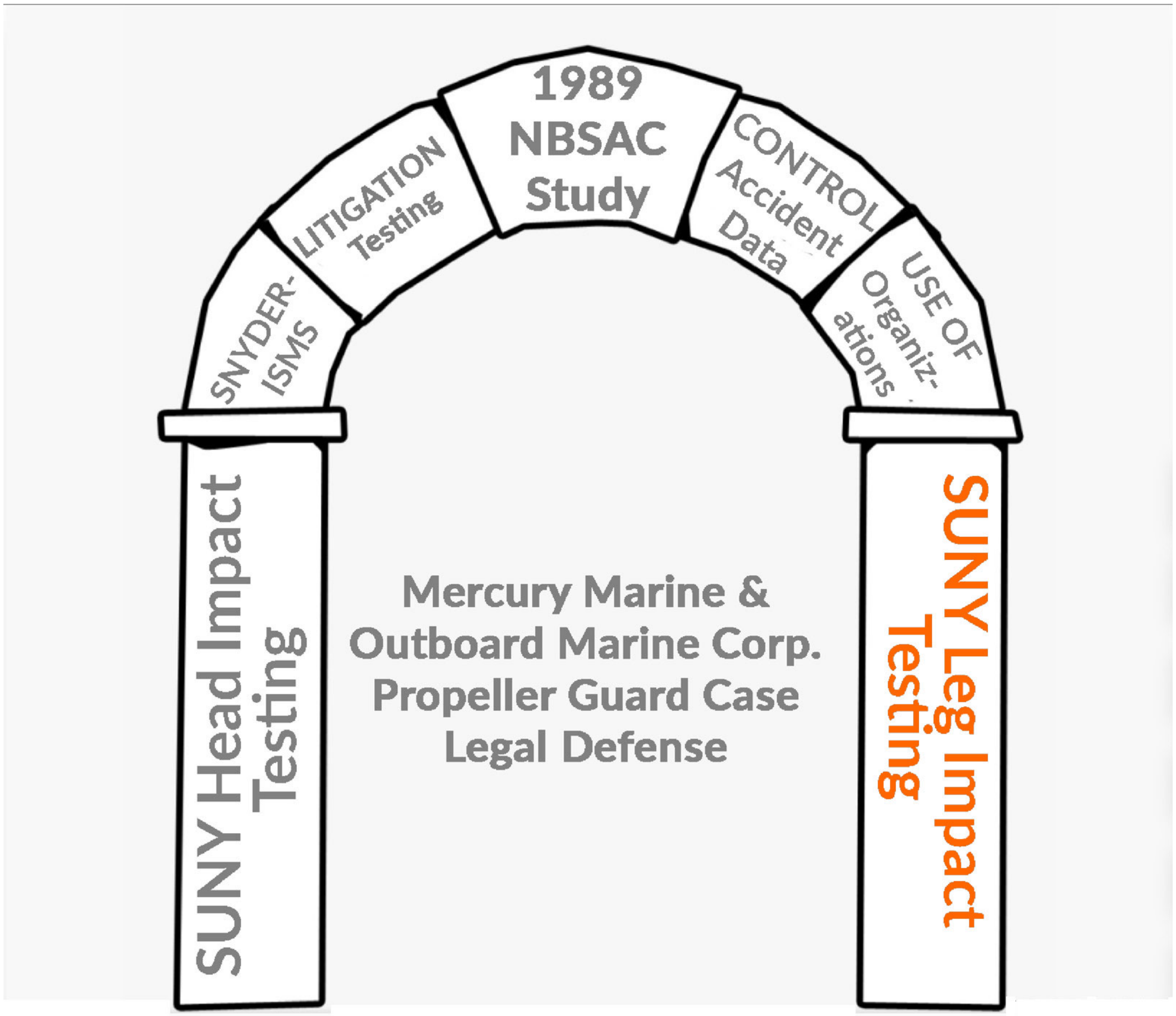

Volume IV: Leg Impact Study

PropellerSafety.com **4 May 2023**

Gary Polson

Abstract: Mercury Marine and OMC worked together in the late 1980s and early 1990s to develop a defense against propeller guard lawsuits.

The keystone of their defense was the U.S. Coast Guard 1989 National Boating Safety Advisory Council (NBSAC) propeller guard subcommittee report.

The report was propped up and enhanced by two underwater impact studies conducted at State University of New York (SUNY) at Buffalo.

This volume, fourth and last of a series, addresses the underwater leg impact study at SUNY led by Tyler Kress of the University of Tennessee.

Embalmed, cadaver legs were suspended horizontally underwater in a very large donut shaped 8 foot deep pool. An outboard motor with a propeller guard was swung around the pool on a long arm to strike the leg with the propeller guard.

Our study will focus on some previously unexplored areas such as:

1. *Tests with an open propeller were expressly forbidden,*
2. *Roving authorship of the study (different authors listed over time),*
3. *Source of funding of the study*
4. *Level of involvement of Mercury and OMC legal departments and legal firms in the study,*
5. *Several edits of the research paper, each looking more favorable to the industry,*
6. *Orientation of the lower leg to the oncoming boat motor and propeller guards*
7. *Simulation of propeller thrust allowed the industry to test at zero trim, leading to more challenging impacts (more challenging to slide off the guard),*

We also expose techniques used by the boating industry previously explored in our coverage of the 1989 NBSAC report.

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Appendix A: Embellishing the Reports

Introduction

As mentioned in **Volume I**, 1988 - 1991 was an especially difficult time for Mercury Marine and Outboard Marine Corporation (OMC) with a multitude of propeller injury lawsuits being filed. The suits claimed their drives should have had propeller guards.

Mercury and OMC had a mutual protection relationship[1] in trying to find relief from these lawsuits prior to the U.S. Coast Guard National Boating Safety Advisory Council (NBSAC) forming a propeller guard subcommittee in May of 1988.

Mercury and OMC both had representatives on the NBSAC subcommittee on propeller guards, plus Dick Snyder, Mercury's long time expert witness in boat propeller cases was also closely involved with the subcommittee.

Mercury and OMC were also involved in a propeller guard project for the U.S. Marine Corps in this era.

Dick Snyder testified underwater propeller guard impact studies grew from a discussion he had with John Snider and Peter Fuller at a seminar on injuries.[2] He was talking with them about their work with cadavers and motorcycle accidents and the potential to do similar research underwater.

The State University of New York (SUNY) at Buffalo has a large circular pool originally constructed for testing humans in special environments. The facility is known as the Center for Research and Education in Special Environments (CRESE).

The boating industry has since used the facilities for several studies.

If you are unfamiliar with the tank at SUNNY see our video[3] or read any of the studies performed there.

Data for the leg impact study, discussed in this volume, and the head impact study discussed in **Volume III** were both collected in December 1990.

Together, these two studies were intended to support the 1989 NBSAC subcommittee on propeller guards study as seen on the cover page of this volume.

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[1] For example: Alex Marconi (OMC corporate lawyer) letter to Dick Snyder (Mercury Marine propeller guard expert) regarding a Chicago Tribune story and a National Public Radio story on an incident in which a pelican (bird impact) caused the crash of a bomber. Marconi wrote of how this could bolster their position with a vivid example of kinetic energy and mass. Letter dated January 26, 1988.

[2] Richard Snyder deposition. Robert Leroy Ard vs. Brunswick Corporation. Circuit Court of Jackson County, Missouri, at Kansas City. Case No. CV95-23303. Volume 1. Pages 58-60.

[3] State University of New York (SUNY) CRESE pool video clipped from 1991 Mercury video.
12 second mp4 video.
http://www.propellersafety.com/wordpress/wp-content/uploads/SUNY-propeller-test.mp4

The Purpose of the Underwater Leg Impact Paper

The purpose of the leg impact research and the resulting papers was stated in the introduction of the preliminary version of Scott's head impact paper.

> *"In May of 1988 the U.S. Coast Guard requested the National Boating Safety Advisory Council (NBSAC) to assess the feasibility of using propeller guards to protect submerged individuals from spinning propellers on outboard motors. The NBSAC's report, presented on November 7, 1989, recommended that the Coast Guard take no regulatory action requiring guards on outboard motors. One of the arguments presented against the use of propeller guards was that the "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. This research project was undertaken to better define the potential for blunt injury trauma to the submerged head when struck by a propeller guard.""* (Page 20. Ref. 1)

> *"The concern that the use of propeller guards* ***may produce a different injury mechanism was based on theoretical analysis with no direct experimental evidence available to support it.*** *This research program was undertaken to investigate the potential for blunt injury in underwater impacts with cage type propeller guards. This research was sponsored by Mercury Marine and Outboard Marine Corporation (OMC)."*

While Scott was speaking about the head impact study, his comments also cross over to the leg impact study. The 1989 NBSAC study basically said you would be worse off if struck by a propeller guard than if you were stuck by a propeller, but no evidence was provided to support their finding.

Kress stated the intent of his leg impact research in the Abstract as:

> *"The intent of this research* (leg impact study) *was to describe and quantify the nature and extent of impact injuries on a swimmer's leg when struck by a particular cage-type propeller guard on a boat outboard motor."*

Kress' intent seemed to change two pages later in the Introduction where he says

> *"marine industry representatives (Mercury Marine Corporation and Outboard Marine Corporation) contracted with the research team to conduct similar tests in water to determine the effectiveness of a particular boat motor cage-type proper guard as a safety device to protect a swimmer's leg,"*

By the time Kress filed his doctoral dissertation, the intent of his leg impact research was:

> *"The intent of this research (leg impact research) was to describe and quantify the nature and extent of impact injuries inflicted on a swimmer's leg when struck by a particular cage-type propeller guard on a boat motor A specific objective was to determine a threshold velocity above which the injury would be considered to be sufficiently severe enough to result in loss of leg function."*[4]

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[4] Part 10. Biomechanical Effectiveness of a Safety Device: A Boat motor Cage-Type Propeller Guard. Impact Biomechanics of the Human Body. Tyler A. Kress Doctoral Dissertation. Page 180.

Different Versions of the Leg Study

Several different versions of the leg impact study were identified:

1. Evaluation of a Boat Motor Cage-Type Propeller Guard as a Protection Device for the Human Leg. Tyler A. Kress & John N. Snider. Both of the University of Tennessee. Jack F. Wasserman and Guy V. Tucker of Industrial Engineering Department of the University of Tennessee. Peter M. Fuller and David J. Porta of School of Medicine, University of Louisville, Louisville Kentucky. August 1991. 14 pages. This 8.5 X 11 inch document lists the Appendices in the Table of Contents, but they are not included. It has no bibliography.

2. Evaluation of a Boat Motor Cage-Type Propeller Guard as a Protection Device for the Human Leg. Tyler A. Kress & John N. Snider. Both of the University of Tennessee. Jack F. Wasserman and Guy V. Tucker of Industrial Engineering Department of the University of Tennessee. Peter M. Fuller and David J. Porta of School of Medicine, University of Louisville, Louisville Kentucky. August 1991. 25 pages. This copy is reduced in size, looks like it might have been scanned into a landscape format and only takes up the left half of the page. Includes Appendices A, D, and E. It has no bibliography.

3. Addendum to Evaluation of a Boat Motor Cage-Type Propeller Guard as a Protection Device for the Human Leg. Tyler A. Kress, John N. Snider, Peter M. Fuller, and David J. Porta. June 1992. 13 pages. The Table of Contents lists 3 Appendices that are not included with this copy. This version discusses the in-air tests and comments on “loss of leg function”.

4. An Underwater Impact Biomechanics Study to Evaluate a Boat Motor Cage-Type Propeller Guard as a Protective Device. Tyler A. Kress, David J. Porta, John M. Snider, and Peter M. Fuller. 9 page technical paper. 1996. This version appears to be the same as #5 delivered at the IRCOBI (International Research Council on the Biomechanics of Injury) Conference, it does not have page numbers, and is in a sans serif font. It includes a bibliography. About two pages of the body of the article discuss the propeller guard debate, along with other propeller guard studies, articles, and statistics that look like they were written by or with the assistance of Mercury and OMC.

5. An Underwater Impact Biomechanics Study to Evaluate a Boat Motor Cage-Type Propeller Guard as a Protective Device. Tyler A. Kress, David J. Porta, John M. Snider, and Peter M. Fuller. 9 page technical paper. Delivered at the 1996 IRCOBI Conference. This appears to be the same as version 4 and was sent to the U.S. Coast Guard attached to a public comment letter from Tyler Kress that was furnished as part of OMC’s public comment against a Coast Guard propeller guard proposal regarding rental boats.

6. An Underwater Impact Biomechanics Study to Evaluate a Boat Motor Cage-Type Propeller Guard as a Protective Device. Tyler A. Kress, David J. Porta, John M. Snider, and Peter M. Fuller. 8 page technical paper. This version resembles the version Kress eventually delivered at IRCOBI but has no page numbers, and is in a serif font, and only has 8 pages.

7. An Underwater Impact Biomechanics Study to Evaluate a Boat Motor Cage-Type Propeller Guard as a Protective Device. Tyler A. Kress, David J. Porta, John M. Snider, and Peter M. Fuller. 9 page technical paper. This version resembles the version Kress eventually delivered at IRCOBI but has page numbers, and is in a sans serif font.

Related Materials

7A. A portion of the 1996 International Research Council on the Biomechanics of Injury (IRCOBI) Proceedings program. 11-13 September 1996. Dublin Ireland.

8. Impact Biomechanics of the Human Body, Tyler A Kress. University of Tennessee, Knoxville. Doctoral Dissertation. Part 10. Biomechanical Effectiveness of a Safety Device: A Boat Motor Cage-Type Propeller Guard. Pages 178-338. 1996.

9. The Anatomy of Experimentally Traumatized Human Cadaver Lower Extremities. David James **Porta**. University of Louisville (Kentucky). Dissertation Approved August 1, 1996. Propeller Injuries. Pages 148-166.

10. **Fault Tree** Analysis for Assessing Propeller Guard Injury Prevention Effectiveness. Tyler A. Kress and Reid L. Kress. Proceedings of the IASTED International Conference. Biomechanics. June 30 - July 2, 2003. Rhodes Greece.

The last four items are #7A a portion of the IRCOBI program, #8 Kress's dissertation which includes some of his work at SUNY, #9 Porta's dissertation which includes some of his work at SUNY, and #10 a paper by Kress on Fault Tree analysis related to his work at SUNY.

Quotes From Version 1 of Kress' paper

Introduction on page 3

> *"Because of the experience and capability developed in this research program (studying pedestrian and cyclist legs when struck by an automobile), marine industry representatives (Mercury Marine and Outboard Marine Corporation) contracted with the research team to conduct similar tests in water to determine the effectiveness of a particular boat motor cage-type propeller guard as a safety device to protect a swimmers leg. Consensus has generally been that a cage guard provides effective protection for a boat velocity range of 0 to 5 mph, but such a consensus has not existed at higher velocities."*

Results on page 9:

> *"The expected vascular and neurological damage was not observed during post-test dissection of the legs. It is believed that this lack of effect was due to the "leather-like" condition of the soft tissue as a result of long-term storage and fixation. Unfortunately, most of the cadaver legs available for this study were all embalmed at various times ranging from about three to seven years ago; the tissue had changed to the point that soft tissue damage could only be inferred from the extent of bone damage."*

Discussion and Recommendations on Page 11.

The legs were cut / sectioned at mid thigh and joined to the same Hybrid III crash dummy previously discussed in the head impact study in **Volume III**. During the the leg tests, all of them pulled loose from the crash dummy.

> *"It is the judgement of these researchers that, for the loading conditions and **population studied** in this project, the prop-guarded cage was not effective in preventing extensive injury to the leg at boat velocities greater than or equal to 13.6 mph. Above this speed, the observed damage was so severe that complete loss of leg function would be expected."*

> *"A total of seven tests is **not enough to establish statistical significance** of these results, however the researcher's opinion is that these results would be reproducible in subsequent tests.*

Discussion and Recommendations on Page 12.

> *"It would be useful to conduct tests with legs that have "fresher" soft tissue. This would allow the researchers to confirm the inference that the soft tissue injury would result in loss of leg function as discussed in this report."*

> *"It would be desirable for future tests to utilize a cadaver population that is somewhat younger to relate better to real-life situations. The **average age at time of death for seven of the cadavers was approximately 75 years**."*

Discussion of Version 1 of Kress' leg impact paper

The introduction mentions Mercury and OMC "contracted with the research team", which they did. Just noting "contracted" sounds like Mercury and OMC had less direct involvement than they actually did. Similarly if the paper said Mercury and OMC had "sponsored and assisted" in the testing one might think they were more involved than if they "contracted" for the research.

The cadaver legs of individuals over 70 years of age had been embalmed for several years making them leather-like. Part of the researchers efforts were to determine when swimmers legs would suffer "loss of leg function".

Kress later defined "loss of leg function" on Page 8 of his Addendum as "that the injured individual would experience permanent disabling damage to the leg (injury could be variable, ranging from a chronic limp to amputation)."

The researchers said that for the **loading conditions** and **population studied** the guard was not effective in preventing extensive damage to the leg at or above 13.6 miles per hour.

Loading Conditions: the leg was strung across horizontally in front of the oncoming leading edge of the guard which is almost as sharp as the leading edge of the lower leg of the outboard motor. Test conditions are approaching that of taking a dull axe to the leg underwater.

Many propeller leg injuries come from people being in a vertical position behind the boat, from being in a longitudinal position (flowing at the propeller like a log parallel to the boat), or are pulled in from the ladder. See the 19 representative accidents in Thibault's 1987 letter to Bolden.[5]

Kress and his researchers put the leg in the most hazardous orientation possible for a guard like the one they were testing that comes to a wedge point at the front.

The even sharper leading edge of the drive would likely cut the leg off in a similar strike at speed, but researchers were forbidden to test with an open propeller for comparison per a SUNY planning meeting. See **Figure 1**.

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[5] Lawrence Thibault letter to Stephen Bolden regarding Thibault's study of propeller guarding, including an analysis of 19 propeller accidents. Is among materials assembled by the 1989 NBSAC study.

OMC OFFICE MEMO

DATE: October 8, 1990

TO: E. Rose

cc: Tyler Kress
Mike Scott
R. Snyder

FROM: D. F. Kueny

LOCATION: Marine Engineering

SUBJECT: Meeting Regarding Underwater Testing

<u>Purpose of Meeting</u>: To review protocol for underwater impact testing.

<u>Time and Place of Meeting</u>: 9:00 a.m., September 27, 1990, NMMA Business Room, McCormick Place.

<u>Persons Attending</u>: Richard Snyder, Mercury Marine
Mike Scott, Biodynamic Research Corporation
Tyler Kress, University of Tennessee
Don Kueny, OMC

<u>Summary</u>:

1. OMC will supply a Johnson commercial 100 hp. Mercury will furnish appropriate Snyder Guards.

2. No testing will be done without a Guard.

3. Testing will be done in 2 groups, head and limb.

4. Mercury will supply photography.

5. Mike Scott is to furnish a refined protocol and estimated costs by November 4, 1990.

<u>Commitments</u>: Don Kueny will purchase and ship the appropriate outboard pending shipping information from Mike Scott.

<u>Discussion</u>: Testing will be in two general groups, all with a Guard in place along with a propeller free to rotate. Propeller thrust will be simulated with spring force applied to the powerhead. Kueny is to provide gross thrust data.

Figure 1: SUNY Planning Meeting

Lets look at a quick list of problems with the leg study so far

1. Flesh of the cadavers was not soft, the researchers refer to it as “leather-like” from being embalmed so long.

2. Researchers say that for the **loading conditions** and **population** studied the guard was not effective at preventing extensive damage at or above 13.6 miles per hour.

   A. Loading conditions used by researchers are not commonly encountered. They put the leg in position to receive the worst possible damage.

   B. The population is 75 year old cadavers that have been embalmed for 3 to 7 years.

3. Researchers said “***it would be useful*** *to conduct these tests with legs that have “fresher” soft tissue”* BECAUSE that would allow them to confirm the supposition they made that soft tissue injury would result in loss leg function.

4. Researchers said, *“**Additional tests should use** entire cadavers instead of sectioned legs connected to Hybrid III dummy components.”* They say it would *“provide more realistic constraints during the impacts.”* What they are really saying is the impacts during this test were not realistic.

5. Researchers also said *“**It would be desirable** for future tests to utilize a cadaver population that is somewhat younger to relate better to real life situations.”* Average age of the cadavers was 75.

6. The researchers were prevented from running an open propeller or even just striking the cadaver leg with the leading edge of the drive with no propeller on it for comparison.

7. The researchers themselves said, *“A **total of seven tests is not enough to establish statistical significance** of these results …”.*

8. From loading conditions and the population, researchers proved: 75 year old cadaver legs, embalmed for 3 to 7 years, strung across the SUNY tank do not hold up well when struck by the leading edge of Snyder’s propeller guard being drug around by a rotating arm while the outboard propeller freewheels.

This list is continued in the last section of this report

Kress's Addendum adds a couple more issues

The authors recognized the relative sharpness of the leading edge of the drive vs. the leading edge of the propeller guard, and said:

> *"It may be of interest to discuss the relationship of injury to that of the geometry (or size) of the leading edge of the impactor (i.e. the edge of the cage vs. the edge of the strut, skeg, or propeller). For simplicity, the cage impacting surface will be referred to as "blunt" and the strut, skeg and propeller edges as "fine." The blunt leading edge has a larger impacting surface area than the fine leading edge. Injuries produced from a fine leading edge are usually associated with more localized damage, however as speed increases to around 13 mph and above (such as those of the six tests referred to in the main report) localized damage can be just as severe from a blunt impact and often worse (e.g. could be more difficult to surgically repair)."*

This not a good idea. The leading edge of the cage, the strut (I am guessing this what they are calling the leading edge of the drive), the skeg, and the propeller are all reasonably sharp when these edges are coming at a human in the water at speeds in excess of 10 miles per hour. The leading edge of Snyder's guard is not blunt. The researchers did no testing to prove the leading edge of the guard is "blunt." It is not a good idea to just assign "blunt" and "fine" edges to underwater surfaces without first testing them underwater.

In addition, some outboard motors have much sharper leading edges than others. Some outboard motors have leading edges less sharp than Snyder's guard.

Toyama's "*Drift-wood collision load on bow structure of high-speed vessels*"[6] published a decade later, addresses the leading edge of ships striking driftwood, crushing into the driftwood, and the dynamics of how the driftwood can slide down and off the leading edge or be pushed aside. The bow slopes back and down like the skeg of an outboard motor. The cross sectional profile of the leading edge of the ship has about a 4 inch radius at the leading edge vs. Snyder's guard having a 5/32 inch radius at the leading edge. The ship is still strong enough to crush into floating logs and even cut some in half. Sharpness is different underwater. Water resists movement of the object being struck. The object does not have to be as sharp to cut or crush something.

Continued

[6] Drift-wood collision load on bow structure of high-speed vessels. Yasumi Toyama. Marine Structures. Vol.22. (2009). Pgs. 24-41.

In the Kress' Addendum, on page 11 the authors said:

*"The injuries resulting from collisions with an outboard motor not equipped with a cage-type propeller guard have not been evaluated in this study, but it **is believed** that the resultant injuries would be of a different nature and less severe (I.e. local traumatic amputation is **perhaps** more likely with a strut or skeg which causes less hip damage and/or total bodily injury than the gripping action of the cage)."*

The quote above is interesting. The authors:

1. Think that having your leg chopped off by the leading edge of the drive is a good thing compared to being whacked by the leading edge of the guard.

2. Discuss the gripping action of this cage as if it represents all cages when it may not even represent this cage in all conditions. See **Gripping Discussion** section later.

3. Act like all cage-type guards have vertical blunt leading edges.

4. B**elieve** the outboard without a guard would cause less severe injuries and they would be of a different nature, but did not test an open propeller under power.

5. Did not test the drive without a guard, but they **believe** that if they had, injuries would have been less severe and of a different nature. Remember, the quote from Michael Scott, lead researcher of the propeller guard head impact tests going on at the same time as the head impact testing. Scott stated the purpose of the head and leg impact testing as:

   "In May of 1988 the U.S. Coast Guard requested the National Boating Safety Advisory Council (NBSAC) to assess the feasibility of using propeller guards to protect submerged individuals from spinning propellers on outboard motors. The NBSC's report, presented on November 7, 1989, recommended that the Coast Guard take no regulatory action requiring guards on outboard motors (Reference 1). One of the arguments presented against the use of propeller guards was that the "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" (Page 20. Ref. 1)

   *"The concern that the use of propeller guards **may produce a different injury mechanism was based on theoretical analysis with no direct experimental evidence available to support it.** This research program* (the head and leg impact study at SUNY) *was undertaken to investigate the potential for blunt injury in underwater impacts with cage type propeller guards. This research was sponsored by Mercury Marine and Outboard Marine Corporation (OMC)."*

   Scott told us that the 1989 NBSAC report told us there may be a different injury mechanism for propeller guards and that mechanism was based on theoretical analysis with no direct experimental evidence available to support it.
   The testing at SUNY was undertaken to gather that evidence.

   Now that head and leg propeller guard impact testing have been completed, we are told the authors believe injuries for those struck without a guard would be of a different nature and less severe, but they did not test without a guard. See Figure 2.

NBSAC final report

guards were rejected in the NBSAC study in part because ***"there may be a different injury mechanism [blunt trauma] for propeller guards and that mechanism was based on theoretical analysis with no direct experimental evidence available to support it."***

Quote by Michael Scott in Introduction of the Preliminary version of his paper.

SUNY technical papers

"The injuries resulting from collisions with an outboard motor not equipped with a cage-type propeller guard have not been evaluated in this study, but it is believed that the resultant injuries would be of a different nature and less severe."

Quote from Kress Addendum pg. 11

In a closer read of the SUNY statement by Kress, they offer examples such as local amputation (of the leg) by the leading edge of the drive or skeg as **perhaps** more likely without a guard. They see amputation as a good thing because amputation may result less damage to the hip. None of which has been proven.

Interestingly, they make no mention of damage that might result from the unguarded propeller.

Figure 2: Circular Logic of NBSAC and SUNY reports/testing

Corrupt Logic of NBSAC and SUNY Reports / testing

1. NBSAC failed to address multiple issues identified in USCG's 1987 propeller guard study by Purcell and Lincoln as needing to be addressed before a decision was made about propeller guards.

2. NBSAC failed to include propeller injury data and well as propeller fatality data. Purcell and Lincoln said injury data must be included because the only difference between a propeller injury and a propeller fatality is often probability.

3. NBSAC performed no impact testing of open propellers or of guarded propellers before recommending, "The U.S. Coast Guard should take no regulatory action to require propeller guards."

4. Per Michael Scott, NBSAC rejected use of propeller guards in part based upon a possible different injury mechanism (blunt trauma) that was purely based on theoretical analysis with no experimental evidence to support it. This different injury mechanism was thought to be more severe than open propeller strikes at speeds in excess of 10 mph. Thus the head and leg propeller guard impact tests were undertaken.

5. Kress performed no underwater leg impacts without a propeller guard.

6. No head or leg underwater impacts were performed with a propeller under power.

7. Researchers placed considerable weight of the findings behind the "gripping action" of the guard. See **Gripping Discussion**.

8. Once the head and leg impact testing was complete, the researchers said, we have not tested it but we believe the injuries without a guard would be of a different nature and less severe than if you were struck by a propeller guard.

   Turning their statement around, being struck by a propeller guard at over 10 mph may have injuries of a different mechanism than being struck by an unguarded propeller, but we did not test an open propeller rotating under power, so we do not know that for sure.

After the NBSAC study, when this journey started, the decision, "The U.S. Coast Guard should take no regulatory action to require propeller guards." was based in part on a purely theoretical, untested analysis about a different, more serious injury mechanism at speeds in excess of 10 mph.

After the SUNY project which Mercury said was completed at a cost of about $300,000,[7] being struck by a propeller guard at over 10 mph may have injuries of a different mechanism than being struck by an unguarded drive. However, unguarded drives have not been impact tested, so they do not know for sure.

One more example of the boating industry's need for "independent" studies / reports against boat propeller guards, Dick Snyder was asked in the ARD case in 2005, *"How many lawsuits are now pending against Brunswick, to your knowledge, involving propeller guard allegations?"*

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[7] Richard H. Snyder deposition in Robert Leroy Ard vs, Brunswick Corporation. Case No. CV95-23303. Circuit Court of Jackson County, Missouri at Kansas City. Volume 1. Pages 58-59.

Snyder responded, *"I don't know with certainty, but I think it could be somewhere in the 20 area, 20 or a little more. "*[8]

[8] Richard H. Snyder deposition in Robert Leroy Ard vs, Brunswick Corporation. Case No. CV95-23303. Circuit Court of Jackson County, Missouri at Kansas City. Volume 1. Page 125.

Gripping Discussion

Researchers found when impacting these particular cadaver legs at speed, they bent around "wrapped around" the leading edge of the propeller guard.

Researchers referred to this as "gripping action" in that the leg was pretty much held captive on the leading edge of the guard. It did not slide off one side or the other, or slide down and off the guard.

Figure 3: SUNY Leg Impact @ 13.6 mph

Figure 3 shows a leg impact at SUNY at 13.6 miles per hour. The image was taken from the bottom of the pool, looking upwards. The yellow/green object of the front of the guard is the leg which has already ripped free of the Hybrid III crash dummy.

The foot on the leg is partially obscured by the black rectangle consisting of video controls.

The leg is severely bent around / “wrapped around” the leading edge of the propeller guard. This represents what the authors refer to as “gripping”

We have no reference as to what a normal leg would look like in **Figure 3** as these legs came from cadavers with an average age of 75 years that had been embalmed for several years.

If the leg were still attached to a human, the human’s body **might** pull it over the front edge of the guard as the outboard passes.

In **Figure 3**, the leading edge of the propeller guard is vertical above where the skeg begins to bend back and down. In the image the drive has been trimmed into a vertical position.

The next four pages are copied from the Head study in **Volume III** with minimal changes to explain “trim” and how the authors tried to use the trim system to simulate propeller thrust. Then we explain how the researchers efforts to simulate propeller thrust made the leading edge of the propeller guard more dangerous.

The Gripping Discussion is picked up again after the next four pages.

Outboard Trim and Tilt

Trim, angle of the outboard, is changed to control attitude of the boat (nose / bow high or nose / bow low plowing though the water). As the boat goes up on on plane (skimming on top of the water) the outboard is normally trimmed out (back and up). This raises the bow, reducing drag.

When the boat is trailered, they are normally tilted up to prevent the propeller or lower end of the drive from impacting something and being damaged. **Figure 4**: Outboard Motor Trim and Tilt was developed from a Yamaha image.

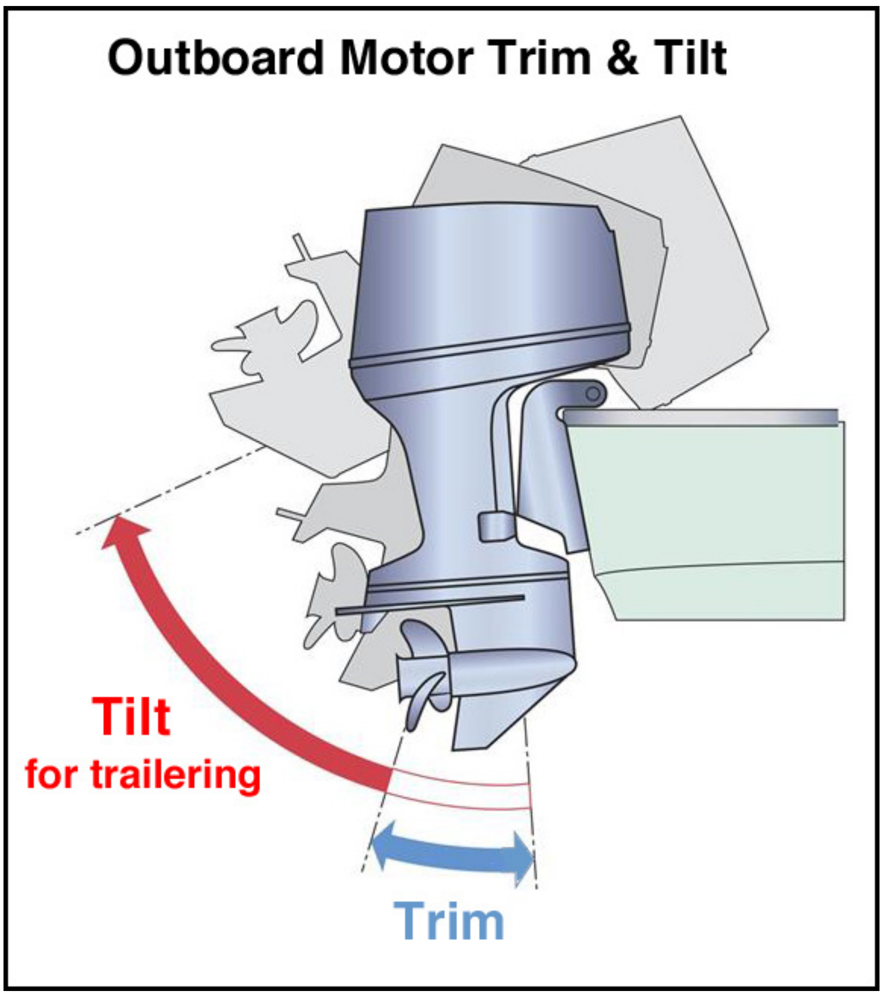

Figure 4: Outboard Motor Trim and Tilt
developed from a Yamaha image

Simulating Propeller Thrust

OMC said propeller thrust for this 115 horsepower outboard motor is about 200 to 320 pounds at the prop shaft.

Tests at SUNY were performed with a large arm swinging the outboard around the circular tank with the outboard motor engine off and the propeller freewheeling (in neutral). The process results in zero propeller thrust which would normally be pushing the drive forward.

If a propeller guard on an outboard motor mounted on a boat in a lake runs into a crash dummy head, the outboard has both kinetic energy due to its mass and speed plus the thrust force of the propeller.

Early plans called for using a spring to simulate propeller force. Basically the outboard would be sprung into the trimmed down position from the structure mounting it above the track (large donut shaped water tank). Instead Don Kueny, OMC Engineering, sent Mike Scott a letter[9] describing a technique in which they could use the trim system to simulate propeller thrust.

Log Strike System

Outboard motors strike floating and submerged debris including logs, rocks, and about anything imaginable in the water. This particular outboard uses a system of relief valves and check valves to allow the outboard motor to tilt up when it strikes something, then slowly back down after it clears the object. For a detailed explanation of a modern version of the process see our “Why Outboards Used in Bass Tournaments Disproportionately Break Off & Flip into Boats Compared to Other Outboard Motors”.[10] Or see actual documents for this outboard’s trim system.[11]

Thrust Rod

A series of holes is provided in the outboard motor mounting structure to receive a thrust rod. This rod extends across in front of the upper end of the leading edge of the outboard, limiting how far down the outboard motor can be trimmed.

Kueny’s Plan

Kueny’s Plan is to set the thrust rod to where the outboard motor can only trim down til the leading edge of the outboard motor is vertical with respect to the ground. He calls for using the electric pump to tilt the outboard down to the pin, then try to push it down further with the hydraulic system which builds up about 800 psi in the rod end of the tilt cylinder. See **Figure 5** and **Figure 6**.

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[9] Don Kueny, of OMC, letter to Mike Scott, of Biodynamic Research Corp. regarding simulating propeller thrust with the trim system. October 16, 1990. 2 Pages. This letter became the last two pages of Scott’s Preliminary Report.

[10] Why Outboards Used in Bass Tournaments Disproportionately Break Off & Flip into Boats Compared to Other Outboard Motors. Gary Polson. PropellerSafety.com. Pages 57-60. http://www.propellersafety.com/wordpress/wp-content/uploads/bass-outboard-flip-paper.pdf

[11] Johnson Outboard Service Manual. 1973-1991. 60-235 horsepower. 2-stroke. SM-04030. Chapter 9. Trim/Tilt. Striking an Underwater Object. Pages 9-6 and 9-8.

OMC

OUTBOARD MARINE CORPORATION

MARINE
300 Sea
Wau
Phone

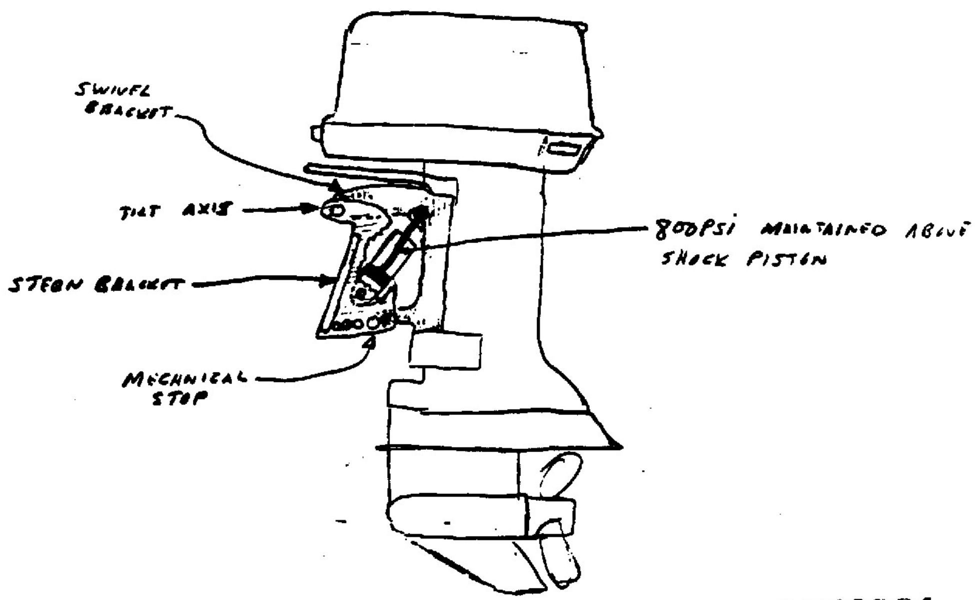
October 16, 1990

Mr. Mike Scott
Biodynamic Research Corp.
9901 IH 10 W
Suite 1000
San Antonio, TX 78229

Dear Mike:

We have discussed further within Engineering how to simulate propeller thrust without interference with normal shock absorber controlled tilting on impact. We have identified what we believe is a simple solution to the problem using the outboard's own power tilt system.

This system, in its "down" mode, loads the outboard in the same direction as prop thrust. When run in the "down" mode to the mechanical stop, the valving maintains 800 psi in the system after the electric motor is turned off. Against the piston of 2 square inches, this provides 1600 pounds of force. Calculated through the appropriate moment arms, this equals about 250 pounds at the propshaft, very close to the 198-321 pound range of estimated thrusts. See sketch.



0020801

Figure 5: Kueny Propeller Thrust Letter page 1

Mr. Mike Scott
October 16, 1990
Page 2

Please have Dr. Labra include this 250 pound force in his simulation.

If necessary, we could use an external pressure source rather than the outboard's own pump to supply pressure to the shock absorber. This would allow us to exactly duplicate prop thrust but would require the controlled external pressure source plus plumbing it to the outboard. It would also require some extra setup and monitoring on site, while the above force can be obtained quite easily.

To obtain this force requires that the adjustable thrust rod be set so that the motor is vertical and the trim motor (12 volt) be run "down" until the system bottoms. This is quite audible.

Sincerely,

D. F. Kueny
Chief Engineer - Advanced Outboards

DFK/rk101690

cc: E. Rose
R. Snyder

002080

Figure 6: Kueny Propeller Thrust Letter Page 2

Gripping Discussion Continued

After viewing the last four pages, you can see how trimming the motor out as the boat approaches being on plane would change the vertical angle of the leading edge of the propeller guard. The upper part of the leading edge could be pitched forward, providing an angled edge the leg could slide down and off the guard.

A lower leg striking in the region of #23 in **Figure 7** below would only have to slide down a minimal amount to be in the area the skeg begins to sweep to the rear. Once they slid down to the skeg region, you can envision them sliding down/being pushed down and off the guard.

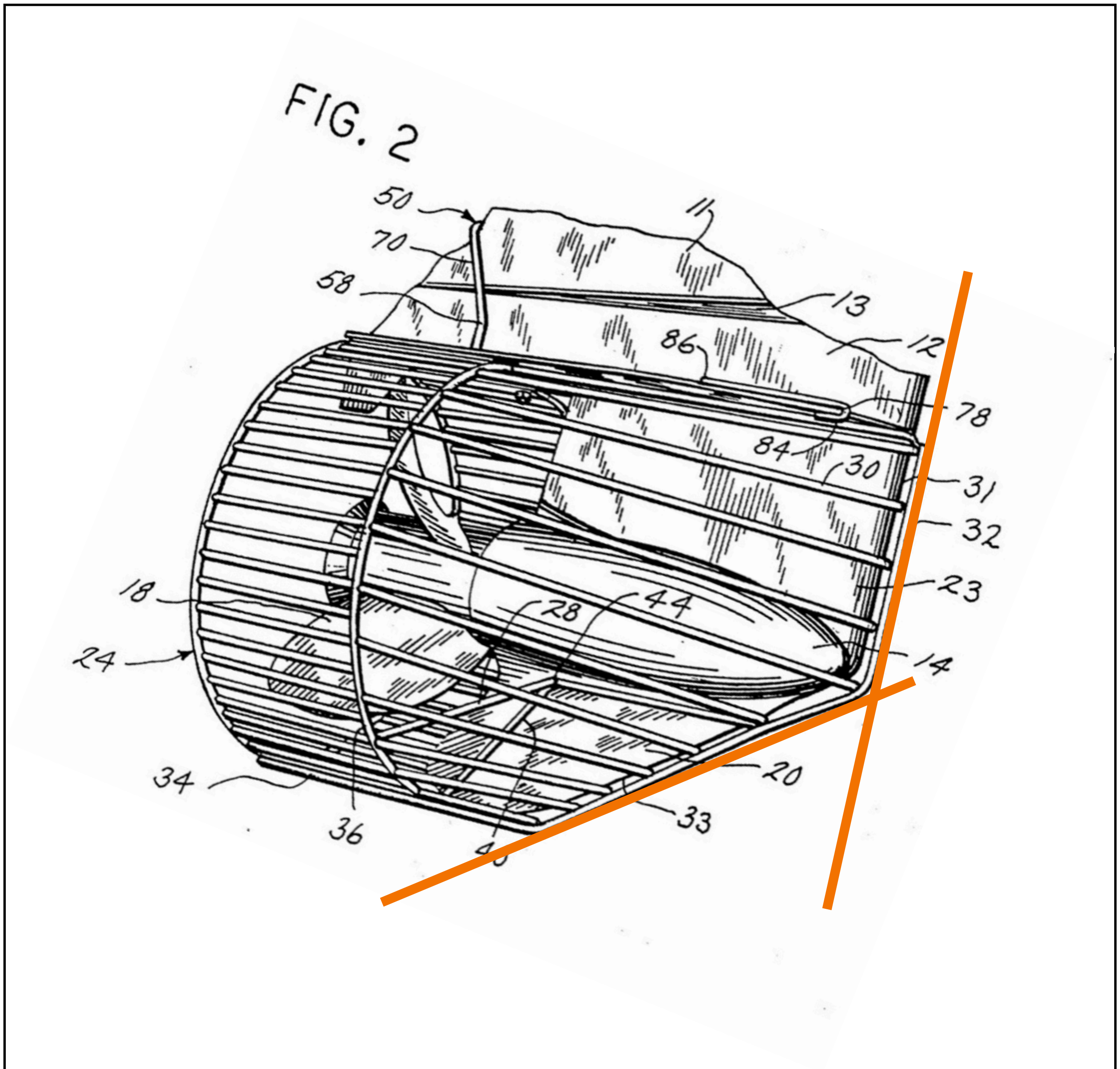


Figure 7: outboard trimmed up some

Bluntness and Sharpness Underwater

In forensic analysis there are ranges of bluntness and ranges of sharpness. Sometimes in the middle of the range between blunt and sharp, they see impacts called “chops”. Somewhat like you struck somebody with a dull axe.

We suggest the range of sharpness is extended underwater. Water resists movement of human bodies plus submerged humans have added mass as discussed in earlier volumes. Less sharp objects can still cause wounds normally attributed to sharp objects. The resistance to movement of humans in the water makes it easier to cut them with objects that might not cut them at the same impact speed in open air.

Thus the leading edge of Snyder’s propeller guard might be considered sharp underwater, but blunt when in the open air.

Snyder’s guard has a 5/16 inch diameter wire running vertically down the front leading edge of the guard. You can see it next to the orange lines in **Figure 7**.

Dick Snyder was among the authors of a study of manatee wounds[12] in 2006. While manatees have tougher skin than humans, they are still cut by some elements of boats and marine drives while suffering blunt trauma injuries from impacting other elements of boats. The paragraph below is copied from that publication.

> ***Characteristics of Watercraft-Related Trauma***
>
> “*Watercraft can inflict both sharp- and blunt-force trauma. Sharp-force trauma involves injuries from sharp skegs, fins, and propeller blades. Blunt force trauma involves injuries from hulls, keels, blunt skegs, and propellers, boat strakes, anti-ventilation plates, trim tabs, propeller shafts, struts, rudders, propulsion system torpedos, or speedometer pickups. In part because the dermis (manatee hide) is so tough, slightly more than half of the lethal trauma inflicted on manatees by watercraft is blunt-force trauma*.”
> Figure 2 from this reference is reproduced as **Figure 8** on the next page.

[12] Forensic Methods for Characterizing Watercraft-Induced Wounds From the Florida Manatee (Trichechus Manatus Latirostris. Rommel, Costidis, Pitchford, Lightsey, Snyder, and Haubold. Marine Mammal Science. Vol.23. No.1. (January 2007) by the Society for Marine Mammalogy. Pages 110-132. See Pages 111 & 113.

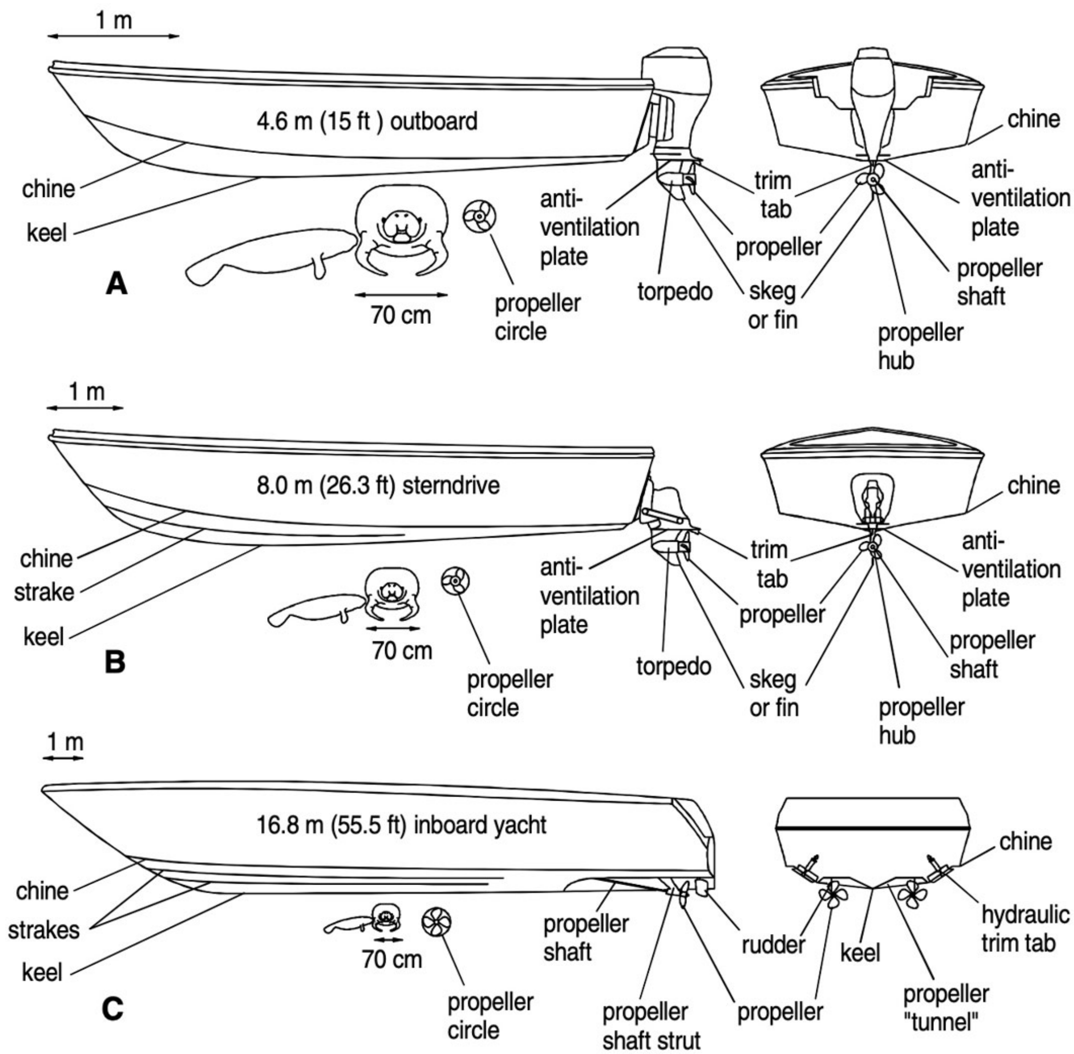


Figure 2. Watercraft hulls, propulsion units, and structures extending from them that can inflict wounds on manatees. A, B, and C watercraft with lengths of 4.6 m (15 ft), 8 m (26.3 ft), and 16.8 m (55.5 ft), respectively. An adult manatee (70 cm [27.6 in.] in diameter) with a nursing calf (130 cm [51.2 in.] in length) are illustrated in each drawing to provide scale for each of the watercraft and propellers shown.

Figure 8: Manatee impact study cited on previous page

Dick Snyder was among the authors

Sharp Trauma

The concept of Sharp Trauma is discussed in another paper on large marine mammals.[13]

> *"Watercraft collisions can take the form of blunt-force impacts involving contact between the animal and some non-rotational feature of the vessel (e.g. hull, rudder, skeg), sharp-force injuries such as incising and/or chopping wounds typically created by the sharp, rotating propeller of the vessel, or a combination of the 2 types of injuries."*

> *"Additionally, a less distinct category is occasionally observed in which a relatively sharp but non-rotating feature of a vessel (e.g. skeg or rudder) has enough speed and sharpness to penetrate the skin, causing a combination of blunt and sharp-force injuries likely best defined as a chop wound. Sharp-trauma injuries to cetaceans and pinnipeds range from mild nonfatal superficial nicks to severe amputations and other lethal wounds."*

Note the description of chop type wounds above.

We can envision an unguarded leading edge of an outboard motor involved in a test like was performed at SUNY with real legs and real people resulting in chop wounds at some speed.

Similarly, we can envision the leading edge of Snyder's propeller guard involved in a test like was performed at SUNY with real legs and real people resulting in chop wounds at some speed.

Thus we consider the leading edge of Snyder's propeller guard to be in a range of sharpness within which the leading edge of this outboard or of some other outboard motors are contained.

---

[13] Theme Section: Criteria and case definitions for serious injury and death of pinnipeds and cetaceans caused by anthropogenic trauma. M.J. Moore, Hoop, Barco, Costidis, Gulland, Jepson, K.T. Moore, Raverty, and McLellan. Diseases of Aquatic Organisms. Vol,103: 229-264. 2013. See Page 251.

Where Did Mention of Mercury and OMC Go? & Why

As cited earlier, Page 3 of the Version 1 of the report stated:

> *"Because of the experience and capability developed in this research program (studying pedestrian and cyclist legs when struck by an automobile), marine industry representatives (**Mercury Marine and Outboard Marine Corporation**) contracted with the research team to conduct similar tests in water to determine the effectiveness of a particular boat motor cage-type propeller guard as a safety device to protect a swimmers leg."*

Version 2. - Mercury and OMC are similarly mentioned.

Version 3 The Addendum. - no mention of Mercury or OMC which might be expected since it is an Addendum.

Version 4 first version prepared for publication - no mention of Mercury or OMC

Version 5 attached to a public comment letter - no mention of Mercury or OMC, but the Kress' public comments appears to be filed in conjunction with OMC's public comment letter.

Version 6 serif font - no mention of Mercury or OMC

Version 7 - no mention of Mercury or OMC

Version 8 Kress doctoral dissertation - up front on page iii Kress expresses appreciation to various sponsors of his research and lists three of them: Mercury Marine Corporation, Outboard Marine Corporation, and the Japan Automobile Manufacturers Association.

Within the portion of the body of his thesis covering SUNY testing (page 178 -338) I see no mention of Mercury Marine or OMC.

Version 9 Porta's dissertation - similar to Kress up front he thanks the same three players: Mercury Marine Corporation, Outboard Marine Corporation, and the Japan Automobile Manufacturers Association. Chapter 5 "Testing of Embalmed Intact Specimens" covers the SUNY Testing. On page 148 Porta describes it as part of a pilot study funded in 1990 by Outboard Marine and Mercury Marine Corporations.

Version 10 Kress's fault tree analysis paper - his work at SUNY is cited, but no mention of Mercury Marine or OMC

We assume Kress gradually wrote Mercury and OMC out of the picture at their request to make the article look more independent and not to look like it was paid for by Mercury and OMC. Actually, OMC's law firm Bowman and Brooke received the $72,459 bill from University of Tennessee of which they forwarded half to OMC and half to Mercury.

See our four page SUNY invoice #17 of which the first page is shown in **Figure 9**.

THE UNIVERSITY OF TENNESSEE

November 12, 1991

Controller's Office
201 Andy Holt Tower
Knoxville, TN 37996-0100
(615) 974-2493
Fax No. (615) 974-2701

Marcia Kull
Bowman & Brook
Suite 600
Midwest Plaza West
801 Nicollet Mall
Minneapolis, Minnesota 55402

RE: Underwater Impact Testing Research

Dear Ms. Kull:

Apparently, Marine Industry representatives contracted with John Snider and Tyler Kress through the Industrial Engineering Department at the University of Tennessee to perform research as outlined in the enclosed proposal titled "The Effects of a Cage-type Prop Guard as a Protective Device for the Human Leg".

It is our understanding that the work was completed and the final report was delivered in August of this year. Thus, we have enclosed a fixed-price invoice for the contract amount as budgeted in the enclosed proposal.

If you have any questions or if this invoice should be directed to someone else's attention, please contact Tonya Cromwell at (615) 974-2493 or Tyler Kress at (615) 974-3333. If not, please remit payment of $72,459.00 to:

OHC at 1/2:

University of Tennessee
Bursar's Office
210 Student Services Bldg.
Knoxville, TN 37996-0100

Sincerely,

James R. Maples

James R. Maples
Controller

JRM:vjm

OMC/PIF trustee .1790

Enclosure

NOV 15 1991

Tennessee's State University and Land-Grant Institution . . . established 1794

Figure 9: University of Tennessee bill to lawyers for Kress study

Did Mercury & OMC Write the Literature Review?

Kress' 1996 IRCOBI presentation (our version 7 of his paper) includes a literature review of documents surrounding the propeller guard debate, statistics of those struck, and medical articles on the 2nd and 3rd pages of his article (pages #354-355).
Articles mentioned in the literature review include:

1. A special subcommittee of the United States Coast Guard National Boating Safety Advisory Council was appointed to investigate the propeller guard issue.

2. 50 page document authored by Baker in 1992 from Jon S. Vernik and Associates.

3. John Hopkins University Injury Prevention Center and Institute for Injury Reduction addressed many of these issues in a report that collected and summarized existing studies.

4. U.S. Coast Guard Boating Statistics Data over the past 20 years (we will address this data later in this volume).

5. Sleight 1974 medial article.

6. Mann 1980 medical article.

7. Kutarski 1989 article / literature review.

8. Gayle 1991 medical article.

9. Gomez 1991 medical article.

10. Gomez mentioned a 1978 DOT USCG report titled "Struck by Boat or Propeller".[14]

11. An unnamed 1987 USCG report saying no further research should be funded until the new data are analyzed and the problem is properly defined.[15]

12. Hartgarten 1994 article on propeller injuries in the State of Wisconsin[16]

The dozen references above, along with a few comments against articles not agreeing with the boat industry's position, and praise heaped on Snyder's guard[17] appear to have been collected by the boating industry to assist the authors.

---

[14] the authors are talking about the Freund report noticeably missing from the NBSAC report and its documents.

[15] the authors are talking about the "Boat and Propeller Impact Injuries and Fatalities" Project 763584.20 Final Report. 1 March 1987. Edward S. Purcell and Walter B. Lincoln. U.S. Coast Guard Development Center. Groton, Connecticut.

[16] the authors noted Hartgarten remarked manufacturers are reluctant to study guards. "This is interesting because a couple of US outboard motor manufacturers have been the primary organizations involved in a significant amount of the research and development that has been completed with regard to the design and feasibility of propeller guards." The authors failed to note they sent the bill for their SUNY testing to the law firm that hired them to do this research.

[17] "A specific cage-type guard was used for this study, and it has been reported to be one of the "safest" modern-day designs of the many that have been developed." quote on page 354.

The same goes for Kress' 2003 Fault Tree paper.[18] It includes about a one page literature review similar to the SUNY paper's content on the previous page.

The same goes for David J. Porta's 1996 Doctoral Dissertation in which about 2 and a half pages have very similar content.[19]

David Porta refers to the leg impact testing at SUNY as a **pilot study**.

> *"The authors first experience with testing intact cadaveric specimens occurred as part of a* ***pilot study*** *funded in 1990 by Outboard Marine and Mercury Marine Corporations."*
> on page 148 of his dissertation.

Tyler Kress' 1996 dissertation at University of Tennessee did not review the propeller guard literature like his previous works did.

We strongly suspect the boating industry supplied reference materials and assisted the authors in writing the literature reviews of propeller guarding. We are just pointing out the boating industry had their hand in writing the papers.

---

[18] Fault Tree Analysis for Assessing Propeller Guard Injury Prevention Effectiveness. Tyler A Kress and Reid L. Kress. Proceedings of the IASTED International Conference. Biomechanics June 30-July 2, 2003, Rhodes, Greece. 5 pages.

[19] Chapter V. Testing of Embalmed Intact Specimens. The Anatomy of Experimentally Traumatized Human Cadaver Lower Extremities. David J. Porta. Doctoral Dissertation. University of Louisville (Kentucky), Pgs. 148-150.

Boating Industry is Still Publishing Event 1 Accident Data

We wrote extensively in **Volume II**, the 1989 NBSAC report volume, about how the Coast Guard records boating accidents as a series of up to three events. For example (Event 1) Collision with Floating Object, (Event 2) Falls Overboard, and (Event 3) "Struck by boat or propeller".

In the era of these studies, the Coast Guard only published Event 1, sometimes called "first event" data in their annual published Boating Statistics report. For full statistics you had to access the BARD database or one of the occasional special reports by USCG.

Dick Snyder used the confusion as an opportunity to mislead the NBSAC propeller guard subcommittee into thinking propeller accidents were extremely rare and recommend USCG take no regulatory action to propose propeller guards.

Earlier we pointed out numerous examples in earlier volumes of the boating industry quoting Event 1 data as representing the total number of propeller injuries and fatalities.

Scott, Kress and Porta followed along and reprinted Event 1 statistics just like the others.

Tyler Kress Version 7 presented at IRCOBI

Tyler Kress presented the IRCOBI paper in 1996.

His second page, Page #354, states:

> ***"The US Coast Guard Boating Statistics Data over the past 20 years shows only about 100 people per year are killed or injured from boat or propeller strikes."***

He is referring to the Coast Guard's annual Boating Statistics report which only provides Event 1 data for "struck by boat or propeller". Just like Dick Snyder did before, the industry continues to mislead everyone they can as to propeller injury statistics.

Kress also quotes Mann quoting earlier propeller strike statistics at the bottom of the same page:

> ***"He (Mann) reported that there were 1,761 injuries from 6,529 reported boating accidents in the United States in 1978. Ninety-two were caused by propellers."***

Mann quoted Event 1 statistics and did not even get them right. His overall injury count (1,761) left out over a thousand fatalities. His propeller stats left out Event 1 fatalities.
See **Figure 10.**

Note - we are not accusing Scott, Kress, or the other authors of deliberately trying to mislead readers about the frequency of boat propeller accidents. As mentioned earlier, OMC and Mercury likely aided in writing this section of the report, and if not, they reviewed Kress' paper multiple times before publication as seen in the SUNY invoices.

We do not have access to the annual BARD databases from the early years that include all three events. Therefore we are going to gather some of the statistics we do have access to in order to prove Kress was quoting Event 1 statistics when he said only about a hundred people per year are killed or injured by propeller strikes.

When Kress wrote the paper the most recent statistics available were likely USCG's 1994 Boating Statistics publication.

The **table below summarizes Event 1 data** from the Five Year Summary of Boating Accidents on pages 22 and 23 of that publication.[20]

Year	Fatalities	Injured	Total
1990	7	180	187
1991	9	191	200
1992	8	111	119
1993	10	173	183
1994	13	126	139
Average	**9.4**	**156.2**	**165.6**

The table aboveooooo is **just EVENT 1 data**. Total "struck boat or propeller" data for all three events for both fatalities AND injuries would be a much larger number.

Kress is likely following Dick Snyder's incorrect and unproven process of reducing propeller strikes (165 average) by 1/3 to about 100 due to 1/3 of them being struck by the boat per Dick Snyder.

For example, in 1993, USCG started listing fatalities by event on page 20 of their annual Boating Statistics. The table below summarizes All 3 Event fatality data for 1993 and 1994.

With only two years of data the average is essentially 50 propeller fatalities per year. The average number of Injuries will be several times the number of fatalities.

Year	Event 1 Fatalities	Event 2 Fatalities	Event 3 Fatalities	Total Fatalities
1993	10	28	7	45
1994	13	32	9	54
Average				**49.5**

[20] Five Year Summary of Boating Accidents. Boating Statistics 1994. U.S. Department of Transportation. United States Coast Guard. September 1995. COMDTPUB P16754.8. Pages 22-23.

Don Kerlin of USCG provided a report of 1983-1987 BARD “struck by boat or propeller” data during the NBSAC study.[21] The data was provided in raw BARD format for individual accidents which would have been challenging for most of them to interpret.

Year	All 3 Event Fatalities	All 3 Event Injuries	All 3 Event Fatalities + Injuries
1983	43	206	249
1984	40	163	203
1985	57	213	270
1986	59	265	324
1987	47	286	333
Average	49.2	226.6	**275.8**

Total of All 3 Events data for fatalities PLUS injuries was approaching and sometimes surpassing 300 in the mid 1980s. Under reporting was still bad in the mid 1990s, but was better than in the mid 1980s.

Pulling our 3 statistics together for “struck by boat or propeller”

1. 1990-1994 **Event 1 Fatalities + Event 1 Injuries** = average of a total of 165.6 Event 1 “struck by boat or propeller” accidents per year
   per annual USCG Boatings Statistics publications

2. 1993-1994 **All 3 Event fatalities** = average = 49.5 reported “struck by boat or propeller” fatalities per year
   per annual USCG Boatings Statistics publications

3. 1983-1987 **All Event fatalities PLUS All Event injuries** = average of 275.8 reported “struck by boat or propeller” injuries and fatalities per year
   per Don Kerlin’s raw BARD data.

As shown earlier, it is likely Mercury and OMC assisted the authors in writing this section of Kress’ report. In addition Kress’ report was reviewed by their legal team multiple times. See **Volume III Appendix SUNY Invoices**.

The boating industry was once again using their Technique of Controlling Outcome by Controlling Accident Data.

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[21] Don Kerlin Summary 1983-1987 “struck by boat or propeller” manual analytics. 1304 cases. 9/22/88.

A similar line about their being less than 100 propeller strikes a year is in **Kress' 2003 Fault Tree paper**[22] we list as **version 9** of his paper. This paper was published about 7 years after the Kess' IRCOBI presentation of the leg impact paper and he still publishes Event 1 statistics.

> ***"The United States Coast Guard Boating Statistics data over the past 20 years shows that only about 100 people per year are injured or killed for boat or propeller strikes."***

And once again, Kress sent USCG a public comment letter 29 August 1996 strongly calling for no action toward requiring propeller guards on rental boats that travel in excess of 10 mph. He attached a non page numbered version of his SUNY leg impact paper which includes the quote below from **Version 5** of his paper.

> ***"The US Coast Guard Boating Statistics Data over the past 20 years show only about 100 people per year are injured or killed from boat or propeller strikes."***

Then along comes David Porta's dissertation.[23] The only direct reference to USCG data we noticed was an old one using Event 1 statistics, But even they are wrong. See **Figure 10**.

> ***"In 1978 there were 1,761 injuries reported to the U.S. Coast Guard from boating accidents. Propellers were recorded as the primary cause of injury in 92 cases."***

Near the bottom of the same page, speaking about the leg impact testing at SUNY, Porta states:

> ***"In this study, the groundwork was laid for the investigation of the efficacy of the propeller guard. The details of this pilot study are noted on the following pages."***

We agree the researchers did great things by being the first to tread multiple paths regarding instrumented cadaver underwater propeller guard impacts. They laid a lot of groundwork for others to build upon.

However, when the boating industry talks about SUNY testing in court, groundwork and pilot study are two phrases that never come up. They treat the December 1990 SUNY studies as final authority on the use of all propeller guards.

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[22] Fault Tree Analysis for Assessing Propeller Guard Injury Prevention Effectiveness. Tyler A Kress and Reid L. Kress. Proceedings of the IASTED International Conference. Biomechanics June 30-July 2, 2003, Rhodes, Greece. Page 1 (numbered as Page 387-022).

[23] Chapter V. Testing of Embalmed Intact Specimens. The Anatomy of Experimentally Traumatized Human Cadaver Lower Extremities. David J. Porta. Doctoral Dissertation. University of Louisville (Kentucky), Page 149.

1978 Event 1 Statistics

Both Kress and Porta quoted 1978 propeller accident statistics. Kress says he is quoting them from Mann. Porta is nebulous about where they came from.

Both say:

> ***"In 1978 there were 1,761 injuries reported to the U.S. Coast Guard from boating accidents. Propellers were recorded as the primary cause of injury in 92 cases."***

Figure 10 comes from U.S. Coast Guard's 1978 Boating Statistics publication.

TYPES OF CASUALTY	FATALITIES					INJURIES				
	1974	1975	1976	1977	1978	1974	1975	1976	1977	1978
Grounding	14	13	13	8	9	37	104	70	65	65
Capsizing	602	609	510	490	469	79	155	105	128	99
Flooding	38	86	107	94	93	14	32	36	25	24
Sinking	80	59	38	29	25	26	20	29	13	7
Fire or Explosion of Fuel	12	12	21	21	6	96	239	167	138	133
Other Fire or Explosion	5	0	1	3	2	7	22	13	14	5
Collision with Another Vessel	53	66	66	71	69	272	673	538	571	525
Collision with Fixed Object	73	79	63	80	105	165	297	239	242	251
Striking Floating Object	17	13	22	26	13	32	57	55	64	63
Falls Overboard	330	317	267	307	359	43	108	118	120	121
Falls Within Boat	10	4	3	3	7	26	42	47	32	44
Struck by Boat or Propeller	21	14	12	5	16	73	110	112	107	95
Other Casualty; Unknown	191	194	141	175	148	123	277	309	260	329
TOTAL	1,446	1,466	1,264	1,312	1,321	993	2,136	1,838	1,779	1,761

Figure 10: Boating Accident Statistics
from USGC 1978 Boating Statistics publication. Bottom Chart on Page 13.

Mann or whomever cited their being 1,761 reported injuries missed the boat on that too.
1,761 injured + 1,321 fatalities = 3,082 injuries and fatalities.

Mann says Propellers were recorded as the primary cause of injury in 92 cases. They are not recorded as the primary cause, they are recorded as the 1st event in 95 "struck by boat or propeller" injuries and as the first event in 16 "struck by boat or propeller" fatalities for a total of 111 first event strikes by "boat or propeller". This is only a portion of the total number of individuals killed or injured by "struck by boat or propeller" accidents that were reported in the 1978 Coast Guard database. The table does not include Event 2 and Event 3 injuries and fatalities. It also does not include non reported accidents of accidents not meeting the criteria to be listed.

Freund of USCG analyzed individual accidents in 1978 USCG "struck by boat or propeller" data[24] and found:

> *"there were 52 fatalities and 171 injuries in 1978 that were caused wholly or in part by the propeller of the boat."*

As to the data in **Figure 10**, in the late 1970s few non-fatal accidents were being reported. For example the ratio of reported injuries to reported fatalities is about 1.33

1,761 injuries /1,321 fatalities = 1.33 injuries were reported per reported fatality

The ratio of reported injuries to reported fatalities in 2020 was 4.16

3,191 injuries / 767 fatalities = 4.16 injuries were reported per reported fatality

Comparing the ratios 4.16/1.33 = 3.1

Over 3 times as many injuries per fatality were reported in 2020 as were reported in 1978.

171 reported injuries in 1978 X 3.1 = 530 injuries if the 2020 ratio of reported injuries to reported fatalities applied to 1978. That is still not considering under reporting in 2020.

---

[24] "Struck by Propeller" Accidents 1978". by Kenneth F. Freund. U.S. Coast Guard.

Updates to the Quick List of Problems With the Study So Far

This list picks up from where the list of problems with the study on **page 12** left off.

From Kress's Addendum

1. Kress' addendum refers to the leading edge of the propeller guard as blunt. At a maximum it is 5/16 inches wide, the diameter of the wire from which it is made. It is not like getting hit by a baseball bat.

2. The authors suggest having your leg chopped off by the leading edge of an unguarded outboard motor is a good thing compared to being whacked by the leading edge of the guard. They conveniently leave out the part after you come off the leading edge of the unguarded outboard motor, whatever is left of you will be struck by the propeller.

3. The authors focus on the gripping action of this cage as if it represents all cages when it may not even represent this cage in all conditions. More youthful legs (cadavers were 70 plus years old and embalmed for several years) may not exhibit as much gripping action. Trimming the outboard motor out may allow legs slide off, only a small fraction of legs will be struck in the manner portrayed in the test (horizontally across in front of the leading edge of the drive. The "gripping action" may change with the propeller actually running.

4. The authors say for simplicity, the leading edge of the guard will be considered blunt. It has a maximum width of 5/16 of an inch and is rounded back from the leading edge with a 5/32 inch radius.

5. The authors **believe** the outboard without a guard would cause less severe injuries and they would be of a different nature, **but they did not impact test the outboard motor without a guard.**

Trim

6. Don Kueny of OMC wrote a letter showing how by trimming the drive down against a pin in advance of each run, they could simulate propeller thrust (resistance of the outboard to swinging up was reasonably equivalent to prop thrust on paper).
   It also places the leading edge of the outboard in a zero trim position (vertical leading edge) making it harder for heads or legs to slide off of.

No Mention of Mercury or OMC

7. All mention of Mercury and OMC was removed from Kress's papers, likely to make them look more independent.

The Bill

8. University of Tennessee sent the research project bill to OMC's lawyers who split it and sent half to OMC and half to Mercury.

Event 1 Statistics

9. The authors (Kress and Porta) and the boating industry continue to quote Event 1 accident statistics which only represent a small portion of the actual number of reported boat propeller accidents.

10. Kress and Porta repeatedly quoted Event 1 statistics when it was obvious their papers were reviewed multiple times by the industry's legal teams. The legal teams were openly allowing incorrect, low ball statistics to be published in documents they planned to turn around and use it court as independent studies.

Pilot Study

11. Porta wrote:

"***In this study, the groundwork was laid for the investigation of the efficacy of the propeller guard. The details of this pilot study are noted on the following pages.***"

The industry considers this study to be one of the two pillars supporting the 1989 NBSAC study. But a coauthor only considered it to be a pilot study laying some groundwork for future research projects that never materialized.

12. Porta wrote on page iv of his dissertation that when they compared embalmed legs to unembalmed legs in impact tests, **"Embalmed legs appeared to show greater fragmentation but much less soft tissue damage than their unembalmed counterparts."**

Purpose of the Study & What Was Accomplished

13. The purpose of this study and what the researchers said they accomplished:

Scott told us that the 1989 NBSAC report told us there may be a different injury mechanism for propeller guards and that mechanism was based on theoretical analysis with no direct experimental evidence available to support it.

Now that the head and leg testing have been completed, we are told to believe the injuries for those struck without a guard would be of a different nature and less severe, but they did not verify that and they did not run enough tests with a propeller guard to be statistically significant.

They began with no supporting data for propeller guard strikes resulting in blunt trauma injuries more severe than striking an open propeller. They ended without proving blunt trauma injuries were more severe than being similarly struck by an open propeller. They were not even allowed to conduct open propeller impacts.

Note the SUNY bills are attached to the head impact study in Volume III

Appendix A

Embellishing the Reports

Embellishing the Reports: An Introduction

The boating industry has a habit of overstating findings of the three studies focused on in these four volumes (1989 NBSAC study, underwater head impact study, underwater leg impact study).

The industry brandishes the three studies against all who challenge the their views as if these three studies provide some sort of spiritual protection.

Then the boating industry exaggerates the:

1. Independence of these three studies. The industry paints it as if they and their lawyers had no involvement in these studies. It is as if the studies just dropped from the sky.

2. Level of involvement of the U.S. Coast Guard in 1989 NBSAC study. The report was authored by a subcommittee of NBSAC with a strong presence of major U.S. recreational marine drive manufacturers. The 1989 study was NOT authored by the U.S. Coast Guard, it was eventually approved by the U.S. Coast Guard.

3. Findings of these three studies. When they recited the findings of the studies, all the hedge words such as “can”, “might”, “seems”, “appears”, “could”, “believe”, “suggests”, “support”, “supports”, “likely”, “probably”, “would be expected”, “would most likely”, “if”, “possibility”, “hight probability”, “could be”, and “may” vanish and are replaced by more certain terms and phrases.

4. Findings of these three studies. They quote text of out the middle of them that was supplied by the industry, including Snyderisms, as findings of the studies. These snippets are not findings, they are content that originated within the boating industry and worked its way into these three papers. For example, Dick Snyder’s line about 80 percent of propeller injuries occurring at speed/on plane or his claim that 1/3 of fatal prop strikes were really boat strikes.

5. Claims the industry makes of their being very few boat propeller accidents by citing U.S. Coast Guard BARD Event 1 accident statistics which only represent a small portion of the total number of reported boat propeller accidents. Similarly, they ignore the much larger number of propeller injury accidents. Often the only difference between an injury propeller accident and fatal propeller accident is probability.

6. U.S. Coast Guard approval of the 1989 NBSAC report. The actual letter from USCG said, “All of the report’s recommendations were accepted.”[25] The letter does not say they USCG approves the entire 1989 NBSAC report, it only says they “accepted” the recommendations. The letter goes on to state the recommendations will be implemented by USCG within the resource limitations outlines in the letter.

7. Importance of the additional forward facing cross sectional area of a propeller guard vs. an unguarded propeller. To a given person in the water, only a maximum of half of the donut shaped area applies. Otherwise their body would be across the propeller and struck by the open propeller. However with the lack of testing with a boat and a propeller under power, and a lack of accounting for the incoming streamlines to the propeller, less to none of the half donut shaped cross sectional area may actually apply to a person in the water.

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[25] Letter from USCG Rear Admiral Robert T. Nelson to Newell Garden, Chairman of NBSAC. February 1, 1990.

8. Importance of the additional forward facing cross sectional area of a propeller guard vs. an unguarded propeller. If the addition of this half donut cross sectional area in the water is so critical, why is the boating industry promoting as many as 3 to 6 very large outboard motors on some boats? Multiple large outboard motors result in many times the submerged cross sectional added by a propeller guard.[26]

[26] See images on Chart #8 of 15, 1989 part 4.

Embellishing the Reports: Sprietsma Brief

The U.S. Supreme Court was considering Sprietsma vs. Mercury Marine in 2002. At issue was the boating industry's very successful Federal Preemption defense against the use of boat propeller guards.

Consistent with Brunswick's use of organizations to backup their claims, they teamed up with the Product Liability Advisory Council which filed an Amicus Curiae brief in behalf of Brunswick[27] (filed a legal document describing why Brunswick should win the legal case). A section of the brief is titled, "The Safety Risks of Propeller Guards Identified by the Propeller Guard Subcommittee are Serious". That section argues that even if the court felt Federal Preemption did not apply, they should not remove the Federal Preemption defense because the 1989 NBSAC propeller guard subcommittee found propeller guards to be dangerous.

Obviously written with heavy involvement of Brunswick / Mercury Marine, this section of the brief is a quick listing of Snyderisms and other unproven or untrue statements from the 1989 NBSAC report. By getting these items into the 1989 report, the boating industry "canonized" them as being true, while are really just unsupported statement by the industry.

Below are several quotes from the 2002 brief. Quotes from the brief are in italics, quotation marks within the italics signify them quoting the 1989 NBSAC report.

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Among other things, the agency (Coast Guard) asked an advisory body, the NBSAC, to "review the available data on the prevention of propeller accidents" and "assess the arguments for and against some form of mechanical guard to protect against propeller strikes."

Note - The brief fails to mention Mercury and OMC, the two largest outboard motor manufacturers in the United States which were both very opposed to the use of propeller guards and failing millions of dollars in propeller injury lawsuits, were both represented on the 4 to 7 person subcommittee of which one member was a Coast Guard liaison to the subcommittee

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The Subcommittee conducted an exhaustive review spanning 18 months, including an investigation of the causes and overall risk of injury or death as a consequence of propeller strikes.

Note - only Event 1 fatality data was considered and that was reduced by about half before it was presented. No injury statistics were considered. Appendix F of the 1989 report did provide three event fatality data for 1980, but then reduced it by 1/3.

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[27] No. 01-706. In the Supreme Court of the United Stats. Sprietesma vs. Mercury Marine/Brunswick. Brief of the Product Liability Advisory Council, Inc. As Amicus Curiae in Support of Respondent. Pages 25-28.

But because "the propeller itself is the sole factor in only a minority of impacts" the number of fatal accidents attributable to propeller strikes is much lower.

Note - *t*wo Coast Guard studies in that era were unable to identify a single BARD reported "struck by boat or propeller" fatal accident in which also being struck by the boat was the responsible for the most serious injuries.

****

In addition, the 20% of all propeller strikes that occur at idling or slow speeds (below 10mph) …

Note - 2009 USCG BARD data shows 59 percent of propeller accidents occur at speeds of less than 10 mph, not the 20 percent claimed by the brief.

****

The result of an object striking a human body in water is that the body absorbs most of the energy of the striking object.

Note - this is not true. Being struck by a propeller guard does not make the boat come to a stop. People slide off the guard or are pushed out of the way, just like a car does not stop when it runs over a pedestrian unless the driver brakes to a stop.

****

It was repeatedly stated that a skull impact at 10 mph or more in water would be generally fatal. A glancing head blow twisting the neck could result in a sheared neck at such speeds.

Note - the boating industry repeatedly stating something does not make it true.

****

Both the mask and ring-type guards significantly increase the underwater profile of a boat "thereby increasing the chances of contact."

Note - if they are worrying about increasing the chances of contact, why are they now selling boats with as many as three to six large outboard motors on them placing countless times more cross sectional area in the water than a single propeller guard?

****

Because propeller guards increase significantly the potential impact area, "they present the additional hazard of blunt trauma injuries, which are often more severe" than the cutting wounds caused by propeller impact.

Note - even one of the industry's researchers (Mike Scott) said this statement was not proven by the 1989 NBSAC report or by his own underwater head impact study. They also fail to note the cutting wounds of a propeller can amputate your limbs and/or cause you to bleed to death or drown.

****

At speeds above 10 m.p.h. (when most propeller strikes occur) "both types of guards - especially the ring - affect boat operation adversely."

Note - as stated earlier, 2009 BARD data shows 59 percent of propeller strikes occur below 10 mph, thus most do not occur above 10 mph. While some guards may impact boat handling of some boats at faster speeds. their effect is or is almost undetectable on many displacement boats (slow moving houseboats and pontoon boats).

****

The Subcommittee also concluded that use of propeller guards would cause some operators to develop a "false sense of security when approaching persons in the water at slow speeds, with the very real risk of impacting an/or entrapping a body appendage."

Note - By this logic all safety devices should be removed from boats and automobiles.

****

All propeller guard designs, moreover, result in increased drag, loss of speed, and dramatically reduced power and fuel efficiency.

Note - some propeller guards have minimal effect on slow moving displacement houseboats and pontoon boats.

****

Finally, a propeller guard, "must not only fit the motorboat but be designed for hydrodynamic compatibility with the hull on which the motor is used." … "Since there are hundreds of of propulsion unit models now in existence, and thousands of hull designs, the possible hull/ propulsion unit combinations are extremely high" and no simple universal design exists that could be used. And the cost of retrofitting millions existing boats would be "prohibitive".

Note - we are normally talking about putting propeller guards on slower moving outboard powered boats. These guards are available off the shelf and are NOT hull dependent. Yes, there are multiple outboard motor manufacturers with multiple frame sizes of outboards out there, but propeller guard manufacturers will quickly hone in on those models being used in slower applications that are buying guards. They are not going to start by making guards for large outboards on go fast boats. Propellers can be made for all these combinations, why can't propeller guards be made for them too.

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None of the points above are found in the Summary or in the Recommendations section of the 1989 report. Several of them are found in the 1989 report on pages 5 and 6 in the list provided following "In defending propeller strike cases edge and boat manufacturers have asserted:".

"Manufacturers have asserted" does not mean the statements are true, especially not when the issue is controversial.

Embellishing the Reports: NBSAC 1989 Report

In **Figure 20 in Volume II (**1989 NBSAC Study) in the wake of the release of the 1989 NBSAC report, we find Laurin Baker, Director of Public Affairs for OMC stating:

> *"propeller guards do not exist for outboard motors used in recreational boating." She also stated, "there is "no basis in science or engineering" for requiring propeller guards."*
>
> *"The council said the guards, if feasible, would cause more injuries than they would prevent"*

Neither statement above occurs in the report.

In the same article, Laurin Baker also brought down maximum speeds for which propeller guards are effective to 5 mph. The NBSAC report never actually came out and defined a safe maximum speed for propeller guards. Speeds above 10mph were touted multiple times as being able to generate fatal skull impacts but no such evidence was provided, The speed of 5 mph, cited by Laurin Baker, is not even mentioned in the 1989 report.

Embellishing the Reports: Scott's Head Impact Study

William H. Daley, III of CED Technologies served as an expert witness for Mercury in Reed vs. Mercury Marine. A 14 year old girl bow riding a pontoon boat was fatally struck in the head by a boat propeller.

Earlier, Mr. Daley was a major player in developing the U.S. Coast Guard propeller guard test procedure. He has also repeatedly spoken at ABYC's annual Marine Law Symposium.

Pages 26-27 Daley's April 15, 2021 in the Reed case find Mr. Daley repeatedly citing Scott's head impact testing report.

Below are two quotes by Mr. Daley:

> "***Testing performed by Scott et al. determined that blunt force trauma leads to significant head injuries at speeds greater than 10 mph when the head was struck by the lower unit of an outboard engine.***"
>
> "Some have suggested that a cage guard would have been an effective device to have prevented Ms. Reed's injuries. **This suggestion apparently ignored published propeller guard testing performed on behalf of the U.S. Coast Guard and was inconsistent with testing performed by Scott, et al., Kress, et al.** and CED."

See the next section titled**, Embellishing the Reports: Scott's Report: Blunt Trauma Part 1**

Embellishing the Reports: Scott's Report: Blunt Trauma Part 1

Even if you use the fourth version of Scott's paper after it had been edited by Mercury and OMC legal teams for years, its conclusion reads:

> "*The results of this study **support** the argument of the NBSAC report that blunt trauma injuries **may become** significant at speeds greater than 10 mph."*

Scott went on to state:

> *"The limited analysis **suggests that**, at impact speeds greater than 10 mph an impact between a submerged head and a lower unit **can** produce head and neck injuries."*

Scott's conclusion is much less definite than Mr. Daley presents on the previous section. In addition this document, **Volume III**, invalidate's Scott's data anyway. Plus only a portion of propeller strikes are head strikes and even fewer of those are center of forehead strikes like those in Scott's study.

Scott said his study **supports** the argument, he does not say it confirms, validates, verifies, or proves it.

Then Scott notes the argument itself says,

> *"blunt trauma injuries **may become** significant at speeds greater than 10 mph."*

So what we really have is that Scott's study **supports** the NBSAC report **claim** that blunt trauma injuries **may become significant** at speeds greater than 10 mph.

The statement above is much weaker than the one Daley put in his report:

> "***Testing performed by Scott et al. determined that blunt force trauma leads to significant head injuries at speeds greater than 10 mph when the head was struck by the lower unit of an outboard engine.***"

Embellishing the Reports: Scott's Report: Blunt Trauma Part 2

An earlier section of this Scott's paper titled, **The Purpose of the Underwater Head Impact Paper Changed,** noted the original purpose of Scott's work was to:

> "*investigate the potential for blunt injury underwater impacts with cage type propeller guards*."

His conclusions state the lower unit can produce head and neck injuries.

Scott does state:

> *"The results of this study indicate that impacts between a submerged head and a guard on a lower unit traveling at these speeds (15 mph or greater)* ***would most likely*** *produce severe head and neck injuries"*

But the entire paper makes no mention of blunt trauma or blunt force trauma.

Scott's Abstract from the fourth version of his paper (SAFE Journal version) states:

> *"The* ***findings suggest*** *that while the use of a propeller guard may be beneficial for low speed head impacts, the problem of blunt trauma injury at speeds greater than 10 mph would make the propeller guard counter-productive in reducing injuries."*

As an example of legal editing, the abstract of the third version of Scott's paper (Safe Symposium version) reads as above except:

> "*the problem of blunt trauma injury at speeds greater than10 mph should be carefully weighted."*

Note, the statement went from needing to weigh the use of propeller guards at speeds in excess of 10 mph to speeds greater than 10mph to making propeller guards totally counter-productive in reducing injuries.

In addition, Scott's testing relied upon a single propeller guard design built by, and supplied by the boating industry.

Embellishing the Reports; Kress' Leg Study

Mr. Daley wrote:

> "*Similarly, testing performed by Mr. Kress et al. determined that blunt force trauma leads to significant leg injury at speeds greater than 13 mph. Additionally, Kress et al. indicated that the loss of leg utility* ***would result in amputation****."*

We refer to the version of Kress's paper given at IRCOBI as the 7th Kress document, or as the 7th Kress file. The 7th Kress document does not even include the phrase "blunt trauma" or "blunt force trauma".

A close reading of Kress' Discussion section (the Conclusions of the 7th Kress document) reveals:

> *"It is the judgment of the researchers that, for the loading condition and population studied in this project (70 plus year old cadavers that had been stored for several years), the prop-guarded cage was not effective in preventing extensive injury to the leg at boat velocities greater than or equal to 13.6 mph." ….*
>
> *"At speeds of about 13 mph (21 km/hr) and above it would be expected that both "impactors" (with and without the cage-type guard) would cause damage so severe that loss of leg function would result which* ***may require amputation****."*

Note Mr. Daley wrote "**would result in amputation**" when the actual quote was, "**may require amputation**."

Page 8 of Kress' Addendum **defined loss of leg function** as:

> "that the injured individual would experience permanent disabling damage to the leg (injury could be variable, ranging from a chronic limp to an amputation"

So Mr. Daley wrote, "would require amputation" when Scott actually wrote "ranging from a chronic limp to an amputation."

Mr. Daley wrote, "**would result in amputation**" as if your lower leg was going to be so messed up it had to be cut off later. We suspect that if you were to similarly strike the same cadaver legs without a propeller guard at speed the leading edge of the drive WOULD amputate them.

We are not sure about Mr. Daley, but as for us, we would rather have a leg with a chronic limp than no leg at all.

Mr. Daley who repeatedly misquoted Scott, spoke down to those suggesting a propeller guard may have protected the young Reed girl as if they were unlearned.

> *"Some have suggested that a cage guard would have been an effective device to have prevented Ms. Reed's injuries.* ***This suggestion apparently ignored published propeller guard testing performed on behalf of the U.S. Coast Guard and was inconsistent with testing performed by Scott, et al., Kress, et al.*** *and CED."*

The END