was apt to be brackish, and not infrequently was discolored by marker dye.

Quite often when the survivor was without any means for catching water, he merely cupped his hands to mouth and tilted his face into the rain. One flier caught water in a pliofilm bag which he held open with his teeth and two hands; this simple method took him 5 days to figure out. Some held their clothes up and, by quickly rinsing out the accumulated salt, were able to wring fresh water into their mouths or into storage vessels.

Occasionally when men had satisfied their immediate thirst, they failed to fill containers. They used a wide variety of objects for receptacles. Not only water jugs, but empty water and food ration tins, malted milk tablet bottles, plastic transparent waterproof bags, shoes, thermos bottles, and condoms are mentioned in the narratives. Sea anchors, bailing buckets, lifejackets, and spare rafts, especially the 1-man raft, were used on innumerable occasions to store rainwater. Excess 1-man rafts were used as "water boats" to hold reserves of water and were towed behind the main raft. They were easy to fill and to keep uncontaminated in the belt of doldrums.

One survivor worried so about the possible evaporation loss of water in an open bailing bucket that he transferred it by mouth into the air bladders of his Mae West, which took him about an hour. When filled, the Mae West holds about 2 quarts. Although the idea of using the bladders in Mae Wests as water reservoirs occurred to and was practiced by many survivors, this function of the Mae West was not widely publicized. In another situation, three survivors tied up about 2 gallons of water in a paulin; when it sprang a leak they set themselves to drinking it.

Raft occupants complained frequently that rainwater was unpalatable, and that it failed to quench thirst. In order to make it more palatable a few experimentally added small quantities of salt water to it. Others flavored it with hard candy, and pronounced lemon flavor the best.

Miscellaneous Water Substitutes

Of the food provided in liferaft rations, the fruit-flavored, or citric acid hard candies were found to be the best thirst quenches. Survivors reported that their tart flavor induced saliva flow.

A surprising number of men in the South and Central Pacific area recorded finding coconuts at sea. Those who succeeded in opening them found that they contained little or no liquid. Some men experimented with chewing seaweed. In desperation, one pilot chewed on a quinine pill and then had to rinse his mouth with salt water. Those who tried to drink the blood of sea birds usually lost it in subsequent retching. To overcome this, one man drained the blood into a bailing cup with fresh water which kept it from coagulating, "thus making a pretty good drink."

In terms of ingenuity, the experiments of the following 21-day survivor are hard to beat:

"Before I ran out of fresh water, I decided to experiment with drinking sea water. First, I tried to rig a distilling apparatus out of two canteens, but was unsuccessful. I tried using halazone tablets, but they have never purified sea water and they never will. I tried iodine in water but that, of course, did not work. I didn't expect it to, but I had nothing to lose by trying. I even tried putting sulfanilamide in the water. Not being a chemist, I thought by some miracle that it might precipitate the salt. It did not. I rigged a valve on the cap [of a glass bottle] and securing the bottle to my fishline, I lowered it into the water. The valve opened at about a 40-foot depth. I thought that the water at that depth, being under terrific pressure, might not have as much salt as the water at the surface. Secondly, I thought that it might be colder than the water at the surface and that it might sweat in the sun like a pitcher of ice water, and I could

lick the sweat off the bottle. Both assumptions were false."

Beer is mentioned in several incidents, and always by transport crews. In one C-47 incident which lasted 17 days, the crew rationed 13 cans of beer over a period of 3 days, after which they fell back on their water rations and rain supplies.

FISH JUICES. Fish fluids are recommended as a water substitute in emergencies by many individuals with more enthusiasm than knowledge. It is true that all flesh contains water, but this water occurs only in the muscle cells and cannot be extracted by any methods available *under liferaft conditions*. However, because of the widespread publicity, many raft occupants during long survivals tried to satisfy thirst with fish juices or so-called "stick water." Of those who experimented with it, none ever suggested or recommended the practice to others.

The simplest method tried was to chew strips of raw fish. Some attempted to collect the fluid by cutting shallow cavities in the fish carcass. Others wrapped chunks or strips of the raw flesh in chute or shirt cloth and twisted it in their hands to wring out the liquid:

"My attempts to wring moisture from the raw flesh of fish were unsuccessful. I tried to cut the meat into small squares and wring it out in parachute silk. The silk became oily, but it wasn't enough even to moisten my tongue. Then I tried wringing it out in gauze with the same lack of results. I took some of the flesh and put it between the rounded sides of two canteens, squeezing and rolling to get a wringer action, but this too was ineffective."

Some used liferaft paddles to gain greater torsion, and when there were two men present, one held one end while the other twisted the bundle. The ooze a few of them managed to collect was insufficient in quantity, high in oil, and usually objectionable in odor. Some individuals were able to drink it, but in most it provoked nausea.

The difficulty of catching fish prevented more men from trying to extract fish fluids. Successful fishermen used large fish, usually dolphin or any of several unidentified species. Some tried it with small sharks, but the strong urea odor of shark flesh was immediately repulsive. Survivors who attempted to alleviate thirst by using fish juices declared unanimously that it was never successful and only served to increase thirst.

URINE. The use of waste body fluids was never openly recommended as a substitute for water, even under extreme circumstances. However, some men were exposed to suggestions of it during survival briefings. A few claim to have been taught such outright fallacies as: "Urine excreted during the first two days may be dilute enough to provide usable water," or "the urine of a normal man may be dilute enough to provide usable water."

Actually, the quantity of physiologically usable water available in the body's waste liquids, no matter how dilute, is practically nil. The concentration of waste body solids increases steadily under progressive dehydration, requires more and more water for elimination, and places a greater load on the kidneys. Thus, urine drinking can only result in a vicious circle.

Urine drinking was attempted only under the most desperate circumstances, where men were without water for long periods. Of the reported instances, the shortest elapsed time before it was tried was 7 days, the longest 13 days. The occasional practice of saving liquid wastes in empty containers undoubtedly suggested the practice in some instances.

The usual reaction was one of revulsion, and the odor alone was enough to deter the more finicky of those who considered it. Those who succeeded often vomited immediately. Nevertheless one or two individuals tried to drink urine several times, and to "keep from gagging" they mixed it with chocolate shavings, hard candy, or lemon juice.

FRESH WATER DILUTION. Although survival instructions clearly indicated that salt water is dangerous and should never be drunk, these warnings were contradicted by other advice given to survivors. They were told "it is physiologically possible to increase water supplies by salt water dilution." The ratio usually recommended was 1 part of salt water to 6 parts of fresh water, and it was often given as high as 1 to 4.

Men were also told, quite correctly, that sea water can be drunk in moderate quantities without harm to the system, but the exact amount was never stated. Such advice was academic and did liferaft survivors no good. There are no advantages in diluting fresh water with sea water, even though the measurements are made with more judgment and accuracy than is possible on a liferaft.

In the course of their ordeals most individuals inadvertently took in more salt water than was safe. Several accounts speak of liferafts so awash that men trying to sleep lying down were immersed whenever a sea broke over them. When water was improperly prepared in desalting or distilling kits, or when rain was collected on salt-encrusted equipment, few survivors could avoid drinking some brakish water.

SALT WATER DRINKING. Next to exposure, the drinking of sea water is believed to be the commonest cause of death in oceanic survival episodes. Once a man succumbed to the temptation to quench his thirst from the sea, he seldom lasted much longer. Not one of the men who managed to survive through long ordeals of 20 or more days on small rations of emergency water ever tried such expedients as drinking urine or salt water.

The presence of "water, water everywhere" was a constant temptation to all castaways, and was often so strong it took a great deal of willpower to resist it. Sea bathing, salt water soaking, and swilling or rinsing the mouth with sea water always permitted an opportunity for swallowing salt water, and tempted men into drinking it. The psychological urge is very strong. Men often spoke of the almost uncontrollable impulse to drink it, and admitted they sometimes could not resist plunging their heads into the sea. The temptation was greatest from the 3rd to about the 5th day after all fresh water supplies had been exhausted. The only preventative was fresh water which, when doled out in amounts as small as 1 ounce, was enough to dissuade men from drinking salt water.

Most men were deterred from drinking salt water by their basic instructions, which warned them of the consequences. In most ditchings, and almost always after bailouts, men involuntarily swallowed so much salt water the accompanying distress was enough to restrain them from trying to drink it later.

Nevertheless a few men reported drinking salt water. One survivor drank surreptitiously at first, usually at night, and eventually drank openly. Two others drank salt water deliberately between rations of fresh water. Ten men on one 5-man raft were without food or water for 3 days. One man drank salt water the first day; when he jumped overboard for the second time early on the morning of the third day, he was left alone and drowned. Other similar cases of violent behavior after drinking salt water appear in the narratives.

One man who survived a 20-day ordeal in 1944 described his experimenting with salt water drinking as follows:

> "Booby birds are goose-like birds with about a five-foot wing span and, I observed, drink the salty ocean water. Each bird has a handful of fat clinging to the belly side of its intestines. I found that by laying the fat on my mirror in the sun, it would liquify on the surface and become very greasy. I used it in conjunction with drinking sea water. I coated my mouth, throat, esophagus, and stomach with the grease and drank sea water until I began to taste the salt. I did this two or three times a day, totalling about one pint of water each day. On the 10th, 11th, and 12th days, I drank sea water without taking fresh water. On the 12th night, I was blessed with a driving rain. In addition to filling my canteen, I drank about a half-pint of rain water. On the 13th and 14th days, I continued drinking sea water; but on the 15th day, I discontinued this dangerous practice. . . ."

After capsizing on the 14th night he involuntarily swallowed a considerable amount of sea water and was so badly nauseated by it he could no longer tolerate drinking it.

Another incident occurred in 1945 among a group of three men who spent 10 days at sea. They had a water reserve of 18 11-ounce cans of tinned water and one desalting kit. The first 2 days all three were seasick and took no food, but used salt water to wash out their mouths. All food taken after the 3rd day was chewed until soft enough to swallow, then washed down with a handful of salt water. "The candy killed the taste of salt water, and it was found that a small amount of salt water removed the sense of dryness and helped wash food down without causing any distress. After the daily meal (at 1400) they shared one 11-ounce can of fresh water. It was necessary to bail about every 2 hours, and each time the bailer would take a couple of swallows of salt water to relieve some of the thirst. They were thirsty all of the time." When rescued, after losing one man overboard, the two remaining survivors still had 8 cans of fresh water in reserve.

As most castaways known to have drunk sea water either died or were seriously ill, delirious, or dying when rescued, the cases cited above suggest that salt water can be taken in small doses. However, the survivors in the above incidents benefited from the use of fresh water or rain water. Their daily allowances of fresh water were sufficient to restrain their desire to drink excessively

of salt water, and apparently gave them enough liquid so that their kidneys were able to function properly.

Despite the highly publicized (and highly questionable) experiences of Dr. Alain Bombard, there is no evidence to date that anyone in a survival situation ever improved his condition or extended his survival time by drinking salt water. The contentions of those who say it can be done are answered most clearly by Dr. Homer W. Smith in his book FROM FISH TO PHILOSOPHER (Little, Brown and Co., Boston. 1953):

"It is well known that men lost at sea cannot drink sea water and survive, and that to do so only shortens life. With the maximal osmotic concentration of human urine set at a level only slightly above that of sea water, very little of the water in the latter could even theoretically be made available for the excretion of other urinary constituents. About 500 cc. [1 pint] of sea water per day is about all that can be tolerated without gastrointestinal disturbances from the unabsorbable magnesium and sulfate. This would yield a meager 143 cc. [¼ pint] of free water, a negligible quantity in the face of the minimal requirement of 500 cc. for urine formation, and upwards of 1500 cc. [1½ quarts] for sweat under conditions of exposure to sun and wind. Consumption of larger amounts would only lead to diarrhea and further dehydration and accelerate catastrophe.

"Nor can a man lost at sea improve his position by drinking urine; his kidneys are already doing the best they can and the only use to which either urine or sea water can be put is to use them to cool his clothing by evaporation, thereby cutting down on water loss in sweat. Taking the minimal urine volume as about 10 cc. [⅓ liquid oz.] per gram of protein metabolized, eating raw fish will not ameliorate dehydration, since all the water available in the fish is required to excrete the protein metabolites. A man might gain some water by drinking the juice expressed from fish muscle, since this is largely free of protein, but no one has yet been able to devise an effective method of doing this in a small boat at sea because the juices of the muscle are most tenaciously held. Man simply cannot venture out upon the sea or into the desert except in the security afforded by his providence."

Reducing Water Needs

The economical use of water is imperative in liferaft survival. This may be accomplished in two ways, first by using emergency water supplies judiciously, secondly by controlling seasickness and sweating.

Few survivors on whose narratives this study is based understood the intricate physiology of the body's use of water, or the causes and effects of dehydration. Survivors in cold latitudes where sweating caused no loss of body water failed to realize how seriously seasickness-induced vomiting dehydrated them.

Nevertheless the men were well aware that they needed more water than they were getting under the circumstances. Though they had no concept of the physiology involved, and expressed the need only as an "overpowering thirst," their comments show they worried about the fluids they were losing, and many took steps to alleviate the loss.

Quite a few of the men who spent more than a day or two on rafts noted that they urinated more than they drank. One 13-day survivor who was rationed to about an ounce of water a day claimed he voided about 8 ounces daily. This phenomenon puzzled them, and they tried to account for it in various ways. Most of them thought it showed they must be taking in more water in some way. A typical narrative: "During the 21 days at sea, I urinated about three times as much as I ever drank. The reason for this may be found in the fact that I was never completely dry. I was sitting in water most of the time and my clothes were continuously wet from the waves breaking over the raft."

He implied by this, of course, the widespread though erroneous belief that the body can absorb water through the skin, which led many raft occupants to "watersoak" themselves regularly. "Each day we left our raft and laid in the water for an hour to let our pores absorb the water, while others took turns looking out for sharks." This was beneficial, nevertheless, especially in tropic waters where the air temperature is 85° or higher, for its cooling effects reduced excessive sweating.

Periodic immersion in the sea is feasible only in shark-free tropic waters, and is always dangerous to men in weakened conditions. Most survivors who "took the water cure" found it refreshing but they generally discontinued the practice because of difficulty in reentering the raft. Some learned the same result can be obtained by wearing clothes soaked in sea water. The vaporization of salt water in place of body water measurably reduces daytime losses from sweating. Wet clothing was found just as effective when wrung almost dry, which by reducing the salt concentration lessened salt-water skin irritations. The disadvantages of this method were first the possible loss of clothing and, secondly the discomfort of

wet clothing, especially when the wind was brisk or when subjected to rapid cooling at nightfall.

Men were conscious of the fact that they were losing body water when they sweated, but other than by watersoaking or wetting their clothes, the only way they could reduce the loss was by avoiding excess activity, by erecting shade, or by removing excess clothing. To control the water lost in breathing, survivors were advised to increase the water content of inspired air by breathing through a cloth saturated with sea water, but there is no evidence that anyone ever put it into practice. In survivals of short duration the water lost in stools was never significant. In survivals of long duration, the attendant constipation prevented the loss of any water in this manner. At no time did survivors mention attempting to inject sea water into the rectum.

FOOD

Raft Food Supplies

The lack of space in rafts and for raft storage in aircraft limited the amount of emergency food that could be carried. Basic food issues varied from three to seven units of rations per man between the Services, and the rated capacity of each type of raft determined the number of units assigned to it. The rations were selected to meet the peculiar dietary needs of liferaft survival, but were designed more for warm than for cold weather use.

Because well seasoned foods provoke thirst and highly palatable ones might make rationing difficult, liferaft rations were purposely made bland. As the amount of food the body can assimilate depends on the amount of water available, they were made high in carbohydrates and low in proteins and fats so as to yield as many calories as possible with a minimum demand on the kidneys. They were a compromise between a wholly adequate diet and the limited water supply.

Standard liferaft rations during World War II consisted of concentrated or dehydrated foods. Candy, chewing gum, and vitamin tablets were the principal items. The candy was either a sucrose or glucose sugar in various fruit flavors; Navy narratives referred to them as fruitdrops, Air Force crews called theirs Charms from the imprinted trade name. Gum was of commercial stock either in sticks or pellets. Vitamins were in tablet form. These foods were hermetically sealed in flat tins. One can of Navy Tablets or of the Air Force Type A liferaft ration contained emergency sustenance for 1 man for 5 to 6 days, or for 5 to 6 men for 1 day. Malted milk tablets were also issued for liferaft use in separate containers; these were called Horlicks.

Survivors often had other standard issue foods. The narratives mention various types of K rations, a field ration normally issued for inflight use. Canned pemmican, boullion powder, soluble coffee, sugar tablets, dehydrated cheese and cracker bars, and D rations (a sweet chocolate bar) were available in jungle or seat-type kits, the C-1 vest, escape kits, or other sustenance kits issued to combat aircrews. It was not unusual for men to carry fruit, usually apples or oranges, and most carried cigarettes or candy in their pockets. Liquor was rare. Only in rare cases did individuals carry small flasks.

Transport and search aircraft crews generally had more freedom in selecting food. They showed a preference for corned beef, crackers, prepared meats, and especially for canned fruit juices. These were usually drawn for inflight use. Many of these food items were also packed in the disaster kits used in emergency airdrops and in the food lockers of the airborne lifeboat.

Food was not considered as essential for survival as water. In the common belief, not always borne out by experience, that 'a man can live 30 days without food," liferaft rations were intended primarily to support morale rather than to provide nourishment and combat hunger. A daily allowance of from 2½ to 4 ounces of food, no matter how high in calories, is very small compared to normal rations.

Rationing

INSTRUCTIONS. Crews in tropical areas were advised to abstain from eating for at least 24 hours after ditching, and thereafter to eat only the recommended daily amount printed on all liferaft ration containers. This advice was based on liferaft tests which showed that men on a daily intake of 16 ounces of water or less had little appetite and voluntarily ate only about 4 ounces of food daily.

The use of wild foods, particularly fish, was encouraged by including fishing tackle in the liferaft

kits. Fish were recommended chiefly as a food and not as a source of water. The use of fish in small quantities was considered beneficial only if the survivor had enough water to allow his digestive and urinary systems to handle its high protein content. It was recommended that fish, bird, or turtle flesh should not be eaten in large quantities without plenty of water, or a minimum of 32 ounces at each meal. Shark meat was considered less desirable, as at least 24 ounces of fresh water were deemed necessary with each 5 ounces of it.

In cold temperatures where food is extremely important to give survivors the necessary resistance to exposure, pemmican and other types of high calorie rations were considered more suitable. Men were urged to eat before flight and if possible before abandoning the aircraft. In liferafts they were encouraged to eat at 2 hour intervals to maintain their resistance and thus increase their survival chances by a few hours.

The quantities of food recommended were determined experimentally, but the tests were not a valid measure of a survivor's needs. Under controlled test conditions men lack the nervous tension and physical energy they usually show in real emergencies, and they are unconsciously influenced by the test's known time limits. Under actual survival conditions, hunger was less common during emergencies of short duration, but in long intervals it was constant and correlated with exhaustion, apathy, and despair.

In the ETO most rescues were made within a 4 to 5 day period during which men ate little. Failure to eat within this period was not necessarily due to lack of appetite, but was largely influenced by seasickness and cold. Inadequate rations jeopardized the survival chances of crews who had to remain at sea 10 days or more. The RAF Institute of Aviation Medicine recognized this fact (1950): "Our pack (liferaft kit) also varies in that we are not convinced that a carbohydrate ration is the only one for survival use." Moreover, there is no evidence that men in cold oceanic waters were ever successful in foraging for wild foods.

PRACTICES. Most men complied with their basic instructions and did not eat for the first 24 hours, but they rarely observed the ration allotment recommended on the food packages. In this they were influenced by illness, by lack of immediate hunger, and by concern over the inadequacy of their food supplies for an extended period of survival. Optimistic crews adjusted their rations to last for a probable period of from 5 to 7 days, but the less hopeful divided their food to last for periods up to 30 days. Rationing often had to be revised downward when stores were lost or water-damaged after capsizing. Allowances were sometimes increased when the sea calmed down and when men obtained wild foods.

Men in one raft usually pooled their food supplies and placed them in charge of one person. When there was more than one raft, all food was pooled and reapportioned to distribute it evenly between the rafts, and each raft usually had its own food overseer.

From force of habit, food was usually issued at regular mealtimes, either once or twice a day. If the men had fruit, they ate it first before it spoiled. If they noted any indication of water spoilage of supplies they tried to salvage what was edible while they could. K rations being very susceptible to salt water contamination, they were usually opened and eaten early. Unused food was stored in waterproof plastic bags, or put in the pouches of the raft, in the accessory kit, or in the survivor's shoes and pockets.

Seasick individuals were given their share of the rations and urged to eat. Lone survivors often tried to eat to control nausea.

Survivors' Attitudes Toward Food

The survivors expressed their reactions to rationing or total lack of food in terms of hunger or appetite. Their remarks cannot be interpreted too literally because individual food preferences varied widely and appetites were variously conditioned by the ordeal. They spoke most often either of appetite or of intense hunger. They sometimes described hunger as "insistent belly pains," and in incidents of long duration the desire for food became so intense men overcame their squeamishness and ate raw and revolting foods with satisfaction.

During incidents of short duration hunger was less compelling, men were more fastidious and could skip meals without discomfort. Even after fasting for 3 or 4 days, survivors spoke of their lack of appetite, though they frequently wished for some favorite food. A sampling of remarks made between the 4th and 9th days: "Not very hungry or thirsty (4 days)"; "Did not miss food (5 days)";

"Never ate from hunger, never conscious of food pains (8 days)"; "No violent feelings of hunger (9 days)." These comments suggest that survivors rejected food at first either because of nausea or because of the ration's lack of appeal. When nausea did not extend beyond 24 hours, men usually ate their first meal the second day. Otherwise, "Nausea negated any immediate rationing problem, but we discussed rationing and were prepared to enforce it."

Table 7 is based on 100 narratives in which men accounted for their food, and shows when they used it. When they had liferaft rations, 51 percent ate their first meal within 24 hours, 35 percent held off eating for periods up to 96 hours. When seasickness was severe, it was not uncommon for men to fast as long as 4 days.

TABLE 7

USE OF FOOD IN 100 SURVIVAL INCIDENTS

	GROUP A *Rations Available*	GROUP B *No Rations*
Total number of incidents	89	11
Number stating seasickness retarded eating	45	
Number stating temperature retarded eating	12	
Number in which wild foods were eaten:		
Fish	6	3
Birds	3	3
Turtles	1	0
Number of men involved	405	46
Maximum time on short rations*	24 days	0
Mean time on short rations	2.3 days	0
Maximum time without food	0	12 days
Mean time without food	0	5 days

*Elapsed time before food was used:

Immediately	4	percent	of	incidents
24 hours	47	"	"	"
48 hours	24	"	"	"
72 hours	6	"	"	"
96 hours	5	"	"	"
Not used	14	"	"	"

The pattern of eating was not entirely governed by illness. When water supplies were short, men were very conscious of the thirst-provoking effects of food. To avoid thirst they did not eat, and they often regretted it later. A number of survivors remarked they would have been wiser to have eaten their drier foods while they still had water to wash them down and before their tongues and gums got too sore for chewing solids. In extreme cases men had difficulty even in swallowing malted milk tablets, and unwisely drank salt water to get them down.

Men asked for more candy or chocolate rations in place of either the K ration or pemmican foods. They found the Charms candy acceptable; it relieved thirst and "cotton mouth" and gave energy, which one man identified as "heat" energy. A few complained of increased seasickness after eating Charms. Most considered malted milk tablets and the chocolate D ration to be thirst provoking. They described bouillon powder as "filling."

Survivors tended to eat and drink lightly when they anticipated an early rescue. The account of an 11-man crew who survived 3 days before rescue states: "We didn't actually take stock [of food and water rations] because we expected to be picked up. As soon as rescue appeared certain, everyone became hungry and emergency rations were broken out."

The narratives show that men disliked the bland, monotonous tastelessness of the liferaft rations. They showed their disapproval by griping, particularly during short survivals and in the early stages of longer ones before they began to feel the pangs of hunger. Other aspects of the issue foods repelled them, such as the unpalatability of rations that had become moldy or rancid through improper packing or storage. Chocolate was the most common offender, for it is apt to mildew in a humid climate and easily picks up odors from other stores. The chief complaint of hard candy was that it tended to melt and stick to clothing after it has been removed from the watertight containers.

Men expressed disgust with all food contaminated by salt water. Until they learned by experience not to open their packets of sea marker to windward, they covered themselves, their rafts, and their food with the yellow dye whenever they used it. There is no evidence that fluorescein dye is harmful when eaten, but few could tolerate the color or the taste it imparts to food.

During hot, calm days in the tropics men had little desire for food. Some ate after dark when it was cooler. In cold water survivals both in the North Pacific and in the North Sea and English Channel men with food often went without eating for periods of 12 to 129 hours. The most frequent suggestion for improving cold weather rations was to include rum, brandy, or cognac in the liferaft stores. Survivors in the ETO expressed a strong liking for the condensed milk supplied in

small tins in the British airborne lifeboat and other emergency drop gear.

The psychological effects of anxiety and of apathy indirectly affected the use of food. Instead of eating, some men spent their time just waiting and worrying about their plights. Fear of the sea and worry about the possibility of capsizing, of losing their rafts, or of being overlooked in a search took away their appetites. On the other hand, one unconcerned pilot after climbing into his raft bailed it out, relaxed, ate a bar of chocolate, and "started to think," but dropped off into a sleep that was disturbed only by the low buzzzing of a wing mate.

Apathy and depression were usually the cumulative effects of exhaustion and of insufficient food, and were more characteristic of long ordeals. They frequently followed despair when aircraft flew by without spotting the survivors, and after such disasters as the loss of food or water rations, the failure of foraging attempts, or the death of one of the crew at sea. Some men were able to keep up their spirits by prayer or by sheer willpower, but in many cases these calamities provoked a listlessness and insensibility to their surroundings.

Physical Effects on Rationing

Men were undoubtedly aware of their deteriorating strength, but few expressed it or related it to their need for more substantial food. They usually noted it as "tiredness" or "fatigue" after exertion such as topping off the raft, paddling, or reentering the raft after an upset. Many imagined on rescue that they still possessed their strength and were astonished to find they were so weak they couldn't stand without help.

Only a few perceptive individuals noted their gradual loss of flesh as their legs and arms grew progressively thinner. Though in at least three cases of extended survival men were able to maintain their body weight by highly successful foraging, there is no question that most survivors lost weight during their ordeal. Too few weight records of survivors are available to allow definite conclusions to be drawn, and those listed in table 8 are presented for their general interest.

Food from the Sea

World War II was remarkable for the attention given to methods for self-survival after air emergencies. Through training programs, survival briefings, and survival exhibits and manuals, air personnel were made aware of the possibilities and opportunities for living successfully in a survival situation. Basic equipment to meet survival needs was designed to conform with the requirements of air transportation.

The emphasis was on "living off the land" because more was known of land survival. By inference, success in "living off the sea" depended largely on the probability of an early landfall, and on the wise use of liferaft stores. Suggestions for living off the sea mainly emphasized fishing, because of the prevailing notions that fish were always a safe source of both meat and fluids, and that merely providing fishing gear solved the problem.

Birds were given scant consideration because less was known of their abundance at sea; hence their potential value as an ocean food was depreciated. Turtles were considered a better possibility because they were marine animals, customarily associated with tropical waters and highly esteemed by epicures. During the latter part of World War II, plankton was proposed as a possible survival food which might provide both nourishment and vitamins.

The problem of living off the sea was further complicated by the scarcity and lack of variety of wild foods at sea, by the difficulty of preparing them in an appetizing way, by the need of adequate fresh water for digesting high protein foods, and by the failure to provide airmen with sound, useful information on the behavior of sea animals.

FORAGING INSTRUCTIONS. It was generally assumed that the average American airman has an inherent interest in hunting and fishing. Consequently, as time for formal training in survival techniques was limited, men were encouraged to become proficient in foraging by those means in their leisure time. This method worked out well for the few who were already interested in such outdoor activities, but not at all for those who considered hunting or fishing just another form of exercise. Successful foraging was rare among ocean survivors because they lacked knowledge and skill in securing wild foods.

Although a few individuals showed remarkable skill in foraging, most were baffled by the ways of wildlife, and couldn't forage even with suitable equipment. Few had any familiarity with the sea,

TABLE 8
WEIGHT LOSSES REPORTED BY SURVIVORS

Days	*Area*	*Flotation*	*Food*	*Pounds Lost*
3	Adriatic	rubber raft	no food or water	20
5	Bay of Biscay	rubber raft	strict rations	20
9	East Greenland	isolated on a rock	little food or water	25
9	East Greenland	isolated on a rock	little food or water	25
9	East Greenland	isolated on a rock	little food or water	32
10	North Atlantic	aircraft	foraged, little water	15
10	North Pacific	rubber raft	strict rations	25
10	North Pacific	rubber raft	foraged, little water	25
11	Central Pacific	rubber raft	foraged, 1 oz. water daily	28
11	Central Pacific	rubber raft	foraged, strict water rations	30
12	Central Pacific	rubber raft	foraged, strict water rations	26
13	Central Pacific	rubber raft	foraged	28
21	Central Pacific	rubber raft	foraged	40
21	Central Pacific	rubber raft	foraged	55
24	Central Pacific	rubber raft	foraged	40
32	Indian Ocean	ship's raft	foraged	56
47	Central Pacific	rubber raft	foraged	87
83	South Atlantic	wooden raft	foraged	87
83	South Atlantic	wooden raft	foraged	75
127	Indian Ocean	native boat	foraged	54
127	Indian Ocean	native boat	foraged	65½
133	South Atlantic	wooden raft	foraged, rations	excellent condition; no apparent weight loss

and those trained on inland bases were given no practical instruction. Lakes and artificial pools are an unrealistic substitute for the sea itself.

To compensate for this obvious gap in training, survival manuals were included in the kits, and printed instructions with the equipment. Survival manuals contained some limited information on poisonous fish and the food resources of the shoreline, but gave little or nothing about fish of the open ocean.

Fishing instructions inserted in fishing kits contained both impractical and contradictory material. Survivors were angered and frustrated to find inappropriate manuals thoughtlessly included in their equipment. In SURVIVOR, Madden describes the despair of his two companions when they found that the survival manual in their raft was designed for jungle use.

The best of the current survival manuals had no valid suggestions on how to catch birds or fish from a raft at sea. Except for plankton, which was never officially recommended as a food source, little consideration was given to the smaller forms of ocean life. Small fish, crabs, barnacles, and other edible and nourishing animals to be found in floating seaweed, logs, and other flotsam were largely overlooked. The few that mentioned small crabs and shrimp did not recommend them because "they are salty and will increase thirst." As most survivors had little or no background of the sea and its animals, they had to make a rapid readjustment to a new environment. Those who used common sense and those who experimented through trial and error succeeded very well.

FORAGING EQUIPMENT. The chief foraging aid in the liferaft equipment was the fishing kit which, as most men who used it found, was "singularly unsuccessful in catching any fish." This was due as much to unsuitability of the tackle, most of which was made for fresh water use, as it was to the men's lack of skill. (A revealing account of the development of raft fishing tackle is given by General Arnold in GLOBAL MISSION, pp. 354-355.)

In 210 narratives survivors used the expression "hooks too large." Because they had only large hooks, they were unable to catch the mass of small fish around their liferafts. When they did hook into larger fish, the hooks frequently straightened out, or the lines parted. The lines were too white, too coarse, and tended to float. With no sinkers, the lines floated with the current, and the fishermen could not drop their bait to fish they could see below them. Those who used the prepared pork-rind bait observed that fish preferred to nibble on the raft. The fish spear or harpoon was described as 'poor" or "useless."

It was exceptional for raft fishermen to be successful in their first attempt to use the fishing kit. Usually men spent many patient hours and often up to 3 or 4 days before they caught anything. "My efforts failed to yield a nibble . . . and after four days I gave up."

Nevertheless, some did succeed in catching fish. Dolphin (or dorado), common to all warm seas, was the species caught most often in the open ocean. The narratives also contain references to mackerel, shad, kingfish, catfish, bass, and trout, all of doubtful identity. Weight estimates averaged around 5 pounds but catches of 10- and 12-pound fish are mentioned.

IMPROVISED FISHING GEAR. Because most deep sea fishing is carried out from large or moving boats, few people realize the abundance of small fish near the surface of ocean waters, particularly in the tropics, which are attracted to the protecting shadow of floating objects. In warm seas small surface fish often gather in quantities under liferafts, and provide an accessible and inexhaustible larder of wild food. This observation was the most important single contribution to living off the sea made by liferaft survivors.

Typical of many comments in the narratives are: "A constant cloud of minnows followed my life raft." "Small fish all around us." "Many fish under the life raft which could have been caught." "After many attempts I gave up trying to catch fish from the schools which constantly followed the raft." "Birds and flying fish were numerous . . . small fish clustered under the raft . . . but no one tried to catch them."

Finding they could not catch these fish with their large hooks and heavy lines, survivors often tried to net them. The mosquito headnet of the jungle kit made a good seine, but it was hard to use without a frame. Men tried to use raft containers, accessory kit bags, bailing buckets, hats, and sea anchors as substitutes with varying luck. Some unravelled the heavy fish or sea anchor lines or their whistle cord, and fashioned small fishhooks from pins, wire, or the morphine syrette plug. For bait they used colored paper, frayed pieces of cloth, bird feathers, and in one instance, the skin peeling from their lips. They made spinners from scraps of tin, the shiny parts of watches, coins, or insignia, which did not work well. "There were an incredible swarm of small fish all around us, but they wouldn't strike at the spinners and we had no bait." One man managed to catch a few small fish on hooks he tied to his fingers.

With patience some succeeded in scooping up small fish in their hands. "In the early morning, in the gray half-light before dawn, hundreds and hundreds of finger-length fish, resembling sardines, collected around the rafts. With practice and diligence, we learned how to scoop them up. The trick was to bring your hand from behind and pin them with a quick move against the raft. But for every one landed, a hundred were lost. Through the last three days we must have caught between 20 and 30." (Rickenbacker by permission from LIFE). A crew of 4 who drifted 33 days reported catching about 30 pounds of fish by hand-grabbing. The consensus of opinion was that a good minnow net would have been worth 6 months' pay.

When survivors saw that the minnows attracted larger fish from 2 to 6 feet long, they tried to improvise spears. The simplest and easiest way to make a spear was by lashing a knife to a paddle, but those who tried it found the fish slipped off the smooth blade. With pliers, knives, or gun butts they fashioned aluminum oars into barbed spears, which were more successful on soft-skinned fish than on sharks, whose hides usually blunted or turned the soft aluminum points. Several tried to use the beaks of large sea birds as spearheads. Attempts to shoot fish or to stun with them with paddles, machetes, shoes, or pistol butts, or to snare them with loops of wire were wasted effort.

ACCIDENTAL CATCHES. Survivors noted that when sharks were about, fishing was poor. When fish, particularly dolphin, vanished suddenly, it usually indicated the presence of sharks. Thus, they discounted the belief that sharks are scavengers. On the other hand, men noted that when

porpoises appeared near the raft, the sharks vanished. The presence of these predators was not always unwelcome, for their prey, in trying to escape, often jumped clear of the water and sometimes landed in the liferaft, giving the survivors food without effort. One man averaged three small fish a night during an 8-day drift. Mackerel and larger fish were also secured in this manner. At night, especially in bright moonlight when survivors used sails, flying fish occasionally landed in the raft.

SEA BIRDS. Another contribution made by castaways towards successful liferaft existence was the observation that the sea is rarely without birds. The accounts mention albatrosses, goony birds, brown boobies, terns, and gulls. Sea birds are apparently drawn to rafts partly out of curiosity, partly by the fish attracted by the raft, but mostly because liferafts afford a place to perch, just as does any other flotsam. Their tendency to roost on the rafts, usually in the early morning and late evening, is mentioned frequently in the narratives. The birds appeared to have little fear of man, at least the inactive raft occupants did not frighten them, and once survivors learned to take advantage of their habits, they found sea birds to be a more dependable source of food than fish.

Rickenbacker's much publicized snatch of a "gull" off the crown of his hat was an extraordinarily good teaching example to all survivors who came after him. There are repeated references in personal narratives to the Rickenbacker episode. However, the feat was not unique, for it had occurred in several earlier lifeboat and raft experiences. Two Australian soldiers in a remarkable 127-day voyage in a native sailing boat early in 1942 caught by hand a total of 60 sea birds. During a 33-day drift from Cebu to Morotai, a crew of 4 subsisted on 15 birds and a small number of fish. Lim Poon for the greater part of his 133 days at sea lived on the birds that came aboard his raft at night.

Sea birds perched on the raft gunwales and often on the head or toes of raft occupants. "I heard a zoom and then an albatross lit on my toe; I stroked it, and it took my finger and shook it puppylike." "Sea gulls" (probably terns, gannets, tropic birds, shearwaters, or petrels) were also very tame and were easily taken by grabbing them across the back to keep the wings from flapping in one's face. "One day was like another except for the numerous gulls that kept me company. They were almost an annoyance as they perched on raft, shoulders, feet. They were very tame and easy to catch. I caught one on my toes by merely bringing it within hand reach."

Some castaways spoke with annoyance of the screeching and other antics of sea birds in the early morning. Others objected to "improperly housebroken gulls" and tried to shoo them away. Several men rigged up a scarecrow out of a paddle and a shirt. Others found that two paddles lashed crosswise and set erect made an effective perch. One individual left the skin and plumage intact when he removed the carcass from a sea bird, and for amusement mounted it as a figurehead on the tip of his oarmast and found that it served as a good decoy.

Most lone survivors welcomed the presence of fish and birds because it satisfied their craving for companionship. One pilot drifted 8 days in the South Pacific accompanied off and on by an albatross he named "Albert" and a large bass-like fish he called "George" who rested in the shadow of his raft. Men often tried to catch sea birds for sport, or with the thought of using them to carry messages.

Hunting Methods. The firearms most frequently used were the .45 automatic pistol and the .38 revolver, although in extended survivals the weapons generally became useless from corrosion. Winging sea birds from a liferaft is difficult, and most survivors found their chances greatly improved by waiting to pot the birds when resting on the sea. The 7-day drift of General Twining and his crew of 4 was highlighted by the General's skill in bringing down the first of two sea birds which were to be their only food.

Most survivors were hesitant to use their tracer ammunition and chose to save it for signaling. In the absence of firearms some individuals considered trying to disable sea birds with a Very pistol or hand-held flares, but reason usually prevailed.

MISCELLANEOUS FOODS. Castaways were sometimes able to salvage food from ships sunk at sea, but most of it was damaged by salt water. Those in tropic waters frequently recovered coconuts, often far out at sea, which always raised their hope for an early landfall. Some coconuts were old and putrid, the better ones furnished good white meat but had brackish milk. On the 16th day of his ordeal one pilot "Picked up two coco-

nuts; stripped off the water-softened fiber with pliers and cracked the shell with my pistol butt. Gained strength to paddle against the seaward drift. Without the coconuts, it would have been physically impossible."

Old coconuts, drifting logs, and other flotsam are sometimes encrusted with barnacles, which have good food value. Barnacles attach themselves readily to wood or metal bottom craft but not to the rubber surfaces of liferafts. In THE RAFT, Dixon, Pastula, and Aldrich record finding on the 22nd day of their drift a tree stump which yielded them barnacles, two small crabs, and two tiny oysters which they ate, and which elevated their spirits. Barnacles made possible the sustained efforts shown by the sailors, Hoogendam and Lim Poon, in their record 83- and 133-day survival ordeals.

A few survivors mention shaking small soft-shelled crabs out of seaweed clumps, which "relieved thirst a bit."

Although mentioned quite frequently in the narratives, turtles were usually too wary to approach, too fast to capture, and sounded quickly while still at a distance. In all the reports examined only two men made actual physical contacts with turtles. In one case a large turtle nudged the raft, and the occupant sat still in fear of capsizing. In the other the survivor awoke after an afternoon nap, rose on one elbow, and spotted a small turtle resting in the shade of the raft. He rose on his knees, and, as the sea was relatively calm, was able to grab it with both hands. He "skinned" it with a penknife, ate all but the head, guts, and shell, and found it "tasted plenty good."

PALATABILITY OF WILDLIFE. Survivors had less appetite for raw, bloody bird meat, which they found tough, stringy, and fishy, than for the relatively tasteless, gristle-like but tenderer meat of fish. However, the pangs of hunger were sometimes strong enough that they ate almost everything but the urea-tainted flesh of sharks.

They pronounced best of all the small minnows that hung around liferafts and which "tasted better than pemmican." Sometimes they first cut or pinched off the head and scaled the body with knife or fingernail, but often they were so hungry they swallowed small fish down whole and still wriggling. They considered the half-digested fish in the gullets of sea birds a delicacy, tasting "like half-cooked meat." "These fish were tender. I could pull the meat away from the bones, chew it, and swallow it. It tasted as though it had been partially cooked. It was perhaps the best thing I had to eat outside of my regular rations." Many survivors soon learned this and gutted all sea birds quickly hoping to find at least one fish.

Flying fish, which "tasted like sardines," and mackerel were preferred to larger fish which had dry, hard, tough flesh, "like gristle," difficult to swallow without water. In comparison, the small minnows had no salty taste and were moist and soft. Even men who lost their false teeth or plates found they could eat small fish easily by cutting or tearing them in pieces small enough to swallow whole.

Usually all leftover fish, fish heads, and guts were saved for fish or bird bait. To preserve surplus fish for food, a few castaways made the error of trying to salt it by dipping it in sea water. Others split and sun-dried fish on their raft gunwales, and kept them up to 36 hours with no ill effects. Stored meat, both fish and bird, was occasionally contaminated by the phosphorescent bacteria common in tropical seas. Several men received something of a fright at night when they noticed the deep glow from the spot where they had stored their catch. One man stated the head and body of the gutted fish stood out distinctly in the dark. Whenever they noticed it, they threw the phosphorescent meat overboard.

Men were often tempted to try shark meat. Usually they shot small ones. They commonly described the flesh as "foul, rancid, gagging"; some tried the "innards" but found them impossible fare.

A few individuals drank bird blood, but it usually provoked nausea and induced retching. They generally skinned and quartered birds for eating. "I found that the best method of cleaning was to skin them as one would skin a rabbit." Some found the lungs thirst quenching, others found the bone marrow more appetizing than the meat, which they unanimously belittled as tough, stringy, fishy, and unpalatable. The strong fish odor of bird flesh repelled the more fastidious, who preferred to use it as fish bait. Albatross meat they described as "red, tough, and coarse," and several noted that albatrosses do not bleed readily, for they had to "squeeze the blood out." Some made bird meat more palatable by slicing it into strips and sun-drying it. Others tenderized it by

storing it in coconut shells. Among the liferaft gourmets, none can speak more authoritatively of this fare than General Twining:

"That [albatross] was the toughest, stinkingest mess of meat ever set before a starving man. Hungry as we were we couldn't eat it. . . . Waggoner cut up the big buzzard and apportioned it out carefully in a canteen. There was just one chunk—about the size and consistency of an old rotten golf ball—for each. It was raw, of course, and tasted like an old dead fish. But we did have a tasty bit of hors d'oevre out of it. There were two flying fish halfway down the old boy's bullet, about half digested. We cut them up, too, and passed around a dainty piece for each man. Tasted like predigested pickled herring. Really delicious."

SIGNIFICANCE OF FORAGING. The standard ration issued in liferafts was adequate to keep a man in fair physical condition for a maximum of 8 days. Because of losses and spoilage, raft food stores rarely lasted a fraction of that time. Many castaways were able to survive long after their issued supplies of food and water were exhausted solely because they early learned to take every opportunity for collecting wild food and rain water.

The record shows no evidence that men adrift in cold northern waters ever succeeded in catching fish or birds, but in warm tropic waters a man's chances of surviving are immeasurably increased by successful foraging. From the many records of those who did so, it appears entirely possible that, given a decent platform, clothing, and a few accessories, a castaway skilled in foraging should be able to maintain himself in most tropic and subtropic waters for at least 30 days. Zamperini and his companion caught "two tiny fish, one small shark, three small birds and four albatross" which sustained them for their remarkable 47-day drift of 1,200 miles.

A 20-day survivor stated:

"When I landed on the sea, I had two days emergency rations with me, six small cans of pemmican, three chocolate bars, a small jar of malted milk tablets, some multiple vitamin tablets, some vitamin B_1 tablets and about three pints of water. The second day I decided to ration my food to make it last at least twelve days. . . . On the fourth morning I found an eight-inch fish . . . I speared fish with my sheath knife . . . I made a seine out of mosquito netting and caught minnows. I shot many birds . . . robbed their gullets . . . ate the liver, drank the blood . . . chewed small pieces of the flesh and swallowed it whole. I had to force it down, but I knew in my mind that my body was getting nourishment. . . . On the nineteenth night after my raft capsized for the third time I was so weak I could hardly get back in. . . . Though my rations were meager I was able to keep my body in fairly good condition but I had absolutely no feeling from the waist down. I lost only twenty pounds in twenty days. . . . I felt that God was with me and I sought my food from the sea. . . ."

Tobacco and Alcohol

TOBACCO. The narratives show that most men who had tobacco with them enjoyed smoking. Castaways found that smoking revived wet, cold bodies, quieted nerves, kept spirits up, and repressed hunger. Madden in SURVIVOR relates that smokes on their first day were an occasion for relaxation and joking. Dissatisfaction with smoking was expressed in only one incident, "We all lit cigarettes to celebrate . . . but this made us dizzy so we did not smoke much."

No tobacco was included in the regular raft supplies, and the only cigarettes available other than what the men happened to have in their pockets were the 4-cigarette packs in the K ration carton. These were often "wild" brands, and the target of some grumbling by those who wanted the standard, popular brands they were accustomed to.

Cigarettes carried on the person rarely escaped watersoaking. However, tobacco was the one item that could be used safely after contamination by salt water. Not a bit was ever discarded. Every shred was gathered up carefully, sun-dried on the raft gunwales, and rerolled in chewing-gum wrappers, notebook or toilet paper—in fact toilet paper was rarely used for anything else—, and "I mean they were the best cigarettes ever made."

When men had dry tobacco and matches or a lighter, they usually had a smoke immediately after getting settled in the raft, unless seasickness, rain, high wind, or spray made it impossible. They smoked during the first 24- or 48-hour period of abstaining from food to resist the pangs of hunger or thirst. Most narratives that mention it imply that smoking did not induce thirst. This is hard to evaluate, for while most men chose to smoke after the water issue, others, particularly those who substituted smoking for food, preferred to smoke first and drink afterward.

Men rationed their tobacco just as strictly as they did their food, and hoarded it as carefully. They usually issued the tobacco ration after the water ration early in the morning or late in the afternoon, at the rate of one cigarette at a time for the group. As match supplies were limited, the men grouped around and shielded the indi-

vidual chosen to light up. They then passed the cigarette from hand to hand, each man taking a single drag in turn. When men had tobacco but no matches, they chewed the tobacco.

The established tobacco routine was broken most often at night, when men smoked because dampness and chill prevented sleep.

ALCOHOL. Except in the ETO, alcohol was not easy to purchase, and there are no references to the use of liquor during survivals in other areas. Most of the notes on the use of alcohol in the ETO were obtained from British survival narratives. Brandy, rum, cognac, and whiskey were preferred in that order. The liquor was carried in pint metal flasks stowed carefully in inside pockets to avoid loss during bailout. Men reported it as helpful in reviving the violently seasick, in keeping warm, and in easing severe shivering after cold-water immersion. A few used it for ceremonious toasts to the occasion. Those who had both alcohol and water generally observed strict water rationing and drank their liquor straight.

Most authorities hold that alcohol, though an excellent stimulus for men suffering from chill, is dangerous to use because it lowers resistance. Men were cautioned that if they carried alcohol they must use it with extreme care, and warned that it would counteract any benefits they might derive from the use of benzedrine or water. Nevertheless men who survived in cold climates commented that "comfort from a bottle" would have been far more desirable and useful than the salt, atabrine, and halazone tablets and the sulfa drugs commonly found in raft stores. The same idea was expressed at times by men in warmer seas. One man rescued after an ordeal 8° north of the equator stated "Rain kept me chilled nine out of eleven days. Would have liked brandy to keep chill off at night after rain soakings."

ANIMAL HAZARDS

Sharks

The likelihood of shark attack is a very real concern to all airmen who fly over water, for there is no longer any question that sharks are a grave danger to anyone exposed to them.

Concern and worry about the possible presence of sharks is expressed in a large proportion of the narratives, particularly those of survivals in tropic waters, but of the 2,500-odd accounts examined, only 38 mention actual contact with sharks, visual or otherwise, and only 12 of these resulted in casualties or injuries from sharks. As these figures are based only on the accounts of survivors, they can be misleading. When sharks are successful, they leave no evidence, and the number of missing airmen who may have succumbed to them cannot be estimated.

A man in the water is usually so helpless against sharks, and the consequences of shark attack are so gruesome and horrible to contemplate, that nobody exposed to the possibility of it can banish it from his mind. Mere statistics are no comfort, for shark attack is always a possibility to be dreaded, no matter how remote and unlikely.

Knowledge of the behavior of sharks towards humans in the water or on rafts has long been largely speculative, and the literature on the subject, both popular and technical, is full of contradictory evidence and opinions. Because of the seriousness of the problem, the absence of any readily available and authoritative reports on the subject, and the paucity of information in the airman's survival accounts, other sources have been used freely in this analysis of the shark menace to men in the water or on rafts.

KINDS OF SHARKS. Very few of the survivor accounts describe the sharks involved in enough detail to identify them accurately. To the man in the water the specific identity of the shark swimming near him is of little importance. Though some of the largest sharks, such as the whale shark and the basking shark, are plankton feeders not able to prey on man, size is the main concern when a shark is encountered. Any shark large enough to hurt a man must be considered dangerous, and that means any shark more than 3 or 4 feet in length.

Of the more than 325 species of sharks known to exist, only a score or so, belonging to eight genera, are known to attack or to be capable of attacking man. The most dangerous sharks are those of the genus *Carcharodon*, which includes the great white shark and several other large so-called "man-eaters." Other species commonly implicated in shark tragedies include the tiger shark, the mako shark, the mackerel shark, the sand shark, the hammerhead, and the gray nurse.

Distribution. Sharks are found in all oceans and seas of the world. Many species live and feed only at considerable depths. Others remain constantly

at higher levels, and it is these "cruising sharks," which hunt near the surface, and whose high dorsal fins frequently project above the water, that come most frequently in contact with man. While found commonly in the open ocean, sharks often enter relatively shallow waters, and may even ascend river mouths.

While by no means rare in high latitudes—several kinds are common in the Arctic and in the Antarctic—only those inhabiting warmer waters are implicated in human tragedies. Shark attacks on humans are restricted, by and large, to the seas and oceans between 40° N. and 40° S. latitude. One reason for this may be that men are seldom exposed to sharks in frigid waters. Another reason is that the shallow water and surface sharks as a group are more abundant and more active where water temperatures are 68° F. (20° C.) or higher. The authentic records of shark attacks north of 40° N. are generally limited to the warm summer months. The evidence shows the sharks in tropic and subtropic seas to be far more aggressive than those in temperate waters.

Feeding Habits. The normal diet of nearly all sharks consists of living animals. All have voracious appetites, and many will turn scavenger. They may travel singly or in packs, and are guided to their food by sight, scent, or sound.

Cruising sharks apparently investigate all floating objects, and are prone to strike at injured or helpless animals, although healthy prey are their normal food. Their sense of smell is highly developed, and it is generally conceded that the presence of blood in the water excites them. They are extremely sensitive to vibrations transmitted through the water, and abnormal impulses such as those made by a fish fighting against a hook and line or by the struggles of an injured or dying animal or a poorly coordinated swimmer, even the rapid, excited progress of another shark approaching food will draw them from a greater distance than the scent of blood. They are known to be drawn by unusual noises such as underwater explosions.

A popular fallacy often encountered is that a shark must turn on its side or back in order to bite. Those sharks whose mouths are well back under the head may turn partly on their sides to reach prey on the surface, but they do not have to. When a shark opens his mouth and dashes forward to strike, he arrives mouth first, the front of him is all mouth, and he can bite a man from almost any position. The jaws of the great white shark and several other species are so far forward that the animals can bite floating objects easily without twisting on their sides.

Man-eating sharks are frequently described as capable of severing a man's body or limbs at a snap, and are even credited with being able to swallow a man whole. Again the white shark (and several others) have such large, sharp teeth and powerful jaws that they may be able to bite off a man's leg or arm, but they are more apt to worry their prey and tear off pieces small enough to swallow easily. They can and will tear great gashes in a man's torso, and remove large chunks of flesh at a snap. Most of the injuries inflicted by sharks are half-moon incisions, often with good impressions of the smaller teeth left in the untorn flesh. A remarkable aspect of shark bite is the high percentage of those who have survived being bitten who are unable to recall feeling any pain from the bite at the time.

Sharks may hunt and attack singly, but most accounts speak of more than one present at a time. The small sharks are particularly apt to occur in schools and to attack in numbers. When a shark finds a victim he is joined at once by all the others in the vicinity. Most are cannibalistic, and will attack and eat their disabled kin as readily as any other prey.

Sharks are known to feed at all hours of the day and night, but the evidence on whether as a group they are more dangerous to man in daylight or darkness is somewhat contradictory. Undoubtedly the different species vary considerably in this respect. Commercial fishermen have found some kinds of sharks to be more active and more easily caught at night. The survival narratives reveal the preponderance of shark contacts and attacks to be made during daylight, a high percentage of them in the late afternoon. Some of the accounts, as will be seen, emphasize the fact that sharks were a menace during the daytime only, and "after dark we had no more trouble." A British Shallow Water Diving Unit at Nassau, Bahamas, spent "perhaps about 4,500 man-hours in the water at night without any serious accidents occurring."

Yet night attacks are reported, though there is room for doubt in many of them that sharks were

the culprits. Certainly fear of shark attack is a far greater mental hazard to a swimmer at night. As the British Unit at Nassau expressed it, "Swimming at night in shark-infested waters is a totally different problem because you lose that tremendous morale-uplifter, viz., underwater vision."

The superstition that sharks can sense death appears in the narratives quite frequently. Rickenbacker remarked that after the death of one of his crew, sharks appeared in greater numbers. A 9-day survivor in the Gulf of Mexico reported that sharks took his companion's body from the raft shortly after he died. Ensio Tiira in RAFT OF DESPAIR tells of the savage and persistent attack by sharks on the body of his companion which was lashed to the raft. Men were hesitant to commit a body to the sea and sometimes delayed doing so for 1 or 2 days; some feared it would attract sharks, and none wished to witness the inevitable mauling of the body. For these reasons, the best time to conduct burials was at night. Those who hesitated in disposing of the dead endangered their own lives.

LIKELIHOOD OF ATTACK. No way exists of telling whether or not a shark will attack, and the survival narratives as well as all other authentic accounts show wide discrepancies in shark behavior under almost identical circumstances. The French skin-diver, J. Y. Cousteau, who has probably had as much firsthand experience with sharks as any man alive, aptly sums up the evidence in THE SILENT WORLD (Harper and Brothers, N. Y.):

"From the data, covering over a hundred shark encounters with many varieties, I can offer two conclusions: The better acquainted we become with sharks, the less we know them, and one can never tell what a shark is going to do."

The following excerpts from the narratives illustrate some of these contradictions. Men have spent hours in the water among sharks without being touched, and in view of the evidence some of the escapes seem little short of miraculous. The one feature all the accounts illustrate is the fact that, though clothing cannot be depended on to prevent attack, sharks are more apt to bite a bare than a clothed body.

A Navy pilot who ditched off Kikai-Shima in the northern Ryukyus entered the water fully dressed except for his shoes, and was supported by a Mae West for the 1¼ hours he remained in the water before rescue:

"Fifteen minutes after landing, W. discovered a shark about 6 feet long, 5 to 6 feet below the water and directly under him. The shark made no runs at him and W. took no affirmative action except to swim easily which was all that was necessary in order to stay up in the water . . . A second shark about 10 to 12 feet long was not noted until the last 20 minutes before pickup. It might have been around during the whole period but W. did not see it until it was about 5 feet away and after it had come to the surface when the dorsal fin and tail projected above the water. At this time he used dye to indicate his position to the approaching plane, and while holding in the dye, the second shark swam through the discolored area with no indication that it saw W."

Another pilot swimming ashore in the Southwest Pacific had at least four sharks come within 25 yards of him, and not one of them made a determined attack. The amount of clothing he wore is not mentioned in his story:

"I left the raft at 1000 because I could see the shore . . . after a 2-hour swim I seemed to be a little closer . . . a few minutes later while swimming on my back I looked to my left and about 3 feet away I saw a shark's fin and he was swimming along beside me. He then turned into me so I rolled over quickly and pushed him away with my right arm. He went out in front of me a few yards and did a 180-degree turn and came back under my stomach. I thrashed the water with arms and legs and I think I scared him away. . . . About 2 hours later there were two of them about 25 yards behind me, and seemed to be following me. After another hour of swimming I saw a splash and a shark's fin in front of me and about ten yards to my left. . . . I began to realize it was a swim for my life, so made up my mind not to get panicky but to keep plugging along until I got there, or the sharks got me."

A Navy ensign who parachuted into Philippine waters off Cape Engano during the carrier strike in October 1944 was just as lucky:

"D. hit the water on his back. He received quite a jolt but was able to untangle himself and get out of his shoes and back pack. He found his liferaft had shaken off when his parachute opened. The front half of his life jacket had a rip in it and the back half had to be inflated orally every half hour. . . . As he swam his socks gradually worked off, leaving his feet as a lure for sharks . . . which promptly put in an appearance. He was shadowed by about four sharks, 4 to 5 feet in length. They did not bother him as long as he continued to kick. As soon as he stopped to rest, one of them would make a pass at him. All of these were dry runs except one in which the shark grazed his legs and left tooth marks. He was picked up by a destroyer after 8 hours in the water."

A Naval officer who spend 12 hours in the water off Guadalcanal after his destroyer was sunk had a very fortunate escape from sharks. He entered the water wearing a kapok lifejacket, but without trousers, shoes, or socks. He supported himself through the night by hanging to two aluminum powder cans about 2 feet long and 5 inches in diameter. At dawn he was relaxed and floating in the water when he felt a scratching, tickling sensation in his left foot:

"Slightly startled, I . . . held it up. It was gushing blood . . . I peered into the water . . . not 10 feet away was the glistening, brown back of a great fish . . . swimming away. The real fear did not hit me until I saw him turn and head back toward me. He didn't rush . . . but breaking the surface of the water came in a steady direct line. I kicked and splashed tremendously, and this time he veered off me . . . went off about 20 feet and swam back and forth. Then he turned . . . and came from the same angle toward my left . . . When he was almost upon me I thrashed out . . . brought my fist down on his nose . . . again and again. He was thrust down about 2 feet . . . swam off and waited. I discovered that he had torn off a piece of my left hand. Then . . . again at the same angle to my left . . . I managed to hit him on the eyes, the nose. The flesh was torn from my left arm . . . At intervals of ten or fifteen minutes he would ease off from his slow swimming and bear directly toward me, coming in at my left. Only twice did he go beneath me. Helpless against this type of attack I feared it most but because I was so nearly flat on top of the water, he seemed unable to get at me from below . . . The big toe on my left foot was dangling. A piece of my right heel was gone. My left elbow, hand, and calf were torn. If he did not actually sink his teeth into me, his rough hide would scrape great pieces off my skin. The salt water stanched the flow of blood somewhat and I was not conscious of great pain." [In the excitement of trying to attract the attention of a ship going by, the officer forgot the shark, which struck again and bit into his thigh, exposing the bone. At this point he was seen, and several sailors with rifles on the ship began firing at the shark.] "A terrible fear of being shot to death in the water when rescue was so near swept over me. I screamed and pleaded and cried for them to stop. The shark was too close. They would hit me first."

Clothing and a pair of binoculars were apparently the decisive factors in the 16 hour survival of Lieutenant (j.g.) A. G. Reading who had to ditch when the engine of his S2N failed 68 miles east of Wallis Island in the Central Pacific. He was knocked unconscious by the impact, but his radioman, ARMC E. H. Almond, managed to lift him from the cockpit, and put on and inflate his lifejacket for him before the plane sank. Here are the significant parts of Lieutenant Reading's report:

"After I came to, A. told me the plane had sunk in 2 minutes and that he didn't have time to salvage the liferaft. He pulled both our 'dye markers' and had a parachute alongside of him. He did not have any pants on at all except for shorts. . . . We soon lost the chute and began drifting away from the dye. It was within a very short time (about ½ hour) when sharks were quite apparent swimming around us. A. and I were tied together by the dye marker cords and it made it difficult to make any headway. An hour later we heard aircraft and I said to A., 'Let's kick and splash around to see if we can't attract their attention.' It failed, but suddenly A. said he felt something strike his right foot and that it hurt. I told him to get on my back and keep his right foot out of the water, but before he could, the sharks struck again and we were both jerked under water for a second. I knew that we were in for it as there were more than five sharks around and blood all around us. He showed me his leg and not only did he have bites all over his right leg, but his left thigh was badly mauled. He wasn't in any particular pain except every time they struck I knew it and felt the jerk. I finally grabbed my binoculars, and started swinging them at the passing sharks. It was a matter of seconds when they struck again. We both went under and this time I found myself separated from A. I also was the recipient of a wallop across the cheek bone by one of the flaying tails of a shark. From that moment on I watched A. bob about from the attacks. His head was under water and his body jerked as the sharks struck it. As I drifted away . . . sharks continually swam about and every now and then I could feel one with my foot. At midnight I sighted a YP boat and was rescued after calling for help."

Unique in shark annals is the 31-hour survival of an Ecuadorian flight officer who, with two companions, ditched off the coast of Ecuador on a flight between Esmereldas and Salinas. The three men removed their clothing before entering the water; all had life vests. One man was hurt and bleeding freely from the nose.

"All this occurred Thursday approximately between four and five of the afternoon. Then placing myself between them so that they could take hold of the harness of my life preserver we proceeded swimming. . . . Later night fell and the desperation and terrification of my companions was increasing progressively as the sea in that section is very rough and the waves caused my companions to swallow water as they had absolutely no control. It was there that my Colonel B., at a time estimated by me some five hours after the moment of the accident, died.

"Afterwards putting the corpse, which floated perfectly, in front of me I continued pushing it, with the objective of taking it out . . . if we managed to reach land. When I had pushed the corpse of my Colonel ahead of me in order to swim to it again, a strange force dragged the body and I did not again see it in spite of searching a long time among the waves. Sub-Lieutenant D., who was

still living, and who had hold of me, made me reflect that it was foolish to wait longer and I continued toward where I believed the coast to be. Sub-Lieutenant D. lived perhaps four or five hours more until at the end, after having had moments before his death of a state of despair which is very painful to narrate, he died. Taking the same attitude as toward that of the corpse of my Colonel, I put the body of my companion in front of me and continued pushing him but not as far ahead as I had done previously with the other corpse. As it was a moonlight night, and during some moments very clear, I was able to observe that strange figures crossed very close to us, until at a given moment I felt that they were trying to take away the corpse pulling it by the feet, on account of which I clutched desperately the body of my companion and together with him we slid until the tension disappeared. . . . Once refloated, with despair I touched his legs and became aware that a part of them was lacking . . . and continued swimming with the now mutilated corpse until the attack was repeated two times more and then, terrorized at feeling the contact of fish against my body, turned loose the corpse . . . convinced that I would be the next victim until daybreak occurred. As soon as it was light I could see the coast at a great distance but I had no hopes of reaching it because with the light of day I could clearly see that various sharks were following me. . . . When I moved my legs slowly, with the object of resting, I touched with my feet the bodies of these animals which were constantly below mine in order to attack me. I would then thrash the water and thus for a few moments the danger would pass. I continued swimming all day Friday until at sundown I found myself some four or five hundred meters from the rock on the coast, and as I was already tired . . . because of the undertow which existed I could not reach the rocks until after making a superhuman effort . . . at which hour I do not know . . ."

The longest shark survival incident occurred in the Pacific and lasted 42 hours. Eight of the 12 men who survived the ditching were fully clothed although some removed or lost their shoes after entering the water. They held themselves up with a salvaged wing float and a sleeping bag, and in addition lashed themselves together. Later, they found a package of emergency food, a blanket, and a thermos half-filled with water. One of the survivors was located by the firing of his .45 automatic, and as he swam towards the group, his companions cautiously watched his approach for fear that he was out of his mind and might shoot them. One man died and his life vest was taken by another who had none. About this time, sharks appeared and the men tried to drive them away by shooting and kicking. Although they were not bothered particularly by sharks during darkness, they continued kicking. At daybreak, one man was bitten slightly, became frightened, and died during the second night. Two others became delirious and had to be protected because they made no effort to help themselves. At 0500 of the third morning, the remaining six men were rescued by a passing merchant vessel whose lookout reported sighting a rocket, although none was fired. The rescuers were greatly agitated by the presence of sharks among the survivors, one of whom noted it and remarked: "We got a kick out of it."

Sharks and Liferafts. Almost all the reported casualties from shark attack were of men in the water, swimming or supported by a lifejacket, but there were exceptions, and men on liferafts were by no means immune to attack.

In practically all the raft narratives reviewed, the survivors had time enough to reach the safety of their platform before the sharks appeared. In 11 of the 38 accounts reporting the presence of sharks, the sharks appeared within 30 minutes after the men had taken to the water. In 36 accounts sharks appeared in the first 24 hours. In some accounts of long duration in tropic waters men reported their first and sometimes only shark on the 4th, 9th, or even 13th day.

Sharks were rarely noted until they came to the surface, usually some distance from the raft, "lazily cruising around." On approaching the raft, most sharks submerged and swam underwater before reappearing on the surface. In very few incidents did sharks approach the raft directly on the surface unless there was vomit or blood in the vicinity of the raft. In these instances, survivors remarked that the sharks appeared excited and "made passes at the raft."

"About 1000 I saw a large fin . . . come toward the life raft along the streak of the dye marker. It disappeared some distance away, . . . shortly afterward reappeared . . . and swam directly toward the raft, approaching quite close, it submerged and swam directly under the raft . . . it was about 12 feet long. It rolled over and reappeared on the other side . . . we all sat very quiet, stopped bailing out the bloody vomit, and the radar man abandoned the idea of defecating over the side for fear of capsizing. The shark repeated this behavior several times at varied intervals but at no time seemed concerned with us or touched the raft."

In another case, this one off Japan in June, after the survivors had been vomiting into the water for about half an hour, eight sharks made passes at the raft as if to upset it. Although the

men fired some 30 rounds of .38 caliber at them, it was another 1½ hours before the sharks left.

Sharks sometimes remained under the raft day and night, and often bumped against the raft bottom. Off Iwo Jima in early summer:

"The raft was followed a great part of the time [10 days] by sharks . . . frequently close enough to cause fear of upset . . . On two occasions . . . shot a shark from above . . . each time, the shark sounded and did not bother them again. These fish came close enough so that they could almost be touched. Aside from the nuisance, they did not bother the raft."

The mere presence of sharks close by can be unnerving. They exerted enough force against the raft deck at times to lift the occupant 3 or 4 inches into the air; this was painful to those whose buttocks ached from raft drumming, and made sleep impossible.

One 17-day group of survivors stated that sharks never left them, and became increasingly bolder, leaping out of the water and spraying the occupants, or battering the soft deck fabric with their tails while trying to stun the fish under the raft:

"Late in the afternoon a shark about four feet long struck at the raft and going right over my shoulder slid into the raft. It took a bite out of C. One of the men and myself caught the shark by the tail and pulled him out of the raft. C. became delirious and died about four hours later . . . "

Sharks habitually follow floating objects because the smaller fish on which they feed take refuge in the shadows. Several survivors commented that the sharks' interest in the raft was not for its occupants, but for the fish that clustered beneath it:

"I believe that it was feeding on the small fish in the shade of the raft. There might have been more than one shark. After the animal demonstrated its benign attitude toward us, our chief concern was that it would abrade our boat with its hide and deflate it, or that it would accidentally capsize us . . . Its approach was heralded by panicked flights of flying fish. . . . It was always chasing fish out into the open and feeding on them."

An F4U pilot who spent 9 days in a raft drifting from Rabaul to Bougainville wrote:

"From practically the first day, sharks were continually hitting up against the boat trying to get the small fish under it. I was quite scared at first, but soon got accustomed to it when I learned what they were after."

Recognition of this aspect of shark behavior gave the man in the raft some comfort and helped make the situation bearable, borne out by such remarks as "Sharks around all the time—no bother," and "he never came very close and did not constitute a problem." But though men sometimes achieved a sense of confidence toward sharks, situations developed which sorely tried their faith:

"He never came very close and did not constitute a problem until two unidentified planes appeared on the horizon at 1,000 feet and coming toward us. We were just debating which was worse, sharks or a strafing by Japs, when they veered off. A few hours later a submarine appeared, and again we debated whether to go overside with the shark or sweat it out in the raft."

"Half a dozen sharks were with me day and night. Only one, however made an attempt to attack, and it was a small one about 4 feet long. Most of them that I saw were at least 6 or 7 feet in length. My lone would-be attacker rolled over on its side and turned almost belly-up to get into position to bite. I could see its curved mouth, ugly teeth, and beady pig-like eyes . . . fortunately he failed to carry out his attack."

Although a few men became accustomed to sharks around their raft, all raft occupants regarded them at least with suspicion if not with fear, and tried in one way or another to drive them away. All expressed relief at their departure.

Though most men remained quiet when a large shark cruised nearby in hopes they would not be noticed, some tried to drive away smaller sharks circling around them by spanking the water with their paddles. In several of these cases the sharks were attracted to the paddles and tried to bite them. The interrogators usually interpreted this reaction as one of attack, but few of these incidents can be regarded as an unprovoked or deliberate attack on a liferaft by a shark.

Several incidents where men on rafts shot at sharks have already been mentioned. One of the most informative personal narratives in this regard is that of a Navy fighter pilot who was forced down in St. George's Channel between New Britain and New Ireland during the Rabaul strikes, and spent 8 days in his dinghy before being picked up by a Dumbo off Cape St. George. He was able to inflate and crawl into his raft a few minutes after ditching. He vaguely remembered something striking his foot while he was in the water. He then noticed he had lost the heel and part of the back of his left shoe, and from the scratches on the shoe hazarded a guess that a shark had bitten it off, though he saw no sharks at all until sundown of his third day when:

"There was a constant cloud of minnows following the boat at all times. I believe they fed on the minute marine life that collected on its bottom, sides, etc. That night larger fish came to feed on those minnows, then larger ones to get them; finally the boys with the peculiar dorsal fins arrived to see what the fuss was about. There were three of them that I could see.

"Finally one of them flashed directly under the boat hitting it with his back. He then turned and started striking it with his head. About the third time he came up to the boat slowly right on the surface and I shot him through the head from point-blank range. He thrashed for nearly a minute, then I could see him sinking down. The others did not touch him. One other shark still stayed about 10 feet away and I fired at his fin scaring him off. After it became dark I had no more trouble.

"That night [his 5th] I shot another shark and tried to bring him aboard, as I'd heard their liver, heart, etc. were good, but he was too slimy and still thrashing around slightly so I gave up. I also found that their hide was like 00 sandpaper!

"[At sundown on his 6th night] The usual ruckus of feeding fish started around the boat and shortly afterwards the sharks arrived. After swimming directly under the boat several times and hitting it with his back and fin, one large one, about seven feet (formerly the sharks had averaged about four to five feet) came to the surface and started to bump the boat with his nose.

"This had become a rather commonplace procedure with me by this time and I put the .45 about six inches from his head and was about to give him his iron for the day. The gun would not fire as the slide had rusted and wasn't all the way forward. Frantically I tried to push it home as the shark unmolested started banging my boat in earnest. Finally, in my excitement, I ejected the shell and it landed in the bottom of the boat and cleverly concealed itself under some other gear there. By now the shark was going beserk (evidently smelling me) and coming up underneath the boat and knocking us both completely out of the water. It then came to the surface again and made rushes at me, spinning the boat completely around 360 degrees several times.

"During all this I was holding grimly on and although I have no recollection of it, undoubtedly screaming! He came to the surface again, lay on his back, and began snapping at the boat. Never was I so grateful to Mother Nature for the placement of his mouth. I'd given up trying to load the .45 and was swinging it by the muzzle at him. I smashed him in the eye, on 'his very vulnerable nose', and his 'soft' belly. He turned over then and I started to pound him on the top of the head. He was as hard as steel there, and I later discovered I'd partially flattened the little steel eyelet on the butt of the gun where the lanyard is attached. He rolled over again still snapping at the boat and I remembered a capsule of chlorine I had so I tried to get it out of my pocket, with no success. I had dropped the gun and was searching my pockets with one hand and was hitting my voracious friend with my other fist. In that ill-advised action, I got two fair-sized splits in my forefinger, when one of his snaps and one of my blows became beautifully timed.

"Giving up the chlorine idea I seized the dye marker can and dumped some of it in his face, and the action ceased. The whole action had lasted from five to ten minutes. Whether the shark realized I was in the boat or whether he was merely venting his rage on this strange yellow object I will never know, but he made a savage and sustained attack and the ultimate end would have been the same, mine!

"After his departure I took stock of the situation and was depressed beyond all hope. The bottom of my boat had eighteen holes in it. One was a slit about four inches long, another a round hole about the size of my fist. The rest were assorted shapes and sizes, all smaller. This was not so bad, but at the small end of the boat in the inflated part there were five slits all leaking badly. I must confess I gave up and believing I was doomed, drank all my remaining water thinking that at least I didn't need to be thirsty any longer.

"[The 7th evening] My gun worked OK and I killed or badly wounded two sharks and had no further trouble. . . .

"After my first encounter with sharks, I never even considered going over the side of the boat to avoid strafing. . . . After the skirmishes with the sharks I'd have about five or ten small minnows in my boat and tried eating them. I thought they were better than the pemican."

ANTI-SHARK MEASURES. Early in World War II the menace of sharks to survivors at sea was not fully appreciated. Authenticated cases of shark attack were rare, particularly in temperate waters, the little available evidence was contradictory and indecisive, and military authorities gave the matter scant attention. The first survival manuals and overwater briefings limited their comments on sharks to the effect that they are a "negligible danger." They described the shark as "slow-moving, cowardly, and easily frightened off by splashing." They reassuringly stated "The shark is a wary fish, suspicious of noise, movement, and unfamiliar forms. This trait alone would restrain a shark from attacking a swimming person."

As the war progressed, the sharp increase in the number of reported and authenticated cases of shark attack on humans after ship disasters and aircraft ditchings gave rise to official concern. Fear of sharks was becoming a morale problem among aircrews operating in tropic areas, which no amount of reassurances could allay in the face of the mounting evidence.

The Services now made strong efforts to develop protective measures against sharks. They followed two main courses of action, first instruction and training in defensive and evasive tech-

niques based on analysis of shark habits and behavior, and second the development of a shark repellent. While neither course was entirely successful in eliminating the shark hazard, both contributed greatly to boosting morale. It is of value to inspect the various recommendations made and the devices tried in the light both of the evidence in the narratives and of other recent investigations with sharks, particularly the observations of the skin divers.

Sound. The use of noise to drive away sharks has repeatedly been recommended. Manuals and bulletins published early in World War II contain such statements as "The shark is a wary fish, suspicious of noise . . . the commotion caused by dropping in the water and freeing the parachute will probably scare all sharks away . . . sharks are cowardly and are easily frightened off by splashing."

Splashing was the method most frequently recommended for making noise, and though the record shows that it was effective at times, it was just as often ineffective, and in some instances attracted instead of repelling the sharks, especially when made by the inept efforts of poor swimmers to move through the water. The British Shallow Water Unit at Nassau, Bahamas, after observations made during several thousand man-hours spent in shark-infested waters, recommended strongly that splashing be avoided when sharks are near, and that all swimming movements be made smoothly and easily.

The myth that underwater explosions will drive sharks away was contradicted by the observations of the British Unit at Nassau:

> "We threw TNT blocks into the water, and within five minutes of the explosion the area was full of sharks feeding on the dead fish. They averaged about 6 feet, the biggest being 8 feet. It was a remarkable sight. . . ."

Yet certain sounds apparently are effective in repelling sharks. One of the earliest records is the report of three survivors of a German submarine sunk off West Africa in 1943. They were attacked and bitten by sharks, but by submerging their heads and "roaring," they succeeded in frightening the sharks away.

The skin diver, Hans Hass, has much to say about shark's reaction to the human voice in his DIVING TO ADVENTURE (copyright 1951 by Doubleday and Co.). He found that he could usually drive overly inquisitive sharks away by shouting at them but that the method was not infallible. "The important thing is always to have enough air left in your lungs for a good underwater yell—and to keep away from sharks that happen to be deaf to human shouts."

Suggestive of the need of further research in the reaction of sharks to sound, and the possibility of developing a noisemaker which will produce frequencies they will avoid, is the narrative of a raft-rider in the wester Pacific who described how several sharks made high speed runs on his raft, only to slow up at the last minute before bumping their noses against the raft's sides. In desperate fear of being thrown into the sea, he rubbed his fingers along the inside of the raft. This produced a high, squeaky noise which apparently caused the sharks to swim off.

Color. In shark lore is an old belief that sharks are unable to see dark objects. From this came suggestions that clothing and lifesaving equipment should be painted black. The belief is almost legendary, and goes back to old sailors' tales of slave-trading days, which claimed sharks would not attack a negro. West Indian negroes today still blacken their palms and the soles of their feet, which are lighter than the rest of their bodies, before swimming in shark-infested waters.

It is questionable whether sharks are able to see light colors better than dark ones, and it is doubtful that color has any effect in preventing shark attack. In experimenting with the attractiveness of various baits (oily, bloody fish was found the best) professional shark fishermen found "The use of a cloth bag to hold bait does not affect the attractiveness of the bait one way or another, and there is no apparent difference in result from bags of white cloth or black cloth." Nevertheless, the blue color of the underside of the liferaft was popularly and officially believed to act as a deterrent to shark attack. However, none of the narratives gives any evidence of sharks reacting any differently to the blue or the yellow side of the raft.

The evidence of color being an effective element in the various chemical shark chasers developed during the latter part of World War II is inconclusive. The scent carried in the dye (see below) was supposed to be the functional ingredient of the repellent, but almost all the survivors who commented on it considered its inky discoloring of the water equally if not more important.

In the absence of shark chaser, many survivors

put their faith in sea-marker dye. The several reports of its use in the narratives are contradictory. One pilot who successfully discouraged the sharks around his raft during a 10-day ordeal in the South Pacific by dumping dye into their faces commented "They didn't like that stuff at all." Another, a swimmer, on perceiving a 12-foot shark swimming with its fin and tail above water about 5 feet from him, released his dye packet, and the shark swam around for some 20 minutes in the discolored water with no indication of seeing the swimmer before it departed. On the other hand, several accounts speak of sharks swimming unconcernedly through the dye and refusing to leave, and two state specifically that sharks came through the dye to snap at their paddles.

Two accounts mention the success of a unique practice in which color may have played a part. An airman whose dinghy was trailed by a shark for several days in the Yellow Sea finally tore up his copy of *Survival at Sea* and threw the fragments in the water. The shark swam after the paper and eventually disappeared. A 5-man crew who swam together after bailing out over a 4-mile expanse of the South Pacific reported that sharks were attracted to them shortly before their pickup. They kept the sharks at bay by kicking, and finally drove them away by ripping up two *Survival Manuals* and scattering the paper in the water.

Odor. The sense of smell in sharks is highly developed and very acute. Odors in the water play an important role in leading them to their food and will attract them considerable distances. Commercial shark fishermen have proved this again and again, and made use of it in luring sharks to their nets and hooks. When efforts were being made to develop an effective shark repellent, odor was considered to be the most promising approach to the problem.

Fliers in the South Pacific apparently reached the same conclusion. Fighter pilots in that theater began to use their halazone tablets for a shark repellent as early as 1943. The active ingredient in halazone tablets, which were issued for purifying drinking water, is chlorine. The fliers placed one or more tablets in a small, perforated, plastic water bottle which they swished around in the water. Though there is no evidence that the practice was proof against shark attack, the survivors considered it worthwhile, and the halazone tablets were shortly replaced by a larger, more highly-concentrated, standard "Chlorine Shark Capsule."

Meanwhile under more careful experimental conditions, chlorine and hundreds of other chemical irritants and fish poisons were being tested. None proved to afford complete protection, but copper acetate was found the most efficient and promising of the substances tried. With it as a base, the Shark Chaser currently in use—a 9-ounce packet of copper acetate and nigrosine dye in water-soluble wax—was developed in 1944 and issued as part of all Mae West and liferaft equipment. In field tests this Shark Chaser repelled 45 to 100 percent of the sharks lured to a bait of fresh fish, and seemed most effective as an inhibitor against those species most closely allied to the sharks known to attack man.

Unfortunately the narratives provide no evidence of Shark Chaser used under survival conditions with sharks present. Skin divers who have used it put little faith in it (see p. 73). The only test it has received under conditions closely allied to a survival situation is its use by the British Shallow Water Diving Unit at Nassau, which reported: "The use by us of shark repellent (copper acetate) did not prove anything. It does not seem reasonable to suppose that a shark in the fury of an attack would pause or retreat from its headlong rush for food because it did not care for the smell of the repellent. Again if the repellent were effective it would be only so down tide."

Beyond question the greatest value of the Shark Chaser was the mental relief and sense of security it afforded the men who had it on hand.

Anti-Shark Weapons. Much advice was given in the early manuals—from which it is still being copied in current editions—on how a swimmer can defend himself against a shark. They recommend "striking him on his tender, vulnerable nose, in the eye, or knifing the more vital gills . . . swim out of the line of his charge, grab a pectoral fin as he goes by, and ride with him as long as you can hold your breath. If you can attach yourself to him, the shark may lose his viciousness and become his usual cowardly self. If you have a knife, cut the shark's belly open. By opening the shark's belly you let water inside; this will kill him almost instantly."

An accomplished swimmer in the best of physical condition might be able to carry out some of these recommendations, but heartening as such fight-talk might be from the morale standpoint, no downed airman hampered by clothing and life

preserver could possibly carry out such a counter-attack. Nevertheless, many overwater fliers carried "shark knives" for moral support, and though the narratives contain only one record of their being used against sharks, it was not uncommon for a survivor to have two of them on his person.

The only humans capable of competing with sharks in the water are the skin divers who have developed since the war the mechanical means of observing sharks in their natural habitat with a minimum of discomfort and an increased sense of confidence. The factual accounts of the British Unit at Nassau show how difficult it is for a man in the water to kill a shark or to injure it enough to render it helpless:

"Several sand sharks [not considered dangerous] have been speared by members of the Unit. The skin is very tough and the only way of getting a spear into them is by driving it into one of his gill slits, or else by using the appropriate heavy duty spear . . . M. and I broke our spears on 4-5 foot sand sharks found in holes in the coral. Striking with all our force we failed to penetrate the hide. . . . Lt. M. has told me that when a shark comes in to investigate or attack if you can manage to hit him across the snout, or even touch his body with a spear, he will then probably be scared off. A shark of 10 feet or over has a big turning circle, and a man who is much more maneuverable in the water . . . should try and keep inside his turning circle."

The most recent and authoritative word on the efficacy of anti-shark weapons comes from J. Y. Cousteau, who recites (THE SILENT WORLD, Harper and Brothers, N. Y.) his experiences when he and a companion 60 feet below the surface were pressed closely by an 8-foot gray, later joined by two 15-footers and several blue sharks, which they had difficulty in keeping from attacking:

". . . above us flying fish gamboled, adding a discordant touch of gaiety to what was becoming a tragedy for us. Dumas and I ransacked our memories for advices on how to frighten off sharks. 'Gesticulate wildly,' said a lifeguard. We flailed our arms. The gray did not falter. 'Give 'em a flood of bubbles,' said a helmet diver. Dumas waited until the shark had reached his nearest point and released a heavy exhalation. The shark did not react. 'Shout as loud as you can' said Hans Hass. We hooted until our voices cracked. The shark appeared deaf. 'Cupric acetate tablets fastened to leg and belt will keep sharks away if you go into the drink,' said an Air Force briefing officer. Our friend swam through the copper-stained water without a wink. His cold, tranquil eye appraised us. He seemed to know what he wanted, and he was in no hurry.

"We did not believe in knifing sharks, but the final moment had come, when knife and camera were all we had. I had my hand on the camera button and it was running, without my knowledge that I was filming the oncoming beast. The flat snout grew larger and there was only the head. I was flooded with anger. With all my strength I thrust the camera and banged his muzzle. I felt the wash of a heavy body flashing past and the shark was twelve feet away, circling us as slowly as before, unharmed and expressionless.

"After seeing sharks swim on unshaken with harpoons through the head, deep spear gashes on the body and even after sharp explosions near their brains, we place no reliance in knives as defensive arms. We believe better protection is our "shark billy," a stout wooden staff four feet long, studded with nail tips at the business end. It is employed, somewhat in the manner of the lion tamer's chair, by thrusting the studs into the hide of an approaching shark. The nails keep the billy from sliding off the slippery leather, but do not penetrate far enough to irritate the animal. The diver may thus hold a shark at his proper distance. We carried shark billies on wrist thongs during hundreds of dives in the Red Sea, where sharks were commonplace. We have never had occasion to apply the billy, and it may prove to be merely another theoretical defense against the creature which has eluded man's understanding."

SUMMARY. The following recommendations are drawn from the narratives and the more recent shark literature examined:

Swimmers should retain all clothing, particularly their shoes. The evidence shows that among groups of men the partly unclad are attacked first, and usually in the feet. Clothing and shoes protect the swimmer from abrasion by the shark's rough skin.

As aimless splashing will attract sharks, swimming movements should be smooth and easy. Slow, coordinated strokes that keep the swimmer riding horizontally on the surface where he offers a difficult target are the safest.

Several men together are in a better position to ward off sharks than a lone swimmer. They can maintain a constant 360-degree watch, and produce a greater striking strength.

If in danger of imminent attack:

- Conserve strength by keeping up just enough commotion to keep the attacker at bay. Time is on the shark's side.
- Try "roaring" under water.
- Release shark repellent if available. (Supplies should not be wasted, but kept until actually needed.)
- Kick and thrash at the attacker. If able to, hit him on the snout, eyes, or gills.

Men on liferafts, even the 1-man rubber dinghy, are relatively safe from shark attack. The presence of sharks around a raft is a natural situation, and must be accepted with tolerance as well as caution.

To discourage attention.

- Keep still and quiet.
- Do not jettison blood, vomit, or refuse from fresh-killed birds or fish.
- Keep hands, legs, feet, clothing, and equipment inside the raft.
- Do not trail legs or arms in the water at any time.
- Conduct all burials as soon as possible; if sharks are numerous wait for night.

If attacked:

- Shoot to kill if possible. Shots close enough to the water to produce heavy concussion may deter further attacks.
- Hit the shark with anything at hand—the heavier the better—on the nose or about the eyes. Use of the bare fist will cause more damage to the survivor than to the shark.

Miscellaneous Animals

WHALES AND PORPOISES. Whenever survivors on rafts encountered whales, as a number of them did, the presence of these large sea mammals disturbed them. The men's usual reaction was to pray and sit perfectly still in hope of avoiding further attention. All were so thoroughly impressed by the great size of the whales at close hand that they realized the futility of trying to drive them off with firearms.

The deep, long drawn-out sound of the whales' breathing was startling, and the playful slapping they make with their flukes sounded to many "like breakers." Several hearing it for the first time at night mistook it for surf and attempted to paddle towards it.

The evidence indicates that men on rafts have little to fear from whale attacks. Whales move leisurely when not alarmed, but their playful habit of nosing or nudging liferafts, mentioned in several narratives, gave rise to disquieting moments. Typical is the story of a pilot who spent 3 weeks on a raft in the Coral Sea:

"I had always wanted to see a whale and during the first week that wish was fulfilled six times. The first appeared on July 16th. I heard a noise like large rollers breaking on a beach. Looking in the direction of the noise, I saw two whales of the sperm or blackfish type. One was coming right toward my raft. He would roll on the surface of the water, blow, then submerge for almost 100 feet before coming to the surface to roll slow again. I tried to paddle out of his way but could make no headway in the heavy sea. I thought of shooting him but realized the shot would just enrage him. I put my pistol and paddles away, checked to see that all my equipment was secured to the raft, inflated my Mae West, and waited for the crisis. The whale came to the surface, put his nose to the starboard side of the rafe and pushed it about 10 feet through the water and then slid under the boat. He was about 40 feet long and, as slid under me, every inch of that 40 feet seemed like a mile. . . . He continued on his way, rolling and blowing as he went."

Porpoises also enjoyed butting rafts, but being much smaller than whales, did not cause as much concern. Survivors did not hesitate to drive them off by striking at them with paddles. "Porpoise butting" caused some annoyance, and even danger, as in one instance when a porpoise butted a 7-man raft with six survivors shoreward toward a Japanese-held beach.

The inability of most of the men to differentiate between porpoises and sharks makes it difficult to interpret the information in some of the narratives. "Early in the morning, porpoises came around the rafts. They didn't bother anyone but we were all frightened at first because we thought they were sharks." Confusion between these two sea animals is certain when the presence of both sharks and porpoises is reported. Most observers noted that when porpoises appeared sharks disappeared, and they frequently refer to the "welcome" appearance of porpoises, whose company they preferred to that of sharks. The men enjoyed watching the playful antics of porpoises, though feared they might accidentally land in their laps when jumping out of the water.

Although conclusive evidence is lacking, it appears that porpoises might harm men in the water. Swimmers at night have reported persistent "scraping or butting" of "large fish" against their bodies and legs. In one 15-hour swim, seven survivors reported that "large fish kept bumping us with inquisitive, hard noses and several were nipped." In another instance a swimmer was lifted clear of the water by a "large fish." These may have been porpoises, but there is no way of knowing.

LARGE FISH. Although few survivors could identify any of the various fish they encountered, they expressed their concern often towards what they called collectively "large fish." One 11-day

survivor stopped paddling at night after his hand accidentally struck a large fish. Another reported his raft collapsed at night when a large fish bit a hole in it. Still another wrote "Late in the afternoon the raft attracted the attention of a large fish . . . it ploughed into the raft full steam, upsetting it and puncturing the fabric." In this incident both occupants made the nearby beach safely.

The noises made by "large fish" were especially disquieting at night. These noises were usually found by daylight to have been made by whales breaching (leaping clear off the water), lobtailing (beating the water with their flukes), or simply turning over; often they were simply the blowing of one or more whales or porpoises.

Of the larger fish that were identified, the swordfish was most feared because of the damage its long, sword-like nose might do to the raft. Swordfishes were encountered quite often, as they bask habitually on the surface. Swordfishes have never been known to make unprovoked attacks, and all the survivors who encountered them sensibly avoided disturbing them, sitting quietly until they swam away.

Marlins and sailfishes, generally known as "spearfishes," have equally sharp snouts, and were held in the same regard. Most records of swordfish attacks on small crafts in the tropics appear to have been made by marlins:

"At dusk on July 18 I heard a very violent splashing off my port beam. I saw what appeared to be a fight between a marlin and a mackerel. The marlin was 7 or 8 feet long, had an 18-inch 'spike,' and apparently was trying to catch the 30-inch mackerel. The fight was one of the most violent actions I have ever witnesed. The two fish came directly toward my raft and the last time they jumped they were just 3 feet from me and I had visions of the marlin's 'spike' piercing my raft and leaving me on the ocean without a seat. God must have been with me, for the fish disappeared and I didn't see them again."

Tuna, bonito, or large mackerel were frequently reported in large schools and because of their numbers, large size, and rapid movements, most survivors preferred to keep clear of their paths.

Although airmen frequently expressed fears of barracuda, none of the narratives examined mentioned attacks by these predatory fish. However, shipwreck records provide sufficient proof of attacks of barracuda in the open sea. "The survivors swam surrounded by sharks and barracudas for 12 hours. There were many casualties. The sharks were worse but barracudas were more annoying as they bite more slowly." Again, "For five days we floated in the water. Barracuda tore at our feet." And, "Sharks and barracudas stalked the lifeboats, and the barracudas bit big chunks from the legs of men clinging to the sides of the boat."

Shipwrecked personnel have recorded another and little known menace—the bluefish (*Pomatomus saltatrix*). This fish of the warmer waters of the Atlantic rarely exceeds 20 pounds in weight. It travels in great schools "like a pack of hungry wolves" and its ferocity and cold-blooded murderous habits have earned it the name of "animated chopping machine." An attack by bluefish on survivors just north of the equator in longitude 26°W is described as follows:

"Men on the [ship's] raft were greatly bothered by the attacks of an extremely ferocious small fish less than a foot long and blunt-nosed. Sharks were around but were no bother. These small fish swam in schools and were very persistent. During the first and each successive night many men sustained deep bites. The bites were clean-cut and upward of an inch or more deep, mostly in the soles of the feet, although in some cases the fish sprang out of the water and bit into the men's arms. Frequently the bites resulted in severed arteries and many men died from this cause. The gratings and nettings of the rafts did not prevent the fish from attacking."

POISONOUS FISH. Though fear of fish poisoning was expressed by many survivors, the narratives contain no evidence of its occurence. Remarks were always general, and could be separated into two categories.

First, there were those who were aware that a number of fishes have flesh more or less permeated with poisonous substances. This group avoided all brightly colored or unusually shaped fish.

The second group were concerned with the use of leftover raw fish, and usually discarded it for fear of contracting ptomaine poisoning.

Present evidence indicates that poisonous fish are almost entirely limited to inshore waters, and are more properly a problem of land survival. The only known exception is the oilfish (*Ruvettus*), which may be caught in the open ocean, but normally at depths between 200 and 400 fathoms, far below the reach of raft fishermen.

BIRDS. Men on rafts and in the water were usually glad to see birds. They were always welcome company, and often a source of food (see p. 61).

Two incidents in the narratives, however, show that birds can cause anxiety. One pilot on a raft off New Ireland mistook an "albatross" standing

on a piece of driftwood for a shark fin, which gave him a few bad moments. The bird stayed near him several days; he became quite attached to it, and called it Albert.

The other case involved a swimming pilot who imagined himself under attack by hovering sea birds, grew panicky, and emptied his pistol at them before he calmed down.

REPTILES. Several survivors in the Coral and Arafura Seas reported seeing sea snakes, and one man in the South China Sea described a "great, brown, diamond-patched snake" swimming by his raft. Sea snakes are highly poisonous and use their poison to disable the small fish on which they feed. Fishermen sometimes catch them in their nets and by hook and line, but though reports of bites are rare, these snakes are not to be trifled with.

A few men encountered turtles without harm (see p. 62). One flier who spent 4 days on a raft in the South Pacific awoke from a doze "when the bottom of the raft was bumped, thinking he had scraped land. He looked and saw a large turtle. He pulled in the sea anchor which the turtle followed to the raft's edges. He tapped it on the nose with the paddle and it left."

One man who was tossed out of his raft onto a reef by heavy surf started to swim across the lagoon to the inner beach when he saw a crocodile "lying in the channel and partly on a coral outgrowth." Wisely he turned back, retrieved his raft, and paddled ashore safely.

INVERTEBRATES. The narratives contain surprisingly few references to invertebrates. In two accounts men reported being stung when they bailed out jellyfish that had washed into their rafts.

THE SEA AND THE SURVIVOR

Keeping Afloat

The vital necessity to the survivor of some means of keeping afloat is stressed repeatedly in the narratives (see p. 41). Various aspects of the problem have already been discussed elsewhere in this study, (pp. 14 to 20), but its importance cannot be overemphasized.

Men in the water without flotation gear had to swim for their lives. They grasped at straws—that is, at any debris that floated out of the crashed aircraft. They clutched at coffee and water jugs, thermos bottles, sleeping bags, Gibson girl kits, ration cases, kapok or rubber seat cushions, oxygen cylinders, mail pouches, a blanket, even a pilot's headset. They grabbed any part of the aircraft that came loose and floated, especially fuel and water tanks and wing floats.

Some made crude water wings by removing their pants, knotting the legs, holding the open waist into the wind to fill with air, and immersing them quickly. These supported them for short periods with the help of some treading. One man managed to stay afloat for 20 hours in this manner. Others used their parachutes to trap air the same way until they became watersoaked and collapsed.

Most who were within sight of land tried to reach the shore, and there are records of successful 15- to 20-mile swims. Many survivors in warm waters, some without Mae Wests or any other support, reached shore after swimming 12 to 24 hours. The longest survival swim without support on record was made by a naked Dutch submariner who reached the coast of Java after swimming continuously for 35 hours. A fully clothed Navy pilot with a Mae West made shore after 73 hours in the water (see p. 78).

SWIMMING. Survivors in both cold and warm waters, with or without life vests, found previous experience in salt water swimming a valuable asset. The inexperienced often became frightened and overanxious, and struggled and splashed frantically to keep afloat. Experienced swimmers automatically found the right way to swim and breath under all conditions.

The best and most often repeated advice to swimmers in the survivor's accounts is the necessity of keeping calm and of taking it easy in the water, especially in rough seas:

> "If in the water with only a Mae West, don't try to swim anywhere, just tread water enough to stay up. Don't fight the sea. Relax; turn your back to the waves and let them take you their way—they will anyway. In a rough sea with a Mae West you cannot swim after a floating liferaft. Don't take off your Mae West in order to swim better."

Swimmers with or without a Mae West usually found the breast stroke the least tiring and the most effective. It keeps the head out of water, aids breathing, and enables the swimmer to face the waves, to sight obstacles, and to keep a desired objective in line. The stroke is simple, easier for poor swimmers to coordinate than overhand strokes, and can be kept up longer. Many survivors reached land by swimming breast stroke

slowly, steadily, rhythmically, and resting every half hour or so.

Some preferred swimming on the back, as did an F4U pilot who managed to reach land in 4 hours after coming down 2 miles offshore without a back pack or a dinghy. On bailout he forgot to break his anti-blackout suit hose connection, which swung him against the tail of the plane, painfully injuring his back and side and partly paralyzing him. After clearing his chute, he tried to take off his antiblackout suit but the leg zippers jammed. He discarded a remaining shoe, knife, pistol and belt, and headed shoreward. The dangling hose got in the way of his legs, and he felt exhausted. But he found he could swim on his back with little trouble, and continued on that way, rolling over on his stomach only to take an occasional bearing.

Swimming and even treading water is tiring, just how tiring few men realized until after rescue they found they could not stand without support. Swimmers learned that, even in Mae Wests, just remaining afloat in a choppy sea and keeping their heads out of water took strenuous effort, and that they could not breathe without swallowing sea water. Eye witnesses and the circumstantial evidence of fatalities showing no bodily injury suggest that foundering after swallowing too much salt water may have caused many deaths.

Failure to estimate the force of seas and to recognize exhaustion resulted in needless loss of life when "good swimmers" tried to swim without Mae Wests from one raft to another or from their raft to rescue craft. The greatest risk taken by men at sea, whether alone or in groups, was to swim away from their raft, as many did for exercise or relief from the heat in tropic waters, or to retrieve articles lost overboard. Even in calm seas the effort to swim and to reenter the raft was physically exhausting. A typical example of such overconfidence and lack of judgment is the following excerpt from the narrative of a 10-day survival:

"Exercise was obtained by taking a swim. V., although swimming a few feet from the raft, was caught by the current and carried away so that he could not get back. B. swam to him with a Mae West while W. paddled the raft towards them. This was a very narrow escape because all three were becoming weak. On another occasion W. went after a paddle. B. and V. lowered the sail and used the other paddle to go after W. but it took half an hour. After that B. gave orders that no one was to leave the raft. Before that occurrence there had been an understanding that any man losing anything outside would go after it. At about 0400 on the tenth day, the raft capsized for the second time. It was righted and the men were dismayed at their losses. B. ordered all hands to crouch in the raft and grab loose gear floating by. W. saw the sailcloth a short distance away, and dove in after it. B. ordered him back but he couldn't make it; the sea was rough and the raft was drifting fast. B. and V. paddled but the heavy swells kept them from reaching him. In desperation, they resorted to pulling in the sea anchor, throwing it out as far as possible, then pulling it in again, but they were too weak. By this time W. had been swallowed up in the darkness, but he kept blowing his whistle. At daylight he was gone."

SOME CASE HISTORIES. Hardships almost beyond human endurance were surmounted by lone, badly injured men. A Corsair pilot with a broken pelvis and sprained ankles managed to reach shore after 15 hours of effort. By lying on his back and using his arms, he swam with the favoring current until a high, breaking comber tumbled him over the island's reef. He hung there all night in pain as he couldn't bring his legs together. At dawn he swam across the lagoon to the inner beach.

A crew of 12 leaped or were blown out of a B-29 by a gas fume explosion just prior to ditching in the Bay of Bengal. They managed to release two liferafts from the plane; each was boarded by three men. These saw two other men some distance away in the water, but neither party could paddle upwind to help them. During the night they tried to strike a light, but in the darkness they could not find the striker inside the match container. After a night of squalls, morning dawned calm and hot, and about 1000 they again spotted the two men and managed to reach them. One was the radar operator who had a compound fracture of the left leg, a torn right leg, a broken right arm, and a broken hip. The waist gunner had supported him, partly unconscious, all night through with the aid of their Mae Wests and an oxygen cylinder. After being blown out of the ship, the gunner had inflated his life vest under water, and rose to the surface groggy and belching salt water. Hearing a yell from the wreckage, he hunted until he found the radar operator clutching an oxygen cylinder. The man could not swim, feared drowning, and complained of pain. To ease him, the gunner, who weighed 125 pounds, pushed his 170-pound comrade up so that the collar of

his Mae West caught on the cylinder; this he had to repeat every few minutes in the rough seas. Swimming was impossible, and the gunner trod water to keep himself up. After a few hours, small crabs appeared and nibbled at the radar man's open wounds. He grew delirious and pulled a knife to kill his companion. When disarmed he tried to remove his Mae West so he would sink and drown. Once on the liferaft he was given the remaining water and morphine.

The longest swimming period recorded was 73 hours. The incident involved two Navy fliers whose Mae Wests were fitted with neck pieces that held their heads clear of the water. One man gave up in 24 hours. The other took a fix on the nearby land and doggedly continued swimming, using a breast stroke and scissors kick. After 30 hours, he said: "I got so exhausted that I could only stay awake by ducking my head under water, and then the water would get in my nose and throat and ears and I was just too damn dry and thirsty to spit it out. I felt that if I couldn't make it to the island by the second morning, I never would make it during the day under the hot sun. That made me panicky, and gave me strength to swim a little harder. I told myself that I was a cheap specimen if I could come so close to land and couldn't get closer." On the eve of his third night in the water, he half stumbled, half swam over the coral reef and reached the shore.

Sailing and Navigating

Survivors in rafts on the open sea usually obeyed their instructions to "keep sea anchor rigged for minimum of 2 days to minimize wind drift and hold raft close to last known point for more effective sea search." Some lay to for as long as 3 days before deciding to 'try and go somewhere."

Endless, aimless drifting made men feel helpless and hopeless; movement in a definite direction, no matter how slow, raised their hopes and gave them strength to withstand their accumulating hardships. One of the best antidotes for depression was a sail, and though few had this in mind, most survivors tried to raise some kind of sail, especially when in sight of land.

SAILING. Raft-borne survivors showed ingenuity in making sails. Retrieved chutes often gave them the idea and materials, but they also improvised sails of raft covers, jackets, spare 1-man liferafts, a salvaged blanket, even a liferaft navigation chart. They used paulins when they had them, and found them not entirely satisfactory because they lacked grommets along the edge for fastening.

They also improvised masts and stays to hold the sail in position. They used paddles or oars for masts, and made the sail fast with fish twine, bandages, shoelaces, and belts. Parachute shroud lines made the best rigging. Sometimes men had to hold both the mast and sail in place by hand. "We were too cold to remove our clothing for the purpose of making a sail, and instead used a waterproofed chart. It was tiring to hold the chart aloft, spread between two men in the bow, and the pain was excruciating." Lone survivors had more difficulty making sail. "I made a makeshift sail of my paulin using my arm as a mast and one hand for a stay, and held the outer edge between my toes." Another made a sail from two paddles and a dip net.

The usual sail was a square of cloth suspended from a paddle lashed crosswise to another paddle used as the mast. A few men made rigs which ran lengthwise instead of across the raft. With square sails, rafts could only run before the wind; lateen sails allowed a little more maneuverability. One raft sailor with a lateen rig claimed "With a paddle for a rudder, and my bony bottom for a keel, I succeeded in making a course 30 degrees away from the wind."

Liferafts were not designed for sailing, and were very difficult to maneuver under sail. Without centerboards or keels, they could neither be brought into the wind nor sailed more than a point or two to windward, and yawing was almost impossible to control. Narratives frequently contained the expression: "Present equipment useless for tacking." "We learned early that it was futile to attempt to maneuver our rafts in any desired direction, and so we drifted with the current and the winds." Stabilizing pockets acted as drags unless pulled up against the raft bottom.

Once survivors succeeded in getting sails set, they were loath to take them down and many left them set in storms and high winds, especially when being blown in a desired direction. "The raft left a churning wake through waves 30 feet high." As a consequence, there are frequent references to ripped or lost sails, and a few suggestions that survivors practice reefing. Most survivors were such self-acknowledged lubbers that one group approached by a submarine was over-

come by laughter when the lookout called to the officer on the conning tower, "They have reefed their sails to cut their way."

RAFT DRIFT. Survivors noted that, even without sails, their rafts moved with the wind. "The light raft was acting like a plump, round sail and our wake proved we were making progress."

In light winds an unloaded raft is estimated to drift at about 10 percent of the wind velocity. In heavy weather with winds of 20 knots or above, the rate of drift decreases to about 5 percent of the wind velocity. The tested speed of drift of a loaded rubber raft without a sea anchor has been determined as 1.15 miles per hour with a 20-knot wind and about .57 miles per hour with a 4-knot wind. A sea anchor reduces raft speed to less than 3 percent of the wind speed.

The direction of drift even in a steady wind is not normally straight downwind, but may vary from 10 to 15 degrees off course. This divergence can be reduced considerably by a sea anchor. "Once aboard, a sail and sea anchor steadied the raft into the wind. The current was strong from south to north, and the wind was between 20 ad 25 knots about 020 degrees. The combination of current and wind caused the raft to drift west at about 1 knot." In 9 hours this survivor made a westing of about 9 miles.

Survivors noted that two or more rafts lashed together made slow progress. An account of two 4-man rafts lashed together reports a drift of 3 miles in 14 hours in a 10-knot wind and 2-knot current. General Twining estimated that his group of 15 men in two 2-man rafts drifted 50 miles during one 24-hour storm.

Rickenbacker observed that his raft moved in a glassy calm. Most survivors expressed surprise at the presence and force of currents they encountered in the open ocean. They usually first became aware of currents when they used sea anchors. One group narrative describes how a 7-man raft, partly deflated and awash, drifted away from the others in a flat calm, despite a dragging chute used as a sea anchor. Another man reported drifting 21 miles in 16 hours when becalmed.

Islands frequently deflect the direction of currents. Survivors counting on an early landing found themselves paralleling the coastline instead, and had difficulty even staying within sight of land, though they paddled until exhausted. "Two hours later, we sighted land 40 or 50 miles away. We began paddling with one paddle, with hands, with shoes. I watched the wind streaks carefully and decided our dr t was almost parallel with the shoreline." One man succeeded in making a landing after 76 hours of almost continuous effort.

As one would surmise, the longer drifts in time and distance usually took place in the larger oceans, but even in smaller ocean basins such as the Mediterranean and North Sea, men sometimes drifted 10 to 15 days before being rescued. With but little control over their course and speed, survivors nevertheless watched continually for a landfall. The possibilities were remote; in the 546 Central Pacific drift records analyzed in Table 3 (p. 41), only 1.5 percent of the rafts made landfalls.

Table 9 lists the essential details for 23 drifts on which data are fairly complete. They range in duration from 4 to 3,129 hours and in distance covered from 3 to 2,300 miles. While distance generally increased with time, the two were not always proportional. Rafts lashed together, overloaded rafts, and rafts held by sea anchors drifted farther and faster with ocean currents than those driven by the wind or by paddles.

RAFT NAVIGATION. Most survivors did the best they could to estimate their position and to plot their raft's progress. Those who had no knowledge of their ditching position expressed their annoyance and frustration: "I had no maps and the navigator had not informed us of our exact position."

In larger groups the navigator, if present, was usually charged with the responsibility of laying out a course. Some navigators managed to save their sextants. "The navigator tried to plot a course into the Japanese Current to lead us to land. We used the liferaft cover as a sail."

Some navigators and pilots managed to salvage their flight maps, but most of them depended on handkerchief or waterproof cloth survival charts. These gave general information on the prevailing currents and winds; they showed ocean current directions and their speed in knots, and had wind roses to indicate average wind directions and wind forces by the Beaufort scale. These charts proved quite accurate and useful in the open ocean. "In 27 hours I drifted 22 miles east, almost exactly the expected drift as indicated by my Pacific drift-

TABLE 9

SOME REPORTED LIFERAFT DRIFTS

Duration (Hours)	Reported Distance (Miles)	Rate of Drift (MPH)	No. of Survivors	No. of Rafts	Type of Raft	Action Taken by Survivors	Region	Manner of Rescue
4	3	.8	1	1	1-Man	Paddled steadily	North Sea	Surface Vessel
7	5	.7	1	1	1-Man	Free drift	Southwest Pacific	Surface Vessel
12	30	2.5	1	1	1-Man	Drift with sea anchor	Southwest Pacific	DUMBO
14	3	.2	8	2	4-Man	Free drift lashed together	Southwest Pacific	DUMBO
16	21	1.3	1	1	1-Man	Drift with sea anchor	Southwest Pacific	Surface Vessel
24	15	.6	2	1	2-Man	Drifted and paddled	Southwest Pacific	DUMBO
27	22	.8	1	1	1-Man	Free drift	Southwest Pacific	Surface Vessel
58	33	.6	1	1	1-Man	Paddled steadily	North Sea	Surface Vessel
96	150	1.6	6	1 1	4-Man 7-Man	Drift with sea anchor Rafts lashed together	South China Sea	Submarine
120	60	.5	1	1	1-Man	Drift and sails	North Sea	Surface Vessel
156	50	.3	1	1 1	2-Man 1-Man	Drift and sails	East Indies	DUMBO
168	200	1.2	6	1	7-Man	Drift with sea anchor	East Indies	Landed, Celebes
360	643	1.8	9	2	5-Man	Drifted, rafts lashed together	Central Pacific	Landed, Espiritu Santo
360	75	.2	15	1	Ship's	Free drift	Gulf of Mexico	Surface Vessel
456	500	1.1	1	1	1-Man	Drift and sails	Southwest Pacific	Surface Vessel
504	65	.1	?	1	Rubber	Free drift	South Atlantic	Landed, West Africa
552	350	.6	14	1	Ship's	Free drift	Indian Ocean	Landed, Colombo
576	350	.6	13	1	Ship's	Free drift	Caribbean Sea	Landed, Barbados
816	1,000	1.2	3	1	4-Man	Free drift and paddled	Central Pacific	Landed, Hawaii
888	647	.7	?	1	Rubber	Free drift	Central Pacific	Landed, Island
1,128	1,200	1.1	1	1	2-Man	Free drift	Central Pacific	Landed, Marshalls
1,992	2,300	1.2	3	1	Ship's	Free drift	South Atlantic	Surface Vessel
3,192	1,000	1.3	1	1	Ship's	Free drift	South Atlantic	Surface Vessel

data chart." Another, after studying his chart and noting that the drift data indicated a current away from enemy-held islands, used a sea anchor and his chute to prevent the wind from blowing him landward. The charts appeared to be less reliable inshore or when drifting in archipelagoes because of uncharted local winds and currents. "Contrary to the data on the chart, I drifted northeast at 5 to 6 knots."

Survivors checked their drift direction and speed by using sea marker, sea anchors, or by trailing life vests or pieces of cloth. They took bearings with a compass, usually the one in the raft accessory kit, but in many cases men carried extra compasses in their pockets. Men who had no compass estimated drift and direction from the stars and moon. A compass from an escape kit helped one survivor make land after 57 hours at sea. Another reached shore after 4 days by trailing a cloth and figuring a reciprocal course with his pocket compass; he estimated his drift speed at 5 to 6 knots before a 25- to 35-knot wind.

Men often deduced the presence of land beyond the horizon by the reflections of shallow lagoon waters in the sky, or from the massing of clouds over low islands in the distance. When drifting near land at night many remarked of the strong smell of land vegetation. The course followed by distant aircraft sometimes gave a clue. Very few referred to the flight of birds as indicating the direction of land, and most of them held that birds were "no good and flew in all directions." Their feeling was forcibly stated by the author of THE BOMBARD STORY: "As for the RAFT BOOK, all its information about birds is tripe and serves only to lower one's morale." Men appeared to take more hope from the occasional insects that landed on their rafts, reasoning that insects normally are not able to fly far from land.

OBSTACLES TO NAVIGATION. The danger of a raft being accidentally run down at night was apparently negligible, except when ditching took place among a large aggregation of ships or during battle action. Survivors expressed fear of being run down mostly when in the vicinity of Japanese ships. To avoid detection when approached by Japanese destroyers, survivors took to the water and overturned their rafts so that the blue bottom would make them less conspicuous. In three narratives survivors reported encountering big timbers or floating trees, which in one night incident were "crashed against the raft sides by the waves."

Chapter V

THE INDIVIDUAL

THE STRAIN and fatigue to which aircrews were subjected prior to a flight are reflected in their narratives. The chances for success in both ditching and survival were seriously jeopardized by a lowering of physical stamina and the accumulation of mental strain. Typical is an Air Force pilot's statement:

"This mission was accompanied by an unusual amount of pre-target physical and mental discomfort [due to low oxygen supplies, close formation flying through heavy overcast, low temperatures, icing conditions, mountainous terrain] and the crew members were worn out before real trouble came along."

A Navy aircraft commander noted:

"With the exception of V., we became physically weak with surprising speed. I attribute much of this to the fact that we had spent several sleepless days at Goose Bay, in which time we had been briefed repeatedly at all times of the day or night for flights which subsequently were weathered out. Also, we had been under a mental strain for a considerable time prior to the actual ditching, and few of us ate a meal of any consequence. Forced eating might have been good insurance, whether or not we anticipated ditching. Our strength was pretty near gone after 24 hours and it took us one hour to bail 6 inches of water out of the raft with our shoes."

Aircrews often avoided heavy meals before a mission to reduce the possibility of a bowel movement while in flight: "I always tried not to eat much before a mission just for that purpose." This lowered their strength and resistance in an emergency.

Survivors generally expressed a strong determination to avoid capture. While the cold temperatures in the ETO sometimes forced survivors to reveal their presence to the enemy, frequently in arduous situations the stronger minded prevailed upon the weaker ones to hang on rather than surrender. In the Pacific Theater hunger and thirst occasionally lowered morale and encouraged defection among survivors: "I thought I'd rather take a chance with the Japs than to starve" (2-day survival). Again, "I resolved to be captured rather than to die of thirst" (3-day survival).

Because they believed they would be searched for and found, most survivors preferred to take their chances with the sea rather than with the enemy. A good illustration of the effort exerted by men determined to avoid capture was a fighter pilot who lost his raft on bailout off a Japanese-held island. While swimming away from shore, he was surprised by two armed Japanese in a small rowboat. He shot both with his .38 but failed to recover their boat. Later in the day while still swimming away from land, he succeeded in attracting the attention of a single aircraft and retrieved an airdropped liferaft. Five days later he was sighted by an American submarine but he would not permit the crew to approach him until he was satisfied, by a repeated challenge, that he was dealing with friends.

The Japanese attitude towards prisoners of war early in World War II was a strong deterrent to surrendering. In the latter part of the War, the Japanese manifested a determination to prevent rescues which was, operationally, out of all proportion to its value. Their failure to appreciate the humanitarian motive behind the American effort to save lives is understandable when it is realized that they themselves had no rescue system, flew without paracutes after 1944, and never gave their crews or pilots emergency drills or survival training. The Japanese outlook toward sea rescues was summarized in a 1945 report by the Commander, Air-Sea Rescue Task Group, Mariannas:

"The exact reasoning is not, and may never be fully known. On many strikes the Japs would make no real effort to stop the strike but would concentrate on the elimination of stragglers, survivors, and disabled airplanes and attempt to prevent rescues. Some of the largest air battles of the latter part of the War developed around DUMBOS and LIFEGUARD submarines. The reasoning behind Jap strategy is not clear . . . to capture prisoners for interrogation . . . for torture . . . or a concentrated attempt to lower morale of the Air Force by lowering the faith they had developed in the success of Air-Sea Rescue."

On the other hand, when the Japanese sighted American survivors from shore, they rarely attempted to capture them, either in fear of sharks themselves, or in certainty that sharks would do the job for them.

PHYSICAL ASPECTS

Presurvival Injuries

COMBAT INJURIES. Many ditchings and bailouts were successful in that crews were able to leave the aircraft uninjured. When the inflight emergency was caused by battle damage there were usually at least one or more wounded on board. Often the survivors could not account for their wounds: "I discovered a bleeding wound in my abdomen. At the interrogation I told them it was a flak wound. That was a lie—I have no idea how I got it."

An analysis of heavy bomber crewmen wounded by missiles in air combat showed that shrapnel caused 88 percent of all combat wounds. Plexiglass, bullets, fragments from the aircraft, and parachute harness hardware accounted for the rest. Splinters from plexiglass were very damaging to eyes. About 95 percent of all wounds were open, either penetrating, perforating, or lacerating. Of fractures, 90 percent were compound. The distribution and frequency of major wounds in 201 crewmen was as follows:

Thighs and buttocks	27 percent
Legs and feet	19 percent
Forearms and hands	15 percent
Arms and shoulders	12 percent
Hands and face	11 percent
Eyes	6 percent
Chest	5 percent
Abdomen	3 percent
Neck	2 percent

The largest number of wounded involved in a single accident in the narratives were 19 casualties evacuated from Guadalcanal in 1942 on a DC-3 with a crew of 6. With its radio knocked out on takeoff, the aircraft soon became lost, and finally ditched on a reef where it remained 10 days until rescue arrived. All 25 on board survived in spite of short food and water rations.

BAILOUT INJURIES. Injuries from bailout were reported more frequently by personnel of single place than of multiplace aircraft. Jammed canopies often had to be forced open at the expense of severely cut hands. In two incidents the hood flew off unexpectedly and struck the pilot in the face, knocking him unconscious and injuring him seriously.

Fighter pilots reported such difficulty raising their bodies against the slipstream they finally resorted to upside-down bailout—this also was preferred by those who feared being hung on stabilizers or tail structures. In several instances following bailout, pilots were injured in midair by their pilotless planes. In two inverted bailouts pilots lost legs, in one case by striking the canopy, in the other the propellor. One of these pilots used his belt for a tourniquet while in the air. On losing the belt in the water he devised a new one by pulling the empty trouser leg tightly around his thigh, and thus stayed conscious for more than an hour until rescued.

Low altitude bailouts between 50 and 100 feet above the water were usually fatal, yet several men survived these falls. Each of them was knocked out and sank deeply before being revived by the cold water. Back injuries were reported from the sudden snap of the opening chute or from hitting the water. A Marine pilot who free-dropped 2,000 feet was severely bruised and had a fractured pelvis and sprained ankles; nevertheless he managed to swim to shore 15 hours after leaving his aircraft.

Injuries during bailout from multiplace aircraft occurred most often when the aircraft was out of control and the crews had to fight their way to and through exits, often cutting their hands. When wings were sheared off, crews were tossed and severely bruised by the violently spinning aircraft. One copilot was torn out of his safety belt, thrown across the cockpit against the instrument board opposite the pilot, then dropped through the plexiglass which ripped off his pararaft and Mae West flashlight. He suffered lacerations and bruises and lost his big toenail.

In a large number of instances multiplace air-

craft personnel reported crew mates drowning in their chutes. Many of these were dazed by the impact and drowned before recovering consciousness.

Strafings during a parachute descent were usually fatal. Survivors strafed in the water or on liferafts often saved themselves by hiding under camouflaged paulins, by diving about 5 feet under water, or by playing 'possum. In Pacific ditchings close to enemy-held shores, more men were hit by shrapnel than by small arms fire. Men towed their rafts farther out to sea before boarding them, or left empty decoy rafts to draw the fire away from themselves. One group of survivors underwent a torpedo attack without harm.

DITCHING INJURIES. The possibility of gasoline fires or explosions was in the minds of all aircrews when ditching. Battle-damaged fuel lines and cells frequently released gas fumes in the aircraft which, in one instance, appeared "thick as smoke," burning eyes, nostrils, and skin.

A B-29 report states that excess fuel dumped prior to ditching vaporized in the bomb bay and blew into the rear compartment, almost asphyxiating the crew, and exploded on contact with the sea. Survivors blown out by explosions 100 feet above the water suffered burns and broken limbs and ankles. When gasoline ignited on the water, burns ranged from minor to severe on the exposed body from the waist up, and especially on the hands and face.

In a typical incident a PV-1 with a crew of six ditched 260 miles off Natal, Brazil. On impact the main door flew open and the bomb bay tanks burst into flame. Spray entering the open ports drenched the three men forward and protected them from burns. The three in the rear jumped out quickly. Meanwhile the forward crew, who were hanging on the wing with uninflated Mae Wests, reentered the rear hatch and secured a 5-man liferaft, though its covers were burning. Two of them had to swim under water to avoid the burning gasoline, and finally cleared it about 10 feet from the aircraft. Had they inflated their Mae Wests they would have suffered worse burns. The aircraft sank in 1½ minutes, and the last flames disappeared in another 30 seconds. All suffered minor burns on the cheeks, ears, forehead, shoulders, and forearm, and their hair was singed. One man in a short-sleeved shirt had almost all the skin burned from his arms and hands, and his entire face was scorched. Later in the day all blistered badly.

After a TBF ditching, the explosion of the bomb load caught two men on the wing and one in the water. The two on the wing were thrown into the sea and badly bruised, the man in the water suffered a broken back and his breast was crushed and partly laid bare, but 2 hours later he was rescued alive.

Crews that made forced landings in shallow water close to shore, in surf, in lagoons, or in shallow lakes reported injuries from concussion. The danger of being trapped was greater in shallow water because the impact frequently wiped off the whole lower surface of the fuselage so that the aircraft sank at once and the inrushing water forced men in the waist up against the top of the fuselage.

In almost every ditching the aircraft struck the water with at least two and sometimes more separate impacts before coming to rest. The first impact often dislodged men from the ditching posture they had assumed, and exposed them in a more vulnerable position to the second and usually more powerful impact. Most of the injuries received in ditching occurred at the second impact.

Crews stationed on the flight deck and in the waist often made the error of releasing safety belts or of rising before the aircraft came to a complete stop and so were needlessly injured. Men tossed against each other suffered broken bones and sprains. The violence of the shock also tore loose safety belts and hand holds so that weakly braced men suffered broken limbs, dislocated shoulders, sprained backs, broken ankles, scalp and facial lacerations, head concussions, cuts, bruises, lost teeth, and blackened eyes. Fingers and knuckles were crimped and skinned from unwise holds on seats.

Loose equipment was propelled with the force of projectiles and caused severe injuries. In one B-24 ditching five of the crew were hit by armor plate, which caused compound fractures of legs and ankles. A crash landing of a PBM in a rough sea flung the galley stove through the bow and knocked the pilot's instruments loose.

When shoulder and safety belts were improperly tightened, pilots sustained severe injuries to head, face, and back. In a B-26 ditching made without safety belts or crash helmets, three bodies

were recovered with serious head injuries and broken necks and with no water in the lungs. The lone survivor stated: "After the tail struck there was a terrific impact and the cockpit filled with water. It is difficult to describe in words the shock." Steel helmets worn too loosely cut foreheads, as did the insignia screw of visor hats.

Pilots reported jamming their feet between the forward seat and the steering column, in the yoke, or against bulkheads. This happened frequently to those who, anticipating a land survival, wore the heaviest leather shoes available, which wedged in unexpected places. In freeing themselves, men wrenched, lacerated, or strained their knees, ankles, and hands.

Americans considered the B-24 a particularly bad ditcher. Its average floating time was 8 minutes. The waist bulkhead often gave way and the upper turret crashed down, pinning and maiming men stationed in the waist. The bomb bay gas tanks threatened fire, explosion, or asphyxiation. Many men were trapped by closed or blocked hatches; others were thrown out so quickly they were unable to tell how they left the plane. In several B-24 ditchings the pilot or the gunner was propelled, seat and all, through the plexiglass and died of internal injuries. In three B-24J accidents involving a total of 31 men, all of whom were equipped with safety belts, 18 died from ditching injuries. In comparison a Halifax II ditched at night with its landing lights and floated 2½ hours on a rough sea; although the pilot was the only man with a safety harness, the entire crew of 8 survived.

Arm injuries made swimming difficult. Injuries of the arms, shoulders, and neck hindered men more in inflating and boarding liferafts than did injuries of the legs or serious body wounds. Sprained elbows made it almost impossible for men to release their rafts, to keep afloat in their life vests, or to use any signaling equipment but the dye marker. Rings were a lesser cause of injury, but often lacerated fingers when they caught as men left the aircraft or tried to break out liferafts. "As I floated upward in the darkness I reached out with my arm. My university class ring caught in the right waist window. I could not let go but finally pulled free about 70 feet under water" (Zamperini).

Liferaft Health Hazards

The physical condition of a survivor upon landing in the water determined to a high degree his chances for survival. Serious injuries or a dazed mind lessened his ability to help himself or to gather or use emergency gear. Broken limbs or open wounds were hard to treat; blood in the water raised the fear of sharks, and sometimes brought the sharks themselves. Nausea, vertigo, and seasickness were common, and, although not recognized as a serious hazard, they often rendered crews helpless in the early stages of survival.

COMFORT AND REST. Liferafts were a mixed blessing; to be without one was disastrous, to be in one was torture. Comfort of any sort was rarely possible in the little space available. No one could stretch out, shift, or relax. "It is most difficult to move about and impossible to rest or sleep with five or more men in a so-called 7-man liferaft." In any and all positions neck and knee muscles stiffened and joints ached.

Space was at a premium in all liferafts, and conditions were even worse when rafts were overloaded and slopping with water. A wet raft is an uncomfortable raft. Men were irritated by the constant shipping of water—usually down their necks, or by the slow seepage of water through the raft bottom. Many reported bailing continuously until "blue in the face."

While no single account conveys fully the intense individual and group distress experienced in an overloaded liferaft, that of General Twining is typical. Fifteen men were crowded for 7 days into two rafts designed to hold four:

> "We were partly submerged. It was like sitting in a half-filled bathtub for a week. We couldn't have been more uncomfortable if we had tried. We had our arms and legs all tangled together like a bowl of spaghetti. You'd go to move your foot and nothing would happen. It got so you couldn't tell which feet were yours. But we had to keep squirming and twisting like a mess of angleworms in a bait can to keep up our circulation."

Survivors felt confined and tethered by the material limits of their platform. They tried their best to exercise, and to get comfortable enough to sleep, but when sleep after a fashion was possible it was often disturbed by hammering rain squalls, cold nights, burning days, breaking seas, or the noisy activity of large fish. Even with only one or two men in a 5-man raft and an extra raft for carrying liferaft kits and other gear, men found

liferafts constraining. "Five days without food or water. Five days, the three of us crowded together in a space not much bigger than the inside of a bathtub. Five days with no sleep by night and a pitiless torture by day" (Trumbull, THE RAFT, Henry Holt & Co., Inc.).

Regardless of the number on board, all spoke of their inability to rise from a sitting position, of the cramped, close quarters, of the continual wetness, of the monotonous slapping of the waves, and the restless and cranky movements of the raft. "When I was sufficiently rested, I worked myself farther into the raft and assumed the sitting position from which, but for a very few exceptions, I was not to stir for 20 days."

Under the best of raft conditions sleep was always a problem. Men usually slept fitfully in 2- to 3-hour naps; Madden averaged 6 hours in 24; many survivors reported their first good sleep on about the 7th to 9th days.

A lone survivor who spent 20 days in a 1-man raft devised the folowing method for sleeping; "Unable to lie down, I tucked my parachute silk under my feet, pulled it back over my knees and over my head, then tucked it in behind me. The silk would then support my head, throwing the weight against my feet. Even with that device I was unable to get more than 2 or 3 hours of sleep each night. The waves and swells were 10 to 20 feet high and would break over the raft. Then I would bail, doze again, another wave, on so on into the night." In a 27-day ordeal (the longest on a 1-man raft noted in the narratives), the survivor said the nights were one long struggle to keep the liferaft balanced.

For added safety, survivors suggested canvas straps be attached to the raft deck to hook arms through when sleeping, and to help brace feet while holding on with hands. "At present I can remember only parts of what happened on the water. I know that I tied myself on the raft. This was quite important, for of the 2 nights spent on the water I rolled off the raft twice in my sleep but had no trouble getting back in."

After nightfall most liferafts grew noticeably limp and had to be topped off. Leaky rafts needed constant topping. One group had to pump about every 25 minutes, while another had to inflate their raft by mouth every 2 hours. This was hard work, and in SURVIVOR Madden relates that by the 10th day 10 strokes on the hand pump left him exhausted.

Survivors preferred to sit on the raft floor to avoid capsizing. The single or double center seats in large rafts left no room for men to stretch out in a comfortable, relaxed position; so they were often torn out. This increased the sag of the floor, which often sloshed with water. The wet, cold, and resilient raft deck provoked "raft bottom" and "immersion fanny." To seek relief from the stiffness and general pain and soreness, the occupants hung overside, injected morphine into their buttocks, or exercised daily in short swims around the raft. During calms short swims were one means of stretching aching muscles. When it was impossible to go overside because of rough or cold weather, or from dread of sharks, the men massaged their legs and arms or did simple calisthenics, but the poor stability of 1-man liferafts ruled this out.

One-man liferaft occupants complained of pain over the kidneys when sitting slouched forward. After about an hour pressure sores developed on back and hip from the constant friction of the body against the liferaft or against other occupants, or because of shrunken, tight clothing. The only woman involved in a survival incident wrote "I was frightened by the unsteady motion of the liferaft and because I couldn't swim. My back and pelvis pained after 13 hours of just sitting in one place."

On the fifth day of his ordeal General Twining took note of the condition of his crew: "We were getting so weak we would have trouble pulling a man back in if he slipped overboard." On the seventh day they received a food and water drop. "But we couldn't reach it . . . we couldn't even pull a paddle. We couldn't even paddle the 10 feet to the hull [of the rescue CAT]." On shore, "We were too weak to stand up." Also they were too weak to eat.

But there were always exceptions. In one 17-day survival only one man of a crew of four was unable to walk after rescue. The USS HAMMERHEAD patrolling in the China Sea put its searchlight on an apparently empty raft late at night; as the submarine bumped against the raft its lone occupant woke from unconcerned sleep.

RAFT DRUMMING. Survivors described the constant slapping or drumming of seas against the

flexible raft bottom as most painful. It bruised buttocks and thighs.

"The constant pounding of the waves was nerve-racking. I soon started cussing at them. The cussing gave way to screaming and then I got hold of myself. I stopped and prayed for strength and to withstand the merciless pounding. When my nerves seemed near the breaking point I used morphine."

Trumbull (in THE RAFT) quotes Dixon on the subject as follows:

"When off watch and lying in the bottom of the boat trying to get some rest, it would be more than annoying to get a face full of cold and heavy salt water, thrown with the force of a bludgeon. Because of this and because of the smaller waves which were continually punching at the thin cover of fabric that formed our bottom, it was impossible to get anything approaching rest except during the latter hours of a protracted, dead calm, when all surface waves had died down. . . . The pounding of the choppy waves beneath the fabric bottom nearly drove me mad. Every night I thought: Tonight I am more tired than I have ever been before, so maybe this time I can sleep. And every night the monotonous jarring hammer beneath me, coupled with the always unexpected drenching from above, drove me to sit up . . . exhaustion closed around me like a tightening hand."

SANITATION. Housekeeping in a liferaft was simplicity itself, and the ocean made sewage disposal easy. But elimination was always difficult in the best of circumstances. In cold regions with temperatures close to zero it was hard to remove layers of wet, heavy clothing, and foolhardy as well. In rough weather the teetering, cork-like movements of the raft discouraged any attempts to be neat, so men had to make the best of an unpleasant situation.

In large rafts men gave each other handholds while each relieved himself to leeward, the others distributing their weight to balance the raft. "We used our shoes to urinate. This prevented someone from falling out of the raft while attempting to relieve themselves by standing or kneeling." Men in one-man life rafts either had to go overside to relieve themselves, or else evacuate into the raft. This was seldom as unsanitary as it sounds, for the seas generally washed in and out enough to keep the raft clean. One survivor stated he preferred to urinate into the water in his raft because it kept him warm and gave him energy for paddling.

Concern about the absence of bowel movement was commented on by many liferaft passengers, who suggested that laxatives be included in raft medical kits. Successful defecation was often greeted by congratulations and cheers from less fortunate mates. Long periods without movements were common, the longest reported was 39 days. One 10-day narrative states the survivors drank small quantities of salt water and had bowel movements about every third day. One man reported only two bowel movements in 20 days—both in the first week.

Men usually urinated daily; no one complained that his kidneys failed to function. The deep orange color of the urine caused comment, and many noted that the amount they voided exceeded the amount of water they drank (see p. 54).

Keeping bodily clean in a liferaft was always a problem, but men did the best they could. After aimless days of drifting, the daily effort to keep clean was often the only routine they maintained. Madden (in SURVIVOR) tells how on the 10th day of his 11-day survival he combed his hair. took off his shoes, and washed his feet, using a bandage for a washcloth. Men welcomed rain not only for the drinking water it supplied, but for the opportunity it gave them to wash and to ease salt burn. They washed out their salt-whitened clothes by holding them up in the rain or by dousing them in the brackish water which collected in the raft bottom. They all enjoyed the cooling and cleansing rain squalls to which they lifted their faces for relief, but the sharp, pelting rain hurt their eyeballs. "The sun was a torture, but no worse than the rain, only different. The rain comes down like a bombardment. Huge drops hit so hard they hurt. They batter your brains 'till you're ready to fight back." (General Twining)

Men wanted to wash their heads and faces more than bodies. Salt caked the hair and the skin, made the scalp and beard itch, and stung and burned tender skin. They also wanted to brush their teeth; some scrubbed off the stain that formed on them with salt water and a finger for a toothbrush. A few tried gargling salt water, but they found it irritating and avoided it for fear it might lead to salt water drinking. Toothbrushes were wanted most by those who had K rations or other solid or fatty foods which left grease on teeth and gums. In one incident, three survivors shared one toothbrush from an Army K-19 kit.

INJURIES FROM THE LIFERAFT. Men seldom injured themselves seriously on liferafts. They were too inactive and the rafts too soft. They cut them-

selves easily on anything hard or sharp, but the commonest injury reported was scraping their water-soaked skin against the fabric. Dragging themselves back into the raft after a swim or a capsizing, they scraped their chest and abdomen. When they paddled the gunnel fabric sandpapered the skin off their arms.

Eventually all lacerations became open sores. Skinned knuckles developed salt water sores in about 48 hours. Just plain sitting, day in and day out, developed boils on buttock and thighs. "We all suffered with ulcer-like sores on our butts. After 3 days, we were out on patrol again."

When loaded liferafts were tied together they banged together and jerked apart so that men had to fend them off or hold them together with their hands. In one such case a sudden lurch broke a man's wrist.

Rings, wristwatches, and zippers caused minor but painful injuries. Rings were most painful when they could not be removed from water-swollen fingers. The tender skin once covered by a wristwatch was susceptible to severe sunburn. Zippers rusted and gummed up so that they could neither be closed or opened, and the metal sawed tender skin.

SEASICKNESS. Although airsickness was recognized as seriously impeding a man's efficiency, the equivalent malady in liferafts received less consideration in briefings and in training. The outlook changed rapidly when 60 percent of water survivors reported seasickness, and it was realized that seasickness occurs for varying periods in almost all survivals. Men were seasick while floating in lifevests, in liferafts, and again on rescue craft. Seasickness probably contributed, directly or indirectly, to many deaths.

Seasickness often began as a reaction to fear of ditching or bailout. 'Someone vomited and that precipitated an epidemic of emesis. I believe I must have puked a gallon of salt water, gasoline, oil, my eyeballs, stomach lining, and a substantial portion of my blood reservoir." Chute oscillations or the rolling of an aircraft hulk started vertigo or nausea. During ditching gasoline fumes and the unavoidable intake of salt water or raw gasoline provoked severe retching, often accompanied by a bowel movement.

General Twining describes a typical situation immediately after ditching. "There was a lot of laughing and joking. Everybody felt fine . . . for awhile. Then we all began to get sick. We had all swallowed enough salt water to make a whale sick. We lost everything we had in our stomachs." Survivors reported that vomit attracted sharks; in one incident sharks made passes at the raft and the men stopped heaving into the water.

Seasickness was not always a matter of vomiting. After stomachs were emptied, men continued to have dry heaves for a long time. "I began with my lunch, and eventually worked down to a point where blood and liquids were all that would come forth. The blood was coffee colored, not bright red [bile?] and did not worry me too much. This lasted well into the night; and even until late next day the irresistible urge would present itself."

The more seriously seasick did nothing but lie down with their eyes shut. Many were so apathetic from seasickness they failed to respond to planes overhead and were presumed dead. One confessed: "I was too sick to eat, drink, sleep, or watch for rescue."

The average individual was ill for at least 3 days; the more hardy recovered in 24 hours. Many suffered intermittently. A sip of fresh water and tentative nibbling of liferaft rations brought most back to normal, but foods taken during periods of retching were completely lost, including antiseasickness pills. One survivor finally fought off a 3-day period of recurring nausea and vomiting by nibbling candy and gum.

Exposure

The two sources of distress mentioned most frequently by water survivors were cold and exhaustion. Water temperature to a great extent determined the possible length of a survival. According to the Surgeon General's Office of the US Navy, "Immersion in waters below 31 degrees F. is considered to be fatal within ½ hour . . . From 60 degrees to 68 degrees F. . . . possibly fatigue is the limiting factor."

Rain and heavy seas washing constantly into rafts made keeping dry impossible and, though few expected it otherwise, survivors could not adjust to the constant drenchings. Chilling accompanied wetting, but the main cause of cold was not the wetness but the wind. At low temperatures wind hastened fatal freezing; even under medium temperatures it brought on chilling and its consequences.

In tropic waters, sun, heat, and glare during the

day were generally anticipated as major survival discomforts, but few foresaw the equally critical effects of chilling winds on wet bodies at night. Although freezing was unlikely in warm seas, all survivors complained of the cold at night and during tropical downpours. Cold after sundown made sleep impossible and hastened general exhaustion. Men in a weakened condition felt the cold more quickly.

COLD. In the Aleutians where the average sea temperatures vary from 47° to 52° F. during August, the warmest month, and between 36° and 38° F. in March, the coldest, total immersion was usually fatal within 1 hour. Only 1 man of 10 from a torpedoed vessel survived a half hour immersion at 29° in a sea of floe ice.

Data from the ETO show that in winter it was unusual for men to withstand more than 20 to 30 minutes in cold water, and that 60 percent of the immersions lasted more than 30 minutes. The mortality rate among 163 men immersed for 10 minutes in the North Sea and the English Channel during 1944, where water temperatures range from 40° in winter to 62° F. in summer, was 42 percent, and recoveries dropped about 20 percent in winter. One survivor stated 'A good swimmer has a very difficult time in cold water and I don't believe a non-swimmer has a chance."

Nevertheless, some men outlived long immersions in cold water. A 22-year-old airman was the only man saved of a 5-man crew that bailed out off the coast of Oregon in winter. He was rescued after 2 hours of swimming, just as he 'began to feel warm and was about to give up." The medics couldn't feel his pulse, but revived him with whiskey and blood plasma. A British pilot in the North Sea outlived 1¼ hours in 42° F. water. Off Kikai Jima (28° N.) in April, a flier rescued after 24 hours reported "Except that I was quite cold from water, I believe I could have lasted only about 3 more days." Another was "chilled to the bone" in a ditching on Klamath Lake in Oregon.

Men knew they could not last long on a liferaft in the North Atlantic in winter; yet several crews were recovered from winter seas off Iceland after 30 minutes of immersion, while another crew off Greenland outlasted a 4½-day paddle through floe ice. A P-40 pilot who bailed out over the Bering Sea managed to inflate his liferaft and lay numb and exhausted on it for 1 hour and 20 minutes before rescue.

Rescued men reported the initial shock of entering cold water left them gasping and exhausted, followed by a numbness which gradually spread through their bodies as a false sense of warmth. "Our feet and legs became numb from cold water so we didn't seem cold." Men had to force themselves to cling to liferafts. Fingers became numb so quickly that men couldn't handle their equipment or operate valves, which was why they preferred the lever CO_2 release to the screw type.

Those who successfully boarded liferafts complained chiefly of sloshing water and of the windchill which gradually numbed them to sleep. The inability to stay awake was dangerous, for wet men froze to death quickly when asleep. Lone survivors who had to sit more or less immobile to balance the dinghy had to exert the utmost concentration to keep awake. They took benzedrine sulfate or "energy pills" freely to fight off sleep, when they could swallow them without water. A few resourceful individuals in the ETO provided themselves with non-issue flasks of brandy, which they credited with keeping them warm.

Continued exposure to low temperatures frostbit all exposed skin surfaces, especially ungloved hands. Gloves and hats could protect hands and ears, but the nose always suffered, and to a lesser degree the cheeks and forehead. Ice crystals formed in hair, beard, and clothing, especially in fog, and spray solidified into a sheath which bound clothing, gear, and bodies to the raft. It was torture to rest hands on the gunnels of the raft or to handle aluminum paddles or other equipment.

The shivering mechanism which comes into effect in humans at about 68° F., is helpful in the early stages of cold water exposure, in that it increases body heat production to as much as four times that produced in the pre-shivering period. The relationship of involuntary shivering to exercise has a practical bearing on survival. Heat production is at its maximum during shivering, and exercise then is of little or no benefit except to control cramps and general stiffening of the muscles. Shivering rarely is beneficial for more than an hour; after that it is fatiguing.

Both cold and warm water survivors experienced the discomfort of cold buttocks, especially the latter because they wore fewer clothes. To relieve it men raised their buttocks and thighs off the cold raft bottom and slept or sat on partly inflated Mae Wests, kapok cushions, rubber pads

from the chute seat, extra clothing, or the accessory bag. Others wore their Mae Wests for warmth, wrapped up in ponchos, paulins, sails, and chutes, or hung in the water, which at night was warmer than the wind. Soaked in brine and chilled by the wind, survivors could not relieve the numbing pain in their stiff legs and buttocks. When rescued, they often could not straighten out.

With high seas running, men preferred to keep their liferafts filled with water rather than risk being flung into the sea and losing their signaling equipment, the meager stores of food and water, and even the liferaft. A crew of eight who abandoned a blimp in 45° F. water on the North Atlantic in November deliberately filled their raft to make it ride low and keep from capsizing. Even so, they had to set a water watch to trim ship in the 40-foot waves. The 1-man liferafts had only hooded aprons or ponchos for shelter; the larger rafts were supplied with sails or paulins. These rubberized sheets were effective wind and spray shields, and survivors repeatedly expressed their surprise at the warmth they afforded even when they were soaked in low temperatures. The sheets were often too small to go completely over the raft and be lashed to its sides, so water continually sloshed in or seeped in through head and arm slits.

To use the hooded poncho or the paulin effectively men had to assume uncomfortable positions for long periods. One man rode out 6 days of a typhoon by sitting with knees raised so that the water would run off his poncho. He stated that the poncho was a better wind than waterproof shelter, and on rescue was suffering from extreme cold exhaustion. Some individuals deliberately left their raft covers unfastened for fear they would be unable to release themselves in an upset. Others complained that those with snap fasteners were too complicated to rig at night or in rough weather. In two North Atlantic winter incidents survivors used a spare, inflated 1-man liferaft as a wind and spray shield, holding it firmly over their heads at a sharp angle to reduce the surface exposed to the wind.

Men landing on ice floes generally drew their rafts out of the water and used them for shelter from the wind. When the cold grew unbearable, they walked in circles to get warm; one man walked for 20 hours. Those with wet feet removed their socks and replaced them with chute cloth or strips torn from their clothing.

In multiplace liferafts men went insane in the unbearable cold, or gave way to despair and the desire to sleep. It then took all the effort of their stronger willed comrades to calm them down or to keep them roused. By singing, talking, and huddling for mutual warmth, by doing arm calisthenics, pummeling each other, and by paddling or grinding on the Gibson girl, survivors tried their best to keep warm. "We rubbed each other's hands and feet, then punched and nudged each other, talked aimlessly and did everything possible to keep each other awake at night."

The injured were sandwiched between the well to keep them warm, but the best guarantee for survival of injured were drops of dry clothing, especially the British sleeping suits. A B-36 crew rescued by an A-1 lifeboat in 1952 noted "All who were picked up reported that the warm, dry clothing on board was the greatest blessing." Chemical heating pads "placed under the shirt and against the chest were a comfort at all times."

Exposure suits issued after 1945 provide some protection against immersion at 40° F. and in freezing air temperatures for 20 or more hours. Although their primary purpose is to keep the wearer dry, the suits have good protective value even when worn over wet clothing. In the relatively short water survivals during the Korean outbreak exposure suits saved many lives. Nevertheless, as recently as 1953 a pilot in Japan wrote:

> "I'm thankful that I've been in a position to observe rather than to experience some of the things we've had happen to the wing here. We've lost a colonel due to over-exposure before water rescue (no immersion suit); and today we had one lad eject and remain in the water an hour and a half just south of Hokkaido, afloat in heavy seas in his Mae West when his dinghy wouldn't inflate. He survived by staying busy in the water but not exhausting himself. I enclose a picture of what little outdated equipment we have, and you'll notice the absence of an immersion suit."

HEAT. The high day temperatures in tropical seas combined with insufficient fresh water commonly limited survival to about 12 days. To get relief from the heat men indulged in overside dips, or sprayed themselves with sea water, which was always cooling. Rickenbacker observed that even when the air and water were warm, the slapping waves seemed like ice water. Most feared the heat of the morning and noon sun more than

that of the late afternoon. Overcast skies gave little relief, for men learned that even on these days the sun could burn. One survivor reported that he was sunburned during a rainy spell.

The common habit of stripping down to a T-shirt when flying was disastrous to the many who ended up on a liferaft. They suffered such severe sunburn by day they could not rest at night. Others were sunburned badly when they took off clothing and shoes to cool themselves. Rickenbacker's description aptly states what hundreds of men can attest to: "Faces, hands, wrists, legs and ankles blistered, turned raw, and burned again. Even the soles . . . were burned raw."

In 99 percent of survival episodes in tropic and temperate waters sunburn is reported the most frequent malady, raising blisters, stripping the skin, and leaving raw flesh exposed to the stinging salt. One man said the pain of his shrapnel wound was more bearable than sunburn. Dark-skinned men suffered equally with light-skinned ones. Natural tanning of the skin was no protection, for there is repeated reference to hands and arms burned black, yet peeling from sunburn.

The best protection from sunburn was to avoid it by retaining all clothing or keeping under cover when possible. A 20-day survivor succeeded so well in this that he minimized sunburn as "no hazard."

Survivors found the sunburn preventive ointment satisfactory for both sunburn and salt sting. Some individuals reported difficulty applying anti-sunburn cream after the skin began to peel. One redheaded pilot complained that the anti-sunburn cream was not heavy enough for him.

Men without sunburn lotions used boric acid ointment, tannic acid jelly or zinc oxide to ease sunburn, salt sting, and gasoline or oil burns. One castaway rubbed himself with albatross fat. The majority tried to escape the sun by floating overside in the shade of the low liferaft, but they found it too exhausting, and the dread of sharks usually discouraged the practice.

Even when under cover crews complained of eye irritation from sun glare, which they held caused as much discomfort and injury as the direct rays from the sun. Glare was felt most on calm days when the sea was slick, and was particularly aggravating to eyes exposed to oil, grease, or gasoline during a ditching. Glare without heat was reported in August by survivors in the Bay of Biscay who complained of being "blinded by sunglare while their feet were frozen." There is little evidence that the eye ointment in the medical kit was extensively used.

WETNESS. The term "bathtub" is applied frequently to all liferafts, not only becaue of their shape, but because they are practically always slopping with water.

In cold oceans the constant wetness brings on "immersion foot," a malady induced by heavy, water-soaked footgear, cold, and the inability to exercise or dry the feet. However, the average survivor was more aware of the cold than of the pain of immersion foot. Although there was little they could do to control immersion foot, anything such as removing footgear and air-drying both feet and stockings whenever possible, and wrapping the feet in scarfs, torn underclothing, or chute material before putting on the shoes helped to keep the feet from freezing. A few massaged or spanked their feet with their hands or flying gloves to counteract the attending numbness. Apparently foot oil was provided in some British type equipment, for there is occasional mention of its use. In lieu of oil, Americans powdered the feet with sulfanilamide.

Immersion foot was seldom reported in tropic waters, but it was replaced there by salt water sores, its equal in pain and discomfort. Lacerations, scratches, boils, and rashes caused by heat, friction with the liferaft fabric or shrunken clothing soon erupted into large sores about the size of a half dollar. These usually appeared in about 2 days, and were slow to heal.

Continuous soaking brought on an even more unpleasant swelling and tenderness of the extremities, and gave rise to 'dishpan" or "prune" hands. After 9 days of almost steady rain in the doldrums of the Sulu Sea, a survivor stated that his feet and hands felt ready to drop off from rain water soaking. Another said after 20 days: "I suffered from pressure sores on my elbows, back, and buttocks. My feet were wrinkled and white from constant immersion."

Miscellaneous Aches and Pains

Men complained of skin dryness almost as much as they did of the water soaking which induced it by washing off the natural skin oils. Chapped hands, arms, elbows, and lips were common in both warm and cold waters. In warm regions

during long, dry, calm periods men suffered from sore lips and mouths, thickened, scaly, prickly tongues, and cracked, dry, corrugated skins, for which rain water afforded only temporary relief. A few had supplied themselves with camphor ice chapsticks, but most applied any of the ointments they found in the kits, regardless of their purpose. Others rubbed their hands, feet, face, and neck with gun oil, mosquito repellent, bird grease, fish oil, or the oil from rancid coconuts. One lucky castaway salvaged a small cake of butter which he used on his skin.

Cramps were reported more often by men in liferafts, especially 1-man rafts, than by those in the water. Some warded cramps off by stretching or relaxing when seizure was imminent. In the tropics a few found relief by going overboard and flexing leg muscles in the water; this also relieved stiffness after night chill.

Men susceptible to lumbago or rheumatism suffered constantly with aching joints from the constant dampness, night cold, and cramped quarters, and could get relief only from morphine. Dentures further irritated swollen or inflamed gums and were quickly removed. One man's nose was bashed and another suffered a broken jaw from a blow by a shark's tail. All who tried to handle small sharks reported that the rough shark skin sandpapered their water-softened hands.

Oil, gasoline, and fluorescein dye irritated skins. A Hellcat pilot, exhausted after several hours swimming in a Mae West, thought himself very lucky to find an empty belly tank, but abandoned it after 2 hours because the leaking gasoline "burned" his hands and arms.

Two pilots who bailed out into cold water reported being almost strangled by shrunken ties or collars they could not loosen with numb fingers.

Treatment of Injuries

Men in the water were greatly concerned by any open, bleeding wounds because of possible weakness from blood loss and fear of attracting sharks. They applied compresses and tourniquets at once when available in first aid kits. Otherwise they used ties, belts, handkerchiefs, strips of chute cloth, the liferaft lanyard, or the mirror or whistle cord to stop hemorrhage. Tourniquets applied over heavy clothing were usually too loose to be effective, and when bleeding could not be stopped they packed the wounds with pieces of their clothing or chute cloth.

Morphine was used whenever it was available to relieve pain. It was almost always given to the seriously wounded and to those with fractured limbs. It was sometimes administered incorrectly to men with head injuries, and when used excessively prior to ditching, it reduced the drugged individual's ability to help himself. Morphine was also administered to control delirium and to give men rest after long periods without sleep. "To withstand the merciless pounding I used the morphine to give me relaxation, and under the influence of dope, the waves ceased to irritate me. I resorted to it on three different occasions, all of which were at night."

The unconscious were revived in various ways. In several instances half-drowned men were resuscitated by repeated hugs around the lower ribs to make them belch or vomit the salt water they had swallowed. Men described as "blue" were pulled into rafts, laid face down, and pummeled or slapped until they came to.

Spirits of ammonia were used rarely; survivors had little use for the ammonia ampules, yet without competent medical help the patient's reaction to ammonia was the only way the seriousness of his injuries could be estimated. If the individual revived, everyone felt better and hoped for the best. A TBF pilot with a bad leg wound and faint from loss of blood kept conscious by inhaling an ampule of ammonia. One survivor faint from hunger found the odor of iodine spilt on salt-caked cloth "most invigorating and pleasant."

Men used knives and fish hooks for surgical instruments to probe fragments out of festering surface wounds and to break blisters. Scissors were rarely mentioned. Lone men examined and tended injuries of the face, neck, and buttocks with the aid of the signal mirror.

Iodine was applied to small cuts, but sulfanilamide was preferred for most injuries, and was sprinkled on at the first sign of a wound, cut, or abrasion. Sulfa drugs were so talked up in briefing that men expected miracles of them, and used them indiscriminately to control pain, to stop internal hemorrhages, for diarrhea, headaches, as a sunburn preventative, and even to make salt water potable. Unless covered with a bandage, crystalline sulfanilamide soon washed off, so survivors mixed sulfa powder with vaseline, boric acid oint-

ment, and tannic acid jelly in applying it to open wounds.

The medical adhesive tape in the first aid kits was usually wet and useless, and safety pins soon corroded and broke. Men made bandages from strips of clothing and chute cloth, improvised splints of wood or aluminum paddle handles, and tied them in place with fishline, lanyards or chute risers.

Fractures were usually attended to last because of their more complex nature, the need to improvise equipment, and the reluctance to cause more pain. Five crewmen suffering from broken legs described a "gruesome night with amateur M.D.'s" trying to splint legs with aluminum paddles and chute cloth, during which 24 sulfa tablets proved a useless substitute for the missing morphine.

MENTAL ASPECTS

Although a man's physical fitness favored survival, it was not the sole criterion of success. He needed mental stamina as well, the will to survive, the fortitude to withstand hardship and suffering, and complete faith in his ability to win through. Some perservered with the help of religion or strong family ties. Others stoutly anticipated rescue each day, firm in the belief that their squadrons would make every possible effort to find them. These strong-willed, hopeful, and determined men often pulled their weaker companions through.

Presurvival Attitude

Premission mental strain was admitted frequently by those who had experienced one or more survivals. Symptoms of their distress are described medically as "extreme emotional trauma, manifestations of an acute anxiety state, apprehension, tenseness, inability to relax or sleep, coarse tremors, a marked startled reaction." The extended "rest leaves" normally given survivors eased the strain somewhat, but even so some showed little enthusiasm for further flying duty. Pilots sometimes indicated a preference for other type aircraft, often for single place aircraft in which they would be dependent on nobody's flying ability or judgment but their own, and responsible for nobody else's safety in an emergency.

Tension during a mission was shown in many ways, usually by lack of thought. Typical was the behavior of the co-pilot of a B-25 abandoned over China. When the pilot told him to bail out, he went to the open hatch to do so, but returned for a final handshake—and found his chute draped over his seat. The importance of keeping one's wits in an emergency is stressed by a pilot who wrote home from Japan in 1953:

"This little tour has taught me quite a bit about how to save one's life. . . . We've had two pilots lost in '84's due to panic in the cockpit, and today we had one lad eject and remain in the water an hour and a half before rescue. He's the only case of no panic."

The effort aircrews have to make to avoid panic suggests that mental make-up is often more important than physical strength in emergencies. One survivor wrote "You can't be calm, cool and collected while undergoing the experience of ditching but you must do everything possible to approach such an attitude." Too often the attitude was just the opposite, "pilot shocked . . . and incoherent as to his actions."

The 1953 report of a jet fighter describing his ejection bailout shows the value of thorough indoctrination in an emergency:

"Oddly enough, I never once became panicky or confused. I seemed to perform the jobs which had to be done as they required doing, and planned ahead as time permitted. I planned my water entry-procedure while still descending. I went through the whole experience more by cold calculating instinct than by conscious mental thought. I had the feeling that I had to do what had to be done in order to survive."

Over a long survival, the more physically fit may do better during the first few days or the first week, but in the long run the quiet, determined individual often showed the most real fortitude. Often men's mental processes refused to accept the situation, as shown by the statement: "The whole thing was unreal. It just wasn't possible to happen to me!" In rare instances, individuals reflected a detached state of mind that allowed almost total relaxation. "None of the 5 days I spent in the raft bothered me much because I thought myself lucky to be alive. Maybe that's why I was in such good shape when picked up. If you don't worry too much about anything when you are downed, you will get along much better. Being homeward bound on that PBM was the best feeling I have had in my life."

Shock

Some physical and mental shock were to be expected in men who went through a ditching. Mental derangement in some degree almost always fol-

lowed severe trauma, and often resulted from tenseness and fear in survivors otherwise uninjured. Many airmen had their first taste of the sea when they ditched, and it immediately frightened and confused them. The actions of General Twining's crew immediately after ditching were not unusual. "Some of the boys were off their nuts, yelling at the top of their voices and striking out for Tokyo, swimming off in all directions as fast as they could flail. We had to strike out after them and pull them aboard."

The most severe form of physical shock was experienced by men entering extremely cold water. Deaths immediately following immersion in cold water have been attributed to drowning following fainting from the initial shock. Those who survived this ordeal suffered mental shock.

Appraisal of physical versus mental shock was greatly hampered by a lack of direct reporting, and by the fact that interrogation and debriefing reports stressed only the physical aspects of emergencies. "I do recall, however, that certain aspects of my experience were omitted since they were of psychological import and could make no contribution to the more physical outline requested by the board of inquiry."

Personal narratives, letters, and dairies throw some light on the thoughts, fears, and actions of survivors who were often too self-conscious to reveal officially information which might reflect on their mental stability. Most survivors, however, were too engrossed with their immediate physical needs to concern themselves overly with their mental processes, and had little interest in recalling the past which, as Rickenbacker so aptly expressed it, is "like trying to remember being dead."

The difficulty of remembering all the events of a ditching in sequence and detail can be appreciated only by those who have undergone the attendant physical and mental strain. Usually the events occurred too rapidly to be recalled except in a general manner. "The plane altered its altitude from one of nose-down descent to a level flight attitude; . . . then a crushing sensation, darkness and wetness with strangulation."

In one incident, a DUMBO pilot reported: "All were in extremely bad physical condition, all but one were injured or wounded, and one was out of his head. They could not be questioned even as to their identity." The survivors' narrative provides the explanation: "When we hit the first time, we skipped back up in the air. At this time, one of the men stood up. When we hit the water again, he was thrown against a stanchion, striking the back of his head. He then lost all sense of reasoning. He gave us considerable trouble, falling out of the airplane, and out of the raft. We finally had two fellows set on him."

One of the byproducts of a severe emergency is extreme fatigue which adds lethargy of mind to lassitude of body. In matters of physical endurance, a survivor can fail in his task if he cannot make the mental effort to save himself; the mind must first prescribe, then force the body to obey its commands. Interrogation reports show that many men sat a moment at rest "to collect their wits" before leaving the ditched aircraft, and that many others, after entering their rafts flopped down exhausted or immediately fell asleep for periods of from 20 minutes to an hour.

Morale

The first 24 hours of survival are a period of deep concern and low spirits even among those who regard rescue as a certainty. "After the last ship had passed over, there was scanty conversation dealing with our chances of being found and the fate of the other crew members. I had to verify again and over again that our last transmission had been 'Rogered.' I still believe that everyone thought I was lying but hoped to God I wasn't."

Time during the first few hours, particularly at night, seemed "like an eternity." While watches remained operative time was the main topic of conversation, and a watch was looked upon as "a close ally and friend." Of the 13 survivors who hurriedly evacuated a foundering PBM, one retained his wristwatch. Without rafts in a rough sea, hindered by injured comrades, and harassed all night by "large fish," the principal concern of the group was time:

> "Almost every 10 minutes someone wanted to know what time it was. Time between 0100 and 0300 seemed an eternity. Sometimes throwing the watch away was under consideration. But the suspense of knowing what time it was until dawn saved the watch. Those who thought of rescue felt that it would come with dawn."

Many prayed. Prayers reflected feelings of both helplessneses and confidence. "The silence was deafening. I began to sing all the old hymns I could remember and saying the Lord's Prayer and the 23rd Psalm to keep up my morale." One survivor,

entangled in his risers and desperate with impending panic, made himself repeat the Lord's Prayer slowly and fervently. Most men's thoughts during the first few hours were of their families or buddies:

"I knew I faced the Grim Reaper, for I expected that I had been given up for lost. I spent my time dreaming of my wife and baby, and friends, thinking, hoping. Every night I prayed for rescue because I had a strong faith in God."

Others recited poetry. One survivor read a Chinese-English dictionary. The majority recommended keeping busy "to make the time fly." Those who tried to keep a daily record usually ended up doubting the exact date and spent many hours checking events backwards to recall the missing day.

Lack of companionship made the lot of lone survivors difficult. Some relieved their loneliness by developing attachments to birds or fish. "Porpoises were companionable beasts and I much appreciated their company." Their daily appearance usually was met with a simple greeting that soon grew into a lengthy one-sided conversation. When conscious of the habit, survivors began to fear that they might be cracking up, and sometimes took mental stock to convince themselves of their sanity. Most concluded that they must be normal, first because they still felt a desire to live, and secondly because they felt that they were being sought.

Those who substituted singing for talking found that singing did not leave them feeling as forlorn and lonely as did talking. Singing helped to keep them warm during cold spells, but a song or two was usually enough exercise for their vocal chords after a day of silence. One lonely soul blew his whistle "for comfort" but the single note proved too mournful, and he lapsed into silence.

Compatibility was a major problem in group survivals. Arguments were ordinarily stopped by instituting the right of majority rule, but when necessary by direct order.

Men kidded each other to keep cheerful, to allay fears, or to ease the pain of the injured. In many interrogation reports, the space for "what contributed most to the survival" was filled in with "Our sense of humor." In the early part of his 11-day drift, Madden amused his two companions with imitations and drew considerable laughter when he fell overboard.

Others played mathematical or geographical games which usually ended up with a discussion of future plans for civilian life. The overwhelming desire for food and dreams of past delicacies completely eliminated the subject of sex. During a 9-day drift in the North Sea a group of British survivors began to wonder the first 2 days why they failed to sight shipping. To pass the time, they played at seeing who could hold his head longest under water. The game ended when one cried: "Hi, there's a bloody great mine underneath us!"

Morale improved when men were sure of their position and could spend time estimating their drift or the nearness of land, or in plotting a course. Enlisted men frequently pleaded: "I suggest that the officers be trained to tell the crew at all times where they are and what the chances of getting out of it alive are."

Keeping busy was essential for good morale, and nearly always routines were established. Men slept or maintained a watch in rotation. Often the day started with morning prayers, and each man took his turn; some marked the end of the day with evening prayers. Readings from the Bible always gave comfort, as did crucifixes, holy medals, and novena leaflets, but some grew bitter and profane at their lack of spiritual favor. To the superstitious or the deeply religious such actions were sacreligious, and the arguments that followed caused bad feelings.

An attempt is made in figure 3 (p. 5) to show how survivors' attitudes changed as time passed. Depression was common on the first day. "The 4-man liferaft was crowded with 4 men. The raft was miserable. It was cold, wet and I was impressed with the absolutely ridiculous position it is for four men to be in the middle of the Pacific Ocean in an undersized innertube. Morale was very poor. The only comfort was the momentary warmness you felt when you urinated on yourself." Days of depression alternated with days of cheerfulness, but the narratives more often record only the low ebb of spirits.

Rickenbacker stated that: "In some respects, the period from the second to the eighth day was the worst" and "The first five or six days were the worst I have ever known." General Twining found that the second day was the longest, the third day the hardest, and that the fifth night was the longest. In many incidents, the third, fifth, and seventh day were marked as periods of low morale. "Our morale was good until about the seventh day, and

then began to slip rapidly. When rescued, we all prayed, cried, and thanked God!" Again, "At the end of 11 days, our finger and toe nails were beginning to deteriorate from malnutrition. Our main discomfort was the difference in temperature between the oven-hot days and the icy-cold nights. Our resistance getting lower and our fear of catching pneumonia was mounting. Our outer effects were sores from salt water, sunburn, and our nerves were completely shattered."

The tantalizing, casual passage of aircraft and ships never failed to raise hopes of rescue, and as they disappeared over the horizon hopelessness and depression settled over the silent survivors. "My morale sank to a new low as I saw the search aircraft fly away." Frustration joined depression when survivors drifted in and out of sight of land, unable to make progress against headwinds and currents. "On the third day, my spirits were low when I realized that I had lost all the previous day's paddling. On the fourth morning, I had again drifted off and was reduced to tears."

Any indication of recognition was accepted as a promise of immediate rescue, although often the final pickup was not made for another day or two. "I waved frantically and the pilot waved back. I was feeling better. The fact that planes flew near my position all night certainly helped my morale. I was sure I'd be picked up in the morning." Or, "the plane turned, made a wide circle. For the first time in my life, and I hope the last, I cried for joy."

The psychological adjustment which was to last throughout the duration was hardest after the third day, when the survivors began to feel there was small hope of early rescue. Those who succeeded in making a mental and physical readjustment to life on the raft—to loneliness, hunger, and seasickness—remained hopeful.

Natural leaders kept busy and alert, devised helpful routines, invented gear, and tried to live off the sea to combat depression. General Twining recognized the value of restless activity, and emphasized the fact by his comments. "Sergeant Waggoner was a real morale builder. He kept reassuring the boys in the other boat. Waggoner was always busy with something. Anything to keep things moving . . . He was always hustling around on some project. When he wasn't doing something else he was hunting for his uppers."

When apathy and listlessness settled on one man, it infected the group, and unless some one individual made a strong effort to combat the spreading gloom the effect was deadly. In these circumstances humor wasn't always effective. A strong will, a restless mind, a thick skin, a rough tongue, or a deep consciousness of God often provided the necessary lift to raise the occupants back into a more hopeful mood. Whittaker's WE THOUGHT WE HEARD THE ANGELS SING describes the "rough tongue treatment":

> "We knew we hadn't been seen . . . Tomblike silence and gloom shrouded our group . . . I think the cussing Rick unleashed now was the masterpiece of his career. In about a minute he had most of the gang roaring mad. Then he got under our skins individually. He finished up with a broadside at the whole bunch. The psychological effect he produced was just what he had been hoping for. It didn't improve his personal popularity then, but that wasn't his aim. The morale of his companions was all that interested Rick."

Discipline

Rank held no special privileges in a liferaft, but the presence of rank was in itself a form of discipline which was most effective when the holder set an example of determination and steadiness. Invariably when the going seemed most helpless, men sought reassurance from their superiors.

Undoubtedly, the presence of a general officer was most stimulating to the 14 men who drifted with General Twining on two rafts designed to hold a quarter of their number. In spite of the constant scrutiny of his fellows and the feeling that they expected more of him than of themselves, the General maintained a composure that strengthened the determination of the group. Because of his skill, tact, and judgment, and despite the absence of food or water, and repeated storms during the 7 days of aimless drifting, his group was rescued without the loss of a man.

The existence of authority provided a basis for establishing routines and delegating responsibilities. Thus, food and water stores were usually the charge of the highest ranking individual as a trust of his impartiality. When unable to compromise differences or to settle on a course of action, the group decision was left to him. When men died, he confirmed the fact and committed the bodies to the sea. Age was no criterion of ability, for often the youngest man in the group was the highest in rank. However most groups were about the same age, and because of their previous association as a flying crew, they retained a spirit of in-

formality and of tolerance that made formal discipline unnecessary.

Men without rafts were likely to show less regard for group cooperation. Here the spirit of self-preservation was paramount, and every man tended to strike out for himself. Here again, the sense of responsibility exerted itself instinctively through leadership, usually in an attempt to hold the group together. The commander of a German plane ditched in the Mediterranean instructed his three men to tie themselves together and to him, and to swim toward the coast over the horizon. At various times during the day and night, one or another became exhausted or delirious and tried to end his life. By restraint, by encouragement, and by gaging the rest periods to the shortest time necessary for recovery, the commander drove his group on. At dawn, even he suffered a severe depression for about 15 minutes, and during that time received, in turn, the encouragement of his 3 crew members. They made their goal in 20 hours.

Irrationality

The state of violent excitement or emotion common to the ditching phase is typified by General Twining's crew swimming off in all directions, but he states that later, "things quieted down then. Everybody had time to assimilate what he had been seeing and doing at such a pace he couldn't fully grasp it before."

In two cases when men abandoned aircraft without making any effort to secure their rafts, they claimed they were too frightened to wait or to secure them. Some men reacted the opposite way and refused to leave the aircraft. "Another survivor appeared on the wing with a flashlight and we yelled to him to jump in and swim toward us. I don't know if he heard or not but he went back and climbed into the ship. The nose section promptly sank and the tail section was no longer visible."

Fright normally wore off as the survivors gained their rafts. But in some incidents crew members were so paralyzed with fear they were helpless. "B. was quite bad off from fright and would not answer us." Many exhibited bad judgment in not using their rafts, or in leaving them when conditions warranted their use. "I did not use my life raft because land seemed so close but due to exhaustion and the increasing size of the waves, I would have drowned if the destroyer hadn't picked me up."

Survivors often became delirious from lack of food or water, or because of exposure and fatigue. Men who spoke of leaving the raft, soliloquists, and those who lapsed into apathetic listlessness were considered deranged but harmless, and were generally ignored. Those who grew violent and tried to attack their mates or to leave the raft had to be subdued, and in some cases sat upon until they calmed down. Knives, machetes, or guns were taken away, and a special effort was made to guard the food and water stores.

Delirium invariably followed salt water drinking, and in one incident led to attempted cannibalism.

The details of the incident are taken from the official report:

"The first several days passed without particular incident. The crew was discouraged because of the loss of water supplies. To add to the tragedy, one of the three remaining cans of water contained salt water. Rough seas made it impossible to catch rain, which fell on two occasions and netted the crew a few tablespoonsful heavily contaminated by sea dye marker and salt. Water was exhausted on the fourth day. On the ninth, they drank their fill of salt water. Shortly afterward, one of the three went out of his mind and lay spiritless in the bottom of the raft. The other two were 'getting ready to put him out of his misery . . . and drink the blood and eat the meat . . . experimented with methods of catching the blood which were not successful . . . after a while the man appeared dead. We gave up because we didn't want to eat the dead meat.'"

HALLUCINATIONS. "It does us no dishonor," said Rickenbacker "to say that we were all becoming a little unhinged. Like the others, I had my difficulties, my particular delusions. One was a dream that repeated itself endlessly."

Dreams were not uncommon but men rarely bothered to interpret or record them:

"We became weak and hysterical. All suffered hallucinations during the latter stages with the exception of J., the youngest. Two of us were visited by a hatless but immaculate American soldier, who sat alternately in the bow and stern. This apparition I recall now and will probably never forget, calmly pointed to various lights around us while we were drifting into a bay and identified them as being 'Norway, Ireland and Iceland.' I always seemed to have my eyes open when this hallucination appeared. I recall also that I weighed the apparition's words quite carefully, and they may have had something to do with the direction in which I decided to sail. Later C. revealed that he had seen the same sort of vision, halluci-

nation, or whatever you care to call it. I remember at one time during our voyage C. pointed towards the bow and said 'Where the hell did you come from?' indicating that a stranger was in our midst. It is possible, and you may say probable, that C. or I suggested the hallucination to one another."

Dreams were often accompanied by music. One survivor heard clearly the chorus of Beethoven's "Glory To God In Nature"; another was disturbed by a squadron song. "You know how it is when you're riding a train and sometimes the wheels will play a familiar tune. That's the way it was that day. The waves splashing against the raft played a song one of our fellows made up, "In a Rowboat to Rabaul." All day long the waves played it. If I could have gotten my hands on M., I'd have wrung his neck."

Soliloquies were common: "Signs of delirium were beginning to show in all of us. Some were lapsing into prolonged, dangerous slumbers, some were muttering off, irrelevant words and while they were actually funny, they didn't seem like anything but pathetic then." A lone survivor picked up at sea by a chance submarine calmly walked on board and informed the crew he had been waiting for them as instructed by the tower at Iwo. The submarine commander pointed out that their position was halfway between Iwo and Japan, but the survivor (who had spent 6 days on his raft) insisted that he had been in touch with the Iwo Tower all the time!

Boat whistles, foghorns, and more often the sounds of aircraft were heard when neither ships nor aircraft were present. At first every low cloudbank on the horizon was greeted as land, and some were accused by their mates with having "island eyes" or "land eyes." At night, but more often at twilight or just before dawn, survivors mistook low, bright stars for ships, flying aircraft, lights on shore, or lighthouses, which were so real they fired flares of Very signals. "Towards morning I mistook a low star for a lighthouse and I started to yell. My error left me feeling foolish."

THE RESCUE

IN almost all survival incidents the moment of rescue was attended by dangers. Attempted landings and pickups brought needless injuries or death, primarily from underestimating sea conditions or through clumsy handling. Survivors inexperienced in handling small craft displayed poor judgment in beaching rafts, with resulting casualties or loss of equipment; rescuers with the best of intentions failed to realize the weakness and helplessness of survivors. Consequently, just as survivors were thanking God for being found, they suddenly faced their worst moments at the instant of rescue. Many narratives list exposure, dehydration, and *rescue* as the three most dangerous hazards of survival.

Shore Landings

Bombard found in his study of disasters at sea that 90 percent of all accidents occur during landing. Most men in rubber rafts had little or no control over their crafts and drifted with the prevailing wind and current or tide. They had little choice in their approach, and often had to land on exposed, windward shores through heavy surf. Pilots operating among Japanese-held islands in the Pacific early recognized the value of ditching at sea rather than in the protected lagoons, for whether escaping seaward or approaching land, surf is a formidable obstacle.

Men decided whether or not to land by the appearance of the coast. They avoided rocky shores for few had the courage to swim through surf and rocks. When the coast was too open, they sought a protected lee where the surf was less severe. Surf heard at night gave all survivors disquieting minutes, for they feared night landings and they used their sea anchor or paddled desperately to hold offshore until daybreak.

Survivors found it difficult to estimate the force and height of the surf breaking over barrier reefs, or to determine the nature of the reef below the foaming water. They could pass through barrier reefs safely only by locating the open channels into the inner lagoon. Unless they negotiated the channels on an incoming tide or at slack water, the outpouring tide swept the raft miles seaward. Some who noted a moment of relative quiet between waves took advantage of it to cross the reef. Others tried to let large waves wash them into the lagoon, and although a few managed it safely, most were swamped or turned over. One survivor who sailed his raft from island to island was dumped out in each of three successive landings: "I misjudged the height and force of the surf." Undertow and backwash made swimming difficult. Few escaped being scraped on the bottom or battered against the coral.

Ship Pickup

Survivors picked up at sea urged over and over "that a more convenient method be devised to pick survivors out of the water." Men watched approaching ships with apprehension, frightened by their speed and force. On numerous occasions they had to jump overboard and swim to avoid being hit, or were left battered, bruised, and full of salt water trying to fend themselves off the ship's sides.

Survivors often were nearly drowned while being hauled on board. When ships resumed speed while men still hung onto ropes, the wash forced them under water and they hung on desperately in fear of being swept back into the propellors. All suffered rope burns, and regretted having thrown away their gloves. After only 20 minutes in the water one pilot was hauled aboard more dead than alive; he needed 2 hours of artificial respiration, 2

quarts of plasma, and several injections of adrenalin to revive him.

Rescuers failed to realize the inability of survivors to help themselves. In one incident a survivor pulling himself up hand over hand suddenly found himself back in the water when a seaman who thought he could hoist the airman from a better position let the rope drop to change his stance. It was tricky to climb the side of a destroyer or small escort vessel even in a calm sea, and in rough weather the heeling and pitching of all vessels made coming aboard a desperate matter. Rope ladders or cargo nets made climbing easier, but even these had their special terrors. One survivor's legs became tangled in the rope ladder, and he was pulled up willy-nilly feet first with his head swinging against the ship's side. Cargo nets were somewhat safer, but in rough seas the rolling of the ship alternately lifted the survivor skyward, then plunged him back in a smother of foam. The exhausted dropped off, fearing they would be smashed against the ship or pushed under it. Seamen tried to help, but when making a line fast around one man's body, the rescuer accidentally tied him to the cargo net.

In very rough seas men could not be taken directly aboard, and boats had to be launched to pick up the survivors. Sometimes the ship stood by until a nearby submarine could pick them up. Submarine pickups required skill, for if the rescuers overshot the survivor, the ship had to circle back for another attempt and it was easy to lose sight of the man, especially a swimmer. Although a submarine's deck is close to the sea surface, it still took great skill to come alongside survivors and pull them aboard without sending men overboard to help. Submarine skippers felt that "Cargo nets are essential to pickup when survivors come alongside."

Pickup by shallow draft boats, such as PT's, was extremely hazardous. When larger waves lifted their bows, the raft was easily sucked under the hull. "When the PT boat came to pick us up we were carried under the bow. It came down on us upsetting the raft. We finally got aboard except for Lt. U. who had been hit on the head when the bottom crashed down on us. He floated away into the night."

Aircraft Pickup

Small float planes were usually less efficient for pickups than larger seaplanes because they had no spare hands to help the survivors. This was always true of the OS2U, for the pilot hesitated to leave the controls except in very calm water. "At times the raft was 5 feet away from the plane and then in a few seconds would end up about 50 feet way." Men with waterlogged clothing, exhausted or numb from exposure, had to be dragged onto the float and then onto the wing. This maneuver could be accomplished in calm water in 10 seconds, but often took minutes. Injured men were even more difficult to handle. Sometimes the aircraft's sea anchor line was looped under the survivor's arms, and then used to lash him onto the wing. Lashing was necessary even when taxiing because sometimes planes had to run a half mile or more to gain airspeed. OS2U pilots recommended using a ladder or line when picking up survivors.

It was equally difficult to board large flying boats. Although the larger craft had more hands to help survivors, only two could stand at a time in the small hatches. Sometimes the aircraft had to maintain seaway, which gave the survivor rough treatment. "DUMBO threw out a line and when I took hold I was jerked out of the raft and towed under water at 10 knots."

Rescues made near enemy shores were so dangerous the rescuers often could not be too considerate of the survivor. "He brought the PBY about 2,000 yards from the shore and 1,000 yards from the survivor. We taxied under intense mortar and dual purpose gunfire and turned to the lee of the survivor. As the plane passed the survivor, a lifebuoy and line were thrown to him and we towed him. Three times the exhausted survivor lost his grip and each time the PBY had to circle back." It was not unusual for PBM's and PBY's to pick up as many as 15 men at one time, but whether it was one man or more, air-sea rescue pilots agreed that the task would have been much simpler and safer with a modified Jacob's ladder. "Lt. F. had some difficulty in boarding the DUMBO until the rescue plane threw out its sea anchor, thus slowing up its drift."

SEARCH PROBLEMS

Coordination of Search and Rescue

Early in the Guadalcanal campaign the only aircraft available for immediate rescue were land-based J2F and ship-based OS2U seaplanes. These were shortly replaced by Catalinas (PBY's)

which were dubbed "Cats." At first, recovery depended largely on an intercepted SOS, an accidental sighting, or the reports of wingmates. But by 1943, search and rescue was better organized and the use of Dumbos (the name originated as a code word for Catalina rescue aircraft) became standard. The steady return of men presumed missing or lost was a tremendous boost to the morale of flying crews.

Out of this experience evolved the principle of Close Strike Protection, developed through the cooperation of the Fifth Air Force, the Naval Task Forces of the Pacific, and the Australian and New Zealand RAF. Rescue plans were synchronized, and amphibious aircraft, land-based search planes, PT boats, destroyers, destroyer escorts, and submarines proceeded close to the target area or along the probable route of the returning strike. The dispersion of rescue craft was largely determined by distance and by local sea conditions. Dumbos and crash boats were used in protected waters, as in the Solomon-Bismarck archipelago. In exposed waters, as in the Central Pacific where amphibious rescue aircraft were sometimes lost in rough open sea landings, destroyers and submarines were more effective. Surface vessels were also more useful in rescues under close inshore action. In the Palau and Woleai battles surface vessels made 83 percent of all the recoveries.

This combination was capable of the extremely close coordination shown in the case of a fighter pilot who bailed out southwest of Okinawa. Five minutes later his wingmate called a rescue Cat, which in turn radioed a B-17, which dropped its airborne lifeboat within 100 yards of the survivor. Meantime the fighter cover had sighted a submarine and directed the Cat to it, which in turn led the sub to the pilot who was still struggling to reach the lifeboat.

The high order of teamwork brought efficient searches and successful rescues, and was one of the more cheerful chapters of the Pacific War. The rescues of flying crews steadily increased and, as the action advanced closer to the Empire, the time men spent in the sea became shorter. The air-sea rescue unit in the Mariannas during one 8-month period flew some 2,000 miles for each person saved. In the difficult search over the Pacific for General Harmon's plane, shore-based aircraft made 995 search flights, covered 1,000,000 miles, and logged 6,264 hours.

During the Korean outbreak the successful coordination of recovery procedures was favored by the limited area of the action and by the relatively high concentration of surface and air rescue facilities. Although about 2 percent of Air Rescue Service missions involved water pickups, the use of helicopter and amphibious aircraft guaranteed almost immediate recovery of all water survivors.

Coordination Difficulties

Throughout World War II, the standardization of recovery procedures was a constant objective in all theaters. The problem was manifold, and its solution was as seriously handicapped by survivors' errors as it was by insufficient training of rescuers. As late as July 1945 an official Air-Sea Rescue field report from the Pacific stated that: "The biggest problem remains the question of effort and communications."

Search and rescue achieved stability early in the European Theater, primarily because of the proficiency of the British Air/Sea Rescue Service. In the Pacific Theater, search and rescue coordination was less proficient. The wider and constantly changing areas of action, the overlapping of commands, the variation in types of search craft, and the tremendous deployment of land-based and carrier-based tactical forces all influenced every phase of rescue.

Areas of action within the theater were also marked. Most air actions in the Southwest Pacific were short, overwater flights, mostly by land-based, light or medium bombers or fighters. In the Central Pacific overwater flights were longer and made primarily by carrier aircraft or long range bombers. Notwithstanding the many difficulties encountered, the rate of recovery in the Pacific campaign by air-sea rescue was impressive.

Using submarines to rescue downed airmen was a unique development of the Pacific Theater. They were first so employed with the naval air attack on the Gilbert Islands in 1943. Submarine support of air operations proved important psychologically, and its practical value was demonstrated by the USS TANG during the strike on Truk in 1944. The TANG recovered 22 of the 35 airmen shot down over water, a record which stood until VJ-Day when the TIGRONE rescued 31 men. During the Southwest Pacific Campaign up to 50 percent of available submarine units were detailed to rescue duty, in the final opera-

tions against the Japanese Empire 40 percent. By the end of hostilities 86 undersea vessels of the Pacific Fleet Submarine Force had returned 504 airmen to duty.

Submarine lifeguarding first became a part of carrier air strikes, and was later extended to land-based air strikes by special arrangement with central Naval headquarters to cover specific areas at certain times. Carrier air strikes at first received better support from Lifeguards than did land-based strikes because better coordination permitted the submarines to take their assigned positions in ample time with detailed information. To improve support of land-based strikes, a standard lifeguard procedure was prepared and issued by the Navy in 1944. SOP TWO "laid down all the rules for lifeguarding [by surface ship as well as submarine] and specified universal radio frequencies for all air-sea rescue communications" with a secret list of reference points and submarine calls.

The long range B-29 bombing raids on Japan made further changes in lifeguard procedures necessary. When missions were cancelled unexpectedly, the Lifeguards waiting for distress signals were exposed unnecessarily to enemy attack, and had to be informed quickly of changes in plan. Where the time-consuming method of contacting the Lifeguards through central Naval headquarters proved impractical, the responsibility was transferred to a surface ship in the immediate area. The control ship and its assigned Lifeguards quickly became known as the 'Lifeguard League," later replaced by two other groups, the "Texas League" and the "National League."

As in previous operations, the land-based B-29 crews were slow to appreciate the value of the submarine Lifeguards. Multiengine pilots, uncertain of the position or the capabilities of the submarines, often preferred nursing their damaged aircraft homeward to risking water landing, especially in rough seas and at night. Consequently, many had to ditch far from the rendezvous station where it was impossible for the Lifeguard to find them. Although started in November 1944, B-29 crews did not take full advantage of the submarine rescue service until April 1945 when joint briefings with naval personnel led to mutual understanding of the problem and gave them more confidence. From then to the end of hostilities submarine pickups became commonplace.

However, careless adherence to standard operational procedures compromised the success of rescue missions. The difficulties listed by Air-Sea Rescue Agency reports were:

a. Inaccurate position reports by aircraft in distress.
b. Disagreement in position reports given by orbiting aircraft.
c. Inaccurate information from witnessing aircraft, especially on numbers of survivors.
d. Confusion between simultaneous crashes.
e. Failure to report immediately accidents or missing aircraft.
f. Failure to instigate rescue procedures directly after the aircraft was reported overdue.
g. Hesitation of pilots to admit being lost.
h. Air control confusion.
i. Failure of vessels other than those directly concerned to report crashes or ditchings.
j. Lack of, or improper coordination between air cover and surface search vessels.
k. Unnecessary use of IFF resulting in false alarms.
l. Lack of, or improper use of recognition signals.
m. Rescue mission's failure to destroy liferafts or other floating gear, which gave rise to false alarms.
n. Failure of communications.

Planning and Procedure

Chances for early rescue were greatly increased by prompt distress reports, but pilots were often reluctant to admit their inability to "make it back," and waited too long to send out a proper distress signal or to make adequate preparations for ditching. Failure to report its position placed the aircraft in the "overdue" or "missing" category, and seriously lessened the chances of rescue.

The importance of preditching messages may be gaged by analyzing 135 ditchings of B-29's. Of the 60 that sent position reports before ditching, 51, or 85 percent, were located by the searches. Of the other 75 only 7, or 9 percent, were found. Of the 67 recoveries, 76 percent were made during daylight, and 24 percent by night. Night rescues succeeded only when the position was given accurately and when the survivors had means of night-signaling. When long distance strikes began early in the morning, ditching or bailout occurred

late in the afternoon, and effective search could not begin until the following morning. Night missions had better prospects of early pickup during the succeeding daylight hours. After the first 24 hours the recovery rate falls sharply, and then continues to decline steadily.

The far higher recovery of crews from whom a signal was received resulted not only from more accurate knowledge of their position, but from the greater and more immediate search effort made when it was known the craft was down. When aircraft failed to signal, precious time was lost before a special search was ordered, and the search was less persistent.

The possibilities of survivors being spotted accidentally depends on the density of air and surface traffic in a given area, and on the alertness of the crews. After trying unsuccessfully to signal some 40 homecoming B-29's with sea marker, a downed 11-man crew criticized "the practice of crews sleeping en route home from target rather than being on the lookout for buddies in distress."

Planned search did not always insure recovery. A search by 50 aircraft and 1 destroyer off Hawaii lasted 4 days; although the survivors saw 9 of the search aircraft they were rescued at dusk of the fourth day by a passing liberty ship. One Air-Sea Rescue unit in the Central Pacific estimated that when the position was known and the search began immediately the chance of recovery was about 90 percent, while random searches starting 1 day after the aircraft was reported missing gave only some 10 percent success.

The first reported position of a downed aircraft was often incorrect. One reported position was 70 miles in error, and the rescue ship, originally only 17 miles away from the correct site, had to be redirected three times before it found the survivors.

Orbiting Difficulties

When search or other aircraft spotted survivors they held their position over the raft by flying in a small circle and, while so orbiting, sent a position report to the nearest source of help, usually mentioning the number of survivors or rafts.

It was important to keep the survivors in sight: "Contact with a survivor at sea, once made, should never be lost. There are instances where it has never been regained, despite the most exact navigation, and when assisted by all known methods for sighting." Darkness was the greatest single cause for losing contact, but men in rafts were often lost in daylight when visibility was obscured by rain, squalls, or sudden storms. Air-Sea Rescue records contain innumerable instances where survivors reported alive and apparently well were never seen again.

It was difficult to forecast a lost raft's position without reliable data on winds and ocean currents. Some whose position was figured incorrectly were found accidentally. In hunting the crew of an overdue C-54, the search aircraft sighted the survivors while maintaining a course outside its specified search area to allow the navigator to establish a fix. Another narrative states "DUMBO underestimated our raft drift. We were given up for lost. Pure chance that they found us. By attracting a passing P-38, we were able to have a PBM directed to our position. Don't assume a crew to be lost."

As orbiting was limited by the fuel capacity of the aircraft, B-29 Superdumbos, PBY's, B-17's, and Privateers could maintain contacts longer than the smaller, single-place aircraft. "Search by combat planes is not conducive to the successful conclusion of an air search. Survivors were sighted by a combat plane in rafts some 400 miles east off Guam but the plane was equipped with combat equipment instead of lifesaving equipment. When the initial contact was lost due to a line squall, it was never regained."

Orbiting allowed surface vessels to find survivors by taking a radar or visual fix on the circling aircraft. Aircraft orbited to attract the help of ships with which they could not establish radio contact. Spotting survivors from submarines and other surface craft with low decks was almost impossible in rough seas. Orbiting aircraft helped the USS TANG make its record recovery of downed fliers at Truk. Large surface vessels often had the same trouble. A 1953 Air Rescue Service report of a B-36 crew pickup which involved close coordination between 7 surface vessels and 21 United States and British rescue aircraft states: "The MANCHESTER's Captain was enthusiastic over the rescue aircraft circling overhead to direct him right to the survivors. Because of high seas, the ship's radar was unable to pick up the A-3 life-boats." The ship's lookouts repeatly lost sight of the survivors because the lifeboats were not distinctly colored.

Air reconnaissance extended the Lifeguard's search radius many miles, and was especially valuable in the B-29 search operations. The long cruising range, great firepower, and large crews of the B-29 Superdumbo furnished air protection for a longer time and more eyes to spot widely scattered survivors, especially after a bailout.

Surface vessels were often confused when the presence of several aircraft in the vicinity made it difficult to determine which was orbiting over the survivor. Excessive drops of equipment and the injudicious use of sea marker littered large areas with false trails.

Communications Problems

Throughout World War II poor communications were to blame for the frequent confusion and poor coordination between air and surface rescue units. When electronic communications failed, aircraft crews tried to attract ships' attention by buzzing: "The number of strike problems in this area, and the number of hilarious pilots in all areas who zoom vessels in spite of all orders to the contrary, have made the standard procedure for directing a vessel to the scene of practically no value" (April 1945).

Approach by unidentified aircraft was a particular concern to the commanders of surfaced submarines who were thus exposed to air attacks from both friendly and enemy sources: "Brief pilots before each mission on the location of submarine patrol zones and bombing restrictions effective in these zones to avoid molesting the Submarine Lifeguard Service." The trend of thought and feeling of submariners is ably expressed in the pamphlet "Don't Dunk That Sub":

a. Don't approach without proper identification on both IFF and VHF.
b. Don't overcrowd LIFEGUARD frequencies.
c. Ditch close to submarine—if you plan to ditch and have sighted the submarine.
d. Give out correct and specific information on crashes, strikes, cancellations, and any other changes in plans.
e. Provide continuous air cover when submarine is operating close to enemy shores or during strikes.
f. The cooperation of survivors is necessary for successful rescue; therefore, they should follow SOP air-sea rescue procedures on signaling at all times, and especially at night.

Much of the misunderstanding between undersea and air units was caused by communications difficulties. "While communication problems continually arise, the consensus of opinion seems to be that the difficulties of communications are not in the equipment or doctrines so much as they are in a lack of thorough knowledge and understanding of the problems involved. A great deal of the difficulty lies in the mutual lack of understanding of the capabilities and problems of airplanes and submarines" (June 1945).

Unless forced to submerge because of the approach of unidentified aircraft, or when called off on another mission, submarines kept faithfully on station. Submarine commanders felt that their navigation was more accurate and their stated positions more precise than those given by ditching aircraft. They repeatedly complained of aircraft that reported their position before ditching and then continued airborne 30 to 40 miles farther before landing. Part of the submariner's problem in locating survivors was eliminated when submarines were provided with direction finders.

Reporting positions in plain language was equally vexing to submariners because it invited attack, but direct voice communication was unavoidable because pilots frequently had no time to encode distress messages. The hazard was partly reduced by using code words for bearings and distances from a known reference point. Direct voice communication was often hampered by vocabulary differences which led to misunderstandings and repeated requests for simplification. "We would like to have a glossary of zoomy expressions. Some of their [pilots'] lingo is out of this world."

Survivors who failed to comply with night recognition signals added to the tension of submarine searches. During the search off Truk the TANG fired Very stars at 15-minute intervals without a reply. Later, one of the survivors admitted he saw the submarine's signals but was afraid to answer them. The submarine's log states: "Hours of futile search. Next day picked up three survivors."

The frustration of air rescue when survivors failed to use their equipment is emphasized by the report of the rescue of a C-54 crew in September 1945:

"Survival Equipment: When the rigid boat was dropped, the survivors boarded it and cast the rubber raft adrift.

Survivors made no attempt to use signaling gear at their disposal in the raft, such as signal mirror, flares, or radar corner reflector. After they boarded the rigid boat, the survivors made no effort to use signal gear in boat, or to get boat underway, or to slow drift of boat by use of sea anchor. They also made no attempt to retrieve a shipwreck kit, signal kit, or two Gibson girl radios which were dropped to them, even though no drop was more than 150 feet away and the gear floated closer. Only when the PT boat was in visual range did they use red Very's pistol flares and blinker lamp.

"Those survivors were evidently totally unfamiliar with air sea rescue procedures and equipment. Without the persistent efforts of the rescuers, the failure of the survivors to use the survival gear in the manner for which it is intended might have been fatal to all of them."

Environmental Handicaps

Rescue reports from the ETO show the best altitude for sighting liferafts to be 800 to 1,000 feet, and for spotting a man afloat in the water to be 400 to 500 feet, with the efficient horizontal limit not more than 500 yards and usually less, depending on waves, spray, fog, haze, or overcast.

Glare made spotting survivors very difficult. It is impossible to see a liferaft, to say nothing of a man in a Mae West, hidden in sunlight reflected from the water. Search aircraft flying into the sun could not hope to spot survivors unless they had lookouts in the tail watching aft, which made multiplace aircraft far more efficient than single-seaters.

Low visibility in clouds, fog, or rain made search disheartening, especially after the first contact was made and lost. Survivors were often taken unaware in thick weather by the rapid approach of aircraft which passed them before they could signal. One Central Pacific search for survivors known to be in an airborne lifeboat was finally abandoned after 25 sorties; foul weather defeated nine of the sorties, and only 12 achieved more than a 50 percent coverage of their assigned areas.

Inability to estimate drift delayed rescue. Searchers could figure ocean currents and regional winds, but could not allow for local storms or the survivor's use of sails, paddles, or sea anchors. The drift of men in Mae Wests depends more on ocean currents than on wind, but rescuers assumed most survivors were in rafts and planned searches downwind. When large crews bailed out, the men were often scattered 10 miles or more, and it was almost impossible for one search craft to round them up. After one B-29 bailout, 5 men were picked up by a destroyer, 3 by a flying boat, 2 by an amphibian aircraft and 1 by a submarine.

Physiological Handicaps

Searchers can keep their eyes working at high efficiency for about 3 hours, after which the eyes lose more than half their efficiency. Because eye-strain handicapped search, it was profitable to take along as many observers as the aircraft would carry so that lookouts could be relieved frequently.

The bright yellow of liferafts, Mae Wests, hats, and paulins was chosen because it contrasts with sea colors. But many tests have shown that yellow is not recognizable at more than 700 feet; beyond that it is easily mistaken for whitecaps or spray. Rescuers often spotted a raft by its silhouette long before they perceived its color. A crew picked up by a destroyer in the Irish Sea early in World War II so crowded their small raft they hid it from sight, but all wore yellow Mae Wests and skullcaps. They had been passed unseen by a seagoing ferry, several fishing boats, a sloop at less than 100 yards, and by aircraft overhead. The alert captain who rescued them had seen their yellow skullcaps.

The same indistinctness that hampered rescue impeded the enemy's much less careful search. Much of the survivor's effort to avoid detection was wasted effort.

False Alarms

Because false or inaccurate information wasted time, manpower, and equipment, Air-Sea Rescue reports constantly stressed the importance of care in reporting all sightings. Aircraft flying at high altitudes made most of the questionable reports. A total of 99 fruitless searches in the Mariannas region were initiated by the following false reports, made mostly by B-29 crews:

Signals (Light or Smoke)	23
Overdue Aircraft	16
Miscellaneous (Floating objects, oil slicks, mirror glints, etc.)	15
Liferafts	13
Sea Marker Dye	11
Reported Crashes	10
Intercepted SOS Distress signals on regular channels, dashes on 500 Kcs., or steady tone signals on 8280 Kcs.	9
Men in Sea	2

The official report accompanying this investigation (1945) states:

"Approximately 40 percent of the flying entailed investigations of false alarms. In each case it was established by two or more of the following means that the initial reports were in error:

a. No aircraft was missing that would have been down in the area.
b. Initial report later retracted following interrogation of the reporting group.
c. Careful investigation of the area was negative, generally resulting in the discovery of a box, crate, spar, seaweed, or other bit of flotsam which probably occasioned the original sighting.

Elimination of such false reports is essential in order to prevent the unnecessary diversion of rescue facilities that may be required at any time for real rescue missions. Furthermore, the fable about the boy who cried 'Wolf' still applies."

To make rescue service more effective and to hold false alarms to a minimum, Air-Sea Rescue officials issued basic recommendations:

a. Use exacting care in establishing and reporting positions of survivors to avoid fruitless search.
b. Pilots should report only things seen.
c. All distress reports should pass through evaluation officers at vital communications centers for proper assessment and to avoid negative searches.
d. Prompt report of arrival of all overdue aircraft.
e. All unaccounted and empty liferafts, electric float lights, etc., should be recovered or destroyed to avoid duplicating rescue calls.

Failure to recover or destroy empty liferafts caused much confusion. In a B-24 bailout in 1945 "The plane crashed some 12 to 15 miles from the point where the crew bailed out. The crew was picked up by a passing tanker within an hour. This information was not received by Air-Sea Rescue. In the meantime their rescue plane circled the two automatically inflated rafts and directed other vessels to the scene. After the rafts were recovered there was nothing to indicate they were from the crashed plane."

To prevent confusion it was suggested that liferafts be labeled with waterproof identification tags bearing the name or number of the vessel or plane to which they were issued.

The presence of a raft was always accepted as evidence that the crew had enough warning of the impending crash to make preparation for ditching and had escaped from the aircraft, but in many ditchings when the impact was so violent it killed everyone aboard, the liferafts ejected automatically and came free to the surface.

"The recent increase in false aircraft distress reports resulting from aircraft failing to establish or maintain proper air-ground communication has seriously endangered the efficiency of Air-Sea Rescue action in the Hawaiian area." (1946).

Mysterious emergency transmissions are frequently picked up by units monitoring the Pacific frequencies. Investigations have failed to reveal their origin. These signals are usually interpreted as harmonics from continental range stations operating close to the emergency frequencies. Communication centers reported hearing a number of Gibson girl signals after two emergencies. The rescue vessel reported in the first case that the aircraft apparently exploded in midair and that the Gibson girl could not have been used. The report on the second incident stated "that the condition of the bodies and widespread shattered and burned litter indicated a terrific impact or violent blast . . . and instant death."

SURVIVAL MANUALS AND TRAINING

THE OFFICIAL REPORT of the British Air/Sea Rescue Service, 1942-1944, states that its rescue support for the VIII Bomber Command and the 8th Air Force was seriously hampered by defects in training of American crews, especially in communications, ditching procedures, the use of emergency equipment, and rescue techniques. Liaison officers with the U. S. Air-Sea Rescue Agency at Pacific bases also criticized American training severely, and found distribution of survival equipment and manuals faulty. One of their reports for 1944-1945 states:

"Briefing and training on water survival was not too good for a long time. Men did not know their equipment or how to use it. One reason was that emergency equipment was meager, especially mirrors and ACR-578 radios; droppable kits were practically nonexistent. Some crews train together, drill together, and carry out successful ditchings, while others have never had a ditching drill. It has been found to date that all aircrews arriving from the States, in general, are very inexperienced in all phases of rescue and survival techniques, and have little knowledge of their equipment. In questioning survivors I have been impressed with one startling fact, which is that equipment failed only because the individual did not know how to use it or that it was in no condition to be used."

Of the 218 water survival incidents reported during the Korean War, about one-third were examined critically for this study. These revealed the same difficulties in operating Mae Wests, liferafts, pyrotechnics, and other survival equipment so manifest in the World War II narratives. Training and discipline in water survival appeared equally haphazard, and in some cases lessened the usefulness of improved water emergency gear.

Survivors' Comments

"The best I can offer as a result of my experience is to give us a survival training course every six months." (5th AF, 9-hour survival (1945), Philippine Sea.)

"The next item of importance is training. All aircrews should be throughly acquainted with all equipment available to them *in the particular aircraft they are to operate.* Of equal importance is the proficiency of each crew member in the use of his equipment. Regular ditching drills should be mandatory, especially at overseas stations." (15th AF, 3-day survival (1945), in the Adriatic Sea.)

"We had plenty of time to think about ditching, therefore we had adequate time to prepare for it. Further, my crew had rehearsed ditching procedures regularly. The impact of waves 40 to 50 feet high, however, coupled with the necessity for getting out of the plane quickly, eliminated any possibility of orderly, calm exiting, with the result that we started our experience in the raft without the benefit of food, water, transmitter, or other aids. There appears to be no remedy for such mishaps when the ditching is either sudden or meets heavy seas. We came through with a 50 percent survival record but we were miraculously lucky." (U. S. Navy, 29-hour survival (1944), North Atlantic.)

Ditching drill practice was often left to the discretion of the aircraft commander; some were more conscientious than others. The sole survivor of a B-29 ditching reported that his crew had only 5 hours of ditching drill in the States, and a brief introduction to a display of survival equipment. Before their last mission, they had practiced ditching 4 times in 3 months.

Other airmen who learned by experience how their intensive training made survival possible stated: "What to do and how to do it seemed to come natural after all the training along survival lines." Again, "Frequent discussion of ditching paid off."

Official reports and the survivor's own accounts show that men who knew their equipment had

the best chances for survival. Some were rescued despite their lack of knowledge that attention to drills would have given them. One pilot sat in his raft lamenting the apparent loss of all his food, water, and signal gear. After climbing aboard the rescue vessel several hours later, the ship's crew solicitously removed from his parachute harness and seat pack the very articles he had supposed lost.

Instructions

Airmen were taught in briefings how to use survival equipment. In addition, instructions were stamped or stenciled on the equipment, or enclosed with it. Briefings, sometimes limited by the experience of the instructor, at least introduced men to their survival equipment. Oral briefings could describe the gear well, but only demonstrations and dry runs could teach them its use in detail. Scarcity of survival equipment often limited demonstrations to the examination of static displays, and many never had a chance to learn by doing.

When the emergency came, men had to fall back on the printed instructions, which were often of least value when needed most because there was no time to read them. Printed instructions were of no value at night:

> "I worked with the screen for about an hour but had difficulty in erecting the reflector properly in the darkness. I finally got one triangle stretched out and kept it rotating over my head until I was tired. I had seen one erected only a few days before, but I hadn't erected it myself. I think all pilots ought to have actual drill in erecting it themselves."

A report issued in 1945 urged that "more instructions be provided on liferaft accessories." Survivors suggested that recognition signals, methods of rigging sails, and a list of accessories be stenciled on the raft deck on gunwales. One crew complained they did not know how to operate the floating flashlights. Airmen who could not distinguish between friendly and enemy ships and aircraft often hesitated to signal.

Manuals

"Survival Manuals" appeared for the first time in World War II. Many different manuals were issued, some for wide general use, others for limited areas. All contained general information on survival know-how and natural history, but with more emphasis on land survival. All copied whatever they wished from one another, and there was a great deal of duplication and reprinting of often erroneous material. The official attitude on survival manuals was expressed bluntly in a 1944 Air-Sea Rescue report: "Needed, a good survival manual. One publication to end all publications."

The AAF Manual 64-1 "Survival," "Survival on Land and Sea" prepared by the Smithsonian Institution for the Navy, and Harold Gatty's "The Raft Book" were distributed in liferafts and emergency kits. Despite the wide distribution of the manuals, survivors made few direct references to them in either official interrogations or personal narratives. Men had them and apparently read items, but their few remarks give little indication of how useful they found them. One survivor remarked that he found his Survival Manual interesting reading when he lay in his camouflaged raft waiting for Jap boats to stop looking for him. Another read his Survival Manual while waiting to be picked up.

Survivors accepted the official service publications at their face value, but frequently questioned specific items. There was more criticism of "The Raft Book"; they recognized its psychological value, but considered it "too bulky with useless arguments. I should hate to be caught on the liferaft, and then have to study it. It's actual value is open to question."

Survival manuals in general played down hazards and discomforts of survival to strengthen morale. In official correspondence on the problem of poisonous fish a military survival expert stated:

> "A civilian specialist in game fishing is going out to the Pacific to save the lives of American fliers stranded at sea by cataloging poisonous fish. Survival handbooks mention only six types but he states that there are literally hundreds of fish containing a poisonous alkaloid so deadly that one mouthful would be fatal. While I don't wish to belittle his efforts, neither am I in a position to contradict him. He should go out and find them before making such statements. He is raising in the minds of some people, who might be forced to live on fish, doubts about *all* fish."

After the War, captured documents showed the Japanese Army lost some 700 men from eating poisonous fish during Pacific operations. The Japanese are a nation of fisheaters, but despite their knowledge of Pacific fish, the Japanese Army had to maintain a biological unit to study the poison fish problem. A 1954 report in the *U. S. Armed*

Forces Medical Journal shows this problem is not yet solved. "The public health and military significance of this disease is grossly underestimated and is worthy of much greater attention than it has received."

Survivor Narratives

Men gained confidence from reading the accounts of survival experiences. Unfortunately, most survival narratives were classified and had a wider distribution among desk-bound than among field personnel. Rickenbacker's experience published in "Life" and Trumbull's "The Raft" were valuable exceptions, for they had wide circulation. Survivors mentioned both publications frequently as having provided apt lessons which helped in their survival.

The narrative of a 3-day ordeal in the Adriatic Sea in 1945 by a 15th AAF pilot concludes: "And last but not least, every man should be exposed to a wide variety of true accountings of actual ditchings. This latter phase is the one that I believe is likely to be omitted."

Chapter VIII

DEVELOPMENT OF WATER SURVIVAL CONCEPTS

THE GROWTH of water survival techniques after air emergencies is revealed by the contemporary press. *The New York Times* was studied because of its world coverage of aviation news, and supplied the greater part of the data used in this chapter. The information for the period of 1942-1946 is based on military records. All overwater accidents of private, commercial, and military aircraft have been summarized. The totals are presented in figure 4.

1913 to 1920

Until Bleriot crossed the English Channel in 1909 all flights were over land. A year later Sopwith completed the first 169-mile flight over the sea. By 1919 the Atlantic had been spanned from both east and west, but scheduled overwater passenger service was available only over the English Channel and the Straits of Florida. The introduction of pontoons in 1910 and later of watertight hulls gave fliers more confidence in their craft over water as, theoretically at least, they could land on the open sea to make emergency repairs.

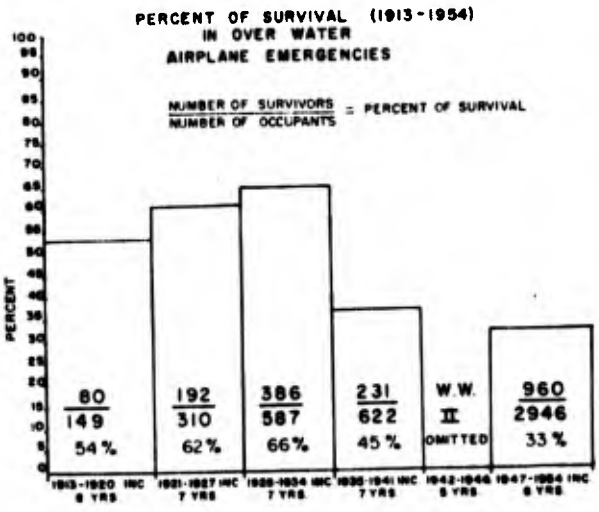

Figure 4

The first real contribution towards survival in this period was Orf's perfection of the parachute. By 1919 the parachute was adopted as required equipment by the Royal Air Force. The period was highlighted by a series of "firsts" in survival and rescue. When Latham tried to beat Bleriot across the English Channel in 1909 he made the first ditching and was rescued by a small boat. The first aviator was lost at sea in 1910; in 1912 two were lost in the Pacific. The first orbiting took place in 1914, remarkable because the pilot also succeeded in summoning aid. In 1916 the first amphibian pickup at sea rescued three aviators.

Most overwater accidents happened on lakes, rivers, bays, or off coastal beaches. As few pilots ventured farther than gliding distance from land, most could be rescued by shore or harbor craft. Some carried inflated inner tubes or ship's life preservers when flying over water, but all found greater safety in their floating aircraft. Fliers who ditched in mid-ocean were saved only if they managed to land near ships.

The open cockpits of the period made it simple to abandon a ditched aircraft, but pilots drowned because they could not release their safety belts quickly. Others were unable to swim. For these 8 years 77 overwater emergencies were examined. They involved 149 persons, of whom 80 (54 percent) were saved.

1921 to 1927

Improvements in aircraft design and increased engine power permitted heavier aircraft loads and encouraged longer overwater flights. The Portuguese crossed the South Atlantic in 1921, but all attempts to fly the Pacific from San Francisco to Hawaii failed. Most attempts to fly the North Atlantic nonstop were unsuccessful, and the resulting disasters prejudiced the public against overocean flying. Nevertheless air passenger service expanded. By 1927 Pan American Airways offered air service from Miami to Colombia, which included a 500-mile overwater leg, in planes carrying 2 to 4 and occasionally 10 passengers.

Survivors of an emergency within sight of land still had to depend on casual bystanders for help and mid-ocean rescues were still a matter of luck, the chance passing of a ship. Almost every landplane forced down in the ocean away from passing ships was lost. Aircraft were still comparatively light, and with empty fuel tanks most would float for several days in a calm sea, but broke up quickly in heavy seas.

After several landplanes were lost trying to fly to Hawaii, the Navy Department announced that "flights of this kind, even when undertaken by the Army or the Navy, must ultimately end in disaster." Yet many seaplanes and flying boats landed safely on the ocean during this period. In two of them the crews were rescued after floating in their aircraft 9 days. The first of these, in 1925, was the first long survival by an aircrew at sea, and the first recorded rescue of aviators by a submarine. The crew had some food with them, which they rationed carefully, and a small still for making sea water potable. With a jury sail and the aircraft compass they navigated the seaplane 400 miles, alternately drifting and sailing, to within sight of land. When rescued they were still in good health and spirits. In the second 9-day drift the following year, the survivors were without food, suffered from thirst and exposure, and were drifting helplessly when found.

Aviators felt keenly the need for collapsible life preservers and lifeboats. The first inflatable life vests were used in 1927 by the German mail pilots the SS. Bremen catapulted at sea. Commander Byrd, when he ditched off the Brittany coast in 1927 was the first flier to use collapsible liferafts. Byrd's liferafts carried two persons and were inflated with compressed air from a tank in the aircraft.

Drowning was still the major cause of death after ditching, but the lengthened survival period brought new hazards in exposure, seasickness, thirst, hunger, and the threat of sharks.

For this 7-year period 101 overwater emergencies involving 310 persons were noted. Of these 192 (62 percent) were rescued.

1928 to 1934

By the end of 1929 more than 100 persons had flown the North Atlantic, but the many attempts that ended in disaster focused public attention on the need for surer ways of rescue. In 1928, Major Carl Spaatz of the First Pursuit Group at Selfridge Air Force Base formed a lifesaving crew "for rescue flights to all parts of the Great Lakes but only in the event of an emergency over water" using Loening air yachts capable of carrying five persons 400 miles. In the same year, when the Russian flier Poliakov was sent out to locate a ship foundering in the Sea of Aral, he completed the first air search-rescue mission. In 1929 the British stationed a 20-knot radio-equipped lifeboat at Dover against possible ditchings on the cross-Channel flights.

The loss of 6 out of 13 persons in the ditching of a London to Paris passenger airliner brought the first public investigation into a commercial air disaster at sea. "Inquiry found that passengers were not properly instructed in the use of lifebelts . . . leaflets giving this information being unavailable." Imperial Airways was charged with the responsibility of looking into these matters and cautioned "to put a person in charge to enforce safety regulations." The first Admiralty case to determine responsibility in the loss of a seaplane's crew of eight revealed that: "The lifesaving equipment on the Donier-Wahl aircraft of the Lufthansa Line was entirely inadequate." The contemporary press echoed the public's concern for new provisions to increase the safety of air passengers on overwater flights.

In 1932 the transatlantic flier, Hausner, drifted 8 days on his derelict Bellanca before rescue by a British tanker. Without food or water, Hausner improvised a fishhook from a compass needle and baited it with skin peeled off his fingers; later he fashioned a fish spear from a pair of metal navigator's dividers and a piece of wood taken from

the airframe. Although unsuccessful in foraging, Hausner's efforts mark the first attempt of an aviator to live off the sea.

During this period military aircraft began carrying collapsible rubber rafts. The first one was used at sea in 1931, and floated the pilot for several days before he was rescued. The first man lost from a raft capsized his "inflated rubber balloon" in 1934. In the same year two Navy pilots made the first successful air-to-water raft-drop.

Closed cockpits made abandoning aircraft after a water landing more difficult. The absence of adequate emergency exits, especially in commercial landplanes, made it necessary for survivors to force their way through holes torn in the fuselage. The widespread use of parachutes and the increased availability of life vests and liferafts raised the chances for survival, but most survivors were still taken from floating derelict aircraft. Those with Very signals, red flags, or kites had some hope of attracting attention, but rescue still depended largely upon favorable weather conditions and the chance passing of a vessel. Aviators forced down in gales were given up for lost.

For this 7-year period of aviation, 160 overwater emergencies were examined involving 587 people, 386 (66 percent) of whom were rescued.

1935 to 1941

Up to this time aircraft were always ditched by landing into the wind at stalling speed. Because contemporary aircraft were light and relatively slow they rarely traveled more than a few feet after landing.

The development of heavier aircraft with higher wing loadings and faster landing speeds made ditching more hazardous. Aircraft were more likely to break up on impact, to cartwheel, or nose over. This decreased their floating time and reduced the occupant's chances of getting out safely. Lack of sea experience and ignorance of the landing characteristics of various aircraft added to the dangers.

Experiments to improve aircraft buoyancy which had been in progress since 1930 were largely replaced by 1937 by greater activity in liferaft development. The earliest use of CO_2-inflated rubber rafts by a large group of survivors occurred in 1935 when the rigid airship "Macon" broke up in squalls off Monterey, California. As the dirigible bounced from water level to 500 feet, the crew slipped down handlines or jumped into the sea. Gasoline on the water caught fire from flares, and one gas cell blew up. Ten 7-man rafts carried 81 men to safety. There were only two casualties, one man killed by a 125-foot fall, the other in the gas cell explosion. Without liferafts few would have lasted the 3½ hours in the 46° F. water.

As passenger loads doubled, overwater flights lengthened, and flotation times decreased, ditching became more critical. By 1936 Lufthansa completed 146 mail and passenger hops across the South Atlantic. Pan American Airways began its trans-Pacific runs in the same year, started flights to Bermuda in 1938, and extended these along the southern route to Europe in 1939. Imperial Airways reached westward across the North Atlantic to Canada. Transocean travel increased steadily in numbers of passengers and in the number of runs until the outbreak of World War II. In 1942 international commercial air transportation was discontinued, but military flights increased.

Two interesting developments in survival equipment appeared during this period. In 1937 Georges Claude reported to the French Academy on the advantages of fluorescein dye "to produce a huge colored spot in the ocean which could be seen from afar and would endure for a long time." A practical way of using fluorescein was worked out by the German Air Force and, when the English learned of it, they made it available to their allies. Wearing a whistle around the neck for attracting passing ships was recommended by the artist, McClelland Barclay.

For this 7-year period of aviation, 120 overwater emergencies were examined involving 622 people of whom 231 (37 percent) were rescued.

1942 to 1946

The steady rise in the number of military air crossings of the Atlantic and Pacific, coupled with the increase in combat activities over water, was reflected in the growing number of aircraft fatalities. The approximately 4,000 to 5,000 ditchings recorded during World War II form the background for this report. The analysis of personal narratives reveals the shortcomings of equipment and training and illustrates the ingenuity and courage of airmen subjected to the twin disasters of war and sea.

The urgencies of war forced the rapid development of measures to preserve life at sea. Whereas liferaft equipment had formerly been issued only to bomber and cargo aircraft if room was available, by 1944 all aircraft were required to carry sea emergency gear on overwater flights. Equipment needs were met by a vast production of rafts, emergency foods, methods for obtaining fresh water, exposure clothing, and shark repellent. New means of attracting help included both visual and electronic devices. Increasing emphasis was given to survival lore and to the problems of ditching or landing aircraft in mid-ocean.

Search and rescue methods were organized. The standardization of Army, Navy, and British raft-types and accessories remained an unaccomplished ideal because of the expediencies of war, technical difficulties, and jurisdictional differences of opinion.

Although many data for this period are not available, air-sea rescue organizations recovered 30 percent of the fliers downed in cold waters and 60 percent of those in warm waters. The importance of lifesaving equipment in ocean emergencies is clearly shown, and the development of a worldwide system of air-sea rescue was an extremely valuable military contribution to civilian air transport needs.

1947 to 1954

With the resumption of international air travel in 1945, commercial air traffic increased rapidly. Two significant developments that accomplished this transition had a bearing on the survival rate of overwater emergencies. First, commercial airlines replaced their small twin-engine aircraft with large four-engine aircraft, some capable of carrying 80 or more persons. Second, landplanes largely replaced flying boats in long overwater hauls. At the same time more attention was given to briefing commercial passengers on ditching procedures.

Weather ships stationed at intervals across the Atlantic by the Coast Guard were a valuable adjunct to search and rescue. An outgrowth of the Plane Guard or Safety Stations of the war period, Weather Ships supplied important preflight and inflight information to civil and military flights, and were always available to assist distressed aircraft in case of need. In 1947 a Boeing 314 landed near a Weather Ship a few minutes before sunset in seas whipped by a 45-mile gale. The flying boat remained afloat during the night, and next morning its complement of 69 persons was transferred safely to the Coast Guard vessel.

After World War II the Air-Sea Rescue organization in Europe reported a large increase in activity. American-owned civil lines operated 64 percent of the North Atlantic traffic in 1946. This declined to 56 percent in 1949 and to 41 percent in 1953. Trans-Pacific commercial flights also increased, but with the decrease in military air travel Pacific Air-Sea Rescue facilities were reduced. When the Air Transport Command and the Naval Air Transport Service were combined into the Military Air Transport Service in 1948, MATS reorganized the Air Rescue Service to provide "search for civilian and military aircraft in remote areas." Military air travel then started to increase, and reached a peak during the outbreak in Korea.

From lessons learned in World War II overwater emergency equipment was improved. The 20-man liferaft afforded more safety, comfort and protection from exposure, and new electronic signaling aids increased the chances for recovery. But the Korean hostilities revealed faults in survival equipment from careless packaging, inferior design, and defective materials and workmanship. The absence of issued items suggests that careless inspection and pilferage are still a menace. Space limitations and inconvenient storage still make it difficult for crews to get at their equipment.

It might be inferred that the great improvements since 1913 in survival materials, survival knowledge, ditching skills, and rescue facilities would increase the percentage of those rescued after forced landings at sea, but the figures do not indicate it. Figure 4 shows that the possibilities of recovery after ditching today are lower than ever. This does not imply that air travel over oceans is becoming more risky. Trans-ocean passenger miles have increased into the millions and, with improved weather forecasting, more flights are made in bad weather.

The present high mortality in ditchings is the result of a number of factors, which are often cumulative. The evidence suggests that the crucial moment in any ditching is when the ship is abandoned. As planes have become larger and heavier, the time a ditched aircraft may float has decreased. The time available for abandoning ship cannot be

predicted. The operation must be accomplished as quickly as possible and in an orderly manner. When many people have to leave through a few small emergency exits, clearing the ship is a slow process. Automatic equipment makes it easier, but often heavy liferafts must be manhandled out before the passengers can leave. Women, children, and the aged have to be helped out of the aircraft and into the rafts, and it has been suggested that the old maritime rule of "women and children first" be altered to permit passengers to leave in family groups.

International air traffic encounters language barriers which make it difficult to help passengers in sudden emergencies. When a French airliner ditched in the Mediterranean the inability of the crew to allay the panic of their polyglot passengers drowned 42 persons in a calm sea. The two survivors reported that in fear the plane would explode, all the passengers jumped overboard. An American pilot's report of a 1949 ditching in which nine died states: "If the passengers had understood English, I don't think that anyone would have been lost."

For this 8-year period 159 overwater emergencies were examined involving 2,946 persons, of whom 960 (33 percent) were rescued.

Air Force—Gunter AFB, Ala (551385) 5M