



National Transportation Safety Board

Washington, D.C. 20594

Safety Recommendation

Date: June 25, 1998

In reply refer to: M-98-85 and M-98-86

To the Manufacturers
of Personal Watercraft
(see attached mailing list)

Personal watercraft (PWC) are a type of recreational boat that has become increasingly popular in recent years. Manufacturers estimate that about 200,000 PWC are sold each year, and more than 1 million are in current operation. PWC now account for more than one-third of the new recreational boat sales in the United States.

Although the overall number of recreational boating fatalities has been declining in recent years, the number of personal watercraft-related fatalities has been increasing. At the time of the National Transportation Safety Board's 1993 recreational boating safety study, there were only 26 personal watercraft fatalities a year, and the Safety Board did not believe that separate consideration of PWC was warranted. However, in 1994, the number of PWC fatalities began to increase noticeably because the number of PWC in operation increased. Preliminary numbers for 1997 indicate 83 PWC fatalities. PWC are the only type of recreational vessel for which the leading cause of fatalities is not drowning; in PWC fatalities, more persons die from blunt force trauma than from drowning. The increase in fatalities and the distinctive way in which fatalities occur prompted the Safety Board to examine the nature of PWC accidents.

The Safety Board initiated a study to more closely examine fatalities and injury in addition to accident characteristics associated with PWC accidents.¹ The study was not designed to estimate how often PWC accidents occur. The Safety Board examined 1,739 PWC accident reports for accidents that occurred during an 18-month period, January 1996 through June 1997. For PWC accidents that occurred between January and June 1997, the Safety Board requested that State marine accident investigators provide the Safety Board with copies of their accident reports and complete a supplemental questionnaire prepared by the Safety Board specifically for this study. The goal of the supplemental questionnaire was to obtain additional information concerning the accident characteristics and details concerning personal injury that have not

¹ National Transportation Safety Board. 1998. Personal Watercraft Safety. Safety Study NTSB/SS-98/01. Washington, DC.

previously been available from State boating accident reports. State accident reports and supplemental information were the sources of the Safety Board's accident information.

For the January-June 1997 period, the Safety Board received boating accident reports and questionnaire responses from 37 participating States and Territories. Boating accident reports were not always accompanied by supplemental questionnaires. Also, because of concerns over personal privacy issues, five States² did not provide the Safety Board with copies of their boating accident reports but did provide supplemental questionnaires. Consequently, the boating accident reports and the supplemental questionnaires represent two different but substantially overlapping sets of data, which contain information on a total of 814 PWC accidents involving 1,218 operators.

The Safety Board also reviewed State reports of PWC accidents that occurred in 1996. A total of 49 States and Territories provided either copies of their boating accident report forms, automated boating accident report database files, or summary information for 1996 and/or 1997.

Because the States voluntarily provided the Safety Board with accident reports and supplemental questionnaire information, and because of the incomplete nature of much of the information, the Safety Board does not claim that the results of the study are representative of all PWC accidents. The Safety Board analyzed 814 (one-third) of the 1997 reported accidents and examined all of the data for the 1996 reported accidents. Consequently, the Board believes that a substantial number of accidents was available to identify the most important safety issues associated with PWC accidents. Further, the Safety Board's analysis did not show any biases in the types of accidents in the half-year of 1997 accidents compared to the full year of 1996 accidents. The Safety Board's interest in truncating the data collection period to 6 months was based on a goal of providing the results of this study prior to the 1998 summer boating season.

Based on the analysis of the data reviewed, the safety issues discussed in the Safety Board's report include the following: protecting personal watercraft riders from injury, operator experience and training, and boating safety standards. The study also addresses the need for recreational boating exposure data. The discussion in this letter is limited to the issues of protecting personal watercraft riders from injury and boating safety standards.

The Safety Board's study of PWC accidents specifically examined injury type and severity. According to Coast Guard data for 1996, drowning is the leading cause of death for all recreational boating accidents (500 of 709); however, injuries of blunt force trauma are more common to the operators and passengers of PWC. Of the 57 deaths attributed to PWC accidents in the Coast Guard 1996 data, 42 PWC operators or other boaters (74 percent) died from causes other than drowning. This distinction led the Safety Board to examine the injury characteristics of PWC accidents to see if there were special considerations for the safe use of these vessels.

² California, Delaware, Nevada, Washington, and the Territory of Puerto Rico.

Injury Coding

For the 1997 PWC accidents resulting in injury, marine investigators indicated injury location on body diagrams on the Safety Board's supplemental questionnaire and, in many cases, the investigator also provided text descriptions of the injuries. To provide some level of assessment of injury severity, Safety Board staff used this information to code each injury according to the Abbreviated Injury Scale, 1990 Revision (AIS 90).³ The AIS, developed by the Association for the Advancement of Automotive Medicine, offers a standardized system for categorizing injury type and severity.⁴ Each injury description was assigned a 6-digit numerical code in addition to an AIS severity score. A composite Injury Severity Score, ISS, was calculated for each victim based on the sum of the squares of the highest AIS severity score in each of the three most severe injuries from a defined set of six body regions.⁵

AIS was originally developed in the early 1970s for impact injury assessment, but subsequent revisions (1976, 1980, 1985, and 1990) have incorporated coding for brain injuries, penetrating trauma, vascular injuries, and burns. AIS 90 includes specific coding rules, which the Safety Board followed to code the injuries in the study cases, and a dictionary of over 2,000 injury descriptions. Because AIS was initially developed to assess injury to victims that were involved in emergency care (that is, its function was to project survivability), it has some limitations for postmortem assessment of injury. For the purposes of this study, fatalities were coded with a maximum severity code, ISS = 75, regardless of the AIS injuries associated with that victim. Drowning was coded as severe inhalation.

Injured Persons

Injuries were recorded for anyone involved in a PWC accident: operators of vessels (whether they were at fault or not), passengers, boaters, swimmers, skiers, and in one case, a nonwater victim. Injury of some level was sustained in 61 percent of the study accidents (500 of 814); there were 563 injured persons in these 500 accidents. The 563 injured persons sustained a total of 835 separate injuries; some persons sustained more than one injury, and multiple injuries were coded separately (this accounts for the larger number of injuries compared to the number of injured persons). Two percent of the reported injuries (15 of 835 injuries) did not contain sufficient information to enable AIS coding.

Although PWC operators were the most likely persons to be killed or injured in the PWC accidents examined for the study, 37 of the persons injured or killed (7 percent) can be considered bystanders; that is, they were not operating a PWC nor were they a PWC passenger. Consumer

³ The Safety Board staff member who coded the injury data had a nursing background, and an NTSB staff physician was available to answer questions.

⁴ AIS 90, which was released in 1990, is the most recent coding revision. A new version, AIS 98, is expected to be released in 1998.

⁵ Baker, S.P.; O'Neill, B.; Haddon, W.; Long, W.B. 1974. The injury severity score: a method for describing patients with multiple injuries and evaluating emergency care. *Journal of Trauma*. 14: 187-196.

Product Safety Commission accident reports for 1997 contain similar reports of injury and death to persons who were not the PWC operators or passengers, but were swimmers, scuba divers, and persons tubing and skiing.⁶

Fatalities

Of the 563 injured persons, 27 were fatally injured. Fatalities included 24 PWC operators, one passenger, one boater, and one swimmer. The characteristics of fatal accidents differed little from those of all PWC accidents. Vessel collisions were the leading type of fatal accidents (40 percent), and when combined with collisions with objects (16 percent), collisions accounted for more than half of all fatal accidents. Overboard was indicated as the type of accident for 30 percent of the fatalities. Each fatality occurred in a separate accident.

Operator inexperience and inappropriate speed were the leading reported causes of the fatal PWC accidents, and they were two of the three leading causes of all PWC accidents. Fewer rented PWC in the Safety Board's sample were involved in fatal accidents; rented PWC accounted for 36 percent of all accident vessels but were only 11 percent of fatal accident vessels.

Types of Injuries

Minor injuries accounted for the majority of the injuries reported (61 percent, or 513 of the 835 separate injuries); moderate injuries accounted for 25 percent (210 of 835). For the purpose of discussion, injuries coded "moderate" under AIS could include fracture of the pelvis, dislocated knee, major skin laceration, two to three broken ribs, or retinal detachment in the eye. There were 68 serious injuries (8 percent); injuries coded severe, critical, and maximum accounted for 3.5 percent.

Lower Extremity Injuries. Collision between two PWC was the most frequent type of accident. When two PWC collide, the likely impact area is slightly above the waterline, where feet and legs straddle the vessel. A high proportion (one-third) of injuries in the Safety Board's 1997 sample occurred in the lower extremities. Skeletal fractures and breaks occurred more frequently than all other types of injuries to the lower extremities; for the 286 injuries to the lower extremities, more than half (165, or 58 percent) were skeletal fractures or breaks. Combined injuries for upper and lower extremities accounted for nearly half (47.5 percent) of all injuries. However, injury to an extremity is rarely life threatening (all but one type of lower extremity injury is defined as AIS-3 or less).

For the PWC accidents involving a single vessel, there were 110 reported injuries to lower extremities. Nearly half (52) involved broken bones (the remaining were contusions, abrasions, and bleeding). This high percentage of broken legs and ankles in accidents that did not involve

⁶ In two cases, PWC struck and killed a swimmer; in two cases, PWC struck and killed a scuba diver; and in three cases, a PWC struck and killed persons who were tubing or skiing.

collision indicates that operators are being injured by their own vessel. The following case examples illustrate the events:

- In the description of one accident, the investigator stated, "Two people on board; made a right turn and flipped to the left catching the operator's leg and breaking it." The resulting break was to the operator's left leg about halfway between the ankle and knee.
- The witness of another accident provided the investigator with the following statement: "[the individual] was just playing around doing figure 8 circles and was going to turn around to stay out of the no-wake zone and a wave hit the side of the Waverunner catching her off guard and threw her off the side. Her ankle got caught between the side and the seat."
- Another accident report included the following statement: "While turning to the right to cross the wake of another vessel, at an excessive speed, the operator was thrown to the left. His foot became stuck in the foot well causing his leg to be broken."

The Safety Board's study did not address the mechanisms of injury; it would be difficult for any large-scale study to do that because of the isolated nature of PWC accidents. However, based on the anecdotal evidence of how injury occurred, it is suspected that some proportion of injury to lower extremities is associated with entrapment of the operator's feet as the person is ejected from the PWC.

Head Injuries. Of greater concern than leg injuries are injuries to the head, neck, and face because these injuries are generally more life threatening than are injuries to the extremities. Head, neck, and facial injuries accounted for one of every four injuries reported in the PWC accidents examined for this safety study. Injuries to the head contain many examples of more severe injuries (severe = AIS 4, critical = AIS 5, maximum = AIS 6). These type of injuries would include most penetration injuries to the head, open lacerations to intracranial vessels, or skull fractures. Because of the AIS coding definitions, it would be expected that head injuries for a large number of accidents would, on average, be more severe than leg injuries.⁷ The Safety Board's 1997 accident sample included 12 head injuries that were categorized as severe or higher (AIS = 4, 5, or 6), 9 of which were fatal (maximum AIS = 6).

A classic response to protect against head injuries would be the use of helmets. This has been true for motorcycling, bicycling, snowboarding, skateboarding, and an array of speed-related sports. The International Jet Sport Boating Association requires PWC riders in competitive races to wear helmets.⁸ However, there are many design questions that must be considered for PWC

⁷ The magnitude of AIS severity coding should not be compared for different body regions because injuries to some areas of the body are not as life threatening as to other areas; for example, injuries to the upper extremities are not as severe as injuries to the head. The AIS coding for upper extremities does not include any situation that can be coded beyond a severity level equal to 3 (minor = 1, moderate = 2, and serious = 3), whereas many head injuries are categorized higher than 3. Consequently, a comparison of average severity by body region is not valid.

⁸ 1998 Official Competition Rule Book of the International Jet Sport Boating Association.

helmet use; for example, should the helmet be a full-face or cutaway design, what is the best material for composition, should it have a face guard, and if so, how would water spray distort vision. Research on helmet load analysis for personal watercraft⁹ has concluded that "the likelihood of neck injury from impact with the water is significantly increased for riders with helmets even at normal riding speeds. Unless the potential for head injury due to collision is significant (like in racing), wearing a helmet is not recommended."¹⁰ Further research is warranted before appropriate head gear protection can be recommended. One PWC manufacturer summarizes the helmet issue as follows:

A helmet is designed to provide some head protection. Although helmets cannot protect against all foreseeable impacts, a helmet might reduce your injuries in a collision with a boat or other obstacle. A helmet may have potential safety hazards, as well. A helmet could catch the water during a fall into the water. This is commonly called "bucketing." The resulting strain on your neck could cause choking, severe and permanent neck injuries, or death. A helmet could also increase your risk of an accident if it reduces your vision or hearing, or if it distracts you or increases your fatigue.¹¹

A closer review of head injuries to separate injuries to the face and neck revealed that 113 injuries (49 percent of 232 head injuries) were facial injuries. Many accident reports contained descriptions of single-vessel accidents in which the operators hit their face on the vessel while jumping waves. Descriptive information included in the investigative reports cannot be assumed to be comprehensive (in many cases there was no indication of the mechanism of injury); consequently, the Safety Board's analyses cannot attribute cause to the facial injuries. However, descriptions such as those that follow provide examples that could be beneficial to future PWC design changes:

- A Missouri investigator stated that the "operator jumped the wake of a passing cruiser. When the PWC came down, the nose of the PWC went straight down into the water. Operator hit her head on the start/stop switch mounting, cutting her forehead. She was treated for lacerations and bruises at the local hospital."
- A Virginia operator stated that "when jumping wakes, you have no control when PWC is out of water." The operator received a laceration to the left eyebrow that required four stitches.

⁹ Robbins, Ron; Taylor, Robert K.; Fuller, Peter M. 1997. Neck loading due to head immersion in water at high speeds. In: *Proceedings, 1997 International IRCOBI conference on the biomechanics of impact*; 1997 September 24-26; Hanover, Germany. [Publisher's location unknown]: International Research Council on Biokinetics of Impacts: 455-456.

¹⁰ Taylor, Robert K. 1997. Presentation at the 1997 International IRCOBI conference on the biomechanics of impact; 1997 September 24-26; Hanover, Germany.

¹¹ Yamaha Motor Corporation, U.S.A. [n.d.] *Yamaha Marine Water Vehicles, WaveRunner GP Owner's/Operator's Manual*. Cypress, CA: p. 1-8.

- An Ohio operator stated that “while wake jumping, I came down and hit my handle bars.” The operator’s front tooth punctured his lower lip.

Safety Board staff visited a PWC dealer in metropolitan Washington, D.C., to examine handlebars of current models manufactured by Bombardier, Yamaha, and Kawasaki. The designs, for the most part, were composed of molded surfaces without edges; however, padding was minimal.

Spinal Injuries. The Safety Board’s study of the 1997 PWC accidents included 19 spinal injuries that were associated with single-vessel accidents. Seven of the injuries were reported by investigators¹² to have involved spinal breaks. A report from the University of Florida’s University Medical Center¹³ looked at serious spinal injuries. Over a 3-year period, that medical facility treated four patients who suffered fractured vertebrae associated with wave-jumping maneuvers. Similar injuries were found in the cases analyzed by the Safety Board. For example, an Ohio accident involved an experienced PWC operator¹⁴ crossing a large wake of a barge. The operator was thrown into the air and “came down on tail bone hard!” There was no property damage but the operator incurred a compression fracture to the spine.

Protecting PWC Riders From Injury

A study by the Centers for Disease Control (CDC) used 6 years (1990 through 1995) of hospital emergency room data (collected through the National Electronic Injury Survey System) to examine PWC-related injuries.¹⁵ A stratified sample of 624 injuries was used to estimate that 32,954 persons with PWC-related injuries were treated in U.S. hospitals nationwide. The distribution of injuries in the CDC study were as follows: head and neck (29.1 percent); arm (11.2 percent); upper trunk (11.7 percent); lower trunk (12.5 percent); and leg (34.4 percent). The proportions of head and leg injuries found in that study closely match those from the Safety Board’s sample. The CDC study specifically identified a case of facial injury resulting from impact with the PWC handlebars.

The CDC, in its report on PWC-related injuries, offered several suggestions that might help prevent injuries to PWC users, including specific training for PWC operators and

¹² For cases of serious injury, investigator reports often, but may not always, include information obtained from hospital visits.

¹³ Solis and others. 1998. Presentation at the 1998 annual conference of the American Academy of Orthopedic Surgeons; New Orleans, LA.

¹⁴ The accident description indicated that the operator had 12 years’ experience on boats and PWC, with over 500 hours on the type of PWC involved in the accident.

¹⁵ Branche, Christine M.; Conn, Judith M.; Annest, Joseph L. 1997. Personal watercraft-related injuries: a growing public health concern. *Journal of the American Medical Association*. 278(8): 663–665. August 27.

enforcement.¹⁶ The Safety Board agrees with the CDC that PWC operators should receive education and training specific to PWC and is recommending that the States, the National Association of State Boating Law Administrators (NASBLA), the U.S. Power Squadrons, BOAT/U.S., and the Coast Guard Auxiliary include information on the safe operation of personal watercraft in all recreational boating courses.

The CDC found that 7 percent of PWC injuries were to persons 14 years and younger and suggested that parental or adult supervision of children using PWC would be appropriate. The Safety Board notes that several States (for example, Georgia, Minnesota, and Utah) require adult supervision; however, the Safety Board's analysis could not determine if supervision affected accident risk. Accidents in the Safety Board's study did occur to young operators who were within sight distance of adults or who had adult passengers on board the PWC. Although it is reasonable to believe that supervision reduces risky behavior, it cannot prevent accidents; consequently, the Safety Board views designation of a minimum operator age and training requirements as better approaches.

It was the CDC's opinion that protection for the face and extremities is warranted, but it is not clear what kind of protection currently available is appropriate for use in water recreation. The CDC advises, and the Safety Board agrees, that more research is needed to determine the appropriate methods for head and extremity protection.

Much of the understanding of injury causation comes from highway accident investigations. When PWC are compared to those vehicles, it is clear that PWC riders do not occupy an enclosed, structurally protected driving space. The vessel is not designed to restrain riders from being ejected (as occurred in 11 percent of the Board's 1997 accident sample), nor does the vessel surround the rider to absorb the forces of impact during collision with objects or other vessels. The physical forces of the accident vessels are transferred directly to the rider upon contact.

It is evident from accident and injury data that PWC riders involved in accidents are susceptible to injury; 39.4 percent of accident-involved operators in the 1997 accidents examined by the Safety Board sustained injury. Further, PWC riders account for over 41 percent of Coast Guard-recorded injuries to all recreational boaters in 1996 (1,831 of 4,427). Because 4 out of 10 accident-involved operators in the 1997 PWC accidents examined by the Safety Board were injured, the Safety Board concludes that there appears to be a high risk of injury associated with PWC operations. The Safety Board's analysis specifically identified a large number of injuries to areas of the head and lower extremities, and this finding is consistent with other research of PWC-related injury. The Safety Board believes that PWC manufacturers should evaluate personal watercraft designs and make changes to improve operator control and to help prevent personal injuries. Consider items such as off-throttle steering, braking, and padded handlebars, and operator equipment such as personal flotation devices and helmets.

¹⁶ The CDC stated that right-of-way guidelines currently in place for boat operators should be considered for extension to PWC users. A review by Safety Board staff for this study indicates that all States do require PWC to comply with the right-of-way guidelines that apply to recreational boats.

Boating Safety Standards

Manufacturers of inboard and outboard motorboats must meet safety standards for the manufacture of boats and associated equipment (33 CFR Part 183), including requirements for certification and labeling (Part 181) and defect notification (Part 179). The standards and regulations of Part 183 specifically address capacity, loading, flotation, electrical systems, fuel systems, and ventilation. In addition to the provisions included in the regulations, many requirements are incorporated by reference.¹⁷

Federal statutes authorize the Coast Guard to issue exemptions from safety standards for manufacturers of boats to which the application of a standard is impractical or unreasonable and when the manufacturer can show that granting the exemption will not adversely affect boating safety.¹⁸ Manufacturers must petition the Coast Guard for exemption from safety standards. The Coast Guard has granted exemptions to every petition received from PWC manufacturers, and for each model for which an exemption was requested.¹⁹

Personal watercraft, as a vessel design category, cannot comply with the Coast Guard standards as currently written, and thus the exemptions from the existing standards are unavoidable. The following examples are provided to explain why PWC need exemptions from the existing standards:

- The safe loading standard, as currently written, is based on the assumption that water will flow into the vessel. If there is no load area into which water will flow, it is impossible to test a vessel in accordance with the safe loading standard; safe loading standards determine the weight limits appropriate for a particular vessel, and, by correlation, determine the person capacity.²⁰

¹⁷ Information incorporated by reference (as listed in Paragraph 183.5) includes recommended practices developed by the Institute of Electrical and Electronics Engineers, Inc., electrical code requirements of the National Fire Protection Association, recommended practices of the Society of Automotive Engineers, Inc., and the Underwriters Laboratory, Inc.

¹⁸ The Coast Guard's authorization was described in correspondence dated January 17, 1995, between U.S. Coast Guard Chief, Recreational Boating Product Assurance Branch, and the Chairman of the National Association of State Boating Law Administrators.

¹⁹ The Coast Guard has issued exemptions from its standards for both inboard- and outboard-powered personal watercraft, hovercraft, airboats, raceboats, and submarines.

²⁰ To receive an exemption, PWC manufacturers provide the Coast Guard with test data to show adequate flotation, boat weight and passenger capacity, and the amount of flotation material installed. Based on this information, the Coast Guard determines whether each PWC model contains sufficient flotation to meet the intent of the standard.

- In addition, if weight capacities cannot be determined in accordance with the safe loading standard, it becomes difficult to determine the required volume of flotation material for compliance with the flotation standard,²¹ thus PWC are also exempted from the flotation standard and from requirements for labeling the capacity of the PWC.²²
- Manufacturers of personal watercraft have also received exemptions from electrical and fuel systems standards and from the requirement for powered ventilation in the ventilation standard. The manufacturers' main justification for requesting these exemptions is that PWC design features minimize the possibility of arcing or sparks; specifically, fuel systems minimize the possibility of fuel vapor leakage, and the comparatively smaller size of the engine compartment compared to larger, more conventional boats limit the air supply and the PWC's ability to support combustion. Because PWC have a tendency to capsize and could take on water through their bowers, the powered ventilation standards, as currently written, cannot be applied.

Voluntary industry construction standards have been developed by the Society of Automotive Engineers (SAE) and the International Standards Organization (ISO); these standards are similar to the Coast Guard boat standards but are specific to PWC. SAE's Personal Watercraft Subcommittee of the Marine Technical Committee has developed standards to address PWC flotation (Recommendation Practice J1973), electrical systems (J2120), fuel systems (J2046), and ventilation (J2034). In its rationale for issuing these standards, the SAE recognized that PWC cannot comply with the Coast Guard regulations for conventional boat system designs, and it recognized the specific differences that affect PWC system requirements. For example, the SAE fuel system standard is more stringent than Coast Guard requirements; the SAE standard requires that the PWC system not leak liquid fuel into the vessel when rotated through a 180-degree roll in either direction or overturned through 90 degrees of pitch in either direction. The Safety Board recognizes that industry representatives serve on SAE committees and that all of the major PWC manufacturers voluntarily comply with the SAE standards. Industry representatives have also contributed to the development of ISO standards, which are similar to SAE standards.

In May 1997, NASBLA asked the Coast Guard to consider developing standards for PWC. Based on this request, the Coast Guard noted the similarities between SAE and ISO standards and specifically identified the differences between SAE standards and the existing safety standards as defined in Part 183. In October 1997, the Coast Guard's Boating Safety Advisory Committee requested the Coast Guard to review how manufacturers determine capacity on multiple-occupant rated PWC models—how the lack of an industry-wide standard for determining and displaying "persons capacity" impacts rider safety, including consideration of accident data.

²¹ Basic flotation, as applied to inboard and inboard-outdrive boats, requires sufficient flotation material so that if the vessel capsizes or swamps, the boat will remain floating with some portion of its hull above the surface of the water.

²² Manufacturers are considering the use of a capacity label that would indicate the rated person capacity. The proposed capacity marking label would state that the vessel complies with ISO 13590 of the International Standards Organization and that it is certified by the National Marine Manufacturers Association.

Coast Guard staff, in a meeting with Safety Board staff on April 10, 1998, indicated that there was no compelling statistical evidence that PWC problems warrant modifying existing safety standards for flotation (capacity), electrical system, fuel systems, and ventilation.

The Safety Board notes that the Coast Guard's four standards were developed, in part, to address the most serious safety concerns of traditional motorboats: drowning, fire, and explosion. The Safety Board's study clearly points out, however, that these are not the most prevalent safety concerns for PWC. PWC, as previously mentioned, is the only type of recreational vessel for which the leading cause of death is not drowning. Also, in traditional boats, falling overboard and swamping would be considered emergency situations; however, for PWC, these are expected events and, consequently, PWC are designed and constructed to different design criteria than traditional boats.

The Safety Board questions the need for the Coast Guard to continue the exemption process for PWC, particularly given that industry standards exist (and in certain areas are more stringent than the Coast Guard's), that there is voluntary compliance with the standards, and that the standards appear to provide an equivalent level of safety as envisioned by the Coast Guard standards. The Safety Board concludes that the existing process of exempting PWC from standards that were defined for conventional boats is an inappropriate method for certifying the safety and seaworthiness of PWC. In the Safety Board's opinion, the exemption process does little in terms of evaluating possible safety risks that may be associated with the unique operating characteristics of PWC. The Safety Board is aware that the Coast Guard is working with the PWIA to incorporate SAE standards by reference as an alternate method of compliance with existing Federal regulations. The fact that PWC do not "fit" existing standards for open-hull vessels does not release the Coast Guard from its responsibility to regulate the safety of these vessels, particularly since personal watercraft now represent more than one-third of the new recreational boats sold. The Safety Board is recommending, therefore, that the Coast Guard eliminate the existing process of exempting PWC from standards that were defined for conventional boats and believes that the PWC manufacturers should develop, in conjunction with the U.S. Coast Guard, comprehensive standards that are specific to the safety risks of PWC.

The Safety Board notes, however, that industry has voluntarily complied only with those standards that address the existing Coast Guard boating safety standards (flotation, capacity, electrical, fuel, and ventilation) that were established for conventional boats. The Safety Board is concerned that there are other safety issues associated with PWC that warrant attention. The need for improved steering control and prevention of "runaway" PWC once an operator is ejected serve as two prime examples of areas where improvements in design could result in a decrease in accidents.

State marine accident investigators have recognized that steering issues are associated with many PWC accidents. The Safety Board reviewed available accident reports for 1996 and 1997 and, based on narrative information contained in the accident reports, determined that more than 350 (20 percent) of the cases reviewed indicated steering or loss of control problems. Accident reports reviewed for the Safety Board's study highlight problems of operator control

during off-throttle steering situations. Some portion of operator control problems may be attributed to the operating design of personal watercraft.

The narrative report of an accident that occurred in Illinois included the following investigator comment: "She (V1) stated that as they came close, she let off the throttle and then tried to turn but couldn't. She stated that V2 hit her in the side of the Sea-Doo causing a tremendous amount of damage....V2 advised that as she came close to V1 she turned to avoid her, but it didn't turn because she let off of the throttle." The report of a fatal Missouri accident included the following investigator comments: "He did not think that she knew that he was behind her. He said that it was less than a second between when she turned and when he struck her. He let go of the throttle, but it did not help."

On September 10, 1997, NASBLA adopted a resolution (No. 97-3) petitioning the Coast Guard to evaluate off-throttle steering of jet-pump propelled craft and to develop appropriate standards. The Coast Guard issued a grant request in October 1997.²³ The objective of this work will be to identify the most effective of the available and emerging technologies/methodologies in the area of off-throttle steering. As part of the background information in the grant description, the Coast Guard stated: "A large percentage of accidents involving jet-pump propelled craft involve collisions with other craft or fixed objects. Because of the unique relationship between the amount of throttle and steering response on jet-pump propelled craft, there is concern that a sudden loss of engine power—either due to part failure or operator decision—may play a significant role in these collisions." Announcement of the grant award is anticipated in the near future. The Safety Board study data support the need for this research, and an evaluation of PWC steering design is warranted. The Safety Board is concerned that the Coast Guard has not taken a proactive role in assessing the safety risks of PWC. Therefore, the Safety Board is recommending that within 2 years the Coast Guard determine, through research, the feasibility of providing PWC operators more control in an off-throttle steering situation. The Safety Board also believes that the Coast Guard should work with the PWIA to use the results of this research to develop appropriate standards for steering on jet-pump propelled vessels.

Therefore, the National Transportation Safety Board recommends that the manufacturers of personal watercraft (Kawasaki, Yamaha, Polaris, Bombardier, and Arctic Cat, Inc./Tiger Shark):

Evaluate personal watercraft designs and make changes to improve operator control and to help prevent personal injuries. Consider items such as off-throttle steering, braking, and padded handlebars, and operator equipment such as personal flotation devices and helmets. (M-98-85)

Develop, with the U.S. Coast Guard, comprehensive standards that are specific to the safety risks of personal watercraft. (M-98-86)

²³ Federal Register, Vol. 62, No. 193, dated October 6, 1997, page 52176.

Also as a result of this study, the Safety Board issued safety recommendations to the U.S. Coast Guard, the U.S. Coast Guard Auxiliary, the National Association of State Boating Law Administrators, the Personal Watercraft Industry Association, the U.S. Power Squadrons, BOAT/U.S., and the Governors of the States and Territories.

The National Transportation Safety Board is an independent Federal agency with the statutory responsibility "...to promote transportation safety by conducting independent accident investigations and by formulating safety improvement recommendations" (Public Law 93-633). The Safety Board is vitally interested in any actions taken as a result of its safety recommendations and would appreciate a response from you regarding action taken or contemplated with respect to the recommendations in this letter. Please refer to Safety Recommendations M-98-85 and -86 in your reply.

Chairman HALL, Vice Chairman FRANCIS, and Members HAMMERSCHMIDT, GOGLIA, and BLACK concurred in these recommendations.

A handwritten signature in black ink, appearing to read "Jim Hall". The signature is written in a cursive style with a large, stylized initial "J".

By: Jim Hall
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