Volume II of the Final Project Report

RISK MANAGEMENT AND HUMAN ERROR IN RECREATIONAL BOATING:

# ANALYSIS OF HUMAN ERROR IN RECREATIONAL BOATING

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This is the final report of one aspect of a multi-year project. (There have been previous partial reports.) It is published separately to allow timely distribution of results. A comprehensive final report will follow. This work was funded by the Aquatic Resources (Wallop-Breaux) Trust Fund, administered by the U.S. Coast Guard.

16. Abstract

This report documents a project to assess the role of human error in recreational boating accidents. In so doing, it reveals both the dominant role of human-error in boating accidents, and the strong relationship between the type(s) of boats involved in an accident and their most-important human-error causes. These relationships are portrayed in tables that present the results of analyzing over 3000 accidents that occurred over a recent 3-year period, (including all the fatal accidents on which sufficient information was available,) in terms of the human-error causes of accidents involving each of nine standard boats types for which data are available. This outcome is useful in developing safety strategies that effectively impact the most important causes of boating accidents.

Related to this, the report also documents the development of a process for determining human-error accident causation on a routine basis, as part of a national system of boating accident statistics. The reports of field investigations that form this system flow from the states into a national Boating Accident Report Database (BARD) that is maintained by the U. S. Coast Guard. In recent years, the BARD had developed to the point of including the narratives of investigative reports, as well as standardized accident descriptors, in an electronic form adaptable to automated access and analysis. For the first time, this allowed convenient viewing of masses of reports that included both accident narratives and the standard accident parameters (which had been manually coded for decades.) The accessibility of the narratives added critical information that allowed insight into the human causes of accidents. This discernment was coupled with a human-error-accident-causation taxonomy which was developed in stages through four years of the project to allow methodical coding and automated analysis of accident causes.

Stages of development of the human-error taxonomy are documented in the report, beginning with over 300 logically-implied categories, refined and limited to the more common, re-expressed in terms particular to different boat types, tested in use over the 2002 boating season in six states, (in computerized and tabular format,) and incorporated into a prototype of a Web-based version of BARD. The approach has wider application in transportation safety.

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# PREFACE

This report is Volume II of the final report of a project titled "Risk Management and Human Error in Recreational Boating" under a grant from the Aquatic Resources (Wallop-Breaux) Trust Fund, administered by the U. S. Coast Guard.[1] This volume treats human error in recreational boating. Wayne W. Becker served as Project Coordinator. A. James McKnight directed this study of human error in recreational boating and served as principal author of this report. Dr. McKnight was assisted by Anthony Pettit, who helped direct and participated in the analysis and coding of boater error. A. Scott McKnight prepared all formats for electronic data entry and analysis of compiled data.

The authors wish to acknowledge the contribution Philip Cappel and Bruce Schmidt of the U. S. Coast Guard Office of Boating Safety. Mr Cappel served as grant monitor, while Mr Schmidt supervised the Boating Accident Reporting Data Base (BARD.) The project could not have been completed without their help. Jim Stakem of CNSI-INC assisted in preparing data formats for inclusion in a prototype Internet-based version, BARD-Web.

The initial classification of over 3,000 boating accidents was carried out by a team experienced in recreational boating, consisting of: Robert Slaff, Richard Dean, Edward Harner, Dan Jarzynski, Richard Miller, and John Gainer. A pilot test was conducted under the auspices of the Boating Accident Investigation, Reporting and Analysis Committee (BAIRAC) of the National Association of State Boating Law Administrators. We appreciate the contribution of the BAIRAC chairperson, Mr. Fred Messmann. Pilot test data entry was assisted by personnel from state boating law administrations as follows: California: Amy Rigby, Ray Tsuneyoshi; Connecticut: Frank Disbrow, Monique Powe; Maryland: Victoria Parker; Nevada: Fred Messman, Kathy Boyne; Tennessee: Darren Rider; Wisconsin: John Lacenski, Alisa Johnson and Leanne LeBoeuf.

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[1] The initial development of these subjects is presented in a report titled Assessment of Risk Management and Human Errors in Recreational Boating Safety Applications which is available on the Marine Safety Foundation (MSF) website, www.marinesafety.org , and from the National Technical Information Service (NTIS) as publication # PB 2002-102695. A second, interim report titled Building the Foundation for Risk Management and Human Error Analysis for Recreational Boating describes basic choices and structure of a proposed risk management system and refines the boating human-error taxonomy through several stages and employs it in the analysis of over 3000 boating accidents reported during the period 1996 - 1998. (This second report is also available on the MSF website and from NTIS as publication # PB 2005-100216.)

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**SUMMARY**

This report describes the objectives, methods and findings of an Analysis of Human Error in Recreational Boating, carried out under a grant from the Aquatic Resource Fund, administered by the U. S. Coast Guard. The project began with the preliminary identification of some 300 possible errors capable of resulting in damage, injury or death in recreational boating. This list was confined to those errors that could be directly tied to accidents on the basis of information available through accident investigation, including those errors involving making the boat safe to operate, preparing for safe operation before shoving off, operating safely while the boat is in use, coping with various unsafe situations, and handling emergencies. It did not attempt to identify various background conditions that could influence the chances of an accident, including characteristics of crew, vessel, or environment whose contribution to a particular accident could not be ascertained with reasonable certainty from the circumstances of the accident. The list was initially applied to some 1000 accident reports read by project staff, resulting in its refinement.

The list of possible errors was applied by a panel of six experienced recreational boating professionals to the analysis of 3,300 boating accidents detailed in the USCG Boating Accident Reporting Database (BARD) over a three-year period. Combining similar error categories and bypassing those errors that seldom or never occurred resulted in a manageable set of 67 errors, contributing to more than 1% of boating accidents for at least one of the nine basic boat types differentiated in the BARD system. This was reapplied to the data with results that showed a surprising difference in the dominant sources of human error from one boat type to another.

With the assistance of the Boating Accident Investigation, Reporting and Analysis Committee (BAIRAC) of the National Association of Boating Law Administrators (NASBLA), a pilot test was undertaken to assess the abilities of accident investigators and BARD analysts to identify and code errors in accidents occurring in six participating states during 2002. The error coding process was simplified by allowing analysts to view the 14-24 errors that were found for a given boat type, rather than the whole list of 67 errors. The error descriptions were also revised to tailor them to the individual boat types. The results of the pilot test were highly positive, providing feedback for improving the error definitions and instructions.

Coincident with completion of the pilot test, the BARD data entry process was being modified to permit state analysts to post reports directly to the Web on a continuing basis. The project staff worked closely with the CNSI, the Web development contractor, to devise a suitable format. Also, a sample of accidents was coded both by BARD analysts and the investigating officers reporting the accidents. The analysts were deemed to provide the most accurate codes.

The results of the project are highly illuminating as to boater errors and furnish data that can be applied to informational and educational programs for recreational boaters. The most illuminating finding is the degree to which the errors vary according to vessel type. Given that recreational boaters generally do most of their boating in just one or two types of vessels, the results carry clear implications for the manner in which boating safety measures can be beneficially tailored to boat type.

## INTRODUCTION

The largest single source of risk in recreational boating is human error. What contributes most heavily to boating accidents is failure to carry out the activities in a way that will minimize risk, such as not putting on a life preserver, overloading a small boat, or operating too close to other boats. However, most of the errors leading to recreational boating accidents do not appear in the statistical summaries provided in analyses of accident causes. Inability to identify the full range of errors hampers attempts to address them in boating safety efforts. For example, while we know that capsizing is a major source of recreational boating fatalities, the statistics that tell us so are not very enlightening as to the reasons why boats capsize. Several errors can lead to capsizing, including standing up at the wrong time, steering an unsafe course through rough seas, and setting out under the wrong conditions. Combating the various errors involves different approaches to instruction, regulation and vessel design.

Recreational boating is far from unusual in the involvement of human error in accidents. Indeed, accidents of all kinds — transportation, household, occupational, recreational — are primarily the result of human error. Yet, like boating accidents, relatively little effort has been made to catalogue the various accident-producing errors. One of the main reasons is the perishable nature of error information. In the aftermath of an accident, the physical structures are available for study. Investigators can examine cars, boats, roads, waterways and other elements of the physical environment for their contribution to accidents. However, the behavior leading to accidents has vanished and can only be inferred from circumstances, supplemented by the testimony of participants or witnesses. A second reason for the lack of insight into errors is the wide range of behavioral contributors. Coding and analyzing what amounts to large numbers of very different causes has been difficult. Yet given the large role played by human error in boating accidents, gaining insight into their nature and magnitude can be highly valuable in efforts to improve boating safety.

### Identification of Accident Causes

There are two basic methods by which the causes of accidents, including human causes, are identified. The most widely applied method is that in which trained investigators examine the conditions surrounding an accident, interview those who were involved in it or observed it, piece together events and make inferences as to cause. This *investigative* analytic method has been applied to accidents of all types and has been the leading source of insight into the direct causes of accidents. The degree of analysis ranges from the immediate on-scene information collected by responding officers to the follow-up, in-depth investigations carried out by teams representing a range of technical disciplines.

The limitation of the purely investigative analysis of accidents is its restriction to the direct causes capable of being inferred from information about the accident available after the accident has occurred. There are, however, many influences upon accidents that cannot be directly tied to an immediate cause.  A good example is alcohol. If a boater drinks heavily, staggers to the boat, is seen to swerve back and forth at high speed, and runs into a dock, alcohol is clearly a cause. However, there are many cases in which the role of alcohol is not so clear; for example, a drinker who lacks a good grip on the boat and falls overboard. Would it have occurred had the person been totally sober? Because of this limitation, the role of alcohol is generally inferred *statistically* by comparing the alcohol levels of boaters in accidents with those of boaters in general. Just such a comparison showed that boaters with the equivalent of five drinks in the system are ten times more likely to die in a boating accident than boaters free of alcohol (Smith et al. 2001). Statistical analyses have been used to study the effects of such background factors as hours of operation, maintenance schedules, and individual experience, although not in recreational boating.

The boating errors addressed by the analysis described in this report are those that are sufficiently closely tied to individual boating accidents, evident through the investigative analyses carried out by marine police who respond to accidents in various jurisdictions within the states. Identifying the more remote contributors to accidents through statistical analysis involves collection of data on the involvement of various factors both in accidents and in everyday boating and, to be done validly, must focus upon one potential cause at a time.

**Sources of Boating Accident Information**

Access to information concerning human error is available in most accident reports through narrative summaries prepared from information provided by investigating officers. Heretofore, this information has rarely been entered into the computerized files maintained by the state agencies responsible for maintaining boating accident records. It has, therefore, often been missing from the records forwarded to the U. S. Coast Guard. However, this picture has been changed with the introduction of the Boating Accident Report Database (BARD). This database contains information recorded in the Boating Accident Report (BAR) completed by those investigating boating accidents within each state and filed with the cognizant state agency.

In participating states, specialists enter data from the BARs into an automated file, a copy of which is forwarded to USCG on an annual basis. The file contains information concerning activities and conditions prevailing at the time of the accident, PFD use, identification and characteristics of the operator and the boat, identification and descriptions of any dead or injured individuals, and extent of damage. The computerized narratives often abbreviate the longer, hard copy versions of the original state reports. Small samples of hard copy and computerized narratives from selected states were reviewed to see how well the latter summarized the former with respect to descriptions of boater error. The outcome was quite favorable. Omitted information consisted primarily of details, the absence of which did not detract from the ability to identify errors. Where human error information was missing from narratives, it was generally missing from the hard copy as well.

It is apparent that the BARD represents a significant technological advance in accident data collection and processing. The availability of BARD allows the analysis of boater errors from the full range of accidents reported each year. The ability to process large numbers is extremely valuable since it allows boater errors to be classified by various characteristics of boats, boaters, waterways and environment, while still having enough numbers in each category for reliable estimation of risk associated with each error.

## Identification of Boater Errors

The BARD provides annual statistical summaries of recreational boating accidents, classified by various characteristics of the boats involved, locations, prevailing conditions, and the boaters. Accident causes associated with the various characteristics are also identified. Of the18 causes that involve errors directly leading to accidents, only half contribute more than 1% of reported accidents. Of these, several fall short of detailing what went wrong to the extent needed to guide preventive efforts. "Careless/Reckless Operation" or "Rules of the Road Infraction" communicate little as to what the boater did wrong. While "No Proper Lookout" indicates the general nature of the error there is no way of knowing where the boater should have been looking. The advice to keep a sharp lookout seems less helpful than saying where to look under various circumstances.

The narrative descriptions of accidents in the BAR's and the BARD system provide a basis for identifying human error yet do not, in themselves, identify errors in a way that can guide preventive efforts. Since various accidents involve somewhat different sets of human errors, it takes a lot of reports to identify the full range of errors that occur. Moreover, focusing preventive efforts where they will do the most good requires knowing *how often* the different errors occur. Doing this with any validity would require interested parties to pore over stacks of reports, keeping in mind which errors seem to crop up most often. Some way for coding and summarizing the errors revealed in the content of the BAR's was needed.

To guide preventive efforts, numbers of boater errors need to be grouped into categories that are specific enough to make clear what is needed to avoid them, yet broad enough to allow similar errors to be dealt with collectively. Categories that are too broad will provide too little guidance to preventive efforts; those that are too narrow will result in too many categories to be practically useful.

## Project Objectives

The objective of the effort described in this report was to develop a scheme for classifying the errors leading to boating accidents for use in reporting and analysis. An analysis of boater errors leading to accidents was undertaken with four objectives:

Methods Development —to develop a rigorous and useful method for classifying boater errors for reporting to the accident data base (BARD) and subsequent analysis

Feasibility Testing — to determine the ability of trained analysts to apply the coding system to a set of accidents

Error Identification — to identify and classify the most common errors leading to boating accidents, and

Pilot Test — to test the ability of BARD data analysts in several states to code accidents, leading to improvements ending in a field-useful coding system.

## METHODS DEVELOPMENT

The first step in the analysis of boater error was to develop a classification of boater errors that could be applied to the BARD narrative reports. It is difficult to arrive at a classification system without knowing something about the items to be classified; it is equally difficult to examine a vast array of items themselves without having some idea as to how they might be classified. The way out this apparent dilemma is typically through an iterative process, starting with an initial classification based upon what is known of the items, attempting to classify items based upon it, and continually modifying the classification to accommodate the items. This iterative process was employed with the BARD narratives.

### Development of Initial Classification

An initial classification was developed based on what is known of boating accidents, borrowing somewhat from accident classifications for other types of transportation vehicles. The BARD accidents were then sorted using the preliminary classification, with repeated revisions of the coding process as individual accidents revealed the need for additional categories, as well as the subdivision or combination of existing categories.

For any actions or behaviors required to operate a boat successfully, failure to correctly complete these actions may take the form of many different identifiable errors. An initial error classification was generated with the aid of an index developed from a number of materials describing the requirements of safe boating. To test the classification, a sample of 1,000 accident reports was drawn from the 1997 BARD file. It included all of the 689 fatal accidents for which narratives were provided, plus a sample of 311 non-fatal injury accidents. The lack of sufficient information in narratives to make valid inferences as to boater error led to exclusion of 58 fatals, reducing the total to 942 accidents. A special format was created in ACCESS to allow the accidents to be classified in terms of the initial coding system. To provide all of the data recorded in the BARD file would have confronted an analyst with far more information than needed and required scrolling through a volume of unrelated information. The format used limited data that could be presented on a single screen and included, for each of the selected accidents, the *narrative*, the *state* in which the accident occurred, the *number injured or dead*, the *date and time* of the accident, the *type, length* and *year* of construction for each boat involved and the official accident report number. The special format was developed strictly for use in the study. Ultimately, entry of human error information would become part of the basic BARD data entry process.

The accident categories in the boater error classification system were assigned code numbers. The project staff then examined the narrative of each accident as it appeared in the file of 1,000 accidents and assigned error code numbers to each accident based upon the narrative. Since more than one error can contribute to an accident, the ACCESS format provided space for up to four error codes for each accident. The order that errors were listed was purely arbitrary; no attempt was made to order the errors in terms of their contribution to the accident. In almost all cases, the elimination of any one of the multiple errors would have prevented the accident from occurring; this is often referred to as the "but for" criterion, meaning that but for the error, the accident would not have occurred. For example, where an accident resulted from setting out in rough weather, not distributing weight properly, and improper handling of the boat, avoiding *any one* of these errors might have prevented a boat from swamping. No one error was more important than another. As the classification progressed, codes needing revision were identified and the classification system was modified accordingly.

**Initial Classification System**

The classification system and codes that resulted from the iterative process consisted of approximately 300 codes. The number of codes had to be great enough to accommodate any and all possible errors. Considerable reduction in numbers could be expected as unused codes were eliminated. The codes were initially classified into the following broad categories:

1000 PREPARATION FOR BOATING — advanced preparation for long term boating
2000 PREPARING FOR OPERATION — preparation for a specific boating occasion
3000 SAFE OPERATION —actual operation of the boat under normal conditions
4000 OCCUPANT PROTECTION —protecting the occupants against death or injury
5000 ENVIRONMENTAL LIMITATIONS — safe operation of the boat in rough weather and limited visibility
6000 EMERGENCIES — responding quickly and effectively to sudden danger

The first three categories represent a sequence of behaviors leading up to and including safe boat operation while the fourth involves protecting occupants against the consequences of unsafe operation. The last two superimpose upon basic boat operation the special demands of certain environmental and emergency situations. The more commonly known division of events into pre-accident, accident, and post-accident is useful in classifying the full range of possible influences upon safety. However, boater behavior falls largely in the "pre-accident" phase. Safety in the "accident" phase is largely dependent upon design and condition while survival in the "post" phase is primarily the province of medical and rescue services, although some involve activities such as retrieving people from the water.

**Results of Initial Analysis**

The number of errors, along with the percent of accidents to which each error contributed, were obtained separately for each of the nine major boat types. There is nothing gained by presenting the numbers here since a later section of the report combines them with data gathered from the larger sample of cases ultimately investigated. The purpose of the initial error analysis was solely to assess the potential of the preliminary list in identifying the behavioral contributors to boating accidents.

The wide range of errors revealed by the analysis should not come as news to anyone familiar with recreational boating, particularly those experienced in what is required to operate the various individual types of boats. What was more illuminating was the relative frequencies of various errors; that is, how often each contributed to a boating accident. Being able to quantify the degree of involvement for different errors can help to (1) prioritize efforts to overcome errors through education and enforcement and (2) track the success of such efforts over time. The number of cases studied in the initial analysis was too small to provide reliable estimates of problem magnitude for most errors, particularly when classified by type of boat. However, the rough numbers supplied were sufficiently enlightening as to accident causes to provide a glimpse of what could be gained by making the accident coding process a part of the basic BARD data entry process. In doing so, a number of modifications of the process would be needed:

> Multi-year samples — As mentioned earlier, the number of cases making up a single year's file is too small to permit reliable estimates of relative error prevalence, particularly when classified by individual boat type. All sail boats combined — auxiliary and sail only — totaled a mere 34 accident cases in the 1997 file. Gaining enough cases for reliable estimation of errors for several of the boat types would require multi-year data samples.
>
> Revision of error codes — During the initial analysis, many errors not on the preliminary list of codes were found in the 1997 BARD file narratives, and many of the codes on the list were not reported in any accidents. Such was expected since the initial list had to be generated through recourse to sources other than boating accidents and was, as noted earlier, considered provisional at the outset. Those errors discovered though the preliminary accident analysis were added to the code list during and following the initial analysis. However, no codes were eliminated for failure to appear within the limited number of accidents reviewed in the initial analysis.
>
> Time required — The identification and coding of errors from narrative and other information was a time consuming process. However, if error coding were to become a part BARD, each accident would be coded as part of the basic data entry process. For analysts already familiar with an accident case through preparation of the narrative and entry of other BARD data, the amount of additional time required to enter error codes would be negligible.

## FEASIBILITY TESTING

The second objective of the project was to assess the ability of trained analysts to code and enter error data by drawing an additional sample of accidents drawn for BARD files and having the errors coded by analysts given instruction in the coding process.

### Methods

To assess its feasibility, the coding system was applied to large samples of recreational boating accidents obtained from BARD files for a three-year period. This discussion of study methods will describe the number of cases making up the sample, the people engaged as analysts, the data entry process and the instruction of the analysts.

Number of cases
The cases selected from the 1997 BARD file for the preliminary analysis just described were added similar samples drawn from the 1996 and 1998 files, the latter being the most recent year for which files were complete at the time of the analysis. The plan was to include all fatal accidents plus enough additional, non-fatal accidents to yield a total of 4,000 accidents. This meant adding a total of 3,000 new accidents, of which approximately 1,300 were expected to be fatal accidents and 1,700 non-fatal. No limits were ultimately placed on the number of auxiliary sailboats, sail only, canoes and kayaks, houseboats, pontoon boats, and rowboats; their relatively small numbers required incorporating all of the accident cases that were available. Accidents involving these boat types made up approximately half of the 4,000 accident sample. The remaining boat types — open motorboats, cabin motorboats and personal watercraft — were selected in proportion to their total numbers to make up the rest of the sample. The sampling process would end up providing a sample that is roughly representative of the population of boats in accidents but with sufficient numbers of all boat types to yield reasonable, reliable estimation of error frequencies of all boats.

Error Analysts
Ultimately, the coding of boater errors would be the responsibility of the analysts who enter data in the BARD system. However, since the coding under study is an emerging system, not heretofore a part of the BARD data entry process, participation of state analysts was not necessary during the feasibility test phase. Being able engage a small group of qualified analysts in one nearby area made the process far more efficiently managed than one requiring the participation of analysts from several states.

Six experienced recreational boating experts agreed to analyze BARD narratives in the feasibility test phase of the study. Each of the analysts was called upon to code 500 accidents, allowing the expected sample of approximately 3,000 additional cases to be completed in two months time while giving each analyst a sufficient number of cases to warrant the preparation it would take. The group included members of the U.S. Power Squadron and USCG Auxiliary, a retired USCG officer, the boating columnist for a local newspaper, a member of a state boating safety advisory council, and a boat broker.

Data entry process
The entry of data employed the same ACCESS process used earlier to enter the error codes in the initial exploratory phase. Under this process, coders were provided a computer display containing the narrative, the state in which it occurred, severity, date and time of the accident, type and length of boat, and alcohol involvement. The format furnished space to enter up to four codes representing errors contributing to the accident. The information provided to analysts did not contain anything that would permit identification of the parties involved in accidents, thus assuring anonymity and privacy. Each analyst was provided a code list with explanations of each code and the number to be assigned. The ACCESS spreadsheet, along with the project-prepared code list, made up the materials provided each project analyst.

Analyst Instruction
The analysts were given a half-day program of instruction in use of the error codes. The program included the following:

Objective — the objective of the coding process, that is, to identify the errors that contributed to the accident or its consequences

Classification — the structure of the errors represented by the codes, the manner in which it reflects the range of activities involved in a boating event, and the organization of the error list.

Codes — explanation of the individual error codes, ambiguities clarified and questions answered.

ACCESS — use of the ACCESS data entry template, including how to enter a code, find a specific case, and change a code.

Practice — a practice session in which analysts coded some 12 cases selected to represent a wide range of errors

Quality Assurance
To assure a reliable coding process, the project staff responsible for its development monitored results of the analysts' activity, submitted through e-mail, on the first group of cases. Use of incorrect codes and failures to use were pointed out to the individual analysts, while problems of a general nature resulted in clarification sent to the group. Eventually, the staff ended up reviewing all cases involving the codes that were causing the most difficulty and correcting the entries where necessary.

**Results of the Feasibility Test**

The feasibility test was intended to reveal two things, (1) the specific errors that led to the occurrence or consequences of accidents involving various types of boats and (2) problems with the process by which errors were identified. While the codes entered by the analysts provided acceptable descriptions of boater error, to be described in the next section of the report, a number of problems were revealed. Some of the problems were identified early in the coding process and led to changes that were incorporated into the process itself. Others discovered later were applied by the project staff after the analysts had completed their coding.

Shortfalls — The numbers of cases analyzed totaled 3,327, considerably below the projected total of 4,000. The shortfall was due to lack of enough accidents to analyze, specifically (1) the large number of the available fatals having no survivor to provide information as the circumstances under which the accident occurred, (2) the number of non-fatals involving more than one boat where no errors could be attributed to the crew of the designated boat type. The number of non-fatals did not fall below projection for the three high-accident boat types (open motorboat, cabin motorboat and PWC's) owing to the large numbers available. The projected total of 4,000 could have been realized by calling upon analysts to go back and add more of the high accident boat types. However, this would have accomplished little since there were already more than enough of these to provide reliable estimates of error frequency.

Limited agreement — During the training period, where analysts were coding the same cases, a comparison of the codes they assigned showed a lack of high agreement among analysts. Most of problem laid in the length of the original code list- close to 300 categories. Navigating through it to find the codes fitting a particular accident could take several minutes, even for someone quite familiar with it. Analysts differed as to how many and which causes they actually looked at in considering individual accidents. Few of their choices could be considered "wrong." However, a shorter list of codes would allow all analysts to review a full set of candidate codes, thus arriving at more valid classifications and higher agreement.

Incomplete data — The degree of detail provided in the BARD narratives varied enormously, as previously mentioned. Where the information provided for a particular accident was too sparse for accurate coding, it was to be bypassed during the feasibility test. In the hands of the BARD analysts, the problem of incomplete data should be greatly reduced by (1) access to the original BARs, which sometimes provided more data than were available in the BARD narrative summaries, (2) the ability to question investigating officers in order to clarify ambiguities and (3) the ability to improve the completeness of original BAR reporting through communication with reporting agencies (the knowledge that information is actually being used might tend to encourage more complete information).

Indirect causes — Certain codes employed in the feasibility test dealt with activity lacking a direct connection to the accident being reported. This was particularly true of the activities in the first category **PREPARATION FOR BOATING,** which had to do with assuring the safety of the boat and the operator rather than circumstances leading directly to the accident. They really fall in the "predisposing condition" category, more suitable to analyses of a statistical nature as described earlier. The lack of needed skill and/or knowledge is an example; it could be considered a cause only where the specific deficiency was clearly evident and not where it was only a presumption on the part of the analyst.

Misinterpretation — The review process disclosed cases in which the analyst clearly misunderstood the description of the error. One source of misunderstanding was the rather generic descriptions needed to accommodate the different forms that errors take with different boat types. The descriptions were often difficult to relate to the errors leading to specific accidents. Another source of misunderstanding was the small distinctions between certain types of errors, making it difficult to determine which code was appropriate to a given case.

Alcohol impairment — The primary source of information on the role of alcohol impairment as an accident cause was primarily the narratives, where the investigating officer indicated that one or more occupants of the boat were clearly impaired and that the impairment clearly contributed to the accident or its consequences. As mentioned in an earlier discussion, alcohol can also be a contributor even where impairment isn't obvious, and its involvement is better determined statistically than from accident circumstances. However, the error coding does at least provide a reasonably valid indication of relative differences across boat types.

## IDENTIFICATION OF BOATING ERRORS

The ultimate objective in the human error identification process is to identify, list, and prioritize the errors leading to recreational boating accidents. Although the purpose of the feasibility test was primarily to evaluate and improve the error coding process, the results gained from applying the procedure to some 3,300 accidents did provide a means of identifying errors leading to recreational boating accidents. This section of the report will describe the means by which results of the coding process were applied to the classification and enumeration of boating errors.

### Classification of Errors

The original list of close to 300 error categories was compiled from a variety of materials dealing with recreational boating accidents. It was intended as a starting point in identifying and inventorying errors contributing to boating accidents. The first step in that process was to fashion a system for classifying errors that would provide a means of directing boating safety efforts where they are most needed. The development of a classification system involved (1) grouping errors into a structure by placing similar errors into categories, (2) separate the classification by boat type, and (3) excluding errors that do not occur often enough in any one type of boat to warrant being made a part of the classification system.

<u>Developing a Classification Structure</u>
The first step to classifying human errors was to develop a structure that groups errors into categories, the elements of which are similar enough to be handled by similar preventive measures. A structure composed of internally homogeneous categories is frequently referred to as a "taxonomy." While this term implies the inherent structure of natural phenomena, the defining property here is primarily functional — errors are grouped on the basis of similarities with respect to what it takes to prevent them.

Creating a structure was a highly iterative, trial and error process. Take, for example, errors with respect to what is termed "lookout" in boating, which is directing eyes and attention toward various aspects of the marine environment. In examining boating accidents, eight different forms of a lookout appeared to be subject to error: general all-round surveillance, the path ahead, a new path (course change), small objects in the water, articles of gear aboard the boat, the depth of the water close to the boat, lookout during darkness, and seeing around or beyond obstructions. All involve somewhat different acts. In this case, the number of categories exceeded those in the list of 300 as the original categories were subdivided. In other cases, the number of categories was reduced as those on the original list were combined; for example, checking the route in advance was reduced from seven to two individual checks.

Categorizing by boat type
As the classification proceeded, it became apparent that the pattern of errors differed greatly across the nine basic types of boats accounting for the overwhelming majority of accidents: auxiliary sailboats, cabin motorboats, canoes and kayaks, houseboats, open motorboats, personal watercraft, pontoon boats, rowboats, and sailboats. Separating errors by type of boat reduced the number of errors that would have to be reviewed in the coding process. In actual data entry, the BARD could be programmed to provide the boat-specific list automatically as analysts entered the boat type. In addition to simplifying the data entry process, boat-specific lists would reduce the problem of misinterpretation by allowing generic descriptions to be replaced by descriptions that are more descriptive of errors encountered with individual types of boats.

Setting minimum frequencies
Most of the errors making up the original list of 300 codes occurred rarely, if at all. Since the objective in generating the original list was to be as exhaustive as possible, minimizing the chance that an error might be overlooked, the inclusion of rarely occurring errors was not surprising. However, the primary purpose in combining errors into categories was to be able to count up accidents by error category and thus allow preventive efforts to focus upon those errors responsible for the most accidents. While every accident is preventable, making every accident - producing error the target of prevention would be prohibitively expensive.

Some minimum contribution to the total accident picture was needed to provide a criterion for inclusion in the BARD error coding process. The criterion set was greater than 1%; that is, an error had to be involved in more than one percent of all accidents for at least one of the nine boat types in order become a part of the classification system. Application of the >1% criterion to the list of errors resulting from the error classification process led to the inclusion of 67 different error categories in the coding process. Because of the sizeable differences across boat types in vulnerability of error, the number of errors per boat type ranged from 14 for pontoon boats to 25 for open motorboats.

**Errors by Boat Type**
The tables that follow in this section of the report present the results of the error classification process, with the numbers and percent of boating errors being shown for each boat type. The table entries are expressed in terms of the *activities incorrectly performed* rather than the errors themselves since this is the form in which the data were collected from the boating experts during the feasibility test phase. However, the discussion that accompanies the tables expresses results in terms of errors as do the data collection formats ultimately developed for integration into BARD, described later in this report.

The boat types are presented in alphabetical order, as they are in most of the USCG data presentations. As noted, the errors listed include only those contributing to more than 1% of the accidents for that boat type. It will become apparent that the pattern and frequency of accident-producing errors differ greatly from one type of boat to another. Only those errors made by the operator or passengers of the particular boat type represented by the table are listed. Where more than one boat type was involved in an accident, the errors occurring on each boat are listed separately.

In the tables, data are provided as follows:

Data Source — The error data were compiled from BARD files for the years 1996 - 1998 as described in the previous section.

Boat types — All boat types listed in the BAR are included except airboats and inflatables, which totaled only six and 19 reported accidents respectively over the three-year period.

Number — "N" refers to the number of accidents involving the particular error found in the three-year BARD.

% — This is the percent of all accidents resulting from the particular error for a given boat type. It can
possibly add up to more than 100% due to multiple causes, but also less than 100% due to errors not listed (that is not more than 1% of cases)

The error frequencies for all boat types are consolidated in a single table as Appendix 1. The differences across boat types are more clearly seen in the single table than the separate tables that follow in the text. However, the separate tables and the discussion that accompany them offer the advantage of wording that is more descriptive of the form that errors take in each boat type.

Precision of estimates

In considering the results, the numbers and percentages based on three years of data should be treated as indicating *order of magnitude* rather than precise quantities. The fact that involvement of individual causes is shown to tenths of a percent should not be interpreted as implying that high a degree of precision in estimating error percentages. The identification of cause represents the judgement of one analyst, reviewed by a member of the project staff, and is based upon information provided in BARD narratives, which at that time was often minimal. Moreover, the error frequencies found in one time period do not necessarily correspond to those that will be found in another. What the numbers do indicate is the *relative* involvement of certain errors in boating accidents for a particular type of boat. As noted earlier, making the analysis part of the BARD data entry process, where analysts often have access to more information than captured by the data base, would furnish more precise estimates of the extent to which the various behaviors contribute to accidents involving each type of boat. However, until that time, the information provided in this report is certainly more informative as to the causes of recreational boating accidents than what has been available to the present time.

Accident Severity

No distinction is made between fatal, injury and property damage accidents in this analysis. First, the numbers at each severity level are too few to provide reliable estimates of error when cases are separated by boat type. Second, and equally important, there is often little difference between the levels of severity when it comes to boater errors. In some other areas of activity, fatal and non-fatal accidents are traced to widely different causes. In automobiles, speed is generally the difference between a fatal crash and a fender-bender. However, in recreational boating, most deaths are due to drowning and whether boaters survive or drown is not highly dependent upon the errors that put them in the water.

**Auxiliary Sailboats**

Errors involving lack of adequate visual search (often referred to as improper lookout) were the leading causes of accidents involving auxiliaries, as is the case in most transportation accidents. Failure to look ahead, exercise all-round surveillance or overcome visual obstructions together contributed to almost a third of the accidents. One contributor to the problem is the sail, notably the jib, which often concealed intersecting boats and could be prevented by positioning someone leeward to look for approaching boats. On other occasions, the helmsperson became distracted by something requiring attention and failed to notice some boat or structure ahead.

**Table 1. Auxiliary Sailboat**
(202 cases)

| Boater errors, i.e., activities not correctly performed | # | % |
|---|---|---|
| Looking ahead to see obstructions to the intended path | 38 | 18.8 |
| Keeping sufficient distance from other boats, particularly for wind/wave conditions | 22 | 10.9 |
| Exercising 180° surveillance, looking around or behind sail | 13 | 6.4 |
| Steering and sail handling so as to maintain balance | 12 | 5.9 |
| Assuring a firm grip, or secure footing on the boat when wind and sea conditions warrant. | 12 | 5.9 |
| Overcoming vision obstructions imposed by, passengers, or other vessels. | 10 | 5.0 |
| Keeping sufficient distance from land and land structures for conditions. | 10 | 5.0 |
| Looking to check position of the vessel relative to depth of water | 8 | 4.0 |
| Giving way to boat on starboard tack. | 7 | 3.5 |
| Using navigational aids to determine position or course relative to hazards | 7 | 3.5 |
| Shortening sail when wind conditions warrant. | 7 | 3.5 |
| Maneuvering at a safe speed when approaching boats, docks or other structures | 7 | 3.5 |
| Assuring that rigging has been properly maintained. | 6 | 3.0 |
| Maneuvering properly in tight quarters, e.g., to bring boat safely alongside dock, other boats. | 6 | 3.0 |
| Assuring that engine has been properly maintained to prevent power loss | 6 | 3.0 |
| Spilling wind where needed. | 5 | 2.5 |
| Controlling one's own consumption of alcoholic beverages | 5 | 2.5 |
| Maintain control in heavy wind, waves, surf. | 4 | 2 |

Problems involving insufficient distance from other boats or fixed structures often resulted from failure to allow for wind or wave action when sailing close to other vessels. Crowded anchorages frequently saw sailboats cutting too close to anchored and moored boats. Low speed steering errors primarily involved docking under power in windy conditions, approaching docks too fast, or not maintaining enough way to steer properly. Failure to give way to boats on the starboard tack may have resulted from failure to see other boats early enough in some cases, but in most cases seemed to involve simply cutting it too close when crossing another sailboat's path, particularly in races.

Difficulties specific to auxiliaries often involved the use of sails. One was failing to shorten sail under windy conditions and being blown aground, into other boats, or onto various structures. Another involved failure to spill wind, more often in response to sudden gusts than to prevailing winds. However, the two categories sometimes overlapped. Given the wind and sea conditions under which sailboats operate, falls on board or overboard would be expected and were frequent causes of an accident. Several could have been prevented by keeping a strong grip on the boat, particularly while handling sails or carrying out other tasks, while others were the result of waves causing violent motion of the boat.

Failure to assure necessary maintenance generally involved engine failure at critical times or failure of rigging (e.g., dismasting). Not using charts or other navigational aids led to running aground or up on rocks. Alcohol-related accidents were relatively infrequent and involved collisions with boats and docks, falling overboard and reckless behavior on board.

**Cabin Motorboats**

Failure of cabin motorboat operators to notice things ahead include other boats, anchored or moving, small floating objects or navigational markers. Many times, operators were distracted by people or various tasks, or their views were obstructed by passengers on the foredeck or by the foredeck itself when the bow was raised at high speeds.

Alcohol-impaired operation of cabin motor boats was high, on a par with that of open motorboats, canoes & kayaks, and rowboats. The majority of alcohol-related accidents on cabin motorboats resulted in collisions with other boats or fixed objects, typically causing damage and often injury to others. Falling overboard figured more highly on other types of boats.

Accidents resulting from allowing insufficient space included getting too close to other boats when docking or traveling, not reacting properly to an unexpected maneuver, or trying to maneuver through a crowded anchorage. Failing to check water depth and hitting the bottom was as common in power boats as sailboats, despite their relatively shallow drafts. It is possible that power boat operators are somewhat less mindful of depths. Some of the problems seem due to frequent operation at night where points of land are not so readily visible. Lack of a firm handhold was a common cause of falls overboard and injuries on board as boats traveling at relatively high speeds hit waves or wakes. Sometimes it happened when passengers were seated on the foredeck or the edge of the cockpit; on other occasions they were in the act of moving around inside or outside the cabin or cockpit.

**Table 2. Cabin Motorboat**

(408 cases)

| Boater errors, i.e., activities not correctly performed | N | % |
|---|---|---|
| Avoiding distraction, looking ahead to see obstructions to the intended path | 62 | 15.2 |
| Controlling consumption of alcoholic beverages | 44 | 11.0 |
| Keeping sufficient distance from other boats for wind and wave conditions | 39 | 9.6 |
| Assuring a firm grip, or secure footing on the boat when conditions warrant | 25 | 6.1 |
| Using navigational aids to determine position relative to hazards, e.g., rocks, dams, current | 25 | 6.1 |
| Looking to depth of water regularly | 29 | 4.9 |
| Adjusting speed to limits imposed by the proximity of other boats | 20 | 4.9 |
| Adjusting the boat's speed to limitations of night visibility | 20 | 4.9 |
| Keeping sufficient distance from land, shallows, navigation aids and other structures | 18 | 4.4 |
| Assuring that propulsion has been properly maintained to start, prevent power loss | 18 | 4.4 |
| Locating and/or detect unlighted objects in or approaching intended path | 17 | 4.2 |
| Assuring that controls are in operating condition (includes start, stop, throttle) | 15 | 3.7 |
| Exercising 360-degree surveillance for boats that may be approaching | 15 | 3.7 |
| Adjusting speed to limits imposed by operation in waves or wakes | 12 | 2.9 |
| Sniffing the bilge for presence of fuel vapors before starting the engine | 11 | 2.7 |
| Checking the intended route in advance for possible underwater obstructions | 9 | 2.2 |
| Maneuvering at low speed in tight quarters, e.g., docking or coming alongside | 9 | 2.2 |

Accidents due to high speed at night were almost unique to powered boats. Cabin motorboats had the second highest incidence (next to PWC'S) of accidents resulting from speeding near other boats. Much of the incidents resulted from creating large wakes near docks, in anchorages, or in narrow passages; however, many accidents involved instances of actually striking other boats. Operating too fast to respond in time to such unlighted objects as anchored boats, buoys, or piers, was also particularly frequent among cabin motorboats. Another speed related error involved operating too fast in approaching waves and wakes, with the result that the boat was damaged, swamped or capsized, or occupants were bounced about or thrown into the water. Finally, inadvertent operation of throttle or shift lever led to unexpected acceleration in forward or reverse, striking other boats, docks, or various structures.

Cabin motorboats exceeded all others in accidents due to failure to use charts and other navigational aids in determining position or charting courses, thereby running aground, striking rocks, or encountering other hazards that would have been otherwise identified. Fire and explosions that might have been prevented by detecting gasoline fumes before starting the engine were most common to this boat type. Low speed docking operations accounted for a number accidents, and several of the problems in adjusting to wind conditions involved docking maneuvers.

Finally, some cabin motorboat accidents were attributable to lack of maintenance. Engine failures caused a variety of accidents, the most common being loss of power or control and drifting into boats or shore structures. Others included cooling system and exhaust failures that caused fires, allowed water into the boat or sprayed occupants with scalding water, or controls that failed to work properly, causing unintended vessel movement resulting in collisions with boats, docks or other structures.

**Canoes and Kayaks**

The classification of boats employed in the BARD system at the time of the human error analysis placed canoes and kayaks in the same category. The results of the analysis are shown in Table 3. However, after the analysis had been completed, concern arose as to the possibility of significant dissimilarities between the errors arising in the two boat types. Canoeing seems a more social and less athletic activity than kayaking. In order to develop error lists for canoes and kayaks separately, the error codes assigned to the 291 Canoe-Kayak cases were reviewed and divided between the two boat types, 220 canoes and 71 kayaks. Since the codes assigned were those making up the original list of 300 errors rather than the final classification involving 67 basic codes, it was not possible to derive error frequencies or percentages corresponding precisely to the behaviors shown in Table 3. However, it was possible to gain a picture of the differences between the two boat types.

For both canoes and kayaks, the proportion of fatal accidents resulting from failure to wear a PFD under conditions creating a significant chance of immersion and drowning was the highest of all boat types. Conditions included high winds, strong currents, cold water and other conditions that threaten one from remaining afloat. Similar problems involved the inability to stay afloat in the case of immersion (cold water and inability to swim). In the case of canoes, some drownings resulted from failure to stay with the boat and make use of its flotation, second only to rowboats in this problem. Failure to have PFD's available to begin with was second highest to rowboat accidents. The conditions requiring a high degree of skill in handling canoes or kayaks were similar to those that warrant wearing PFD'S, including strong current (e.g., rapids), rough weather and the poor navigability of the waterway (rocks, tree limbs, etc.). The accidents that could have been avoided had canoeists and kayakers considered these conditions relative to their skill in deciding whether to operate the vessel added up to almost a fifth of the total. The inability to handle rough weather or to seek shelter from it once it was encountered amounted to almost a tenth of all accidents. These overlapped the previous category but didn't include all cases involving the decision to operate since conditions were not always apparent in advance.

Accidents involving failure to check routes for waterfalls and dams is a situation largely confined to canoes and kayaks, and is a function of the types of waterways along which they .

**Table 3. Canoes and Kayaks**
(291 cases)

| Boater errors, i.e., activities not correctly performed | N | % |
|---|---|---|
| Wearing PFD when conditions create significant risk of immersion | 50 | 17.2 |
| Controlling consumption of alcoholic beverages | 43 | 14.8 |
| Operating safely while constrained by current | 41 | 14.1 |
| Remaining seated to avoid capsizing or swamping the vessel | 27 | 9.3 |
| Having the required number and type of PFD'S , e.g., wearable, throwable | 22 | 7.6 |
| Considering the weather in deciding whether to operate | 22 | 7.6 |
| Checking the intended route for locations of hazardous currents, (e.g., rapids) | 21 | 7.2 |
| Considering adequacy of the skills and knowledge relative to expected conditions | 20 | 6.9 |
| Wearing PFD when cold water would jeopardize chances of remaining afloat | 17 | 5.8 |
| Wearing PFD by occupants unable to swim and exposed to the risk of immersion | 14 | 4.8 |
| Responding to rough conditions when they occur. | 13 | 4.5 |
| Considering the basic design of canoes and kayaks relative to intended use | 13 | 4.5 |
| Seeking shelter from rough conditions | 13 | 4.5 |
| Using the capsized or swamped boat for flotation instead of trying to swim | 12 | 4.1 |
| Checking the intended route for waterfalls and dams | 11 | 3.8 |
| Looking ahead to see obstructions to the intended path. | 7 | 2.4 |
| Keeping sufficient distance from other boats | 6 | 2.1 |
| Having clothing appropriate to the elements, e.g., cold air or water | 6 | 2.1 |
| Assuring that occupants possess the skill needed for the intended operation | 6 | 2.1 |

travel. Not looking ahead was less of a problem than for faster moving boats, but accidents resulted in failure to notice boats, markers, logs, and trees, among other objects. Considering the low stability of canoes, it is not surprising that failure to remain seated led to a large proportion of capsize accidents (exceeded only by rowboats). Specific causes included attempts to change position, move gear, relieve oneself, or horseplay. Paddling too close to other, usually larger boats, resulted in damage, particularly when strong wind or current made for difficult control. Several accidents resulted from actions by inexperienced crew, such as playing games, jumping in the water and having the canoe blow away, becoming confused in an emergency, and capsizing the boat while trying to recover gear. Finally, the involvement of alcohol in canoe accidents was on a par with that of open motorboats, both being the highest of all boat types. Drinking contributed to many of the instances of capsizing and swamping noted.

The more challenging environment in which kayaks operate becomes apparent in accidents, injuries and death from failure to wear sufficient clothing for conditions, lack of awareness of and ability to handle rapids, and failure to wear helmets where the possibility of head injury exists (e.g., rocky waterways). Differences between the two boat types will be seen in the data entry formats prepared for a Web version of BARD, to be described later in this report.

**Houseboats**

Low speed maneuvering alongside boats, docks or other structures was a bigger problem in houseboats than all others combined, largely a consequence of their beam and windage, but complicated by the frequent failure of inexperienced operators to recognize the skill required.

**Table 4. Houseboats**

(132 cases)

| Boater errors, i.e., activities not correctly performed | N | % |
|---|---|---|
| Maneuvering at low speed in tight quarters, e.g., docking or coming alongside | 24 | 18.2 |
| Operator considering the adequacy of skills (e.g., handling tight quarters) before setting out) | 15 | 11.4 |
| Approaching slowly enough to maneuver properly when coming alongside | 12 | 9.1 |
| Operator limiting consumption of alcoholic beverages | 11 | 9.8 |
| Assuring the engine has been properly maintained | 8 | 6.1 |
| Avoiding distraction and looking ahead to see boats, obstructions to the intended path | 6 | 4.5 |
| Recognizing the occurrence of rough weather conditions that warrant action. | 6 | 4.5 |
| Responding to rough conditions when they occur | 5 | 3.8 |
| Assuring that controls are in operating condition (includes start, stop, throttle) | 5 | 3.8 |
| Seeking shelter from rough conditions | 4 | 3.0 |
| Exercising 360-degree surveillance for boats that may be approaching | 4 | 3.0 |
| Having the proper anchor and being ready to lower in the right manner | 3 | 2.3 |
| Having sufficient scope to prevent dragging, but not to swing into other boats | 3 | 2.3 |
| Having the boat equipped with anchors suitable to intended operating conditions | 3 | 2.3 |
| Checking the fuel and propane distribution lines to detect leaks | 3 | 2.3 |
| Handling fuel in a manner that cannot cause combustion or spill | 3 | 2.3 |
| Keeping sufficient distance from land and land structures | 3 | 2.3 |
| Activity involved in extinguishing fires aboard | 3 | 2.3 |
| Assuring a firm grip, or secure footing on the boat when docking, transferring, moving | 3 | 2.3 |

The difficulty in maneuvering frequently led to the houseboat approaching docks or other boats at high a speed, particularly when confronted by strong wind, resulting in collisions with considerable damage. While engine maintenance on houseboats may be no bigger problem than on other boats, engine and engine control failures have more severe consequences owing to the vessel's low maneuverability and susceptibility to the winds, particularly when docking or otherwise near land.

The windage of houseboats tends to make rough weather a somewhat greater challenge than for other craft. Operator shortcomings included failure to recognize when conditions are too severe, to respond to them safely in operation of the boat, or to seek shelter soon enough. Not having an anchor ready to be dropped quickly when needed (e.g., engine quits) resulted in being blown into other boats or the shore. A similar problem was not paying out enough scope on anchor lines in strong winds. Both were infrequent problems but largely restricted to houseboats and pontoon boats. Problems in visual search were essentially the same as encountered with other boat types. Failure to look ahead adequately included not watching the boat ahead, pulling out of slips without looking, not keeping an eye out for objects in the water (e.g., markers), and becoming distracted.

Misuse of alcohol appears not as great as with cabin and open motorboats but higher than with sailboats or PWC'S. Impairment, coupled with the limited maneuverability of houseboats, resulted in many collisions with docks and other boats. However, many also involved falls overboard.

Unsafe fuel conditions involved failure to ventilate engines and remove fuel vapor completely in known leaks, as well as undetected leaking of propane. Inability to reach extinguishers in time complicated the problem. Falls overboard due to failure to have a good grip came about when docking, transferring to another boat or simply falling on the boat.

**Open Motorboats**

Interest in the causes of open motorboat accidents is heightened by their sheer numbers, over a third of all accidents reported. Excessive consumption of alcohol was a leading contributor to accidents in open motorboats. For reasons mentioned earlier, the 14.6% figure given in Table 5, is an underestimate of alcohol's role since it only includes those instances in which intoxication was obvious and the accident could be clearly traced to that condition. On open motorboats, it led to falls on board and overboard, as well as erratic operation leading to collisions with other boats and shore facilities, capsizing and swamping, and maneuvers that ejected passengers.

The speed with which open motorboats travel places a premium on keeping a good watch ahead, and failure to do so was the next most common error. Another visual shortcoming was failure to keep an eye peeled for small objects in the water, particularly swimmers, but also logs, small markers, and ski ropes. As with most other powered craft, boats coming from other directions were somewhat less of a problem than those in the path ahead.

## Table 5. Open Motorboat

(1176 cases)

| Boater errors, i.e., activities not correctly performed | N | % |
|---|---|---|
| Controlling consumption of alcoholic beverages | 172 | 14.6 |
| Looking ahead and paying attention to see obstructions to the intended path | 163 | 13.8 |
| Waterskiing safely and operating the boat in a safe manner when towing skiers | 99 | 8.4 |
| Assuring a firm grip, or secure footing on the boat as conditions warrant | 92 | 7.8 |
| Wearing PFD when conditions create significant risk of immersion | 88 | 7.5 |
| Keeping sufficient distance from other boats | 82 | 7.0 |
| Adjusting speed to limits imposed by operation in waves or wakes | 70 | 6.0 |
| Keeping the boat clear of waterskiers in the process of recovery | 59 | 5.0 |
| Remaining seated when boat stability or conditions warrant. | 52 | 4.4 |
| Exercising 360-degree surveillance for boats that may be approaching. | 43 | 3.7 |
| Looking to check position of the vessel relative to depth of water | 44 | 3.7 |
| Keeping sufficient distance from land and land structures | 38 | 3.2 |
| Adjusting the boat's speed to limitations of night visibility | 38 | 3.2 |
| Adjusting speed to limits imposed by the proximity of other boats | 35 | 3.0 |
| Assuring that controls are in operating condition (includes start, stop, throttle) | 32 | 2.7 |
| Loading and distributing weight within the limitations of small boats. | 29 | 2.5 |
| Considering the weather in deciding whether to operate | 28 | 2.4 |
| Looking at the surface to detect small objects or people in the water | 27 | 2.3 |
| Wearing of PFD by occupants unable to swim and exposed to the risk of immersion. | 27 | 2.3 |
| Controlling the turning rate relative to speed to avoid too abrupt turns | 26 | 2.2 |
| Adjusting speed to limits imposed by the nature of maneuvers to be performed. | 26 | 2.2 |
| Having the required number and type of PFD'S, e.g., wearable, throwable | 26 | 2.2 |
| Checking the intended route for possible underwater obstructions | 25 | 2.1 |
| Wearing PFD when cold water, hypothermia, would jeopardize chances of remaining afloat. | 25 | 2.1 |
| Assuring that propulsion system has been properly maintained | 25 | 2.1 |

Excessive speed when negotiating waves and boat wakes creates conditions that invite such consequences as capsizing or swamping the boat, losing passengers overboard, and causing injury to passengers inside the boat. The latter two were also the result of occupants failing to have a firm grip or secure footing at all times. Speed, combined with too abrupt a turn, produced consequences similar to those just mentioned. Finally, speeding in and around other boats, close to land and various structures on or near land, and failing to reduce speed to the limits of night visibility were also frequent accident causes, just as they are for cabin motor boats.

All of the conditions just mentioned create a significant risk of immersion calling for use of PFDs by those who cannot swim or those in danger of going overboard, particularly in very cold water. Open motorboats equal canoes in the extent to which failure to wear PFDs under these circumstances resulted in death. The same was true of simply not having the right type and number available and accessible.

Not remaining seated was a frequent cause of injury and drowning. Some cases were like those encountered in cabin motorboats, where a standing passenger fell overboard or was injured inside the boat because of standing up in rough water or a sharp turn. Other instances were more like canoes and rowboats, where the standing passenger capsized the boat. Also, similar to the smaller boats was the frequency of accidents due to overloading and to poor distribution of people, leading to capsizing and swamping.

As would be expected, open powerboats were the primary source of waterskiing accidents. However, the causes were the same as those leading to other accidents, such as not seeing skiers or getting too close to them in the water, accelerating while skiers are getting in or out of the ski boat, being distracted by watching the skier, or other accidents that could involve people other than waterskiers. One code specific to waterskiing involved boat operators or skiers acting in a manner that is uniquely unsafe for the waterskiing activity, including skiers attempting to perform unsafe tricks, skiing too close to the boat, getting entangled in the tow line, simply falling while skiing, or the boat operator turning too sharply and striking the skier or forcing the skier into another boat or other object. It would be possible to isolate all accidents involving waterskiing — those unique to waterskiing and those common to other activities — by selecting all cases in which waterskiing is indicated as the “Activity at the Time of Accident” on the BAR. This data element was not included on the ACCESS format used in the analysis since the focus was upon boater behaviors rather than the operations taking place. A separate analysis of errors leading to propellor strikes disclosed a number that took place during waterskiing.

Failure to check and maintain engine controls resulted in broken steering, throttle and gear linkages, leading to loss of control and collisions with boats, shore structures and markers, as well as ejection of occupants. Loss of propulsion was less of a problem for open motorboats than some others, but resulted in low speed collisions when docking, drifting into other boats, grounding or swamping in heavy waves.

**Personal Watercraft**

With the highest of all per-boat accident rates, PWCs are a worthy object of attention in the search for accident causes. The inclination of operators to travel in close proximity to other vessels, including other PWCs, shows up in the number of accidents resulting from failure to leave enough distance between boats — a third of all PWC accidents and three times the percent of any other type of boat. Most accidents involved PWCs traveling in groups. Often they operated alongside one another with one making a sudden turn into the other; or one was traveling close behind another when the lead vessel stopped suddenly; or the operator attempted to pass just as the boat ahead initiated a turn.

**Table 6. Personal Watercraft**
(612 cases)

| Boater errors, i.e., activities not correctly performed | N | % |
|---|---|---|
| Keeping sufficient distance from other boats | 212 | 34.6 |
| Looking ahead for boats, particularly other PWC's when following closely | 143 | 23.4 |
| Adjusting speed to limits imposed by the proximity, particularly other PWCs (e.g., games) | 97 | 15.8 |
| Looking to the side and behind before starting a turn | 58 | 9.5 |
| Deliberate wave jumping | 49 | 8.0 |
| Exercising 360-degree surveillance for boats that may be approaching. | 48 | 7.8 |
| Adjusting speed to limits imposed by operation in waves or wakes | 45 | 7.4 |
| Giving way to avoid the risk of collision, particularly turning right in a head-on situation | 37 | 6.0 |
| Maintaining thrust where needed for steering force | 33 | 5.4 |
| Controlling consumption of alcoholic beverages | 31 | 5.1 |
| Controlling the turning rate relative to speed to avoid too abrupt turns | 24 | 3.9 |
| Operators considering the adequacy of their own skill in deciding whether to operate PWCs | 23 | 3.8 |
| Keeping sufficient distance from land and land structures | 22 | 3.6 |
| Giving way to a vessel ahead or coming from the right | 21 | 3.4 |
| Overcoming vision obstructions to see well ( structures, vessels, other PWCs) | 17 | 2.8 |
| Adjusting speed to the nature of maneuvers to be performed | 16 | 2.6 |
| Adjusting speed to the proximity of land, docks, moored boats, etc. | 13 | 2.1 |

Many collisions in close quarters occurred in playing games, such as trying to spray one another or occupants of other boats. About a fourth of PWC accidents took place while jumping waves or wakes. Injuries resulted primarily from collisions with other boats or contact with the water. Operating too close to land also led to collisions with docks, piers, rip-rap, trees and branches,

Traveling in close company demands close attention to the presence of other vessels. Failure to keep an eye on developments ahead led to about a quarter of accidents, considerably more than for other boat types. Most of the cases involved changes in speed or direction of the boat ahead that was not noticed until it was too late to avoid hitting it. When zigzagging to jump one another's wakes, operators often misjudged the other boat's proximity. Watching other PWCs often distracted an operator's attention from the path ahead. Additional sources of trouble that were unnoticed by PWC operators were various objects close to shore, such as rocks, logs, underwater structures, and overhanging branches. Almost a tenth of the collisions resulted from failing to look to the side or behind before initiating a turn, more than that for all other boat types combined. Finally, a number of accidents occurred where boats were not necessarily in close proximity, and each was quite visible to one another. Had one been surveying the scene, a potential collision situation might have been detected in time to avoid a collision.

Much of the enjoyment of PWCs seems to come from operating them at high speeds; the danger comes from the crowded waterways in which they operate. Instances in which the two were combined to cause an accident amounted to about half of all those involving operating close to other boats. In other words, traveling at a slower speed would have allowed half of the reported collisions to be avoided. Attempting to cross waves or wakes at too great a speed was also one of the more common contributors to accidents, resulting in the PWC plowing into the wave and ejecting the rider or causing loss of control with the result of striking boats, docks and other structures. Attempting turns at too high a speed also often resulted in ejecting and injuring the rider, occasionally leading to loss of control and striking something. The flip side of the speed problem is maintaining enough thrust to steer, a requirement almost unique to PWCs. A number of accidents occurred when a PWC was approaching a dock or other boat and cut the throttle, losing control of steering. In some cases, the attempt to correct the problem resulted in sudden over-acceleration. As to the remaining causes, failure to give right of way consisted primarily of making a turn across the path of an oncoming vessel. It is not possible to determine how often this was due to an expectation that the other vessel would yield, versus simply misjudging distance.

PWCs are over-represented among the vessels operated by individuals having little or no experience with boats. Their lack of skill, combined with unfamiliarity with basic rules of boating, makes them particularly vulnerable to an accident.

**Pontoon Boats**

The design of pontoon boats, along with the environment in which they operate have an obvious influence upon the nature of accidents and the errors contributing to them. Most are open platforms for fishing, swimming and socializing so there were many falls, onboard and overboard, that could have been prevented by assuring a firm grip and good footing when standing or moving about, or remaining seated in rough water. Falls overboard often came from bow-riding (particularly with the gate open), playing games, unsupervised children, and leaning over the side or bow (e.g., retrieving anchors) among other activities, without having a firm grip on anything. Closely associated was not having passengers stay inside the cockpit area when circumstances warranted, including rough weather but also when the passengers were children, non-swimmers, or people incapacitated by injury. The social nature of pontoon boating often gave rise to excessive drinking, resulting in alcohol-related accidents; such accidents involving confusion, passing out, or falling overboard rather than reckless behavior likely to endanger others. The risk of immersion, giving rise to the need for PFD wear, arose less from weather conditions than from on-board activities that require getting close to the water, such as freeing lines, doing repairs close to the water, or children playing near the edge of the boat.

**Table 7. Pontoon Boat**
(161 boats)

| Boater errors, i.e., activities not correctly performed | N | % |
|---|---|---|
| Assuring a firm grip, or secure footing (rails, bow gate) when conditions warrant | 25 | 15.5 |
| Looking ahead and giving attention to possible obstructions to the intended path | 20 | 12.4 |
| Controlling consumption of alcoholic beverages | 29 | 12.4 |
| Keeping sufficient distance from other boats to respond to sudden changes | 13 | 8.1 |
| Remaining inside the cockpit area when it is appropriate, e.g., in rough weather | 10 | 6.2 |
| Looking to check position of the vessel relative to depth of water | 9 | 5.6 |
| Maneuvering at low speed in tight quarters, e.g., docking or coming alongside | 7 | 4.3 |
| Wearing PFD when conditions create significant risk of immersion (e.g., rough seas) | 6 | 3.7 |
| Considering the adequacy of one's skill and knowledge in deciding to operate | 5 | 3.1 |
| Keeping sufficient distance from land and land structures | 5 | 3.1 |
| Considering the weather in deciding whether to operate | 5 | 3.1 |
| Looking to the side and behind before starting a turn | 4 | 2.5 |
| Having the proper anchor and being ready to lower in the right manner | 4 | 2.5 |
| Taking steps to prevent injury by swimmers getting on and off the boat | 4 | 2.5 |

Accidents resulting from failure to look ahead, all around the boat, or to the side before turns differed little from accidents experienced on other types of boats and generally involved failure to notice other boats, waves, or various objects in the water, particularly near shore. There appears to be a high degree of distraction by activities taking place on the boat, including watching children, preparing to fish and attending to passengers. Checking the depth of the water is particularly important given the shallow waters in which pontoon boats operate. Operators may have been lulled into thinking the shallow draft of pontoon boats exempted them from grounding.

Cases of failure to keep enough distance from other boats occurred under two general conditions: traveling or stopping in the company of other boats and getting too close, and having to maneuver in close quarters when docking. The first is more a matter of choice than the second. Not leaving enough distance from land and land structures such as docks tended to occur when conditions dictated keeping extra distance, including low visibility and distracting activities taking place on board.

Like houseboats and PWCs, pontoon boats are often operated by people with little previous experience with boats of any type. Failure of unskilled operators to consider their lack of adequate ability did not generally involve particularly challenging situations but rather simply attempting to operate at all without experienced help. Accidents involving rough weather were relatively infrequent for vessels intended primarily for use in quiet waters. Some instance of rough water accidents could have been prevented by considering weather before starting out, and some might have been prevented by having an anchor available when it was too rough to continue or when the engine failed.

Finally, the fact the pontoon boats often serve as swim platforms resulted in accidents and drownings due to attempts to swim too far or under unfavorable conditions. While such incidents were infrequent, those reported were largely confined to pontoon boats.

**Rowboats**

**Table 8. Rowboat**
(128 cases)

| Boater errors, i.e., activities not correctly performed | N | % |
|---|---|---|
| Having the required number and type of PFDs | 20 | 15.6 |
| Wearing PFD when conditions create significant risk of immersion (e.g., rough seas) | 19 | 14.8 |
| Controlling consumption of alcoholic beverages | 19 | 14.8 |
| Remaining seated when boat stability or conditions warrant | 15 | 11.7 |
| Limiting the total weight of passengers and gear (e.g. avoid overloading) | 14 | 10.9 |
| Assuring a firm grip on the boat when conditions warrant | 10 | 7.8 |
| Operating safely while constrained by current | 9 | 7.0 |
| Using the boat for flotation (e.g., capsized boat) staying with the floating boat | 8 | 6.3 |
| Looking ahead to see obstructions to the intended path (primarily under power) | 7 | 5.5 |
| Considering the design of the boat relative to intended use | 7 | 5.5 |
| Considering the weather in deciding whether to operate | 6 | 4.7 |
| Distributing the weight of occupants and gear to achieve safe balance | 6 | 4.7 |
| Wearing PFD when cold water would jeopardize chances of remaining afloat | 6 | 4.7 |
| Controlling the turning motion in a safe manner when under power | 5 | 3.9 |
| Recognizing / responding to weather conditions as they change | 5 | 3.9 |
| Using some form of flotation, where conditions or swimmer ability indicates | 3 | 2.3 |
| Keeping sufficient distance from land and land structures | 3 | 2.3 |

| | | |
|---|---|---|
| Exercising 360-degree surveillance for boats, primarily when under power | 3 | 2.3 |
| Assuring that the hull is free of leaks or other opportunities for entry of water | 3 | 2.3 |

Rowboats exceed all other boat types in failure to have required numbers and types of PFDs aboard, and equal canoes in failure to put them on under risk of immersion. Such conditions included rough seas, the boat filling with water, danger of capsizing, swift current, particularly near rocks, ledges or low head dams, overloading, carrying out dangerous maneuvers, working over the side (e.g., pulling pots), passengers engaged in horseplay, and the inability to swim. Another problem was failure to wear PFDs when cold temperature threatened survival in the water. For passengers in the water, attempting to swim ashore rather than remain with the floating boat led to several fatalities, as was the case in canoes. All told, failure to have or use flotation devices accounted for more than a third of fatalities.

Acts leading directly to immersion included overloading the boat, poor distribution of weight, not remaining seated, and not having a good grip when leaning over the side or standing up or when the boat was subject to severe roll. Attempting to use rowboats in strong currents, such as in rapids and near low head dams, led to capsizing and swamping. Setting out in rough weather was also a contributor to accidents typically resulting in immersion

Because of the low speed with which they generally travel, rowboats seldom have problems with seeing far enough ahead. However, some accidents do occur when the boat is under power (usually outboards), or when the rower is looking behind and moving in a fast current or being rowed fast (e.g., racing shell). Making abrupt turns under power often resulted in capsizing. As a source of accidents due to drinking, rowboats were up with the leaders. Again, as with canoes and pontoon boats, the dangerous consequences of drinking were largely confined to the drinkers themselves rather than other boaters, involving primarily capsizing or swamping boats.

**Sailboats**

It is not surprising that problems in sail handling would be the leading contributors to accidents for small boats depending upon sails for propulsion . Such problems included failing to shorten sail when the wind was more than could be safely handled (including lowering them completely), and not spilling the wind in gusts. Most of the time the result of such shortcomings was capsizing, although in some cases injury occurred from contact with some part of the boat, such as the boom.

Failure to shorten sail and failure to spill wind tended to occur together. There were many cases in which they did not; that is, the wind was steady and shortening sail would have been the better option, or it was only gusty and spilling wind would have been more appropriate. There were also a few instances with smaller boats where not venturing out at all would have been the best decision, considering forecasts or conditions prevailing at the time. The underlying predisposing conditions in all of these cases was strong wind, and the distinctions as to which course of action was most appropriate are not always clear. What is clear is that skippers of small sailboats need to make better decisions concerning when to slack off and spill the wind, to shorten sail, or to avoid sailing at all.

**Table 9. Sailboats**
(148 cases)

| Boater errors, i.e., activities not correctly performed | N | % |
|---|---|---|
| Posting a lookout for boats obscured by the sail (e.g., crossing situations) | 18 | 12.2 |
| Shortening sail when wind conditions warrant | 17 | 11.5 |
| Looking ahead or paying attention to obstructions to the intended path | 14 | 9.5 |
| Considering the weather in deciding whether to sail at all | 12 | 8.1 |
| Spilling the wind to avoid extreme roll or capsize | 11 | 7.4 |
| Assuring that the hull is free of leaks or other opportunities for entry of water | 8 | 5.4 |
| Keeping sufficient distance from other boats to allow for wind or wave conditions | 7 | 4.7 |
| Assuring that the crew possesses the skill needed for the intended operation | 6 | 4.1 |
| Checking forecasts of weather in deciding whether to sail | 6 | 4.1 |
| Wearing PFD when conditions create significant risk of immersion (e.g., rough seas) | 4 | 4.1 |
| Responding to rough conditions when they occur | 6 | 4.1 |
| Considering the adequacy of one's own skill and knowledge relative to conditions | 5 | 3.4 |
| Giving way to boats on the starboard tack | 5 | 3.4 |
| Controlling one's own consumption of alcoholic beverages | 5 | 3.4 |
| Keeping an eye on swing of boom | 4 | 2.7 |
| Having the boat equipped with serviceable lines (dock, anchor, tow) | 4 | 2.7 |
| Keeping sufficient distance from land and land structures | 4 | 2.7 |
| Assuring a firm grip, or secure footing on the boat when conditions warrant | 4 | 2.7 |

Accidents due to improper lookout were similar to those experienced with auxiliaries. Failure to look ahead involved not paying enough attention to what was going on and running into other boats or, in some cases, fixed objects such as buoys. Failure to exercise all-round surveillance generally involved crossing situations, often where the approach of another boat was obscured by the sail. There were also some cases when the intersecting boat was seen, but the skipper on the port tack misjudged clearance. Related to these accidents are those in which the boat was sailed close to other boats or other structures (e.g., docks) without allowing for wind changes and momentary loss of control. Some of these situations occurred at the start of races where space is at a premium and collisions not uncommon. One other accident situation involving lookout, unique to sailboats, is not watching for swing of the boom, which was an infrequent but significant contributor to injuries.

Failure to wear a PFD under recognized risk of immersion is judged to have led to several drownings within the sample. All resulted from failure to wear PFDs in high winds. Other drownings involved instances where the risk of drowning was elevated, including an inexperienced skipper, inability to swim, intoxication, difficulty of being found in the water, possible collision, and other instances in which a risk was present but not likely to have been fully recognized. Accidents resulting in part from lack of adequate boat maintenance included leaks and rigging failure. Leaks most often occurred in pontoons on catamarans, but also involved holes in the hull and failure to insert plugs in monohulls. Inadequate inspection and replacement of mooring and anchor lines led to boats coming loose and drifting.

Deficiencies in the performance of skippers included instances of inadequate ability and excessive drinking. In the case of the former, sailing is an activity that requires a relatively high degree of skill and knowledge, and the decision to tackle challenging conditions without assuring abilities needed, in operator and crew, is a significant contributor to accidents (the conditions in question were ones that competent operators and crew should be expected to deal with). Turning to alcohol, as with auxiliaries drinking was not a major contributor to accidents. The relatively few cases of heavy drinking led to attempts to sail under less than salutary conditions, mishandling the boat, and falling overboard. None placed others in serious jeopardy.

## PILOT TEST

The result of the analytic effort that has been described was identification of errors accounting for more than 1% of boating accidents for each of the nine BARD boat types. The final step in the process was to ascertain the ability of the coding process to be applied by BARD data entry personnel in the several states. Through the offices of BAIRAC, Boating Law Administrations (BLAs) in six states volunteered to take part in a pilot implementation of the coding process by applying it to samples of boating accidents occurring in 2002. The participating states were California, Connecticut, Maryland, Nevada, Tennessee, and Wisconsin.

### Data Entry

For the six pilot test states, a data entry format was developed to allow errors to be coded simply and quickly, making addition of human error to the data a small addition to the BARD data entry process. The format employed ACCESS 97 and 2000 in order to accommodate the programs in use by the participating BLAs. Each state was provided a copy of the human error data entry program to load on the computers that were being used to enter BARD data, although the two data programs remained separate. The entry of human error data for an accident took place after the basic BARD data entry was complete and analysts were familiar with the accident. When the human error file was opened, the BARD analysts were presented a page with a window that provided instructions and additional windows corresponding to the nine basic boat types. The instructions described the data entry format and the means of entering human error codes.

When analysts clicked on the type of boat responsible for the accident being recorded, they were presented with a page that listed the errors for that boat type, as given in the tables shown earlier. However, at the suggestion of various NASBLA representatives, errors were described in terms of the mistake made rather than in terms of what would have been the correct activity, as was the case in the earlier tables. To facilitate locating errors in the list they were arranged in terms of the stage of boating involved: *Pre-Boating* — errors made in preparing the boat for safe operation, *Pre-accident* — errors made that exposed the boat or crew to danger, *Accident* — errors that led directly to the accident and *Post-Accident* — errors made after the accident that led to death, injury, or additional damage.

Analysts first recorded the accident number to permit the project staff to later compare the codes used by the analyst with information furnished in the BARD file for the same accident. To record an error, analysts only had to click a button next to the error description. They were informed that two conditions had to prevail before an error could be entered. First, if the error had not occurred, there would have been no accident, or significantly less damage, injury or death as a result of an accident. This condition applied even with more than one error. For example, consider a drowning when a canoeist sets out in threatening weather, fails to seek shelter when the water gets too rough to operate safely, and fails to wear a PFDs. Avoiding any one of these errors would have prevented the fatality. The second condition was that the error must represent failure to do what any reasonable and prudent boater would do under the circumstances. Take someone who is sitting in the cockpit of an anchored cabin cruiser when it is struck by a speeding open motorboat and who falls over the side and drowns. While a PDF might have prevented the death, failure to wear one under the circumstances cannot be considered an error.

As noted earlier, errors were generally coded by analysts immediately after the regular BARD data entry, while the case was fresh in their minds. Three columns of buttons were provided to allow up to three errors to be recorded for each accident. No significance was attached to the order in which errors were entered; they were all equal. Analysts were also provided a means of changing their choices or correcting accidental data entry.

In addition to the errors, two additional codes were provided: "Error not on list" and "Error not identifiable from information provided." When the coding process was completed, the analysts entered the code by clicking an "Add Record" button bar and proceeded to the next case. Analysts were asked to e-mail forms for the accidents completed to the project staff once a month. At the same time, the BARD files for the same accident were obtained from the USCG Office of Boating Safety.

**Review of Error Coding**

The error codes assigned by analysts in each state were reviewed by the project staff against the complete BARD files for the same accident numbers. On the whole, the results were very encouraging. Mistakes in coding errors were largely confined to the first few cases and may have been the result of unfamiliarity with the error list and data entry procedure more than misinterpretation of error descriptions. Most of the later discrepancies between actual and coded errors were the result of unclear wording of error descriptions. The error descriptions and data entry instructions were revised to overcome ambiguities.

One difficulty reported by analysts was the number of errors that were not listed, having fallen short of the "more than 1%" criterion for the particular boat type. Because of large interstate differences in recreational boating, some of the unlisted errors could exceed the >1% criterion in certain states. For example, boats being pinned against dams were frequent in Tennessee, given the large number of TVA dams on rivers in the state, but not in the other states sampled. The plan was to review the BARD files for those cases and identify the error from narratives and other data elements provided. The manner in which were ultimately handled will be described later.

All participating BARD analysts were provided reports, indicating the data entry problems encountered and what revisions of error descriptions and data entry were envisioned for the future. The pilot test process had envisioned further coding of 2003 accident samples to assess the adequacy of revisions in error descriptions and entry procedures. However, before that occurred a Web version of BARD was developed by CNSI-INC, a BARD contractor, and scheduled for testing in 2003. USCG elected to include the human error coding in the test of the BARD Web without further pilot testing. The participating BLAs and analysts were notified of the change and thanked for their help in improving the data entry process.

Following completion of the pilot test, USCG considered that the operating environments and the operators of canoes and kayaks are sufficiently different to warrant separating canoes and kayaks in the analysis of errors leading to accidents. As previously noted, the BARD files for the three-year period surveyed earlier were reviewed for the 291 canoes and kayaks and the errors tabulated separately for the two boat types. The discussion of canoes and kayaks earlier (Table 3) mentioned the types of errors that were characteristic of each type of boat.

**Investigator Error Coding**

All of the work that has been described took place withing the BARD system of accident coding. The project itself took place under the Coast Guard recreational boating program within which BARD forms the basic means of communicating accident data for analysis. However, the information upon which the BARD is based comes from accident reports prepared by those agencies responsible for accident investigation and reporting within the several states and territories. A clear alternative to error coding by BARD analysts is to have the coding performed by the investigators preparing the original accident reports. The investigators typically come from the ranks of the agencies that carry out enforcement of recreational boating laws.

The Boating Accident Investigation, Reporting and Analysis Committee (BAIRAC) of the National Association of Boating Law Administrators suggested an inquiry into the suitability of the state accident investigators as sources of error coding under BARD. The Investigators would have access to information available at the accident scene, obtainable from boaters involved in and witnesses to the accident. Not all of this information may appear in the accident narratives upon which BARD analysts base their error coding, although the analysts can and do seek follow-up information directly from the investigators. Countering the apparent advantage of direct access to accident-related information would be the need to code errors in hard copy rather than electronically. While BARD analysts could quickly access windows displaying only 14-24 boat specific errors, each described in the form that errors actually occurred for that boat, the investigators had to find errors in the complete list of 76 errors, each described in generic terms.

Comparison of BARD and Investigator Coding

To compare the relative accuracy of error coding within the BARD data entry process with codes provided by accident investigators, Boating Law Administrators in the states of Nevada and Connecticut agreed to have investigators code sets of accidents separately from the BARD coding. The investigators were provided a one-page checklist containing all 67 error codes. In addition they were supplied a booklet containing error definitions and instructions for carrying out the error coding process. Both appear as Appendix 3.

Some 87 accidents were coded both by investigators using the generic list of 67 errors and by BARD analysts using the lists of boat-specific error descriptions. To provide a criterion against which the codes could be evaluated, all of the accidents were error coded by a representative of the project staff who participated in development and test of the error coding system. Which set of codes were the more valid, analysts or investigators, was not the issue; nor was the validity of the judgments made by the project staff representative comparing them. The question was how well each of the two source codes met the definitions making up the error descriptions developed by the staff.

Summary of Results

The results of the comparison between analyst and investigator coding can be summarized as follows.

- More codes were assigned by investigators than by analysts, 2.7 per case versus 2.0 per case in Nevada; 3.8 versus 2.3 in Connecticut.
- More erroneous codes were assigned by investigators than by analysts, 1.1 per case versus 0.3 per case in Nevada; 1.7 versus 0.2 in Connecticut.
- More appropriate codes were missed by investigators than by analysts, 0.5 per case versus 0.3 per case in Nevada; 0.6 versus 0.3 in Connecticut.
- There appeared to be only one case where the investigators identified a human error that could not be properly coded by analysts, whereas there were many more cases that were coded more accurately by analysts than the investigators.
- There were two codes that appeared to be overused by investigators, namely “Ability of the operator” and “Control while maneuvering in tight quarters.” In the analysts’ coding, no individual codes were overused.

- The “nine series” codes, meaning that no human error was listed or could be identified, were much more by analysts than investigators.

In summary, what do these findings reveal? First, it would appear that the BARD analysis system results in more accurate coding at the present time. Most important, it provides a closer focus on the human factors most responsible for the accident, with fewer wrong codes and fewer missed codes. Using more codes per case on the average is not advantageous if the additional codes are only marginally descriptive of errors better. The investigators evidenced a tendency to use as many codes as permitted, even when it meant employing codes of questionable relevance to the accident. Also, where analysts failed to find an appropriate error code for a particular boat and indicated the error as “unlisted,” investigators often selected what was an inappropriate code from the complete list of 67 errors. It appears that the BARD analysts were presented with fewer choices and therefore fewer opportunities to seek questionable codes if none of the specific codes for the given boat type formed a good fit.

What the results do not say is whether the analysts or investigators are the better equipped to code human errors. Had the investigators been given training and access to lists of errors and error definitions that were boat-specific, they might have equaled or surpassed the analysts in use of the error codes. However, the need to carry separate error lists for each boat type would make for a cumbersome report form and might tend to discourage error reporting by investigators. This limitation might be overcome by the increasing use of hand-held electronic devices for recording accident information. Also, some reorientation of investigators would seem necessary if they are to code error. Since they are law enforcement officers they tend to infuse legality into the identification of causes. For example, in one case the investigator gave “inadequate lifejackets” as an error code, whereas it really didn't contribute to the particular accident in any way. One can appreciate how an officer seeing a violation of law would feel compelled to mention it.

Investigator reporting would require training and equipping substantial numbers of officers throughout the state rather than one or two analysts. This could become time-consuming and expensive, particularly in states where the responsibility for boating law enforcement is spread across the several jurisdictions. The accident rates in many states are such that the most individual field investigators go long periods of time without the need to report an accident and code errors. The results of training could be largely dissipated before the recipients would have a chance to apply them.

In summary, a number of obstacles must be overcome before the task of identifying and coding errors can be entrusted to officers investigating and reporting recreational boating accidents. In the meantime, BARD analysts appear to be quite capable of applying the error coding system comprehensively and accurately with minimal instruction and practice.

**Revision of Data Entry Format**

The format used to enter errors during the pilot test was separate from the regular BARD data entry process. The plan was to develop a format for human errors that could be integrated into BARD. Before the human error format could be revised for integration into the basic BARD data entry process, that process was revised to allow direct Web access to BARD data entry formats. Instead of periodically sending BARD files to Coast Guard headquarters for entry into the Boating Accident Report Database, analysts could enter reports directly into the database. However, at the time the Pilot Test was completed, details of the forthcoming BARD Web had yet to be determined. The data entry format was revised for incorporation into BARD based upon what was known at the time, with the expectation that it could be further revised as needed.

Error Descriptions

The original BARD format limited the space available for data entry. To help assure that the entry of human error data could be accommodated by the eventual web format, the error descriptions were made as brief as possible yet still communicate the nature of the error. This appeared to be possible within a limit of 61 characters.

To help analysts to locate individual errors in a list of errors, the descriptions were grouped into the same four stages as employed in the pilot test (Pre-Boating, Pre-Accident, Accident, Post-Accident) but without the stage headings. The error lists for each boat type appear in Appendix 2. To help analysts to locate a particular error quickly, each description was preceded by a one-word category label, such as *Maintenance*, *Control*, or *Lookout*. Most categories included more than one error and two contained as many as five ("Speed" for Open Motorboats and "Weather" for sailboats). While individual errors could be further pinpointed by the use of two-word labels, doing so will make for somewhat longer definitions. The one-word label was judged to allow the correct descriptions to be quickly identified. In addition to captions, the error descriptions included the code number assigned to each of the errors on the master list.

The boat-specificity of the individual errors allowed the descriptions to be worded in terms specific to the manner in which they occurred on each boat type, much like the descriptions that appear in the tables provided earlier for each boat. However, at the suggestion of CNSI, those errors that were essentially the same across boat types used common descriptions in order to provide a quickly recognizable "standard" description.

As with the earlier pilot test version of the human error data entry format, provision was made for entry of up to three different errors for any one accident. During the pilot test, three errors were identified in approximately 30% of the accidents. Discussion with analysts indicated that three errors would be sufficient to describe the significant contributors to any accident. To allow a greater number could encourage inclusion of marginal contributors, something that was apparent in the earlier feasibility testing phase of the project.

The Web format ultimately devised by CNSI devoted an entire page to entry of human error, allowing space for longer descriptions. However, since the shorter descriptions appeared adequate to communicate the specifics of an error and could be viewed at a glance, no change seemed necessary. As will be noted shortly, the opportunity to review and evaluate the inclusion of human error data in the BARD Web, permit shortcomings to be revealed and lead to improvements over time.

Unlisted Errors

During the pilot test "Error not on list" was indicated in close to a quarter of the cases coded. In about a tenth of the cases, it was the only entry. Some accidents truly involved "one of a kind" errors that cannot be included in a manageable error coding process and would not contribute significantly to prevention of boating accidents. Most of the remaining unlisted errors fall into three categories. One category consists of errors that were on the master list of 67 basic errors but not on the list for the particular boat type involved in the accident being coded. The regional variation in accident patterns mentioned earlier results in many errors exceeding the >1% criterion for a particular boat type in one or more individual states, while failing to do so across the entire BARD. This problem has been overcome by providing the master list of all 67 errors as part of the human error Web page. Analysts can enter the code number assigned to the particular error and the "Unlisted Error" space provided at the end of each boat-specific error list.

A second category of unlisted errors consists of cases in which analysts misinterpret the information provided in the accident narrative or the error description provided by the BARD Web format and conclude that the error is not among those listed. During the pilot test, instances of this nature tended to occur early in samples of cases coded, and declined as analysts became more familiar with the error lists. As noted earlier, much of the problem lay in misleading descriptions, a condition remedied by rewording the error descriptions. To allow these problem cases to be identified, analysts are invited to enter a typed description of the error, using their own words, in the "Unlisted Error" space provided.

A related third category of unlisted error is the rare accident cause that failed to meet the >1% criterion for any boat type in the three-year data base used in developing the error list. It is likely that most of these fall into the rare, "one-of-a-kind" category that is not appropriately addressed by a national data base. However, two possible exceptions warrant attention. One is the "regional" error, occurring in too few locations to meet the criterion nationally. While below the threshold for nation attention, the errors may be numerous enough in particular states to become appropriate targets of preventive efforts locally. The second exception is the error whose frequency changes over time. Such changes can occur due to variation in the nature of boating, e.g.. the design of boats and the uses to which they are put. Others could be "percentage" changes; as preventive efforts succeed in reducing the percent of accidents involving one type of error, the percentages involving others will necessarily rise, even though there is no change in absolute numbers of accidents. Allowing analysts to enter descriptions of unlisted errors will permit regional problems and those changing over time to be identified for appropriate action.

<u>Further Development of Human Error Database</u>

The identification and compilation of boater errors, their organization into a useful functional structure, the separation of errors by the type of boat on which they occur and the preparation of formats though which human error can be made a part of the Boating Accident Report Database fulfill the objectives of the analytic effort that has been described. At this point the collection, analysis and reporting of boater error moves from the status of a project to an element of the basic BARD.

Like any pioneering effort, the development of BARD has been an evolutionary process. As well planned as any complex undertaking may be, experience with its application typically equals or exceeds initial planning in determining what is eventually put into use. The process in the case of

BARD has benefitted greatly by a close working relationship between the developers and the users — respectively, the USCG Office of Boating Safety and the National Association of Boating Law Administrators. The human error component of BARD is unlikely to prove an exception to the need for evolutionary development. Two needs for the future have already been anticipated. One involves enabling states to incorporate state-specific error sources into data collection and analysis, for example, identifying errors that exceed the >1% criterion for a particular boat type in a particular state and adding it to the list. Another would involve plotting trends in accident causing errors over time in evaluating the effects of preventive measures. Other needs will very likely become evident in time.

## SUMMARY OF FINDINGS

That human error underlies the great majority of accidents is well known. The leading source of error in accidents involving boats is the people who use them, passengers as well as operators. Boating is no exception. Indeed, if "human" were to include everyone connected in some way with boats — design, manufacture, legislation, enforcement and so on — almost all accidents could be attributed to error somewhere along the line.

Also, rather well known is the nature of accident-producing errors. Most experienced boaters have witnessed enough mistakes, of their own and others, to know what can go wrong on the water. Fortunately, but a small fraction of errors results in significant harm. In most cases, accidents are avoided by some form of intervention or good luck and the net result is to leave the boater a little wiser and less likely to commit the same error again. A decline in accidents with experience is well established.

What is not so well known is the pattern of errors leading to accidents. While all errors are logical targets of preventive efforts, the greatest payoff will come from a focus on those that are responsible for the greatest accident loss. To identify the greatest sources of trouble requires collecting data on accidents, and the errors underlying them, then classifying them into categories having similar sources so that their numbers can be counted and the degree of loss associated with each can be totaled.

### Classification of Boating Errors

A team of experienced boaters studied narratives of more than 3,000 recreational boating accidents as recorded over a three-year period in the USCG Boating Accident Report Database (BARD). Up to three errors could be recorded using a preliminary set of 300 data codes. The list was confined to those errors that could be directly tied to accidents on the basis of information available through accident investigation, including those involving; *making the boat safe to operate, preparing for safe operation before shoving off, operating safely while the boat is in use, coping with various unsafe situations, and handling emergencies*. To provide a workable data entry process, the number of codes was then reduced through a classification system that grouped together errors sufficiently similar in nature to be described in the same terms. The categories needed to be specific enough to provide well-defined targets for preventive measures without becoming so specific and so numerous as to make the classifying individual errors a laborious task.

Combining similar error codes into categories of similar errors, and dropping those codes that seldom or never occurred, resulted in a manageable set of 67 categories of errors, each error contributing to more than 1% of boating accidents for at least one of the nine basic boat types differentiated in the BARD system. The numbers of accidents involving errors in each category were totaled to reveal the extent to which each error contributed to the accidents among recreational boaters across the country.

**Errors by Boat Type**

When errors were classified by type of boat, it became readily apparent that the pattern differed greatly across types. For example, alcohol impairment was evident in 15% of accidents with cabin and open motorboats, but only 3% of those involving sailboats. Not paying sufficient attention to things in the path ahead was a factor in personal watercraft accidents ten times as often in accidents involving canoes and kayaks (differences observed between the two kinds of paddle craft later led to their separation into two basic boat types). Knowing which errors were the most frequently involved in accidents to each boat type would allow preventive efforts to be directed where they would do the most good — for *pontoon* boats the need to make sure that passengers have a firm grip on the boat whenever it is in motion, for *houseboats* the importance of being able to maneuver in tight quarters, particularly in windy conditions. Within the enforcement realm, there is a clear need to prevent operators of personal watercraft from engaging in activities that involve operating at high speed in close proximity to other boats, including other PWCs.

In addition to permitting differences across boat types to be identified, the ability to tailor the descriptions to the specific forms that errors take for a particular boat facilitates both the analytic process and the application of results. Providing BARD analysts with descriptions of boater errors phrased in terms of the specific boat-type enables them to match accident narratives with errors more easily and validly than leaving them only the more generic descriptions. On the application side, it allows prevention efforts to focus on the specific form that errors take in a particular type of boat. As an example, lack of full 180º surveillance on auxiliary sailboats included failure to post a lookout to leeward to see around a headsail, a rather different problem than the surveillance limitation created in some cabin motorboats when the bow rises as speed is increased. Each of these surveillance limitations calls for different preventive measures.

**Error Coding Process**

To become a means of improving boating safety, the identification of errors leading to accidents must be made a standard part of accident reporting and analysis. Since the BARD is currently the primary and almost sole source of recreational boating accident information at a national level, boater errors must be an integral part of that system if it is to serve its purpose. A pilot test carried out in six states under the auspices of a committee of the National Association of State Boating Law Administrators assessed the ability of BARD analysts to code successfully a sample of reported boating accidents. Analysts were provided a format which allowed them to select the boat-type involved in an accident and view the list of errors for that type. They could enter up to three error codes as well as indicate where no error was evident or the error was not listed. With a small amount of written instruction and limited practice, the analysts were able to enter codes that matched the error descriptions prepared, although the latter had to be revised somewhat to overcome some ambiguities. Carrying out the error coding concurrently with the other BARD data entry added little time to the accident analysis process.

Following the pilot test, the error list was modified to better fit into the overall BARD data entry. This occurred at the time that a Web version of BARD was being developed to allow state analysts to enter individual accident reports directly into the national BARD. Many of the error descriptions were extremely long, some requiring more than 150 characters. Just what form the BARD Web data entry format would take was not known at the time the pilot test was completed. To help assure that the human error descriptions would fit into the eventual Web format, they were reduced to a limit of 61 characters. The abbreviated changes in wording came at no sacrifice of clarity. The result of the revision was to put the human error coding in a form that could be made part of the basic BARD data entry process.

**Responsibility for Error Coding**

Although the human error data entry process was designed as a part of the BARD, an alternative would involve making the classification and coding of errors for individual accidents an element of the original accident reports prepared by field investigators collecting the accident information. This possibility led to a question as to whether the investigators could code errors as well as or more validly as the BARD analysts. Favoring the investigators is their direct access to the accident scene and witnesses. Countering this apparent advantage would be the need to review a printed page containing all 67 generic codes for any accident rather than a much shorter, computer-displayed list of boat-specific codes, as well as the need to train and supervise large numbers of investigators spread across states and territories, each of whom would get limited opportunities to carry out the process.

To compare the relative accuracy of error coding, samples of accidents in two states were coded both by individual investigators using the generic list of all errors and by state-level BARD analysts using the boat-specific errors lists. The two were evaluated to determine how well each source's codes met the definitions making up the error descriptions. The comparison showed the analysts assigning fewer erroneous codes and missing fewer correct codes than the investigators, an outcome attributed largely to the analysts' access to the boat-specific error lists.

**Implications of Results**

While all accident-producing errors warrant attention, the most efficient use of limited resources requires that the most frequent errors become the primary targets of prevention. Knowing how often various errors lead to accidents also allows the effectiveness of individual preventive measures to be charted over time. At present, the importance of having PFDs available and putting them on when conditions raise the risk of immersion is generally accepted. Less well recognized is the more pervasive need to keep a sharp eye out ahead when in motion or to allow a large margin of error when operating in the vicinity of other boats. By cataloging, classifying, counting various boating errors, preventive programs can focus their efforts on improvements in areas that will do the most good.

Equal to their importance in prioritizing safety measures is the value of study findings in revealing the nature and magnitude of differences in accident-producing errors among different boat types. Much of the present day prevention effort is a one-size-fits-all approach. This is particularly true of safety instruction. There is certainly a benefit in preparing boaters to deal with a full range of threats to safety; most safety practices generalize across boat types and people often move from one type of boat to another over time. And, it is rarely possible in a basic safety course to delve into the specific hazards of various boat types, even those that contribute heavily to accidents for certain boats. However, while it may be inefficient to devote classroom time to addressing problems that are of concern to a minority attending a course, the special needs of individual boaters can be accommodated by tailored instruction and materials such as pamphlets, CDs, or videos.

The numbers of accidents in each hour of recreational boating have been dropping steadily over the years. The drop is particularly steep within the newest addition to the recreational fleet, personal watercraft, as the dangers they face become better identified and appreciated. One route to further reduction in all accidents lies in identifying the causes that continue to appear. The BARD program of accident reporting provides a long-term means of meeting the need for continued identification. By extending the list of data elements to the human errors that contribute to significant numbers of accidents, prevention measures can be directed specifically toward reduction in those accidents. Of the often cited "Three Es," *education* will be particularly critical to reduction in human error. (*Engineering* has succeeded in reducing error rate by designing around the sources of error in such areas as control systems, electrical devices, and navigational aids. In errors that involve unlawful behavior, such as excessive alcohol consumption and various forms of reckless operation, *enforcement* becomes a necessary ingredient of prevention.)

The work of identifying human errors in recreational boating is far from finished. The tasks to be completed include (1) finding ways of identifying errors that are frequent accident causes in some states, while not meeting the >1% criterion nationally, (2) preparing accident investigators to handle error-identification at such time as equipment allows electronic data entry to replace paper reports, and (3) developing programs that will assist states in analyzing their own relatively unique accident causes and plotting trends over time. In the identification of human errors leading to boating accidents, the present project is only a start.

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## APPENDIX 1 ERRORS BY BOAT TYPE

Percent of all accidents involving the particular error for the boat type indicated, for errors accounting for more than 1% of all errors for any type. AS=Auxiliary Sail, CM= Cabin Motorboat, CK= Canoe/Kayak, HB= Houseboat, OM= Open Motorboat, PW=Personal Watercraft, PB= Pontoon Boat, RB= Rowboat, SO= Sailboat.

| Code | Error | Description | AS | CM | CK | HB | OM | PW | PB | RB | SO |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 100 | **Preparation** | | | | | | | | | | |
| 110 | Vessel suitability | Using a vessel with design characteristics (type, length, etc.) basically unsuited to the intended operation | | | 5 | | | | | 6 | |
| 121 | Maintenance: hull | Not making sure the hull is free of 5 or other opportunities for entry of water | | | | | | | | 2 | 5 |
| 122 | Maintenance: controls | Operating with controls (steering, trim plate, throttle, shift, outboard or stern drive trim) in need of repair/adjustment or fitted with wrong replacement parts | | 4 | | 4 | 3 | | | | |
| 123 | Maintenance: engine | Operating with propulsion that has become unreliable for lack of maintenance (engine fails to start or stalls, weak battery, power loss, etc.) | 3 | 4 | | 6 | 2 | | | | |
| 124 | Maintenance: fuel system | Failing to detect leaking fuel distribution lines(engine, stove heating) through periodic inspection / testing | | | | 2 | | | | | |
| 125 | Maintenance: check fumes | Starting the engine without first operating a bilge blower and sniffing for presence of fuel vapors | | 3 | | | | | | | |
| 126 | Maintenance: rigging | Failing to assure proper maintenance of rigging, including shrouds, lines to prevent failure and damage to boat | 3 | | | | | | | | |
| 127 | Maintenance: lines | Failing to assure that the boat is equipped with serviceable lines (dock, anchor, tow) | | | | | | | | | 3 |
| 128 | Maintenance: fire control | Not having the right number or type of fire extinguishers in working condition | | | | 2 | | | | | |
| 131 | Ability: operator | Setting out with an operator who clearly does not possess the ability needed for handling crew responsibilities, including sails, docking, emergencies | | | 7 | 11 | | 4 | 3 | | 3 |
| 132 | Ability: others | Not making sure that passengers and crew possess the ability needed to avoid risk in the intended operation | | | | | | | | | 4 |
| 141 | PFD: availability | Not having the required number and type of PFDs ( e.g. wearable, throwable, children's) readily available | | | 8 | | 2 | | | 16 | |
| 142 | PFD: risk of immersion | Not wearing PFD when conditions create significant risk of immersion, including rapids, dams, rough water, working outside rails, impaired passengers | | | 17 | | 8 | | 4 | 15 | 5 |
| 143 | PFD: risk of hypothermia | Not wearing PFD when cold water would jeopardize chances of remaining afloat | | | 6 | | 2 | | | 5 | |
| 144 | PFD: non - swimmers | Not requiring occupants unable to swim and exposed to any risk of immersion to wear a PFD | | | 5 | | 2 | | | | |
| 145 | Protective clothing | Not having or wearing clothing appropriate to the elements, e.g. cold air or water | | | 2 | | | | | | |

| Code | Error | Description | AS | CM | CK | HB | OM | PW | PB | RB | SO |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 151 | Alcohol: operator | Becoming impaired by alcoholic beverages and certain drugs | 3 | 11 | 15 | 10 | 15 | 5 | 12 | 15 | 3 |
| 161 | Location: check | Not checking of the intended location of operation in advance for hazardous conditions, including rapids, strong currents, waterfalls, lowhead dams, underwater obstructions | | 2 | 4 | | 2 | | | | |
| 162 | Location: hazards | Operating in areas known to be hazardous to the particular type of vessel, including rapids, lowhead dams, underwater obstructions, breaking swells. | | | 7 | | | | | | |
| 171 | Loading: weight | Carrying too many passengers and/or too much gear for the size of the boat, sea conditions and weather | | | | | 3 | | | 11 | |
| 172 | Loading: distribution | Allowing passengers/gear to be positioned in a way that reduces the stability of the boat, increases the chances of swamping/ capsizing, or obstructs the operator's view | | | | | | | | 5 | |
| 173 | Loading: fuel | Handling fuel in a manner that can cause combustion or spill | | | | 2 | | | | | |
| 200 | **Operation** | | | | | | | | | | |
| 211 | Control: maneuvering | Failing to maneuver properly in tight quarters, e.g., docking, anchoring, coming alongside other vessels, negotiating obstructions or clearing away from such situations | 3 | 2 | | 18 | | | 4 | | |
| 212 | Control: power | Loss of steering because of power reduction, e.g., jet propulsion. | | | | | | 5 | | | |
| 213 | Control: turning | Turning too sharply and falling from or losing control of vessel (e.g., PWC). | | | | | | 4 | | 4 | |
| 214 | Control: balance | Lack of proper steering, sail handling, weight distribution to maintain balance | 6 | | | | | | | | |
| 215 | Control: wind/ waves/current | Losing control in heavy wind or waves or heavy current, resulting in fall and/or collision | 2 | | | | | | | | |
| 216 | Control: activities | Deliberate wave jumping or spraying resulting in loss of control, falling from or striking vessel | | | | | | 8 | | | |
| 221 | Navigation: aids | Not using navigational aids adequately to determine position or course relative to shallow water and hazards, including land, jetties | 4 | 6 | | | | | | | |
| 222 | Navigation: current | Failing to account for current in terms of available propulsion, degree of control, and ability | | | 14 | | | | | 7 | |
| 231 | Lookout: surveillance | Not exercising all-round surveillance for boats that may be approaching | 6 | 4 | | 3 | 4 | 8 | | 2 | |
| 232 | Lookout: path | Being distracted and not looking ahead or paying sufficient attention to boats and other obstructions to the intended path | 19 | 15 | | 5 | 14 | 23 | 12 | 6 | 10 |
| 233 | Lookout: course change | Failing to look along the intended path of travel before initiating a turn | | | | | | 10 | 3 | | |

| Code | Error | Description | AS | CM | CK | HB | OM | PW | PB | RB | SO |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 234 | Lookout: small objects | Not looking closely for small objects or people in the water where they are likely to be present | | | | | 2 | | | | |
| 235 | Lookout: gear | Failing to look out for swing of the boom or other items of gear that can cause injury | | | | | | | | | 3 |
| 236 | Lookout: depth | Underway without visually checking depth of water often enough | 4 | 5 | | | 4 | | 6 | | |
| 237 | Lookout: night | Not locating / detecting unlighted objects (or flashing marks) in or near the intended course through use of searchlight, binoculars, radar, etc. | | 4 | | | | | | | |
| 238 | Lookout: obstructed | Failing to take steps to overcome vision obstructions e.g. sails, boat structures, other boats, passengers, sun glare or spray | 5 | | | | | 3 | | | 12 |
| 241 | Speed: maneuvers | Attempting maneuvers at a higher speed than the operator can safely manage, including when approaching another boat, dock, or other structure. | 4 | | | 9 | 2 | 3 | | | |
| 242 | Speed: turns | Attempting a turn at too high a speed, resulting in loss of control, capsize, swamping | | | | | 2 | | | | |
| 243 | Speed: reduced visibility | Moving too fast for the limitations of night or other forms of reduced visibility | | 5 | | | 3 | | | | |
| 244 | Speed: obstructions | Operating at too high a speed in close proximity to obstructions, including land, docks, moored vessels | | | | | | 2 | | | |
| 245 | Speed: waves/wake | Attempting to navigate through waves or wake at too great a speed for wave size | | 3 | | | 6 | 7 | | | |
| 246 | Speed: other boats | Operating at too high a speed in proximity to other boats, including activities involving games with other PWCs | | 5 | | | 3 | 16 | | | |
| 251 | Distance: other boats | Keeping insufficient distance from other boats to allow for wind, wave action, or other conditions that might result in collision | 11 | 10 | | | 7 | 35 | 8 | | 5 |
| 252 | Distance: land/structures | Keeping insufficient distance from land, shallow water, and structures such as docks, rocks, navigational aids | 5 | 4 | | 2 | 3 | 4 | 3 | 2 | 3 |
| 261 | Stability: boat | Committing acts that jeopardize stability and result in capsize, including standing, leaning, reaching or hanging over the side, shifting weight abruptly, not trimming the boat properly for the operation | | | 9 | | 4 | | | 12 | |
| 262 | Stability: occupant | Not keeping a firm grip on the boat; standing in the boat, sitting on seat backs or other locations that invite being thrown off | 6 | 6 | | 2 | 8 | | 16 | 8 | 3 |
| 271 | Give way: right-of-way | Failing to yield to a vessel with the right-of-way | 4 | | | | | 3 | | | 3 |
| 272 | Give way: collision | Failing to give way to avoid a collision | | | | | | 6 | | | |

| Code | Error | Description | A S | C M | C K | H B | O M | P W | P B | R B | S O |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 281 | Capsized /swamped | Not remaining with the boat when capsized or swamped, or using the boat for flotation | | | 4 | | | | | 6 | |
| 300 | **Weather** | | | | | | | | | | |
| 311 | Weather: recognition | Not recognizing conditions that are too severe for safe operation | | | | 5 | | | | 4 | 8 |
| 312 | Weather: operation | Operating in wind and/or wave conditions that are clearly unsafe for the type of boat, including canoes and kayaks, rowboats | | | | | 2 | | 3 | 5 | 4 |
| 313 | Weather: ability | Setting out under weather conditions that are beyond the operator's experience | | | 8 | | | | | | |
| 314 | Weather: forecasts | Not checking forecasts for conditions that make operation unsafe | | | | | | | | | 4 |
| 315 | Weather: handling | Not responding appropriately to rough wind/water conditions through safe handling | | | 5 | 4 | | | | | |
| 316 | Weather: shelter | Not seeking shelter from rough conditions once they become clearly dangerous | | | 5 | 3 | | | | | |
| 317 | Weather: spill wind | Not watching for gusts and spilling the wind to avoid extreme heel, capsize, or loss of control | 3 | | | | | | | | 7 |
| 318 | Weather: shorten sail | Not shortening or lowering sails when wind conditions warrant. | 4 | | | | | | | | 12 |
| 319 | Weather: security | Remaining in a secure place aboard in rough weather (inside cockpit, rails) | | | | | | | 6 | | |
| 400 | **Activities** | | | | | | | | | | |
| 411 | Anchor: type | Using inadequate ground tackle for the weather likely to be encountered (anchor of correct size and type and with adequate scope to prevent breakaway) | | | | 2 | | | | | |
| 412 | Anchor: preparation | Not having the anchor ready to lower in the right manner | | | | 2 | | | 3 | | |
| 413 | Anchor: use | Not anchoring correctly, including lack of enough scope for wind | | | | 2 | | | | | |
| 421 | Swimming: off/on | Not having a safe method to get off and reboard the boat by those voluntarily entering the water (e.g. to swim) | | | | | | | 3 | | |
| 422 | Swimming: flotation | Not using some form of flotation when entering the water with inadequate swimming ability | | | | | | | | 2 | |
| 423 | Waterskiing: procedures | Towing waterskiers, tubes and other devices unsafely or permitting unsafe practices (e.g. wave jumping ) | | | | | 8 | | | | |
| 424 | Waterskiing: recovery | Not keeping boat clear of skiers in the water in the process of recovery | | | | | 5 | | | | |

# APPENDIX 2 HUMAN ERROR DATA ELEMENTS

The following lists of human errors are grouped by boat type, as classified by the Boating Accident Reporting Database.

**Sail With Auxiliary Power**

| Taxonomy Number | Error Description |
|---|---|
| 0 | Cannot identify error from information provided |
| 0 | No Error |
| 123 | Maintenance - Poor engine maintenance, causing stalls, power loss |
| 126 | Maintenance - Poor rigging maintenance, causing failure and damage |
| 151 | Alcohol - Becoming impaired by alcohol |
| 211 | Control - Poor maneuvering in tight quarters (boats, docks, obstacles) |
| 214 | Control - Lack of steering, sail handling needed to maintain balance |
| 215 | Control - Poor control in heavy seas |
| 221 | Navigation - Inadequate use of navigation aids to locate shallows, hazards |
| 231 | Lookout - Inadequate 180º surveillance (looking around, behind sail) |
| 232 | Lookout - Not looking along path forward or behind (when backing) |
| 236 | Lookout - Not visually checking current water depth |
| 238 | Lookout - Not overcoming vision obstructions by people, other boats |
| 241 | Speed - Approaching dock, boat, structures too fast to maneuver properly |
| 251 | Distance - Insufficient distance from other boats for wind/water conditions |
| 252 | Distance - Insufficient distance from land/ structures for conditions |
| 262 | Stability - Insufficient grip/footing for conditions, activity (Slips, falls) |
| 271 | Give-Way - Not yielding ROW to visible boat on starboard tack |
| 317 | Weather - Not observing gusts, spill wind keep control, stability |
| 318 | Weather - Not shortening sail when wind conditions warrant |

**Cabin Motorboat Boating Errors**

| Taxonomy Number | Error Description |
|---|---|
| 0 | Cannot identify error from information provided |
| 0 | No error |
| 122 | Maintenance - Poor maintenance of engine/steering controls |
| 123 | Maintenance - Poor engine maintenance (no start, stall, power loss, etc.) |
| 125 | Maintenance - Not sniffing, using blower before starting engine |
| 151 | Alcohol - Becoming impaired by alcohol |
| 161 | Location - Not checking charts beforehand for hazards (rocks, current, dam) |
| 211 | Control - Poor maneuvering in tight quarters (docking, coming alongside) |
| 221 | Navigation - Inadequate use of navigation aids to locate shallows, hazards |
| 231 | Lookout - Inadequate 360 º surveillance (boats crossing/overtaking) |
| 232 | Lookout - Not looking, giving attention to path ahead (boats, obstructions) |
| 236 | Lookout - Not visually checking position relative to water depth |
| 237 | Lookout - Not detecting unlighted objects in path (lights, radar, etc.) |
| 243 | Speed - Going too fast for visibility (night, fog, etc.) |
| 245 | Speed - Going too fast through waves, wake |
| 246 | Speed - Going too fast near other boats |
| 251 | Distance - Insufficient distance from boats for wind/wave conditions |
| 252 | Distance - Insufficient distance from land, shallows, buoys, structures |
| 262 | Stability - Insufficient grip/footing for conditions, activity (slips, falls) |

**Canoe Boating Errors**

| Taxonomy Number | Error Description |
|---|---|
| 0 | Cannot identify error from information provided |
| 0 | No error |
| 110 | Vessel - Wrong type of canoe for conditions |
| 131 | Ability - Not having the skills for expected conditions |
| 141 | PFD - Not having the required number/ type of PFDs |
| 142 | PFD - Not wearing PFDs in high chance of immersion |
| 143 | PFD - Not wearing PFD in extremely cold water |
| 144 | PFD - Not requiring PFDs for non-swimmers |
| 151 | Alcohol - Becoming impaired by alcohol |
| 161 | Location - Not checking route for hazards (rapids, falls, dams rocks) |
| 222 | Navigation - Operating unsafely in strong current |
| 261 | Stability - Committing acts that capsize the canoe (standing, games) |
| 281 | Capsize - Swimming instead of using capsized/swamped canoe for flotation |
| 315 | Weather - Not responding to weather too severe for canoes |
| 316 | Weather - Not stopping or seeking shelter in rough conditions |

**Houseboat Boating Errors**

| Taxonomy Number | Error Description |
|---|---|
| 0 | Cannot identify error from information provided |
| 0 | No error |
| 122 | Maintenance - Poor maintenance of engine/steering controls |
| 123 | Maintenance - Poor engine maintenance (no start, stall, power loss, etc) |
| 124 | Maintenance - Not detecting leaking fuel/propane through inspection |
| 128 | Maintenance - Not having the right number/type of working fire extinguishers |
| 131 | Ability - Not having the skills needed to operate safely (tight quarters) |
| 151 | Alcohol - Becoming impaired by alcohol |
| 173 | Loading - Handling fuel in a way that can cause combustion or spill |
| 211 | Control - Poor low speed maneuvering tight quarters (docking, coming alongside) |
| 231 | Lookout - Inadequate 360 º surveillance (boats crossing/overtaking) |
| 232 | Lookout - Not looking, giving attention to path ahead (boats, obstructions) |
| 241 | Speed - Maneuvering at higher speed than skill allows (docking etc) |
| 252 | Distance - Insufficient distance from land, shallows, buoys, structures |
| 262 | Stability - Insufficient grip, standing, moving about, exposed position |
| 311 | Weather- Not recognizing wind/wave conditions unsafe for houseboats |
| 315 | Weather - Not handling rough conditions safely (waves/winds) |
| 316 | Weather - Not seeking shelter from rough conditions soon enough |
| 411 | Anchor - Not having, using correct anchor for weather (type, size,) |
| 412 | Anchor - Not prepared to lower anchor when needed |
| 413 | Anchor - Improper anchoring (from stern), recovery |

**Kayak Boating Errors**

| Taxonomy Number | Error Description |
|---|---|
| 0 | Cannot identify error from information provided |
| 0 | No error |
| 110 | Vessel - Wrong type of kayak for conditions |
| 131 | Ability - Not having the skills for the expected conditions |
| 142 | PFD - Not wearing PFDs under high chance of immersion |
| 145 | Clothing - Not properly outfitted for conditions (clothing, helmet) |
| 161 | Location - Not checking route for hazards (waterfalls, dams, obstructions) |
| 162 | Location - Operating in hazardous areas (waterfalls, dams, obstructions) |
| 222 | Navigation - Operating unsafely in strong current (trapped by rocks, limbs) |
| 313 | Weather - Starting out in weather too severe for ability |
| 316 | Weather - Not stopping or seeking shelter in rough conditions |

**Open Motorboat Boating Errors**

| Taxonomy Number | Error Description |
|---|---|
| 0 | Cannot identify error from information provided |
| 0 | No error |
| 122 | Maintenance - Poor maintenance of engine controls |
| 123 | Maintenance - Poor engine maintenance (no start, stall, power loss) |
| 141 | PFD - Not having the required number and type of PFDs |
| 142 | PFD - Not wearing PFD under high risk of immersion |
| 143 | PFD - Not wearing PFD under danger of hypothermia |
| 144 | PFD - Not requiring PFDs for non-swimmers under chance of immersion |
| 151 | Alcohol - Becoming impaired by alcohol/ drugs |
| 161 | Location - Not checking charts beforehand for hazards (rocks, current, dam) |
| 171 | Loading - Operating with excess weight, poor trim (capsize/swamping) |
| 213 | Control - Turning too abruptly for operating speed |
| 231 | Lookout - Inadequate 360º surveillance (boats crossing, overtaking) |
| 232 | Lookout - Not looking, inattention to path ahead (boats, obstructions) |
| 234 | Lookout - Not looking at surface for swimmers, small objects in water |
| 236 | Lookout - Underway without checking depth often enough |
| 241 | Speed - Attempting maneuvers at too high a speed |
| 242 | Speed - Attempting turn at too high a speed (control loss, capsize) |
| 243 | Speed - Going too fast for visibility (night, fog, etc.) |
| 245 | Speed -Going too fast for large wakes or waves |
| 246 | Speed - Going too fast near boats, when approaching blind bends |
| 251 | Distance - Insufficient distance from boats to respond to sudden changes |
| 252 | Distance - Insufficient distance from land, shallows, aids, structures |
| 261 | Stability - Not remaining seated when conditions require (wind, waves) |
| 262 | Stability - Insufficient grip when standing, moving, in exposed position |
| 312 | Weather - Operating under marginal weather/water conditions |
| 423 | Skiing - Operating in an unsafe manner for towing skiers |
| 424 | Skiing - Not keeping boat clear of skiers during recovery |

**Personal Watercraft Boating Errors**

| Taxonomy Number | Error Description |
|---|---|
| 0 | Cannot identify error from information provided |
| 0 | No error |
| 131 | Ability - Not having the basic skills for safe operation |
| 151 | Alcohol - Becoming impaired by alcohol |
| 212 | Control - Reducing power and losing directional control |
| 213 | Control - Turning too sharply and falling or losing control |
| 216 | Control - Activities that can cause loss of control (wave jumping, spraying) |
| 231 | Lookout - Inadequate 360º surveillance for other boats (other PWCs ) |
| 232 | Lookout - Not looking, giving attention to path ahead (PWCs, obstructions) |
| 233 | Lookout - Not looking to the side and behind before turning |
| 238 | Lookout - Not reducing vision obstructions (PWCs/glare/spray) |
| 241 | Speed - Going too fast for attempted maneuvers |
| 244 | Speed - Going too fast near land, structures, moored boats |
| 245 | Speed - Going too fast for large waves, wakes |
| 246 | Speed - Going too fast near other boats ( PWC games etc) |
| 252 | Distance - Insufficient distance from land, docks, shallows |
| 271 | Give way - Not yielding to a vessel approaching ahead or from right |
| 272 | Give way - Not giving way to avoid collision risk (wrong turn) |

**Pontoon Boat Boating Errors**

| Taxonomy Number | Error Description |
|---|---|
| 0 | Cannot identify error from information provided |
| 0 | No error |
| 131 | Ability - Not having the basic skills for safe operation |
| 142 | PFD - Not wearing PFD under risk of immersion |
| 151 | Alcohol - Becoming impaired by alcohol |
| 211 | Control - Poor maneuvering tight quarters (docking, coming alongside) |
| 232 | Lookout - Not looking, inattention to path ahead (boats, obstructions) |
| 233 | Lookout - Not looking to the side and behind before starting a turn |
| 236 | Lookout - Underway without checking depth often enough |
| 251 | Distance - Insufficient distance from boats to react to sudden changes |
| 252 | Distance - Insufficient distance from land/structures for conditions |
| 262 | Stability - Lack of firm grip/footing (outside rails, on bow gate) |
| 312 | Weather - Operating in wind and wave conditions clearly unsafe |
| 319 | Weather - Not remaining in a secure place on board in rough weather |
| 412 | Anchor - Not having the right anchor, not ready to lower correctly |
| 421 | Swimming - Not having safe way for swimmers to get on and off |

**Rowboat Boating Errors**

| Taxonomy Number | Error Description |
|---|---|
| 0 | Cannot identify error from information provided |
| 0 | No error |
| 110 | Vessel - Using a boat unsuited to activity/conditions (too small) |
| 121 | Maintenance - Not checking/fixing leaks, other ways water may enter |
| 141 | PFD - Not having the required number and type of PFDs |
| 142 | PFD - Not wearing PFD under high risk of immersion (wind, etc.) |
| 143 | PFD - Not wearing PFD under danger of hypothermia |
| 151 | Alcohol - Becoming impaired by alcohol |
| 171 | Loading - Passengers/gear to heavy for boat size, weather conditions |
| 172 | Loading - Not distributing weight of passengers/gear to assure safe balance |
| 213 | Control - Turning too sharply and falling or losing control |
| 222 | Navigation - Operating unsafely in strong current |
| 231 | Lookout - Inadequate 360º surveillance for boats when under power |
| 232 | Lookout - Not looking along path ahead under power/ racing shell |
| 252 | Distance - Insufficient distance from land/structures (rocks, dam, bridge etc.) |
| 261 | Stability - Not remaining seated when conditions require (capsize/swamp) |
| 262 | Stability - Insufficient grip/foothold when, standing, moving about |
| 281 | Capsize - Not staying with capsized/swamped boat; attempting to swim |
| 311 | Weather - Not recognizing to changes in weather conditions (waves) |
| 312 | Weather - Operating in marginal weather/water conditions |
| 422 | Swimming - Not using flotation when entering water unable t swim well |

**Sail-Only Boating Errors**

| Taxonomy Number | Error Description |
|---|---|
| 0 | Cannot identify error from information provided |
| 0 | No error |
| 121 | Maintenance - Not checking for leaks, other ways water may enter |
| 127 | Maintenance - Not having serviceable lines (dock, anchor, tow) |
| 131 | Ability - Operator unable to handle responsibilities (sails, emergencies, etc.) |
| 132 | Ability - Crew unable to handle tasks ( sails, emergencies, etc) |
| 142 | PFD- Not wearing PFD under high risk of immersion |
| 151 | Alcohol - Becoming impaired by alcohol |
| 232 | Lookout - Not looking, inattention to path ahead (boats, obstructions) |
| 235 | Lookout - Not looking at possible sources of injury (boom, gear) |
| 238 | Lookout - Not overcoming vision obstruction by sail (post lookout) |
| 251 | Distance - Insufficient distance from boats for wind/wave conditions |
| 252 | Distance - Insufficient distance from land/ structures for conditions |
| 262 | Stability - Insufficient grip/footing for conditions, activity (slips, falls) |
| 271 | Give way - Not yielding ROW to visible boat on starboard tack |
| 311 | Weather - Not recognizing to changes in weather conditions (strong wind) |
| 312 | Weather - Not stopping in conditions too severe for operation |
| 314 | Weather - Not checking weather forecasts before setting out to sail |
| 315 | Weather - Not responding appropriately to rough water (handling, position) |
| 317 | Weather - Not observing gusts, spill wind keep control, stability |
| 318 | Weather - Not shortening sail when wind conditions warrant |

# APPENDIX 3

## INVESTIGATOR CODING MATERIALS

### Instructions

### Checklist of Recreational Boating

### Description of Recreational Boating Errors

### Instructions
### Using the Checklist of Recreational Boating Errors

# Instructions
## Using the Checklist of Recreational Boating Errors

That most accidents are the result of human error is well known; just what the errors are is not as well known.. Those who investigate and report boating accidents generally have a good idea what caused them. Generally this information is reported in narratives. But, there is no way that others can learn of the causes without pouring through hundreds of narratives. The Boating Accident Report (BAR) does provide an opportunity to check off accidents in broad categories, such as "Improper Lookout" or "Passenger/Skier Behavior." Yet, without knowing just where the boater failed to look, or just what "behavior" was involved, the information is not as helpful in guiding efforts to prevent mistakes as it might be.

The Checklist — The Checklist of Recreational Boating Errors allows the errors underlying boating accidents to be classified in more specific terms than called for on the BAR. It is based on an analysis of over three thousand boating accidents across the country and lists those errors contributing to more than 1% of accidents for one or more of the nine major boat types. A list of all errors would be extremely long. Besides, errors that occur no more than 1% of the time are not the most appropriate targets for prevention efforts. After completing the BAR, enter the case number, circle the boat type and then circle the number of each error that, in your best judgement, contributed to the accident. Submit the checklist along with the BAR.

Familiarization — First, take a few minutes to get the layout of the checklist. You will notice that the errors are grouped by category; four major categories, with subcategories in each. Learning the categories helps make the list easy to navigate.

Definitions — Next, read through the explanations of the individual errors on the following pages. You don't need to memorize them; the idea is just to learn enough to be able to decide which errors on the checklist are the most likely possibilities in a particular accident.

Assigning errors — For each accident, decide which of the errors in the checklist contributed to the accident. There are two conditions for an error to be circled:

- If it had not occurred there would have been no accident or no damage, injury or death as the result of an accident.
- It must be an action that a reasonable and prudent boater would not have made; we can't expect perfection.

Number of errors — Some accidents will involve more than one error. To be checked, each error must be one which, if avoided, would have prevented the accident from happening. For example, if a motorboat is traveling at high speed and turns so sharply that a passenger seated on the rail goes overboard, there are two errors in that the accident would not have occurred if either the boat had not turned sharply at high speed (242) or the passenger had been seated in the cockpit (262).

Multiple Boats — In most cases, when two or more boats are involved in an accident, only one of the boaters will have made the error leading to the accident. However, where more than one of the boaters contributed to the accident a separate checklist should be completed for each boat. In the case of multiple boats, an error is not just creating the situation that caused the accident but also failing to exercise a reasonable precaution that would have prevented being involved. For example, a PWC stops suddenly and is struck by one following closely behind. While the trailing PWC is the one “at fault” for following too closely (251) the other operator’s failure to check behind (231) before closing the throttle, a reasonable precaution, also meets the conditions for an error. The precaution must be one that a reasonably prudent operator would take; no one is expected to be psychic.

Unlisted/Unidentifiable Errors — Many accidents involve errors that do not occur more than 1% of the time and, therefore, are not on the checklist. In other cases error cannot be identified from the information available through investigation. If, after surveying the list of errors nothing seems to fit, then use either the “Unlisted” or “Unidentifiable” categories at the end of the checklist. Do not try to force fit an accident to the list of errors. The narratives of reports with unlisted errors will be reviewed periodically to see if, over time, certain errors occur often enough to be added to the checklist.

Quality Assurance — It is important to be as sure as possible as to an error before checking it off. Better not to check an error at all than to check one incorrectly. It is wise to consult the definitions even after you feel you know them. Should your memory play tricks on you, it is possible that you won't realize it and, without consulting the definitions, you may go on checking the wrong error.

**Case Number**

______________________

## Checklist of Recreational Boating Errors

**Boat type (Circle one) Auxiliary Sailboat Cabin Motorboat Canoes/Kayak Houseboat Open Motorboat Personal Watercraft Pontoon Boat Rowboat Sail Only**

Circle error(s)

| 100 | **Preparation** | 200 | **Operation** | | **Operation** (cont.) | 300 | **Weather** |
|---|---|---|---|---|---|---|---|
| 110 | Vessel: stability | 211 | Control: maneuvering | 241 | Speed: maneuvers | 311 | Weather: recognition |
| 121 | Maintenance: hull | 212 | Control: power | 242 | Speed: turns | 312 | Weather: operation |
| 122 | Maintenance: controls | 213 | Control: turning | 243 | Speed: low visibility | 313 | Weather: skill |
| 123 | Maintenance: propulsion | 214 | Control: balance | 244 | Speed: obstructions | 314 | Weather: forecasts |
| 124 | Maintenance: fuel system | 215 | Control: wind/ waves | 245 | Speed: waves/wake | 315 | Weather: handling |
| 125 | Maintenance: check fumes | 216 | Control: wave/jump | 246 | Speed: other boats | 316 | Weather: shelter |
| 126 | Maintenance : rigging | 221 | Navigation: aids | 251 | Distance: other boats | 317 | Weather: spill wind |
| 127 | Maintenance : lines | 222 | Navigation: current | 252 | Distance: land/structures | 318 | Weather: shorten sail |
| 128 | Maintenance : fire control | 231 | Lookout: surveillance | 261 | Stability: boat | 319 | Weather: security |
| 131 | Ability: crew | 232 | Lookout: ahead | 262 | Stability: occupant | 400 | **Activities** |
| 132 | Ability: others | 233 | Lookout: turn | 271 | Give way: Right of way | 411 | Anchor: type |
| 141 | PFD: availability | 234 | Lookout: small objects | 272 | Give way: collision | 412 | Anchor: preparation |
| 142 | PFD: risk of immersion | 235 | Lookout: gear | 281 | Capsize/swamped | 413 | Anchor: use |
| 143 | PFD: risk of hypothermia | 236 | Lookout: depth | | | 414 | Anchor: recovery |
| 144 | PFD: non-swimmers | 237 | Lookout: night | | | 421 | Swimming: off/on |
| 145 | Clothing | 238 | Lookout: obstructed | | | 422 | Swimming: flotation |
| 151 | Alcohol: operator | | | | | 431 | Waterskiing: proced. |
| 161 | Location: check | | | | | 432 | Waterskiing: recovery |
| 163 | Location: hazards | | | | | 998 | Unclassifiable |
| 171 | Loading: weight | | | | | 999 | Unidentifiable |
| 172 | Loading: distribution | | | | | | |
| 173 | Loading: fuel | | | | | | |

# DESCRIPTION OF RECREATIONAL BOATING ERRORS

| | | |
|---|---|---|
| 100 | **Preparation** | |
| 110 | **Vessel** suitability | Using a vessel with characteristics (type, length, etc) basically unsuited to the intended operation |
| 121 | **Maintenance:** hull | Not making sure the hull is free of leaks or other opportunities for entry of water |
| 122 | Maintenance: controls | Operating with controls in need of repair/adjustment, including steering, trim plate, throttle, shift, outboard or stern drive trim; uses correct replacement parts |
| 123 | Maintenance: propulsion | Operating with propulsion that has become unreliable for lack of maintenance (engine fails to start or stalls, weak battery, power loss, etc.) |
| 124 | Maintenance: fuel system | Failing to detect leaking gasoline or propane distribution lines through periodic inspection / testing |
| 125 | Maintenance: check fumes | Starting the engine without first operating a bilge blower and sniffing for presence of fuel vapors |
| 126 | Maintenance: rigging | Failing to assure proper maintenance of rigging, including shrouds and other lines, in a manner that will prevent failure and damage to boat |
| 127 | Maintenance: lines | Failing to assure that the boat is equipped with serviceable lines (dock, anchor, tow) |
| 128 | Maintenance: fire control | Not having the right number or type of fire extinguishers in working condition |
| 131 | **Ability**: operator | Setting out with an operator who clearly does not possess the ability needed for handling crew responsibilities, including sails, docking, emergencies |
| 132 | Ability: others | Not making sure that passengers and crew possess the ability needed to avoid risk in the intended operation |
| 141 | **PFD**: availability | Not having the required number and type of PFDs ( e.g., wearable, throwable, children's) readily available. |
| 142 | PFD: risk of immersion | Not wearing PFD when conditions create significant risk of immersion, including rapids, dams, rough water, working outside rails, impaired passengers |
| 143 | PFD: risk of hypothermia | Not wearing PFD when cold water would jeopardize chances of remaining afloat |
| 144 | PFD: non swimmers | Not requiring occupants unable to swim and exposed to any risk of immersion to wear PFDs |
| 145 | **Clothing** | Not having or wearing clothing appropriate to the elements, e.g., cold air or water |
| 151 | **Alcohol**: operator | Becoming impaired by alcoholic beverages and certain drugs |
| 161 | **Location**: check | Not checking the intended location of operation in advance for hazardous conditions, including rapids, strong currents, waterfalls, lowhead dams, underwater obstructions |
| 162 | Location: hazards | Operating in areas known to be hazardous to the particular type of vessel, including rapids, lowhead dams, underwater obstructions, breaking swells |
| 171 | **Loading:** weight | Carrying too many passengers and/or too much gear for the size of the boat, sea conditions and weather |
| 172 | Loading: distribution | Allowing passengers/gear to be positioned in a way that reduces the stability of the boat, increases the chances of swamping/capsizing, or obstructs the operator's view |
| 173 | Loading: fuel | Handling fuel in a manner that can cause combustion or spill |
| 200 | **Operation** | |

| | | |
|---|---|---|
| 211 | **Control:** maneuvering | Failing to maneuver properly in tight quarters, e.g., docking, anchoring, coming alongside other vessels, negotiating obstructions or clearing away from such situations |
| 212 | Control: propulsion | Loss of steering because of reduced power and propulsion, e.g., jet propulsion |
| 213 | Control: turning | Turning too sharply and falling from or losing control of vessel |
| 214 | Control: balance | Lack of proper steering, sail handling, weight distribution to maintain balance |
| 215 | Control: wind/waves | Losing control in heavy wind/waves or surf, including turning around in rough inlet conditions or allowing stern area to be exposed |
| 216 | Control: wave/jump | Deliberate wave jumping resulting in loss of control , falling from or striking vessel |
| 221 | **Navigation:** aids | Not using navigational aids adequately to determine position or course relative to shallow water and hazards, including land, jetties |
| 222 | Navigation: current | Failing to account for current in terms of available propulsion, degree of control, and ability |
| 231 | **Lookout**: surveillance | Not exercising all-round surveillance for boats that may be close or approaching, including positioning someone to see around obstructions (e.g., cabin, sails) |
| 232 | Lookout: ahead | Being distracted and not looking ahead or paying sufficient attention to boats and other obstructions to the intended path |
| 233 | Lookout: turn | Failing to look along the intended path of travel before initiating a turn |
| 234 | Lookout: small objects | Not looking closely for small objects or people in the water where they are likely to be present |
| 235 | Lookout: gear | Failing to look out for swing of the boom or other items of gear that can cause injury |
| 236 | Lookout: depth | Underway without visually checking depth of water often enough |
| 237 | Lookout: night | Not locating / detecting unlighted objects (or flashing marks) in or near the intended course through use of searchlight, binoculars, radar, etc. |
| 238 | Lookout: obstructed | Failing to take steps to overcome vision obstructions, including passengers, boat structures, sun glare, spray, sails, or boats ahead |
| 241 | **Speed:** maneuvers | Attempting maneuvers at a higher speed than the operator can safely manage, including when approaching another boat, dock or other structure |
| 242 | Speed: turns | Attempting a turn at too high a speed, resulting in loss of balance or control, capsizing, swamping |
| 243 | Speed: low visibility | Moving too fast for the limitations of night or other forms of reduced visibility |
| 244 | Speed: obstructions | Operating at too high a speed in close proximity to obstructions, including land, docks, moored vessels |
| 245 | Speed: waves/wake | Attempting to navigate through waves or wake at too great a speed for wave size |
| 246 | Speed: other boats | Operating at too high a speed in proximity to other boats, including activities involving games with other PWCs |
| 251 | **Distance:** other boats | Not keeping sufficient distance from other boats to allow for wind, wave action, sudden changes in speed or direction, or other conditions that might result in collision |
| 252 | Distance: land/structures | Not keeping sufficient distance from land, shallow water, and structures such as docks, rocks, navigational aids |
| 261 | **Stability**: boat | Committing acts that jeopardize stability and result in capsize, including standing, leaning, reaching or hanging over the side, shifting weight abruptly, not trimming the |

| | | |
|---|---|---|
| | | boat properly for the operation |
| 262 | Stability: occupant | Not keeping a firm grip on the boat; standing in the boat, sitting on seat backs or other locations that invite being thrown off |
| 271 | **Give way:** Right-of-way | Failing to yield to a vessel with the right-of-way |
| 272 | Give way: collision | Failing to give way to avoid a collision |
| 281 | Capsized/ Swamped | Not remaining with the boat when capsized or swamped or using the boat for flotation |
| 300 | **Weather** | |
| 311 | Weather: recognition | Not recognizing conditions that are too severe for safe operation |
| 312 | Weather: operation | Operating in wind and/or wave conditions that are clearly unsafe for the type of boat, including canoes and kayaks, rowboats |
| 313 | Weather: skill | Setting out under weather conditions that are beyond the operator's skill |
| 314 | Weather: forecasts | Not checking forecasts for conditions that make operation unsafe |
| 315 | Weather: handling | Not responding appropriately to rough wind/water conditions through safe handling |
| 316 | Weather: shelter | Not seeking shelter from rough conditions once they become clearly dangerous |
| 317 | Weather: spill wind | Not watching for gusts and spilling the wind to avoid extreme heel, capsize, or loss of control |
| 318 | Weather: shorten sail | Not shortening or lowering sails when wind conditions warrant |
| 319 | Weather: security | Remaining in a secure place aboard in rough weather |
| 400 | **Activities** | |
| 411 | **Anchor:** type | Using inadequate ground tackle for the weather likely to be encountered (anchor of correct size and type and with adequate scope to prevent breakaway) |
| 412 | Anchor: preparation | Not having the proper anchor or not being ready to lower in the right manner |
| 413 | Anchor: use | Not anchoring correctly, including lack of enough scope for wind, current, or bottom; anchoring from the stern |
| 414 | Anchor: recovery | Improper recovery of anchor including driving the boat ahead before full recovery |
| 421 | **Swimming:** off/on | Not having a safe method to get off and reboard the boat by those voluntarily entering the water (e.g., to swim) |
| 422 | Swimming: flotation | Not using some form of flotation when entering the water with inadequate swimming ability |
| 431 | **Waterskiing:** procedures | Towing waterskiers, tubes and other devices unsafely, or permitting unsafe practices (e.g., wave jumping ) |
| 432 | Waterskiing: recovery | Failure to maintain a safe separation between the boat and skier while maneuvering for recovery |
| | | |
| 998 | **Unclassifiable** | The error does not appear on the list |
| 999 | **Unidentifiable** | No error can be identified from the information provided |