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THE INVOLVEMENT OF COLD WATER IN RECREATIONAL BOATING ACCIDENTS--ETC(U)

APR 79 R M HARNETT, M G BIJLANI DOT-CG-72074-A

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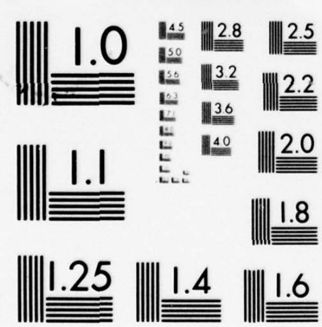

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THE INVOLVEMENT OF COLD WATER IN RECREATIONAL BOATING ACCIDENTS

FINAL REPORT

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16. Abstract
This report presents an assessment of the historical significance of cold-water immersion as a threat to the lives of recreational boaters. The analysis is based on a detailed review of the fatal accident history of a selected typical year (1974). A demographic analysis of cold-related fatalities is presented to establish the nature of high-risk populations. This information is intended to be useful in directing programs aimed at reducing cold-related fatalities among recreational boaters.

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PREFACE

This final report documents work conducted under Task Number 2 of Contract Number DOT-CG-72074-A from January 17, 1978 to January 31, 1979. The work was performed at Clemson University under the auspices of the U. S. Coast Guard, with LTjg Steven F. Wiker serving as program technical monitor. The principal investigators were Dr. R. Michael Harnett and Manohar G. Bijlani.

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THE INVOLVEMENT OF COLD WATER IN RECREATIONAL BOATING ACCIDENTS

FOR

UNITED STATES COAST GUARD

U. S. Coast Guard Headquarters

Contract No. DOT-CG-72074-A

Task Number 2

From

Clemson University

by

R. M. Harnett, Ph.D. and M. G. Bijlani

April 30, 1979

1.0 INTRODUCTION

1.1 General Background

It is well known that the cold aspect of cold-water immersion may be fatal. There are at least three mechanisms by which the cold can produce fatalities. First, it has been suggested by Welch (1) that sudden, whole-body immersion in cold water may precipitate a lethal stimulation of two conflicting reflexes -- the "torso reflex" and the the "dive reflex". The torso reflex is stimulated by cold water coming in contact with the torso. When stimulated alone it produces an elevation in heart rate and potentially uncontrollable gasping respiration. It was observed by Keatinge, et al., (8) who cited large increases in blood pressure and pulse rate and hyper-ventilation during cold showers (0-2.5°C) over the chest. The dive reflex is stimulated by cold water on the face and produces a depression in both heart and respiration rates. Nemiroff, et al., (9), summarized in (10), cite the retarding effects of the dive reflex upon heart activity as a partial explanation of survival of cold-water submersions lasting several minutes. When these two reflexes are stimulated simultaneously the result is uncertain and probably varies from individual to individual. Simultaneous stimulation may interfere with normal cardiopulmonary activities sufficiently to produce a fatality through what is often called "sudden drowning syndrome". In this report the term "sudden death" shall be used.

Second, if the victim survives the initial immersion, the debilitating effects of cold exposure may soon render him unable to save himself. In the absence of flotation assistance, this cold-induced debilitation could precipitate a drowning that would not have occurred in warm water or if the victim had been adequately protected. Cold debilitation may be either physical or mental. The physical debilitation is typified by reduced grip strength and results largely from the surface cooling of musculature. Mental debilitation is characterized by clouded consciousness and impaired cerebration, is associated with the cooling of deeper tissues and may result from the cold-induced production of histamine-like substances (7).

A third potentially-lethal mechanism associated with immersion in cold water is hypothermia -- loss of heat from the body core. Table I summarizes a variety of publications correlating various cold-related symptoms to their associated levels of core cooling and indicates "severe hypothermia" at all rectal temperatures below 33°C. It is not a trivial matter to establish levels of hypothermia which would be lethal. As indicated in (5), some evidence has been found that the only definitive criterion for lethal hypothermia is the failure of the victim to respond to resuscitation attempts. Notwithstanding the variation in the temperature at which it occurs, lethal hypothermia must be regarded as eminent at rectal temperatures below 26°C. As indicated in Table I, a victim would normally experience physical and mental debilitation before hypothermia progresses to lethal levels. Survival beyond the onset of the debilitation would normally require flotation assistance.

The distinction between these three lethal mechanisms may be important from an avoidance point of view. Equipment which could protect an individual from sudden death might be of little value in hypothermia protection. Similarly, equipment which might give good protection against hypothermia might not protect the limbs well enough to preserve the capability to perform life-sustaining self-aid actions.

From the point of view of an accident investigation, it may be very

TABLE I

LEVELS OF HYPOTHERMIA

°F	°C		
99.6	37.6	"Normal" Rectal Temperature	
96.8	36	Increased Metabolic Rate in attempt to balance heat loss	
95.0	35	Shivering maximum at this temperature	
93.2	34	Patients usually responsive and normal blood pressure	
91.4	33	<u>SEVERE HYPOTHERMIA BELOW THIS TEMPERATURE</u>	
89.6	32	Consciousness clouded	Pupils dilated most shivering ceases
87.8	31	Blood Pressure difficult to obtain	
86	30	Progressive loss of consciousness	
		Increased muscular rigidity	
85.2	29	Slow pulse and respiration	
		Cardiac arrhythmia develops	
82.4	28	Ventricular fibrillation may develop if heart irritated	
80.6	27	Voluntary motion lost along with pupillary light reflex, deep tendon and skin reflexes - appear dead	
78.8	26	Victims seldom conscious	
77.0	25	Ventricular fibrillation may appear spontaneously	
75.2	24	Pulmonary Edema develops	
73.4	23		
71.6	22	Maximum risk of fibrillation	
69.8	21		
68.0	20	Heart Standstill	
66.2	19		
64.4	18	Lowest <u>Accidental</u> Hypothermic patient with recovery	
62.6	17	ISO-ELECTRIC EEG	
48.2	9	Lowest Artificially Cooled Hypothermic patient with recovery	

To assure that all relevant available data was reviewed in performing this task, a number of attempts were made to identify institutional sources for data and analyses relevant to the objectives of this task. Included in these attempts were the following:

1. A check of the National Safety Council's Accident Facts
2. Contacting the National Center for Health Statistics
3. Contacting the 25 largest life insurance companies in the U. S. (criterion for size was amount of life insurance in force)
4. Contacting the American Council of Life Insurance (ACLI)
5. A check made by the ACLI of Medical Risks: Patterns of Mortality and Survival which is jointly sponsored by the Association of Life Insurance Medical Directors and the Society of Actuaries
6. Contacting the Commission on Professional and Hospital Activities
7. Contacting the Health Insurance Association of America

The result of these checks was the finding that in none of the respective data bases was there a classification of hypothermia as a cause of death. Specific responses from the insurance companies ranged from, "We never see the diagnosis of 'hypothermia'," to "While hypothermia is listed in the International Classification of Diseases, the ultimate death code falls under the miscellaneous category of 'ill-defined and unknown causes'." Of course the problem is not so much that hypothermia is ill-defined as it is that hypothermia is difficult to specifically diagnose. No method is presently known which will determine whether a reduction in body temperature took place before and was the cause of death, or whether the reduction occurred after the victim died of other causes.

After unsuccessfully making the attempts listed above to obtain additional information, the scope of Task 2 reduced, largely, to an analysis of the data contained in the BAR's archived at U. S. Coast Guard Headquarters. The exception is an attempt to collect certain specific items of data determined to be particularly useful. This collection of supplemental data is discussed in Section 4.2 of this report.

2.0 RELEVANT DATA AND ANALYSIS

This chapter characterizes the information available in the file of BAR's archived at U. S. Coast Guard Headquarters and summarizes previous analysis aimed at immersion hypothermia.

2.1 Boating Accident Reports

The Federal Boat Safety Act of 1971 requires that the operator of a boat involved in an accident which resulted in either a fatality, an injury, or property damage in excess of $100, file a report. The Coast Guard-approved form for reporting boating accidents is form CG-3865 (Rev. 5-75), a copy of which is in Appendix A. The various states are permitted to include additional reporting requirements if they so choose. The general types of information which are contained in a complete BAR are the following:

1. Information on the operator of the boat
2. Description of the boat
3. Time and place of accident
4. Environmental conditions prevailing at the time of the accident
5. General flotation aid information
6. Name, address, age, swimming skills and cause of death (drowning, disappearance or other) for each fatality, and
7. Brief narrative description of accident

The BAR's for accidents involving fatalities are often accompanied by additional information of the following types:

1. Detailed narrative reports of investigating officers
2. Statements of survivors and/or witnesses
3. Death certificates
4. Autopsy reports

BAR's are sometimes submitted with no back-up information and/or incompletely filled out. Some fatal boating accidents are not reported at all. These unreported fatalities are sometimes detected through newspaper articles describing the accident to some level of detail. Copies of these clippings are available in the accident report files at Coast Guard Headquarters. Several data elements on the BAR are of particular relevance to a determination of the possible causal involvement of immersion hypothermia. They are:

1. Water temperature
2. Water conditions (weather)
3. The victim's swimming ability
4. The victim's usage of flotation aids

In addition air temperature could have some influence on the occurrence of hypothermia; but its contribution in affecting the onset of immersion hypothermia would normally be dwarfed by that of the water.

In addition to the file of reports, a computer information system at Coast Guard Headquarters contains coded summaries of the BAR's. This coded data serves as the basis for the Coast Guard's annual publication of Boating Statistics (CG-357). This computer data base has a category of information called "Accident Descriptors". A list of 45 coded descriptors is available. The individual coding the accident may choose up to 3 of the 45 descriptors as is appropriate. One of the descriptors (Number 7) is, "exposure, shock, hypothermia".

The complete reports for certain years are also available on microfiche.

2.2 The Accident Recovery Model

The Accident Recovery Model (ARM) was developed to support the evaluation of the role of personal flotation devices (PFD's) in saving lives and the effectiveness of proposed regulatory and educational programs. ARM was constructed to be representative of reported recreational boating accidents in an "average" year and is based on a sample of 1,513 boating accident victims whose histories were drawn from the Coast Guard collection of BAR's for 1969 through 1977. The greatest sampling was from 1975 (47.5%), 1973 (14.5%) and 1970 (10.9%). The least sampling was from 1974 (0.8%).

Among other subjects of analysis, Reference 2 addresses a quantification of the frequency of hypothermia-related fatalities. The determination was based on the distributions of "time in the water" and water temperatures among fatal accidents. This data from ARM was combined with survival-time data for heavily clothed people by Hayward, et al., (3). Several interesting observations are made in (2).

1. "water temperatures are unknown for almost 56% of the victims that wind up in the water."

2. "time in the water is unknown for nearly 62% of the victims who enter the water."

3. "between 26 and 202 boating deaths per year are influenced by hypothermia."

4. "nearly three-fourths of the fatalities, for whom time in the water is known, occur in the first 15 minutes."

It should be noted that items 1 and 2 are expressed as percentages of boating accident victims who enter the water, not as percentages of boating accident fatalities. It would be expected that time in the water would be unknown for an even larger percentage if only fatalities are considered. It should also be noted that the total time a deceased victim was in the water is not the correct basis for determining the onset of hypothermia. Only the amount of time in the water prior to death is relevant. For example, an individual could die of asphyxiation in cold water and subsequently cool sufficiently to give the appearance of profound hypothermia. Only "time alive in the water" is relevant in determining the potential involvement of hypothermia.

The range of uncertainty in the number of hypothermia-related fatalities (item 3) results from the incomplete data referred to in items 1 and 2 above. Based on an estimated 1,467 annual boating fatalities, this range of uncertainty represents from 1.8% to 13.8% of boating fatalities. The fourth observation is significant in that it indicates that hypothermia could not have occurred in the group of fatalities mentioned but that sudden drowning syndrome can not be ruled out.

The ARM-based hypothermia analysis (2) exhibits specific deficiencies with respect to the objectives of the present effort.

1. while a range of hypothermia-related boating fatalities is given from 1.8% to 13.8% of all boating fatalities, no point estimate of this percentage is given

2. time other than time alive in the water may have been used in determining the onset of hypothermia

3. no efforts were made to resolve the fundamental problem - lack of water temperatures and time alive in the water data

4. the 26 fatalities determined to be hypothermia-related do not constitute an adequate basis for a demographic analysis of high-risk populations

These deficiencies arise primarily because ARM was concerned with all types of boating accidents not just fatalities. Of the 1,513 individual's accident circumstances reviewed and included in the ARM sample, only 277 were fatalities.

2.3 Preliminary Conclusions

Based on a review of the nature of the data available for analysis (BAR's and backup reports) and the previous analysis directed toward hypothermia assessments (ARM analysis) several preliminary conclusions were drawn concerning the most appropriate directions for the present effort.

1. the analysis should be based on an intensive review of boating fatalities
2. specific fatalities involving hypothermia as a causative factor should be identified because of the detailed data needed to support the demographic characterization of high-risk populations
3. the computer coding of the BAR's should not be used as the sole data source because of the additional information available in the narrative on the BAR's and in the materials attached to them
4. the analysis should be based on the records for a year which were available in their entirety on microfiche because of the volume of BAR's and supporting material to be reviewed. The most recent such year (1974) was chosen
5. as had been anticipated earlier, attempts to obtain supplemental information would be needed and reasonable attempts should be made (discussed in Chapter 4)
6. a systematic schema (discussed in Chapter 3) is needed, for classifying fatalities regarding the involvement of hypothermia as a causative factor, which makes maximum use of available and obtainable data.

Conclusions 2 and 3 are based upon the notion that a better result will be obtained by a thorough review and systematic interpretation of the basic data, than by an analysis of accident patterns based largely upon assumptions. Conclusion 4 is based upon the realization that the BAR's and all associated supplemental reports must be available to the research team on a daily basis and that paper-copy duplicates of this material represents a prohibitive volume of paper. By basing the analysis on one year's data, the only question to be considered in using the results is the representativeness of the year chosen.

There was nothing outstanding about the weather in 1974 as there was in 1976 and 1977. Based on data presented in Boating Statistics 1976 (CG-357), the average number of annual boating fatalities in the 10 years from 1967 through 1976 was approximately 1437. The 1446 fatalities cited in CG-357 for 1974 makes it very representative of this period. The same could not be said for 1971 (with 1582 fatalities), 1973 (with 1754 fatalities) or 1976 (with 1264 fatalities). Additionally, the continual improvement in the completeness and quality of reporting of boating accidents was felt to support the selection of the most recent representative year to serve as the basis for analysis.

3.0 METHOD FOR CLASSIFICATION OF ACCIDENTS

This chapter describes the process by which the reports concerning 1974 boating fatalities were reviewed and analyzed leading to the classification of the fatalities regarding the involvement of sudden death, debilitation death and hypothermia.

3.1 Classification System

The classification system which was used for summarizing the findings of reviewing the BAR's represents an attempt to distinguish between those fatalities which were cold-related and those which were not; but it also represents an attempt to distinguish between occurrences of the three cold-related, lethal mechanisms discussed in Chapter 1.0. The classifications employed are as follows:

1. Fatality involves sudden death
2. Fatality involves debilitation death
3. Fatality involves hypothermia
4. Fatality involves debilitation death or hypothermia
5. Report indeterminate
6. Fatality not cold-related
7. Report missing

It is important to keep in mind that, even though the report is being addressed in two of these classifications, the individual fatalities are being classified and not the accidents. The term "indeterminate" is used to classify a fatality which is generally well reported but which can not be resolved regarding hypothermia involvement. The term "missing" is applied to reports which could not be found in the 1974 microfiche even though the computer file contains the case numbers.

Fatalities which are reported sufficiently well to be classified are assigned one of the first 6 classifications. Classifications 1 through 4 are assigned to fatalities which are definitely cold-related. Classification 5 indicates that available data does not indicate conclusively whether or not cold played a causal role in the fatality. Classification 6 indicates that we have sufficient evidence to conclude that the fatality was not cold related. This general trichotomization of the classifiable fatalities regarding the causal involvement of cold exposure is suggested by the survival time - water temperature relationships shown in Figure 1 which were developed by DeForest and Beckman (4). The recognition of a marginal zone is consistent with the uncertainty arising from the variability in response to cold exposure to be expected as a result of inter-individual variations in somatotype, clothing and other factors.

3.2 BAR Review Logic

There are a number of bases on which one might conclude the involvement of hypothermia in a boating fatality. The bases to be used in this study were selected and then reduced to the form of a logic chart. This facilitated the classification of the boating fatalities which occurred in 1974. The logic utilized for reviewing the BAR's consists of a sequence of 14 questions (indicated Q1 through Q14) depicted in Figure 2. The logic distinguishes among the first 6 classifications listed in Section 3.1 as appropriate descriptors for the fatality. The outcome of each BAR review is an arrival at one of the terminal nodes (indicated by circles) in Figure 2. The nodes correspond to the 6 classifications as follows:

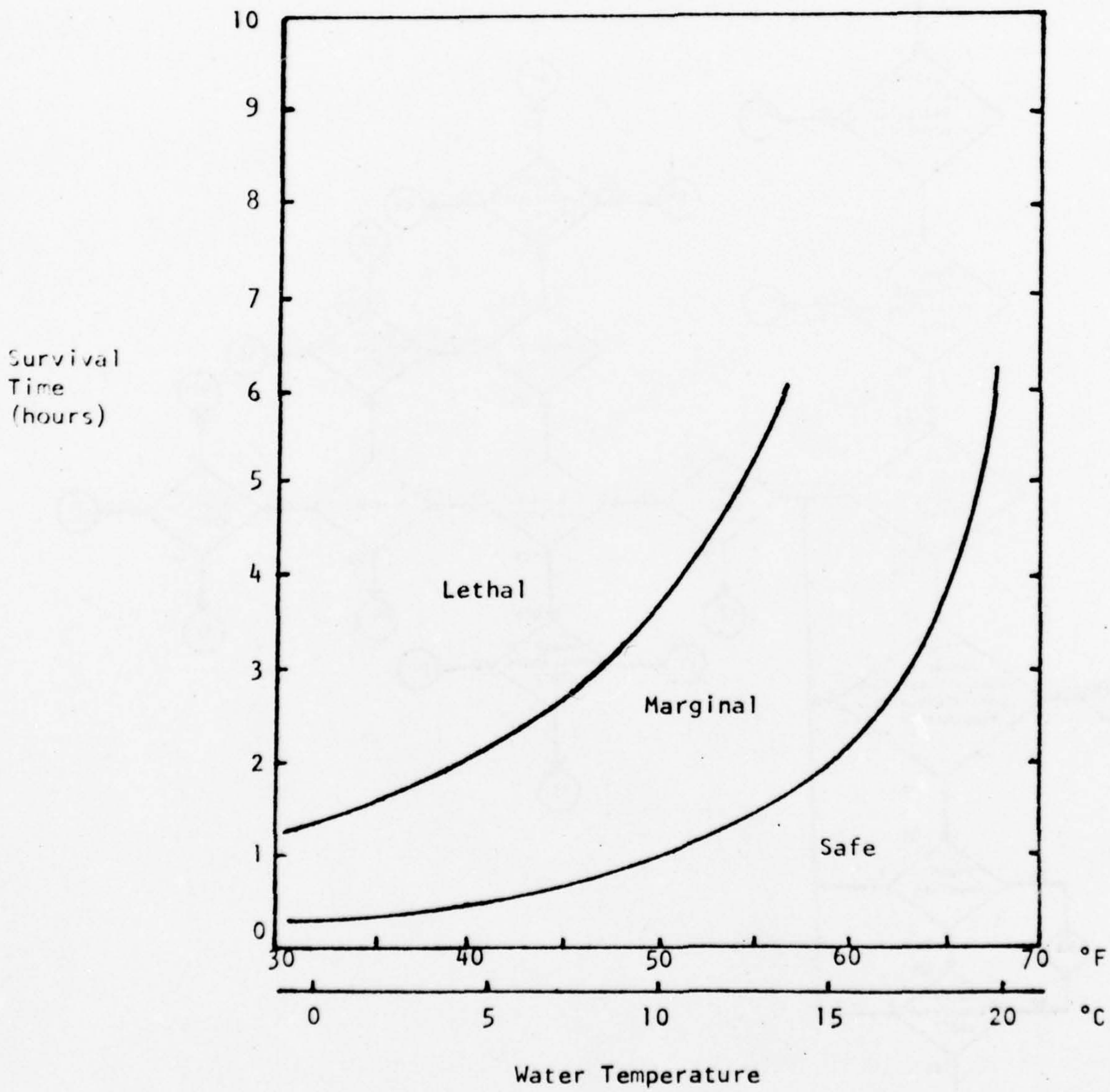
Node	
S	Sudden death
D	Debilitation death
H1, H2, H3	Hypothermia
DH	Death due to debilitation or hypothermia
U1, U2	Report indeterminate
N1, N2, N3, N4, N5	Fatality not cold-related

Logical conclusions at nodes S, D, H1, H2, H3 or DH are taken collectively as indications of cold-related fatalities.

The logic was modified after the analysis to eliminate certain detailed provisions which were not needed to classify the 1974 fatalities (e.g.; treatment of uncertainty at block Q7 of Figure 2). Since the objective did not call for developing completely general logic that could be used for any year, the logic presented in Figure 2 was simplified to include only those provisions needed to classify the 1974 fatalities.

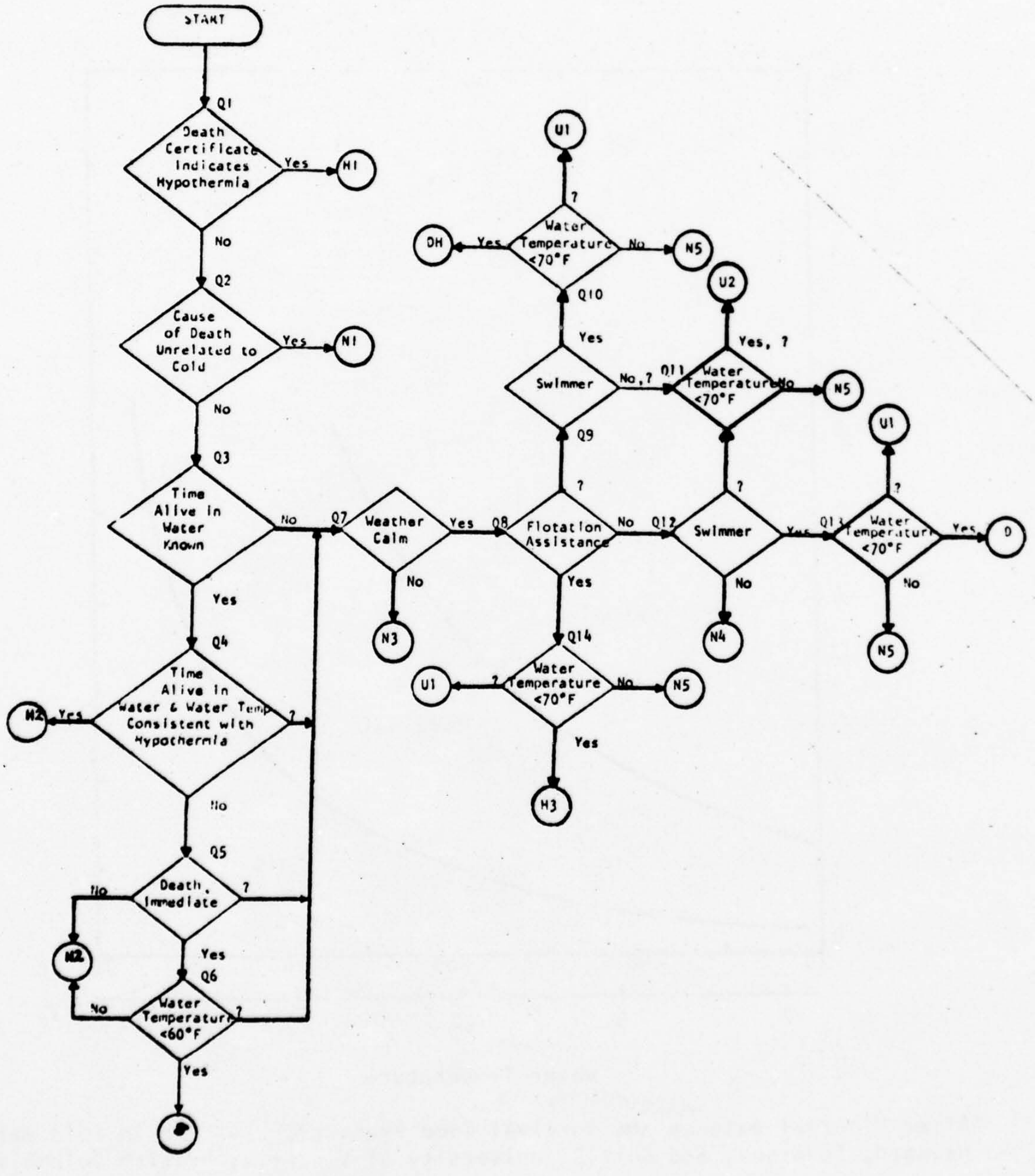
FIGURE I

HYPOTHERMIA SURVIVAL TIMES VERSUS WATER TEMPERATURE *



*After "Thermal Balance and Survival Time Predictions of Man in Cold Water", Hayward, Eckerson, and Collis, University of Victoria, British Columbia.

FIGURE 2
BAR REVIEW LOGIC



Bases for Concluding Fatality Not Cold-Related

The first basis for determining that a fatality is not cold-related (node N1) is that there is an identifiable definitive cause of death which is not cold-related. Examples of such causes of death are heart attacks and trauma. They do not include such things as drowning or disappearance as indicated on either the death certificate or the BAR.

The second basis for concluding that a fatality was not cold-related (node N2) is that node H1 was not reached, water temperature and time alive in the water are found to be associated with the safe region of Figure 1, and either the fatality was not "immediate" or if it was it occurred in water so warm (over 60°F) as to render it unlikely that it was cold-induced. These last checks are intended to preclude sudden deaths from being included in the N2's. The assumption is made that debilitation deaths do not occur in the safe region of Figure 1.

The third basis for concluding that a fatality was not cold-related (node N3) is that nodes H1, H2 and S were not reached and the weather was not calm. The precise definition of calm weather is given as a ground rule in Section 3.3. The unsettled nature of the weather is taken as an indication that the water surface was sufficiently rough to provide an identifiable definitive cause for the fatality regardless of PFD usage or swimming skills. It is possible that an individual with good general water skills and good personal flotation could, by controlling his breathing, survive the continual impingement of rough water upon his breathing passages and survive long enough for hypothermia to become life-threatening. However, it is recognized that only one episode of the uncontrolled breathing, associated with the stimulation of cough, swallow, or sneeze reflexes, may be needed to precipitate an irreversible aspiration or ingestion of water resulting in drowning. This fact is the basis for adoption of the logical convention of declaring rough weather/water a definitive cause for drownings.

The fourth basis for concluding that a fatality was not cold-related (node N4) is that nodes H1, H2 and S were not reached and the victim was a non-swimmer and was not supported by flotation assistance. The methods observed for receiving flotation assistance are discussed in Section 3.3. The absence of both swimming skills and flotation assistance is regarded as adequate definitive explanation for a water-immersion fatality, removing the necessity to resort to more complicated mechanisms.

The last basis for concluding that a fatality was not cold related (node N5) is that nodes H1, H2 and S were not reached and the water temperature is known to be at least 70°F. While the definitive cause of death in these cases is uncertain, it is a virtual certainty that they were not cold-related.

Basis for Concluding Sudden Death Syndrome Involved

The basis for concluding a fatality to have resulted from sudden death syndrome (node S) is that node N1 was not reached, the death is known to have occurred "immediately" after immersion, and it occurred in water sufficiently cold (below 60°F) to make sudden death a plausible definitive cause of death. The term "immediate" in block Q5 refers to circumstances described in the narrative reports as, for example, "he fell into the water and never came up." A victim seen struggling in the water for even a few minutes would not be expected to suffer sudden death. There is no particular water temperature known above which sudden death will not occur. Its occurrence depends on the individual's clothing, somatotype and physical susceptibility as well as water temperature. It is predicated upon the simultaneous stimulation of the dive reflex and the torso reflex. The basis for using 60°F in block Q6 is that Welch (1) mentions several research findings indicating the dive reflex is not "pronounced" until water temperature is below 68°F and that the torso reflex is accentuated by cold water (52°F) compared to warm (82°F).

Bases for Concluding Debilitation Death or Hypothermia Involved

The first basis for concluding that hypothermia was a causative factor (node H1) is its appearance as "cause of death" on a death certificate. Of course this is rarely found because of the difficulty in diagnosing hypothermia. Consideration was given to ignoring this finding in some cases based on other facts which may be known about the fatality. However it was decided that the individuals making the determinations immediately after the accidents were in a better position to make a judgment about the cause of death than are the reviewers of their written records. The error they should more commonly make is the declaration of "drowning" as the cause of death which, in fact, resulted from a complex set of interacting factors.

The second basis for determining hypothermia involvement (node H2) is that node N1 was not reached and a water temperature and time alive in the water were found which are associated with the lethal region of Figure 1. It should be noted that the H2 classification explicitly excludes cases of sudden death and presumably excludes debilitation death as well.

The remaining conclusions of hypothermia and the conclusions of debilitation death result downstream of block Q8 and are summarized, under the assumption that water temperature is less than 70°F in Table 2.

The H3 conclusion of hypothermia results when nodes N1, N2 and N3 were not reached and the victim had flotation assistance, regardless of swimming skills. The rationale is that flotation assistance should, in calm weather, preserve life beyond the time when cold-debilitation has removed one's ability to save himself. Unless a rescue is accomplished to deter the onset of hypothermia, it will develop to lethal levels. This serves as a sufficient definitive cause for the fatality.

The conclusion of debilitation death (node D) results when nodes N1, N2, and N3 were not reached and the victim was a swimmer but had no flotation assistance. In this case he can save himself as long as he is able to swim but is very susceptible to cold-induced physical and mental debilitation.

The conclusion of debilitation death or hypothermia (node DH) results when nodes N1, N2 and N3 were not reached, the victim was a swimmer, and it is not known whether or not he had flotation assistance. In this case we conclude that either debilitation death or hypothermia was the definitive cause of the fatality but we are unable to distinguish which it was because of the absence of flotation assistance data.

Bases for Concluding Report Indeterminate

The first basis for concluding a report to be indeterminate (node U1) is that H1, H2, N1, N2, N3 and S were not reached, the water temperature is unknown but the victim possessed either swimming skills, flotation assistance or both. Based on the swimming ability and/or flotation assistance the victim is ascribed a reasonable chance of survival, but based on the uncertainty about water temperature it is not possible to draw an inference concerning the causal involvement of cold exposure. The U1 classifications are illustrated in Table 4.

TABLE 2
SELECTED CLASSIFICATIONS:
WATER TEMPERATURE BELOW 70°F

Classification		Swimmer		
		Yes	No	?
Flotation Assistance	Yes	H3	H3	H3
	No	D	N4	U2
	?	DH	U2	U2

TABLE 3
SELECTED CLASSIFICATIONS:
WATER TEMPERATURE AT LEAST 70°F

Classification		Swimmer		
		Yes	No	?
Flotation Assistance	Yes	N5	N5	N5
	No	N5	N4	N5
	?	N5	N5	N5

TABLE 4
SELECTED CLASSIFICATIONS:
WATER TEMPERATURE UNKNOWN

Classification		Swimmer		
		Yes	No	?
Flotation Assistance	Yes	U1	U1	U1
	No	U1	N4	U2
	?	U1	U2	U2

The other basis for concluding a report to be indeterminate (node U2)is illustrated in Tables 2 and 4. It results when nodes H1, H2, N1, N2, N3 and S were not reached and the absence of swimming skills or uncertainty about them combine with the absence of flotation assistance or uncertainty about it and also with water which is either below 70°F or of unknown temperature. The further classification of a fatality initially classified as U2 would require water temperature data and either a positive finding concerning swimming skills or flotation assistance or a negative finding concerning both. The U2 fatalities can not be resolved by the acquisition of water temperature data alone.

3.3 Ground Rules

There are many factors in addition to those appearing in the review logic in Figure 2, which may affect the outcome of a boating accident. The logic involves many simplifications made as concessions to clarity in communicating the major points. The logic should be regarded, as it was employed, as a general guide for logical analysis. Many special cases were found during the review which required special consideration. This section presents statements of ground rules which were adopted for dealing with the more significant ones.

Type of Hypothermia Considered

The term hypothermia in Figure 2 is interpreted to mean immersion hypothermia. Only possible immersion-hypothermia fatalities were reviewed beyond block Q2.

Cause of Death

The cause of death referred to in block Q2 of Figure 2 is interpreted to mean a definitive cause of death as opposed to an unsupported indication of drowning or disappearance.

Time Alive in the Water

In some cases time alive in the water is not known exactly but a bound (upper or lower) on its value is determinable. In these cases, the analysis proceeds to block Q4 and the bounding value is used in conjunction with water temperature (if it was known) and the information in Figure 1 to determine if a conclusion could be supported. For example, if a victim was alive less than 2 hours in 60°F water the review continues to block Q5. If the time bound had been 3 hours, no conclusion would be supported at block Q4 and the analysis would proceed to Q7.

Immediate Death

The term "immediate" death used in block Q5 is determined on the basis of narrative descriptions of the accident and is not based on a particular time period for the occurrence of the fatality.

Weather

The "calm" weather referred to in block Q7 is taken to mean winds not exceeding 15 miles per hour and waves not exceeding 2 feet. Other combinations of conditions are regarded as "rough" weather.

Turbulent Water

Turbulent water as found in mountain rivers and streams and in ocean surf is treated as rough weather at block Q7. This determination relied heavily on descriptions of the accident sites in narrative reports.

Flotation Assistance

Flotation assistance is regarded as being satisfactorily provided by any of several media, including a properly-used, Coast Guard-approved PFD, a capsized boat and a tree top. A victim is normally found wearing his PFD if he was wearing one properly when the accident occurred. Modes of flotation assistance other than PFD's are recognized only if there are witness accounts specifically indicating their use.

Swimming Skill

The classification of an individual as a swimmer, at blocks Q9 and Q12, is negated by factors such as the wearing of hip boots, the existence of appropriate injuries, and the impairment of a panicked non-swimmer holding the swimmer.

Unconscious Victim

An unconscious victim is regarded the same as a conscious non-swimmer at blocks Q9 and Q12.

Alcohol

The use of alcohol by a boating accident victim is treated in one of two ways depending upon the amount consumed generally as indicated in narrative reports. Victims who were described as "drunk" are regarded as functional non-swimmers. Victims who were not described as drunk but had been drinking are regarded as retaining their intrinsic swimming skills.

3.4 Types of Errors Anticipated

The review procedure discussed in this chapter was formulated to be systematic, understandable, and consistent with existing information on the three cold-related, lethal mechanisms, and to make maximum use of all obtainable data. It involves a number of simplifying assumptions which can be expected to result in certain errors whose nature may be predicted. These errors manifest themselves as erroneous classifications and are discussed as such in the following paragraphs. Because of the conservative nature of the H1, H2, and N2 classifications no logical errors are expected.

Errors in S Classifications

For a fatality to be classified as sudden death (block Q6) it is required that the water be below 60°F, that no other identifiable definitive cause of death be known and that it be known that the death or disappearance occurred immediately after entry into the water. For this last fact to be known generally requires that the accident have been witnessed by an observer, either a bystander or a surviving companion in the boat. It is reasonable to expect that sudden deaths may occur in circumstances which preclude us from having information on the immediacy of the fatality. These fatalities will be classified as appropriate downstream of block Q7 and will not be classified as sudden deaths. Thus the single S node is a conservative classification which will provide a lower bound on the number of sudden deaths.

Errors in N3 Classifications

Weather and water conditions are assigned a prominent role in determining the outcomes of the logical analysis schema shown in Figure 2. Rough water is taken as a satisfactory definitive cause for a fatality regardless of the victim's PFD condition and swimming skills. The requirements for a victim of rough-water immersion to survive, even with a PFD, were described in Secton 3.2. The probability that a recreational boater could survive even an hour of the treatment resulting from rough-water immersion is not regarded as large; but it is not 0.0. Thus some cold-related fatalities may be erroneously classified as N3. An error of this type results in excess N-node classifications.

Errors in H3 Classifications

The H3 classification, at block Q14, of hypothermia involved is based on information that flotation assistance was used by the victim. Flotation assistance is defined to include some objects, such as trees and capsized boats, which may require some conscious effort by the victim to keep him afloat. If the victim does not take steps to secure himself to his source of flotation he may become separated from it due to cold-related debilitation. The only significance of this to the classification schema is that two cold-related lethal mechanisms are imperfectly distinguished with the result that some debilitation deaths may be classified as hypothermia deaths.

Errors in N4 Classifications

The N4 classification at block Q12 is predicated, in part, upon the determination at block Q8 that the victim had no flotation assistance. Considered as no flotation assistance are the proper use of a non-approved PFD and the improper use of an approved PFD as well as the improper use of a non-approved PFD. These off-nominal PFD conditions may give some individuals sufficient flotation for a reasonable expectation of survival. Thus some of the fatalities classified as N4 may be directly due to debilitation or hypothermia resulting from cold-water immersion.

Errors in D Classification

Because of the simplifications involved in disregarding off-nominal PFD conditions (discussed in the previous paragraph) the debilitation death classification at block Q13 could be applied to some fatalities which were in fact due to hypothermia.

Summary

The logical errors made in the H3 and D classifications effect only the distinction between hypothermia and debilitation deaths and are, in fact, offsetting errors. The logical errors made in the S, N3 and N4 classifications all serve to erroneously increase the number of N-node classifications. Some of the real sudden deaths may be finally classified as D, H3 or DH but some may be classified N3 or N4. Therefore it must be concluded that the logical schema in Figure 2 tends to classify too many fatalities as "not cold-related. The magnitude of this error is not thought to be large.

4.0 ACCIDENT DATA REVIEWED

In finality two general types of data were used as the basis for reviewing the 1974 boating fatality history. First, data which could be extracted from the BAR's and their associated narrative reports was summarized and reviewed. This led to the immediate classification of many fatalities and also to the identification of certain important data voids. Efforts to fill these voids produced the supplemental data which was also used in the review.

4.1 Data From BAR's

Boating accidents in 1974 which involved one or more fatalities were identified by printing from the computer summary lists of case numbers, states and dates of accidents involving fatalities. These lists were used as the directory to BAR's in the microfiche which report fatalities.

The BAR's and narrative reports for each fatal accident so identified were reviewed and the following data was summarized for each fatality on special coding sheets.

1. reviewer's initials
2. case number
3. state
4. date of accident
5. victim's name
6. victim's sex
7. victim's age
8. victim's PFD condition
9. victim's swimming ability
10. definitive cause of death (if known)
11. distance from shore
12. time alive in water
13. water temperature
14. air temperature
15. name of body of water
16. type body of water
17. review's finding (node from Figure 2)
18. remarks

The remarks field was used to record any pertinent observations about the victim's state of alcohol intoxication and about the prevailing weather and/or water conditions at the time of the accident.

The review and summary of the BAR's produced many data voids, particularly in PFD condition, swimming ability, time alive in the water, and water temperature. These four data items were the principal ones needed to allow completion of the classification of several fatalities. Of the four data items, it was felt that a reasonable expectation of obtaining supplemental data existed only for swimming skills and water temperature.

4.2 Supplemental Data

The supplemental data which was sought to allow more complete classification of the fatalities was of two types - swimming skills data and water temperature data.

Swimming Skills Data

An effort was directed toward obtaining additional data regarding the swimming skills of victims of 1974 boating fatalities. This effort produced the following results.

Skill Level	Number	Classification
Poor	8	Non-swimmer
Fair	6	
Good	21	Swimmer
Excellent	14	
Unknown	1	Unknown
Total	50	

The supplemental swimming-skills data effort led to the identification of 35 out of 50 fatalities who possessed swimming skills sufficiently well developed to indicate a good chance of survival even without flotation.

Water Temperature Data

The best source for water temperature data on a nation-wide basis was found to be the National Water Data Exchange (NAWDEX) operated by the Water Resources Division of the U. S. Geological Survey (USGS) in Reston, Virginia. They, of course, have access to the annual USGS water data reports, which are published by State, and the USGS Water Data Storage and Retrieval System (WATSTORE). In addition, NAWDEX has direct access to the Storage and Retrieval System (STORET) maintained by the Environmental Protection Agency. Also NAWDEX maintains a computerized Master Water Data Index identifying other water-data-collecting organizations (e.g., Corps of Engineers) around the country and the specific water data parameters they monitor. Thus NAWDEX could not only provide some data, but could provide referrals to appropriate agencies for the data they could not provide.

Having identified the best single point of contact for nation-wide water temperature data, the next question was how to communicate to NAWDEX the times and places at which water temperature data was needed. Because of the considerable volume of data requests to be made and to facilitate NAWDEX processing the data requests, it was decided to identify the specific water data collection stations from which the data was desired. It was felt that NAWDEX should be able to respond more quickly and easily to requests for specific stations than to requests involving a narrative description of the accident site. The identification of the stations was made possible by the USGS's publication of a Catalog of Information on Water Data (6) which describes data collection station locations by body of water, state, county, nearby landmarks and longitude and latitude. Using this catalog and a set of USGS Hydrologic Unit Maps the station or stations nearest the boating fatality sites were determined and identified by their OWDC numbers. It appeared in (6) that the OWDC station numbering system was the only such unified, naton-wide scheme. Therefore data requests filed with NAWDEX were stated in terms of the OWDC numbers and the corresponding dates for which surface water temperature was desired. The requests asked that if temperature data was not available for the specific dates requested, then it be provided for the two nearest available dates before and after the requested date. They also asked that if data was not available for 1974, then it be provided for the three most recent years for which it is available.

It was determined that water temperature data was needed and would be useful for classifying 200 fatalities occurring at 179 accident sites in 1974. Because data was often not available at the exact locations of interest, it was necessary to sample multiple stations in the area of some accident locations. Water temperature data was requested from the USGS at 310 station/date combinations and an additional 7 combinations were requested directly from various agencies in California. The 310 requests made of USGS produced referrals to 52 different local, state and regional organizations for data on 147 station/date combinations. Data was obtained directly from USGS for 113 of the remaining 163 station/date combinations. Requests were transmitted to the 52 referred organizations for the 147 station/dates involved. Five of these organizations responded by issuing referrals to other organizations. These "third generation" requests were also made. Useful data was received for 87 of the 147 referred station/date combinations and for 4 of the 7 California combinations. In all, data was obtained for 204 of the 317 requested station/date combinations, for a 64 percent success rate. This data supported the estimation of the water temperature associated with 157 of the 200 boating fatalities addressed.

Summary

Boating fatalities for 1974 were identified by reviewing the BAR's for accidents indicated in the Coast Guard computer data base to have involved fatalities. Of the 1490 boating fatalities identified in this way, BAR's could not be obtained for 15. Thus the logical classification schema discussed in Chapter 3 was applied to 1475 boating fatalities. The supplemental swimming skills data obtained for 49 fatalities was combined with the supplemental water temperature data obtained for 157 fatalities. Together, these data supported the successful classification of 111 fatalities which could not otherwise have been classified.

5.0 CLASSIFICATION AND ANALYSIS OF 1974 BOATING FATALITIES

5.1 Results of Classifications

The results of applying the classification schema discussed in Section 3.0 to the most complete data obtainable for 1974 boating fatalities are summarized in Table 5. The 1490 identified fatalities are dichotomized into 1254 for which a definite classification could be obtained and 236 which are uncertain. Of the 236 fatalities with uncertain findings of cold-related mechanisms, no information could be found for 15. For purposes of the analysis to be performed here, there are no fundamental differences among findings of U1, U2 or Report Missing. These findings all represent fatalities for which a determination of the involvement of a cold-related lethal mechanism was not possible. Of the 1254 fatalities which were definitely classified, 197 were found to be cold-related and 1057 were found to be unrelated to cold.

5.2 Analysis of Results

It is desired to compute point and interval estimates for the percentages of annual fatalities which are cold-related and also for the percentages involving each cold-related lethal mechanism. The point estimators are to be best unbiased estimators for each desired percentage based on the data available for review. Two types of intervals have been constructed around each point estimate to demonstrate how much the point estimates may be expected to deviate from the actual values. A deterministic "interval of uncertainty" has been constructed to show the extreme range of variation, for each point estimate for 1974, which results from the inability to classify each of the 1490 fatalities as a node S, D, H or N. This interval does not arise from random variation in a point estimate. Its limits are absolute for the 1974 data. Random variation is considered in the construction of the second type of interval - a bound on the "95 percent confidence interval" for each point estimate. The confidence interval expresses the year-to-year variation which may be expected in the point estimate due to randomness assuming that the results of the 1254 definite classifications are representative of the real occurrences of cold-related boating fatalities.

TABLE 5
CLASSIFICATIONS OF 1974 BOATING FATALITIES

Node	Number	Subtotal	Classification
S	6	197	Cold Related
D	101		
H1	11		
H2	11		
H3	25		
DH	43		
N1	198	1057	Not Cold Related
N2	159		
N3	378		
N4	248		
N5	74		
U1	43	236	Uncertain
U2	178		
Report Missing	15		
TOTAL	1490		

Point Estimation

The point estimators, p, are all constructed using the general relation:

$$p = \left[\frac{\text{number of occurrences}}{\text{number of definite classifications}}\right] \cdot (100)$$

The estimated percent of fatalities which are cold related is denoted by p_c and is given by:

$$p_c = \left[\frac{197}{1254}\right] \cdot (100) = 15.7\%$$

The corresponding percentages for hypothermia and debilitation deaths require an allocation of the 43 conclusions of node DH between their respective numbers of occurrences. This will be done under the assumption that each mechanism occurred among the 43 DH fatalities in the same relative proportions that were exhibited in the D and H nodes. These proportions are 47/ (101 + 47) = 0.318 for hypothermia fatalities and 101/ (101 + 47) = 0.682 for debilitation deaths. Thus the percentages for hypothermia, p_h, and debilitation death, p_d, are:

$$p_h = \left[\frac{(0.318) \cdot (43) + 47}{1254}\right] \cdot (100) = 4.8\%$$

and $$p_d = \left[\frac{(0.682) \cdot (43) + 101}{1254}\right] \cdot (100) = 10.4\%$$

The percent of fatalities which involved sudden death, p_s, is given by:

$$p_s = \left[\frac{6}{1254}\right] \cdot (100) = 0.5\%$$

Because of the reasons indicated in the discussion in Section 3.2, this estimate is conservative and could involve a large proportional error. It would only require 6 undetected sudden deaths for the proportional error to be 50 percent (6/12 × 100%). However, correction of this error would only increase the estimate of the percent of fatalities which are cold related by 0.5 percent.

Interval of Uncertainty

Having composed the best point estimates of the percentages supported by obtainable data, it is necessary to recognize the uncertainty which exists in these results. Since definite conclusions regarding cold involvement could not be supported for each fatality, the actual percentages for 1974 must lie within an interval of uncertainty which can be constructed by considering the extreme combinations of involvement which the uncertain cases might have had. The lower limits of these intervals, p^{ℓ}, are constructed by:

$$p^{\ell} = \left[\frac{\text{minimum possible number of occurrences}}{\text{total number of fatalities}}\right] \cdot (100)$$

The upper limits of the intervals, p^{u}, are obtained from:

$$p^{u} = \left[\frac{\text{maximum possible number of occurrences}}{\text{total number of fatalities}}\right] \cdot (100).$$

For the combination of all cold-related fatalities these lower, p_c^{ℓ}, and upper, p_c^{u}, limits are:

$$p_c^{\ell} = \left[\frac{197}{1490}\right] \cdot (100) = 13.2\%$$

$$\text{and} \quad p_c^{u} = \left[\frac{197 + 236}{1490}\right] \cdot (100) = 29.1\%$$

The smallest percentage possible, results when the 197 identified cold-related fatalities are the only ones of the 1455 fatalities which were cold related. The largest percentage possible, results when all fatalities with uncertain cold involvements are assumed to involve a cold-related lethal mechanism.

The corresponding limits for debilitation death are:

$$p_d^{\ell} = \left[\frac{101}{1490}\right] \cdot (100) = 6.8\%$$

$$\text{and} \quad p_d^{u} = \left[\frac{101 + 43 + 236}{1490}\right] \cdot (100) = 25.5\%$$

It should be noted that in computing the upper limit on the percent of debilitation deaths the 43 node DH fatalities were all assumed to result from debilitation. These were fatalities which could be classified as "debilitation or hypothermia" but which could not be further distinguished. Therefore, they are included in the ranges of uncertainty for debilitation deaths and hypothermia (p_d^u and p_h^u) but not for sudden death (p_s^u). The limits of the interval of uncertainty for hypothermia are:

$$p_h^{\ell} = \left[\frac{47}{1490}\right] \cdot (100) = 3.2\%$$

$$\text{and} \quad p_h^{u} = \left[\frac{47 + 43 + 236}{1490}\right] \cdot (100) - 21.9\%$$

The lower limit for sudden death is constructed as were those for the other mechanisms yielding:

$$p_s^{\ell} = \left[\frac{6}{1490}\right] \cdot (100) = 0.4\%$$

The upper limit for sudden death is constructed using only those uncertain classifications for which sudden death can not be ruled out based on the time the victims are known to have been alive in the water. The resulting upper limit is:

$$p_s^{u} = \left[\frac{6 + 211}{1490}\right] \cdot (100) = 14.6\%$$

Bound on the 95 Percent Confidence Interval

It is interesting to consider the random variation which might be seen from year to year in the percentages of occurrence of the cold-related lethal mechanisms. The normal method of quantifying this variation is to establish an interval within which the parameter being considered is known to lie with some established confidence level (probability). The 95 percent confidence level is commonly used and will be used in this report. To avoid making unsupportable assumptions about the precise nature of the probability distributions governing these occurrences, a non-parametric method (Chebychev's inequality) has been used to establish a bound on the 95 percent confidence interval for each of the point estimates computed previously. The following minimal assumptions must be made to establish the desired confidence interval.

1. The proportional data embodied in the 1254 definite classifications is representative of the occurrences of the various types of cold-related boating fatalites.
2. Cold-related boating fatalities occur independently.

The first assumption could be invalidated if major meteorological or economic changes in the future affect recreational patterns and the associated occurrence of cold-related recreational boating fatalities. The second assumption is not strictly valid since the tendencies toward cold-related deaths, when several individuals are simultaneously immersed, are linked by the temperature of the water. The cold-related fatalities shown in Table 5 include single-and multiple-fatality accidents as follows.

No. Fatalities Per Accident	No. Accidents	No. Fatalities
1	121	121
2	28	56
3	4	12
4	2	8
TOTALS	155	197

Multiple-fatality accidents accounted for (76/197) ·(100) = 38.6 percent of all cold-related fatalities. It is not suggested that there is complete linking between these occurrences. Rather it is suggested that the fatalities which occur within each multiple-fatality accident may not be independent. The maximum number of "linkages" possible among n entities is equal to the number of combinations of n things taken two at a time. That is, n(n-1)/2. The maximum number of linkages possible among 197 fatalities is 19,306. The number of linkages possible in the multiple-fatality data cited above is:

$$28\left[2(2-1)/2\right] + 4\left[3(3-1)/2\right] + 2\left[4(4-1)/2\right] = 52.$$

Thus while 38.6 percent of all cold-related fatalities could be involved in "related" accidents, they are involved in such a way that only (52/19,306) (100) = 0.27 percent of the maximum possible linkages in the outcomes could be expected.

The construction of the bounds on the confidence intervals using Chebychev's inequality requires estimates of the variances of the point estimators. The development of the confidence interval bounds will be shown here for the proportion of cold-related fatalities. Then special steps will be described which are necessary for confidence interval estimation on the proportions of the three cold-related mechanisms. The estimation begins by defining a binary variable X_i as follows:

$$X_i = \begin{cases} 0 \text{ if fatality } i \text{ not cold-related} \\ 1 \text{ if fatality } i \text{ cold-related} \end{cases}$$

$$\text{for } i = 1, 2, \ldots, 1254$$

Notice that the number of cold-related fatalities is $\sum_{i=1}^{1254} X_i$ and the proportion of cold-related fatalities is $p_c = (1/1254)\left[\sum_{i=1}^{1254} X_i\right]$. To obtain the confidence interval around the <u>actual</u> proportion, an estimate of the variance of p_c, denoted by $Var(p_c)$ and $S^2_{p_c}$, is required. The following basic relationship will also be used.

$$\mathrm{Var}(p_c) = \mathrm{Var}\left[(1/1254)\sum_{i=1}^{1254} X_i\right]$$

$$= (1/1254)^2 \cdot \mathrm{Var}\left[\sum_{i=1}^{1254} X_i\right]$$

$$= (1/1254)^2 \cdot \left[\sum_{i=1}^{1254} \mathrm{Var}(X_i)\right] \quad \left\{\text{Assuming Independence}\right\}$$

$$= (1/1254)^2 \cdot \left[\sum_{i=1}^{1254} S_x^2\right]$$

$$= (1/1254)^2 \cdot \left[1254 \cdot S_x^2\right]$$

$$\mathrm{Var}(p_c) = S_x^2/1254$$

The estimation of S_x^2 uses the following relation.

$$S_x^2 = (1/1253)\left[\sum_{i=1}^{1254} X_i^2 - (1/1254)(\sum_{i=1}^{n} X_i)^2\right]$$

$$= (1/1253)\left[197 - (1/1254)\ (197)^2\right]$$

$$S_x^2 \simeq 0.132$$

Therefore $S_{p_c} \simeq 0.010$. Using P_c' to represent the <u>actual</u> proportion of fatalities which are cold-related and Pr for "probability that", Chebychev's Inequality states:

$$Pr\ (\ |p_c - P_c'| \geq k \cdot S_{p_c}) \leq 1/k^2,$$

or equivalently

$$Pr\ (p_c - k \cdot S_{p_c} < P_c' < p_c + k \cdot S_{p_c}) > 1 - 1/k^2 .$$

The expression in the parentheses defines upper and lower limits of a confidence interval around P_c'. The right-hand side of the inequality is the bound on the confidence level associated with this interval. It is desired that $1 - 1/k^2 = 0.95$ so $k = 4.472$ and Chebychev's Inequality gives the following bounds on the 95 percent confidence interval.

$$Pr\ (0.111 < P_c' < 0.203) > 0.95$$

This indicates that the percent of deaths which are cold-related will be between 11.1 and 20.3 percent <u>at least</u> 95 percent of the time.

A similar approach may be used to establish a confidence interval on P_d', the proportion of debilitation deaths. The variable X_i would be defined as follows.

$$X_i = \begin{cases} 0 \text{ if fatality } i \text{ does not result from cold debilitation} \\ 1 \text{ if fatality } i \text{ results from cold debilitation} \end{cases}$$

$$\text{for } i = 1, 2, \ldots, 1254$$

In this case, because of the DH nodes, not all of the X_i can be determined. However, in calculating p_d it was estimated that $(0.682)\ (43) + 101 \approx 130.33$ fatalities involved cold debilitation. Thus although all the X_i can not be determined, it is estimated that 130 of them would be 1, 1 of them would be 0.33 and the remaining $1254 - 131 = 1123$ would be 0. This information is sufficient to allow interval estimation as follows.

$$S_x^2 = (1/1253)\left[130.11 - (1/1254)(130.33)^2\right] \approx 0.093$$

$$S_{p_d} \approx 0.009$$

$$Pr(0.065 < P_d' < 0.142) > 0.95$$

This indicates that the percent of debilitation deaths would be between 6.5 and 14.2 percent at least 95 percent of the time.

An analysis completely analogous to the preceding one may be performed for the $(0.318)\ 43 + 47 = 60.67$ hypothermia fatalities expected among the 1254 definitely classified boating fatalities. The results are as follows.

$$S_x^2 = (1/1253)\left[60.45 - (1/1254)(60.67)^2\right] \approx 0.046$$

$$S_{p_h} \approx 0.006$$

$$Pr(0.021 < P_h' < 0.075) > 0.95$$

The corresponding confidence interval for the percent of sudden deaths produces the following results.

$$s_x^2 = (1/1253)\left[6 - (1/1254)(6)^2\right] \approx 0.005$$

$$s_{P_s} \approx 0.002$$

$$Pr(-0.004 < P_s' < 0.014) > 0.95$$

Because we know P_s' may not be negative, the lower bound may be adjusted to 0.

Summary

The point estimates, intervals of uncertainty and 95 percent confidence intervals are summarized in Table 6 for the cold-related lethal mechanisms individually and collectively. It should be noted that the "Total Cold-Related Deaths" row in Table 6 can be obtained by summing the rows above it only for the "Point Estimate" column. Because of multiple inclusions and exclusions of uncertain and node DH classifications, the limits on the intervals of uncertainty are not additive. Because of the nonlinear way in which risk levels combine, the bounds on the 95 percent confidence intervals for the individual mechanisms are not additive. It should also be noted that the point estimates are all very much closer to the lower limits of the intervals of uncertainty than to their upper limits. This indicates that the actual percentages for 1974 are probably considerably closer to the lower limits than the upper limits.

TABLE 6
PERCENTS OF 1974 BOATING FATALITIES
INVOLVING COLD-RELATED LETHAL MECHANISMS

Lethal Mechanism	Point Estimate	Interval of Uncertainty For 1974		95% Confidence Interval	
		Lower Limit	Upper Limit	Lower Bound	Upper Bound
Debilitation Death	10.4	6.8	25.5	6.5	14.2
Hypothermia	4.8	3.2	21.9	2.1	7.5
Sudden Death	0.5	0.4	14.6	0	1.4
Total Cold-Related Deaths	15.7	13.2	29.1	11.2	20.3

6.0 DEMOGRAPHIC ANALYSIS OF COLD-RELATED FATALITIES

This chapter presents a demographic analysis of the 197 boating fatalities which were previously classified to be cold-related. The following characteristics are considered in this analysis.

1. time of year of fatalities
2. state in which fatalities occurred
3. temperature of water
4. victim's age
5. victim's sex
6. victim's swimming ability
7. victim's use of flotation assistance
8. type of body of water
9. operator's age and experience
10. operation at the time of the accident (general and specific activities)
11. type of boat
12. type of casualty

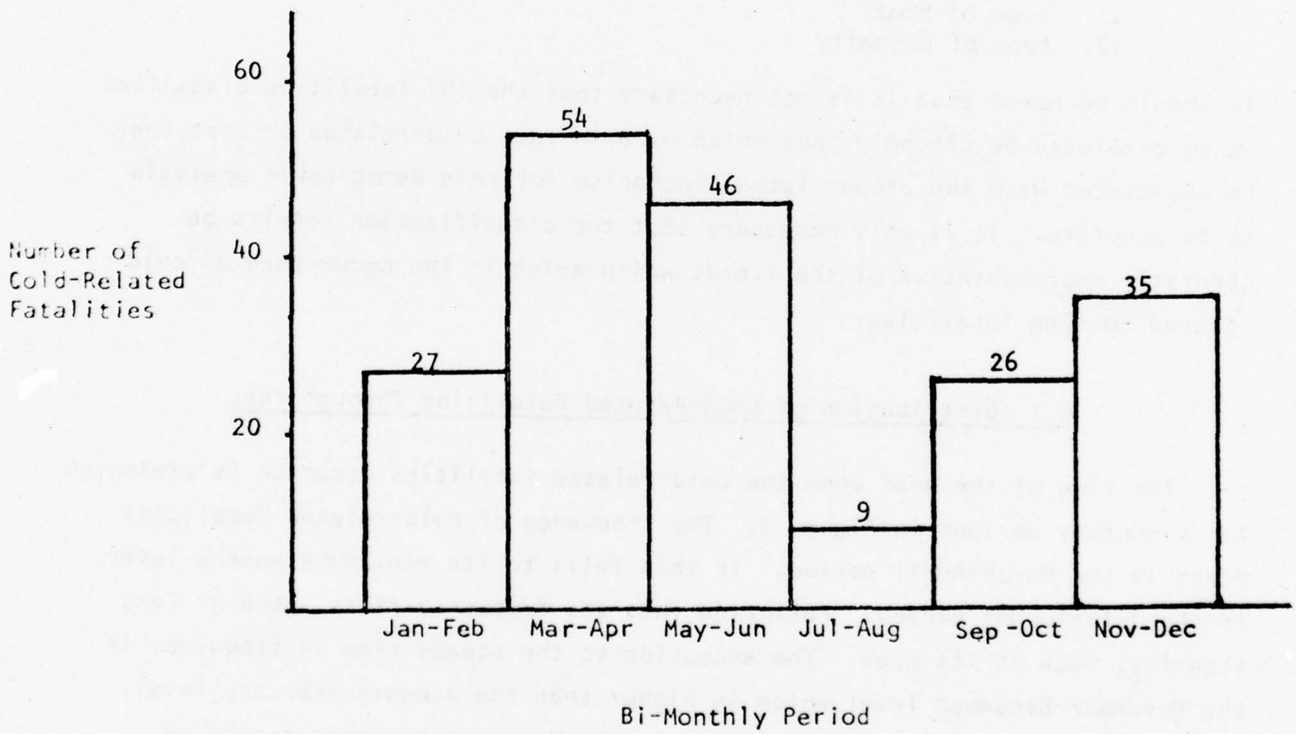
It should be noted that it is not necessary that the 197 fatalities classified as cold-related be the only ones which were in fact cold-related or that they be associated with the proper lethal mechanism for this demographic analysis to be accurate. It is only necessary that the classification results be generally representative of the trends which exist in the occurrence of cold-related boating fatalities.

6.1 Distribution of Cold-Related Fatalities Through Year

The time of the year when the cold-related fatalities occurred is presented for bimonthly periods in Figure 3. The frequency of cold-related fatalities peaks in the March-April period. It then falls to its minimum 4 months later in the July-August period. Following this the frequency rises, more or less steadily, back to its peak. The exception to the steady rise in frequency is the November-December level which is higher than the January-February level. This might be due to increased hunting in the November-December period as compared to the January-February one. The occurrence of the peak frequency in the March-April period might result from the high level of outdoor recreation accompanying the return of warmer weather at a time when the temperatures of most bodies of water are near their annual minimum. The data shown in Figure 3 suggests that public service announcements calling attention to the risks of cold-water immersion should be presented with greatest frequency beginning in October or November and continuing through April or May of each year.

FIGURE 3

DISTRIBUTION OF COLD-RELATED FATALITIES THROUGH YEAR



6.2 Geographical Distribution of Cold-Related Fatalities

Several measures may be used to examine the geographical distribution of cold-related boating fatalities across the states. First, the number of such fatalities occurring in each state may be compared. In addition, several measures of "rate occurrence" of cold-related boating fatalities in each state could be constructed. Two such measures are the ratio of the number of cold-related fatalities to the volume of boating activity and the proportion of all boating fatalities which are cold-related. These three measures are presented in Columns A, C and E of Table 7 for each of the 50 states and the District of Columbia. The states are ranked in Table 7 in order of decreasing number of cold-related fatalities (Column A). The distribution of the 236 "Uncertain" classifications among the states is shown in Column F.

The number of cold-related fatalities ranges from 0 for several states to 16 for California. The geographical distribution of cold-related fatalities across the United States is shown in Figure 4. Each asterisk represents one cold-related fatality. The locations of the asterisks are significant only as indications of which states the fatalities took place in. Their locations within the states is not intended to indicate the exact locations of the fatalities. The average number of fatalities in each state (including the District of Columbia) is 197/51 = 3.86 fatalities per "state". Figure 5 indicates by asterisks the 23 states which had above-average numbers of cold-related fatalities. This data indicates the highest concentrations of cold-related fatalities in states in the northeast, deep south, Great Lakes and west coast regions. The biggest surprise in this result is that so many cold-related fatalities were found in gulf-coastal states.

Boating activity is difficult to measure directly. Table 7 (in Column B) presents the percent of all numbered boats in 1974 which were registered in each state (based on CG-357 (1974)). These percentages do not sum to 100 since Guam, Puerto Rico, the Virgin Islands and American Samoa were not included in Table 7. Using these percentages as measures of the relative amounts of boating activity in each state, the ratio of cold-related boating fatalities to relative amount of boating activity is shown for each state in Column C of Table 7. The ratios range from 0.0 for several states to 30.0 for Alaska. The overall ratio is 2.0. Figure 6 indicates by asterisks the 22 states which have values of the Column C ratio above 2.0. These "high risk"

TABLE 7

COLD-RELATED FATALITIES BY STATE

Column	A	B	C	D	E	F
State	Number Of Cold-Related Fatalities	Percent Of 1974 Boats Numbered	Col. A / Col. B	Total 1974 Boating Fatalities	Col. A / Col. D	Uncertain Classifi- cations
California	16	7.2	2.2	127	.13	17
New York	14	5.3	2.6	85	.16	15
Alabama	10	2.3	4.3	51	.20	4
Michigan	10	7.8	1.3	69	.14	8
Alaska	9	0.3	30.0	48	.19	8
Minnesota	9	6.5	1.4	41	.22	13
Mississippi	8	1.0	8.0	19	.42	5
Virginia	8	1.8	4.4	46	.17	3
Washington	8	1.9	4.2	33	.24	5
Florida	7	4.4	1.6	87	.08	19
Ohio	6	3.7	1.6	38	.16	7
Oregon	6	1.5	4.0	29	.21	4
Pennsylvania	6	2.1	2.8	30	.20	0
Maine	5	1.4	3.6	30	.17	2
Maryland	5	1.7	2.9	50	.10	5
Tennessee	5	2.8	1.8	36	.14	2
Texas	5	6.6	0.8	77	.06	17
Wisconsin	5	5.6	0.9	33	.15	5
Arizona	4	1.0	4.0	17	.24	2
Illinois	4	3.1	1.3	49	.08	5
Louisiana	4	2.3	1.7	77	.05	13
New Jersey	4	1.8	2.2	21	.19	2
North Carolina	4	1.7	2.4	36	.11	7
Arkansas	3	1.5	2.0	20	.15	6
Idaho	3	0.8	3.8	12	.25	3
Iowa	3	1.9	1.6	20	.15	1
Kentucky	3	1.3	2.3	27	.11	4
Massachusetts	3	2.0	1.5	28	.11	5
Montana	3	0.3	10.0	9	.33	1
Utah	3	0.5	6.0	8	.38	1
Georgia	2	2.4	0.8	37	.05	16
New Hampshire	2	0.2	10.0	11	.18	2
Oklahoma	2	2.1	0.9	18	.11	7
South Carolina	2	2.1	0.9	54	.04	1
Connecticut	1	1.0	1.0	15	.07	1
Indiana	1	2.2	0.4	12	.08	5
Kansas	1	1.0	1.0	7	.14	0
Missouri	1	2.6	0.4	29	.03	6
North Dakota	1	0.2	5.0	7	.14	2
Wyoming	1	0.2	5.0	7	.14	2
All Other States	0	3.6	0.0	40	.00	5
TOTALS	197	99.7	2.0	1490	.132	236

FIGURE 4
DISTRIBUTION OF COLD-RELATED FATALITIES
IN THE UNITED STATES

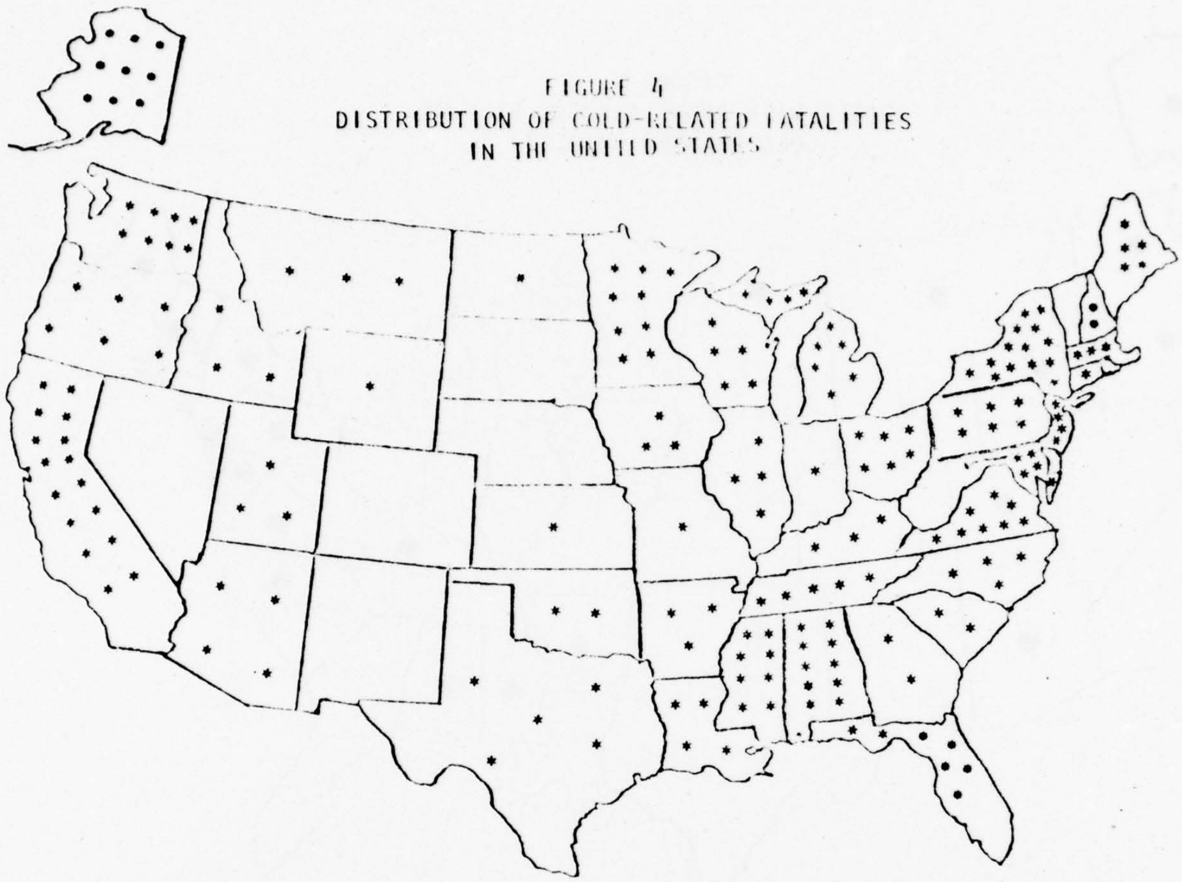
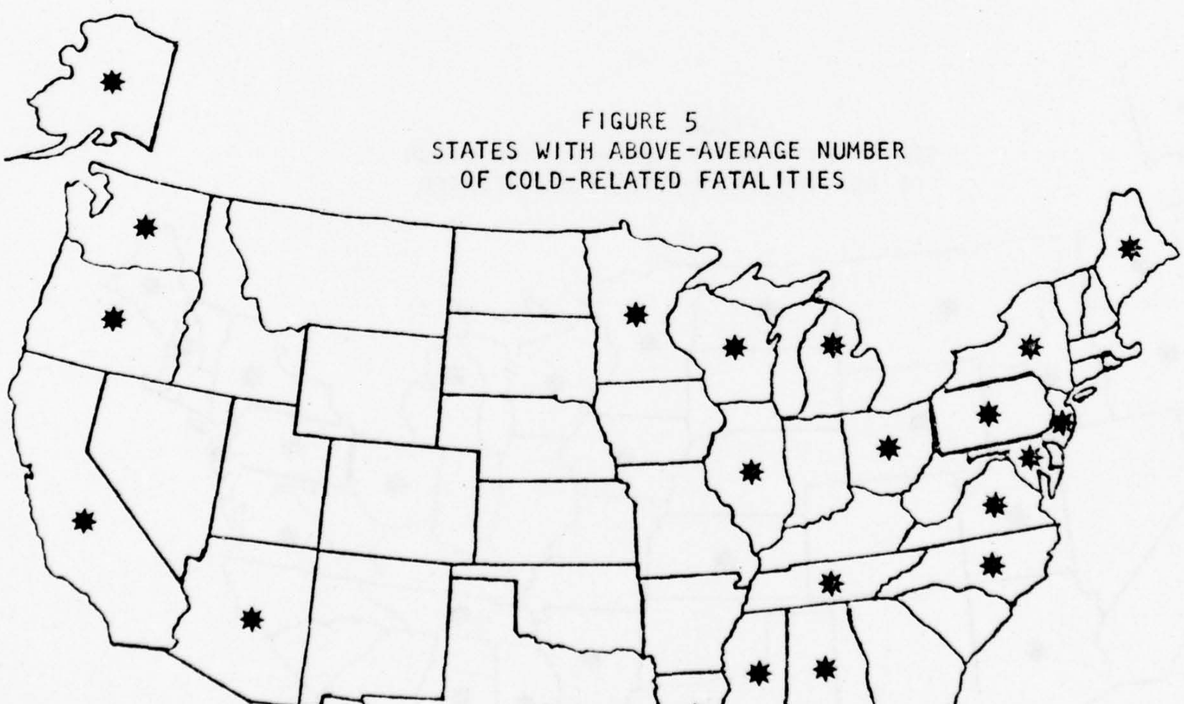


FIGURE 5
STATES WITH ABOVE-AVERAGE NUMBER
OF COLD-RELATED FATALITIES



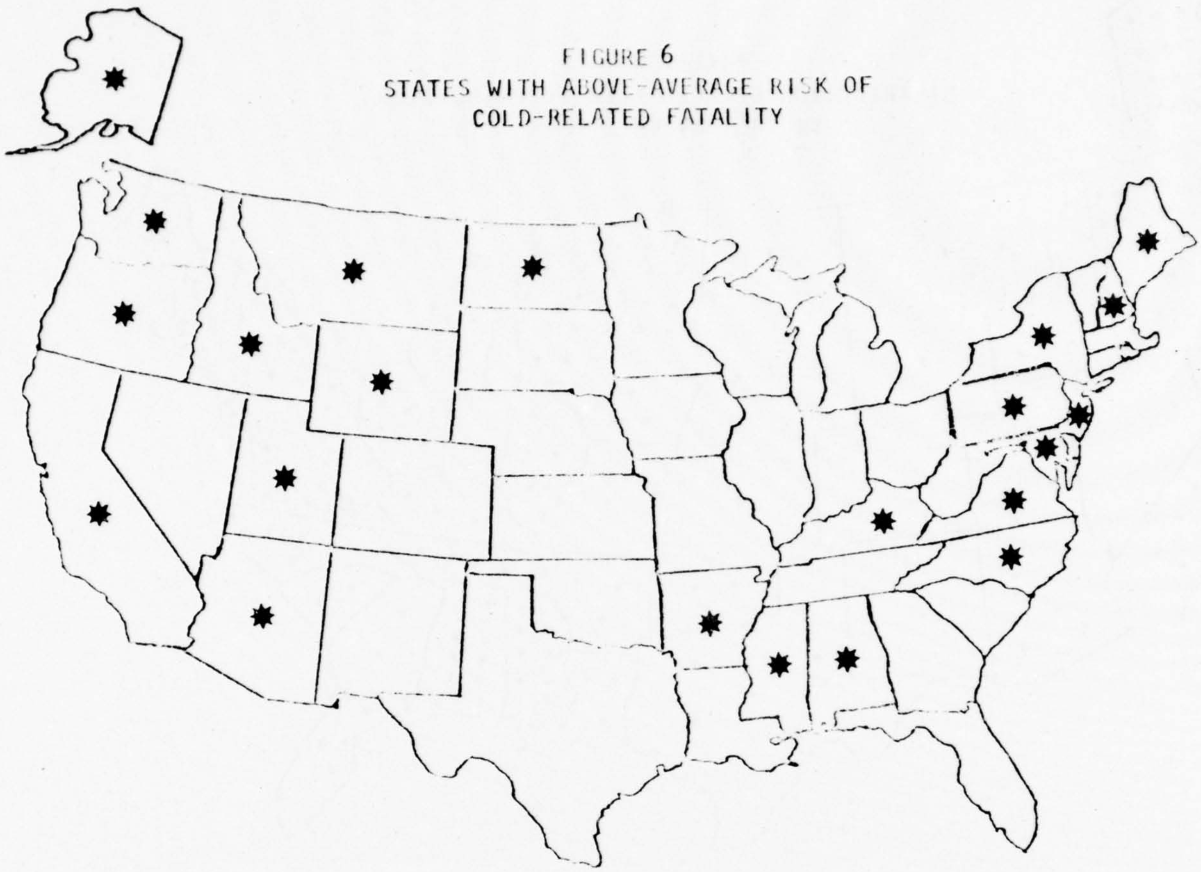


FIGURE 6
STATES WITH ABOVE-AVERAGE RISK OF
COLD-RELATED FATALITY

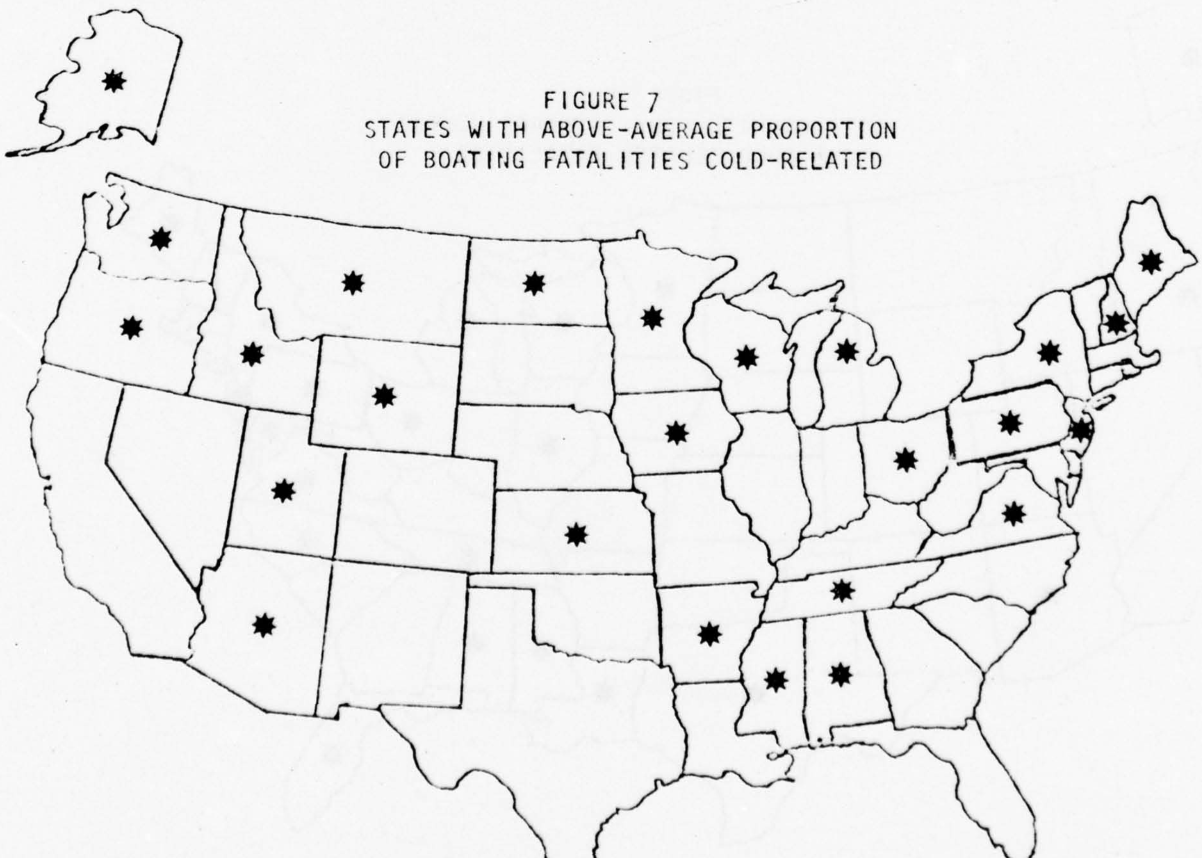


FIGURE 7
STATES WITH ABOVE-AVERAGE PROPORTION
OF BOATING FATALITIES COLD-RELATED

states follow the same general pattern as shown in Figure 4 except for the below average risk shown for Great Lakes states and the above average risk shown for Idaho, Montana, Wyoming and North Dakota. Of course, complete agreement between the two measures shown in Figures 5 and 6 should not be expected.

Column D in Table 7 shows the total number of boating fatalities determined for each state. They were identified by reviewing the BAR's for boating accidents indicated, by the Coast Guard computer data base, to have involved one or more fatalities. Column E contains the proportion of boating fatalities in each state found to be cold-related. These were obtained as ratios of elements in Column A to corresponding elements in Column D. These proportions range from 0.00 for several states to 0.42 for Mississippi. The overall average proportion is shown to be 0.132. Figure 7 indicates by asterisks the 25 states which exhibit proportions above the national average. It may be seen that the heaviest involvement of above-average proportions includes states in the northeast, Great Lakes, deep south and northwest regions. California is just below the national average.

Three logical bases have been presented for directing the geographical distribution of efforts to reduce cold-related boating fatalities. They are the following.

1. the number of cold-related fatalities in each state
2. the ratio of cold-related fatalities to the percent of numbered boats registered in each state. This is an estimation of the number of "cold-related fatalities per unit of boating activity"
3. the proportion of all boating fatalities which are cold-related in each state

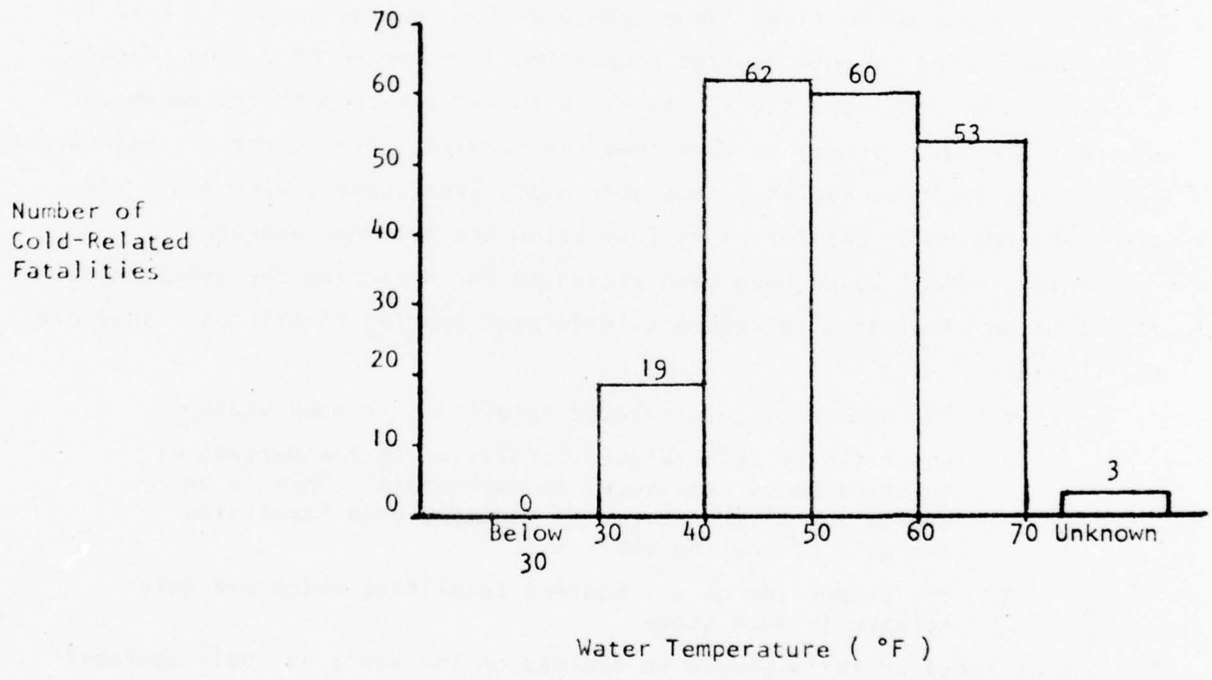
The use of these criteria should be decided on the basis of their appropriateness to the type of effort being considered for the reduction of cold-related boating fatalities.

6.3 Temperature of Water

The numbers of cold-related fatalities occurring in water of various temperatures are shown in Figure 8. The distribution is essentially uniform between 40°F and 70°F with a much smaller number (fewer than 10%) occurring in water in the 30's. Three fatalities were classified as cold-related without knowledge of the temperature of the water involved. These are shown as "Unknown" in Figure 8. Of course, no fatalities occurring in water over 70°F were classified as cold-related.

FIGURE 8

COLD-RELATED FATALITIES BY WATER TEMPERATURE



6.4 Age of the Victims

The number of cold-related fatalities occurring in various age groups are shown in Figures 9 and 10. The age groups used in CG-357 for "operator age" were used in Figure 9. Figure 10 shows a more detailed and uniformly sub-divided age range. The distribution of victims' ages follows a pattern which is grossly unremarkable. The frequency of cold-related fatalities climbs quickly above age 10 to its peak in the 20 to 25 years interval. It then declines quickly to age 35 and is more or less constant until age 65. Only about 5 percent of the fatalities occurred at ages over 65 while about 50 percent occurred in the 20 year interval between ages 15 and 35.

6.5 Sex of the Victims

The representation of the sexes among victims of the fatalities classified as cold-related is highly non-uniform. The numbers of fatalities experienced by each sex are as follows.

TABLE 8
COLD-RELATED FATALITIES BY SEX

	Number	Percent
Male	180	91.4
Female	17	8.6
TOTAL	197	100.0

With over 90 percent of the cold-related fatalities occurring among males, there would seem to be merit in the notion of directing efforts to reduce cold-related fatalities, where possible, toward males.

6.6 Swimming Skill and Use of Flotation Assistance

The distribution of the 197 fatalities, classified as cold-related, over the possible combinations of swimming ability and flotation assistance usage is shown in Table 9.

FIGURE 9
COLD-RELATED FATALITIES BY VICTIM'S AGE

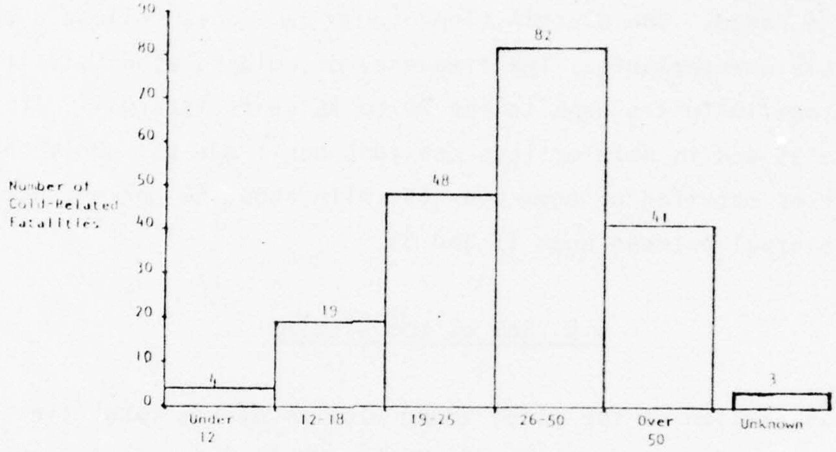


FIGURE 10
COLD-RELATED FATALITIES BY VICTIM'S AGE

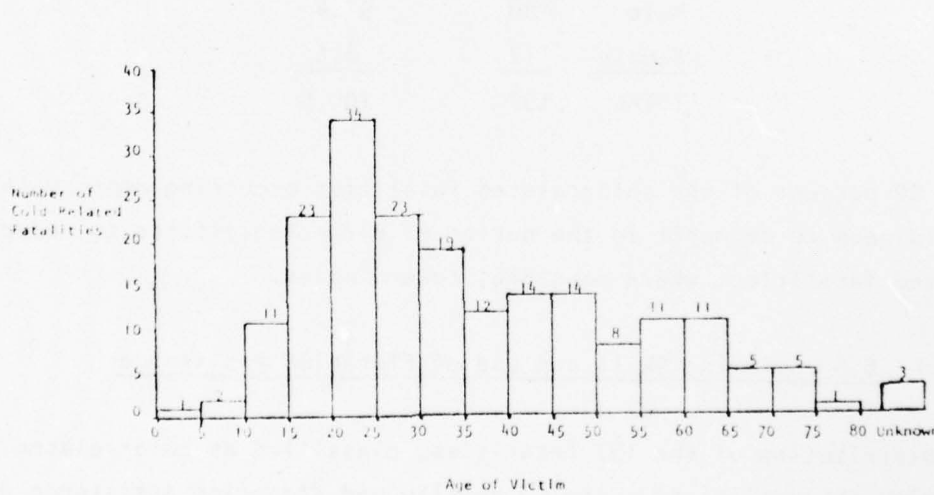


TABLE 9
SWIMMING SKILL AND USE OF FLOTATION ASSISTANCE

Number of Cold-Related Fatalities		FLOTATION ASSISTANCE USED: Yes	No	Unknown	Totals
Swimmer	Yes	29	110	40	179
	No	4	0	0	4
	Unknown	9	3	2	14
TOTALS		42	113	42	197

It should be recalled that the definition of flotation assistance includes approved PFD's properly used as well as other reliable sources of support which were known to be used. Table 9 indicates that over 55 percent of cold-related fatalities involved swimmers without flotation assistance. These are fatalities which might not have been averted by the additional use of simple flotation assistance alone.

6.7 Type of Body of Water

The distribution of the cold-related fatalities over the various types of bodies of water in which they occurred is shown in Table 10. Comparing the percentages of the 197 fatalities classified as cold-related occurring in each type of body of water to the overall percentages, it may be seen that there is very little difference in the two distributions. A slightly larger percentage of cold-related fatalities than overall boating fatalities occurred in oceans and gulfs. A slightly smaller percentage of cold-related fatalities occurred in non-tidal waters.

6.8 Age and Experience of the Operator

The percents of fatalities which occurred from boats being operated by individuals in various age groups is shown in Table 11.

TABLE 10
PERCENTS OF FATALITIES BY TYPE OF BODY OF WATER

	Cold-Related Fatalities	All Boating Fatalities*
Ocean, Gulf	12.2%	7.7%
Great Lakes	3.6%	4.1%
Tidal Waters	18.3%	16.6%
Bay	(9.1%)	
Inlet	(2.0%)	
Sound	(6.6%)	
Harbor	(0.5%)	
Non-Tidal Waters	66.0%	71.6%
Rivers	(28.4%)	
Creeks	(2.0%)	
Canals	(0.5%)	
Lakes & Reservoirs	(34.5%)	
Ponds	(0.5%)	

* Computed from data in CG-357(1974)

TABLE 11
PERCENTS OF FATALITIES BY OPERATOR AGE

	Cold-Related Fatalities	All Boating Fatalities *
Less than 12 years	0%	0.3%
12-18 years	7.6%	5.6%
19-25 years	15.7%	14.7%
26-50 years	45.2%	42.9%
Over 50 years	17.8%	16.7%
Unknown	13.7%	19.5%
No Operator	0%	0.3%

*Computed from data in CG-357 (1974).

Comparing the two distributions of fatalities, it may be concluded that cold-related boating fatalities occur from boats operated by individuals whose ages follow the same pattern as exhibited by the whole of boating fatalities.

Table 12 indicates the percent of fatalities which occurred with the operators of the boats having experience in each of several categories.

TABLE 12
PERCENTS OF FATALITIES BY OPERATOR EXPERIENCE

Type of Boat	Experience	Cold-Related Fatalities	All Boating Fatalities *
Same	Less than 20 hours	11.2%**	9.4%
Same	20-100 hours	13.2%	13.1%
Same	100-500 hours	25.9%	16.4%
Same	Over 500 hours	23.4%	18.9%
Same	Unknown	25.4%	41.9%
Same	No Operator	0	0.3%
Different	100-500 hours	1.0%	0

*Computed from data in CG-357 (1974)

**Includes 0.5% (1 operator) with over 500 hours of experience in a different type boat

The type of boat shown in Table 12 refers to whether the operator's experience was in the same type of boat as that from which the fatalities occurred or in a different type of boat. Comparing the two experience distributions it may be seen that the main difference is that a smaller percentage of operators have unknown experience in the cold-related fatality group than in the overall boating fatality group. The reduction in the percentage with unknown experience for the cold-related fatalities is distributed largely across the two categories involving the most experience (100-500 hours and over 500 hours). Therefore it could not be said that cold-related fatalities occur in a disproportionate way due to lack of experience on the part of the boat operators.

6.9 Operation at Time of Fatality

There are two distinct aspects of the "operation" in which a victim was involved at the time of his fatal accident. There is a general aspect which describes the nature of the activity which prompted the individual to venture out in the boat to begin with. This general aspect may be particularly useful in identifying groups, such as hunters, which are significantly represented among cold-related fatalities. These groups may be reached more or less directly by programs aimed at reducing the occurrence of cold-related fatalities. There is also a specific aspect of the activity at the time of the accident which may convey useful information about the causes of these accidents for various types of general activities. Table 13 shows the distribution of the 197 cold-related boating fatalities across the various combinations of the affected 4 general activities and 11 specific activities. The general and specific activities are ranked in order of decreasing total occurrences.

Reviewing Table 13, the following results may be seen.

1. Approximately 43 percent of the cold-related fatalities occurred during fishing outings.

2. The 84 cold-related fishing fatalities shown in Table 13 account for approximately 33 percent of the 255 fatalities indicated in CG-357 to have occurred while fishing.

3. Less than 10 percent of the cold-related fatalities occurred during hunting outings.

4. The 19 cold-related hunting fatalities shown in Table 13 account for approximately 83 percent of the 23 fatalities indicated in CG-357 to have occurred while hunting.

5. Approximately 48 percent of the cold-related fatalities occurred while cruising.

TABLE 13

COLD-RELATED FATALITIES BY OPERATION AT THE TIME OF THE ACCIDENT

Number of Cold-Related Fatalities		General Activity: Fishing	Boating	Hunting	Unknown	TOTALS
Specific Activity	Cruising	40*	34	14	6	94
	Drifting	27	3	5	3	38
	Rowing & Paddling	2	17		2	21
	Sailing		9			9
	Docking	3	4			7
	Weighing Anchor	5	1			6
	At Anchor	4			1	5
	Rafting		4			4
	Racing		2			2
	Under Tow		2			2
	Unknown	3			6	9
TOTALS		84	76	19	18	197

* Includes 2 who were trolling

6. Approximately 48 percent of the cold-related fishing fatalities occurred while cruising.

7. Approximately 74 percent of the cold-related hunting fatalities occurred while cruising.

It may be seen that a substantial proportion of cold-related fatalities occur while fishing and a substantial proportion of fishing fatalities are cold-related. But while a very large proportion of hunting fatalities (from a boat) are cold-related, only a small proportion of cold-related fatalities occur while hunting. It may also be seen that a large proportion of cold-related fatalities occur while cruising. This proportion among hunting fatalities is even larger, possibly due to the statistical smallness of the number of hunting fatalities.

6.10 Type of Boat

The numbers of cold-related fatalities occurring from the different types of boats involved are shown in Table 14. It may be seen that a very broad range of boat types are represented in Table 14; but open motorboats from 12 to 16 feet in length account for 39 percent of the cold-related fatalities.

6.11 Type of Casualty

The term "type of casualty" is used in CG-357 to refer to the principal event which caused the accident. A more common usage would refer to the outcome of the accident, particularly to a person. The term is used here to avoid ambiguity in a comparison to results obtained from CG-357(1974).

Table 15 presents a comparison of the distribution of the cold-related fatalities and all boating fatalities across the types of casualties affected. The "unknown" category was not used in CG-357 indicating that such casualties were probably included in the "other personnel casualty" category. This would account for the differences in the two distributions in these categories. The distributions coincide very closely, particularly for the major casualties - capsizing and falls overboard. The only significiant remaining difference is in the flooding category, with nearly 8 percent more cold-related fatalities resulting from flooding of the boat than is the case for all boating fatalities combined.

TABLE 14
COLD-RELATED FATALITIES BY BOAT TYPE

Type of Boat	Number of Cold-Related Fatalities		
I. Motorized	140		
A. Flat Bottom Boat		13	
1. 12' - 14' in length			(9)
2. 14' - 18' in length			(2)
3. Unknown length			(2)
B. Open Motorboat		99	
1. Less than 12' in length			(1)
2. 12' - 14' in length			(57)
3. 14' - 16' in length			(20)
4. 16' - 18' in length			(7)
5. 18' - 20' in length			(4)
6. Over 20' in length			(6)
7. Unknown length			(4)
C. Cabin Motorboat		23	
1. 16' - 24' in length			(9)
2. 25' - 30' in length			(10)
3. Over 30' in length			(4)
D. Auxiliary Sail		5	
1. 30' - 60' in length			(3)
2. Over 60' in length			(2)
II. Manual	56		
A. Sailboats		11	
1. 14' - 18' in length			(7)
2. Over 18' in length			(2)
3. Kayaks & canoes with sails			(2)
B. Kayaks and Canoes		21	
C. Row boats and Dinghies		18	
D. Rafts		5	
E. Pontoon with Paddles		1	
III. Unknown	1		
TOTAL	197		

This seems plausible since swamped boats, as differentiated from sunk boats, would generally cause immersion of its occupants but would not necessarily threaten eminent drowning. This would present cold-related lethal mechanisms an opportunity to act if the environmental conditions permit and the victims are not satisfactorily protected.

TABLE 15
PERCENTS OF FATALITIES BY TYPES OF CASUALTY

	Cold-Related Fatalities	All Boating Fatalities*
Grounding	1.5%	1.0%
Capsizing	43.1%	41.6%
Flooding (swamping)	10.2%	2.6%
Sinking	1.5%	5.5%
Fire or Explosion (fuel)	0.5%	0.8%
Fire or Explosion (other)	0 %	0.3%
Collision With Another Vessel	1.0%	3.7%
Collision With Fixed Object	8.1%	5.0%
Striking Floating Object	2.0%	1.2%
Other Casualty to Vessel	0 %	3.7%
Falls Overboard	20.3%	22.8%
Falls Within Boat	0 %	0.7%
Struck by Boat or Propeller	0 %	1.4%
Other Personnel Casualty	1.5%	9.5%
Unknown	10.2%	0 %

* Computed from data in CG-357(1974)

7.0 SUMMARY AND CONCLUSIONS

A systematic schema has been developed for the logical review of the circumstances surrounding boating fatalities. It produces classifications of the fatalities regarding the causal involvement of three cold-related lethal mechanisms - - sudden death, debilitation death and hypothermia.

An intensive review of the boating fatalities occurring in calendar year 1974 has been conducted. This produced an estimate that 15.7 percent of all boating fatalities involve one of the cold-related lethal mechanisms. In a typical year involving 1500 total boating fatalities, approximately 236 of them may be expected to be cold-related. Assuming 1974 to be a representative year, it has been shown that the percent of boating fatalities which are cold-related may be expected to vary due to randomness, from 11.1 percent to 20.3 percent. The corresponding range of cold-related fatalities, in a year of 1500 total fatalities, is from 166 to 304.

A demographic analysis of the fatalities in 1974 classified as cold-related has produced the following observations.

1. 50 percent of cold-related fatalities occur in the 4 months from March through June.
2. The states most heavily involved in cold-related fatalities are in the northeast, Great Lakes, deep south and west coast regions.
3. 50 percent of the victims of cold-related fatalities were between 15 and 35 years old and 5 percent were over 65.
4. Over 90 percent of cold-related fatalities involve male victims.
5. Over 55 percent of cold-related fatalities involve victims who could swim but were without flotation assistance at the time of their accident.
6. Cold-related fatalities occur in various types of bodies of water in essentially the same proportions as do all boating fatalities combined.
7. Cold-related fatalities occur from boats operated by individuals whose ages and experience are very representative of those involved in all boating fatalities combined.
8. Approximately 43 percent of cold-related fatalities occurred during fishing outings while 10 percent occurred during hunting outings.

9. 48 percent of cold-related fatalities resulted from accidents which occurred while cruising.

10. A very broad range of boat types were involved in cold-related accidents but 39 percent of the fatalities occurred from open motorboats between 12 and 16 feet in length.

11. The percent of cold-related fatalities resulting from boat swampings was slightly larger than the corresponding percent of all boating fatalities.

Cold-related lethal mechanisms have been estimated to account for approximately 16 percent of all boating fatalities. This estimate probably lies in the middle ground between two schools of thought on the significance of cold. While the cold is by no means involved in a majority of recreational boating fatalities, it must be concluded to be involved in a significant proportion of them.

The problem has been shown to be more pervasive than might have been expected. The period of most frequent occurrence extends into early summer. The geographical regions of greatest risk include the deep south. Victims affected the most range from 10 to 65 years in age. Cold-related fatalities occur from all types of boats operated by individuals in all age and experience ranges.

Yet there are some clues to the nature of a high-risk population. The vast majority are males. Over half are swimmers without flotation assistance. Half are from 15 to 35 years of age. Nearly half are on a fishing outing. Nearly half are cruising at the time of their accidents. Approximately 40 percent are in open motorboats between 12 and 16 feet in length. These characteristics of the high-risk population may enable efforts aimed at reducing cold-related fatalities to be most fruitfully directed.

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APPENDIX A

BOATING ACCIDENT REPORT FORM

DEPARTMENT OF TRANSPORTATION
U. S. COAST
CG-3865 (Rev. 5-75)

BOATING ACCIDENT REPORT

OMB No. 04-R[illegible]

The operator of every vessel involved is required to file a report [illegible] whenever [illegible] accident results in loss of life [illegible] treatment or disability in excess of 24 hours or property damage in excess of $100. Reports in death and injury cases must be submitted within 48 hours; reports in other cases are required within 5 days. All reports must be submitted (a) to the state where the vessel number is issued (b) if the vessel has no number where the vessel is principally used (c) the state where the casualty or accident occurred if it occurred outside the state where the vessel is numbered, or the place where the accident occurred. See addresses on reverse.

COMPLETE ALL BLOCKS *(Indicate those not applicable by "NA")*

NAME AND ADDRESS OF OPERATOR	AGE	OPERATOR'S EXPERIENCE
OPERATOR TELEPHONE NO.	OWNER TELE. NO.	THIS TYPE OF BOAT: UNDER 20 HOURS / 20 TO 100 HOURS / 100 TO 500 HOURS / OVER 500 HOURS — OTHER BOAT OPERATING EXP.: UNDER 20 HOURS / 20 TO 100 HOURS / 100 TO 500 HOURS / OVER 500 HOURS
NAME AND ADDRESS OF OWNER	RENTED BOAT: YES / NO — NO. OF PERSONS ON BOARD	FORMAL INSTRUCTIONS IN BOATING SAFETY: NONE / USCG AUXILIARY / U.S. POWER SQUADRON / AMERICAN RED CROSS / STATE / OTHER *(Indicate)*

VESSEL NO. 1

BOAT NUMBER	BOAT NAME	BOAT MAKE	BOAT MODEL	MFR HULL IDENTIFICATION NO.
TYPE OF BOAT	HULL MATERIAL	ENGINE	BOAT DATA *(Propulsion)*	BOAT DATA *(Construction)*
OPEN MOTORBOAT	WOOD	OUTBOARD	NO. OF ENGINES	LENGTH
CABIN MOTORBOAT	ALUMINUM	INBOARD GASOLINE	MAKE OF ENGINE	WIDTH BEAM
AUXILIARY SAIL	STEEL	INBOARD DIESEL	HORSEPOWER *(Total)*	DEPTH *(Inner Transom To Keel)*
SAIL *(ONLY)*	FIBERGLASS *(Plastic)*	INBOARD OUTDRIVE	YEAR BUILT *(Engine)*	YEAR BUILT *(Hull)*
ROWBOAT	OTHER *(Specify)*	OTHER *(Specify)*	TYPE OF FUEL	
OTHER *(Specify)*				

ACCIDENT DATA

DATE OF ACCIDENT	TIME ___ AM ___ PM	NAME OF BODY OF WATER	LOCATION *(Give location precisely)*
STATE	NEAREST CITY OR TOWN		COUNTY

WEATHER	WATER CONDITIONS	TEMPERATURES *(Estimated)*	WIND	VISIBILITY	WEATHER ENCOUNTERED
CLEAR / RAIN	CALM	AIR ___ °F	NONE	GOOD	WAS AS FORECAST
CLOUDY / SNOW	CHOPPY		LIGHT (0-6 MPH)	FAIR	NOT AS FORECAST
FOG / HAZY	ROUGH	WATER ___ °F	MODERATE (7-14 MPH)	POOR	NO FORECAST OBTAINED
	VERY ROUGH		STRONG (15-25 MPH)		
	STRONG CURRENT		STORM (Over 25 MPH)		

OPERATION AT TIME OF ACCIDENT *(Check all applicable)*	TYPE OF ACCIDENT	WHAT IN YOUR OPINION CAUSED THE ACCIDENT
CRUISING / AT ANCHOR	GROUNDING / COLLISION WITH FIXED OBJECT	WEATHER CONDITIONS / FAULT OF HULL
APPROACHING DOCK / TIED TO DOCK	CAPSIZING / COLLISION WITH FLOATING OBJECT	EXCESSIVE SPEED / FAULT OF MACHINERY
WATER SKIING / FUELING	FLOODING / FALLS OVERBOARD	NO PROPER LOOKOUT / FAULT OF EQUIPMENT
RACING / FISHING	SINKING / FALLS IN BOAT	OVERLOADING / OTHER *(Specify)*
TOWING / HUNTING	FIRE OR EXPLOSION *(Fuel)* / BURNS	IMPROPER LOADING
BEING TOWED / SKIN DIVING OR SWIMMING	FIRE OR EXPLOSION *(Other than fuel)* / HIT BY BOAT OR PROPELLER	HAZARDOUS WATERS
DRIFTING / OTHER *(Specify)*	COLLISION WITH VESSEL / OTHER *(Specify)*	RESTRICTED VISION

PERSONAL FLOTATION DEVICES / FIRE EXTINGUISHERS

WAS THE BOAT ADEQUATELY EQUIPPED WITH CG APPROVED LIFESAVING DEVICES?	WAS THE VESSEL CARRYING NON APPROVED	WERE THEY USED? *(If yes, list Type(s) and number used.)*
YES / NO	LIFESAVING DEVICES: YES / NO	YES
WERE THEY ACCESSIBLE: YES / NO	WERE THEY ACCESSIBLE: YES / NO	NO
WERE THEY USED: YES / NO	WERE THEY USED: YES / NO	NOT APPLICABLE

PROPERTY DAMAGE *(Est.)*	DESCRIBE PROPERTY DAMAGE
THIS BOAT $ / OTHER BOAT $ / OTHER PROPERTY $	

NAME AND ADDRESS OF OWNER *(Damaged Property)*

DECEASED

NAME	ADDRESS	DATE OF BIRTH	WAS VICTIM	DEATH CAUSED BY
			SWIMMER / NON-SWIMMER	DROWNING / DISAPPEARANCE / OTHER
			SWIMMER / NON-SWIMMER	DROWNING / DISAPPEARANCE / OTHER
			SWIMMER / NON-SWIMMER	DROWNING / DISAPPEARANCE / OTHER

INJURED

NAME	ADDRESS	DATE OF BIRTH	NATURE OF INJURY	INCAPACITATED OVER 24 HOURS
				YES / NO
				YES / NO
				YES / NO

PREVIOUS EDITIONS ARE OBSOLETE

GPO 9?? 091

ACCIDENT DESCRIPTION

DESCRIBE WHAT HAPPENED (Sequence of events. Include Failure of Equipment. If diagram is needed attach separately. Continue on additional sheets if necessary.)

VESSEL NO. 2

NAME OF OPERATOR	ADDRESS	BOAT NUMBER
TELEPHONE NUMBER		BOAT NAME
NAME OF OWNER	ADDRESS	

WITNESSES

NAME	ADDRESS	TELEPHONE NUMBER
NAME	ADDRESS	TELEPHONE NUMBER
NAME	ADDRESS	TELEPHONE NUMBER

PERSON COMPLETING REPORT

SIGNATURE	ADDRESS	DATE SUBMITTED
QUALIFICATION (Check one) ☐ OPERATOR ☐ OWNER ☐ INVESTIGATOR ☐ OTHER		TELEPHONE

(do not use) - FOR REPORTING AUTHORITY REVIEW (use agency date stamp)

NAME OF REVIEWING OFFICE	DATE RECEIVED	CAUSES BASED ON (Check one) ☐ THIS REPORT ☐ INVESTIGATION AND THIS REPORT ☐ INVESTIGATION ☐ COULD NOT BE DETERMINED
PRIMARY CAUSE OF ACCIDENT		REVIEWED BY
SECONDARY CAUSE OF ACCIDENT		

STATE BOATING LAW ADMINISTRATORS

Dept. of Cons. & Nat'l Res. — Water Safety Div.
Administrative Building
Montgomery, AL. 36104

Commission of Public Safety
Pouch "N" Capitol Building
Juneau, AK. 99801

Government of American Samoa
Pago Pago, AS. 96920

Arizona Game and Fish Department
222 W. Greenway Road
Phoenix, AZ. 85023

Arkansas Game and Commission
State Capitol Grounds
Little Rock, AR. 72201

Dept. of Navigation & Ocean Development
1416 Ninth Street
Sacramento, CA. 95814

Division of Park & Outdoor Recreation
1845 Sherman
Denver, CO. 80208

Boating Div. — Dept. of Environmental Protection
State Office Building
Hartford, CT. 96115

Dept. of Nat'l Resources & Environmental Comm.
D Street
Dover, DE. 19901

Metropolitan Police Dept. — Harbor Section, SOD
550 Waterfront Street, S.W.
Washington, D. C. 20020

Dept. of Natural Resources
Larson Building
Tallahassee, FL. 82304

Game & Fish Div. — Dept. of Nat'l Resources
Room 707-C, Trinity - Washington Building
Atlanta, GA. 30334

Dept. of Public Safety
Agana, GU. 96910

Dept. of Transportation — Harbors Division
79 S. Nimitz Highway
Honolulu, HI. 96813

Dept. of Law Enforcement
P.O. Box 34
Boise, ID. 83731

Conservation Department
400 South Spring Street
Springfield, IL. 62706

Dept. of Natural Resources
606 State Office Building
Indianapolis, IN. 46204

State Conservation Commission
300 Fourth Street
Des Moines, IA. 50319

Forestry, Fish & Game Commission
Box 1028
Pratt, KA. 67124

Division of Water Enforcement
Frankfort, KY. 40601

Wildlife & Fisheries Commission
400 Royal Street
New Orleans, LA. 70130

Bureau of Watercraft Reg. and Safety
State Office Building
Augusta, ME. 04330

Natural Resources Police
Tawes State Building
Annapolis, MD. 21401

Marine & Recreational Vehicles
64 Causeway Street
Boston, MA. 02114

Michigan Dept. of State Police
714 S. Harrison Road
Lansing, MI. 48823

Dept. of Natural Resources
Centennial Office Building
St. Paul, MN. 55155

Boat & Water Safety Commission
Room 403, Robert E. Lee Bldg.
Jackson, MS. 39201

Division of Water Safety
P.O. Box 603
Jefferson City, MO. 65101

Enforcement Div. — Dept. of Fish & Game
Helena, MT. 59601

State Game and Parks Commission
2200 North Third Street
Lincoln, NE. 68503

Fish and Game Department
P.O. Box 10678
Reno, NV. 89510

Department of Safety
Concord, NH. 03301

Dept. of Environmental Protection
Division of Marine Services
P.O. Box 1889
Trenton, NJ. 08625

Park and Recreation Commission
P.O. Box 1147
Santa Fe, NM. 87501

State Park & Recreation
South Swan Street, Bldg. — South Mall
Albany, NY. 12223

Wildlife Resources Commission
Raliegh, NC. 27611

State Game and Fish Department
Bismarck, ND. 58501

Dept. of Natural Resources
Fountain Square
Columbus, OH. 43224

Dept. of Public Safety
P.O. Box 11415
Oklahoma City, OK. 73111

Oregon Marine Board Director
3000 Market Street, N.E. #505
Salem, OR. 97310

State Fish Commission
P.O. Box 1673
Harrisburg, PA. 17120

Operation Division Maritime Department
Puerto Rico Authority
GPO Box 2829
San Juan, PR. 00936

Division of Boating Safety
Quonset Administration Building
Davisville, RI. 02854

Division of Boating
P.O. Box 12559, Ft. Johnson Road
Charleston, SC. 29412

Dept. of Game, Fish and Parks
State Office Building
Pierre, SD. 57501

Wildlife Resources Agency
Ellington Agriculture Center
P.O. Box 40707
Nashville, TN. 37204

Parks and Wildlife Department
John Reagan Building
Austin, TX. 78701

Division of Parks and Recreation
1596 W. North Temple Street
Salt Lake City, UT. 84116

Marine Division
Department of Public Safety
Montpelier, VT. 05602

Charlotte Amalie
St. Thomas, VI. 00801

Commission of Game & Inland Fisheries
P.O. Box 11104
Richmond, VA. 23230

Boat & Water Safety
Washington State Park & Recreation
P.O. Box 1128
Olympia, WA. 98504

Dept. of Natural Resources
Charleston, WV. 23505

Dept. of Natural Resources
P.O. Box 450
Madison, WI. 53701

Game & Fish Department
P.O. Box 1589
Cheyenne, WY. 82001

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METRIC CONVERSION FACTORS

Approximate Conversions to Metric Measures

Symbol	When You Know	Multiply by	To Find	Symbol
		LENGTH		
in	inches	*2.5	centimeters	cm
ft	feet	30	centimeters	cm
yd	yards	0.9	meters	m
mi	miles	1.6	kilometers	km
		AREA		
in^2	square inches	6.5	square centimeters	cm^2
ft^2	square feet	0.09	square meters	m^2
yd^2	square yards	0.8	square meters	m^2
mi^2	square miles	2.6	square kilometers	km^2
	acres	0.4	hectares	ha
		MASS (weight)		
oz	ounces	28	grams	g
lb	pounds	0.45	kilograms	kg
	short tons (2000 lb)	0.9	tonnes	t
		VOLUME		
tsp	teaspoons	5	milliliters	ml
Tbsp	tablespoons	15	milliliters	ml
fl oz	fluid ounces	30	milliliters	ml
c	cups	0.24	liters	l
pt	pints	0.47	liters	l
qt	quarts	0.95	liters	l
gal	gallons	3.8	liters	l
ft^3	cubic feet	0.03	cubic meters	m^3
yd^3	cubic yards	0.76	cubic meters	m^3
		TEMPERATURE (exact)		
°F	Fahrenheit temperature	5/9 (after subtracting 32)	Celsius temperature	°C

*1 in ≡ 2.54 (exactly). For other exact conversions and more detailed tables, see NBS Misc. Publ. 286, Units of Weights and Measures, Price $2.25, SD Catalog No. C13.10:286.

Approximate Conversions from Metric Measures

Symbol	When You Know	Multiply by	To Find	Symbol
		LENGTH		
mm	millimeters	0.04	inches	in
cm	centimeters	0.4	inches	in
m	meters	3.3	feet	ft
m	meters	1.1	yards	yd
km	kilometers	0.6	miles	mi
		AREA		
cm^2	square centimeters	0.16	square inches	in^2
m^2	square meters	1.2	square yards	yd^2
km^2	square kilometers	0.4	square miles	mi^2
ha	hectares (10,000 m^2)	2.5	acres	
		MASS (weight)		
g	grams	0.035	ounces	oz
kg	kilograms	2.2	pounds	lb
t	tonnes (1000 kg)	1.1	short tons	
		VOLUME		
ml	milliliters	0.03	fluid ounces	fl oz
l	liters	2.1	pints	pt
l	liters	1.06	quarts	qt
l	liters	0.26	gallons	gal
m^3	cubic meters	35	cubic feet	ft^3
m^3	cubic meters	1.3	cubic yards	yd^3
		TEMPERATURE (exact)		
°C	Celsius temperature	9/5 (then add 32)	Fahrenheit temperature	°F