136553 CGD 95-041

The National Boating Safety Advisory Council

USCG-2001-10299-25

REPORT

OF THE

PROPELLER GUARD

SUBCOMMITTEE

Presented
November 7, 1989

AUG 24 1995

CAPT. James E. Getz, Chairman, State Member
Mr. Donald J. Kerlin, U.S.C.G. Representative
Mr. Richard H. Lincoln, Industry Member
Mr. William D. Selden, Public Member
Mr. Herman T. VanMell, Public Member

146

REPORT OF THE PROPELLER GUARD SUBCOMMITTEE OF THE NATIONAL BOATING SAFETY ADVISORY COUNCIL

I. INTRODUCTION: THE SUBCOMMITTEE AND ITS PURPOSE

At the request of the U.S. Coast Guard, the National Boating Safety Advisory Council (NBSAC) on May 11, 1988, appointed a subcommittee to consider, review and assess available data concerning the nature and incidence of recreational boating accidents in which persons in the water are struck by propellers. Feasibility of some form of mechanical guard or other action to prevent such contact was to be examined. A copy of the charge to the Propeller Guard Subcommittee (the Subcommittee) is attached as Appendix A.

The Subcommittee determined that no minutes or transcripts would be kept but that, at the conclusion of its work, all documentary materials received be delivered to the Coast Guard for its files, and that the Subcommittee's final report to NBSAC, together with minority or dissenting statements, if any, stand as the definitive record of its work.

II. INFORMATION OBTAINED

At the outset, the Coast Guard supplied materials from its files to the Chairman, who sent requests to the persons and organizations listed in Appendix B asking for files, data, case histories and other information bearing on the subject. Documents received were copied and distributed to each member of the Subcommittee for study prior to the first meeting. At the conclusion of that meeting, the Subcommittee developed a comprehensive list of further documentation, materials and information to be sought, and of persons to be invited to meet with the Subcommittee. Documents and materials were also volunteered by interested parties. Video tapes and other visual materials were exhibited at the meetings. Appendix C lists all documents received and considered, along with video tapes and visual materials reviewed by the Subcommittee.

III. MEETINGS HELD

The first meeting of the Subcommittee was held at the Boston Whaler facilities at Rockland, Massachusetts, on September 22 and 23, 1988. Various types of propeller guards, both commercially available and experimental, underwater motor housing appendages and other relevant materials were presented but not deposited with or retained by the Subcommittee. Members of the Subcommittee also viewed and were given a hands-on opportunity to operate Boston Whaler boats used by the U.S. Marine Corps, one equipped with a "Chadwell" ring-type guard, and the other without.

The second meeting was held in New Bern, North Carolina, on November 14, 1988, and a third meeting at Couer d'Alene, Idaho, on May 12 and 13, 1989. Following that session, the Subcommittee concluded that sufficient written and verbal presentations and demonstrations had been seen and heard to cover the field; collection of documentary material amassed and reviewed was reasonably representative of presently available, relevant data; and further document search or additional meetings with concerned persons was unlikely to produce substantial additional information.

Between the May 1989 and November 1989 NBSAC meetings, this report was drafted and unanimously approved by Subcommittee members, and the Chairman was directed to deliver it to NBSAC at its regular meeting scheduled for November 6, 1989. The Chairman was directed that, following NBSAC action on the report, all documents and other materials collected by the Subcommittee be delivered to the U.S. Coast Guard for its files.

IV. INDIVIDUALS HEARD

The following persons made presentations to the Subcommittee and generally made themselves available for questioning and discussion. Other interested persons attending the meetings are listed in the order of appearance:

1. Richard Snyder: Principle Engineer-Product Evaluation with Mercury Marine. Has testified in behalf of Mercury as Defendant in opposition to guards.
2. Brian Chadwell: designer, manufacturer and seller of ring-type propeller guards. Has testified on behalf of plaintiffs in propeller strike litigation.
3. Ben Hogan: attorney for plaintiffs in such cases and proponent of guards.
4. Donald Blount: civilian naval architect, 34 years with the U.S. Navy, heading the section for design and testing of small boats. Has testified for defendants.
5. Lars Granholm: at one time employed by the Coast Guard as an engineer, currently Director of Industry Safety Standards for the National Marine Manufacturers Association. Has testified for defendants.
6. D. P. Huelke: Professor of Anatomy, University of Michigan, researcher and consultant on trauma injuries, particularly in the automobile industry. Has testified for defendants.
7. Robert Taylor: marine engineer and naval architect, formerly of the University of Michigan and U.C. Berkley, former ship designer for the U.S. Navy, and currently Supervising Marine Engineer of Failure Analysis, Inc. Has furnished statistical data on behalf of defendants.

8. Dr. James Benedict, M.D., Biodynamic Research Corporation, a researcher on effect of traumatic impact on the human body. Has testified on behalf of defendants.

9. Ms. Linda Barnby: victim of a propeller strike injury and advocate of guards. Represented the Florida Audubon Society.

10. Dr. Albert Burstein: New York City's Hospital for Special Surgery, a mechanical and biomechanical engineer specializing in sports related injuries and development of protective devices.

Dr. Lawrence E. Thibault, of Biomechanics, Inc., and the University of Pennsylvania, who has testified as a plaintiff's expert biomechanics witness in numerous propeller strike cases, accepted an invitation to participate in, and was scheduled for the Idaho meeting, but failed to appear. (The Subcommittee had previously received a copy of his report and letter dated August 14, 1987, prepared for plaintiff's attorney Stephen R. Bolden in seven of the 19 propeller strike cases described in the report).

In the Subcommittee's deliberations, reports prepared by engineers John G. Hill, Arthur M. Reed and Robert Taggard, in support of plaintiffs in litigation, were reviewed, along with other pertinent documents. (See Appendix C)

V. KEY POINTS COVERED BY VERBAL INPUT AND WRITTEN MATERIALS

1. Litigation

A number of law suits have been filed by victims of alleged propeller strikes to recover damages from the operator of the striking vessel and also against the manufacturer of the propulsion unit and/or boat. In those cases seeking to hold the engine manufacturer liable, the following legal theories have been asserted by propeller guard advocates:

a. The manufacturer has a duty to design boat propulsion machinery in a prudent manner, which includes a duty to design against hazards, if feasible. Since propeller injuries are a known hazard, and guards are presumed feasible, a manufacturer is negligent and liable for damages (regardless of, or in addition to, liability of the boat operator), for failing to incorporate guards.

b. Alternatively, if no feasible guards presently exist, the manufacturer is nevertheless presumed liable for failure to have funded and conducted whatever research and development may be needed to design and produce effective guards.

c. Guards, in addition to protecting persons, also protect propellers from destructive bottom contact. They are currently feasible and available, and manufacturers should be liable because they choose not to furnish guards in order to profit from sale of replacement propellers.

Advocates have petitioned federal and state legislators and regulators to mandate propeller guards. Such mandate would necessarily be predicated on the feasibility of guards and establish prima facie manufacturer liability in having failed to provide them. Feasibility, accordingly, is one of the important questions before the Subcommittee.

In defending "propeller strike" cases, engine and boat manufacturers have asserted:

a. Guards are feasible only at idling or very low speeds and for limited purposes, but are not feasible at normal operating speeds at which the majority of propeller strike accidents occur.

b. A very high percentage of the reported accidents of "struck by boat or propeller" do not involve propeller strikes, but involve impacts with the boat hull or a stationary component of the lower unit.

c. At normal recreational boat operating speeds the increased drag and hydrodynamic characteristics created by known types of guards cause a new hazard by dangerously affecting the handling and stability of the vessel.

d. Since all types of known guards substantially increase the frontal area of the underwater appendages of an engine, the chances that a victim will be hit are greatly increased.

e. A victim hit by other than a very slight glancing blow from the guard on a boat operating at normal or planing speeds, will suffer impact injuries more devastating than being cut by a propeller.

f. The ring-type and wire mesh or "catcher's mask" guards create a new hazard of catching and trapping a victim's limbs resulting in more severe injuries and/or drowning.

g. To recover normal operating speeds lost to guard drag, the engine horsepower and fuel consumption must be raised by at least 50% with consequent and proportionate increases in exhaust emissions.

h. To retrofit the propulsion units now in existence would require the design and manufacture of several thousand different guard models, since each one must be individually designed for the engine to which it is to be fitted. Every unit must be engineeringly modified for the boat hull on which the engine is mounted, to guard against dangerous handling characteristics.

Manufacturers are opposed to mandatory propeller guards and assert that propeller strike accidents constitute less than 5% of the total annual boating fatalities. They assert that safety efforts and education should address operator incompetence, negligence and alcohol involvement. Improvement in the overall field of safe boat handling would, in the same proportion, beneficially affect the incidence of propeller strikes and underwater impacts.

2. Statistical dimensions of the problem

Statistical sources include accident reports filed with the Coast Guard, hospital emergency room sampling by the National Electronic Injury Surveillance System (NEISS), state records, insurance records, and statistical sampling and analysis of selected groups of cases by professional organizations. There are obvious variations in reported statistics. No universally accepted, accurate and complete compilation came to the Subcommittee's attention.

Reports of individual accidents are made at varying times after the accident and may be prepared by the operator, the victim, or an enforcement officer who normally has not seen the accident and must rely on witnesses, if available. Attending physicians in emergency rooms, under the pressure of giving immediate medical or surgical attention, will have difficulty in understanding exactly what happened and in what sequence. Of these people, very few, if any, will have undergone specific training to qualify them as experts in determining the cause of such injuries.

The standard form of boating accident report as prepared by the Coast Guard and followed by many state agencies has one category to be checked under the box "type of accident" identified as "hit by boat or propeller". Such reports, principal source of statisticians, do not distinguish whether the victim's injury resulted from striking by the boat, the underwater propulsion unit which precedes the propeller (namely, the gear housing, skeg, anti-ventilation plate), or by the propeller, or a combination of all three. (See Figures A and B) The reporting form also does not have a specific space for reporting speed at the time of the accident.

The Coast Guard believes that only 5 to 10% of all boating accidents, not involving fatalities, are reported. The Subcommittee believes that the

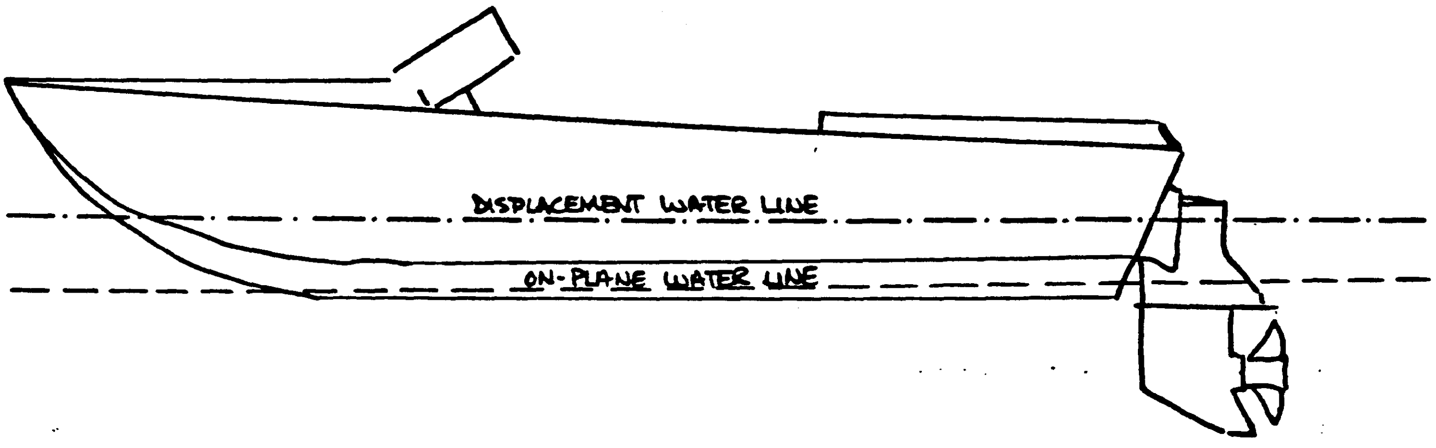


Figure A

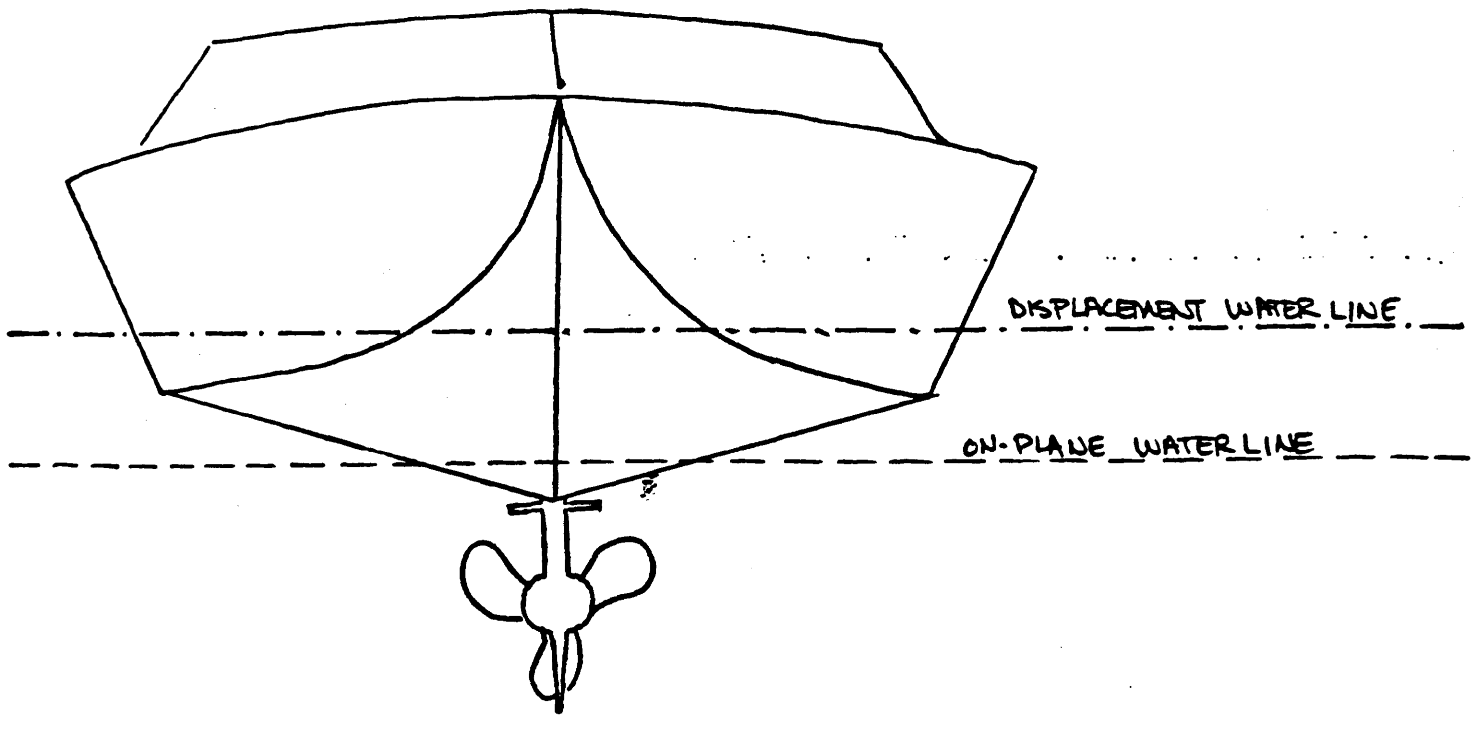


Figure B

completeness of accident reporting varies proportionately to the severity of the injury, from nil in the case of very minor injuries, to fairly complete in fatalities.

Although available statistics are imperfect and incomplete, it is probable that the circumstances influencing the preparation and filing of reports remain constant. Thus year-to-year comparisons and trends, particularly as to fatalities, are reasonably informative and valid for the purposes of this inquiry.

In contrast to the obvious deficiencies of accident reporting, statistics on the number and types of boats and engines manufactured and in use can be considered accurate. The following data was used by the Subcommittee:

Boat population of the United States as of 1988

Horsepower of the engine(s)	number
*None (rowboats, canoes, inflatables)	4,100,000
1 to 5	1,600,000
6 to 10	2,100,000
11 to 30	1,700,000
31 to 50	2,300,000
51 to 100	2,500,000
Over 100 horsepower	2,700,000
	17,300,000
Boat length by feet	
Under 16	9,515,000
16 to 25	7,149,000
26 to 39	568,000
40 to 65	95,000
Over 65 feet	11,000
	17,300,000

* Exception: only occasional use of low horsepower engines.

3. Annual recreational boating fatalities

Robert Taylor of Failure Analysis, Inc. presented information from his organization's data base which had been compiled from all major statistical sources (See Appendix E). Summarizing such statistics for the year 1982: fatality total for recreational boating was 1,183 compared to 1,594 for swimming pools, 1,900 for firearms (excluding homicide and suicide), 2,800 swimming, 4,453 motorcycles, with motor vehicle fatalities exceeding 43,000. For open motorboats of 14 to 18 feet in length, the contributing factors to fatalities were: falls overboard 35.8%, capsizing 31.9%, collisions 21.2%, swamping/flooding 8.9%, and struck by propeller 4.9%.

The calculated risk of fatality in 1982 per each million activity hours of recreational boating was said to be 1.26 for inflatables, 0.62 for canoes/kayaks, and 0.59 for rowboats, in each case with no engine being involved, compared to a risk of 0.14 from all causes for open motorboats (within which the risk of propeller strike itself is a very small fraction). The estimated number of fatalities per million exposure hours in recreational boating (0.14) was compared at the bottom of a list of other recreational activities, with 0.88 in hunting, 1.41 in high school and college football games, 3.08 in scuba diving and 17.34 in private flying.

Water skiing was considered a special risk in itself (separate from the category of recreational boating) and, according to Failure Analysis data, accounted for some 40 annual fatalities (only a portion of which were propeller strikes). It is estimated that over 14,000,000 persons participate in water skiing annually.

4. How propeller strike accidents occur

In almost all cases the victim is in the water, as a swimmer, snorkeler or scuba diver, a downed water skier, or more frequently, as a result of falling or being thrown from a boat. While some victims have been struck by propellers in the air in accidents where one vessel collides with and passes over another vessel, such incidents appear to be rare.

Passengers moving about or improperly seated, such as "bow riders", or persons sitting on the gunwales or transom, are ejected by sharp turns, wave or wake bounces, all at speeds which may be too fast for the prevailing conditions. Persons also are ejected from boats by collision with another vessel or fixed object. Operator inexperience, incompetence, negligence, and alcoholic intake are significant contributing factors in reported "propeller strikes" as well as in other kinds of boating accidents. Ejections can also be caused by sudden acceleration or deceleration, either from operator error, equipment failure or malfunction, or striking masses of weeds or other submerged objects.

Presentations illustrated that approximately 80% of all accidents occur when a boat is operating at speeds in excess of 10 miles per hour, i.e. normal operating or planing speeds. Accidents occurring at idling or slow speeds (2 to 10 miles per hour) most typically appear to happen when the operator is in the process of picking up a fallen water skier, moving in the vicinity of swimmers, or inadvertently putting an engine in gear when swimmers are using a boarding ladder or platform.

5. Types of propulsion

The most common propulsion unit used is the outboard motor, mounted on the stern of a boat and rotated to steer the boat. Second is the inboard/outboard device, powered by an engine mounted inside the boat, with an exterior drive unit containing a gear case and propeller, which is moved from side to side to steer the boat. In both cases, the lower unit, including the propeller, serves as the rudder in steering the boat.

A third common means of propulsion is an engine mounted in the boat to power a shaft passing through the hull, and generally through a supporting strut, at the end of which the propeller is mounted. Such boats are steered by one or more separate rudders and may be either planing or displacement boats. Included in displacement boats are sailing vessels with inboard mounted engines and a shaft through the hull, sometimes off-center and sometimes on center line, with a cut out or other space between the shaft and a rudder. Such auxiliary sail boats commonly travel at speeds, when under engine power, well below 10 mph. Many small sailboats use low power outboard motors for auxiliary propulsion at low speeds. Auxiliary powered sailboats did not figure in any propeller strike accidents coming to the Subcommittee's attention.

In a fourth propulsion method, water is taken in through a submerged scoop and ejected by an impeller as a high speed jet of water pushing astern. A steering rudder may be required. Outboard jet engines have appeared on the market in recent years, particularly for fishing in very shallow water. Manufacturers state that jet drive outboards are 25% less efficient than comparable horsepower propeller driven outboards. In traditional boat types, jet propulsion units do not appear to have succeeded commercially. This has not been the case, however, with "personal watercraft". This jet-driven type of boat is increasingly figuring in accident and fatality statistics through collisions with other vessels or with swimmers in the water and operators falling in the vicinity of other craft.

6. Propeller guard designs and availability

Although many variations have been conceived and patents granted, there are essentially only three basic configurations of "propeller guards".

First is a ring band device commonly secured to the submerged portion of an outboard motor or stern drive unit and within which the propeller revolves. Unless supplemented by sufficient bars or mesh across the rim front and back, fingers, hands, arms, etc., can enter the ring and contact the propeller. Proponents of guards assert that most victims are struck at an angle to the boat, rather than frontally; that a boat in motion creates a pressure wave tending to push bodies to the side; and, therefore, that in most impacts a victim would receive only a minor glancing blow from a guard.

As to frontal hits with a guard in place, it is asserted that the leading edge of the ring could be constructed of crushable material to absorb the energy of the impact, or be cushioned with flexible material covering metal or plastic parts, thus preventing serious injury to the struck victim.

Opponents assert that a blow from a guard, either frontally or at an angle from a boat traveling at speeds of over 6-10 miles per hour or any boat at planing speed, could cause serious or fatal impact if hitting the head or chest; that at such speeds a human body in the water is held stationary relevant to the striking force, and there is no wave effect pushing bodies to the side. Also, there is no known material available which, as a part of a propeller guard, could absorb energy on impact with the human body in water and maintain its shape and structural integrity under normal use. Opponents further assert that this guard significantly increases the total area of possible underwater impact.

The second general type of guard is a screen surrounding the propeller like a fan cage or catcher's mask, constructed of wire mesh, bars or wires. Some patents show bars forward of the propeller, some vertical, some horizontal or combinations. To maximize protection, mesh must be small enough to prevent insertion of limbs and/or appendages and totally encompass the propeller. The mask device also significantly increases the total area of possible underwater impact. In the use of both the ring and the mask-type guards, opponents have stressed that the frontal impact area would be increased by three times by attaching the guard (See Figure C). They further contend that, while a submerged body limb may not be struck by the rotating blades of the propeller, they would certainly be struck by the guard, if the limb were in the path of the lower unit.

A third type is shrouding the propeller in a tunnel or tube, and in its most common application is referred to as the Kort nozzle. This was

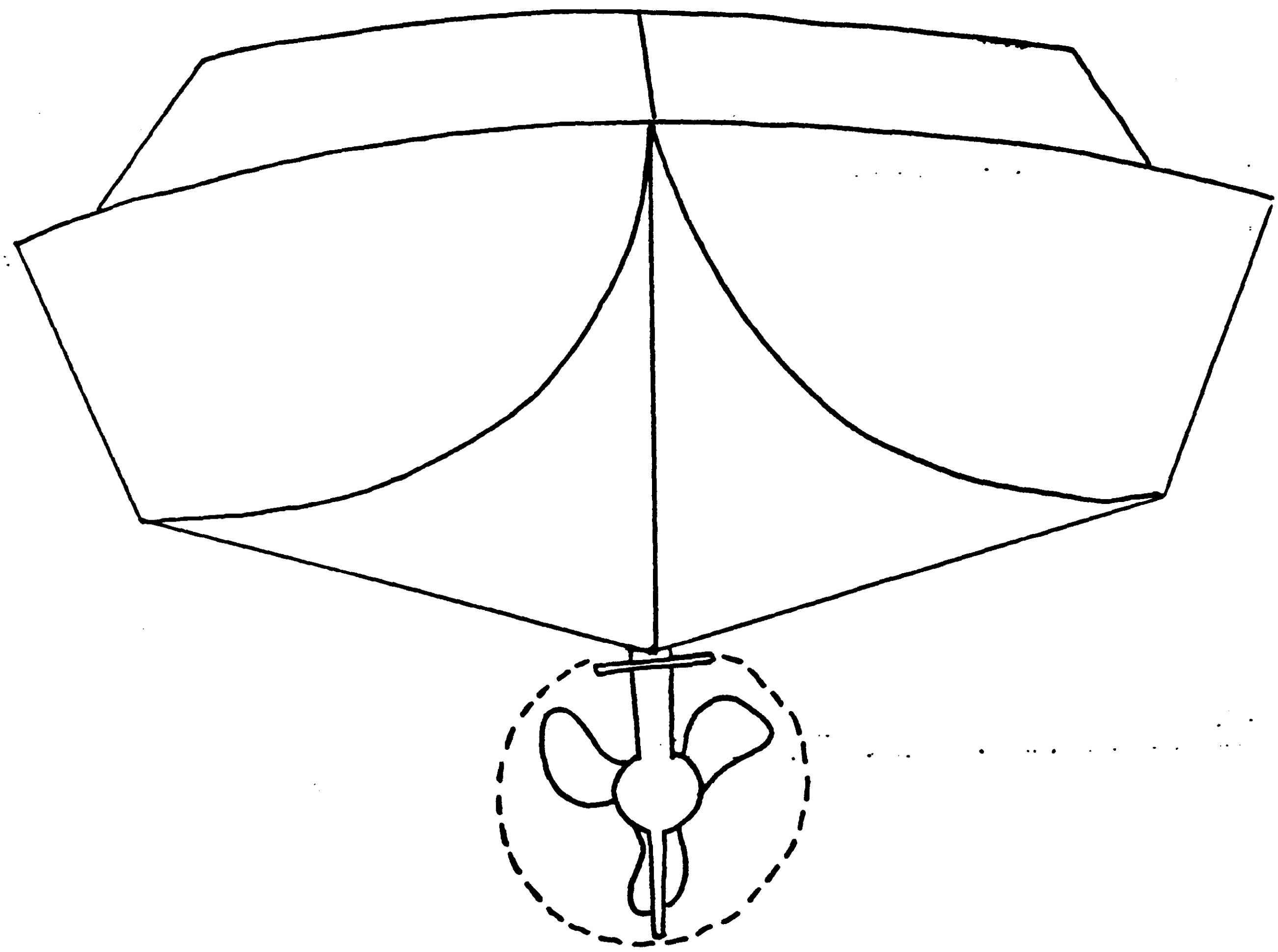


Figure C

designed to control water flow to and through a propeller to increase its efficiency by producing greater power at low speeds, such as for tug boats and large ships. Vanes can be inserted in both the forward and aft ends of such nozzles to direct the flow of water for maximum efficiency and serve as barriers to the entry of body parts.

Examples of the ring and mask types of guards were examined by the Subcommittee. No example of any nozzle device suitable for recreational boat use at normal operating speeds was brought to the attention of the Subcommittee. No guard device suitable for inboard engine drive propellers on displacement or planing motor boats, or on auxiliary sail boats was presented.

7. Present use of guards

Fine mesh cage guards have been used for many years on amusement park bumper boats, which operate at very slow speeds (approximately 2 miles an hour or less) where problems of drag, engine efficiency, structural integrity and boat handling are negligible. Also, a blow to a person in the water at such very slow speeds has minimal effects. No evidence indicated that this solution had any validity for normal use of pleasure boats at normal planing speeds.

The mask guard with spaced rods is used in various parts of the world on rescue boats, often on inflatables, powered with 25 or more horsepower engines. In the typical rescue operation, the boats speed to the rescue scene and then operate at slow or idle speed while carrying out the rescue. The wide spacing of the bars required to minimize critical drag in speeding to the rescue scene does not prevent entry of body appendages.

It was reported that approximately 2,000 of the "Chadwell" ring-type guards have been sold, with some used on rescue boats in Australia and New Zealand and California. Some boats used by the U.S. Marines have been equipped with these guards. The intended use is to deposit Marine personnel in the surf and then stand off-shore to await their recovery. In this simulated combat situation, it is critical to keep the motors operating, while also affording a certain degree of protection to personnel in the water. The Subcommittee understands that the U.S. Marine Corps is undertaking additional, more extensive study on the use of different types of guards. The U.S. Navy makes limited use of guards (although it was not stated whether they were rings or masks) to minimize entanglement of diving hoses on some boats used as diving platforms. The Navy has used "nozzle shrouds" around propellers of landing boats operating from well decks on the mother ship to move cargo and personnel ashore. This usage has a prime objective of protecting propellers from mechanical damage in striking the bottom of the well deck or submerged objects on the beach, while achieving high thrust at low speeds for more efficient operations.

8. Mechanical and hydrodynamic problems inherent in guards

It was clearly demonstrated that the ring-type guard creates severe steering and trim effects which cause serious safety and control problems. In the demonstration of the Boston Whaler boat equipped with a ring-type guard, the boat could not be brought out of a turn at high speed unless power was quickly reduced. In the hands of an inexperienced or negligent operator, a serious accident could result. Rings and their mounting devices increase drag with corresponding loss of speed.

An engineer for one of the engine manufacturers described experimental work done for the Marine Corps on a mask guard which would have less severe steering and trim hazards than a ring guard and was expected to be less subject to critical damage on hitting bottom or submerged objects. The first cage, built of 5/16" diameter steel rod stood up structurally, but its drag reduced boat speed from 35 mph to 19 mph (when compared to use without a propeller guard). The second, built of 1/4" diameter steel rod more widely spaced solved steering but not drag problems, and vibration forces broke the welds. The added drag due to this mask or cage reduced boat speed from 37 mph to 27 mph (with two 70 horsepower engines). It was stated that, to regain the desired speed of 37 miles an hour, horsepower would have to be increased 100% to a total of 280. It was also found that the mask, as well as the ring-type guards, was vulnerable to crushing on hitting the bottom, pushed down by the weight of the boat bouncing in the waves, with consequent disablement of the engine. It was further stated that the objective of simultaneously protecting the propeller from damage, protecting landing personnel, and making no material sacrifice of speed involved irreconcilable physical laws and an insoluble manufacturing dilemma. To make the guard strong enough to withstand hitting the bottom or hard object resulted in unacceptable drag and handling - and to conserve desired speed, steering control and prevent entry of body appendages the guard would have to be so lightly constructed that it could not stand up to normal operating loads.

9. Biomechanical considerations

The density of water is approximately 830 times that of air. The density of the human body is approximately the same as water. Therefore, it follows that a human body immersed in water cannot move independently of the water around it. The result of an object striking a human body in the water is that the body absorbs most of the energy of the striking object. As the speed of a striking object increases, the transferable energy increases by the square of that speed, and the force of the blow becomes correspondingly greater. The resistance force on body movement in water at 1 mile per hour is the same as a force of 29 mph in the air. It was repeatedly stated that a skull impact at 10 mph or more in the water would be generally fatal. A glancing head blow twisting the neck could result in a sheared neck at such speeds, and a chest strike could result in rib flexing in an unsustainable amount. Even with an idealized cushioning material, not currently known to exist, head or body cavity strikes at speeds over 10 mph could likely be fatal.

The auto industry and independent researchers have an extensive data bank resulting from numerous crash tests using technically sophisticated, instrumented mannikins, from which generally accepted tables have been constructed concerning the forces which result in serious and fatal injuries. Although there are no such completed studies available regarding underwater impacts, tests have been conducted which reveal significant similarities. Video films of boats striking simulated limbs, surgically comparable to human limbs, and other submerged objects illustrated the injury-causing forces involved when an 18 to 25 foot boat, weighing up to thousands of pounds, traveling at speeds varying from 10 to 35 mph hits a body or object.

The human body has numerous rotational joints, i.e. the neck, wrists, fingers, elbows, ankles, etc. All are subject to serious and permanent injury depending on the force and mass involved in the impact. An oblique strike by any underwater appendage can result in rotational injury or injury transmitted to another part of the body. According to Failure Analysis data, sports trauma, such as high school and college football, has nine times the fatality risk of recreational boating. This data reinforces the premise that serious or fatal injury can result from even relatively low speed and/or mass impact depending on the angle of the striking force and the location of the impact.

Propellers present the hazard of cutting wounds and penetrations of the body, while other underwater appendages, including guards (which increase significantly the potential impact area) present the additional hazard of blunt trauma injuries, which are often more severe.

It was stated that at a speed of 10 miles an hour, any fixed appendage of a boat (example: the skeg of an outboard motor) crosses a submerged limb in 1/50th of a second. With the water holding the limb relatively immobile, the limb tissue is torn, then the bone is crushed, producing a wound more serious than propeller cuts. Due to its revolutions, a propeller generally produces a series of evenly spaced cuts which are relatively easier to repair surgically.

All machinery or objects, whether created by man or nature, can inflict injury. It is impossible to make everything totally free of hazard. At a cost, we can be protected against many hazards. Most of the annual 43,000 motor vehicle fatalities, for example, could probably be prevented by mandating a national speed limit of 10 mph. The economic and social cost, however, would be unacceptable.

By definition, a guard must both diminish a hazard and leave the object capable of normal function, at a cost which is reasonable in proportion to the extent of the hazard. Diminishment of hazard is classically accomplished by various means, including barriers, shut down devices, warnings and education for safe use. Above all, it is fundamental that a guard should not create a condition which leads to a new or worse hazard.

VI. SUMMARY

Up to 80% of underwater impact accidents occur at normal operating speeds, in excess of 10 mph and more usually in the 13 to 35 mph range. The craft most typically involved is in the 15 to 25 foot range, powered by an outboard or inboard/outboard unit or units of 25 horsepower or more. This also is the bracket where the great majority of all accidents involving powered vessels occurs. Recent data reveal an increasing level of involvement of personal watercraft in boating accidents. The risk of accident increases during water skiing activity.

Nevertheless, boats and motors should be designed to incorporate technologically feasible safety features to avoid or minimize the consequences of inexperienced or negligent operation, without at the same time (a) creating some other hazard, (b) materially interfering with normal operations, or (c) being at economic costs disproportionate to the particular risk.

Proponents assert that propeller guard technology and/or availability meets the foregoing criteria and that guards should be mandated. The Subcommittee does not agree and offers the following comments:

1. The concept of mask and ring-type guards is feasible at idling and very low speeds. Fine mesh guards can prevent propeller contact but are not feasible above 2-3 mph, which rules them out for recreational boating. Masks with wide mesh or spaced bars and ring guards may prevent cuts from body contact with a propeller but substitute the potential of blunt trauma injury, which becomes increasingly significant at speeds over 10 mph, leading to an ascending serious risk of fatality as speeds increase. In recent accident reconstruction training exercises, it has been demonstrated that boats and their appendages can easily be construed as projectiles. Boats operating at planing speeds can easily penetrate or cause serious damage to other boats. These demonstrations serve to reinforce the damage potential of boat impacts with persons in the water. Either guard presents an underwater profile of significantly larger frontal area, thereby increasing the chances of contact. In the case of the ring-type guard, a new hazard is created, in that an arm, leg, etc., may be

caught by the bars or ring and held against the rotating propeller. Operators of a "guard-equipped" boat can be expected to have a false sense of security when approaching persons in the water at slow speeds, with a very real risk of impacting and/or entrapping a body appendage.

2. At speeds of approximately 10 mph or greater, both types of guards - especially the ring - affect boat operation adversely. Both guard types result in drag increasing proportionally to the square of speed, resulting in substantial power and speed loss. This will require greatly increased power and fuel consumption to regain the lost speed.
3. Propellers encased in the Kort nozzle, or tunnel, substitute impact for propeller cut hazard, have rapid loss of efficiency above 10 mph and are not operationally feasible at normal pleasure boat speeds. The Kort nozzle is viewed as a low speed efficiency enhancer and not a guard.
4. Water jet propulsion eliminates the propeller and diminishes the underwater appendage impact area, but at a minimum 25% loss in efficiency and results in newly created operational handling problems.
5. No known materials are available to construct "soft" propellers or to construct or coat guards so as to absorb impact energy and prevent injury, yet maintain structural integrity and serve the intended purpose.
6. Adequate seat belts, if used by all boat passengers, could prevent some operator and passenger ejections into the water. A belted person involved in a capsizing, however, would then be subject to the risk of death by drowning.

7. Any guard would have to be both hydrodynamically and structurally compatible with the intended propulsion unit. Further, guards must not only fit the motor but be designed for hydrodynamic compatibility with the hull on which the motor is used. Since there are hundreds of propulsion unit models now in existence, and thousands of hull designs, the possible hull/propulsion unit combinations are extremely high. No simple universal design suitable for all boats and motors in existence has been described or demonstrated to be technologically or economically feasible. To retrofit the some 10 to 15,000,000 existing boats would thus require a vast number of guard models at prohibitive cost.

8. The suggestion that guards should be mandated, at least for water ski boats during which activity accidents occur at both high and very low speeds, and for boats equipped with swimming platforms and ladders, presents other problems. Water skiing or swimming from a boat is a part-time and limited activity and does not describe a boat type. Recreational boats are multi-purpose in nature, which precludes the practicality of an off-on use of a propeller guard. If guards were readily removable, automotive experience clearly shows that they would be by-passed by permanent removal. The Subcommittee feels that it is not practical or feasible to mandate guards for specific uses, such as water skiing or while a boat is being used as a swim platform. Furthermore, the removal of a guard could result in inadvertent or intentional overpowering of the boat.

CONCLUSIONS

1. Accident data and the analysis of accident data must be an integral

component of a study of this nature. There is no one single source, best source, or all-inclusive source of accident data. However, the available sources can be utilized collectively to give an accurate portrayal of the significance, frequency, and relative magnitude of underwater impacts to other causes of boating accidents in particular and accidents in general. There is no indication that any change in reporting would reflect significant changes in the relative position or percentage of injuries/fatalities due to underwater impacts. Therefore, propeller guarding at ~~least~~ best could have only a negligible impact on improving boating safety.

2. Injuries/fatalities caused by underwater impacts result from a person coming into contact with the propeller or any part of the propulsion unit (i.e., lower unit, skeg, torpedo, anti-ventilation plate, etc.) and even the boat itself. Currently reported accidents make it obvious that all such components are involved in the total picture, and that the propeller itself is the sole factor in only a minority of impacts. The development and use of devices such as "propeller guards" can, therefore, be counter-productive and can create new hazards of equal or greater consequence.

3. Operator error is clearly a significant factor in the vast majority of underwater impacts which result in injuries/fatalities. Mandatory equipment requirements could be expected to have only a negligible impact on this problem. The most rational approach to the problem is to educate boaters, especially operators. They must be made to understand the abilities and limitations of their equipment. They must be aware of and understand the hazards their boat can cause to people in the water. Above all, they must be made to understand the consequences of careless or negligent operation of their watercraft, and how they, as boat operators, can act to prevent accidents.

4. Although the controversy which currently surrounds the issue of propeller guarding is, by its very nature, highly emotional and has attracted a great deal of publicity, there are no indications that there is a generic or universal solution currently available or foreseeable in the future. The boating public must not be misled into thinking there is a "safe" device which would eliminate or significantly reduce such injuries or fatalities.

RECOMMENDATIONS

1. The U.S. Coast Guard should take no regulatory action to require propeller guards.
2. The U.S. Coast Guard should, through improved accident reporting and analysis, develop a complete and comprehensive data base on underwater impact accidents. This should involve, as an integral part, U.S. Coast Guard involvement in the National Electronic Injury Surveillance System (NEISS) and the appropriate training of involved hospital personnel.
3. The U.S. Coast Guard should implement necessary steps to have included in national and state level educational and awareness campaigns the information regarding potential hazards associated with careless or negligent boat operation. Such programs should be on a continuing basis and be as vivid as possible in depicting underwater impact accident scenarios. These programs should state in a positive manner how such accidents can be prevented by diligent, informed boat operators.
4. The U.S. Coast Guard should work with appropriate voluntary standards making organizations (such as ABYC and SAE) to develop meaningful warning labels, and define their most effective locations, concerning the hazards of underwater impacts.
5. The U.S. Coast Guard should review manufacturing safety standards of

watercraft, emphasizing the importance of keeping passengers and operators in the boat, and maintaining the unobstructed fore and aft view of the boat operator.

6. The U.S. Coast Guard should encourage a systematic review of current enforcement programs aimed at reducing boat accidents, and should provide all possible support to implement, maintain and expand those programs targeting the prevention of accidents.

Unanimously adopted by the Propeller Guard Subcommittee

by ______________________________
James E. Getz, Chairman

for: Donald J. Kerlin
Richard H. Lincoln
William D. Selden
Herman T. VanMell

APPENDICES

APPENDIX A

Charge to the Subcommittee

APR 13 1988

NBSAC COMMITTEE

Propeller Guards/ [Propeller Strikes/Propeller Protection]

Charge to the Committee:

* Review the available data on the prevention of propeller-strike accidents and the Coast Guard study of various methods of shrouding propellers to prevent contact with a person in the water.

* Assess the arguments for and against some form of mechanical guard to protect against propeller strikes reflecting the positions of state boating law administrators, the recreational boating industry, and the boating public.

* Among points to be considered:

a. what is the incidence of such accidents?

b. is there a trend toward more or fewer such accidents?

c. what are the possible solutions and their advantages/disadvantages?

d. how is this problem being addressed in other nations?

e. what would be the direct costs and indirect costs (fuel economy, maintenance, etc.) of mechanical solutions?

f. can the risks be addressed adequately by education?

g. should the Coast Guard move towards a federal requirement for some form of propeller guard?

h. assess the potential for propeller equipped with each of several propeller guard designs to cause injury. How much has the propeller guard reduced the injury potential compared to the injury potential of the same propeller operating in an unguarded manner?

i. should only new boats and motors be equipped with propeller guards, or should all boats eventually be equipped with a guard?

j. what is the practical boat length limit beyond which propeller guards would not be required? are there other parameters which would dictate upper limits for guard installation?

Committee members:

Jim Getz (Chairman)
William Fast
Dick Lincoln
Don ~~Ellison~~ Kerlin (USCG rep.)

APPENDIX B

List of Subcommittee Contacts

APPENDIX B

The following list represents the contacts made in behalf of the Subcommittee requesting information relevant to the Subcommittee's charge:

Dr. James Benedict, PhD., M.D.
Biodynamic Research Corporation
9901 IH 10 West
San Antonio, Texas 78230

Mr. Donald L. Blount, P.E.
Head, Combatant Craft Engineering Department
Naval Sea Combat Systems Engineering Station
P.O. Box 10418
Norfolk, Virginia 23513

Mr. Steve Bolden
Fell & Spaulding
211 South Broad Street, 8th Floor
Philadelphia, Pennsylvania 19017

Dr. Albert H.Burstein, PhD.
Director
The Hospital For Special Surgury
Department of Biomechanics
535 East 70 Street
New York, New York 10021

Mr. Brian Chadwell
Prop Guard, Inc.
1901 Shelter Island Drive
P.O. Box 6276
San Diego, California 92106

Dr. Michael Gallery, PhD.
Emergency Medical Foundation
Box 619911
Dallas, Texas 75261

Mr. Lars Granholm
Director, Technical Services
National Marine Manufacturers Association
401 North Michigan Avenue
Chicago, Illinois 60611

Director
Emergency Room Services
Falmouth Hospital
Ter Heun Drive
Falmouth, Massachusetts 02540

Director
Emergency Room Services
Jordan Hospital
275 Sandwich Street
Plymouth, Massachusetts 02360

Director
Emergency Room Services
Lakes Region General Hospital
Highland Street
Laconia, New Hampshire 03246

Director
Emergency Room Services
Quincy City Hospital
114 Whitwell Street
Quincy, Massachusetts 02169

Director
Emergency Room Services
Salem Hospital
81 Highland Avenue
Salem, Massachusetts 01970

Executive Director
International Rescue and Emergency Care Association
8107 Ensign Curve
Bloomington, Minnesota 55438

Mr. Dennis Heussner
National Life Saving Director
Surf Life Saving Association of Australia
'Surf House', 128 The Grand Parade
Brighton-le-sands, N.S.W. 2216, Australia

Mr. John G. Hill
Naval Architect - Marine Engineer
P.O. Box 114
Oxford, Maryland 21654

Mr. R. Ben Hogan, III
Hogan, Smith, Alspaugh, Samples & Pratt, P.C.
2323 Second Avenue North
Birmingham, Alabama 35203-3758

Dr. Donald F. Huelke, PhD.
The University of Michigan
Transportation Research Institute
2901 Baxter Road
Ann Arbor, Michigan 48109-2150

Dr. Jack C. Hughston, M.D.
Editor
American Journal of Sports Medicine
428 East Preston Street
Baltimore, Maryland 21202

Mr. Alex B. Marconi
Senior Counsel/Litigation
Outboard Marine Corporation
100 Sea Horse Drive
Waukegan, Illinois 60085

Ms. Francis Munnings, Executive Editor
"The Physician and Sportsmedicine"
McGraw-Hill Healthcare Group
4530 West Seventy-Seventh Street
Minneapolis, Minnesota 55435

Mr. Arthur M. Reed
9106 Warren Street
Silver Springs, Maryland 20910-2140

Mr. Richard H. Snyder
Principle Engineer - Product Evaluation
Mercury Marine
W6250 West Pioneer Road
P.O. Box 1939
Fond Du Lac, Wisconsin 54936-1939

Mr. Robert K. Taylor, P.E.
Managing Engineer
Naval Architecture & Marine Engineering
Failure Analysis Associates, Inc.
2225 East Bayshore Road
P.O. Box 51470
Palo Alto, California 94303

Dr. Lawrence E. Thibault, Sc.D.
Biomechanics, Inc.
1611 Valley Greene Road
Paoli, Pennsylvania 19301

APPENDIX C

List of Documents and Materials Reviewed

APPENDIX C

The following is a listing of the documents and materials reviewed by the Subcommittee:

"Prediction of Whole-Body Response to Impact Forces in Flight Environments," by Ints Kaleps, a paper reprinted from the Conference Proceedings No. 253, Models and Analogues for the Evaluation of Human Biodynamic Response, Performance and Protection, North Atlantic Treaty Organization.

"Water Jet Propulsion - Competition for Propeller?," by Ralph E. Lambrecht, Society of Automotive Engineers, Automotive Engineering Congress, No. 740283, February 25-March 1, 1974.

"Review of the State of the Art of Swimmer Protection from Outboard Propellers," by Robert Taggart, 16 February 1979.

"Waterskiing Injuries," by Larry R. Pedegana, M.D., and Janice Lang, The Physician and Sportsmedicine, Vol. 7, No. 6, 1979.

"Propeller Injuries Incurred in Boating Accidents," by Ronald J. Mann, M.D., The American Journal of Sports Medicine, Vol. 8, No. 4, 1980.

Unpublished letter to Mr. Al Marmo, U.S. Coast Guard from Mr. Dick Snyder, Mercury Marine, reference propeller guards, dated December 15, 1980.

"Waterskiing-Related Injuries," by Gregory Hummel, M.D., and Barry J. Gainor, M.D., The American Journal of Sports Medicine, Vol. 10, No. 4, 1982.

"Hi-Performance Boat Operation," a booklet published by Brunswick Corp., No. 90-86168 3-184, 1984.

"Steering/Struck-by-Propeller Accident Study, 1983 Recreational Boating Accidents," by Gary Traub, U.S. Coast Guard G-BP-1, December 18, 1984.

Surf Life Saving Training Manual, issued by the Surf Life Saving Association of Australia, 27th Edition (Revised), 1985.

Inflatable Rescue Boat Training Examination and Operations Manual, issued by the Surf Life Saving Association of Australia, Third Edition, 1986.

Coast Guard Memorandum to Chief, Marine Safety Technology Branch, from Chief, Medical Operations Branch, reference Mercury Marine tests, dated June 12, 1986.

"Everything You Need to Know About Propellers," a booklet published by Brunswick Corp., No. 90-86144, Third Edition, 1987.

"The Technological Feasibility of Propeller Guarding for Pleasure Planing Craft," by John G. Hill, February 10, 1987.

"Boat and Propeller Impact Injuries and Fatalities," Project 763584.20 Final Report, by Edward S. Purcell and Walter B. Lincoln, U.S. Coast Guard Research and Development Center, 1 March 1987.

"Motorboat Propeller Injuries," by Charles T. Price, M.D., and Charles W. Moorefield, M.D., The Journal of the Florida Medical Association, Vol. 74, No. 6, June, 1987.

"The Feasibility of Propeller Guarding," by Arthur M. Reed, July, 1987.

"Propeller Guarding," a letter report by Lawrence E. Thibault to Mr. Stephen R. Bolden, Esq., dated August 14, 1987.

"Principles of Human Safety," by Ralph A. Barnett and William G. Switalski, Safety Brief, Vol. 5, No. 1, Tiodyne, Inc., February, 1988.

Letter to CAPT. Roger T. Rufe, Chief, Congressional Affairs Staff, U.S.C.G., from The Honorable Orrin G. Hatch, United States Senator, reference Mr. Jackson Howard's concerns about propeller guards, dated March 28, 1988.

Letter to The Honorable Orrin G. Hatch, United States Senator, from the Coast Guard responding to Mr. Howard's concerns, dated April, 1988.

Letter to Mr. James D. Martin, Alabama Commissioner of Conservation and Natural Resources, from Mr. R. Ben Hogan, III, reference propeller guarding, dated April 11, 1988.

Letter to Mr. Al Marmo, Chief, Policy Planning and Evaluation Staff, U.S.C.G., from Mr. R. Ben Hogan, III, reference propeller accidents in Alabama, dated May 5, 1988.

Letter to Subcommittee Chairman Getz from Mr. Lars Granholm, National Marine Manufacturers Association, reference 1979 Coast Guard study, dated May 31, 1988.

"Specification Criteria for the Manufacture, Testing & Commissioning of Safety Guards for Use on Inflatable Rescue Boats Engaged in Inshore Rescue Activities, and Schedule of Approved Guards," Bulletin No. 504-88, The Surf Life Saving Association of Australia, National Council, May, 1988.

Slide photographs of various guard devices, components of lower units, and tests submitted by Mr. Richard Snyder, Mercury Marine, submitted August 12, 1988.

Struck by Boat or Propeller manual analysis of 1983-1987 Coast Guard data by Subcommittee member Kerlin, dated September 22, 1988.

Letter to Subcommittee Chairman Getz from Mr. Donald L Blount, P.E., reference a summary of his presentation to the Subcommittee on September 22, dated October 1, 1988.

Letter to Subcommittee Chairman Getz from Mr. R. Ben Hogan, III, reference propeller guarding information, dated October 6, 1988.

Letter to Subcommittee Chairmann Getz from Mr. Dick Snyder, Mercury Marine, reference a summary of his presentation to the Subcommittee on September 22, dated October 6, 1988.

Collection of propeller guard patents, compiled by Subcommittee member Montgomery, dated October 18, 1988.

Letter to Subcommittee Chairman Getz from NBSAC Chairman Garden, reference NEXUS data bank of published newspaper articles concerning propeller-related accidents, dated October 23, 1988.

Letter to Subcommittee Chairman Getz from Mr. Alex Marconi, OMC Senior Counsel/Litigation, reference response to the article "Motorboat Propeller Injuries" by orthopedic surgeon John Nordt, M.D. of Coral Gables, and other related matters, dated November 9, 1988.

Letter to Subcommittee Chairman Getz from Dr. D.F. Huelke, reference a summary of his presentation to the Subcommittee on November 14, dated December 19, 1988.

Letter to Subcommittee Chairman Getz from Mr. R. Ben Hogan, III, reference his updated article on propeller guarding, dated January 23, 1989.

Letter to Subcommittee Chairman Getz from Mr. Dick Snyder, Mercury Marine, reference a clarification of his presentation to the Subcommittee on Sptember 22, 1988 concerning USCG statistics, dated February 23, 1989.

Photographs of Dr. Thibault's Deposition Exhibits, OMC ATS Glabman, April 13, 1989.

Letter to Alex Marconi, OMC Senior Counsel/Litigation, from Kelly J. Flood, reference transcripts of Swint and Bruton San Diego Test videos, dated April 17, 1989.

Personal Watercraft Accident Summary, compiled by Subcommittee member Kerlin, dated May 9, 1989.

Letter to Subcommittee Chairman Getz from Mr. Richard Snyder, Mercury Marine, reference a summary of his work with the U.S. Marine Corps delivered at the May Subcommittee Meeting, dated May 30, 1989.

Letter to Subcommittee Chairman Getz from Mr. R. Ben Hogan, III, reference August 9, 1989 stunt man prop guard tests, dated August 11, 1989.

Letter to Admiral Paul A. Yost, Commandant, U.S. Coast Guard, from Mr. Benjamin Kelley, President, Institute for Injury Reduction, reference the Institute's recent news conference and subsequent questions for the Coast Guard, dated August 15, 1989.

Letter to Mr. Benjamin Kelley, President, Institute for Injury Reduction, from Captain W.S. Griswold, U.S. Coast Guard, responding to Mr. Kelley's August 15 letter to Admiral Yost, dated August 23, 1989.

Letter to Subcommittee Chairman Getz from Mr. R. Ben Hogan, III, reference video tapes of a deposition of Dr. Charles Price (08/29/89), propeller guard segment on "CBS This Morning" (08/31/89), and prop guard demo (08/09/89).

Letter to Subcommittee Chairman Getz from the Biodynamic Research Corporation, reference an outline of Dr. Benedict's presentation to the Subcommittee in May, dated September 20, 1989.

Video Tapes, as follows:

Simulated Underwater Limb Impact Tests (SULIT), Mercury Marine, 1988, (21 min.)

Hirsch, Glover, Robinson & Sheiness, Hammonds vs. Yates, Marine Corps Raiders, (4 min.), Guard Operation by Snyder, (4 min.), Mercury and OMC Log Jumps , (4 min.), Ehrhardt Cage Test "Wynne", (6 min.).

Simulated Underwater Flesh Impact Test (Sausage Tests), Mercury Marine, (5 min.).

Chadwell Propeller Device On-Water Tests, Mercury Marine, (8 min.).

Sporting Life IRB's, New Zealand, (25 min.).

March 1989 San Diego Tests, and March 1989 San Diego Tests, Bruton Tapes, Underwater Video, High Speed Film, Speed Runs.

Institute for Injury Reduction news conference release tape, propeller injuries/propguards, June 1989.

Ben Hogan/ stunt man propeller guard tests, conducted August 9, 1989 (2 tapes).

Deposition of Dr. Charles Price, dated August 29, 1989.

Propeller guard segmant of "CBS This Morning," dated August 31, 1989.

APPENDIX D

Subcommittee Agendas

The National Boating Safety Advisory Council

PROPELLER GUARD SUBCOMMITTEE MEETING

BOSTON WHALER FACILITIES - ROCKLAND, MA

SEPTEMBER 22 & 23, 1988

AGENDA

Thursday, September 22

8:30 AM - 9:50 AM	Subcommittee Welcome, Orientation, and Literature Review
10:10 AM - 11:00 AM	Presentation to the Subcommittee Mr. Richard Snyder - Mercury Marine
11:10 AM - 12:00 PM	Presentation to the Subcommittee Mr. Brian Chadwell - Propeller Guard Designer
1:00 PM - 1:50 PM	Presentation to the Subcommittee Mr. Ben Hogan - Attorney for Advocates
2:00 PM - 2:50 PM	Presentation to the Subcommittee Mr. Alex Marconi - Attorney for Outboard Marine Corp.
3:10 PM - 5:00 PM	Participation with the Subcommittee Previous participants will give points, counterpoints, rebuttals to other presentations, in addition to questions/answers with the Subcommittee

Friday, September 23

8:30 AM - 10:00 AM	On-water propeller guard demonstration Boston Whaler representatives will provide a boat with and without a propeller guard
10:20 AM - 12:00 PM	Subcommittee review of newly presented information and plans for the future needs of the subcommittee, with a projected timetable for subcommittee work

The National Boating Safety Advisory Council

PROPELLER GUARD COMMITTEE MEETING

NEW BERN, NORTH CAROLINA

NOVEMBER 14, 1988

\- - - - -

AGENDA

\- - - - -

1. Presentation by D.F. Huelke, Professor of Anatomy, University of Michigan

2. Review of papers submitted by previous speakers.
   Blount
   Hogan
   Snyder

3. Review of Garden letter, dated October 23, 1988, Re: Nexus.

4. Review of Committee charges from September Meeting.

   Getz...............Capt. Griswold letter
   Dr. Thiebault

   Kirlin.............U.S.C.G. Statistical Analysis
   Consumer Product Safety Commission
   David Taylor Model Basin

   Mongomery..........Patents
   Lexus
   Insurance Carriers

   Lincoln............Robert Taylor Graphs

5. Future Committee Schedule.

The National Boating Safety Advisory Council

PROPELLER GUARD SUBCOMMITTEE MEETING

COEUR D'ALENE, IDAHO

MAY 12 & 13, 1989

AGENDA

Friday, May 12

1:00 - 1:10 PM	Review by Subcommittee Chairman
1:10 - 1:30 PM	Presentation to the Subcommittee Mr. Richard Snyder - Mercury Marine
1:30 - 3:00 PM	Presentation to the Subcommittee Mr. Robert Taylor - Failure Analysis, Inc.
3:15 - 5:00 PM	Presentation to the Subcommittee Dr. Lawrence Thibault - Biomechanics, Inc.
7:00 - 9:00 PM	Presentation to the Subcommittee Dr. James Benedict - Biodynamic Research Corporation

Saturday, May 13

8:00 - 10:00 AM	Presentation to the Subcommittee Dr. Albert Burstein - The Hospital for Special Surgery
10:00 AM - 5:00 PM	Subcommittee Review/Report Assignments

APPENDIX E

Failure Analysis Associates Summary

Failure
Analysis
Associates®

FAILURE ANALYSIS ASSOCIATES®, INC.
ENGINEERING AND SCIENTIFIC SERVICES
2225 EAST BAYSHORE ROAD, P.O. BOX 51470
PALO ALTO, CALIFORNIA 94303 (415) 856-9400 TELEX 704216

August 2, 1989

Captain James E. Getz, Chairman
Propeller Guard Subcommittee
National Boating Safety Advisory Council
Illinois Department of Conservation
110 James Road
Spring Grove, IL 60081

RE: Boating Accident Statistics

Dear Jim:

I am sorry, but I became busy and forgot to send you hard copies of some of the material pertinent to my Propeller Guard Subcommittee presentation. Enclosed are several charts showing accident (Fatality and Injury) statistics reflecting general activities, boating, and incidents involving being struck by "boat, propeller, or lower unit." Following are some comments regarding each chart.

Chart 1 "Accident Types" for Fatal Accidents for Boats with Motors 1976-1981

The average number of recreational boating deaths from 1976-1981 is 1,325 per year. Of all fatal accidents for boats with motors 5.2% of the accidents involve being "struck by boat or propeller."

For the years presented, this amounts to an average of 49 fatalities per year associated with this accident mode. We know this number is higher than actual because we cannot subtract the subset "related to propeller contact" from those accidents where the individual was struck by only the boat or only other motor or steering appendages and not by the propeller. Estimates show that boating fatalities involving the propeller are probably closer to 30 per year.

Chart 2 Annual Fatalities

This chart indicates annually there are approximately two million deaths. The great majority of those deaths are associated with natural causes and disease. Only 5% of all deaths are premature accidental deaths. Nearly half of all accidental deaths involve motor vehicles. One percent of accidental deaths (1384 in 1980) are attributable to boating. Of these, approximately 30-49 incidents per year are associated with propeller involvement. On an absolute basis this is one third to one half the number of fatalities associated with being struck by lightning (94 in 1981).

Chart 3 Risk of Fatality by Activity

This bar chart depicts the relative comparative risk of fatality for various activities. Risk is computed by dividing the number of fatalities for a given activity or accident mode by the opportunities for the accident to occur. In this case, the opportunity is selected as one million exposure hours. An exposure hour is defined as one person spending one hour in pursuit of the activity. In other words, this chart shows the relative risk (or chance of fatality) for different activities if one spent an equal amount of time (million hours in this case) in pursuit of that activity.

The risk of fatality on a per hour basis while boating, in general, is about one-fourth the risk of operating a motor vehicle and is comparable with the risk of flying in a domestic scheduled airline.

The risk of fatality of being "struck by boat or propeller" is one-third of the risk of traveling in a school bus for an equal amount of time.

Chart 4 Risk of Boating Fatality in 1981

This chart indicates that all boat types do not have the same relative risk of fatality. In fact, boats without motors (inflatables, rowboats, and canoes/kayaks) tend to be substantially more risky than boats with motors.

Chart 5 Rate of Boating Fatalities In Which the Accident Was Described As "Struck by Boat or Prop" 1975-1981.

This chart shows that even motor driven boats without external propellers (jet boats) are involved, on a per-boat basis, in a comparable number of "struck by boat" incidents.

Obviously, this fact demonstrates that in the real world there is no free lunch. Because jet boats have either no or minimal lower steering appendages, they tend to be more difficult to maneuver; consequently, jet boats are involved in collision type accidents. So, in this case, by eliminating one accident mode-- propeller strikes-- other accident modes have been created or increased-- collisions.

Chart 6 Risk of Injury by Activity

This chart shows the comparative injury risk (non-fatal incidents) for various activities. Its derivation is similar to the Risk of Fatality chart. Hospitalized injuries related to propellers while boating or water-skiing are approximately one-half of one percent of the risk of injury while boating or water-skiing.

I would be pleased to elaborate on any of the above issues. If the committee has specific questions they desire to be addressed or if you need further explanation of the background or references for the summary charts, please call.

Sincerely,

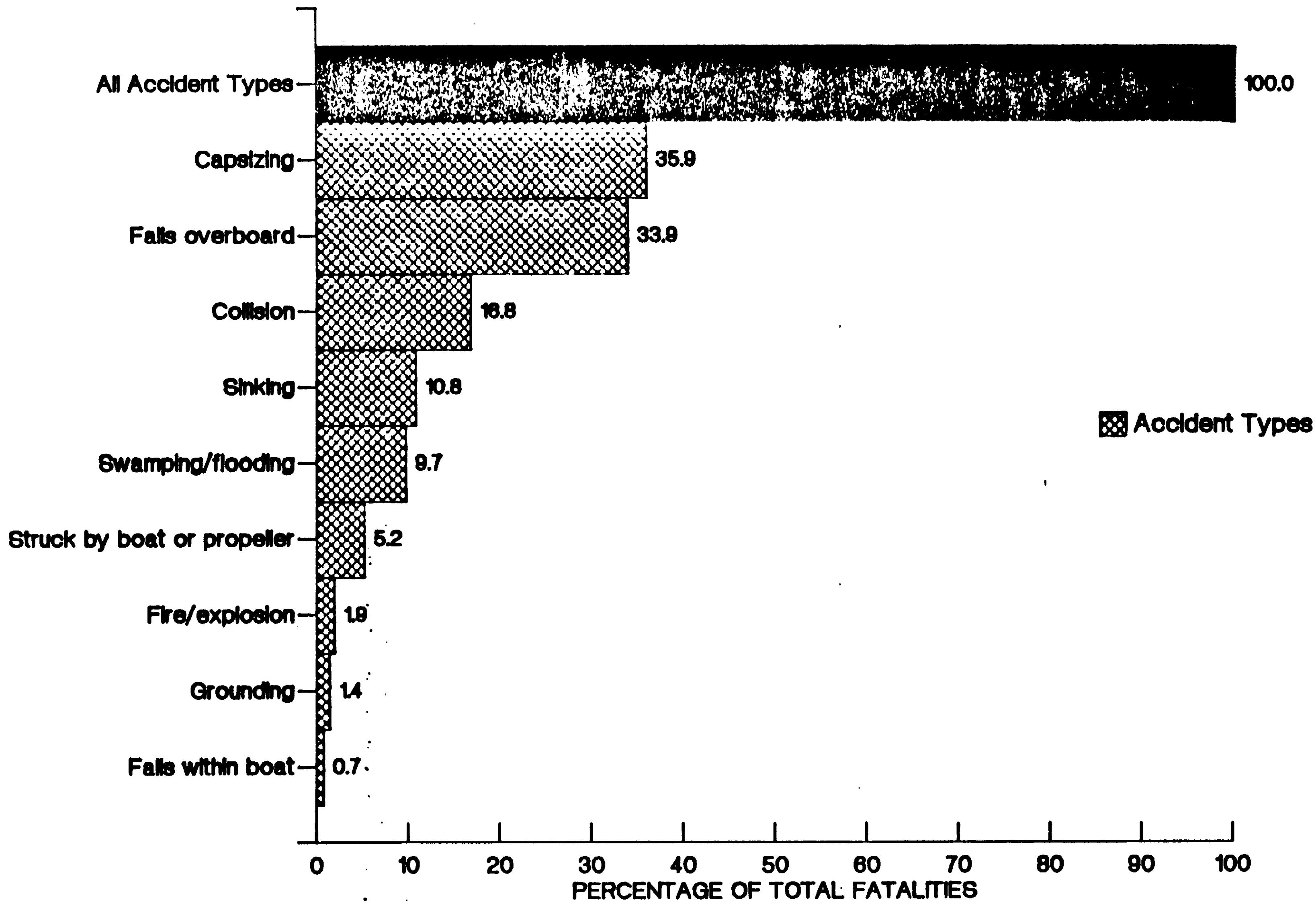
Robert K Taylor

Robert K. Taylor, P.E.
Managing Engineer
Naval Architecture & Marine Engineering

RKT:dg\getz.doc

Enclosure
Charts (1 orig & 6 Color Copies)

"ACCIDENT TYPES" FOR FATAL ACCIDENTS
Boats with Motors, 1976-1981



Percentage includes cases with multiple accident types; therefore total exceeds 100%.

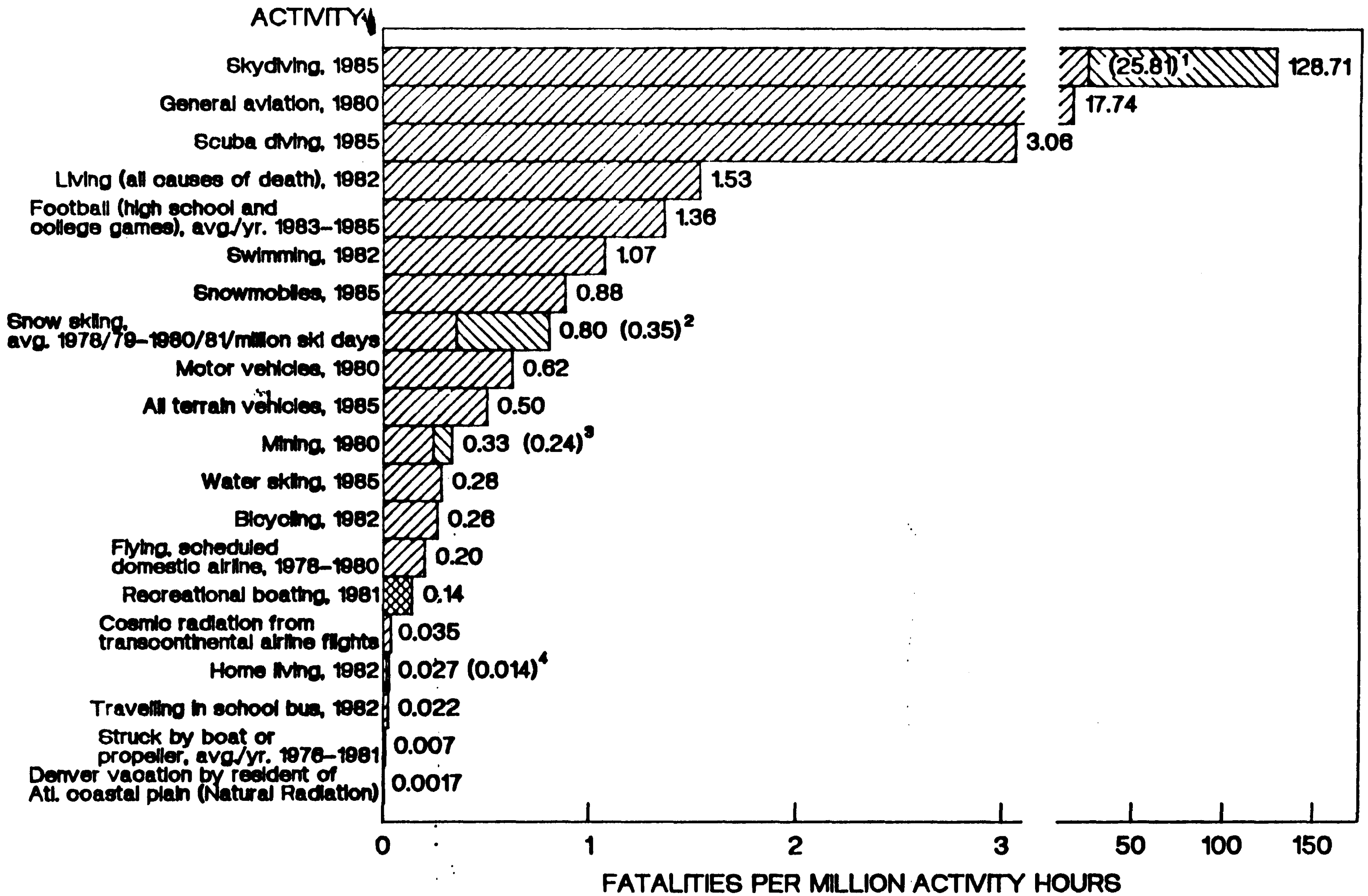
CHU8811

ANNUAL FATALITIES

All Causes, 1980	1,989,841
All Accidents, 1980	105,718
Motor Vehicles, 1980	53,172
Suicide, 1980	26,869
Homicide, 1980	23,967
Falls, 1980	13,294
Drowning, 1981	6,404
Swimming, 1981	2,513
Fires, Burns, 1980	5,822
Ingestion of Food, Object, 1980	3,249
Construction, 1980	2,500
Recreational Boating, 1980	1,384
General Aviation, 1980	1,237
Bicycling, 1980	965
Mining, 1980	500
Flying Scheduled Domestic Airline, annual avg. for 1978-1980	98
Lightning, 1980	94
Scuba Diving, 1980	89
Skydiving (Jump and Flight), 1980 (Jump Only)	47 (45)
Skiing, annual avg. for 1978/79-1980/81 (Raw Data)	37 (16)

Note: Fatalities for recreational boating from U.S. Coast Guard Boating Accident Reporting System (BARS), and includes water skiing fatalities.

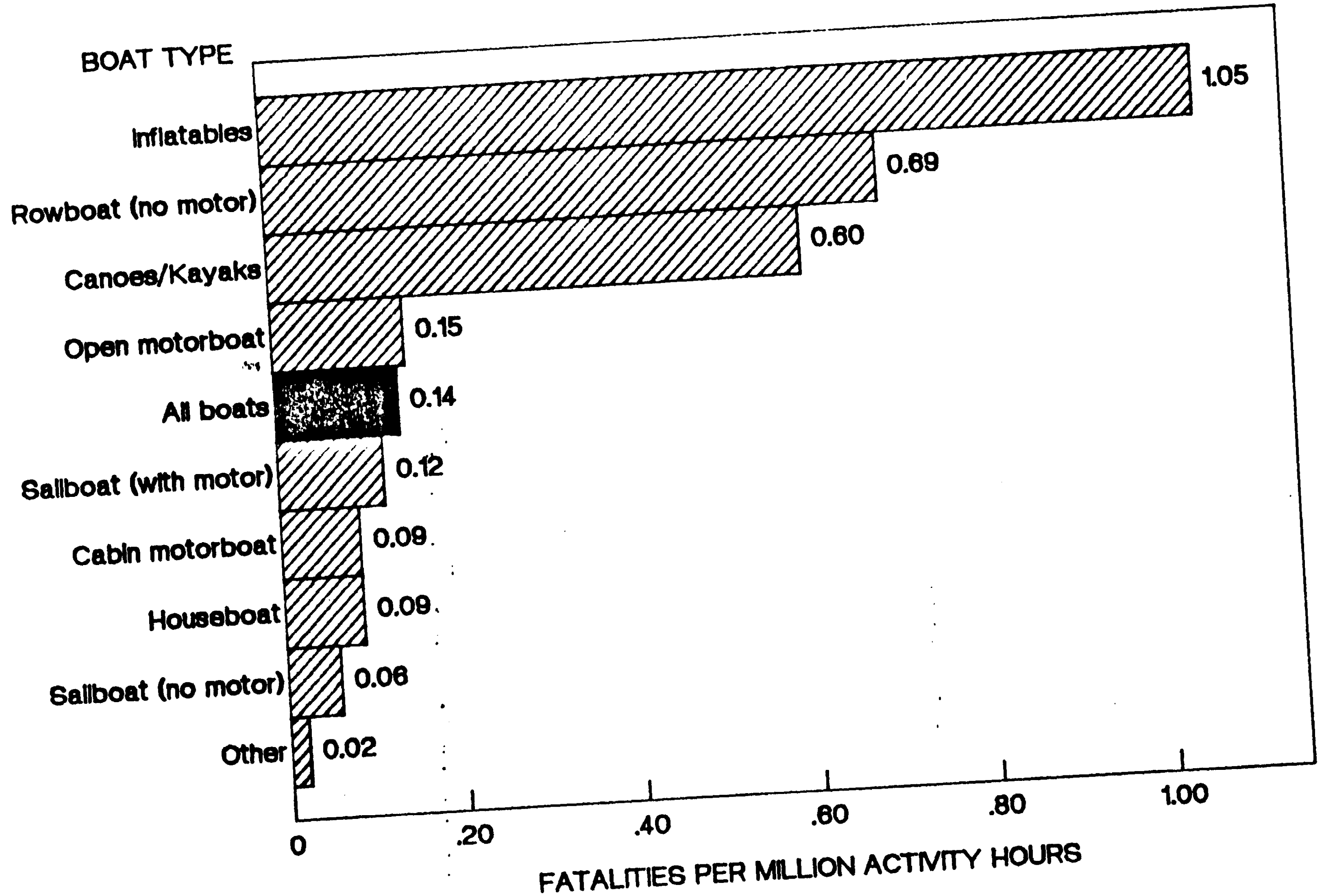
RISK OF FATALITY BY ACTIVITY



Note:
1. The risk for jump time only is 128.71. The number in parentheses, (25.81), is the risk for jump and flight time.
2. The number in parentheses is the risk calculated from the raw data only.
3. The risk for production workers is 0.33. The number in parentheses, (0.24), is for all employees.
4. The risk for active home living is 0.027. The number in parentheses, (0.014), is for active and passive time.
5. Values for some activities may vary from year to year.

Failure Analysis Associates

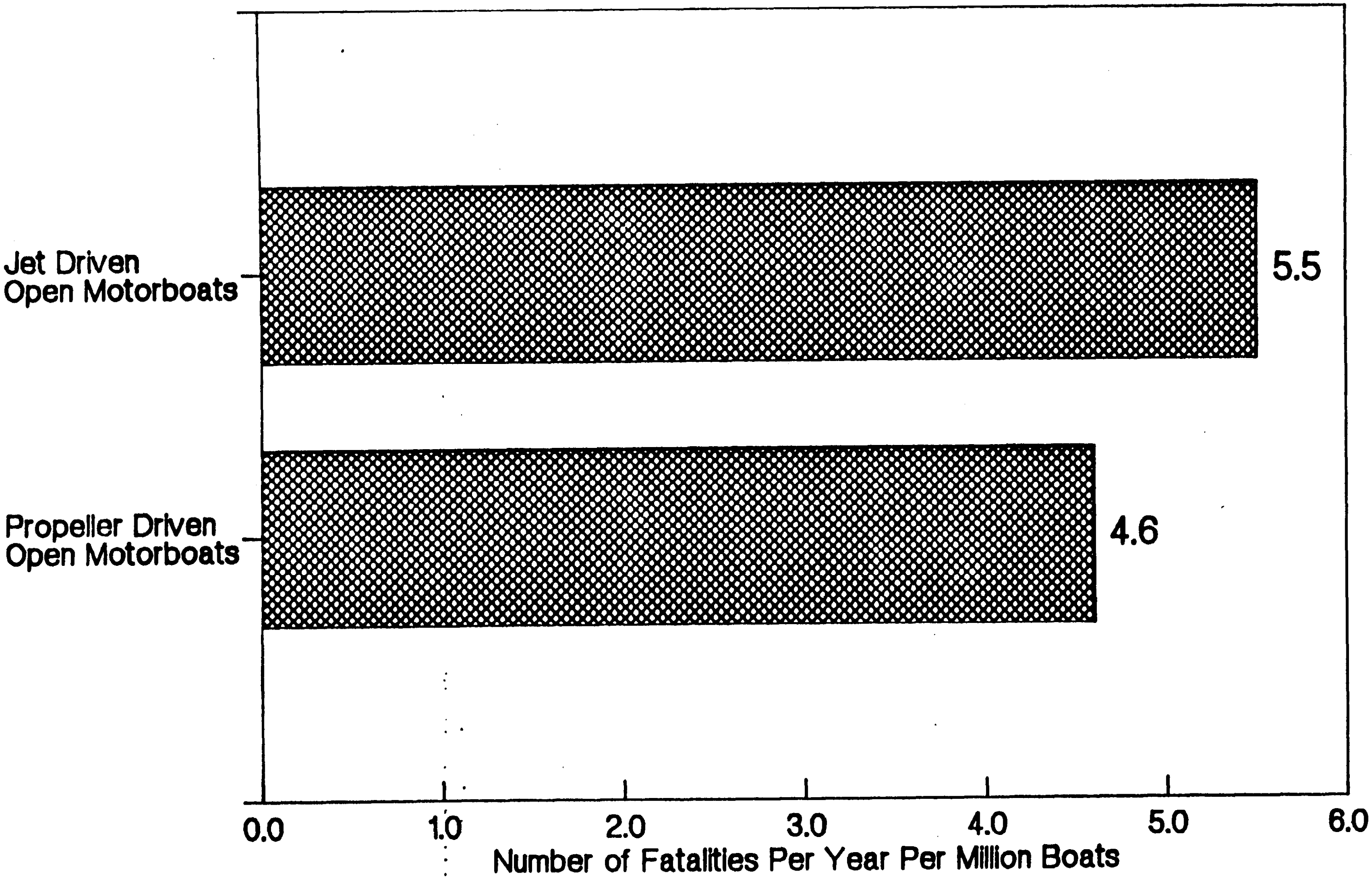
RISK OF BOATING FATALITY IN 1981



Note: Data from United States Coast Guard.

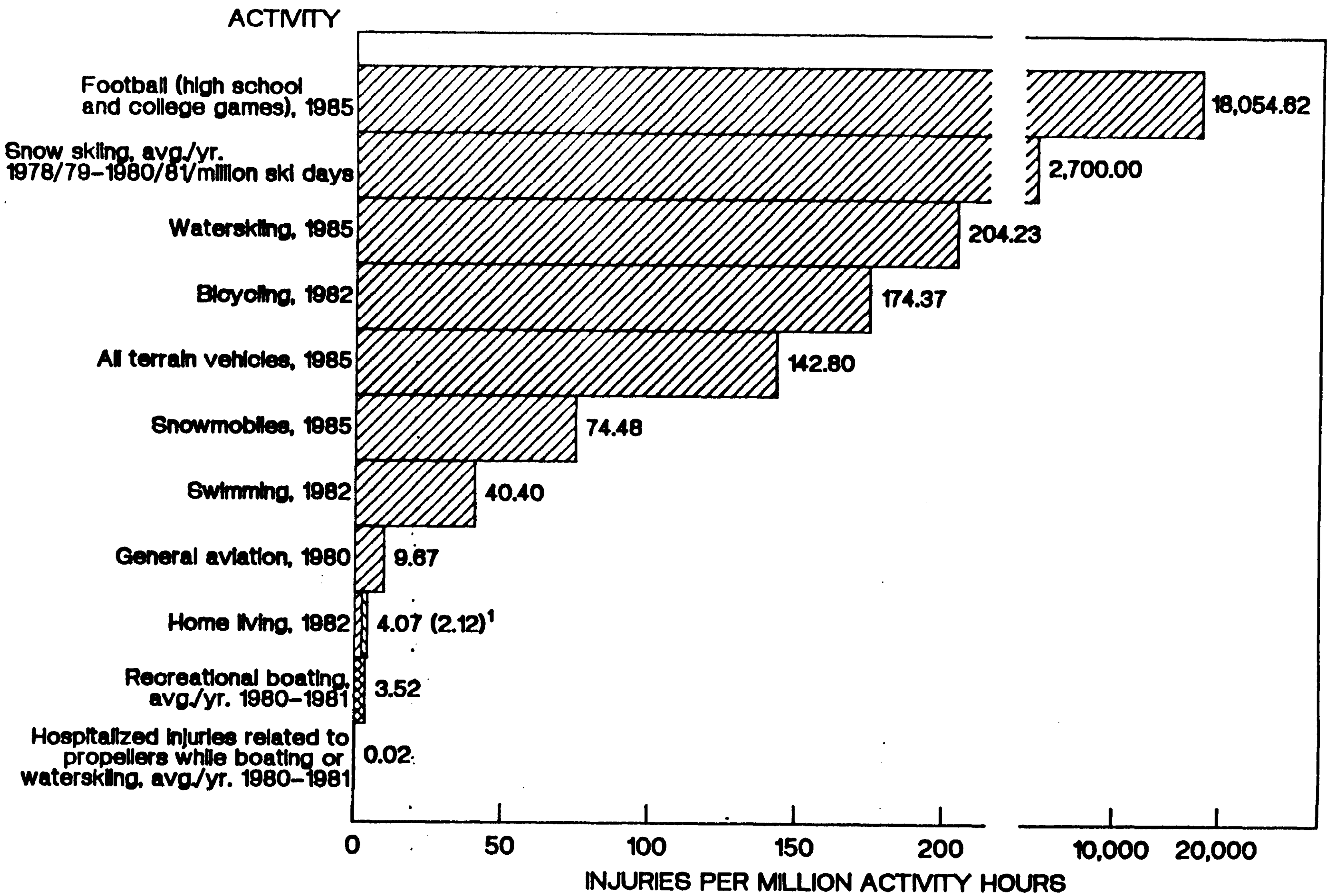
Failure Analysis Associates

RATE OF BOATING FATALITIES IN WHICH THE ACCIDENT WAS DESCRIBED AS "STRUCK BY BOAT OR PROP" 1975-1981



Failure Analysis Associates

RISK OF INJURY BY ACTIVITY



Note:
1. The risk for active home living is 4.07. The number in parentheses, (2.12), is for active and passive time.
2. Values for some activities may vary from year to year.

Failure Analysis Associates

APPENDIX F

Subcommittee Members

APPENDIX F

The following members participated in the Subcommittee's deliberations and consideration of conclusions and recommendations:

CAPT. James E. Getz, Chairman, State Member
Mr. Donald J. Kerlin, U.S.C.G. Representative
Mr. Richard H. Lincoln, Industry Member
Mr. William D. Selden, Public Member
Mr. Herman T. VanMell, Public Member

The following members served at various lengths on the Subcommittee, but were not on the Subcommittee at the time of the consideration of conclusions and recommendations:

Mr. William M. Fast, Public Member
Mr. Roy T. Montgomery, Industry Member
LT. Joe L. Ruelas, State Member