

Skin and Scuba Diving Fatalities in the United States

DANIEL P. WEBSTER

NO RECREATIONAL SPORT has perhaps enjoyed as phenomenal a growth in the United States as that of underwater diving. A recent report in *Time* indicates a total participation of 9 million persons; of these, 8 million are skin divers and the other 1 million use scuba equipment (1). An industry spokesman, however, estimates that only 2 million Americans regularly participate in scuba and skin diving.

Both scuba and skin diving have unusually serious accident potentials. In skin diving, the swimmer uses only the air supply carried by his lungs or obtained by using a snorkel tube. In

Mr. Webster is acting chief of the school and recreation section, Division of Accident Prevention, Bureau of State Services, Public Health Service. B. E. Empleton, editorial committee chairman for the textbook of the Council for National Cooperation in Aquatics entitled The New Science of Skin and Scuba Diving, reviewed the paper for technical accuracy.



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scuba diving, a supplementary air supply is used, from which the sport derives its name—self-contained underwater breathing apparatus.

In common with sky diving, spelunking, mountain climbing, and automobile racing, underwater diving entails many calculated risks. Undoubtedly the challenge of these risks adds fascination to the sport. Moreover, as proficiency increases, skin and scuba divers seldom remain content with casual diving in so-called “safe” waters of limited depths, but constantly attempt more exciting and hazardous feats, including self-competition for greater depth and duration of dives. Also, some unusual variations have been introduced since underwater diving developed as a carryover from World War II—variations which may involve uncalculated risks. Underwater exploration of caves, deliberately diving in the presence of barracuda and killer whales, and the bizarre sport of octopus wrestling, for example, afford supreme

tests of a diver's strength and stamina, coolness of head, and skill.

Case studies of underwater diving accidents and fatalities, the experiences of underwater diving experts, and the opinions of physicians who have made studies of the subject have resulted in a growing concern for safety in this sport. The unusual physical demands of scuba diving have been extensively reported by the U.S. Navy (2) and by physicians E. H. Lamphier and H. W. Gillen (3-5), A. W. Dewey (6), and others. The Pfizer Laboratories have developed a graphic description of underwater physiological changes relating to barotrauma, asphyxia, decompression, oxygen and gaseous poisoning, and other hazards (7). Reports of illnesses and possible fatalities resulting from impure compressed air supplied for use in underwater breathing apparatus caused the State of New Jersey to pass a law early in 1964 governing air quality and equipment standards for scuba tank-filling stations (8).

Skin and scuba diving accidents as public health problems have also been given considerable attention in publications of the States of California (9) and Florida (10), where there have been numerous fatalities. The Council for National Cooperation in Aquatics (11) and other organizations have developed training and reference materials on the individual physical and emotional requirements for underwater diving; the selection, maintenance, and use of equipment; the environmental hazards of the sport and their avoidance; the personal skills needed and emergency procedures; and the basic rules for safe public participation.

A deterrent to greater emphasis on accident prevention, however, has been the lack of data on the extent and circumstances of underwater diving fatalities. Routine death certificates seldom provide complete accident information. It may also be some time before the voluntary reporting system introduced by the Underwater Society of America will provide useful data on a national scale.

To define the problem, I conducted a study of newspaper reports of underwater diving fatalities of Americans which occurred in U.S. and foreign waters during 1965. I was able to identify 86 victims and determine the principal factors in the accidents. Incidents involv-

ing armed services personnel during combat or military operations were not included in the study.

Incidence and Circumstances of Drownings

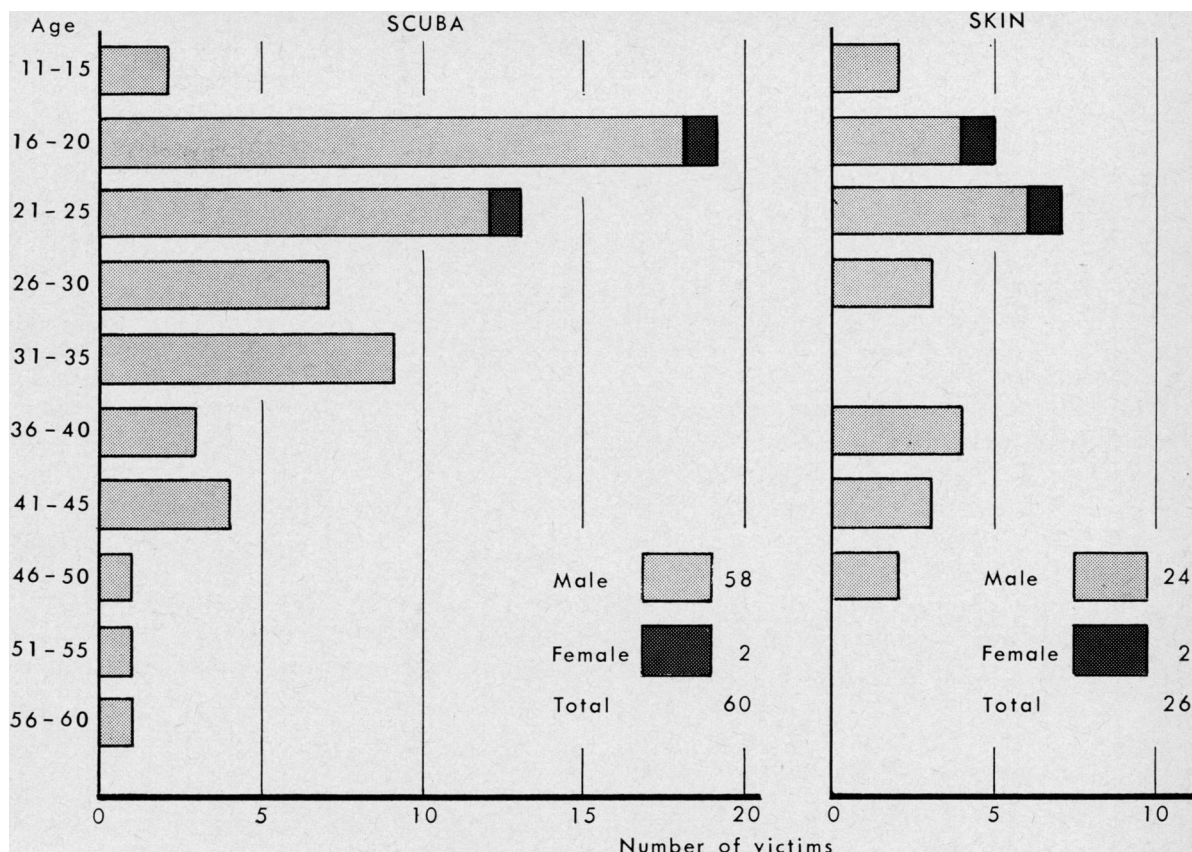
Geographic distribution. More than half (28) of the 50 States were the sites of the underwater diving drownings of the 86 Americans reported in newspaper accounts in 1965. Florida led with 21 fatalities, followed closely by California with 19. An additional 26 States each recorded one to four fatalities. Two victims drowned in waters of other countries. The number of victims by State in which they drowned was as follows:

Alabama	1
Arizona	1
California	19
Florida	21
Georgia	1
Hawaii	4
Illinois	1
Indiana	1
Kansas	2
Kentucky	1
Louisiana	3
Maryland	1
Massachusetts	2
Michigan	4
Missouri	1
Montana	1
New Hampshire	1
New Jersey	1
New York	3
North Carolina	1
North Dakota	1
Ohio	2
Oklahoma	1
Oregon	1
Pennsylvania	1
Texas	3
Virginia	1
Washington	4

Drownings in skin and scuba diving. Skin diving accounted for 26 drownings; 24 of the victims were male (fig. 1). Their ages ranged from 11 through 49 years. By 5-year spans, the peak age group for drownings in skin diving was 21 through 25; there were seven victims in this age group.

Scuba diving accidents accounted for 60 victims of drowning, 58 of them male. Their ages ranged from 14 through 59 years. The 5-year span 16-20 was the peak group, accounting for 19 victims.

Figure 1. Drowning victims in skin and scuba diving by age and sex



In both skin and scuba diving, the drowning victims were generally youths or men in the prime of adulthood. The peak age group was 16 through 20 years in both sports; 24 of the 86 victims were in this age span.

Two tragedies involved more than one victim. In one instance, two scuba diving youths drowned when they became lost and trapped in an underground cave. The other double drowning involved a skin diver and a swimmer.

Inexperience as accident factor. Many of the young victims were reported to have been unusually skilled swimmers. Some were members of school or organizational swimming teams—in one instance a State champion. For the most part, however, these young people were inexperienced in underwater diving. Seven drownings were reportedly of divers making their first open- or deep-water dives. The study data did not include relative exposure or participation in underwater diving by age, yet some idea of the amount of experience of the victims

can probably be deduced from their ages—13 of the victims were 17 years of age or less (table 1).

Seasonal variations. When did the fatalities

Table 1. Skin and scuba diving drownings in 1965 of Americans under age 21

Age (years)	Skin and scuba	Scuba		Skin	
		Male	Female	Male	Female
11.....	1	0	0	1	0
12.....	0	0	0	0	0
13.....	0	0	0	0	0
14.....	2	1	0	1	0
15.....	1	1	0	0	0
16.....	2	1	0	1	0
17.....	7	3	1	3	0
18.....	6	5	0	1	0
19.....	4	4	0	0	0
20.....	5	4	0	1	0
Total.....	28	19	1	8	0

occur? As might be anticipated, the warm months May through August were peak periods. Of the 86 drownings, 16 took place in July, 11 each in May and June, and 10 in August (fig. 2). The nine drownings in October, following a drop to four in September, are not explained. The eight fatalities in March may have been influenced by cold water or other adverse weather conditions and inadequate physical conditioning.

Days of week and holidays. Weekends, as also was to be expected, accounted for most of the drownings. Sundays led with 25 deaths, and Saturdays were next in frequency with 22; the combined weekend drownings (47) comprised more than half the total for all days of the week. In contrast, only four drownings took place on holidays or holiday weekends.

Tuesday, Wednesday, and Thursday each accounted for nine drownings; Friday accounted for seven and Monday for five.

Location. Almost half—42 of the 86 reported fatalities—happened in oceans, gulfs, bays, and other large bodies of open water.

Next in frequency were drownings in small lakes and in other inland bodies of water of limited size—17 fatalities. Third in order were caves, springs, abandoned mines, quarries, and other excavations. These places of small area but considerable depth were the locale of 11 fatalities.

Following are the number of underwater diving victims by location:

Ocean, sea, bay, or gulf.....	42
Minor lake, pond, slough, or reservoir.....	17
Pit, cave, mine, quarry, spring, or excavation....	11
River or stream.....	8
Major lake, dam, or reservoir.....	3
Swimming pool.....	3
One of the Great Lakes.....	2

Activities of victims. At the time of the accidents, most of the victims were engaged in skin or scuba diving in comparatively shallow waters for the refreshment of exercise and the thrill of underwater adventure. In three instances, the victims were testing equipment; one piece of equipment being tested was a homemade device. Two victims drowned while attempting

Figure 2. Drowning victims in skin and scuba diving by calendar month

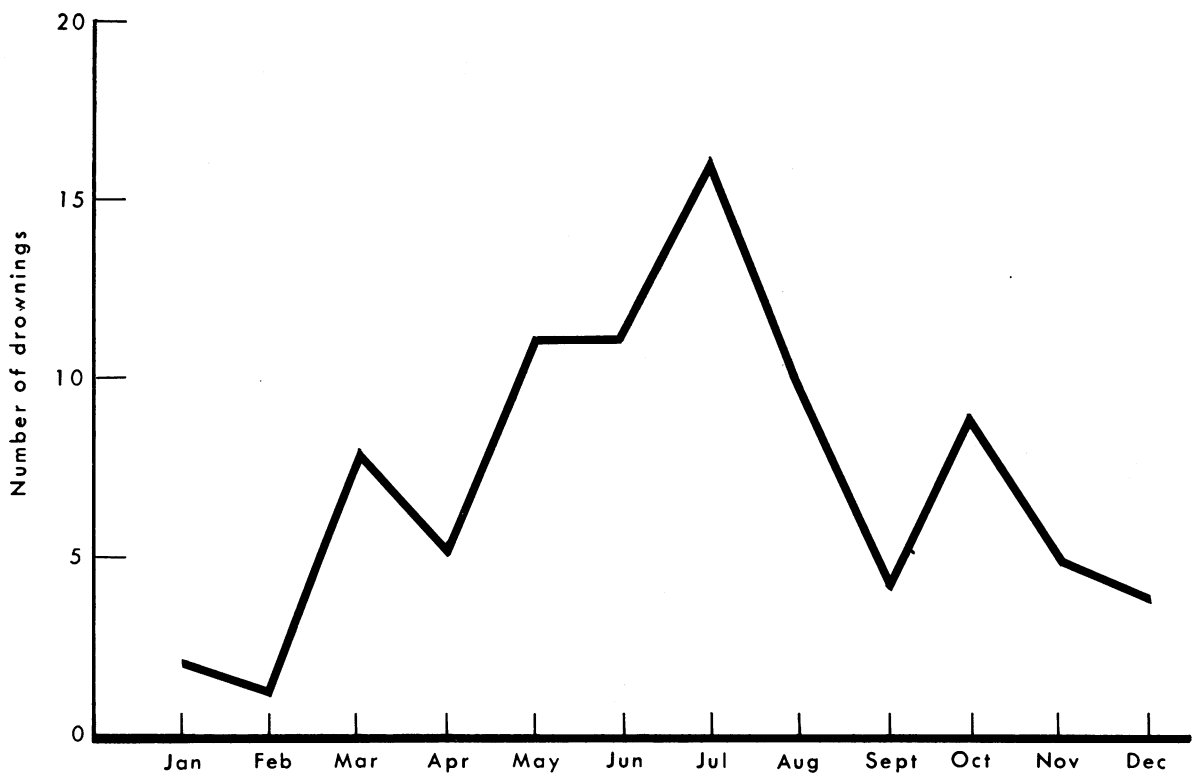


Table 2. Person first discovering the accident and elapsed time between accident and discovery

Person making discovery	Elapsed time (minutes)				
	Total	0-15	16-29	30 or more	Not stated
Companion.....	57	56	0	0	1
Family member..	11	9	0	2	0
Bystander.....	7	5	0	1	1
Lifeguard.....	1	1	0	0	0
Other.....	1	1	0	0	0
Not stated.....	9	0	0	0	9
Total.....	86	72	0	3	11

recovery of a body, and one drowned after successfully rescuing a skin diving companion.

Lone searches for lost objects—tools, an outboard motor, a hunting knife, fishing gear—accounted for a few of the tragedies. A number of the more experienced diving victims were engaged in spear fishing, lobstering, or sponge diving, and in searching hulks of submerged vessels for treasure or souvenirs.

Accidents among experienced divers. In those newspaper accounts in which the victim's diving experience was mentioned, experienced divers were as frequently the drowning victims (17) as were those with little experience (16). Three victims were reported to be professional divers.

Proximate causes. In the majority (46) of the drownings, exhaustion—frequently related to panic—was mentioned as the proximate cause. Entrapment or entanglement under ice and underwater ledges, in kelp, and in various lines resulted in 16 drownings. Striking objects in the water was related to three deaths; being swept into deep or dangerous water was related to two more deaths. Only one diver was reported to have drowned as the result of a cramp.

Contributory causes. In virtually all of the accidents, the victims' disregard of one or more of the recognized rules or procedures for safety was found to be a contributing cause. Overestimation of ability by the divers was considered to be the underlying cause of 28 drownings. Solo diving was related to 15 drownings, and swimming or working under water at a dis-

tance from the diver's partner was associated with 24 deaths. Diving in threes, a situation in which divers again do not have individual partners for protection and assistance in emergencies, was a factor in a number of accidents.

Physical conditions contributed to the loss of at least two lives—one victim was paralyzed from the waist down and another was known to have had a few beers.

Lack of equipment or defective equipment was related to the loss of 23 lives. Substandard equipment included defective air-tank valves and air regulators, improperly fitting mouthpieces, cracked glass on face masks, and inoperable lifevests. In other instances, the victim failed to use safety equipment or to remove his weight belts under emergency conditions. Failure to provide or to use lifelines, lifevests, flashlights, and other devices were cited in a number of instances. A number of cases were reported in which the victim lacked a knife with which to free himself from entrapment in seaweed or kelp and from anchor and other lines. Two fatalities occurred in the use of unfamiliar borrowed equipment. At the time of recovery of victims, exhaustion of the air supply often was indicated.

Underwater diving under adverse weather or water conditions contributed to 22 drownings. Common factors were cold water and heavy sea or rough surf.

Discovery of accidents. Knowledge that the victim was in difficulty or failed to surface following a dive was made within 15 minutes in 72 of the 75 incidents in which this information was reported (table 2). In 57, or approximately 70 percent of the incidents, it was the diver's companion who first became aware of the accident; an additional 11 occurrences were first noted by a family member, who may also have been the diver's companion. In 65 of the 68 incidents in which the diver's companions or family members were the first to realize something was wrong, the incident was discovered within 15 minutes; 7 additional accidents were discovered by other persons within the same period.

The newspaper accounts showed that when the accident was not quickly discovered, it was likely that no one became aware of the tragedy for 30 minutes or much longer.

Recovery of body. In contrast to the usual early discovery of the accident itself, in more than half the cases the victim's body could not be located and retrieved until one-half hour or more had elapsed after discovery of the event (table 3). Of the 24 victims who were located and brought to places of safety within 15 minutes following discovery of the accident, it was the divers' companions who most frequently made the recovery. When the victims could not be located until a longer time had elapsed, police and fire rescue and emergency squads with scuba divers most frequently recovered the body.

Revival efforts. In only 29 of the 86 incidents did the newspapers report that some form of resuscitation had been attempted (table 4). In only 24 of these incidents was the person administering the resuscitation identified. Resuscitation attempts included those made during transportation of the victim to a hospital or other location.

In most instances in which the newspapers described the revival efforts, more than one type of resuscitation was administered, and the first aid endeavor frequently was shifted from one person to another. For example, the diver's companion might have administered mouth-to-mouth breathing until the arrival of a rescue squad with a mechanical device such as an inhalator or a resuscitator. For the purpose of

Table 3. Person recovering victim's body and elapsed time between discovery of accident and recovery

Person recovering body	Elapsed time (minutes)				
	Total	0-15	16-29	30 or more	Not stated
Companion.....	17	13	3	1	0
Family member..	4	3	0	1	0
Bystander.....	3	3	0	0	0
Lifeguard.....	3	2	0	1	0
Rescue squad....	12	0	1	11	0
Scuba diver ¹	27	3	1	21	2
Other.....	2	0	0	0	2
Not stated.....	14	0	1	8	5
Not recovered....	4	0	0	4	0
Total.....	86	24	6	47	9

¹ Scuba divers who were members of rescue squads are listed as scuba divers.

Table 4. Highest level of resuscitation and person administering it

Person administering	Total ¹	Mouth to mouth	Closed chest massage	Mechanical aid ²	Type not specified
Companion.....	5	2	1	1	1
Family member..	2	1	0	1	0
Bystander.....	3	0	0	0	3
Lifeguard.....	2	0	1	0	1
Rescue squad....	12	1	1	4	6
Not stated.....	5	2	0	0	3
Total.....	29	6	3	6	14

¹ In 37 of the 86 cases of drowning studied, the newspaper accounts included no mention of resuscitation efforts; in 20 others in which such efforts were mentioned, the type of resuscitation and who administered it was not stated. These 57 cases are not included in this table.

² Inhalator, resuscitator, or other device.

analysis, only the terminal or highest level of resuscitation was recorded. In no instances did newspaper reports specify the methods of manual resuscitation other than for mouth-to-mouth breathing and closed-chest massage. These methods may constitute many of the entries under the heading "Type not specified" in table 4.

Discussion

Potential increase in fatalities. The number of drownings in underwater diving will undoubtedly increase unless more stringent controls are developed and enforced that will insure the adequacy of the participant's health and physical status, equipment, and training. The sport has grown to the point that enthusiasts may be found in every State, whether it is landlocked or borders upon a major lake or ocean.

In California, the number of victims of skin and scuba diving accidents has almost doubled over the past few years (9). Los Angeles, because of many such incidents in its harbor, now has an ordinance that requires any person engaging in underwater diving in that area, unless he is in designated recreational locations, to possess a permit to dive; the city has also established specific conditions and restrictions for harbor diving.

Health and physical conditions. Unlike boating, swimming, and many other water activities, underwater diving is seldom a family

sport. Physician-divers attest to the unusual physical and emotional demands of the skill. Many believe that participation should be limited to mature persons in the best of health and physical condition. Some physicians consider that even a minor cold or respiratory infection, any history of a heart condition, deviations from normal blood pressure, an allergy or asthma, or other temporary or chronic illnesses or abnormalities should rule out participation. Persons who smoke are discouraged from underwater diving. Physicians also caution that anyone who has a history of tuberculosis should not participate regardless of his current health status.

Age for participation. Children are reported to be increasingly engaging in skin and scuba diving and at progressively earlier ages. Parents sometimes encourage these sports by providing equipment or lending their own equipment to their children.

Much controversy has arisen about the minimum age at which youths should be permitted to engage in underwater diving, particularly scuba diving. Chronological age in itself admittedly is a poor criterion. More adequate measurements of physical, mental, and emotional maturity are needed to assure that potential participants possess the necessary attributes of judgment, strength and stamina, and the potential for skill acquisition. Lack of such criteria has resulted in arbitrary designations of minimum ages for the training and certification of divers by national and local underwater diving groups. Most authorities agree that participants should be not less than 16 or 17 years of age. There are numerous exceptions, however, to this opinion. Physicians associated with the sport have expressed the belief that the minimum age should be higher.

The two national organizations which conduct organized programs of training and certification of scuba divers and instructors are the National Association of Underwater Instructors, which is the instructional branch of the Underwater Society of America, and the Young Men's Christian Association. NAUI limits instruction in scuba diving to persons at least 15 years old. The YMCA will not accept students under the age of 17 years. The NAUI training

program includes practice sessions in open water. The YMCA course usually is limited to pool and poolside teaching.

Many national youth-serving and athletic organizations follow the standards of these two organizations to determine which of their members shall participate in scuba diving activities, although there are local variations. The Boy Scouts of America recently authorized youths of 16 years to participate in scuba diving in organized Explorer Scout activities. This authorization represents a reduction of 1 year from the YMCA's minimum age requirement, which previously had been followed in scouting.

The highly developed underwater safety program of the Los Angeles Department of Parks and Recreation includes a junior program to develop basic skin diving skills in swimmers 10 through 14 years of age and an adult skin and scuba certification course for qualified swimmers over 16 years of age (9). Recently, a branch of the Young Women's Christian Association in the Washington, D.C., area announced a 16-week scuba diving program open to young people 13 to 18 years of age.

A followup study to determine comparative exposures in number of persons and hours of participation by skin and scuba divers of various ages would be helpful in evaluating a possible relationship between these factors and the frequency of underwater diving accidents and in providing guidelines to organizations conducting training programs.

Nonadherence to safety rules. That violations of accepted safety rules (11) contributed to virtually all of the tragedies reported by the newspapers may be ascertained from information in the newspaper accounts. Heading the list of violations was the victims' disregard for the cardinal rules of safe diving—never to dive alone and never to dive except in pairs. Since incidents involving such violations sometimes occurred in organized diving parties, underwater diving clubs might well give these important principles greater emphasis.

Provisions for more rigid inspection and approval of diving equipment, both for completeness and for operational condition, along with an enforceable means of prohibiting divers from engaging in underwater activities if their gear does not meet recommended standards,

would help reduce the number of drownings in skin and scuba diving.

Three other factors commonly associated with skin and scuba diving accidents are an overextended period of submersion, diving under adverse conditions, and panic. Each of these factors points to the need for expanded educational and training programs. In those accidents in which scuba divers stayed under water until their air supplies were exhausted or dived under poor weather and water conditions, it is not known whether they were unaware of the hazardous conditions or if they deliberately disregarded warning signs. Further study is needed on how divers may be taught to avoid taking unnecessary risks. Above all, precertification and periodic refresher programs should stress underwater diving practice under simulated emergency conditions, including mouth-to-mouth resuscitation. The number of instances in which distressed divers failed to take necessary emergency steps or fought off their rescuers indicates the need for such additional training.

Scuba diving to recover a body. Scuba divers not only engage in many of the attempts to recover their underwater diving buddies following accidents, but their services are also called upon in many hundreds of other drownings each year. These heroic attempts to assuage the grief of a distressed family by recovering the body of a loved one are commendable. On the other hand, many of these recovery efforts are carried on for many hours under highly hazardous conditions, and attempts persist long after reasonable hopes of effecting rescue and revival have vanished. Medical experience and research are needed to determine how long a victim can be submerged and still be revived. Such guidelines could help in deciding whether or not further use of emergency scuba teams is appropriate and advisable from the standpoint of avoiding additional drownings.

Newspaper reports as sources. Newspaper reports of drownings in skin and scuba diving, possibly because of the uniqueness of these accidents, were found to provide the best available source of information about the persons involved and the circumstances of

these incidents. Unfortunately, newspapers seldom included medical findings or reports of autopsies, data which might have revealed some physiological factors as the cause or the result of the accident. Likewise, it is possible that some additional underwater diving accidents resulting in delayed deaths were not reported in newspapers.

Summary

At least 86 Americans, above average in athletic and aquatic ability, drowned in underwater diving in 1965. Newspaper reports studied by a staff member of the Public Health Service's Division of Accident Prevention revealed peaks in drownings in periods May through August, during weekends, and at ages 21 to 25. Thirteen victims were under age 18. Florida with 21 victims and California with 19 led 28 States in the number of victims. Of the 86 victims, 26 were skin divers (24 male) ages 11 to 49, and 60 were scuba divers (58 male) ages 14 to 59. Almost half of the drownings took place in oceans, gulfs, and bays; inland waters were next in the number of incidents; three drownings occurred in swimming pools.

Violations of accepted safe practices included diving alone, not diving in pairs, diving under adverse weather or water conditions, and lacking or failing to use emergency equipment. Revival chances were poor; 30 minutes elapsed before two-thirds of the victims were found.

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Public Health Service Staff Appointments

Margaret McLaughlin has been appointed chief nurse officer of the Public Health Service. Miss McLaughlin has been regional nursing consultant, Public Health Service, Department of Health, Education, and Welfare Region 3, since 1952.

Born in Eureka Springs, Ark., Miss McLaughlin is a graduate of the Cook County School of Nursing, Chicago; she earned a B.S. degree from Washington University, St. Louis, and an M.A. from Columbia University, New York.

She was on the faculty of the Jewish Hospital School of Nursing and served as a staff nurse and supervisor with the Visiting Nurses Association, both of St. Louis, prior to joining the Service in 1945. During her Service career, she has been nursing consultant on nutrition studies, 1945 to 1948; nurse representative, Office of Personnel, 1948 to 1951; and assistant chief of the Division of Public Health Nursing, 1951 to 1952.

Miss McLaughlin has received the Meritorious Service Medal of the Public Health Service. She is a member of the American Nursing Association, the National League for Nursing, and is a fellow of the American Public Health Association.

Dr. Henry C. Huntley has been appointed chief of the Division of Health Mobilization, Public Health Service. Prior to this appointment Dr. Huntley was special assistant to the Associate Chief for Program, Bureau of State Services, Community Health, serving as liaison to the Appalachian Regional Commission staff for health programs.

A native of Missouri, Dr. Huntley received his M.D. from Washington University, St. Louis, and an M.P.H. from the University of Michigan School of Public Health. He began his career in general

practice in Elsberry, Mo., served as local health officer in Oklahoma and Michigan, and was chief of preventive health services of the West Virginia State Department of Health.

In 1953 Dr. Huntley entered the Commissioned Corps of the Public Health Service and became regional director, Federal Civil Defense Administration, Public Health Service Region 2, Westchester, Pa. He was general health programs consultant for Regions 1 and 2 from 1955 to 1961, and regional health director, Region 1, Boston, for the following 4 years.

Dr. Huntley has received the Public Health Service's Meritorious Service Award. He is a member of the American Board of Preventive Medicine and a consultant to its subcommittee on examinations. He is also a fellow of the American Public Health Association and a member of the Association of Teachers of Preventive Medicine.

Dr. Ernest C. Siegfried has been appointed medical director, Federal Bureau of Prisons, Department of Justice. Dr. Siegfried, who will hold the rank of Assistant Surgeon General, has been Indian health area director, Public Health Service, Phoenix, Ariz.

A native of Marietta, Ohio, Dr. Siegfried received his M.D. degree from the University of Chicago. He joined the Service in 1949 as an intern in the Staten Island Hospital and served his residency in internal medicine there. He has worked in Service hospitals in Boston and Seattle.

In his new position, Dr. Siegfried will head the medical program administered cooperatively by the Department of Justice and the Public Health Service.