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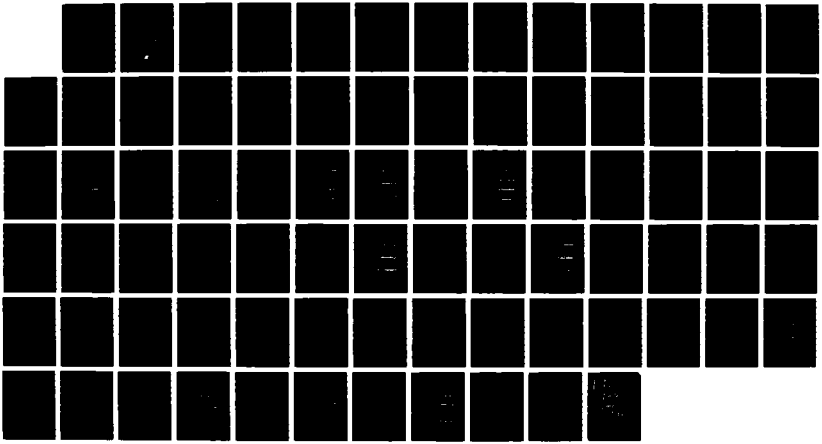

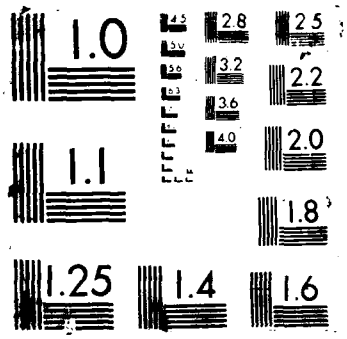
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Alcohol in Fatal Recreational Boating Accidents

AD-A195 864

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Transportation Systems Center
Cambridge, MA 02142

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Final Report

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16. Abstract

Data on the blood alcohol concentration (BAC) of fatal recreational boating accident victims were assembled for four states with reasonably good reporting on BAC between 1980 and 1985. In all there were data on BAC for 370 dead boaters. Of these victims, roughly 30 percent had BACs above 0.10 percent, which is considered intoxicated on the highways. Another 20 percent had BACs between 0.04 and 0.10 percent, which indicates some alcohol-induced impairment. Elevated BACs were found to be significantly associated with accidents on Friday or Saturday night, males, two or more persons on the boat, and calm water conditions.

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PREFACE

Alcohol has been suspected as a major contributor to boating accidents for many years. In this study, reliable data on the blood alcohol concentrations of fatal boating accidents victims has been assembled and analyzed for the first time.

The work was performed by the US Department of Transportation, Research and Special Programs Administration, Transportation Systems Center, Cambridge, Massachusetts under the sponsorship of the US Department of Transportation, US Coast Guard, Office of Boating, Public and Consumer Affairs, Washington,D.C.

The authors are grateful to Dr. Jerome Boden and Dr. Donald Sussman for their careful reviews of the report and helpful suggestions for improvements, to Ms. Barbara Gray for providing the US Coast Guard's data on fatal boating accidents, and to Dr. John Gardenier, Lt. William Cairns, and Lt. John Smith for assistance in getting the project underway.

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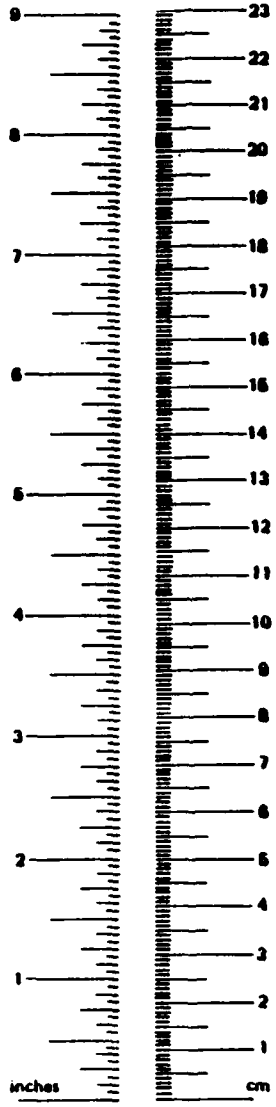
METRIC CONVERSION FACTORS

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 cm (exactly). For other exact conversions and more detail tables see NBS Misc. Publ. 286, Units of Weight 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

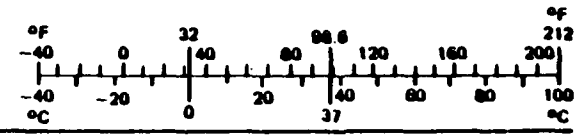


TABLE OF CONTENTS

Section		Page
EXECUTIVE SUMMARY		E-1
1.0	BACKGROUND AND OBJECTIVE	1
1.1	Background	1
1.2	Objectives	2
2.0	DESCRIPTION OF THE DATA	4
2.1	Sources of Data	4
2.2	Individuals Covered	4
2.3	Selection of States	5
2.4	Victims With Unknown BAC	6
2.5	Description of Data and Comparision to U.S.	10
3.0	ALCOHOL AND BOATING FATALITIES	15
3.1	Circumstances Where Alcohol is Over-Involved	15
3.2	Interdependence Among the Factors	26
3.3	Conclusions	31
4.0	ALCOHOL AS A CAUSE OF FATAL ACCIDENTS	33
4.1	The Effects of Alcohol	33
4.2	Accident Description	35
4.3	Conclusions	43
5.0	SUMMARY AND CONCLUSIONS	46
REFERENCES		49
Appendix A:	Information on the TRB Workshop Objectives	51
Appendix B:	Contacts Providing BAC Information	56
Appendix C:	Attributes of Boating Accidents Not Found To Be Significantly Associated With BAC	57

LIST OF TABLES AND FIGURES

		Page
Table 2.1:	Blood Alcohol Concentration in Boating Accident Victims	6
Table 2.2:	Reasons for Unreported BAC in North Carolina and California Boating Fatalities, 1985	8
Table 2.3:	Information Available in the Merged BAR - Victims Data Base	11
Table 3.1:	Attributes of Boating Accidents Not Significantly Associated with Alcohol	17
Table 3.2:	Models of Three-Dimensional Tables	30
Table 4.1:	Availability and Use of Coast Guard Approved Life Saving Devices	45
Figure 2.1:	BAC Levels in Dead Boaters	12
Figure 2.2:	Comparison of Four States to Total U.S. Percent of Fatalities by Accident Type	13
Figure 2.3:	Comparison of Four States to Total U.S. Percent of Fatalities by Accident Cause	14
Figure 3.1:	Distribution of BAC by Victim Role and Sex Percent of Fatalities Within Category	18
Figure 3.2:	Distribution of BAC by Victim Age Percent of Fatalities Within Age Categories	20
Figure 3.3:	Distribution of BAC by Day/Time of Accident Percent of Fatalities Within Category	22
Figure 3.4:	Distribution of BAC by Water Conditions Percent of Fatalities Within Conditions Category	23
Figure 3.5:	Distribution of BAC by Persons on Board Percent of Fatalities Within Category	25
Figure 4.1:	Distribution of BAC by Accident Type Percent of Fatalities Within a Type Category	37
Figure 4.2:	Distribution of BAC by Accident Cause Percent of Fatalities Within a Cause Category	40

EXECUTIVE SUMMARY

This report documents available information on the involvement of alcohol in fatal recreational boating accidents. The data on the blood alcohol concentration (BAC) of boaters who died in recreational boating accidents was obtained from the U.S. Coast Guard and from state sources. Additional information on the boat and the boating environment at the time of the accident came from the Coast Guard's computerized Boating Accident Report.

Data were limited to states and years where a high proportion of the victims had BAC information available to reduce the likelihood of selection bias in reporting BAC. BAC information on victims under 15 years old was seldom available so these victims have been eliminated from the study. Four states were judged to have data of adequate quality: California, 1984 and 1985; North Carolina, 1980 to 1985; Maryland, 1984 and 1985; and New Jersey, 1985. Examination of the reasons for non-reporting in 1985 for California and North Carolina showed no obvious bias. Further examination of the distribution of victims with unknown BAC over variables found to be associated with high and low BACs revealed no statistically significant association. So, there appears to be no reason to believe that the data on BAC of the victims with known BAC differs from the data on the victims with unknown BAC.

There were 370 boating fatalities where the victim is over 15 years old in the years and states identified above. Blood alcohol information was available for 75 percent of these victims. Thirty percent of the victims with known BAC had a BAC at or above 0.10%, a level which is considered intoxicated on the highway. Another 21 percent of the victims with known BAC had a BAC above 0.04% and below 0.10%,

levels indicating some alcohol induced impairment. The remaining 49 percent had either no alcohol in their blood (40%) or very low levels of alcohol (9%).

The proportion of victims at the highest BAC levels ($\geq$ .10%) was highest on Friday and Saturday night (6:00 pm to 5:00 am) and in calm water conditions. This suggests that enforcement would be most beneficial during these times and conditions.

Females are rarely fatal boating accident victims and are less likely to be drinking than males. The proportion of victims at high BACs increases with age until about 50 years old where it falls substantially. Finally, drinking is more prevalent when there are two or more persons on board the boat when the accident occurred. These observations suggest that safety education campaigns warning of the dangers of boating while intoxicated should be focused on young to middle-age males in parties of two or more.

In an attempt to get an indication of how alcohol might be involved as a cause of the boating fatalities, the type of accident with the highest proportion of victims who were in the high BAC category was identified. Almost 40 percent of the fatal fall overboard accidents involve high BACs in the victims. The known effects of alcohol on balance and coordination make it seem likely that the high BACs contributed to these accidents. Further examination of these fall overboard accidents showed that the sober victims were more likely to be the only person on the boat, so no help was available, while the high BAC victims were likely to have others on the boat who were also drinking, and perhaps because of alcohol impairment, unable to rescue the victim. Here again the known effects of alcohol on coordination make it seem likely that the alcohol contributed to the fatal accident.

While it seems reasonable to assume that high levels of BAC contribute, perhaps with other events, to cause many types of boating accidents, the observations above do not establish this role. In order to estimate the increased risk of fatal boating accident which is associated with elevated BACs, the proportion of boaters not involved in accidents who are at elevated BACs must be known. This information will be sought in a continuation of the study which developed this report.

ALCOHOL IN FATAL RECREATIONAL BOATING ACCIDENTS

1.0 BACKGROUND AND OBJECTIVE

The objective of this report is to summarize the information TSC has prepared on the blood alcohol concentrations (BAC) of victims of fatal recreational boating accidents. The study is sponsored by the United States Coast Guard.

1.1 Background

In order to investigate the role of alcohol in recreational boating safety, the Coast Guard contracted with the Transportation Research Board of the National Research Council to develop a priority ordered list of research topics in the area of alcohol in recreational boating. This list is documented in the TRB report "Workshop on Alcohol-Related Accidents in Recreational Boating". The Coast Guard selected three high priority projects which best served their boating safety objectives. They were:

- Assessment of the appropriateness of non-chemical tests of intoxication in the boating environment;

- The development of remote detection cues for alcohol intoxication in recreational boat operators; and

- An assessment of the increased risk associated with alcohol intoxication in fatal recreational boating accidents.

This study is a part of the third project. Two pieces of information are needed to assess the risk associated with a given blood alcohol concentration: (1) the proportion of accident victims at the BAC level; and (2) the proportion of the boating public at the same level. This study presents the information assembled on the BACs of fatal boating accident victims .[1] The data collection necessary to obtain the proportion of boaters at various BAC levels, the second piece of information, is planned to begin later.

1.2 Objectives

The overall objective of this report is to summarize the available data on the presence and extent of alcohol intoxication in fatal recreational boating accidents. This information has two potential uses. It could be used to target boating enforcement activities to circumstances where fatal boating accidents are most likely to involve alcohol. It can be used to target educational materials, media and safety training, toward those boaters most likely to be involved in fatal alcohol involved boating accidents. Chapter 3 of this report presents the information on BAC and how it varies with the circumstances of the accident and the characteristics of the boaters and the boat.

The other perspective on this BAC information is to develop a better understanding of how alcohol intoxication contributes to recreational boating accidents. Chapter 4

[1]The TRB report identified nine questions that could be answered with the information from these two parts of the study. The best answers available from the information of the first part, on the BACs of dead boaters, is presented in Appendix A.

considers this perspective by examining the types of accidents most commonly associated with elevated BAC and considering the changes of human functioning associated with elevated BAC and how these changes could have led to the accident.

2.0 DESCRIPTION OF THE DATA

2.1 Sources of Data

The data used in this study came from the Coast Guard's Boating Accident Reports. Some of the data are computerized by the Coast Guard. The computerized data describe the accident, boat, and operator but not the victim. Other data were coded by TSC from the accident reports provided to TSC by the Coast Guard and from additional information on blood alcohol concentration of victims provided directly by the states.

TSC identified states that collect information on BAC by calling state boating law administrators in states with annual boating fatality counts of more than ten. Accident reports on file at the Coast Guard were requested for the states which reported collecting BAC for a large proportion of the fatal victims. These reports were provided by the Coast Guard on microfiche. In most cases, the Coast Guard accident data did not contain as complete information on BAC as was available from the states. The states provided additional compilations of data that TSC used to augment the data provided directly by the Coast Guard.

2.2 Individuals Covered

Only fatal accident data was used because almost all fatal accidents are reported. Data on the BAC of fatal boating accident victims was collected because it was much more commonly available than data on the operators. Conceptually, passenger intoxication can have a very significant influence on the fatal accident risk in

boating because passengers can cause boating accidents, unlike automobiles or general aviation where only operators are likely to cause accidents.

2.3 Selection of States

Only four states, California, Maryland, New Jersey, and North Carolina, had data on the BAC of more than 50 percent of the boating accident victims.[2] States with BAC data for less than 50 percent of the fatalities were excluded from the study because testing in these states is very likely to be selective and, therefore, biased. Testing is more likely to be done on victims suspected of being under the influence of alcohol resulting in a distortion of the proportion of the fatalities at high BAC levels. Victims under 15 years old have been excluded from this study because few are tested and even fewer have BACs above 0.0.

Table 2.1 presents the distribution of BAC for victims over 15 years old for each of the four states and years with reliable BAC data. North Carolina data from 1980 to 1985 represents 136 boating victims where the blood alcohol concentration is known. California data from 1984 and 1985 contains 93 boating victims where the BAC is known. Maryland data from 1984 and 1985 contains 35 boating victims where BAC is known. New Jersey data from 1985 has only 14 cases with known BAC.

BAC information is available for about 75 percent of all recreational boating accident victims in these states in the years noted. Notice that at least 30 percent of the victims in the full sample of 370 had no alcohol in their blood. (This would be

[2]Appendix B lists the people in each of the four states who helped TSC obtain the information on the BAC of the boating accident victims.

exactly 30 percent only in the unlikely event that all those with unknown BAC had some alcohol in their blood.) At least 23 percent had BACs in the 0.0 to .10 range and at least 22 percent have BACs exceeding .10.

Table 2.1: Blood Alcohol Concentration In Boating Accident Victims

	BAC CATEGORY (% OF KNOWN)				TOTAL (% OF TOTAL)		
	ZERO (%)	0-.04 (%)	.04-.10 (%)	≥.10 (%)	KNOWN	UN-KNOWN	TOTAL
CALIFORNIA	47 (51)	9 (9.7)	18 (19)	19 (20)	93 (68)	43 (32)	136
MARYLAND	6 (17)	6 (17.0)	13 (37)	10 (29)	35 (94)	2 (5.4)	37
N.CAROLINA	56 (41)	9 (6.6)	25 (18)	46 (34)	136 (76)	42 (24)	178
NEW JERSEY	2 (14)	1 (7.1)	3 (21)	8 (57)	14 (74)	5 (26)	19
TOTAL	111 (40)	25 (9)	59 (21)	83 (30)	278 (75)	92 (25)	370

If only those with known BAC are considered, about 40 percent had no alcohol, 30 percent were in the 0.0 to .10 range and 30 percent had BACs at .10 and above. If there were no bias in the selection of those dead boaters who were not tested for BAC, this last set of percentages would be the best estimates of the proportions in each BAC category.

2.4 Victims With Unknown BAC

Twenty-five percent of the recreational boating fatalities in the sample do not have a recorded BAC. If the proportion of high BAC fatalities which are unreported is

not the same as the proportion where the BAC is reported, the sample used in this study is biased and would not yield reliable results. The most serious bias in the sample would result if those selected for testing were selected because they were suspected of drinking. This would result in a substantial difference between those victims tested and those not tested for BAC. To assess the likelihood of this type of selection bias, all of the victims with unreported BACs in North Carolina and California in 1985 were studied further to establish the reasons that the BACs were unreported. The reasons were then examined for indications of bias.

These two states were selected for this examination because they maintain extensive accident records. By using the most recent year available it was more likely that the reporting officer would remember the case. Twenty five cases where no BAC was recorded were found in the two states in 1985. These cases were analyzed using accident report narratives and telephone calls to investigating officers and government officials.

Table 2.2 shows the reasons the BACs were unreported. The predominant reason for an unreported BAC is that the body was not found. The body was not recovered in almost half, 44 percent, of the fatalities without BACs. It does not seem likely that alcohol intoxication would itself influence whether or not the body is found given that the fatality occurred.[3] So, there is no reason to believe that these fatalities without a reported BAC have a different BAC distribution from those which are reported.

[3] Alcohol intoxication may be associated with the circumstances of the accident which is in turn associated with the probability that the body is recovered. The association of alcohol with the circumstances of the accidents is examined in Chapter 3. The association of alcohol testing with the circumstances of the accident is also examined in Chapter 3.

Table 2.2: Reasons for Unreported BAC in

North Carolina and California Boating Fatalities, 1985

Reasons for BAC Unknown	North Carolina	California	Total (%)
Missing body	3	8	11 (44)
Late recovery of body (after 3 days)	3	2	5 (20)
No apparent reason	2	7	9 (36)
Total	8	17	25 (100%)

The second reason for non-reporting is late recovery of the body. Reliable measurements of the BAC at the time of the accident is very difficult for bodies recovered long after the accident. Bacteria growth generates alcohol in the blood as part of the decomposition process so that the decomposed body often has a higher BAC than actually existed at the time of the accident. As with unrecovered bodies, alcohol intoxication does not seem likely to influence late recovery of the body of an accident victim.

In the remaining 36 percent of the fatalities with unreported BAC, no specific reason has been identified. Local and state officials suggested many possible reasons:

- In a few cases (at least two of the remaining nine in this sample) the lack of BAC data could be due to processing errors; the blood sample or the report of the results of the test is mislaid at some point in the process between the test and recording;

- The coroner may declare a boating fatality an accidental death and fail to request a BAC test (increasingly less common). The jurisdiction to which the victim belongs or where the accident occurs can affect the availability of the test results since a military fatality or accident on a military installation is subject to military procedures which may not parallel civilian requirements;

- Fatalities occurring during the summer may be investigated by inexperienced, seasonal law enforcement officials who are unaware of the requirement to request a BAC test. In multi-victim accidents involving death and injury, the immediate pressures to aid the victims may cause the investigating officer to overlook the requirement to request a BAC test on the fatalities; and

- Finally, a BAC test will not be performed when a fatality follows hospital admission.

This varied list of possible reasons for not reporting BAC probably accounts for most of the remaining nine cases. Some of these reasons could be related to the level of intoxication of the victim, while others are probably not related to intoxication. Overall, the fatalities without reported BAC appear to have been drawn from the sample of all recreational boating fatalities in 1985 in California and North Carolina without explicit consideration of the extent of intoxication. Some bias may exist in the nine cases where there was no apparent reason for not reporting the BAC, and some bias may exist because alcohol intoxication is indirectly associated with another factor which affects whether or not the victim is tested for BAC. In the following

two chapters, the distribution of the fatalities without a reported BAC with respect to other factors which might be associated with intoxication is examined in a further attempt to assess the extent of bias in the BACs of victims without a reported BAC.

2.5 Description of Data and Comparison to U.S.

Figure 2.1 shows the frequency distribution of BAC for those victims with BACs above zero for the four states in the sample. Also shown on the figure are three of the four categories of BAC that will be used in the analysis that follows in Chapters 3 and 4. (Those with BAC = 0 are the fourth category.)

In addition to the victim's BAC, the victim's age and sex and whether or not the victim was the operator were coded from the Boating Accident Report form. The state, date and time of the accident and the accident number were also recorded so that the victim data could be linked to the Coast Guard's computerized Boating Accident Reports (BAR). Once linked, a rich set of information on the accident and the victim were available for analysis. Table 2.3 presents the list of variables available in the merged file.

In order to determine whether the data from these four states and years are representative of the data from the United States, the four states' data (including those with unknown BAC) were compared to the data from the Coast Guard's Boating Statistics, 1984. The predominant types and causes of accidents are examined. Figure 2.2 compares the proportion of fatalities in the leading accident types. The data from the four states are very similar to those from the full U.S. Figure 2.3 shows the proportion of fatalities by the leading causes of the accidents. Again, the

major cause in the U.S., environment (strong current, rough water, and weather) is the major cause in the four state sample and the causes in the U.S. appear to be very similar to those in the four states. While this brief analysis is not conclusive, it suggests that the data from the four states which have good reporting of BAC information are similar to data from the full U.S.

Table 2.3: Information Available in the Merged BAR - Victims Database

VICTIM AGE	TYPE OF BOAT
VICTIM SEX	HULL MATERIAL
OPERATOR/PASSENGER	PROPULSION
BLOOD ALCOHOL CONCENTRATION	HORSEPOWER
VISIBILITY	RENT/OWN
STATE	YEAR BUILT
DATE	LENGTH
TIME	WATER TEMPERATURE
OPERATOR AGE	PFD USE AND AVAILABILITY
TYPE OF BODY OF WATER	OPERATOR EXPERIENCE
WATER CONDITIONS	PERSONS ON BOARD
WIND	OPERATOR INSTRUCTION
ACCIDENT TYPE	ACCIDENT DESCRIPTION
	ACCIDENT CAUSE

Fig.2.1: BAC Levels in Dead Boaters

Data Limited to BAC's above Zero

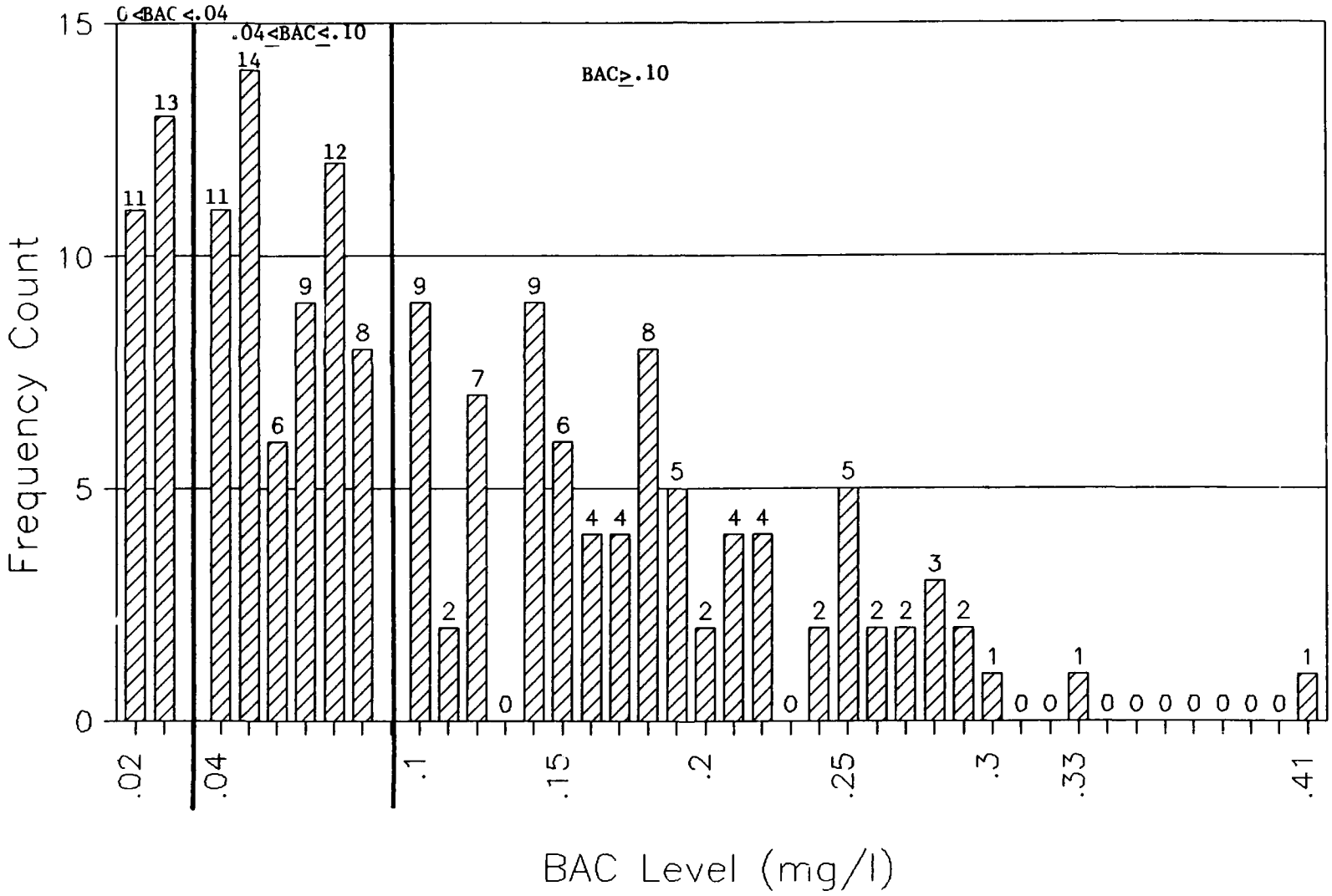


Fig.2.2: Comparison of Four States to Total US

Percent of Fatalities by Accident Type

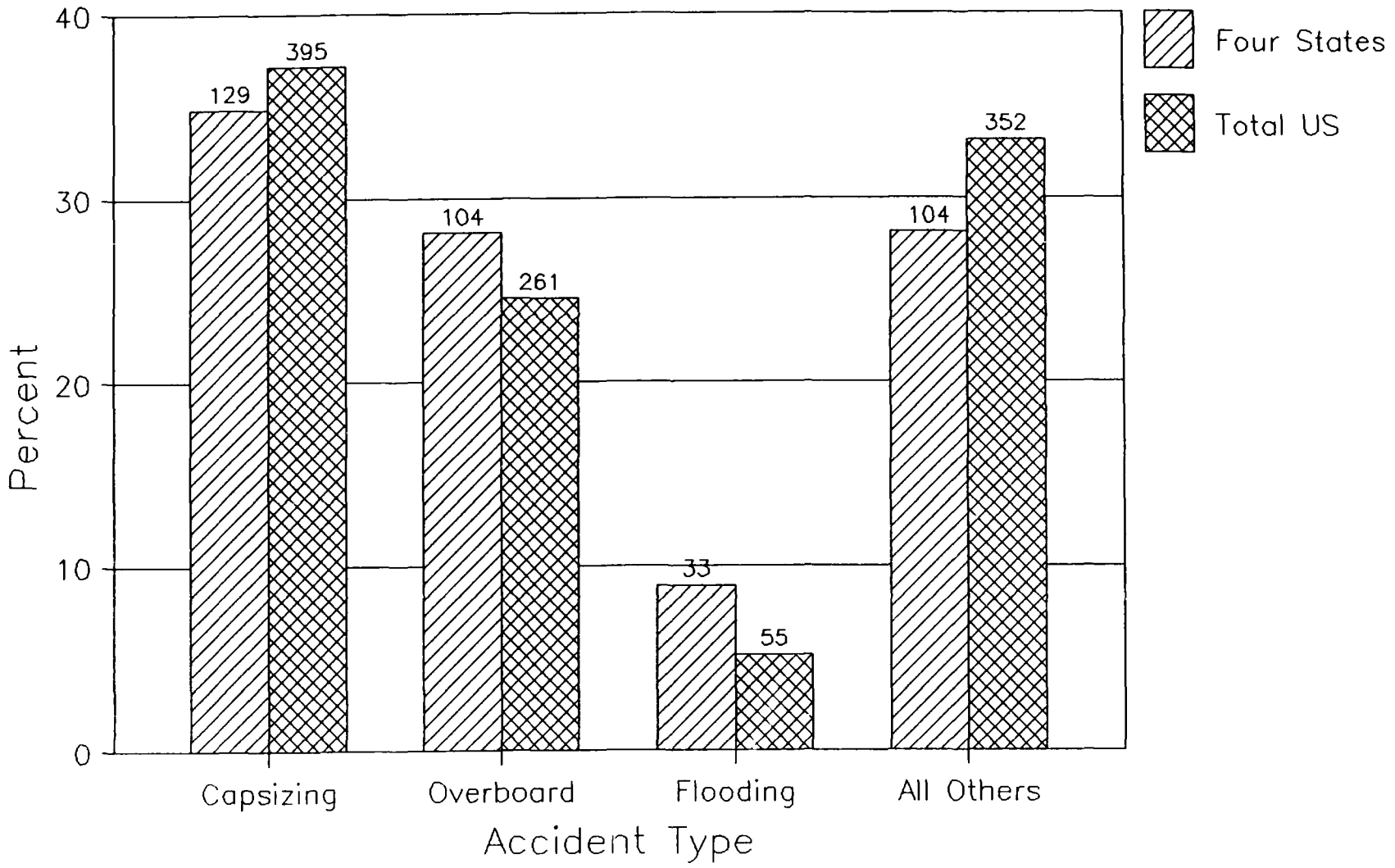
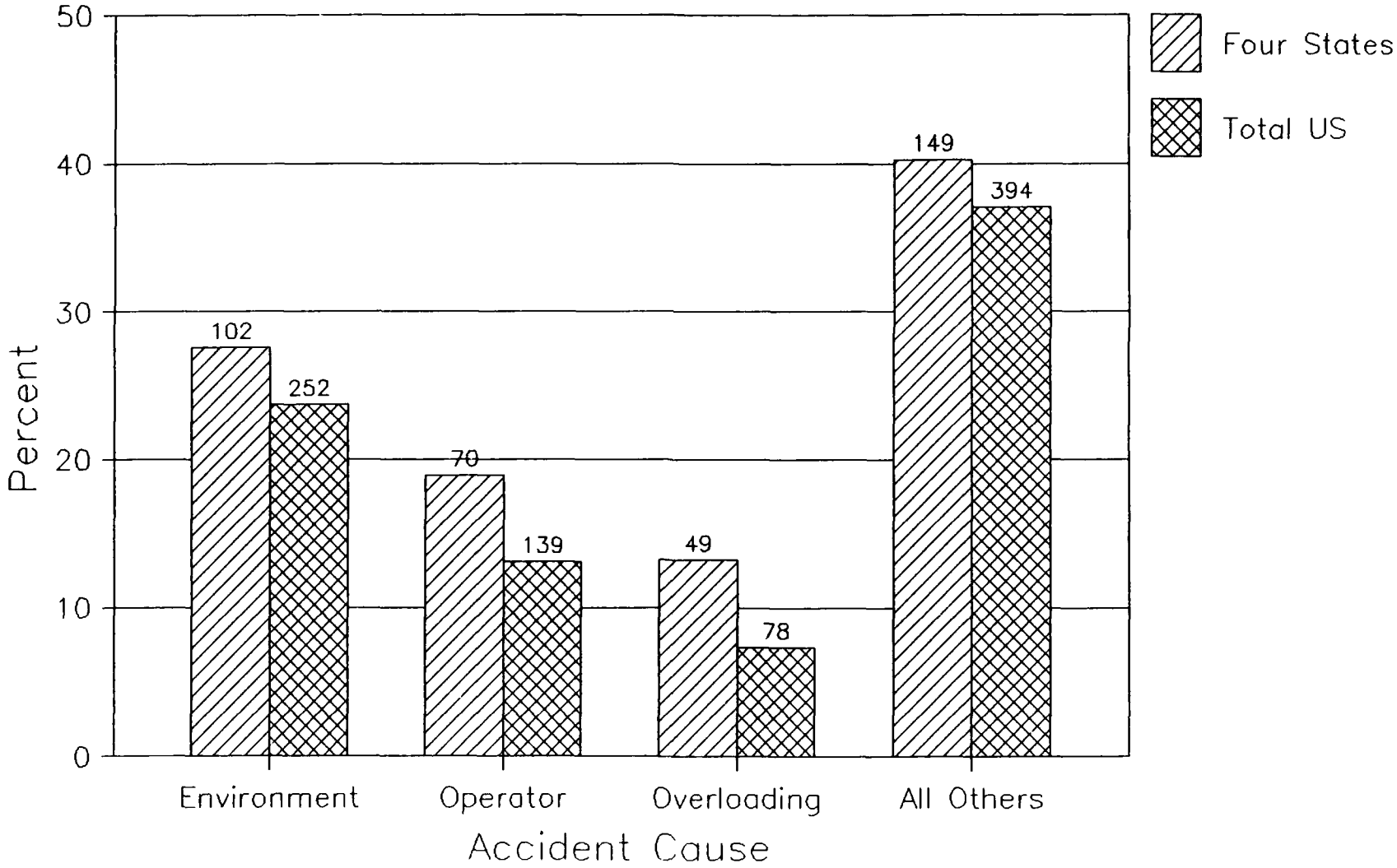


Fig.2.3: Comparison of Four States to Total US

Percent of Fatalities by Accident Cause



3.0 ALCOHOL AND BOATING FATALITIES

In this chapter, characteristics of boats, environment, and boaters are examined to determine which types of boating fatalities are associated with intoxication. This information might be useful to boating enforcement officers in focusing their activities on times and circumstances where elevated levels of alcohol have been found in the victims of fatal accidents. The information might also be useful in targeting alcohol and boating safety media campaigns more effectively.

It is important to understand the limits of the analysis. The analysis identifies association between BAC levels in the dead boaters and other characteristics of the boaters, boats and boating environment. Alcohol may or may not influence the probability that an accident will occur. The increased incidence of elevated BACs in dead boaters could be either because all boaters (those involved in accidents and those not involved) are more likely to have elevated BACs in the circumstance or because elevated BACs make it more likely that an individual will be involved in a fatal accident. Information on the proportion of living boaters with elevated BACs is needed to separate these two possibilities.

3.1 Circumstances Where Alcohol Is Over-Involved

In this section, those characteristics or circumstances of accidents where elevated BACs are found more or less frequently than average (over all accident victims) are identified. Characteristics which are associated with BAC are identified by estimating the probability (p) that the observed distribution of BACs for each category of the characteristic would have resulted by random chance sampling

variation from the overall distributions of BAC and of the characteristic based on the chi-square distribution. The lower the probability (p) the less likely the observed counts would have resulted from the overall distributions. Probabilities below p=.1 were judged to be significantly associated with BAC.[4] Selected categories of five characteristics were found to be associated with either high or low BACs more frequently than would be expected by the chance sampling variation and the overall distributions of the characteristic and of the BAC:

1. Victim role/sex ,(p=.09);

2. Victim age (p=.02);

3. Time of day/day of week of the accident (p<.01);

4. Water conditions (p=.04); and

5. Number of persons on board (p=.04).

Each of these variables is discussed more fully below along with an assessment of the distribution of victims with unknown BAC. The differences in the proportions of dead boaters at high or low BACs for categories of other attributes (presented in Table 3.1) of the accident could have occurred by chance with a probability (p) greater than .1. These attributes are judged not significantly associated with BAC.

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[4]See Bishop, Fienberg, and Holland, 1975 (pp. 24-31) for a description of the methods.

Graphs of the percentage of each sub-group in each BAC category are presented in Appendix C.

Table 3.1: Attributes of Boating Accidents Not Significantly Associated with Alcohol

SEASON

WATER TEMPERATURE

RENT/OWN

VISIBILITY

FORMAL OPERATOR INSTRUCTION

HORSEPOWER

OPERATOR EXPERIENCE

BOAT LENGTH

MEANS OF PROPULSION

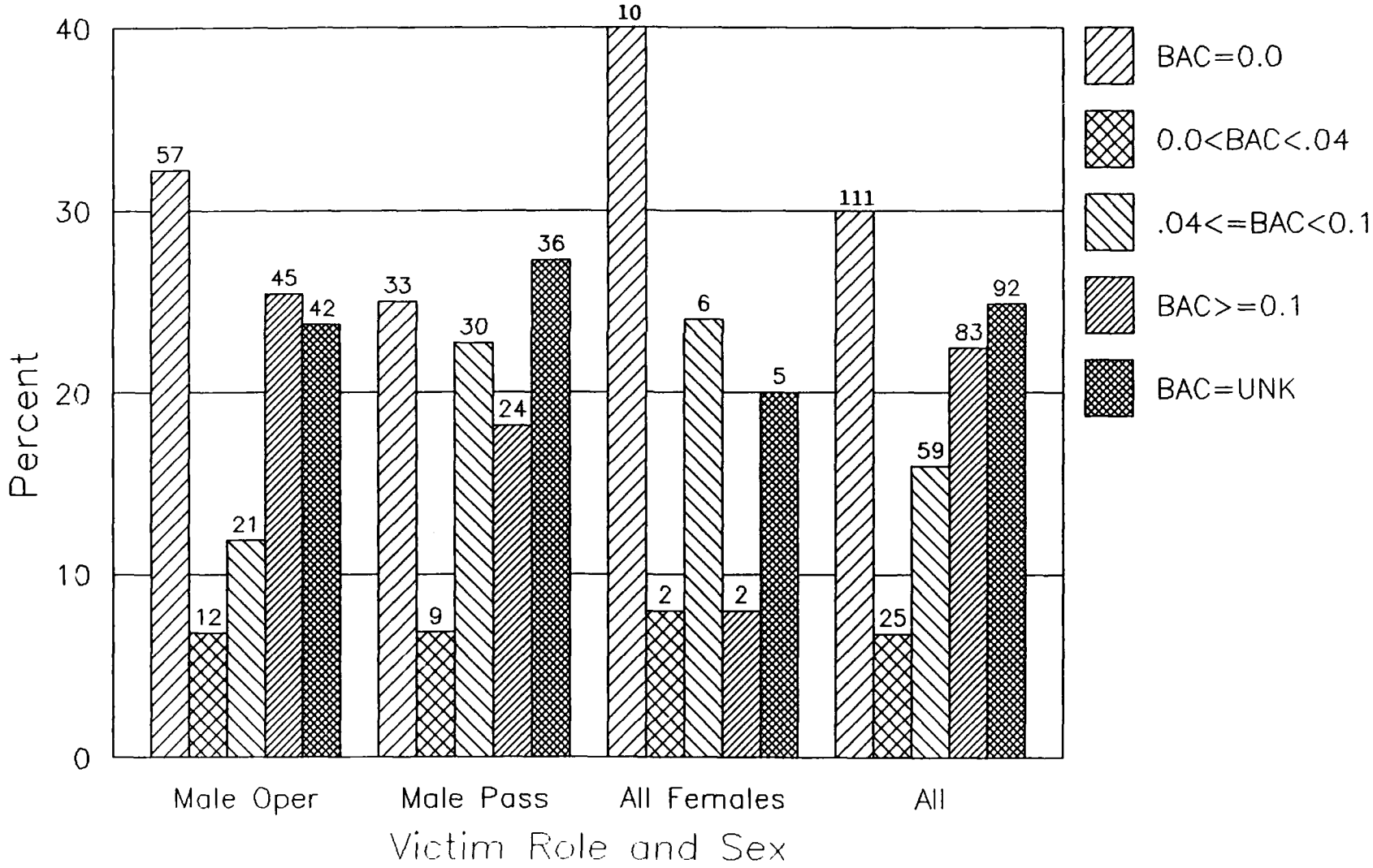
VESSEL AGE

OPERATOR AGE

The proportion of boaters in each of the four BAC categories for each of three victim role and sex categories is shown in Figure 3.1. Recall that the probability was low, p=.09, that the differences among role/sex categories in the proportion of victims at low or elevated BACs was due to chance. Notice that very few females are the victims in fatal boating accidents (count appears above the bar in the graph) and that a larger percentage of females have a BAC of zero than either male passengers or male operators and that a smaller percentage of females have BACs at .10 and above.

Fig.3.1: Distribution of BAC by Victim Role/Sex

Percent of Fatalities within Category



The percentage of dead boaters in each role/sex category who are not tested for blood alcohol are also shown on the graph. If there were no bias in the selection of the untested with respect to role/sex then the percentage would be constant across role/sex categories. While the percentage is not precisely constant, the variation could easily have occurred by chance (p = .89) indicating that the victims not tested for BAC are unlikely to be different from those with known BAC based on role/sex category.[5]

Figure 3.2 presents similar data for four age categories of boaters. Recall that the probability was low, p=.02, that the differences among the age categories in the proportion of victims at elevated or low BACs was due to chance. The percentage of boaters with BACs at or above 0.10 rises from about 10 percent for the 15 to 19 year old group to about 30 percent for the 30 to 49 year old group before declining for the 50 and older group. The percentage not drinking (BAC = 0.0) within each age category starts off at 40 percent for the youngest group then drops to just above 20 percent before increasing back up to about 35 percent for the oldest group.

The differences among the age categories in percent not tested for BAC are small and could easily have happened by chance (p = .44). So, there does not apear to be significant bias attributable to the selection of victims for BAC testing on the basis of age.

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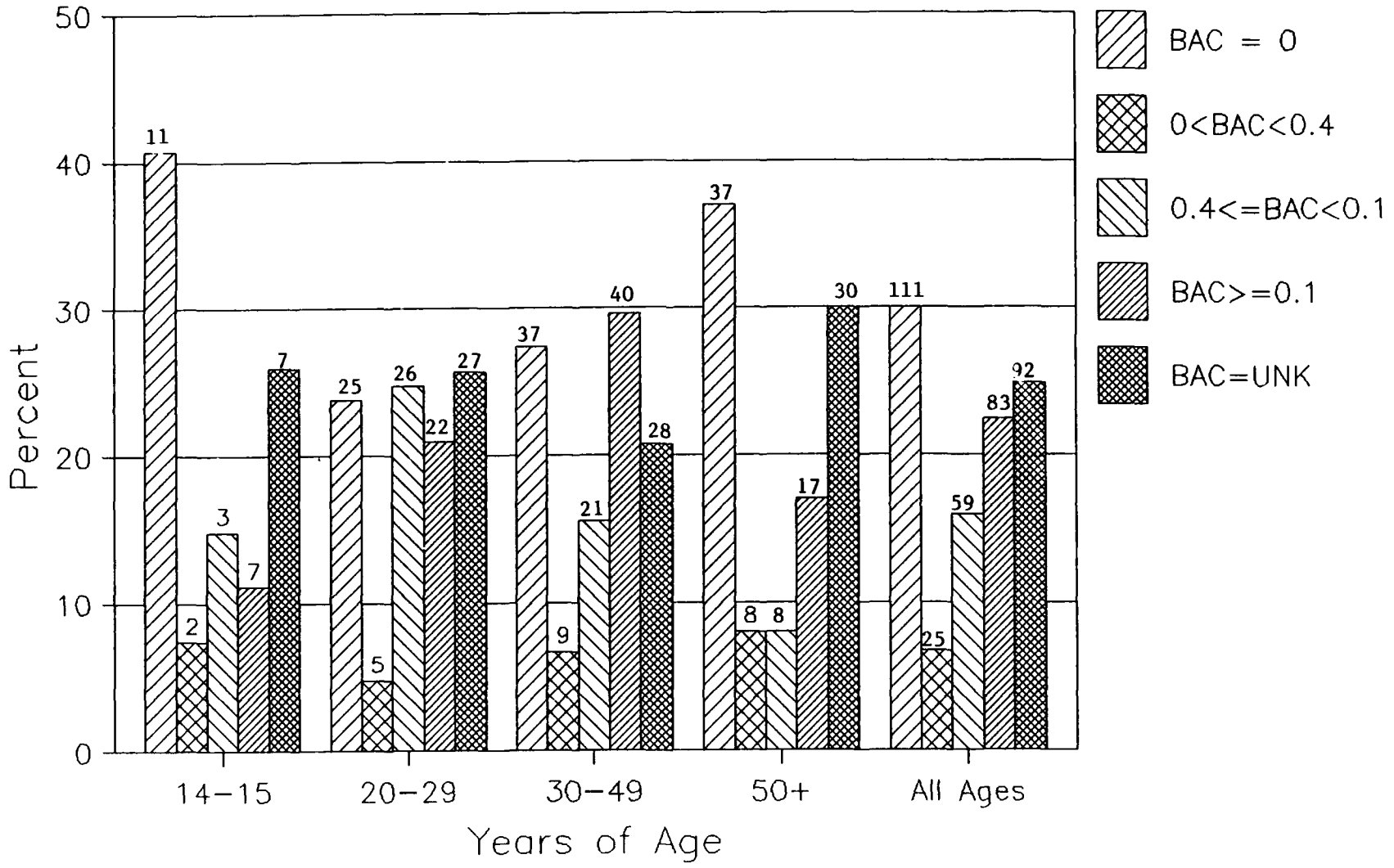
[5]In this situation, when the probability (p) is higher than .1, there is an indication that the difference between the distribution over the characteristic where BAC is known and the distribution over the characteristic where the BAC is unknown could easily have happened by chance and is not significant.

Fig.3.2: Distribution of BAC by Victim Age

Percent of Fatalities within Age Category



The distribution of BAC by time of day/day of week category is shown in Figure 3.3. Recall that the probability was low, $p<.01$, that the differences in BAC among the time of day/day of week categories was due to chance. As expected by analogy to the highway situation, the percentage of dead boaters at the highest BAC levels is much higher on Friday and Saturday night (6:00 pm to 5:00 am) than at other times. The percentage at elevated BAC levels is very similar for week end days and weekdays. The Saturday and Sunday category is 5:00 am to 6:00 pm Saturday and 5:00 am Sunday to midnight Sunday. The weekdays category extends from midnight Sunday to 6:00 pm Friday.

The sum of the victims with unknown BAC across the day/time categories does not total 92 because some victims die in accidents at unknown times. As with the previous two variables, the differences among the time of day/day of week categories in the percent not tested could easily have happened by chance ($p = .70$). So, there is no significant bias in the selection of victims for testing based on the time of day/day of week of the accident.

The probability is low, $p=.04$, that the differences in the proportion of boaters at elevated BACs between the calm and not calm water conditions could have happened by chance. A higher percentage of dead boaters have BACs at or above 0.10 in calm water than in other water conditions as shown in Figure 3.4. Not calm water conditions include choppy, rough, very rough, and strong currents. Since it seems unlikely that intoxicated boaters are safer in not calm water, alcohol use must be less frequent in not calm water conditions. This can only be established by collecting data on BACs of the boating public during calm and not calm water conditions.

Fig.3.3: Distribution of BAC by Day/Time

Percent of Fatalities within Category

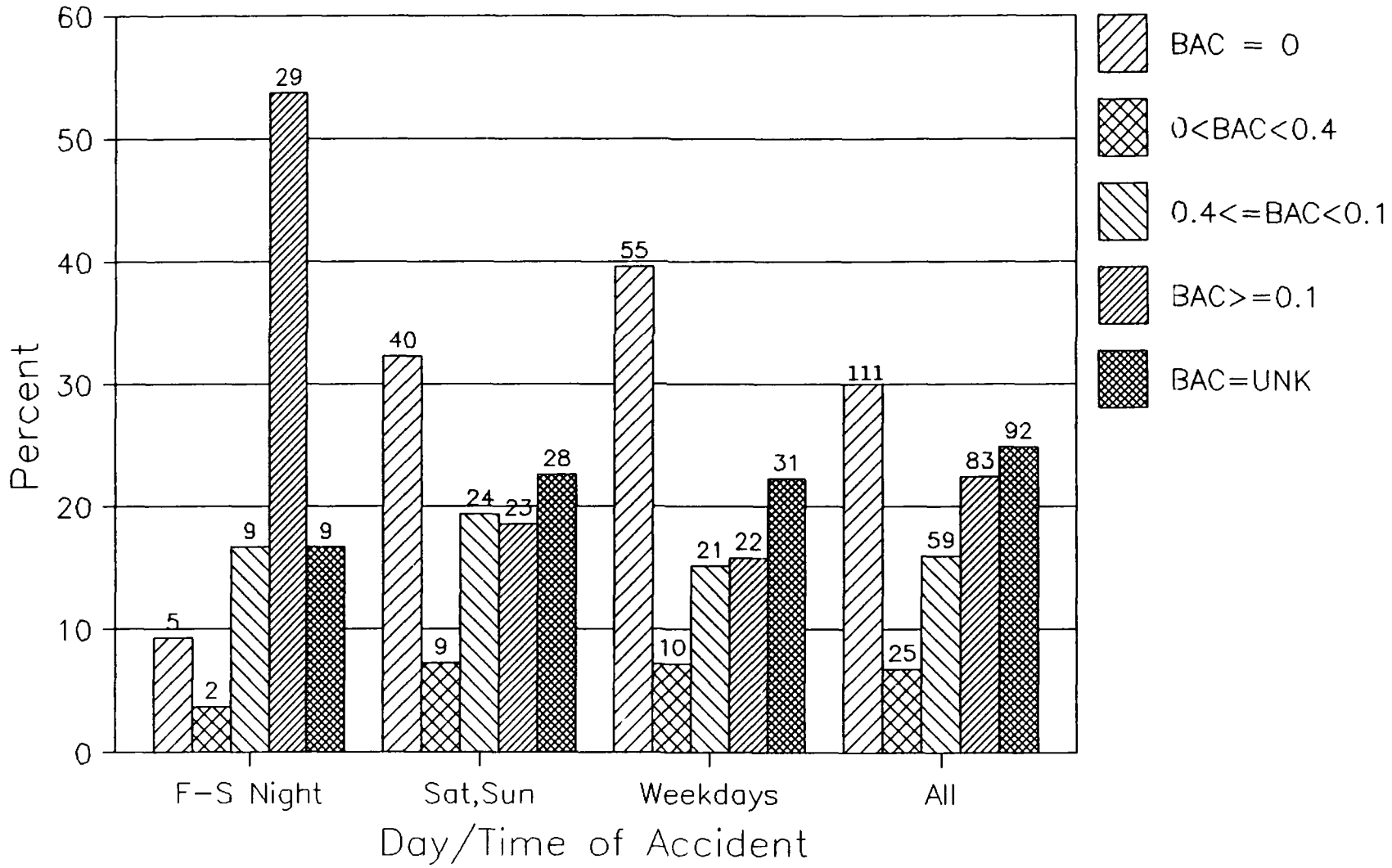
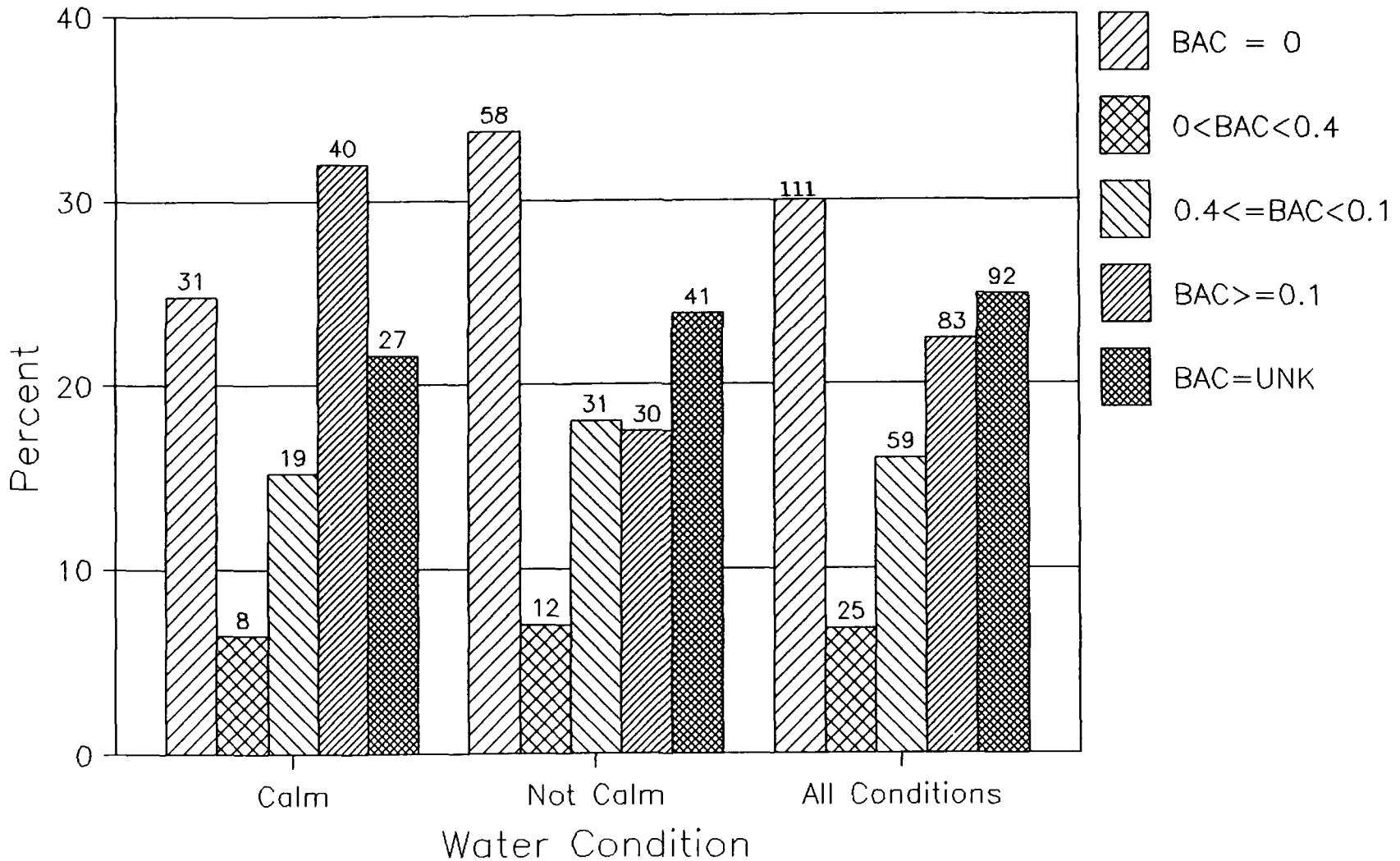


Fig.3.4: Distribution of BAC by Water Conditions

Percent of Fatalities within Conditions Category



Again, the sum of the victims with unknown BAC over the two water condition categories does not total the 92 victims with unknown BAC in the full sample because there are many victims where the water conditions were unknown and the BAC was unknown. Differences in the percent not tested between calm and not calm water conditions are small and could easily have happened by chance ($p = .35$). So there does not appear to be significant bias in the testing with respect to water conditions.

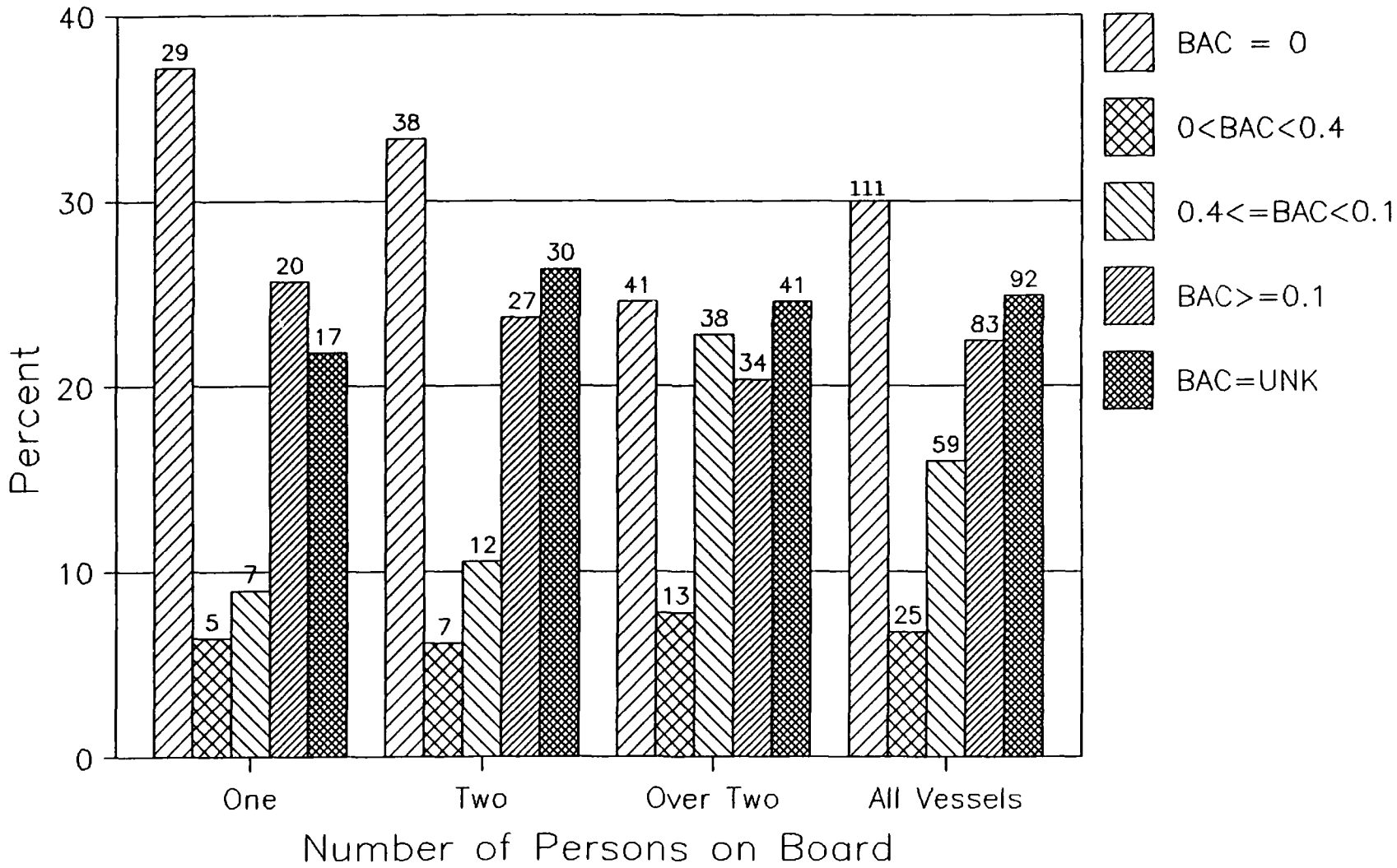
Figure 3.5 shows the percentage of dead boaters in each BAC category stratified by the number of persons on the boat. The probability is low, $p=.04$, that the differences in the proportion in the BAC categories among the persons on board categories was due to chance variation alone. The percentage not drinking (BAC=0) is highest when only one person is on board. This percentage decreases when two persons are on the boat and decreases still further when there are more than two persons on board.

Differences in the percent not tested among the persons on board categories are small and could easily have happened by chance ($p = .79$). So, there does not appear to be a significant bias in the testing with respect to the number of persons on board.

All of the other characteristics of the accidents in Table 3.1 were examined for association with BAC testing. Associations between these characteristics and testing is not a serious indication of bias in the sample, unlike the five characteristics identified above, because these characteristics are not statistically associated with either high or low BAC. So, the association with testing does not indicate either an

Fig.3.5: Distribution of BAC by Persons on Board

Percent of Fatalities within Category



over or an under representation of victims with high BAC among those not tested for BAC. Only three characteristics were associated with whether or not the dead boater was tested for BAC: (1) Season (p=.00); (2) Water temperature (p=.00); and (3) Operator age (p=.03). During fall and winter a boating victim is less likely to be tested for BAC than during spring and summer. When the water temperature is below 50°F the victim is less likely to be tested than when it is above that temperature. Finally, the victim is less likely to be tested when the boat operator is over 50 years old. None of these factors are significantly associated with either high or low BAC levels (i.e. more than would be expected to occur by chance). So there is no reason to expect the sample of dead boaters where the BAC is known to have a different distribution of blood alcohol levels than those victims where the BAC is unknown.

3.2 Interdependence Among the Factors

In the previous section, the analysis of the association of alcohol with other attributes of fatal boating accidents was based on data on 370 boating accident victims. That analysis of association identified five characteristics which were associated with the alcohol categories. It is possible that some of these characteristics are interrelated and that the distribution of BAC in the sample can be understood with fewer characteristics. For example, the analysis above showed that the proportion of victims with BAC $\geq$ .10 was very high on Friday and Saturday night. It also showed that the proportion of victims in this high BAC category was very high in calm water conditions. If the water conditions were almost always calm on Friday and Saturday night, this would explain the high BACs in calm water, or alternatively it would explain the high BACs on Friday and Saturday night. The

point is that the information on both factors provides redundant information about the association of alcohol with other accident characteristics.

This section identifies the most important associations or interactions with the alcohol categories. While the above analysis dealt with two-dimensional tables of BAC category and one other attribute, the analysis in this section deals with BAC category and two other attributes. The other two attributes are limited to combinations of the five identified as interacting with BAC in the analysis above.

As in the section above, the analysis explores whether the observed tabulations of dead boaters could be expected to occur by chance given the distribution of boaters over each category for the aggregate sample. There are two ways that the observed tabulations could happen. One is that the factors affecting the counts in the table are captured by the aggregate distributions used to "model" the table.[6] The other is that there is a large degree of variability in the table cell counts making many alternative counts possible. While the analysis of the three-dimensional tables is performed to identify the factors affecting the observed table cell counts, it is possible that the reason the table could have been generated by the "model" by chance is that the table counts have large sampling error. For this reason, the analysis is used to identify important factors which have a statistically significant interaction with alcohol in boating fatalities. It cannot be used to show that some factors do not interact with alcohol because a larger sample of boating accident victims with a smaller sampling error may show these factors to interact with alcohol also.

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[6]See Bishop, Fienberg and Holland,1976 for a discussion of models of two-, three-, and four- dimensional tables.

Because the three-dimensional tables result in a finer categorization of the data than the two-dimensional tables, many of the categories of the attributes were aggregated to keep the table cell counts as high as possible and the associated sampling error low.

- The BAC category above zero and below .04 was added to the zero category, resulting in three BAC categories: $0.0 \leq BAC < 0.04$, $0.04 \leq BAC < 0.1$, and $BAC \geq 0.1$;

- Friday and Saturday night is distinguished from all other times;

- Victims under 30 are separated from those over 30;

- Males and females are distinguished;

- One person on board is distinguished from more; and

- Water condition distinguishes between calm and not-calm, as before.

Using these new definitions of categories resulted in some changes in the analysis of the two-dimensional tables. The cell counts for tables involving alcohol and two of the other variables could have resulted from the univariate distributions by chance. The table of sex versus alcohol could have resulted from the univariate distributions of alcohol and sex with probability, $p=.19$. The table of persons on board versus alcohol could have occurred from the univariate distributions with probability, $p=.13$. These variables were eliminated from further analysis.

Table 3.2 shows the results of the analysis of the three-dimensional tables. The three possible three-dimensional tables involving alcohol and two of the other three variables are shown in the first column. The most parsimonious model (that is the model with the fewest terms) which reduces the residual, unaccounted cell counts to relatively likely ($p>.1$) chance occurrences is presented in the next column. The notation in this column requires explanation: univariate distributions are represented by the variable abbreviation in additive form (BA+TD+AV in the model for the first table); interactions are represented by the variable in multiplicative form with the variable it interacts with (TD*AV in the model for the first table). The last column in the table is the probability that a residual larger than that observed could have occured by chance.

The first table, alcohol by time/day by victim age requires knowledge of the joint distribution of time/day by victim age as well as the independent distributions of alcohol, time/day, and victim age in order to reduce the residuals to relatively likely chance occurrences. This suggests that victim age distributions vary by time/day. Note that this analysis did not find an interaction between alcohol categories and the other variables even though the other variables were found to interact with alcohol when considered independently. This is probably because the sample was too small to capture these interactions, but may also be because the definitions of the BAC categories and the categories for the other variables have changed.

Table 3.2: Models of Three-Dimensional Tables

Three-Dimensional Table		Parsimonious Models	Probability of a Larger Residual Occuring by Chance
BA X TD X AV		TD*AV + BA+TD+AV	p=.16
BA X WC X TD		WC*TD + BA*WC + BA+WC+TD	p=.62
	or	BA*WC + BA*TD + BA+WC+TD	p=.26
BA X WC X AV		WC*AV + BA+WC+AV	p=.23
	or	BA*WC + BA+WC+AV	p=.09

BA = Blood Alcohol Categories
WC = Water Condition Categories
TD = Time of Day/ Day of Week Categories
AV = Age of Victim Categories

The second table, alcohol by water conditions by time/day, requires knowledge of two joint distributions either time/day by water conditions and blood alcohol by water conditions or alcohol by water condition and alcohol by time/day to reduce the residual cell count to relatively likely chance occurrences. This suggests that blood alcohol levels vary substantially by water conditions and that information on this variation is needed to understand the second three-way table. Additional information is needed to understand this three-dimensional table as well: Either the joint distribution of water conditions by time/day or blood alcohol by time/day.

The third table, alcohol by water conditions by victim age, requires knowledge of the joint distribution of either water conditions by victim age or blood alcohol by water conditions in addition to the independent distributions of the three variables.

All the three-dimensional tables can be understood by knowing the overall, independent distributions of boating victims for the four variables plus the joint

distributions of alcohol by water conditions, alcohol by time/day, water conditions by time/day, victim age by time/day, and victim age by water conditions. Alcohol by victim age is not required. This suggests that further research on alcohol in the boating public should distinguish Friday and Saturday night from other times and calm water from other water conditions. Only with this information on alcohol levels in the boating public will it be possible to distinguish the increased risk of dying in a boating accident from the increased prevalence of alcohol on Friday and Saturday night and in calm water conditions.

3.3 Conclusions

The analysis of the association of BAC testing with characteristics of boats, boaters or circumstances of the accident revealed no significant associations where the characteristics were also associated with either elevated or reduced BAC levels among those tested. So, there is no evidence to suggest that the BAC distribution of the victims whose BACs were not tested differs from the BAC distribution of the victims who were tested.

Without information on the proportion of boaters in the general boating public with elevated BACs, it is not possible to know whether the attributes associated with elevated BACs increase the risk of fatal accident or simply reflect attributes associated with more frequent drinking. However, the information does show the attributes of boaters and situations where people die and have elevated BACs and this information could be used to target segments of boating and/or boaters for increased enforcement or increased media information on the problems of boating and alcohol.

The above information suggests that enforcement of laws prohibiting intoxication would be most effective on Friday and Saturday night, and in calm weather. Boats with two occupants or more in the 30 to 49 age group are more likely to carry individuals at or above .10 BAC. Females are more likely to abstain (BAC=0) than males. These observations suggest that educational material referring to the risks of boating and alcohol should be aimed at males in the 20 to 49 age group who are boating in groups of two or more.

4.0 ALCOHOL AS A CAUSE OF FATAL ACCIDENTS

In this chapter, hypotheses regarding the circumstances surrounding the deaths of sober and intoxicated victims are discussed based on the known effects of alcohol and tested against the available data.

4.1 The Effects of Alcohol

There are many effects of alcohol on human performance, but some are particularly relevant to recreational boating safety. The effects of alcohol on balance are well-known. However, alcohol also has a detrimental effect on hand-eye coordination (Idestrom and Cadenius, 1968) and the ability to make precise positioning movements of the limbs (Maraman, 1970). Alcohol also increases choice reaction time, i.e., it increases the time a person needs to decide which of two responses is correct (Idestrom and Cadenius, 1968). Alcohol may also increase risk-taking behavior (Cohen, Dearnaley and Hansel, 1958). (See Carpenter, 1963 for a survey of studies on the effects of alcohol.) These effects and the effects of exposure to the marine environment can interact to impair performance on complex tasks, sometimes at low blood alcohol concentrations (BACs). In the highway environment, driving skills have been observed to deteriorate at BACs less than .05 (see Carpenter, 1963). It is also known that at any given BAC, experienced drinkers show less impairment than inexperienced drinkers (see Coldwell, et al, 1958). Thus, even at the same BAC, individual differences in performance on the same task may be marked.

In the marine environment other phenomena may interact with the effects of alcohol. According to an aquatic safety expert (see NTSB, 1983) alcohol can magnify the

effects of caloric labyrinthitis. Caloric labyrinthitis is seen when water that is ten degrees or more colder than body temperature enters the ear canal. This can result in disorientation, nausea, or both. In the absence of other cues, such as daylight, an affected swimmer is as likely to swim down as to swim toward the surface. Cold water may also compound the effects of alcohol. For example, alcohol may exacerbate the detrimental effect of cold water on breath holding time. More importantly, the effects of alcohol on physical coordination may add to the effects of cold water on muscle control (peripheral hypothermia) and further impair a swimmer's abilities.

These sensory and motor effects of alcohol lead to specific hypotheses about the differences in the types of accidents that claim the lives of sober and intoxicated boaters. Given the effects of alcohol on balance, intoxicated boaters would be expected to fall overboard more than sober boaters. Furthermore, given the effects of alcohol on physical coordination, intoxicated boaters would be expected to have more difficulty recovering from falling overboard (i.e., swimming to safety or reboarding the boat) than sober boaters. Note that unlike accidents on the highway and in the air, a fall overboard is not a reportable accident unless a drowning or other disaster occurs. Also, intoxication among those who would effect a rescue increases the chances that a fall overboard becomes a drowning. Therefore, it is reasonable to expect that proportionately more intoxicated than sober boaters would die from falling overboard. With respect to the causes of accidents, intoxicated boaters would be expected to be involved in accidents caused by factors that could be alcohol-related, such as inattention or carelessness, more than accidents attributed to external factors, such as bad weather or rough water. Conversely, accidents involving sober boaters would be expected to be attributed to external factors such

as the weather or water conditions than to operator error. These hypotheses are evaluated in the next section.

4.2 Accident Description

Descriptions of boating accidents given on the accident report forms were more likely to be listed as "alcohol or drugs involved" (16 percent of the cases) than any other description. While this fact implicates alcohol as having been a causal factor in these fatalities, it cannot provide a definitive indication of the prevalence of the number of alcohol-related fatalities for three reasons:

- First, there were no objective criteria for the accident description; it was the subjective assessment or "best guess" of the accident investigator.

- Second, an accident description was only given in 39 percent of the fatalities reported; and

- Third, alcohol use was combined with drug use in this category of accident description so that alcohol use alone cannot be factored out;

Thus, the available accident description categories are not very conclusive.

To more accurately assess the role of alcohol in fatal recreational boating accidents, the circumstances of specific accidents and the blood alcohol concentration (BAC) of the victims were examined. While the data from victims at all levels of BAC were examined, the data from the two extreme categories--BAC equal to zero and BAC

equal to or greater than .10--were used to provide more focus. "Sober" victims were defined as those having no alcohol in their bloodstream (BAC equal to zero). "Intoxicated" victims were defined as those with a BAC equal to or greater than .10. These levels of BAC were chosen because they are clear indications of sobriety and intoxication. Intermediate values of BAC are not as useful, given the individual differences in the effects of alcohol on performance. Furthermore, while the BAC of the operator is the key to a complete understanding the circumstances of the accident when the accident is attributed to operator error (e.g., carelessness) and important under any circumstance, most of this data is currently unavailable because the operator is not tested for BAC unless he or she is also a victim.

The classifications of accident "type" (e.g., capsizing, grounding, collision, etc.) and "cause" (e.g., rough water, operator inattention, etc.) are indicators of the circumstances of the accidents which are available in the database.[7] Information on accident type is more reliable than information on accident cause because the cause of an accident is usually the subject of speculation. Where "type" asks what happened in a "check one" format on the accident report form, "cause" asks why it happened and is listed as "what, in your opinion, caused the accident to happen" on the form.

Figure 4.1 shows the distribution of BAC by accident type. Note that victims with an unknown BAC constituted 25 percent of the sample. These victims were distributed evenly across the two accident types discussed below as would be expected if there was no bias in the data. That is, since unknowns constitute 25

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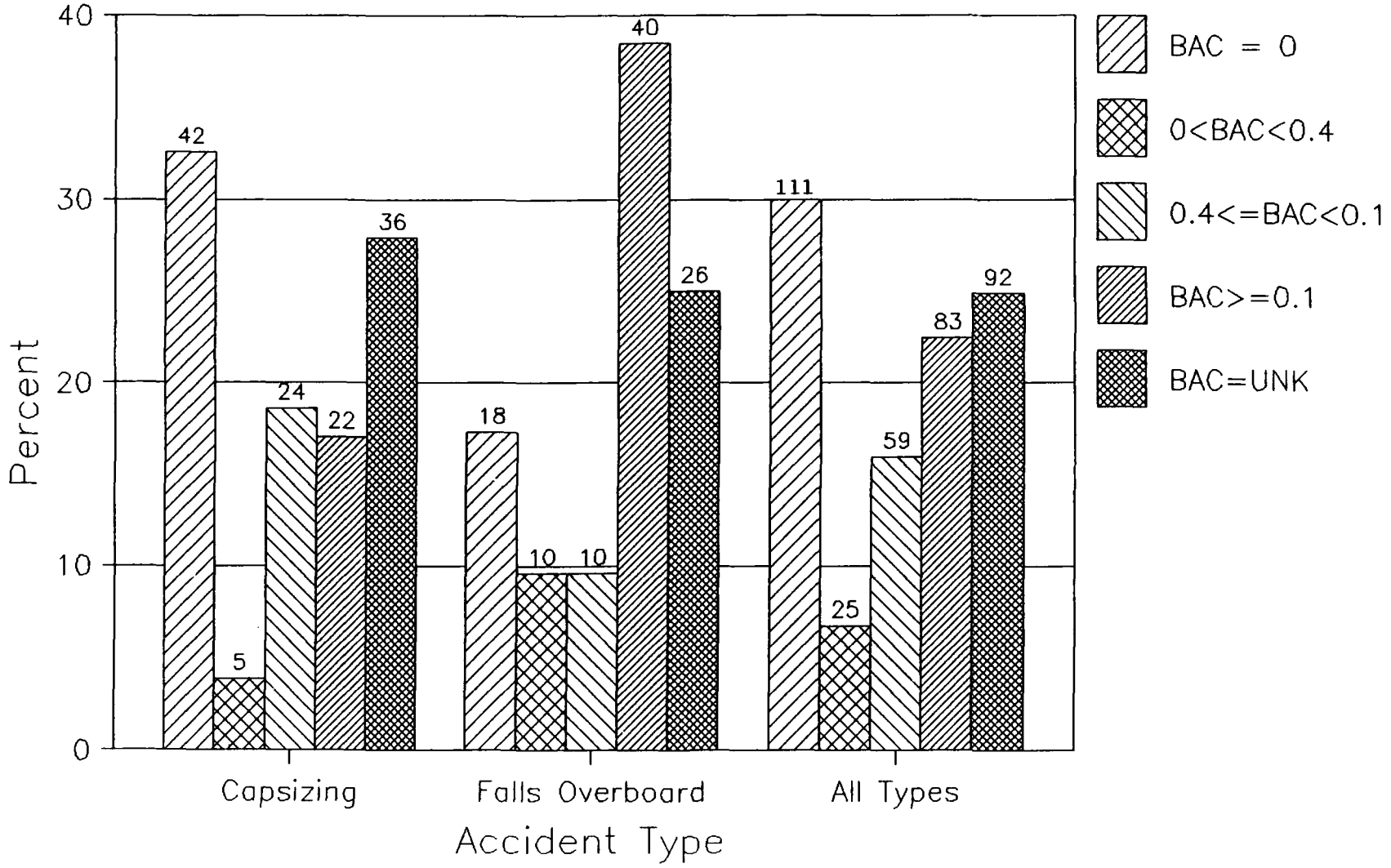
[7]Most of the accident types and some of the accident causes are defined in the glossary of the Coast Guard's annual report entitled Boating Statistics.

Fig.4.1: Distribution of BAC by Accident Type

Percent of Fatalities within Type Category



percent of the total sample, this group would be expected to constitute approximately 25 percent of each accident type, unless the probability of testing the BAC was related to accident type.

As can be seen in Figure 4.1, proportionately more sober victims (i.e., those with a BAC equal to zero) were involved in a capsizing accident than were victims with a high BAC (equal to or greater than .10). In fact, sober victims more frequently died from capsizing accidents than from any other type of accident. On the other hand, victims with a high BAC were more likely to die from falling overboard than from any other type of accident[8]. Proportionately more victims with a high BAC died from falling overboard than did sober victims. The number of fatalities from falling overboard was significantly higher for victims with a high BAC (47% of all victims with a high BAC) than for sober victims (16% of all victims with a BAC equal to zero) ($p < .01$).[9] Thus, the hypothesis that intoxicated boaters die from falling overboard proportionately more than sober boaters was supported by the data. It seems likely that the effects of alcohol on balance and coordination not only put the intoxicated boater at risk of falling overboard, but also increase the likelihood that the boater cannot reboard the boat. Whether or not the victim was alone in a falling overboard accident would be expected to be a crucial factor in the survivability of a fall overboard, assuming that the other person(s) were capable of providing assistance. An examination of the cases in which the number of people on

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[8]There are 14 accident types in the data including capsizing and falls overboard, the two most common accident types. Swamping/flooding and collision with another vessel are the next most common accident types but together they represent only about 60 percent of the falls overboard fatalities or about 25 percent of the fatalities involving falls overboard and capsizing.

[9]The test of significance used was a two-by-two contingency table based on the chi-square test for small samples (Beyer, 1966, p.128).

board was known showed a significant difference between the proportion of intoxicated and sober victims who were alone when they fell overboard, ($\chi^2(1) = 7.2$, $p < .05$). Seventy-six percent of the sober victims and only 33 percent of the intoxicated victims who fell overboard were the only person on board at the time of the accident. Therefore, the majority of the sober victims had no assistance available to them because they were the only person in the boat. The majority of intoxicated victims who fell overboard, however, had at least one other person on board at the time.

Figure 4.2 shows the distribution of BAC by the primary cause of the accident.[10] Proportionally more victims with a BAC equal to zero were involved in accidents attributed to "environmental factors" (rough waters, strong current, etc.) than victims with a high BAC. In fact, accidents involving sober victims were more likely to be attributed to environmental factors than any other single factor.

Proportionally more victims with a high BAC (equal to or greater than .10) were involved in accidents attributed to operator inattention or carelessness, listed as "operator" in Figure 4.2 than sober victims. In fact, this cause was attributed to 30 percent of the fatalities in the high BAC category. It is important to realize that, in the majority (65%) of these high BAC cases, the victim was the operator. This helps to explain the connection between victim BAC and operator carelessness.

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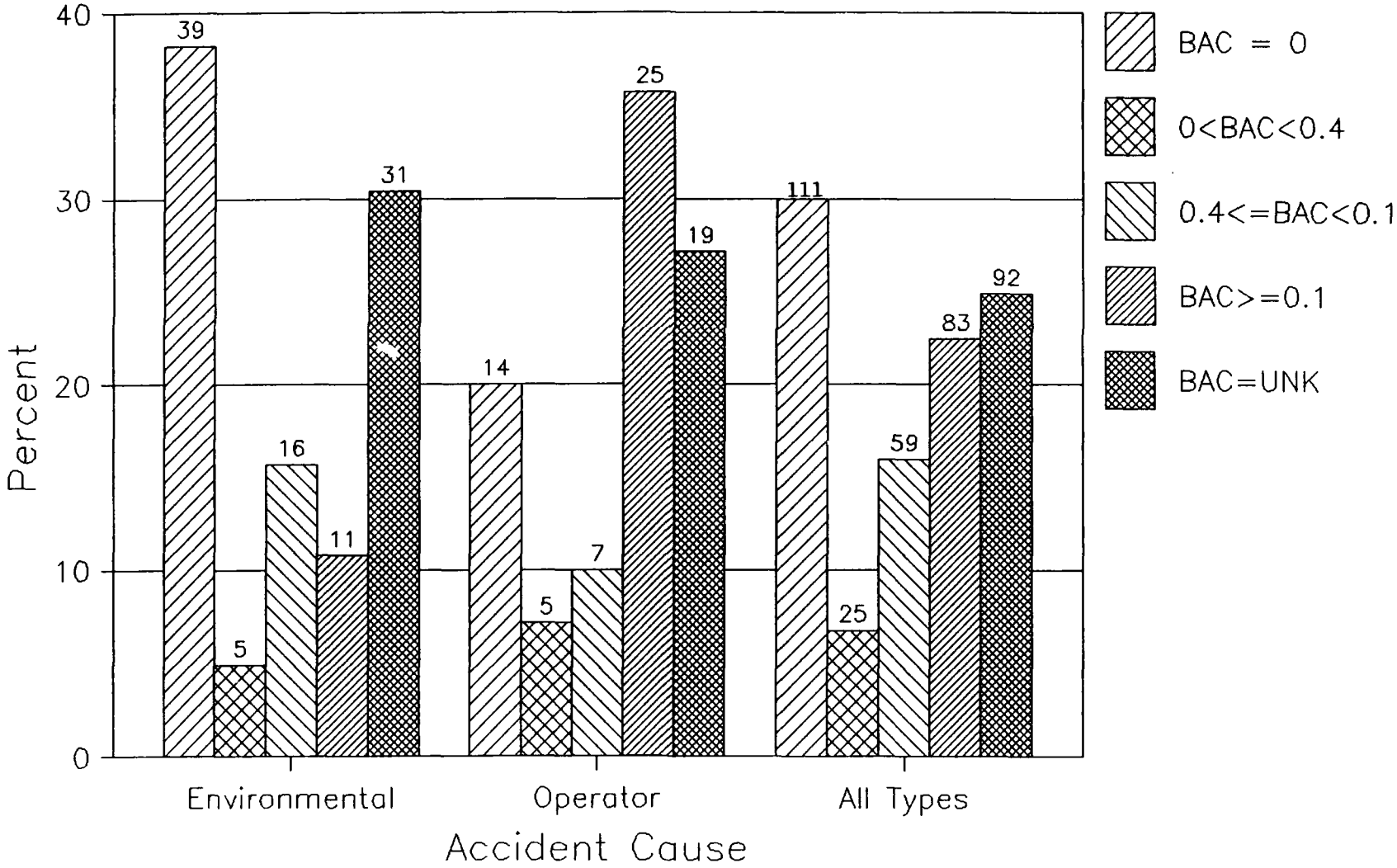
[10] Three accident causes are listed in the BAR database: primary, secondary and tertiary. In most cases, only a primary cause was given on the accident report form. The two causes shown in Figure 4.2, environmental and operator, are the most common accident causes. The next most common are overloading and improper weight distribution.

Fig.4.2: Distribution of BAC by Accident Cause

Percent of Fatalities within Cause Category



It also seemed likely that, due to the nature of the outing, either all of the persons on board were drinking or all were not drinking. To test this hypothesis, accidents involving more than one victim were examined. In accidents where there was more than one victim, the overall probability that a victim had been drinking was .59, but when at least one other victim in the same accident had been drinking, the probability that a victim had been drinking rose to .72. This difference is statistically significant (χ^2 (1) = 9.34, $p < .01$). So, when one person on a boat has been drinking others on the boat are more likely to be drinking.

Finally, the victims with unknown BACs were evenly distributed across the accident causes discussed, except for a slight increase from 25 overall to 30 percent in the environmental category. In fact, 33 percent of all fatalities with unknown BACs were associated with this accident cause. This is probably due to the difficulty in recovering victims' bodies in strong current and rough weather and the greater likelihood that severe weather will be encountered offshore where bodies are less likely to be recovered.

Most of the victims in this data had not used Coast Guard approved lifesaving devices, even though they were available in most cases. Unfortunately, whether or not the victim was actually wearing a personal flotation device or using another approved lifesaving device cannot be determined from the available data. The relevant item on the accident report form asks whether the boat was "adequately equipped with Coast Guard approved lifesaving devices," if these devices were "accessible," and if they were "used." Thus, from this item alone it is impossible to determine whether or not the victim was using a lifesaving device whenever there

was more than one person on board or more than one victim, since only some of the persons on board or victims may have used them.

The fact remains that lifesaving devices were used in only 18 percent of the cases, even though they were known to be available in 57 percent of the cases. There was also a slight difference between the sober and intoxicated victims in use of lifesaving devices. In the cases in which the availability of approved lifesaving devices was known (see Table 4.1), it was found that they were used in 28 percent of the sober deaths and known to be available in 66 percent of these cases. In cases involving victims with a high BAC, the devices were known to be available in 70 percent of the cases, but used in only 18 percent. Thus, intoxicated victims were slightly less likely to be wearing a personal floatation device (PFD) than were their sober counterparts. This difference is attributable to the difference in PFD use in calm water conditions. When use of lifesaving devices is examined in different water conditions, PFD use is found in comparable proportions in cases involving sober and intoxicated victims in water conditions other than calm (i.e., choppy, rough, very rough or strong current). In cases in which the availability of PFDs was known, the devices were used in 33 percent of the cases involving sober fatalities and 30% of the cases involving intoxicated fatalities. In calm water, however, (again, in cases in which PFD availability was known) PFDs were used in 20 percent of the cases involving sober victims and 11 percent of the cases involving intoxicated victims. Thus, the small overall difference in PFD use between sober and intoxicated boaters was accounted for by the difference in PFD use on calm water.

4.3 Conclusions

The effects of alcohol on sensory processing and motor control and the interactions of the effects of alcohol and the marine environment help to explain the differences in the circumstances surrounding the fatalities of sober and intoxicated boaters. Sober victims (BAC equal to zero) died more frequently in capsizing accidents and in severe environmental conditions (e.g., events that may have been less "recoverable"). Intoxicated victims (BAC equal to or greater than .10), on the other hand, died more frequently from falls overboard and in accidents attributed to "operator inattention and carelessness." This suggests that alcohol may be a causal factor in falling overboard and being unable to swim to safety. It seems likely that the detrimental effects of alcohol on balance may contribute to the intoxicated boater falling into the water, an event that might not be a reported accident if the victim were unimpaired or the individual remaining in the boat were capable of helping the vicitm. Once in the water, the effects of alcohol on motor control and coordination may impair swimming ability and increase the likelihood of drowning. This factor is especially important since the boater is not likely to be wearing a personal floatation device. This can be a dangerous situation, particularly when combined with possible complications such as caloric labyrinthitis or peripheral hypothermia. The detrimental effects of alcohol on reaction time and on performance on complex tasks may help to explain the disproportionate number of intoxicated fatalities attributed to operator carelessness; in an emergency or unusual situation, intoxicated boaters would not be expected to respond as effectively as their sober counterparts.

It should be noted that these data alone do not prove that drinking increases the risk of dying from falling overboard, since, for example, the number of intoxicated

and sober boaters who fall overboard and survive is unknown. In order to assess the risks associated with drinking and boating, the proportions of intoxicated and sober boaters must be known so that they can be compared to the proportions of intoxicated and sober fatalities. However, there are distinct differences between the accidents that result in the deaths of boaters with no alcohol in their bloodstream and those that result in the death of boaters with a BAC greater than or equal to .10. The relation between the circumstances that surround the death of intoxicated boaters and the effects of alcohol on behavior is clear and implicates alcohol as a causal factor in these accidents. It is clear that alcohol use poses hazards to boaters as alcohol can impair balance, swimming ability, and the skills required to safely operate a boat. This suggests that alcohol is not simply associated with certain types of accidents, but is actually a contributing cause of these accidents.

Table 4.1: Availability and Use of Coast Guard

Approved Life Saving Devices

(Percent of cases in which availability was known)

	All Fatalities	BAC = 0.0	BAC ≥ .10
Used	23	28	18
Available, not used	51	38	54
Not available	26	34	28

(Percent of cases in which device was used)

	All Fatalities	BAC = 0.0	BAC ≥ .10
Used in calm water	19	20	11
Used in water that was not calm	28	33	30

5.0 SUMMARY AND CONCLUSIONS

A reliable, unbiased set of data with information on the Blood Alcohol Concentration (BAC) of boating accident victims was assembled from information contained on the Coast Guard's Boating Accident Reports and state data for selected years in California, North Carolina, Maryland, and New Jersey. Data on victims under 15 years old were eliminated from the sample because they rarely are tested for BAC and are usually at BAC=0.0 when tested. Data are available for 370 boating accident victims. Data on victim BAC were available for 75 percent of these 370 victims. These data contain accident types and causes in proportions which are similar to those in the US as a whole.

Overall, 30 percent of the victims in the sample who were tested for BAC had BACs over .10. Sixty percent of the tested victims had some alcohol in their blood.

The association between blood alcohol concentration of boating accident victims and characteristics of boats, boaters, and the boating environment was explored. Five factors were found to be associated with alcohol more than would be expected by chance:

- Role and sex of the victim;
- Victim age;
- Time of day/day of week of the accident;
- Water conditions; and
- Number of persons on board the boat.

Females were the victims only 20 times in recreational boating accidents (out of 251 victims where BAC and role/sex was known) and they were much less likely to be drinking than males. Male passengers were somewhat less likely to be at a BAC of zero or at a BAC above 0.10 than male operators.

Young (15-19 year olds) and old (>50 year olds) victims were more likely to have abstained (BAC = 0.0) than other age victims and the proportion of the victims who were above a BAC of 0.10 increased steadily with age untill the above 50 years category where it declined substantially.

The proportion of victims who were intoxicated (BAC > 0.10) was highest on Friday and Saturday night when it reached about 55 percent. Weekdays did not differ much from daytime weekends in the proportion intoxicated.

Intoxication was much more prevalent among victims who died in calm water conditions than in other water conditions. This is probably because drinking is more common in calm conditions, though this evidence is also consistent with the unlikely hypothesis that intoxicated boaters are safer than sober boaters in rough water.

Finally, victims who were the only person on the boat were less likely to be drinking (BAC > 0.0) than victims on boats where there were other persons on board. Moderate drinking (0.04 < BAC < 0.10) was most common on boats where there were more than two persons on board.

Further analysis of these five factors revealed that two factors were dominant: calm water and Friday and Saturday night had much higher BACs. This suggests that

enforcement of boating while intoxicated laws should be concentrated in these circumstances and that data collected on the BACs of the general boating public should include water conditions along with time of day/day of week and other information about the boat and boater.

The data also suggests that safety education should target males in the 29-50 age bracket, and should emphasize the dangers of falls overboard even when there are other persons on board and the water is calm. The incidence of alcohol involvment is higher in these situations and there is reason to believe that the effect of alcohol on human performance could make alcohol a cause in these circumstances. However, further information on the proportion of boaters in the general boating public at each BAC category would be needed to establish the relative risk of boating at elevated BACs.

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Appendix A

Information on the TRB Workshop Objectives

In 1985, the U. S. Coast Guard sponsored the Transportation Research Board workshop that identified the need for research on alcohol involvement in recreational boating accidents and established objectives for this research. The nine objectives for the research to assess the role of alcohol in boating accidents (Problem No. A1.1) are given below along with the extent to which the data contained in this study satisfy these objectives. While the objectives refer to all accidents, only the fatal accidents can be addressed here.

1. Determine the proportion of recreational boating accidents that were alcohol related.

There are currently no criteria to determine whether or not a boating accident was alcohol-related. We can, however, determine whether or not the victim had alcohol in their bloodstream at the time of the accident. Currently, the concentration of alcohol in the blood (BAC) is only taken on fatalities. While alcohol in the victim's blood does not imply that it was a causal factor in the accident, the level of BAC is certainly a useful tool in helping to determine the circumstances of the accident and understand its causes.

Forty-five percent of the 370 fatalities in the database had some alcohol in their bloodstream; 22% had BACs equal to or greater than .10. A more reliable estimate of the proportion of fatal recreational boating accidents that involved alcohol is based on the number of fatalities with known BACs, rather than the total, and assumes

that the victims with known BACs are representative of the victims with unknown BACs. Of the 278 fatalities who were tested for BAC, 60% had some alcohol in their blood and 30% of the victims had BACs equal to or greater than .10.

2. Identify the number that involved drinking operators.

Of the 182 fatalities known to be the operators of the boat, 141 had been tested for BAC. Of these 141, 80 (57%) had alcohol in their bloodstream and 48 (34%) had a BAC equal to or greater than .10.

3. Identify the number that involved drinking passengers.

Of the 158 fatalities known to be passengers, 114 had been tested for BAC. Of these 114, 74 (65%) had alcohol in their bloodstream and 25 (22%) had a BAC equal to or greater than .10.

4. Determine whether any accident victims were sober or drinking.

See items 1 through 3.

5. Identify the number of accidents where problem drinkers/alcoholics were involved.

It has been suggested that "problem drinkers or alcoholics" might be defined as victims with a BAC equal to or greater than .20. Twenty-nine of the 370 (7.8%) fatalities or 29 of the 278 (10%) of the fatalities tested for BAC had BACs equal to

or greater than.20. However, there is no consensus that such a high BAC necessarily implies that the victim was a problem drinker.

6. Determine the relative risk of boating accidents at various BAC levels.

The relative risk of fatal boating accidents and boating fatalities at various BAC levels cannot be determined from these data alone. In order to determine risk, the proportions of boaters at various BAC levels must be determined (by testing a representative sample of the boating population) to provide a reference point for the proportion of fatalities at various BAC levels. For example, we know that 30% of the fatalities in our database had a BAC equal to or greater than .10. If it was found that 5% of all boaters had BACs equal to or greater than .10, then it would be safe to assume that drinking substantially increased the risk of a fatal boating accident. However, if 30% of the boaters were found to have a BAC equal to or greater than .10, then alcohol would not be implicated as having increased the risk of a fatal boating accident.

7. Identify the BAC level at which the risk of having a boating accident gets relatively high (5 to 10 times) compared to that of accidents involving a sober operator.

The BAC level at which the risk of having a boating accident is five to ten times higher than that of a sober operator cannot be determined from the available data alone. See item 6.

8. Determine whether the personal characteristics, behaviors (e.g., drinking, sitting, standing, wearing a life preserver) and environmental circumstances of alcohol-involved boating accidents differ from non-alcohol-involved boating accidents.

The only personal characteristics of victims currently available from the accident report form are age and sex. Overall, 93% of the victims were male. Only three percent of the victims with a BAC equal to or greater than .10 and nine percent of the victims with a BAC of zero were female. Table 1 shows the percentage of victims in each BAC category by victim age. The most striking difference here is that while the victims with no alcohol in their bloodstream were evenly distributed across the three age groups, almost half of the victims with a BAC equal to or greater than .10 were between the ages of 30 and 49.

Water conditions at the time of the accident also snow interesting differences between the accidents involving sober and intoxicated victims. Table 2 shows the percent of victims with a known BAC distributed by the water conditions at the time of the accident. Almost half of the victims with a BAC equal to or greater than .10 died in calm water, only 28 percent of all victims with a BAC of zero died in calm water. Furthermore, severe water conditions (rough waters, strong current, etc.) was the most commonly listed cause of sober fatalities; this was not true of accidents involving intoxicated victims. The category "weather", however, is not as informative. Seventy-two percent of all accidents were reported to have happened in clear weather. The proportions of accidents that happened in clear weather were comparable for accidents involving victims with a BAC of zero (66%) and those involving victims with a BAC equal to or greater than .10 (70%).

With respect to "behaviors", it is impossible to determine whether the victim or operator was "drinking, sitting, standing, or wearing a life preserver" at the time of the accident. None of this information is requested on the accident report form and the precise activity of the victim at the time of the accident would be difficult, if not impossible, to determine. There is, however, information available on the type of operation being conducted at the time of the accident. Table 3 shows the activity at the time of the accident by BAC. There are no interesting differences between accidents involving intoxicated and sober victims with respect to the operation at the time of the accident. Whether or not the victim was wearing a life preserver also cannot be determined because this information is not requested on the accident report form. The relevant item on the form asks whether the boat was "adequately equipped with Coast Guard approved life saving devices", and if these devices were "used". Thus, from this information alone, it is impossible to determine whether or not the victim was using a life saving device, whenever there was more than one person on board.

9. In collecting the above data, consider how alcohol may affect the boat operator or passenger in combination with the additional stressors of the boating environment and determine at what BAC level the additional stressors become factors.

In order to determine the BAC level at which additional stressors become factors in fatal accidents, the proportion of the general boating public at each BAC level in each category of stressor (e.g., rough waters) must be determined.

Appendix B

Contacts providing BAC information

California
Carl Moore, Supervisor, and Mike Ammon
Safety and Regulations
Department of Boating and Waterways
State of California
1629 S Street
Sacramento, California 95814-7291
(916) 322-1823

Maryland
Sgt. M.E. Waddell
Natural Resources Police
Department of Natural Resources
Tawes State Office Building
Annapolis, Md. 21401
(301) 269-2247

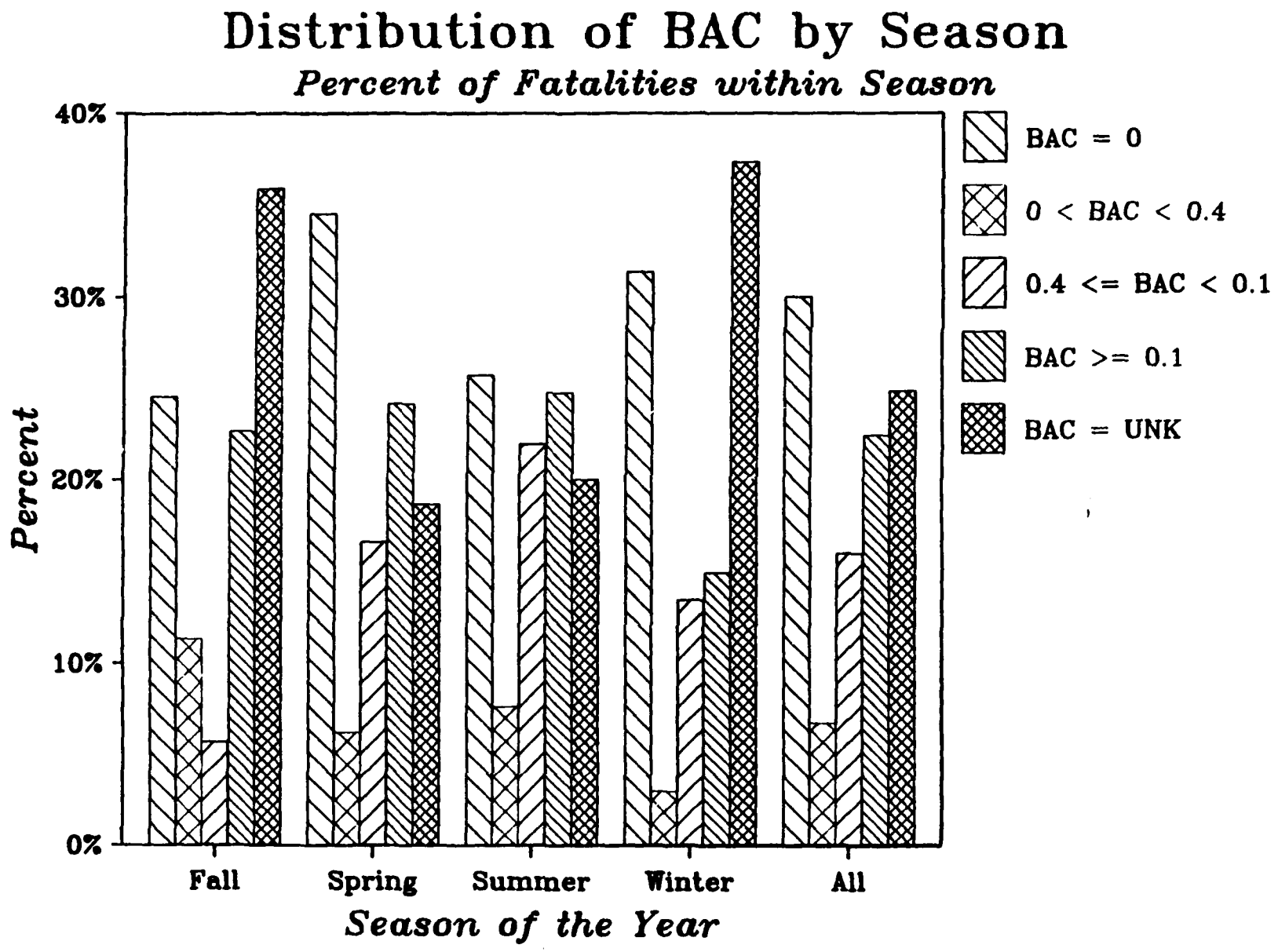
New Jersey
Data for New Jersey was available on the Coast Guard supplied Boating Accident Reports.

North Carolina
Ed Jenkins
Division of Enforcement
North Carolina Wildlife Resources Commission
512 North Salisbury St.
Raleigh, North Carolina, 27611
(919) 733-7191

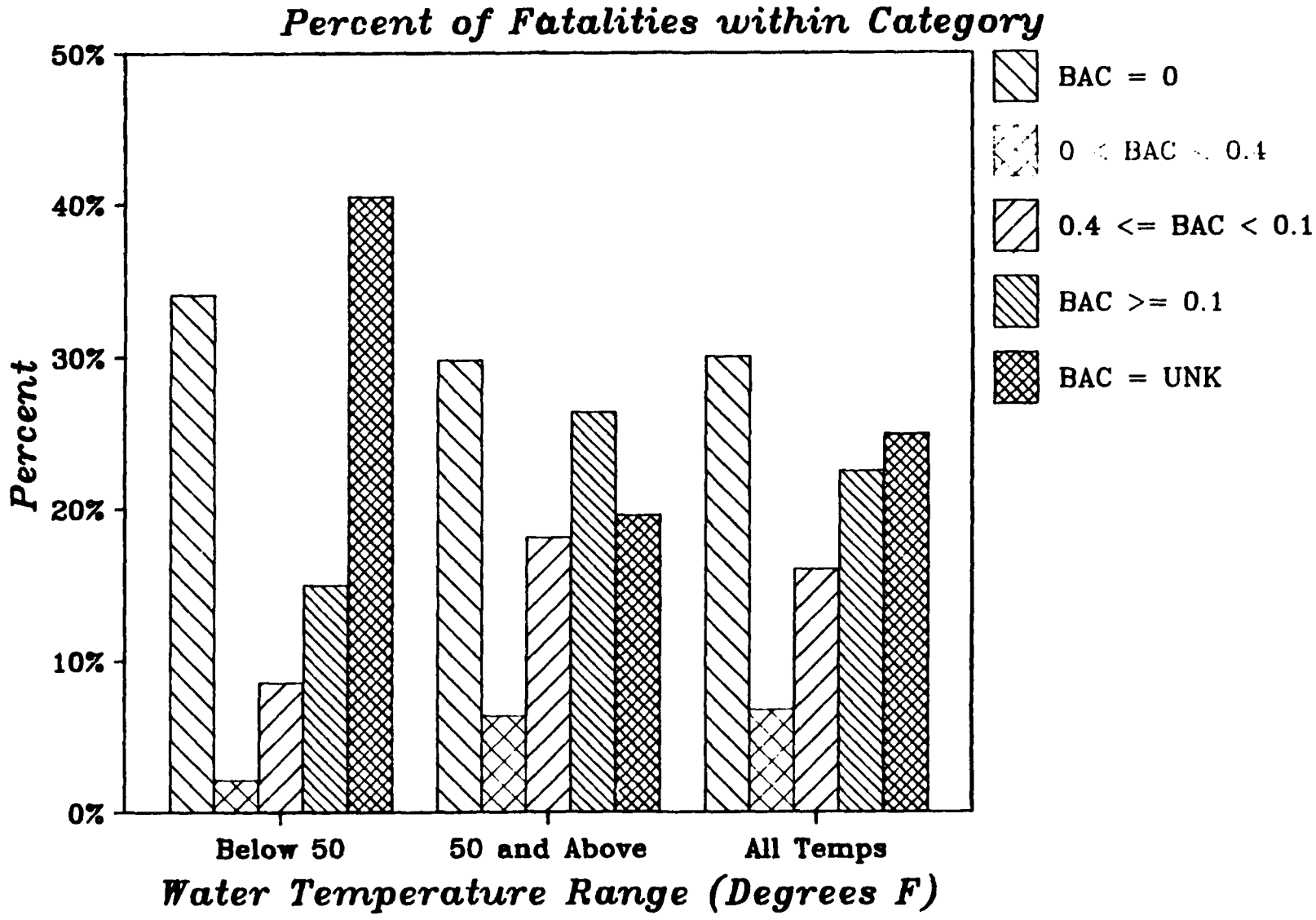
Michael Patetta
North Carolina Medical Examiner's Office
Raleigh, North Carolina, 27611
(919) 733-4728

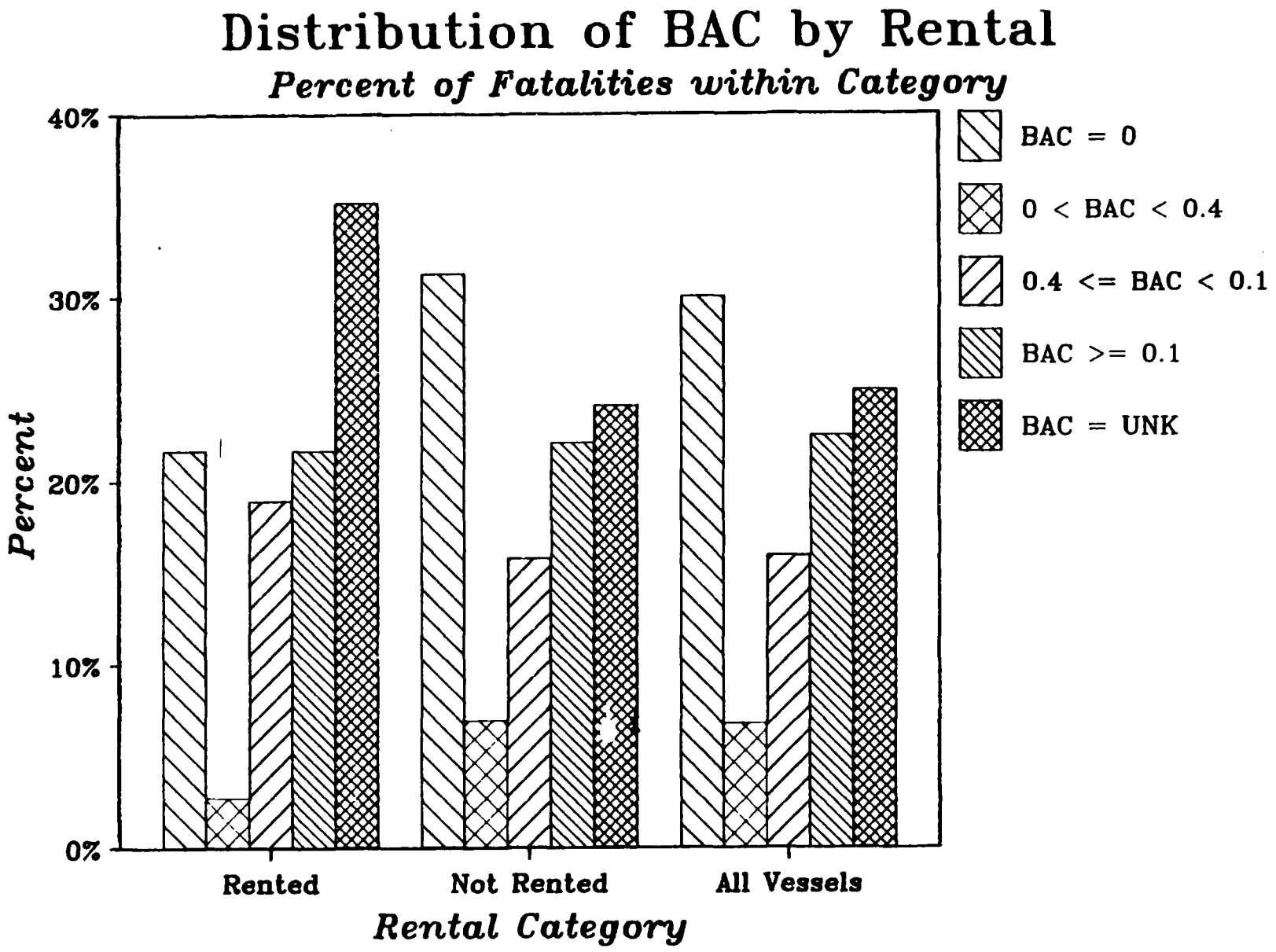
APPENDIX C

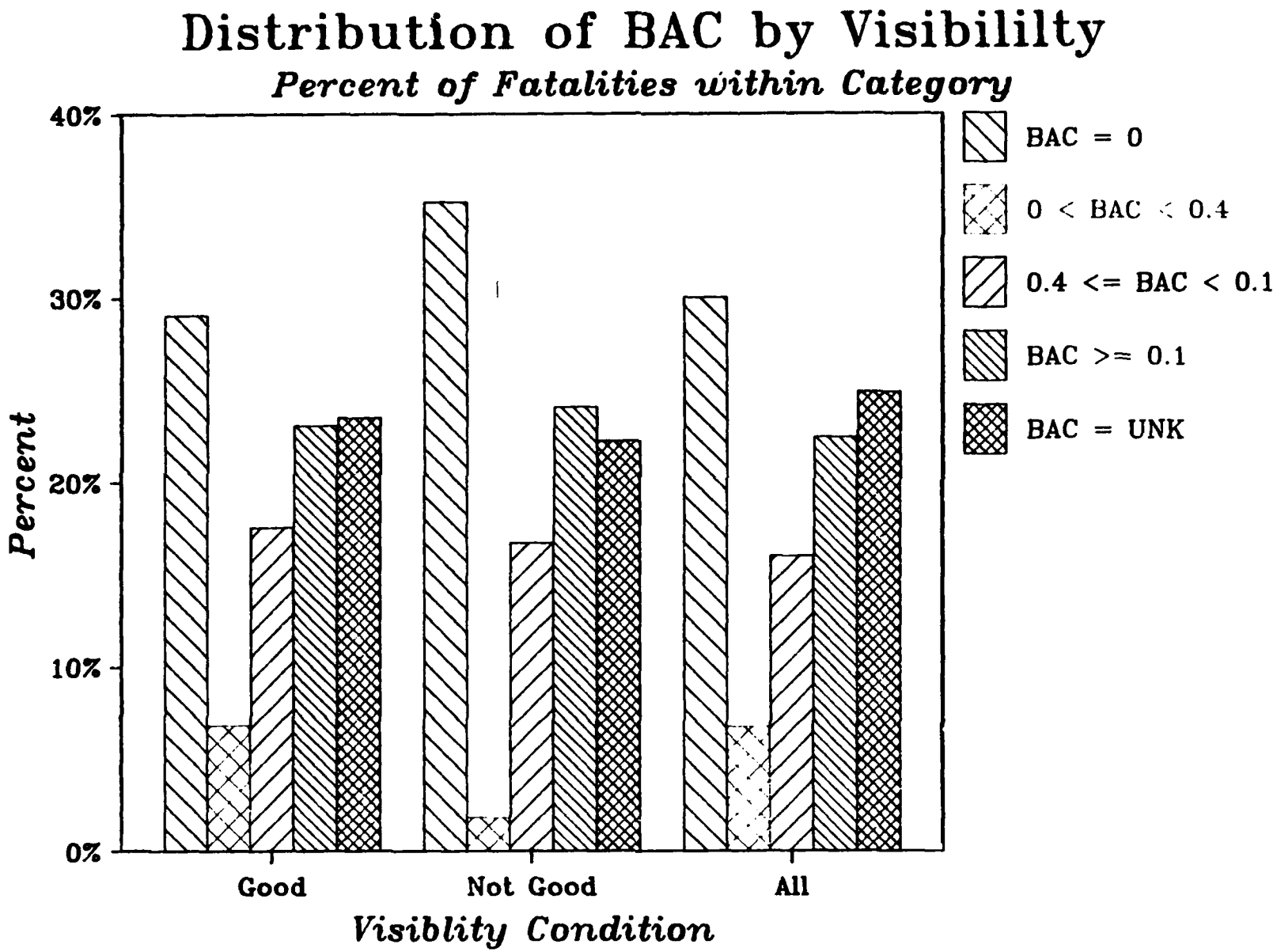
ATTRIBUTES OF BOATING ACCIDENTS NOT FOUND TO BE SIGNIFICANTLY ASSOCIATED WITH BAC


Distribution of BAC by Season
Percent of Fatalities within Season
40%
30%
20%
10%
0%
Percent
Fall
Spring
Summer
Winter
All
Season of the Year
BAC = 0
0 < BAC < 0.4
0.4 <= BAC < 0.1
BAC >= 0.1
BAC = UNK

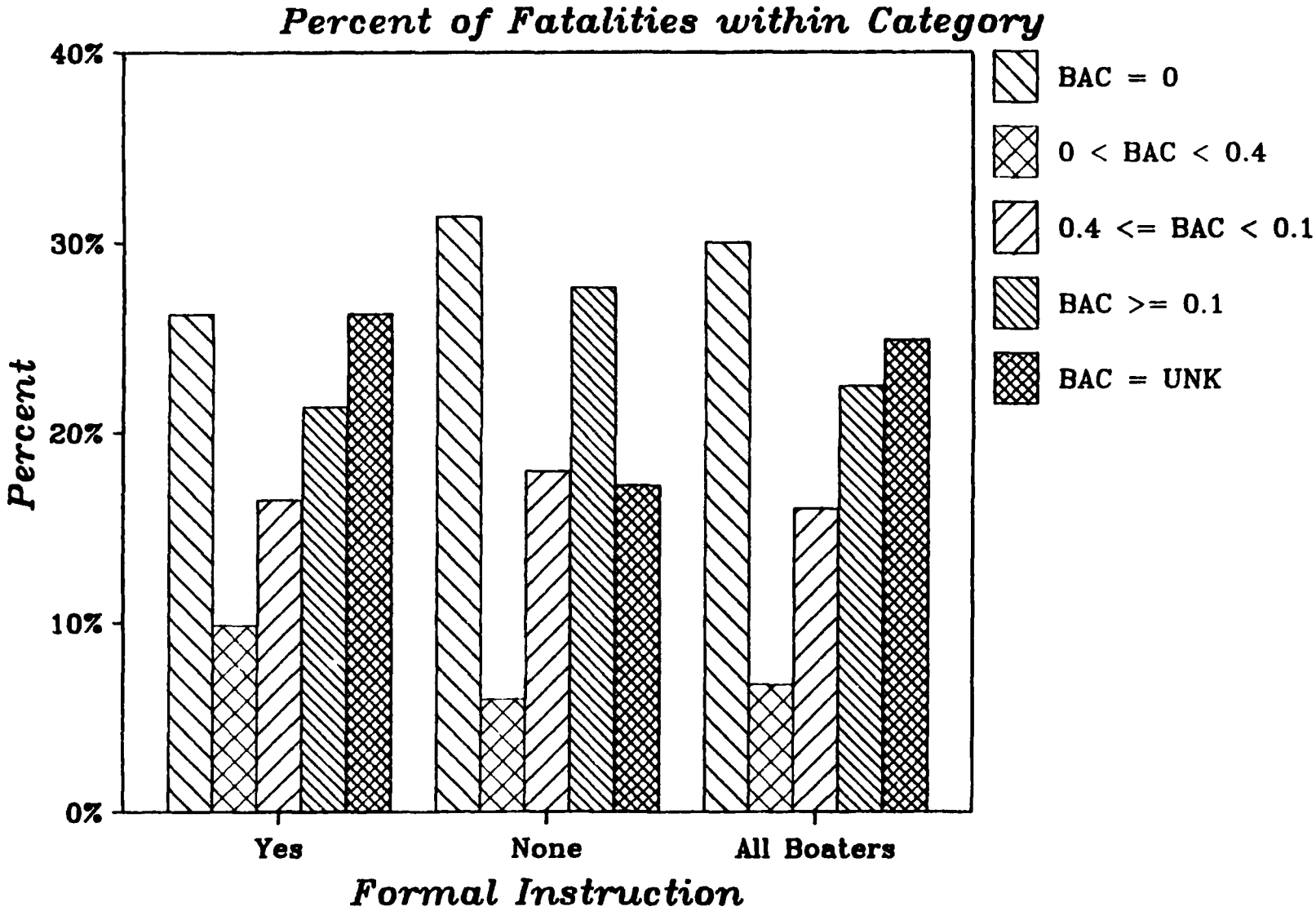
Distribution of BAC by Water Temperature

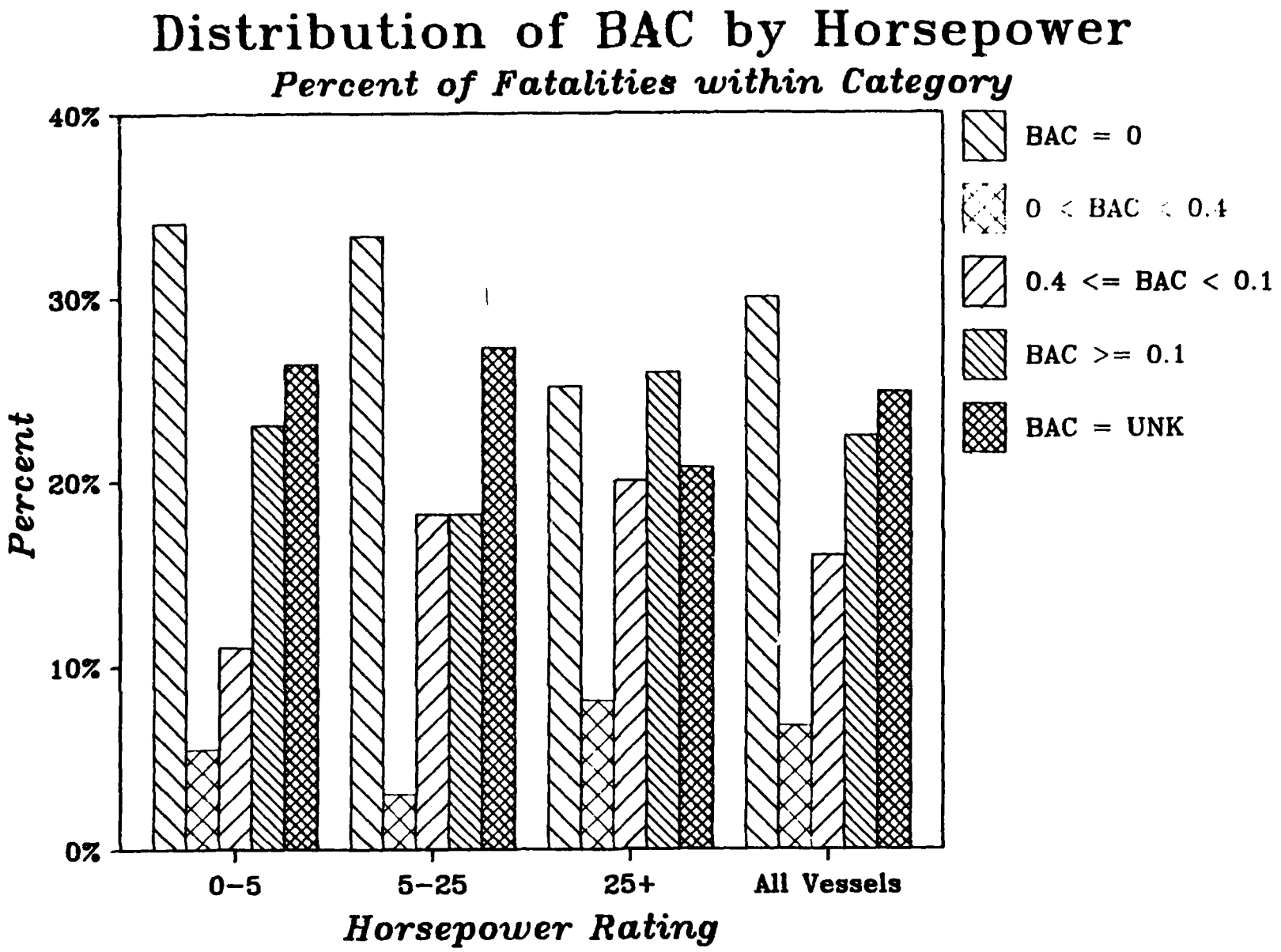



Distribution of BAC by Rental
Percent of Fatalities within Category
40%
30%
20%
10%
0%
Percent
Rented
Not Rented
All Vessels
Rental Category
BAC = 0
0 < BAC < 0.4
0.4 <= BAC < 0.1
BAC >= 0.1
BAC = UNK

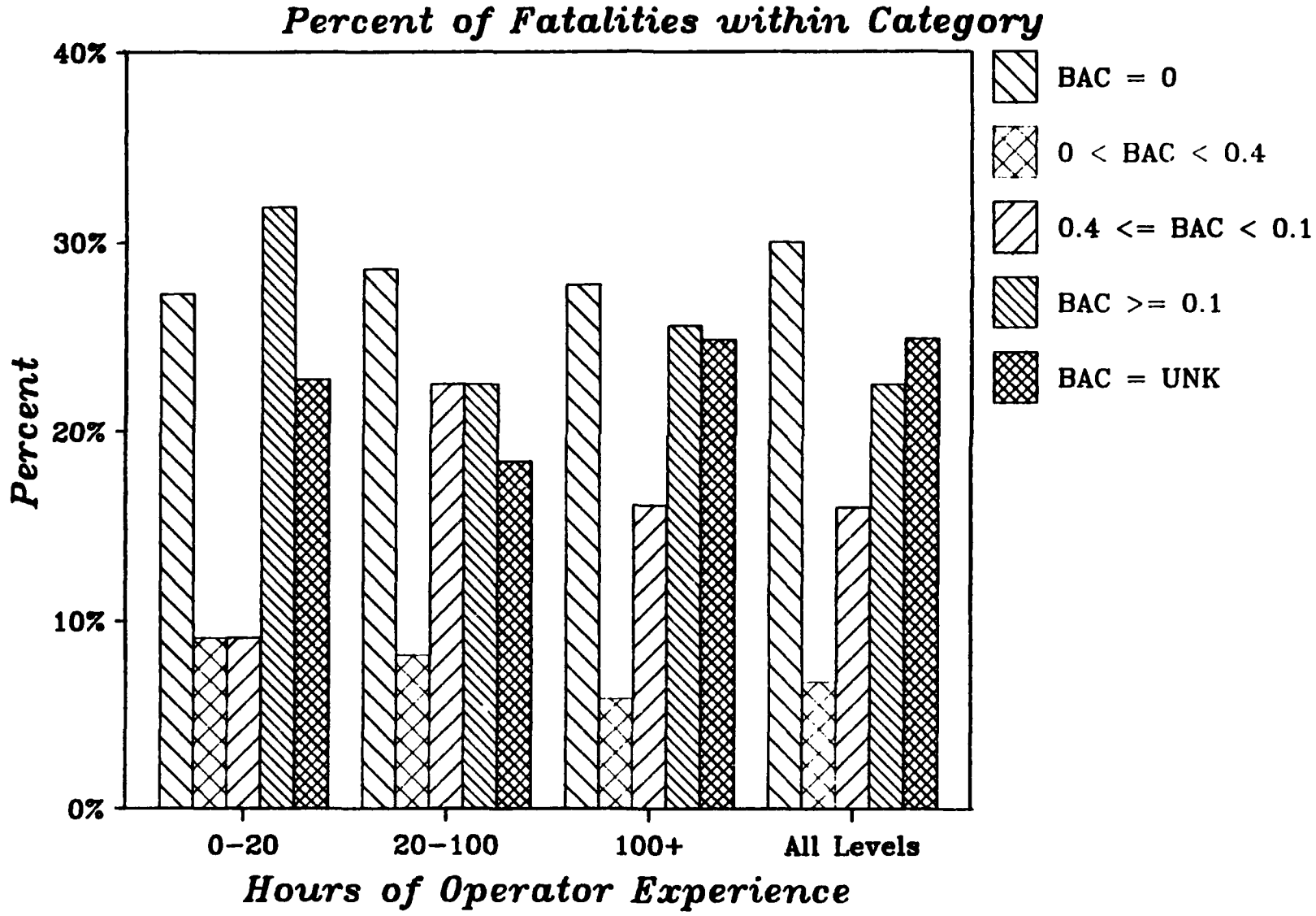

Distribution of BAC by Visibililty
Percent of Fatalities within Category
40%
30%
20%
10%
0%
Percent
Good
Not Good
All
Visiblity Condition
BAC = 0
0 < BAC < 0.4
0.4 <= BAC < 0.1
BAC >= 0.1
BAC = UNK

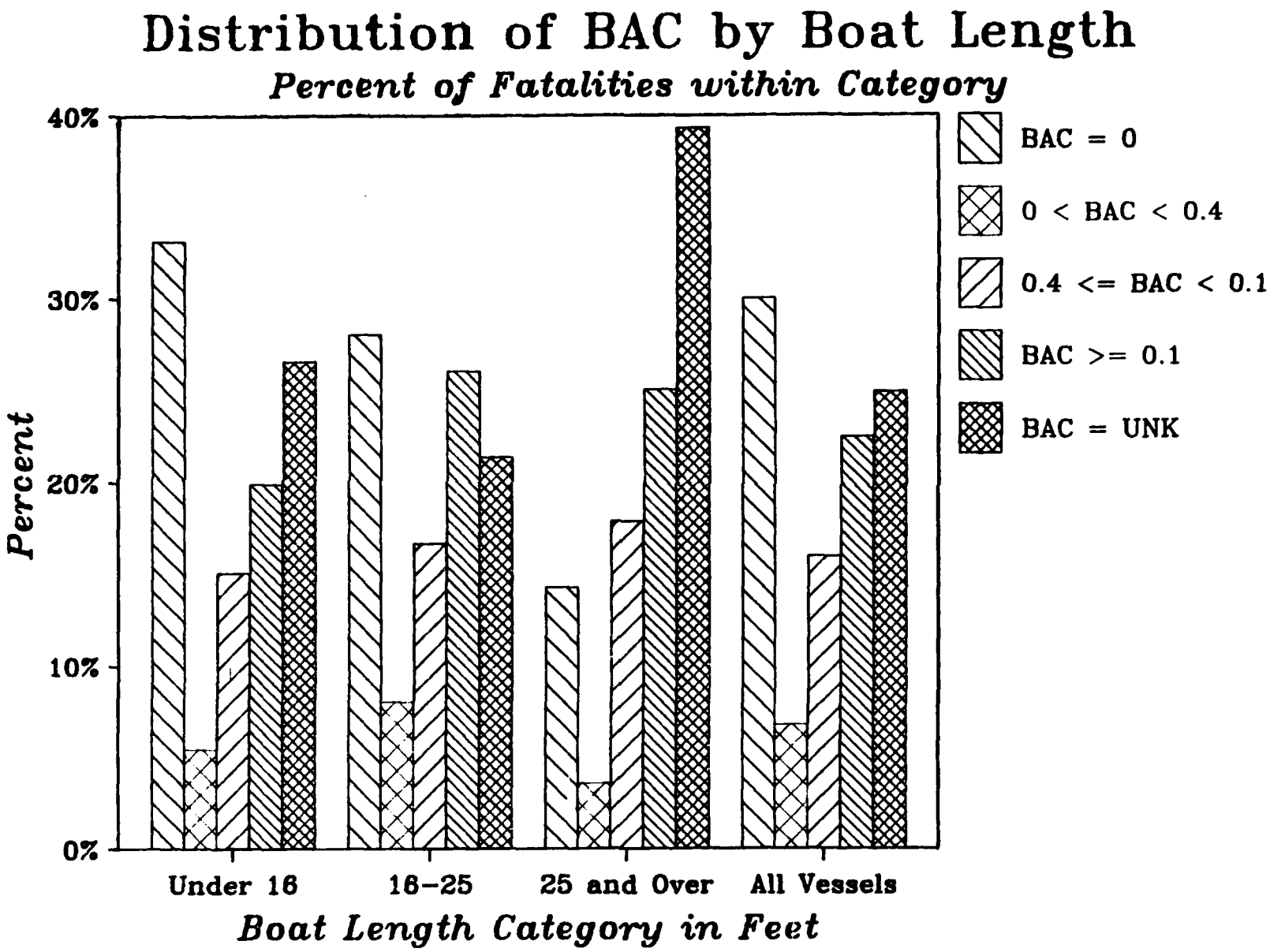
Distribution of BAC by Formal Instruction

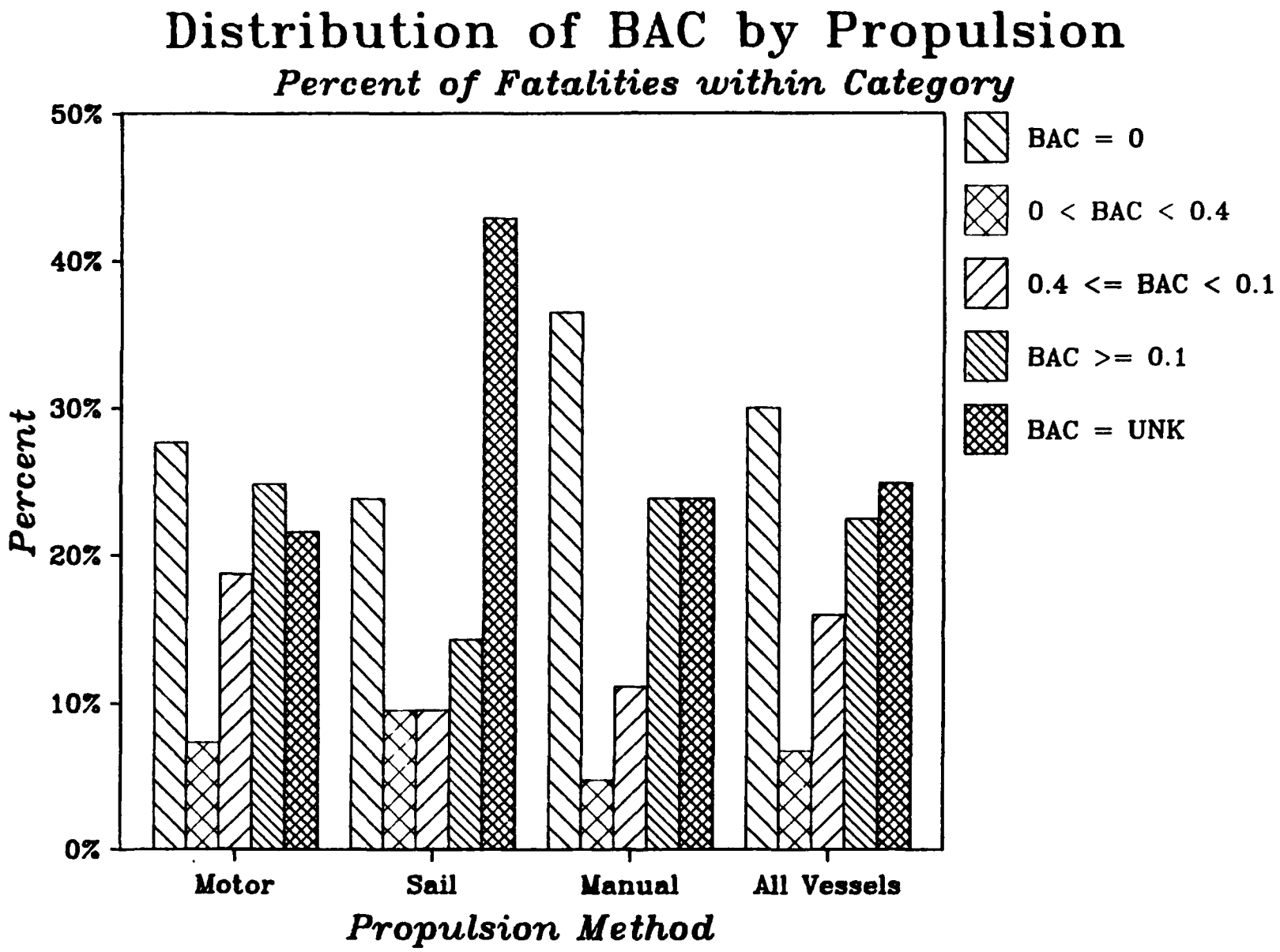


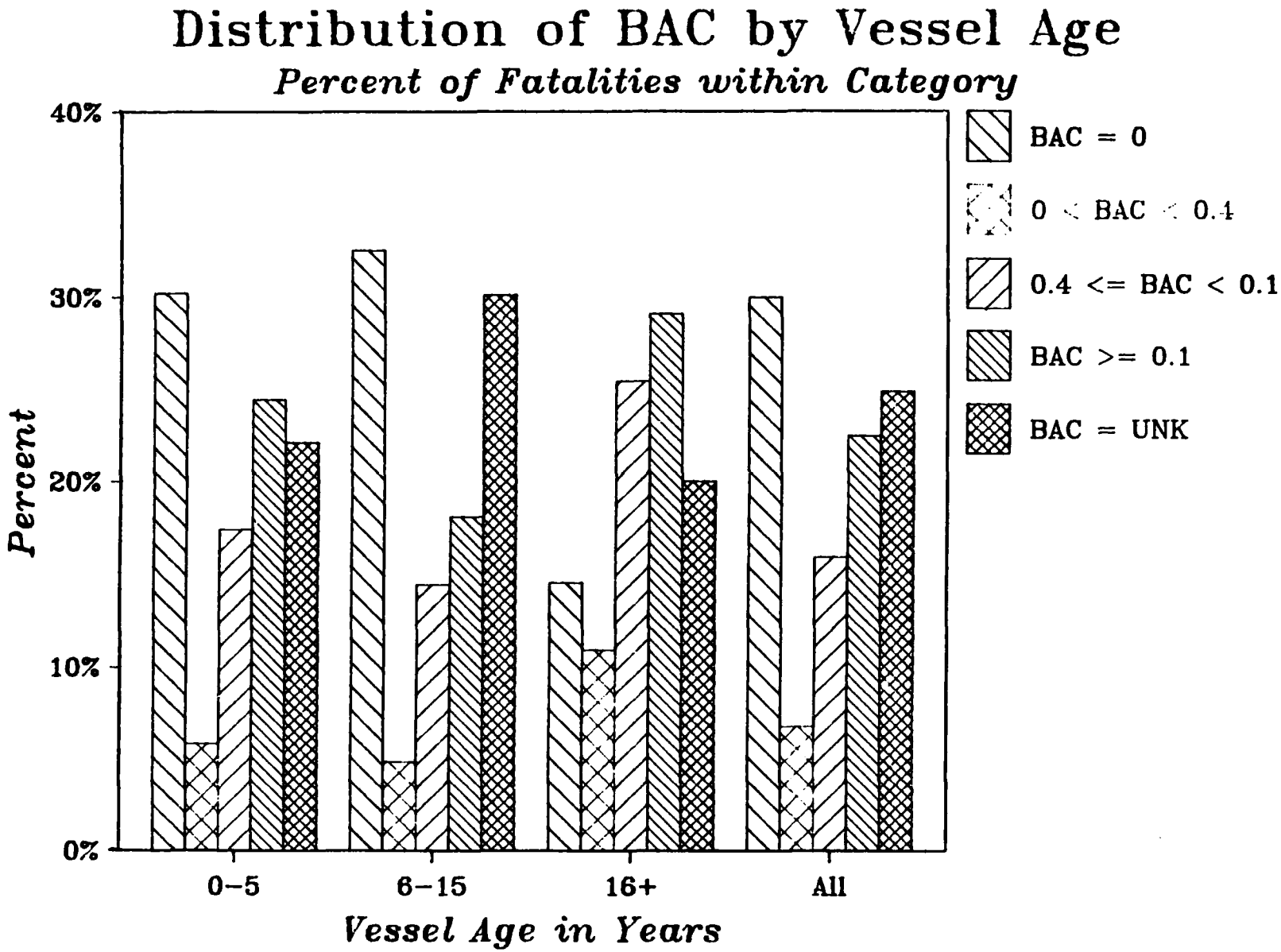

Distribution of BAC by Horsepower
Percent of Fatalities within Category
40%
30%
20%
10%
0%
Percent
0–5
5–25
25+
All Vessels
Horsepower Rating
BAC = 0
0 < BAC < 0.4
0.4 <= BAC < 0.1
BAC >= 0.1
BAC = UNK

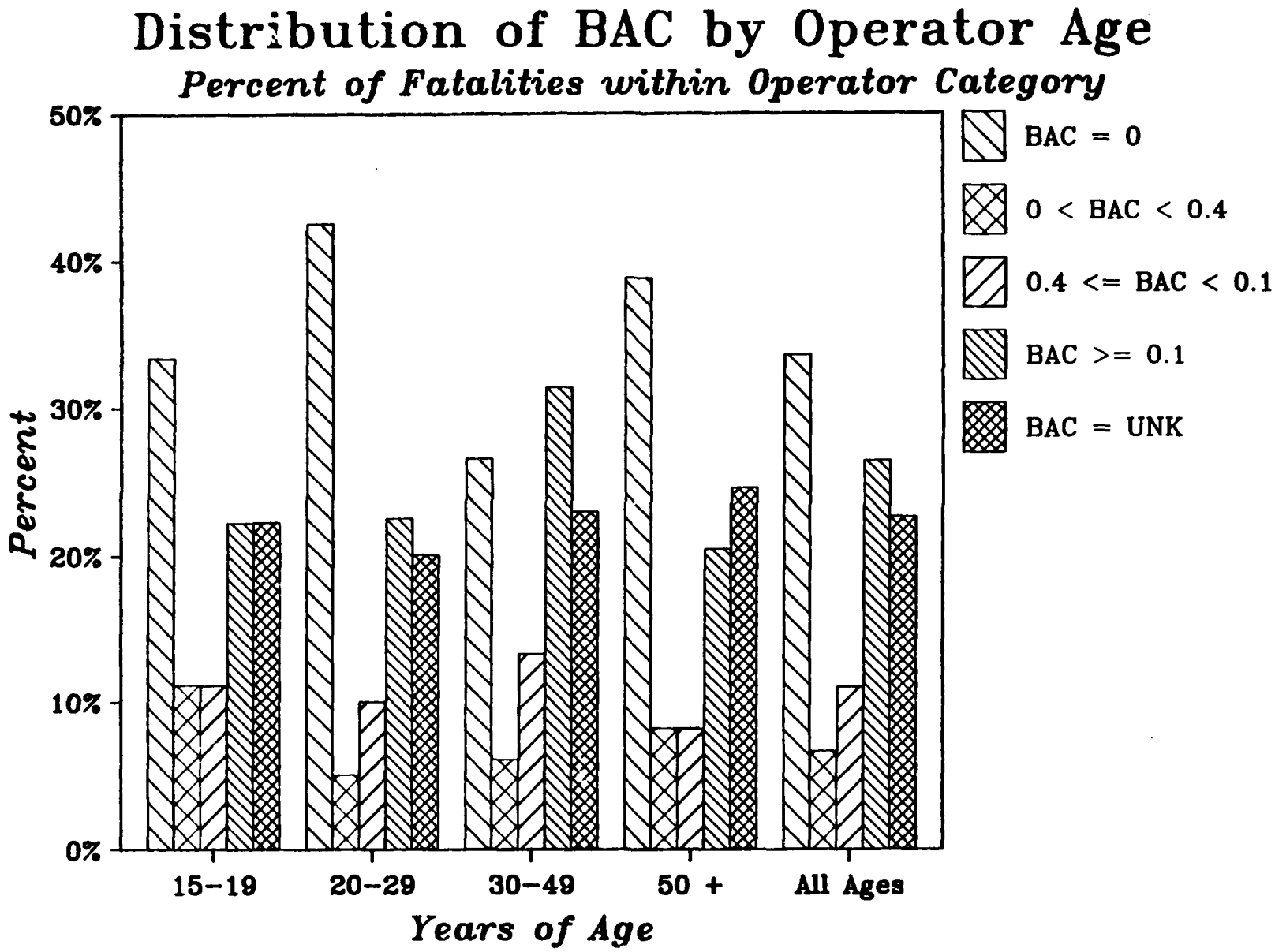
Distribution of BAC by Operator Experience




Distribution of BAC by Boat Length
Percent of Fatalities within Category
40%
30%
20%
10%
0%
Percent
Under 16
16-25
25 and Over
All Vessels
Boat Length Category in Feet
BAC = 0
0 < BAC < 0.4
0.4 <= BAC < 0.1
BAC >= 0.1
BAC = UNK


Distribution of BAC by Propulsion
Percent of Fatalities within Category
50%
40%
30%
20%
10%
0%
Percent
Motor
Sail
Manual
All Vessels
Propulsion Method
BAC = 0
0 < BAC < 0.4
0.4 <= BAC < 0.1
BAC >= 0.1
BAC = UNK


Distribution of BAC by Vessel Age
Percent of Fatalities within Category
40%
30%
20%
10%
0%
Percent
0–5
6–15
16+
All
Vessel Age in Years
BAC = 0
0 < BAC < 0.4
0.4 <= BAC < 0.1
BAC >= 0.1
BAC = UNK


Distribution of BAC by Operator Age
Percent of Fatalities within Operator Category
50%
40%
30%
20%
10%
0%
Percent
15-19
20-29
30-49
50 +
All Ages
Years of Age
BAC = 0
0 < BAC < 0.4
0.4 <= BAC < 0.1
BAC >= 0.1
BAC = UNK

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