

This document is a collection of annotations (or summary of usefulness) for a series of international studies in relation to alcohol, impairment, and the effects that those things can have on rates of fatalities and traumatic injuries as it pertains to recreational boating. A total of 51 studies are included in this annotation document. The subsequent documents will include summaries of reports and studies involving alcohol and reports on what information is available. It will also highlight the fact that reporting is still inadequate, leaving us with unanswered questions that still need to be addressed.

A problem highlighted throughout these studies is that little information is available on who was actually consuming alcohol (i.e., the operator or passenger prior to an incident). Alcohol use by passengers is equally dangerous to that of an operator, as not all injuries and fatalities are attributable to operator error, or even occur while the boat is in motion. Namely, the method of designating a sober operator alone is not effective.

The articles included in this document also help us identify risk factors, injury prevention strategies, and to identify the ideal target demographic based upon the highest risk population.

Key points:

- Alcohol use by passengers presents a danger regardless of the activity of the operator.
- There is inadequate reporting of alcohol involvement in on-water incidents.
- Adult males are at the highest risk of drowning and alcohol-related injuries/fatalities.
- Impairment is detectable in persons with a blood alcohol concentration far below 0.08 percent (the federal BAC limit for land and water operation).
- The relative risk of death is equivalent for drinking operators and drinking passengers, and for men and women.

Executive Summary of Alcohol and Drug Use in Recreational Boating

51 International Studies

Published range: 1974 – 2015

Alcohol use by passengers presents danger regardless of the activity of the operator.

- Countermeasures that reduce drinking by all occupants of a boat are more likely to be effective in reducing boating fatalities (American Medical Association, 2001).
- According to a U.S. Coast Guard study, only 54% of alcohol-related boating fatalities could be attributed to operator error (The Journal of the American Medical Association, 1993).

There is inadequate reporting of alcohol involvement in on-water scenarios.

- On the boat accident report form administered by the U.S. Coast Guard, information about the level of alcohol use and by whom is not requested.
- In 1984, it was estimated that only five to 10% of boating incidents that don't involve fatalities are reported to the Coast Guard, greatly skewing our knowledge of the level of alcohol involvement in recreational boating.
- Even in fatal crashes, alcohol testing is not consistent.

Adult males are at the highest risk of drowning or alcohol-related injuries/fatalities.

- In 2011, two-thirds of reported drowning deaths occurred in people aged 15 and over. Almost 50% of all drownings that year occurred in males older than 15.
- The higher rates of male exposure to aquatic environments is compounded by high risk behaviors such as swimming alone, not wearing a personal flotation devices (PFD) when boating or swimming, and alcohol consumption.

Impairment is detectable in persons with a blood alcohol concentration (BAC) far below 0.08%.

- Given that even low BAC's present greatly increasing relative risk in an on-water situation, alcohol use may actually be more hazardous on a boat than in other settings.
- The relative risk of death is similar for operators and passengers and increases for both groups as BAC increases.

Relative risk of death is equivalent for drinking operators and drinking passengers, and for men and women.

- The relative risk of death is similar for operators and passengers and increases for both groups as BAC increases (American Medical Association, 2001)
- In a case-controlled study on relative risk, it was determined that the relative risk of drowning was 31.8 among persons with a blood alcohol content of 0.10% or greater. The relative risk of any person with a BAC above 0.0% but below 0.10% is 4.6 (American Medical Association, 1999).
- The relative risk of death increases 1.3-fold at a BAC of 0.01%, when compared to a BAC of 0.0. That odds ratio indicates a 52.4-fold increase in relative risk of death at a BAC of 0.25% (Stempski et. al, 2014).

Note: The following annotations are organized chronologically by year of study. If the year was not found, the annotations are at the end of the report and recorded with the notation N.D. (no date).

The key findings, included after several annotations in this report, pull out the most important statistics and conclusions from the study. The goal of separating out these findings is to reinforce these points to readers and to indicate potential topics for future study.

Drowning: Epidemiology and Prevention

Park E. Dietz – 1974

Two epidemiological studies cited in this article suggested that alcohol intoxication is a factor in 12 to 14 percent of accidental drownings. Drowning is often heightened during the warmer months of the year, 62 percent of all drownings in this study happened between the months of June and August, and 90 percent of drownings happened in the six months between April and September. The greatest number of drownings (61 or 52 percent, depending on the study) occurred in natural water.

This article analyzed different activities that people were engaged in prior to drowning. A significant statistic is that 62 percent of boating deaths occurred on the weekends, which isn't consistent with other activities.

Forty-five people were selected out of the focus group who met the criteria needed to investigate the role of alcohol in drowning cases. Forty-seven percent of these cases had positive BACs ranging from 0.03 to 0.26. Only four of these individuals had a blood alcohol concentration (BAC) lower than 0.10.

This article also includes information on the frequency of alcohol use in drowning cases by country.

Alcohol and Public Policy: Beyond the Shadow of Prohibition

Mark H. Moore and Dean R. Gerstein – 1981

This article begins by referencing the perception of things, such as alcohol consumption, that leads to policy changes, such as prohibition. Whatever the degree, any level of intoxication can alter the mental, behavioral, and physiological capacity of drinkers. While the effects of alcohol can be dependent on other factors, it is also dependent on the demographics of an individual.

While this article does not provide information on the impact of alcohol on the operation of a boat or other motor vehicle, it does provide detailed information on the types of impairment that can result from alcohol consumption.

Safety Study: Recreational Boating Safety and Alcohol **National Transportation Safety Board – 1983**

Between the years of 1978 and 1982, the U.S. Coast Guard reported that only approximately six percent of recreational boating fatalities were attributable to alcohol. However, the states indicated that the problem was actually significantly worse (potentially up to 10 times worse) than what was reported.

It was not disputed at the time that alcohol was a major problem of the waterways, but the problem was that they could not determine the extent of the effects. Although adequate data was not available, researchers looking at the statistics gathered in 1974 concluded that the problem of alcohol on – water could be as great as twice as severe as the problem on roadways. Nearly 50 percent of drownings in that year were attributable to alcohol, and by the time a person's BAC was 0.035 percent, the impairments in relatively normal boating procedures were significant (this research dates back to 1950).

In 1980, it was considered that alcohol had played a role in up to 69 percent of reported drownings, and in 1981, that number stayed fairly steady at 65 percent.

The major problem laid out in this study is that there is no requirement for consistent reporting of on – water alcohol use in a boating incident (who was drinking, how much, etc.). Typically, accident reports are completed by the people involved in the accident or the next of kin, who may not provide accurate or objective accounts of the situation.

South Carolina's report for the year 1983 recorded that 30 of 37 (81 percent) of deaths involving watercraft and 63 of 81 (78 percent) of drownings were "alcohol – related." (Page 8 of this report references the laws pertaining to drinking and boating in six states).

At the time of this study, boating safety education courses did not contain specific information on the dangers of drinking and boating. The then president of NASBLA said that the greatest challenge was to identify the extent of the problem, which to this point has not been done. As it was, and possibly still is, many alcohol – related incidents and fatalities are reported incorrectly or not at all. Although most states have laws against operating a vessel under the influence of alcohol, there is no defined limit and very little enforcement.

Key findings:

- Researchers looking at statistics gathered in 1974 concluded that the problem of alcohol on – water could be as great as twice as severe as the problem on roadways.
- Nearly 50 percent of drownings in 1974 were attributable to alcohol.
- By the time a person's BAC was 0.035 percent, the impairments in relatively normal boating procedures were significant.
- The issue of consistent reporting and a requirement to report on the full extent of alcohol involvement should be addressed.

Proceedings of the Workshop on Alcohol-Related Accidents in Recreational Boating

U.S. Coast Guard, 1986

An average of one third to two thirds of recreational boating fatalities may involve alcohol. Alcohol use in an on-water situation can affect more than just one's inhibitions. For example, there is a greater risk of cardiac arrest when thrown into the water unexpectedly, an increased susceptibility to hypothermia, and an increased occurrence of vertigo, which can cause extreme disorientation.

The behavioral cues of drunkenness on water may be different than those tested for through a standard roadside field sobriety test. These behavioral cues need to be recorded and measured through a hands-on, scientifically backed test. As of the reports writing, there was no way to perform a field sobriety test on-water.

Consistent reporting of an incident, proper equipment for determining blood alcohol concentration (BAC) levels, and detailed reports of who (operator, passenger, deceased) was drinking when alcohol is involved are crucial components to combating the problem.

On the boat accident report form administered by the U.S. Coast Guard, information about the level of alcohol use and by whom is not requested. In 1984, it was estimated that only five to 10 percent of boating accidents that don't involve fatalities are reported to the Coast Guard, greatly skewing our knowledge of the level of alcohol involvement in recreational boating. Many reports tell us what happened, but not why it occurred.

How alcohol use is addressed in on-water situations may need to be re-evaluated. Environmental stressors on the water heighten impairment more quickly even at lower BAC levels. Some studies detect impairment at a BAC of 0.035 percent on the water. With this in mind, 0.08 percent may be a very dangerous concept to employ. Do parallel legal limits on the water really work?

Alcohol in Fatal Recreational Boating Accidents

Paul Hoxie et. al – May 1988

All of the data for this study has come from the Coast Guard's Boating Accident Reports, which has previously been indicated as not a complete picture of the problem. Once states who recorded blood alcohol concentration (BACs) were identified, that data was requested from the Coast Guard as well. In many cases, the Coast Guard did not include complete information on BAC as was available from the states.

The study only included specific information on four states (California, Maryland, North Carolina and New Jersey), as they were the only ones that had BAC data for more than 50 percent of boating incident victims. Of all the data in these four states, 30 percent of the victims had no alcohol in their blood at all, 23 percent had BACs in the 0.0 to 0.10 range, and at least 22 percent had BACs exceeding 0.10, the rest were unknown. If only those with a known BAC are considered, about 40 percent had no alcohol in their system, 30 percent were between 0.0 and 0.10, and 30 percent had BACs at 0.10 or above. Twenty-five percent of the recreational boating fatalities did not have a recorded BAC. The dominating reason for BAC not being reported was that the body was not recovered (44 percent). The three relevant reasons for not

reporting BAC was that the body was never found, it was discovered more than 3 days later, or there was no apparent reason for the lack of reporting.

This article contains more information on characteristics of BUI offenders as well as charts by demographic.

Safety Report: Progress of State Laws on Alcohol Use in Recreational Boating National Transportation Safety Board – 1988

In 1987, the Coast Guard reported a decrease in general (not only alcohol related) boating fatalities when compared to any other year since fatalities had been recorded. The Coast Guard credited this decrease to increased awareness of the dangers associated with operating a boat after/while drinking alcohol or using drugs. *More information contained in this document is about state – specific legislation.*

A Pilot Survey of Aquatic Activities and Related Consumption of Alcohol, with Implications for Drowning Howland et. al – 1990

As of 1990, drowning was ranked third in the United States for causes of unintentional injury and death. BOATUS did a survey of boat owners and recorded that 35 percent of respondents indicated drinking while their boat was underway. This data is consistent with the findings of a previous U.S. Coast Guard study from 1976 (40 percent of respondents to this survey routinely carried alcohol with them on boating outings).

In Howland's survey, 221 people reported having participated in aquatic activities. Twenty-three percent of these people reported drinking on the most recent occasion and men were significantly more likely to report drinking (36 percent of men and 11 percent of women).

For people who drank within two hours of beginning or ending their aquatic activity, the average number of drinks consumed was 3.8 drinks (4.0 for men and 3.1 for women).

Drowning is more common in men of all ages than it is in women. The ratio of drowning rates for men to women is 12:1 in boating-related fatalities and 5:1 for nonboating drownings. At this time, boating incidents accounted for only 17 percent of all drownings annually.

A Study of the Relationship Between the Risk of Fatality and Blood Alcohol Concentration of Recreational Boat Operators Paul Mengert – March 1992

The interviewers as a part of this study used a friendly approach to collect data. This proved to be successful as, out of the 350 boat operators that were stopped, only one person refused the interview. The investigators used an Intoxylizer 5000 (breathalyzer). The reading was not revealed to the operator unless they requested to see it, and the investigator did not analyze the results until the end of the day.

The study consisted of three units and lasted approximately 2 weeks. Data collection was performed seven days a week for 6 hours a day, and each day was spent at a different site (with one exception, no site was visited twice).

A total of 357 boat operators were contacted in a 1988 – 1989 California study. One person refused the interview as a whole, 28 people refused the Intoxylizer test, nine of the tests did not yield results, so 319 good tests were reported. Of these 319 tests, 244 tests had a zero blood alcohol concentration (BAC), 75 tests yielded a BAC above zero, 35 tests yielded a BAC at or above 0.04 percent, 12 tests yielded a BAC at or above 0.08 percent, and nine tests yielded a BAC at or above 0.10 percent.

The study included a listing of cases from a database of California boating fatalities from 1984 and 1985. Of the 70 operator deaths captured, 17 had an unknown BAC, and 53 good tests were reported. Twenty-eight had a zero BAC, 25 tests yielded a BAC above 0.0, 18 tests yielded BACs at or above 0.04 percent, and 11 yielded a BAC at or above 0.10 percent.

This article also provides information on potential sources of bias and other risk factors.

Alcohol and non-traffic unintended injuries

Jonathan Howland – 1993

Drownings are a problem particularly seen in 16 to 25-year-old men. Though the age group consists of only seven percent of the population, 21 percent of drownings occur within the age group.

In a survey of Massachusetts state boaters during the summer of 1990 found that 36 percent of men and 11 percent of women reported drinking on the last occasion that they were on or near the water. Nearly one third of the people reportedly drinking four or more drinks (defined as binge drinking).

Depending on the study, Howland & Hingson reported that between 27 to 47 percent of drownings involved alcohol. Five other general population studies report alcohol involvement ranging from 21 to 46 percent. Of the seven studies, 34 percent of drowning cases involved drinking.

People who are willing to partake in alcohol consumption in an aquatic setting are statistically less likely to wear life preservers, and more likely to swim alone or in unsupervised areas.

This article provides information on alcohol involvement in other accidental deaths.

Key findings:

- Though the demographic group (16-25-year-old men) consists of only seven percent of the population, 21 percent of drownings occur within the age group.
- People who are willing to engage in one type of risky behavior are more likely to engage in other types of risk behavior, too. Individuals who partake in alcohol consumption in an aquatic setting are statistically less likely to wear life preservers, and more likely to swim alone or in unsupervised areas.

Missing the Boat on Drinking and Boating

The Journal of the American Medical Association – August 1993

Alcohol is increasingly a risk factor in boating fatalities. In a study of four states, 60 percent of boating fatalities had elevated blood alcohol levels. Thirty percent of boating fatalities involved an operator that was intoxicated (BAC greater than 0.10).

Of the 924 boating fatalities reported by the Coast Guard in 1991, 28 percent (260) involved falls overboard and 18 percent (168) involved collisions with other things. Of the boating fatalities, 41 percent (381) occurred while boats were drifting, four percent (34) while boats were at anchor and two percent (14) while boats were docked. This means that 46 percent (429) of fatalities occurred when the vessels were not underway.

According to the Coast Guard, fault for the fatalities could be attributed to the operators in no more than 54 percent of cases. Operator error was not a factor at all in 26 percent of fatalities. In 20 percent of fatalities, error could not be determined. Weather was only a contributing factor in 19 percent of fatalities.

Over the last two decades, surveys indicate that 30 – 40 percent of boaters drink while on their vessel. Current information demonstrates only that: the boat operators should stay sober (no mention of the dangers of passenger drinking) and that the risk only occurs when the vessel is underway (ignoring the significant fatalities that have occurred when a boat is drifting, at anchor or at dock).

Reports of boating fatalities typically do not give enough information to attribute a boating fatality to alcohol use by the operator as opposed to the passenger.

Key finding: Drinking passengers are at-risk and susceptible to the survival-impairing effects of alcohol, whether the boat operator is sober or intoxicated and whether the boat is underway or not.

Perceptions of Risks of Drinking and Boating among Massachusetts Boaters **Howland et. al – 1996**

Between 25 and 50 percent of the people in boating-related incidents in this study had alcohol in their system. A 1992 U.S. Coast Guard study showed that 60 percent of people who died in boating-related incidents had elevated BAC and 30 percent met the definition of intoxication (BAC of 0.08).

In 1994 there were 784 people who died in boating incidents. Proving that intoxicated passengers present a risk independent of the condition of the driver, 26 percent of these people died as a result of falls overboard, and only 20.8 percent died as a result of a collision with other boats or objects. Operator fault could only be determined in 49 percent of the cases.

Since drunken driving data has largely been a charge to reduce drunken boating, a lot of the prevention focus has been on the boat operator. The data above proves that the only significant way to prevent alcohol-related boating fatalities would be to target both operators and passengers to enforce a “dry water” approach to safety.

Legal limits are another method that has been used to prevent driving under the influence (DUI) deaths on the roadways, but this study suggests that there is no precise amount of alcohol, above 0.0 percent, that can be specified as safe, especially in an on-water condition.

Key findings:

- Many boating manuals are lacking in the necessary information to deter people from drinking and boating.

- Many boating courses address PFD use as a safeguard when falling overboard, but most don't discuss the role of alcohol in precipitating the fall.
- The only significant way to prevent alcohol-related boating fatalities would be to target both operators and passengers to enforce a "dry water" approach to safety.

Fatigue, alcohol and performance impairment

Scientific Correspondence – July 1997

This study was comparing the effects of sleep deprivation and how it compares to levels of intoxication. This was a controlled study, alcohol was provided to the participants in a controlled dosage and they were asked to perform a series of tests to determine their level of impairment. Likewise, another set of participants were kept awake for a long period of time and at different intervals were asked to perform a series of tests to determine their level of impairment.

At 17 hours of wakefulness, the participants displayed a level of performance indicating that their impairment was equal to that of an individual with a 0.05 blood alcohol concentration (BAC).

Key finding: Relatively moderate levels of fatigue shows impairment greater than that of current acceptable levels of intoxication. (This study was performed in Australia, where the legal limit is 0.05 percent BAC).

Alcohol and Boating: Who Drinks and Who Dies

Johns Hopkins University – 1998

From May – October 1997 and 1998, boaters were selected at random and surveyed. Interviews and breath samples were taken from the boat operator and two random passengers. Breath samples were obtained from 82 percent of boaters. Although 33 percent of respondents reported drinking during the day, only 24 had a positive blood alcohol concentration (BAC) (10 percent of those had a BAC above 0.05 percent, and five percent had a BAC above 0.10 percent).

At 9 a.m., four percent of those surveyed had a positive BAC as opposed to 40 percent at 9 p.m. High BACs were similar in boat operators and passengers, and among males and females, but were highest among the 25 – 44-year-old age group.

In 1994, a random digit dial telephone survey that was conducted found that 31 percent of 597 respondents admitted to having operated a boat while under the influence of alcohol at least once in the year prior. In 1998, the Coast Guard reported that alcohol use was the main cause in 14.6 percent of boating fatalities.

Key finding: While sober car drivers may greatly reduce the risks to their passengers, the same is not true on the water. The finding that people are more likely to drink on the water than when driving a car also suggests that there is a need to develop improved strategies to reduce drinking on the water.

Alcohol “on board,” man overboard – boating fatalities in Canada
Canadian Medical Association – 1998

This article attempts to profile the victim of a boating fatality in an effort to help us better target this person in efforts of research, education and prevention.

According to their profile, the typical victim of a boating fatality is a male, operating a small motorboat for recreational purposes and there would likely be evidence of alcohol in his system. He would not be wearing a personal flotation device (PFD) and would not be dressed appropriately to protect himself from the harsh wind and waves or cold water.

This profile derives partially from findings that indicate alcohol was detected in more than two-thirds of victims of boating-related drowning who were tested, and many had BACs well over the legal limit. Additionally, only eight to ten percent of boaters have PFDs available and wear them properly. In one-third of cases, PFDs were found in the boat (available) but not worn.

Key findings:

- Alcohol use and PFD non-use constitute the two primary modifiable risks for boating related deaths.
- The starting point is to make consumption of alcohol before or while operating a boat as socially unacceptable as drinking and driving.
- In one-third of cases, PFDs were found in the boat (available) but not worn.

Water traffic accidents, drowning and alcohol in Finland, 1969-1995
International Epidemiological Association – 1998

Between 1987 and 1995, 63 percent of the water traffic incidents reported were associated with alcohol intoxication. In water traffic incident related drownings in people 15 or older, 66 percent of drownings were associated with alcohol intoxication. Fatal water traffic incidents with alcohol involvement accounted for 12.5 percent of all accidental deaths associated with alcohol intoxication.

During this study, the blood alcohol concentration (BAC) was determined for 274 boat operators and 58.8 percent of operators had a BAC that exceeded the legal limit (50 percent of rowing boat operators and 63.4 percent of motorboat operators).

Among passengers, 73.5 percent of rowboat passengers and 62.2 percent of motorboat passengers exceeded the legal BAC limit. Among those who fell into the water, 64.1 percent of victims who drowned and 53.4 percent of victims who survived had BACs at or above the legal limit.

In Finland, water traffic incidents are almost exclusive to adult males, and 97.3 percent of the victims are at or above 15 years old. In a 1970s pilot study on drunken driving in Finland, 424 motorboat drivers were tested, 29.7 percent of these tested positive for alcohol, but only 1.2 percent had a BAC higher than the legal limit.

Quantifying the performance impairment associated with fatigue

Nicole Lamond – 1999

Dawson and Reid in 1997 demonstrated that one night of sleep deprivation produces impairment that is equal to or greater than the impairment level that is considered acceptable for alcohol intoxication.

Depending on the cognitive tests, individuals reached a level of impairment equal or greater to the impairment detected at 0.10 percent at between 20.3 and 25.1 hours of wakefulness. This study suggests that after only 20 hours of sustained wakefulness, when tested early in the morning, performance impairment was equivalent to that consistent with a BAC level of 0.10 percent.

As a subjects BAC increased, performance decreased on all tasks except one. Since no performance decrements were observed in subjects who were given a placebo, it was assumed that the performance decrements observed were caused solely by increasing alcohol concentration.

Trends in Unintentional Drowning: The Role of Alcohol and Medical Care

American Medical Association – 1999

In the year 1995 in the United States, the Center for Disease Control and Prevention (CDC) cited 4,350 deaths that were attributed to unintentional drowning. In a case-controlled study on relative risk, it was determined that the relative risk of drowning was 31.8 among persons with a blood alcohol of 0.10 percent or greater. The relative risk of any BAC above 0.0 percent but below 0.10 percent is 4.6.

Of the deaths, 97 percent of them were attributed to alcohol when the individual had a blood alcohol above 0.10 percent BAC. When a person had a BAC between 0.0 percent and 0.10 percent, 78 percent of the deaths were attributable to alcohol.

Of the drownings deaths that occurred in 1995, 440 of the victims were aged 15 or over. When it comes to determining BAC levels, 10.7 percent of the subjects had unknown alcohol values because their blood sample was drawn more than 24 hours after their death, and 20.2 percent had unknown alcohol values for other reasons. Of the 304 deaths whose alcohol value could be determined, 61.5 percent of individuals had no alcohol in their system, 8.6 percent of individuals had BAC levels between 0 and 0.10 percent, and 29.9 percent of individuals had BAC levels of 0.10 percent or greater. An optimistic finding from the article is that the proportion of deaths of persons ages 15 and older that were attributable to alcohol decreased over time, from 50 percent in 1975 to 22 percent in 1995.

Epidemiology of unintentional drowning and near drowning in Denmark in 1995

Injury Prevention, Peter Lindholm – 2000

In this study, 167 cases of unintentional drownings were analyzed. There were 120 cases in adults and 35 of those cases (29.2 percent) were positive for alcohol intoxication. A telephone survey was performed in the United States and the results indicated that men have a greater exposure to aquatic environments, especially high exposure activities, and they drink more alcohol than women when they are on or near the water.

In a 1989 – 1993 Danish study, it was concluded that between one-third and one-half of adult cases involved alcohol. In American and Australian studies, a positive blood alcohol was detected in 47 percent of adults and 37 percent of adult males.

Key findings:

- The predominant risk factor in male drowning and boating-related fatalities is the use of alcohol. Other than emphasizing the risk, the only way forward seems to be shifting the societal perception of the acceptability of alcohol in an on-water environment.

Development of Measures of Fatigue: Using an Alcohol Comparison to Validate the Effects of Fatigue on Performance

Road Safety Research Report – 2000

This study was intended to perform a sleep study on subjects to determine at what hour of sleeplessness indicates a similar level of impairment as levels of alcohol consumption. There was also a controlled dosing of alcohol to certain levels of impairment. Subjects were given calculated doses of alcohol to raise their blood alcohol at 0.025 percent intervals. All subjects were asked to perform a series of tests to indicate their levels of impairment.

The tests were as follows: simple reaction time, unstable tracking, dual task, Mackworth clock vigilance test, symbol digit coding, visual search task, sequential spatial memory, logical reasoning, and subjective fatigue rating scales.

About 30 minutes after each dose of alcohol, each subject's blood alcohol concentration (BAC) was measured and recorded, a test was administered, and a post – test BAC measurement was recorded. For all tests administered, a significant reduction in function occurred between 0.05 and 0.10 percent BAC.

Based upon current legal limits for alcohol use when driving, the results showed that at about 17 – 18 hours of sleeplessness, a subject's performance on tests had dropped to the level that is seen at the legal limits for safe driving.

A Review of the Scientific Literature Regarding the Effects of Alcohol on Driving-Related behavior at Blood Alcohol Concentrations of 0.08 Grams per Deciliter and Lower

NHTSA – January 2000

Similar to the National Highway Traffic Safety Administration (NHTSA) report cited above, this study looks at a combined 177 studies that were reported on in 1988 by Moskowitz and Robinson. This study particularly is looking at the effects of low blood alcohol concentration (BAC) on impairment.

Of the 177 studies, 21 percent of the studies reported a detectable performance impairment at 0.04 percent BAC, 34 percent of the studies reported a detectable performance impairment at 0.05 percent BAC, 66 percent of the studies reported a detectable performance impairment at 0.08 percent BAC, and nearly all of the studies reported a detectable performance impairment at 0.10 percent BAC.

This study reiterates that scientific evidence supports a reduced BAC to 0.05 percent.

The authors of the Kruger et. al study in 1990 Germany found that social and controlled behaviors were reportedly impaired at between 0.030 and 0.049 percent BAC in actual traffic, but many automatic or learned (practiced) behaviors did not exhibit impairment before 0.05 percent BAC.

In the vigilance test (requiring subjects to rapid press a button when a tone was heard), all studies showed impairment at BACs of 0.03 percent and above.

In the psychomotor skills test (requiring subjects to maintain their balance), 65 percent of the tests showed impairment at or above 0.04 percent BAC. When subjects reached a BAC of 0.08 percent or above, 100 percent of the tests showed impairment.

Key findings:

- In the vigilance test (requiring subjects to rapid press a button when a tone was heard), all studies showed impairment at BACs of 0.03 percent and above.
- In the psychomotor skills test (requiring subjects to maintain their balance), 65 percent of the tests showed impairment at or above 0.04 percent BAC.

A Review of the Literature on the Effects of Low Doses of Alcohol on Driving-Related Skills

NHTSA – April 2000

In a 1988 National Highway Traffic Safety Administration (NHTSA) report, the authors criticized studies that only examined performance at a single blood alcohol concentration (BAC) because a report of impairment at one BAC does not do anything to answer the question of whether or not there might be signs of impairment at a lower BAC. The data from the 1988 study did not identify a threshold BAC below which impairment did not occur. The authors also concluded that scientific evidence supported lowering the national legal limit for driving to 0.05 percent BAC.

Consistent with this criticism, other studies have detected impairment at BACs as low as 0.03 percent. F.A. Holloway, who has written studies on the effects of low-dose alcohol consumption, reported that in 70 – 80 percent of studies, impairment was detected at BACs at or below 0.04 percent.

In looking at a dataset of 109 separate studies, 27 percent of the studies reported impairment by 0.039 percent BAC, 47 percent of the studies reported impairment by 0.049 percent BAC and 92 percent of the studies reported impairment by 0.079 percent BAC. These figures indicate that nearly half of the studies suggest impairment lower than 0.05 percent, the scientifically backed figure for a legal limit, according to NHTSA.

By the time subjects' BACs reach 0.030 percent, the number of impaired behavioral areas was greater than the number not impaired. Some behavioral tests are far more sensitive to the effects of alcohol than others.

At 0.060 percent BAC, reaction time test showed impairment in more cases than not, an important statistic when it comes to operating a vessel (car or boat), but this can be further compounded in an on-water situation by the inability of a vessel to make a sharp turn, sudden stop, etc.

Key findings:

- The study did not identify a threshold BAC below which impairment did not occur.
- By the time subjects' BACs reach 0.030 percent, the number of impaired behavioral areas was greater than the number not impaired.

Recreational Boating Injuries Treated in U.S. Emergency Departments **Emergency Nurses Association Departments of Research, Practice and Injury Prevention – 2001 – 2005**

An important statistic records the U.S. Coast Guard estimate that only 10 percent of boating incidents nationwide are actually reported, but the Red Cross estimates that only 2.5 percent of boating incidents are actually reported.

This study was conducted in 75 emergency departments across the nation and was intended to develop an information database concerning individuals who were treated at their facility as a result of recreational boating injuries and to develop recommendation and strategies to prevent and mitigate fatalities and injuries caused by recreational boating incidents. Results from the overall 2001 – 2005 data cited operator error as the most frequent contributing factor (speed or inattention). The study recommends that mandatory boater education would be a solution to this problem. The strategic recommendation is that incentives should be offered to those that complete a boater education course (for example, lower insurance costs).

This study mirrors others in its emphasis that traumatic injury is very much a public health problem. At the time of this study, for people ages one – 44 years old, death from injuries far surpassed those from cancer, and was the leading cause of death for children ages one to three. Fatalities and serious injuries as a result of car accidents have drastically decreased since the 1980s due to improved safety and engineering standards for motor vehicles, national laws regulating speed limits and alcohol consumption while driving, and driving safety education. This strategy is referred to as the 'Four E's' of prevention: education, engineering, enforcement and legislation, and economics.

Similarly, but not to the same level, we have seen a decrease in recreational boating fatality rates from 8.3/100,000 to 5.3/100,000 registered boaters since 1991. Notably, this does not include non-registered boaters or traumatic injury cases. Also, there has been a 13 percent increase in registered boaters since 1991, so the decrease could be attributed to a larger sample size.

Underreporting is a significant problem for the community of recreational boating. Data from one state in 2003 showed the underreporting or inaccurate reporting problem in clear view. In 2003, California Department of Boating and Waterways reported 963 incidents (opposed to the 745 incidents that the U.S. Coast Guard data reported for California) and the two had a \$200,000 discrepancy in property damage data.

The *International Classification of Diseases, 9th Revision, Clinical Modification* is the most recent codification system that categorizes external cause of injury codes, commonly referred to as E-codes. These E-codes contain information on intent, mechanism (for example, recreational boating) and detailed circumstances. Another reported issue is the inconsistency of information provided in emergency department reports (injury severity classification, a trauma

score, drug/alcohol levels, etc.) The report records that less than 50 percent of hospital discharges included E-codes. E-codes are used primarily for insurance submissions, but the problem here is that the information provided in them is often very broad, and don't provide adequate detail for injury surveillance.

Health care professionals may not be aware of the need to report recreational boating incidents in the same manner or with the same detail as they report motor vehicle crash-related injuries. Only about 47 percent of U.S. medical schools include injury prevention in their curricula. Only about one-fourth of the U.S. emergency departments have a level I or II trauma center, and thus don't report to a trauma registry. Data standardization is needed.

Alcohol and drug use were listed as a contributing factor in 7.5 percent of boating incidents in the years 2001 – 2002, and that percentage increased to 19.2 percent of boating incidents in the years 2004 – 2005.

This document contains more information on the broken-down statistics for the years 2001 – 2005, including patient characteristics and demographics.

Assessment of fatal and non – fatal injury due to boating in Australia **National Marine Safety Committee – 2001**

Demographically, the largest proportion of boating fatalities were in the 20 – 54 years age group (making up 68 percent of fatalities). Deaths were the highest in the more specific age group of 25 – 29, and 93 percent of deaths were males. The article found that 39 percent of fatalities and 38 percent of fatal incidents in Southern Australia involved alcohol. Similar proportions were reported for deaths on the roadway.

Drinking and Recreational Boating Fatalities **American Medical Association – 2001**

From 1980 – 1985, data from four states was analyzed and concluded that 51 percent of people involved in boating fatalities had a BAC at or above 0.04 percent, and 30 percent had a BAC at or above 0.10 percent. Given that even low BAC's present a greatly increasing relative risk in an on-water situation, alcohol use may actually be more hazardous on a boat than in other settings.

The conclusion of this study is that prevention efforts that are targeted only at operators of the boat are ignoring the many boaters that are at high risk. Countermeasures that reduce drinking by all occupants of a boat are more likely to be effective in reducing boating fatalities. Despite what prevention efforts would indicate, the relative risk associated with BAC was not significantly different between boat operators and passengers, male and female subjects, persons of differing ages or on different types of boats.

The finding that relative risk is greatly increased even at a low BAC is evidenced by experimental studies that find significant impairment in safety-related tasks at a BAC below 0.05. Although there is a great amount of evidence and research surrounding the risk associated with alcohol consumption and drinking and driving, there is very little evidence evaluating the risks associated with drinking and boating.

Unfortunately, due to the potentially misguided focus of on-water alcohol education, this survey found that 30 – 40 percent of boaters admit to drinking while boating, and many

believe that they can safely drink when the boater is at anchor or when they are a passenger. This can also be attributed to the fact that current legislation focuses solely on the boat operator, prohibiting operation while intoxicated.

Only about half of boating fatalities can be attributed to operator error, which emphasizes the fact that intoxicated passengers put themselves at risk regardless of the operator's actions or alcohol use. The relative risk of death is similar for operators and passengers and increases for both groups as BAC increases.

Relative risk is a ratio of the probability of an event occurring in the exposed group versus the probability of the event occurring in a non-exposed group. In the context of boating and alcohol, when alcohol is involved, the risk of death is similar for passengers and operators. The risk increases as BAC increases.

A comparison of boat and demographic characteristics for fatality and control subjects, Maryland and North Carolina, is included in a chart in Appendix A.

Key findings:

- Over half of analyzed fatalities had people involved with a BAC at 0.04 or above (under the federal legal limit)
- When alcohol is involved, the risk of death is similar for passengers and operators. The risk increases as BAC increases.
- Alcohol has significant impairing effects at or below a BAC of 0.05 percent.

Effects of low-dose alcohol exposure on simulated merchant ship piloting by maritime cadets

Accident Analysis and Prevention – 2001

This study found that significant performance decrements typically began at BACs between 0.04 and 0.05 percent, although impairment was detectable at levels before 0.04 percent. Participants that were impaired were generally unaware of the performance decrements under the condition of alcohol impairment. This further proves the danger of low-BAC alcohol impairment, as even the most dedicated individuals who would never risk operation of a piece of machinery or motor vehicle when intoxicated would do so at a low-BAC if they were unaware of any such impairment.

As many law enforcement personnel well know, it is very difficult to detect impairment by observation alone, even when the individual is legally intoxicated. It is important to note, especially when considering the results of this study, that experience could mitigate the performance effects of low-dose alcohol exposure.

Key finding: People can show signs of impairment whether they are aware of their impairment or not.

Low Blood Alcohol Concentrations: Scientific and Policy Issues **Transportation Research – 2001**

In most cases, improvements in alcohol – related driving deaths occurred when the U.S. lowered the legal limit to 0.08 and when other countries lowered their limits to 0.05. The improvements may be related to a variety of factors around the time of the switch (only to increase again later). These factors could be: increased media attention, a general sense that laws are stricter, the idea that enforcement is more likely and the shift in societal norms.

Some studies can detect impaired performance at a BAC of 0.01 – 0.02 percent. These low levels could be compounded by the condition of an on – water situation. It is very important to increase public awareness of the impairment that can occur at the lowest levels of intoxication in order to change the attitudes toward alcohol and driving/boating behavior. Officers and the public should be better trained to recognize behavioral cues of impairment at low BACs. Given this empirical information, the question remains whether or not legal limit laws really work. There is no BAC level at which impairment doesn't occur. At low BAC levels, small changes make a huge difference.

No specific behavioral cues to identify low, but impairing, BACs have been identified. With this in mind, although impairment is proven, how do detection and field sobriety tests work if we don't know the behaviors to watch for? This could be another reason that legal limits are not the answer, as we don't have a clear way to tell officers what to look for. At any rate, if an officer detects a behavioral cue or sign of impairment, it is always better to be safe than sorry. How can we go about prosecuting a low, but impairing, BAC?

Even in fatal crashes, alcohol testing is not consistent. In order to increase our understanding of the problem, consistent alcohol testing of all occupants of a vessel involved in a crash is needed. Drug testing of individuals with very low BACs would also help us understand the interaction between drugs and low levels of alcohol and their role in impairment.

Again, this article highlights anti – alcohol on water education should be broadened to include the passengers of a vessel, as well as the operator. The committee's recommendation, as it parallels to boating, is as follows: boating safety courses, empowered officers and training, tougher penalties and heightened enforcement, and research on what works.

Field sobriety tests are becoming more difficult, as defense attorneys are no longer arguing the tests, but the officer's ability to administer them. How will this work for the new seated battery? Furthermore, for a repeat offender, it is not possible to know whether or not a skill is being learned through practice in order to resist impairment. Expectations need to be shifted as one problem that can occur is that drinkers don't expect any kind of impairment, as long as they stay below the legal limit. Information to correct this expectation could promote safety.

Key findings:

- It is very important to increase public awareness of the impairment that can occur at the lowest levels of intoxication in order to change the attitudes toward alcohol and driving/boating behavior.
- Officers and the public should be better trained to recognize behavioral cues of impairment at low BACs.

- Consistent alcohol testing of all occupants of a vessel involved in a crash is needed.
- There is no BAC level at which impairment doesn't occur. At low BAC levels, small changes in BAC, even down to the hundredth of a percent, make a huge difference in impairment.
- Expectations need to be shifted as one problem that can occur is that drinkers don't expect any kind of impairment, as long as they stay below the legal limit. Information to correct this expectation could promote safety.

Alcohol and Other Risk Facts for Drowning among Male Active Duty U.S. Army Soldiers

NIH Public Access – 2001

Drowning deaths are the fifth leading cause of injury death overall, and the third leading cause of injury deaths for Americans between the age of 15 and 25. Men are at a much greater risk of drowning throughout the span of their life than women.

After the age of four, the drowning death rate for women declines to less than one per 100,000 people per year, and remains that low for the rest of their life. The rate for men is consistently higher than that for women, peaking at age 18 with a rate of nine per 100,000 people per year. This rate could be partially attributed to the fact that men are significantly more likely to swim in open water (often not monitored or manned by a lifeguard), to swim alone (within the past year), to drink alcohol while swimming alone and to drink alcohol while boating without a life-jacket. This is consistent with the likelihood of a person to engage in multiple types of risky behavior if they are willing to engage in one.

Drowning rates for men under 25 years old are higher than for those over 25, and the rates for soldiers remain consistent with this data. The average drowning rate for soldiers under 25 years old was 5.2 per 100,000 people per year. The rate for soldiers over 25 was 2.8 per 100,000 people per year.

In nearly one-third of the drowning cases (30.7 percent), alcohol use was a documented contributing factor and in almost half of these cases (14.8 percent), heavy drinking was indicated. In 47 percent of these cases though, the reports did not include information on the nature of alcohol use preceding the event. When the analyses were restricted to only include cases that specifically mention alcohol use, 58 percent of these reports indicated alcohol played a role in the event.

Alcohol involvement in this study relies heavily on witness statements regarding alcohol use preceding the event, safety officers' impressions and their willingness to record this. Alcohol use may have a direct effect on survivability upon submersion.

In this study, six percent of off-duty drownings and 21 percent of on-duty drownings occurred in the presence of safety equipment that was either not used or not used effectively. However, lifesaving equipment was only present in 59 percent of the cases.

Key finding: Alcohol use may have a direct effect on survivability upon submersion.

A population – based case – crossover and case – control study of alcohol and the risk of injury

Department of Family and Community Medicine – 2002

A report out of Australia noted that 55 percent of boating fatalities cases had a measurable blood alcohol concentration and 27 percent had a BAC of 0.10 or higher.

In the case – crossover analysis, alcohol consumption in the six hours prior to injury, compared with drinking in the same six – hour interval the day before, was associated with a four – fold increase in the risk of injury. With amounts up to six drinks in six hours, the increase in risk is exponential.

The conclusion of this study, as a whole, indicates that the consumption of three to four drinks is associated with a four – to six – fold increase in risk of injury.

Often, injury risk is associated with people who are alcohol dependent or engage in hazardous drinking practices. However, this study indicates that injury risk is associated more strongly with the quantity of alcohol consumed at one time on a given occasion.

Key finding: A person is more impaired on a boat than they would be on land with the same amount of alcohol in the same amount of time.

Watercraft-Related Drownings Among New York State Residents, 1988 – 1994
Public Health Reports – 2003

From 1988 – 1994, 216 residents of New York State died as a result of drowning from watercraft-related incidents. Of those victims, 201 (93.1 percent) were male, consistent with other studies alleging that drowning is a male dominated occurrence. In several national studies, 29 – 32 percent of respondents reported alcohol use during or within two hours of a recent boating outing. In the New York State study, information from those with valid BAC data yielded that approximately 44 percent of watercraft-related drownings were associated with alcohol use (this is about 1.4 times the frequency for alcohol use by boaters estimated in the national survey).

Only 12 of the victims could be positively identified as boat operators, and eight of the 12 had positive BACs.

Qualitative similarities in cognitive impairment associated with 24 h of sustained wakefulness and a blood concentration of 0.05 percent

Marina G. Falleti – 2003

The concept of legal limits has been debated in multiple articles, but this article explains even more broadly how legal limits don't capture a great portion of impairment. Significant impairments of psychomotor skills were detected in this study in subjects who had a blood alcohol concentration (BAC) less than 0.08 percent, the current legal limit in the United States.

When compared to loss of sleep, 24 hours of sustained wakefulness exhibited characteristics that one would expect with a BAC of 0.10 percent.

For the alcohol condition, impairment was greatest for the accuracy of memory and learning responses. Significant performance decrements were detected in people with BACs between 0.05 and 0.08 percent.

This study sought to measure impairment sustained by hours of wakefulness and compare that to legal blood alcohol limits.

Review of the role of alcohol in drowning associated with recreational aquatic activity

Injury Prevention, 2004

Telephone surveys conducted in the United States in the 1980's and 1990's, suggest that between 30 and 40 percent of people on boats admit to drinking alcohol while onboard, that men tend to drink more and engage in higher risk activities while drinking and that available boater training is inadequate and lacks information that would alert boaters to the dangers of alcohol consumption in an on-water context.

According to a cited report that was published by Howland & Hingson in 1985, between 25 and 50 percent of adults who drowned unintentionally had consumed alcohol. Other studies that were not limited to a focus on drugs and alcohol recorded that drowning is an overwhelming cause of death in association with recreational aquatic activity and between 30 and 70 percent of people who drown in association with recreational aquatic activity have detectable alcohol in their system and between 10 and 30 percent of deaths name alcohol as a contributing factor. Drinking passengers create a risk regardless of the operator's alcohol use or impairment because of the effect alcohol can have on an individual's balance, judgement, swimming ability and response to cold.

This article also combats the idea that risk is only evident when the boat is moving, as 24 percent of boating fatalities in 2000 occurred when the boat was stationary or drifting.

This article features a lot of specific information on alcohol and drowning.

Key findings:

- The use of alcohol in association with the operation of a boat should be seen as socially irresponsible, as is drinking and driving a car.
- Drinking passengers create a risk regardless of the operator's alcohol use or impairment because of the effect alcohol can have on an individual's balance, judgement, swimming ability and response to cold.
- There is risk whether or not the boat is moving. Twenty-four percent of boating fatalities in 2000 occurred when the boat was stationary or drifting.

Causes and prevention of boating fatalities

Accident Analysis & Prevention – 2005

The role of alcohol in boating deaths is similar to the role of alcohol in road deaths, demonstrating a need to draw public attention to the issue of drinking and boating and that the severity of consequences is parallel to drinking and driving a car.

Use of Designated Boat Operators and Designated Drivers Among College Students

Jeewon Cheong – 2005

According to a 2003 U.S. Coast Guard study, in the year 2001 there were a total of 232 fatalities and 530 injuries resulting from alcohol use in boating incidents in the United States. This means that alcohol accounts for 34 percent of fatalities and twelve percent of injuries in boating incidents.

In this study, 3,052 students were asked to participate and the 885 students who reported boating during the previous summer were included in the analysis. Approximately 45 percent of the 885 participants reported drinking while boating on at least one occasion, and more than eight percent of participants reported drinking on every boating occasion.

Approximately 62 percent of people reported boating with people who were drinking, and 58 percent of participants thought that drinking alcohol increases their enjoyment of boating. Nearly 70 percent of boaters reported the use of a designated boat operator (DBO), but nearly 25 percent of these boaters also reported that their DBO consumed alcohol during the voyage.

A very clear limitation of this study is that there was no differentiation in alcohol use between boat operator and passenger.

Neurobehavioral Performance of Residents After Heavy Night Call vs. After Alcohol Ingestion

J. Todd Arnedt – 2005

This article takes a new angle on the comparison of impairment between wakefulness and alcohol intoxication by looking at night shift workers over a period of time. The finding was that after four weeks of heavy call compared with light call rotations, individuals demonstrated impairment similar to that of a person with 0.04 – 0.05 percent blood alcohol concentration (BAC).

An interesting finding is that people who are groggy or sleepy may have a very hard time recognizing the degree to which they are impaired. This runs parallel to individuals who have a low BAC and may not recognize their own impairment.

Immersion- and Recreational-Boating Related Injuries in Alaska

Diana Stark Hudson – 2005

This article contains findings from four studies that were conducted from 2003 – 2005 to describe factors associated with fatalities and injuries related to boating and other recreational activities in Alaska. These are the first known studies to focus specifically on Alaska. According to a report from the World Health Organization in 2002, the year 2000 yielded approximately 5.1 million deaths due to trauma. There was a much larger number requiring hospitalizations or other medical care. Safety promotion is strongly related to injury prevention. The biggest challenge to prevention efforts is the mentality that injuries “just happen” and therefore nothing can be done to prevent them. Because many victims of drowning are declared

deceased at the scene rather than at a healthcare facility, there is a tendency by medical professionals to greatly underestimate the number of deaths by drowning.

Known risk factors for drowning include a lack of personal flotation device (PFD) use, and alcohol use by the victims. Other risk factors include age (young children are at high risk) and gender (males are much more likely to drown). Estimates are that alcohol use is involved in 25 – 50 percent of adolescent and adult deaths associated with water recreation in the United States. A study cited in this article, Chen et al. (2005), found that the odds ratio of dying from drowning was 3.48 times higher for current drinkers than it was for the general population of the United States.

This article also contains information on cold water immersion.

The Epidemiology of Drowning

Christine Branche and Ed Van Beeck – 2006

The definition of drowning is the process of experiencing respiratory impairment from submersion/immersion in liquid. The authors' recommendation concerning alcohol as a risk factor for drowning is that alcohol consumption in water recreation activities predisposes a person to drowning and serious action should be taken against it. They also caution against advertisements that portray alcohol use on the water, and suggest that the availability of alcohol at water recreation facilities, marinas, etc. should be greatly restricted.

The authors express great dissatisfaction with the reporting formats, and the amount of data that is available on drowning. If we don't know how vast the problem is, it's difficult to find a solution, so this is a very limiting factor in the research. For the reports we do have, many are regional and not national, so it's hard to get a clear estimate on the nature of the problem for a country as a whole. Risk factors for drowning include age, sex, alcohol consumption, race, epilepsy, heart and cerebral disease, type of activity, accessibility of water, climate, hypothermia, lifeguard services, types of watercraft used and degree of affluence. Other risk factors which are not well-documented are swimming ability, availability of swimming lessons, etc. In order for legislation and enforcement to be effective, a lot more research is required.

A meta-analysis included in this article found that 49 percent of adult drownings involved alcohol and 34 percent of those cases had a blood alcohol concentration (BAC) at or above 0.10 percent. Another important risk factor in drownings that has not been considered in other studies included in this research is the risk of parents or guardians consuming alcohol while supervising young children in water recreation activities. The risk of drowning in any setting, tubs, pools or open water, is elevated at any BAC after a departure from zero, and there is a 52-fold increase in the odds of dying while boating when a person's BAC reaches 0.025 percent. This article greatly encourages legal limits, despite the assertion by many other authors that these limits are ineffective.

A study out of Alaska from 1991 to 1996 suggests that 45 percent of the people that died due to man-overboard cases were not entangled in gear, were observed falling overboard, and should have been floatable and/or recoverable had they been wearing a PFD.

This article includes charts that may be useful to look at drowning on a global scale.

Key findings:

- A meta-analysis included in this article found that 49 percent of adult drownings involved alcohol and 34 percent of those cases had a blood alcohol concentration (BAC) at or above 0.10 percent.
- There is a 52-fold increase in the odds of dying while boating when a person's BAC reaches 0.025 percent.

National Institute on Alcohol Abuse and Alcoholism**National Institutes of Health – Department of Health and Human Services – 2006**

The importance of the information in this article references the major gap in our knowledge of drinking and driving from the perspective of the passenger. This article provides findings from the NESARC survey, which uses a large sample size to provide us with information on alcohol, drugs and mental disorders over time.

The measures of drinking and driving in the case of the driver is either driving while drinking or driving after having too much to drink. The measures of passenger-based alcohol-impaired driving is either riding with a drinking driver or riding as a passenger while drinking. The prevalence of drinking and driving is highest between the ages of 18 and 29 with a prevalence rate of 6.8 percent. In every age group, including this one, drinking and driving is much more prevalent in men. The highest prevalence of drinking and driving by race is in Native American men.

While males are still at a higher rate of riding with a drinking driver, the numbers are much closer between genders than they are in terms of the operator. When the prevalence of drinking while driving is broken down by age, the age with the highest rate of driving while drinking in males is 25 with a prevalence rate of 13.9 percent. The age with the highest rate of driving while drinking in females is 23 with a rate of 8.0 percent.

Between the years of 2001 and 2002, 11.3 percent of American adults reported engaging in at least one of these four drinking-driving behaviors. Prevalence rates for men were at least double that of women.

More than 80 percent of individuals engaged in these behaviors were classified as binge drinkers. Between 30 and 43 percent of these individuals were classified as alcohol dependent. The likelihood of an adult male to engage in risky behaviors, in addition to their greater rates of drinking and driving, contributed to the overwhelming male traffic fatality rate of 78 percent.

Future prevention and intervention can be dependent on the understanding of passenger-based factors in terms of their alcohol use and their participation in risky behaviors.

Human error in recreational boating**Accident Analysis and Prevention – 2007**

Some of the best data we have comes from a comparison of the alcohol levels of fatally injured drivers and blood alcohol levels taken from drivers at random roadside checkpoints. One data point that must be looked at very carefully is the officer's inference, from observed behavior, of the involvement of alcohol in a crash. Sometimes at low-level BACs, impairment can be concealed from observation. In a sample set of non-fatal alcohol incidents, two-thirds of

the incidents involved alcohol. The general expectation of this study is that alcohol involvement in fatal incidents would be greater than that.

Alcohol Violations and Aviation Accidents: Findings from the U.S. Mandatory Alcohol Testing Program

National Institute of Health – 2007

Between 1995 and 2002, major airlines conducted random alcohol tests and reported 511,745 of them to the Federal Aviation Administration. Of the 511,745 attempted tests, 111 were not carried out because the employee refused to be tested. The findings yielded an overall prevalence rate of 0.09 percent, and 329 of the employees tested had a BAC at or above 0.04 percent. This finding reinforces the idea that even employees with zero tolerance professions will go into work with a low BAC and may be unaware of their level of impairment.

The relationship between alcohol consumption and fatal motor vehicle injury: high risk at low alcohol levels

National Institutes of Health – 2012

At any and all levels of consumption, the odds of dying in a motor vehicle crash are significantly higher than for zero alcohol consumption, and were approximately 13 times higher at the legal limit of 0.08 percent blood alcohol concentration (BAC).

Reaching Zero: Actions to Eliminate Alcohol – Impaired Driving

National Transportation Safety Board – 2013

Due to the efforts made (by MADD and others) to educate and reduce the number of drunk driving deaths on the roadways, alcohol – related crashes were reduced by 53 percent from 1982 – 2011. Still, nearly one in three of all highway deaths is alcohol – related. In 2010, a survey was done to gather data about the rate of drinking and driving episodes. When the data gathered is extrapolated to the general population, researchers estimate that four million people drove drunk or impaired approximately 112 million times during that year. Survey respondents, however, were in favor of legislation that would require extra precautions, such as an ignition interlock device, to be standard in all cars.

On the roadway (keep in mind, these numbers would only be increased by the conditions of an on – water situation), a study found that at a blood alcohol concentration (BAC) of 0.05 percent, drivers are 1.38 times more likely to be in a crash than sober drivers. At a BAC of 0.08 percent, the risk of a crash is 2.69 times higher than that of a sober driver.

This study reiterates that driving – related impairment can be degraded at a BAC as low as 0.01 percent.

Even at sobriety checkpoints, traditional methods of determining impairment identify less than half of the drivers who have a BAC at or above the legal per se limit. Another challenge is that many repeat offender drunk drivers continue to drive impaired on a suspended license. For boating, this comes into play as someone whose license has been suspended for driving impaired could still operate a boat without any repercussions (as the license suspension is not connected).

Many people generally believe that drinking and driving a car poses a significant risk, but they do it anyway. This perception/culture is even worse in boating as it is seen as a recreational activity, and the public does not generally recognize the dangers as being equal (or greater) than that of the dangers on the roadways.

Drowning deaths in Sweden with emphasis on the presence of alcohol and drugs **BMC Public Health – 2013**

In 2004, 388,000 people died as a result of drowning. In Sweden, drowning accounts for six percent of all unnatural deaths. The presence of drugs and alcohol was analyzed in 4,812 cases of drowning, 313 cases were excluded because the bodies had already decomposed. In total, 91 percent of individuals who died as a result of drowning were tested for the presence of alcohol, and 38 percent of these had a blood alcohol concentration (BAC) at or above 0.2 percent BAC. The presence of alcohol was higher in cases of unintentional drowning than in cases of suicide. The presence of alcohol was higher in cases of male drowning than in females. In drownings as a result of a collision, 30 percent had alcohol.

Alcohol was present in 44 percent of unintentional drownings and 78 percent had a BAC of 0.15 or higher. Of the 21 recorded homicides, alcohol was present in 37 percent of cases. Alcohol was present in 54 percent of man overboard drownings and in 68 percent of snow mobile riders who drowned after falling through ice. In the undetermined drowning group, 45 percent of tested individuals had alcohol in their blood. More than half of the individuals who drowned at sea had alcohol in their blood.

Alcohol was present in unintentional drownings in 44 percent of cases in Sweden, 51 percent of cases in Finland, 35 – 55 percent of cases in the U.S., 50 percent of cases in New Zealand, 62 percent of cases in Ireland and 22 percent of cases in Australia. It is important to note that there are differences in alcohol policy and consumption in each of these countries. Of boating fatalities for all of the countries referenced above, 54 percent were alcohol positive.

Until 2010, the legal limit for the operation of large boats was 0.05 percent BAC in Sweden. After 2010, this limit was lowered to 0.02 BAC.

Key finding: We need to reach middle/older age groups. Information about the dangers of combining drugs and alcohol should be given heavily to males and the older age group. It is much more difficult to protect adults from drowning than it is to protect kids. The focus should be on swimming ability, ice pods and personal flotation devices (PFDs).

Low Life Jacket Use among Adult Recreational Boaters: A Qualitative Study of Risk Perception and Behavior Factors

Department of Health and Human Services – 2014

This article is applicable because many alcohol – related drowning deaths involve subjects who were not wearing a personal flotation device. Most (63 percent) of participants in this study reported wearing a life jacket less than half of the time while boating. This is an example of a person's likelihood to engage in multiple types of risky behavior if they are willing to engage in one type of risky behavior.

This article also reports that, while statistics weren't taken as a part of the survey, a conclusion was drawn that alcohol use is prevalent among recreational boaters.

Barriers to Life Jacket Use Among Adult Recreational Boaters

Department of Health and Human Services – 2014

No or low life jacket use is correlated to any level alcohol use. Estimates are that alcohol contributes 10 – 30 percent of attributable risk for all drowning deaths. Even very low alcohol levels (such as 0.01 BAC) can be seen to increase risk of death among recreational boaters. As of the writing of this article, the Coast Guard actively enforced the federal legal limit of 0.1 percent BAC. It is likely that boaters who engage in risk-taking behavior, such as alcohol consumption on – water, also engage in behavior that disregards life jacket use. Given that drinking increases risk of certain activities (such as capsizing, collisions and falls overboard) increased life jacket use would effectively reduce fatalities.

Although most states do not have mandatory life jacket laws for adults, further enforcement of boating under the influence laws may be linked to encouragement of life jacket use. Some have suggested implementing measures similar to those effective at reducing impaired drinking (on the roadways). This would include designating a sober operator, sobriety checkpoints and increasing public awareness of laws and enforcement campaigns. Unlike on the roadways, additional strategies may be needed to reduce the risk of drowning and injury for impaired passengers.

Key finding: No or low life jacket use is correlated to any level of alcohol use because of the correlation between different types of risky behavior.

Knowledge of Alcohol Impairment in Boaters in Southern Illinois

The Journal of Emergency Medicine – 2014

Since roughly 2000, boating incidents have decreased overall, but alcohol-related boating incidents and deaths continue to increase. At the time of this article's writing, alcohol was the fifth leading contributor to boating incidents and the leading contributor to boating deaths, accounting for 16 percent of boating deaths overall.

Consistent with other studies, this study records that alcohol is found in the blood of between 30 and 70 percent of drowning victims and is considered to be a contributing factor in 10 – 30 percent of drownings.

A mail-in survey of registered boaters conducted in 1996 in Massachusetts yielded the following findings: 43 percent of respondents believed that it was safe for passengers to consume alcohol as long as the driver was sober, and 45 percent believed that there was no Federal law against drinking and boating.

Over the previous 20 years, surveys had consistently show that only 30-40 percent of boaters admit to drinking while boating, but this survey found that 76 percent of respondents report drinking while boating.

Alcohol use while boating is more likely in males and individuals between 25 and 34 years of age. Drowning rates are 14 times higher in males than in females.

Key findings:

- Unlike in cars, passengers who drink are at a greater risk, independent of the behavior of the driver.
- The number of fatalities that are due to falls overboard (28 percent vs. 18 percent for collisions) suggests that it is more dangerous for passengers of a boat to drink than drivers.

Drowning Deaths in Australian Rivers, Creeks and Streams: A 10-year analysis **Royal Life Saving – 2014**

In Australia, research shows that the odds of a person having a drink on their boat are decreased when the operator/passenger has completed a boating safety course, or when a child younger than 12 is on the boat.

However, in Australia, alcohol is very seldom mentioned in boating safety courses.

In the 10-year study, conducted between July 1, 2002, and June 30, 2012, alcohol was shown to be involved in 37 percent of drowning deaths in rivers. Of the 274 cases known to involve alcohol, 82 percent of the subjects were male. The highest number of alcohol-involved drowning deaths was found in the 45 – 54 age group with 19 percent. Drowning deaths involving alcohol account for 49 percent of all drowning deaths in the 45 – 54 age group, followed by 47 percent in the 55 – 64 age group and 46 percent in the 25 – 34 age group.

Half of all drowning deaths where alcohol was deemed to be contributory had a blood alcohol content exceeding 0.2 percent, 17 percent had a blood alcohol concentration (BAC) of 0.3 percent or higher and the highest blood alcohol recorded was 0.523 percent.

This document also contains information about drug-related drownings.

A case – controlled study of boat related injuries and fatalities in Washington state

Stempski et. al – 2014

The Washington state study found that on-water fatalities were 70 percent more likely to have alcohol involved. Alcohol was involved in 41 percent of fatalities and 25 percent in traumatic injuries. When alcohol is involved, the average relative risk increases from 1.0 to an average of 1.7. In 2002, 8.7 percent of non – fatal and 22.6 percent of fatal boating – related incidents had alcohol or drugs listed as a contributing factor. Over half of the boating incidents that occurred between midnight and 5:59 a.m. involved alcohol.

Boating is a unique condition in that boaters are subject to the normal land-based injury risks (falls, cuts, burns), but can also suffer additional injuries unique to the on-water condition such as, asphyxia, submersion and hypothermia. This study defines existing knowledge of the subject including the finding that prior boating injury studies have shown risk for death increases 52.4 – fold at a BAC level of 0.25 percent. This prior knowledge comes from the 2001 study by Gordon Smith and the American Medical Association (cited above) that found the relative risk of death to increase 1.3-fold at a BAC of 0.01 percent, when compared to a BAC of 0.0. That odds ratio indicates a 52.4-fold increase in relative risk of death at a BAC of 0.25 percent.

Key finding: This study defines existing knowledge of the subject including the finding that prior boating injury studies have shown risk for death increases 52.4 – fold at a BAC level of 0.25 percent.

Interacting Factors Associated with Adult Male Drowning in New Zealand

James L. Croft – 2015

Alcohol was detected in 30-70 percent of people who drown while involved in recreational aquatic activity and probably contributes to death in 10-30 percent of cases. Although the study centered on New Zealand, the conclusion that impairment is probably under reported in witness statements due to the negative societal and legal implications of operating a vessel while impaired. In Australia, alcohol was found to be present in 22 percent of drowning deaths but was not reported in 35 percent of those cases.

The majority of accidental immersion drownings (62 percent) involved alcohol. The most prevalent group for drownings involving alcohol in males is 20 - 24 years old.

There were 77 cases analyzed that involved alcohol and boating. A life jacket (buoyancy aid) was only worn in one of these cases, and in 26 of these cases, a life jacket was available but not worn. None of the drowning victims from power boats wore a life jacket. Men who drank and went power boating were less likely to wear life jackets (9 percent) than those who did not drink (30 percent).

There was a very low incidence of wearing a life jacket while consuming alcohol across all types of boating, but the availability of life jackets appears to have been much lower.

Key findings:

- Typically, males underestimate risk and overestimate their ability to cope.
- Excessive alcohol usage is likely to contribute to poor risk assessment and decision-making in recreational aquatic activity.

Recreational Drowning Prevention Intervention for Adults, 1990 – 2012: A Review

Journal of Community Health – 2015

The majority of research related to drowning up until this point has been focused on children under five years old. It is clear from the evidence that interventions need to be targeted to the adult male demographic to prevent the greatest number of drownings on a global scale. As with other public health initiatives, prevention requires “booster campaigns” to maintain and sustain behaviors that involve multilevel intervention efforts.

According to the World Health Organization, in 2011 drowning was the third leading cause of unintentional injury internationally, resulting in an estimate 359,449 deaths and seven percent of injury associated deaths. Two-third of reported drowning deaths in 2011 occurred in people aged 15 and over, and almost 50 percent of all drownings occurred in males older than 15.

The higher rates of male exposure to aquatic environments is compounded by high risk behaviors such as swimming alone, not wearing a personal flotation devices (PFD) when boating or swimming, and alcohol consumption.

Of the two studies analyzed in this study, it was concluded that wearing a PFD reduced the risk of drowning by nearly half, and that there was no significant association between drowning and minimum legal drinking age.

Key finding:

- Drowning must be recognized as a serious public health issue and receive the same attention as other public health priorities.

Alcohol and Flying: A Deadly Combination

Federal Aviation Administration, N.D.

This study, focused on pilots, found that the number of serious errors committed by a pilot dramatically increases at or above concentrations of 0.04 blood alcohol concentration (BAC). However, other studies have shown decrements in performance with a BAC as low as 0.025.

Federal Aviation Regulation 91.17

- Eight hours from “bottle to throttle”
- Do not fly when under the influence of alcohol
- Do not fly while using any drug that may adversely affect safety

Cautions: A more conservative approach is to wait 24 hours from the last use of alcohol before flying. Eight hours “bottle to throttle” does not mean you’re in the best condition to fly.

Alcohol and Boating-Related Fatalities in North Carolina

Foss et.al, N.D.

The United States Coast Guard reported that 821 people died in boating-related incidents in 1997, but due to limitations in data collection, it is believed that that number is much higher. Alcohol use was considered a contributing factor in many of these fatalities.

Although an operator’s alcohol use has an effect in some cases of boating-related fatalities, it is more common that drownings are independent of the operator’s impairment, and more focused on the individual’s alcohol use. Only about 20 percent of boating fatalities are due to crashes and the resulting trauma. The majority of boating-related deaths are due to drowning. In boating, unlike in driving, a passenger’s sobriety has a great effect on their own safety as well as that of others. Alcohol use may contribute to the death of a passenger just as much, if not more so, than alcohol use by the operator.

Due to compounding factors, impairment from alcohol use is particularly more dangerous for persons in an aquatic environment. *This article also includes findings on low-BACs and time of day as related to risk.*

Key finding: In boating, unlike in driving, a passenger’s sobriety has a great effect on their own safety as well as that of others. Alcohol use may contribute to the death of a passenger just as much, if not more so, than alcohol use by the operator.

APPENDIX A

Table 2. Comparison of Boat and Demographic Characteristics for Fatality and Control Subjects, Maryland and North Carolina

	No. (%)	
	Fatality Subjects (n = 221)	Control Subjects (n = 3943)
Boat type		
Cabin motorboat	18 (8.1)	597 (15.1)
Open motorboat (>3 m)	154 (69.7)	3118 (79.1)
Small boats*	49 (22.2)	228 (5.8)
Time of day		
7:00-10:00 AM	26 (11.8)	79 (2.0)
10:01 AM-noon	21 (9.5)	336 (8.5)
12:01-2:00 PM	31 (14.0)	649 (16.5)
2:01-4:00 PM	43 (19.5)	971 (24.6)
4:01-6:00 PM	27 (12.2)	853 (21.6)
6:01-8:00 PM	46 (20.8)	724 (18.4)
8:01-10:00 PM	20 (9.0)	296 (7.5)
10:01 PM-midnight	7 (3.2)	35 (0.9)
Day of the week		
Weekend	124 (56.1)	2685 (68.1)
Weekday	97 (43.9)	1258 (31.9)
Sex		
Male	204 (92.3)	2860 (73.4)†
Female	17 (7.7)	1034 (26.6)
Race		
Black	52 (24.3)‡	132 (3.8)‡
Nonblack‡	162 (75.7)	3324 (96.2)
Occupant status		
Operator	97 (43.9)	2108 (53.5)
Passenger	124 (56.1)	1835 (46.5)
Age, y		
18-20	14 (6.3)	89 (2.6)†
21-30	45 (20.4)	634 (18.4)
31-40	45 (20.4)	1008 (29.3)
41-50	42 (19.0)	858 (24.9)
51-60	36 (16.3)	557 (16.2)
61-70	25 (11.3)	205 (6.0)
>70	14 (6.3)	88 (2.6)
Activity§		
Cruising	90 (40.7)	1858 (47.1)
Fishing	85 (38.5)	1926 (48.8)
Drifting	36 (16.3)	1763 (44.7)
Anchored	16 (7.2)	785 (19.9)
Waterskiing	6 (2.7)	315 (8.0)
Racing	6 (2.7)	11 (0.3)
Towing	2 (0.9)	12 (0.3)

*Includes all boats less than 3 m long and all canoes, kayaks, and rowboats.

†Numbers do not equal n because of missing values.

‡Nonblack consists of 97% white fatality subjects and 98% white control subjects, with the remainder other nonblack races or unknown.

§There may be more than 1 activity per fatality subject and control subject; thus, the percentage will not add up to 100.