C44 Hydrodynamic and Biomedical Engineering Factors in Propeller Contact Injury

Paul Kamen, ME, 1224 Campus Drive, Berkeley, CA 94708; and Laura L. Liptai, PhD*, BioMedical Forensics, 1660 School Street, #103, Moraga, CA 94556*

After attending this presentation, attendees will have a better understanding of factors that increase risk of injury due to propeller contact in certain types of recreational boating applications, especially those involving high thrust and relatively low vessel speeds such as waterskiing, wakeboarding and parasailing.

This presentation will impact the forensic community by describing risk factors not generally understood by vessel operators and by presenting a methodology for their analysis and mitigation. A specific example will be presented.

Propeller injuries generally involve multiple deep lacerations and bone damage distributed over a wide area of the body. There is a characteristic pattern to the geometry of these injuries, each cut corresponding to the path of a propeller blade as the moving water pulls the victim through part of the disk area swept by the propeller. The orientation of these lacerations can be useful in studying the angle of contact, boat/victim kinematics, principal direction of force for the trauma, and possible point of entry into the water.

Applications requiring high thrust at relatively low speeds result in unusual demands on both the propulsion system and on the maneuvering- capabilities of the vessel. As a result there are additional hazards associated with propeller contact that may not be anticipated by small craft operators.

Three unanticipated factors will be examined in this presentation: the first is the size and shape of the inflow field upstream of a propeller operating at relatively high thrust and low forward speed. This is the case for water- ski or wake board towboats, especially during the initial acceleration phase, and for parasail winchboats, especially when operating against a headwind.

1) Propeller inflow: Propellers work by pressurizing and accelerating water, resulting in forward thrust by momentum conservation. Continuity and incompressibility require that the flow field upstream of the propeller is wider than the propeller diameter.

In the case of towboats and winchboats, relatively low speed and high thrust is common. This results in a wider inflow field than would be experienced at speed or at low thrust.

While the operator may only be aware of the outflow jet, the inflow field ahead of the propeller is by far the more dangerous. The widening of the inflow field as speed drops and relative thrust increases is not understood by the majority of vessel operators, and is even less likely to be understood by passengers or guests swimming in close proximity to a propeller.

2) Maneuverability under tow load: The tow vessels discussed have the added complication of increased likelihood of placing people in the water near the propellers. In the case of ski and wakeboard towboats, the skier normally enters the water near the propeller. Parasail winchboats require an unobstructed aft deck with no rails around the stern of the vessel, making accidental water entry near the propeller a much more likely occurrence than on other types of boats.

3) Time required to stop propeller rotation: Time to stop propeller rotation can be a major contributor to propeller contact accidents. On a windy day, the inflated parachute of a parasailing vessel can keep the boat moving through the water and produce considerable torque on the propeller.

A vessel operator, when recognizing the emergency of people in the water, is faced with three choices: a) use power and steering to maneuver the stern of the vessel away from people in the water; b) shift the gearbox into neutral to disconnect the propeller from the engine; or c) cut the engine power but leave the propeller in gear so that propeller rotation stops quickly. Circumstances and power train characteristics will dictate which course of action is best.

The presentation will describe tests that: (a) quantified steering force to maneuver the propeller clear of people in the water, (b) determined time lag between shift-to-neutral and propeller stopped, and (c) mapped a victim's injuries with the reconstructed propeller motion as well as the current and wind effects on the movement of the vessel through the water.

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