

# INFORMATION PAPER ON MILITARY HIGH-SPEED BOAT INJURIES

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**Note: The content provided in this product is current as of February 2025 and is subject to change as new findings become available.**

## RELEVANCE TO THE DEPARTMENT OF DEFENSE

Crew members operating military high-speed boats, particularly U.S. Naval Special Warfare Combatant-Craft Crewmen, are at an increased risk for musculoskeletal injuries of the lower back and neck, as well as head injuries and chronic pain due to hull impacts induced by wave-slammaing.

## IMPACT TO THE WARFIGHTER

- U.S. Naval Special Warfare Combatant-Craft Crewmen, also referred to as SWCC, who operate on high-speed marine vessels, are at risk for musculoskeletal injuries and potentially TBI as a result of wave slamming.
- The most common acute injuries are to the lower back, neck, and head, and in some studies nearly three-quarters of SWCC have chronic pain years after their service.
- Further research can help identify and improve boat hull designs, suspension seating, and other prevention strategies that more effectively limit the trauma induced from wave slamming.
- There is a lack of research on the acute and long-term impact of wave slamming on TBI and post-concussive symptoms in warfighters operating on high-speed boats, indicating a need for further prospective investigation to improve operational safety and performance.

## PURPOSE

The purpose of this information paper is to summarize the available evidence regarding military high-speed boat injuries, with particular focus on injuries that affect service members' brain health.

## BACKGROUND

Many crew members of high-speed boats, and particularly boats used by the military in large bodies of water, report chronic injuries. A common mechanism for those injuries is wave slamming-induced hull impacts.<sup>1</sup> Wave slamming occurs during normal operations of marine vessels but in rough seas can occur as random, violent and non-linear events. Injuries are frequently reported when the body of the boat drops at or greater than 0.4 meters per

second.<sup>1</sup> Boat hulls and equipment are typically designed to withstand peak impacts of 5 to 6 G-force, and suspension seats are specified to mitigate impacts up to 4 to 5 G-force.<sup>2</sup> However, slamming-induced impacts to high-speed boats can exceed 20 G-force.<sup>3,4</sup> Wave slamming causes injuries that are distinct from motion sickness, a syndrome most common in those who rarely travel by boat and characterized by headache, nausea, and dizziness.<sup>5</sup> Instead, wave slamming can result in musculoskeletal injuries and traumatic brain injuries, particularly if sustained on multiple occasions.

## SUMMARY OF RESEARCH

U.S. Naval Special Warfare Combatant-Craft Crewmen, who operate on small high-speed boats (up to 60 knots), are at a particularly high risk for wave-slamming injuries.<sup>6</sup> SWCC make up a small special operations force with about 800 active-duty crewmen and 50 to 125 reservists.<sup>7</sup> They are part of the U.S. Naval Special Warfare Command, which is a component of the U.S. Special Operations Command. U.S. Navy SEAL officers hold SWCC officer positions. The SWCC are known for their expertise in maritime direct-action operations, special reconnaissance, and inserting and extracting other special operations units. SWCC operators work with U.S. Navy SEALs and other special forces to complete operations and are extensively trained to execute high-risk warfare and reconnaissance missions in river and coastline settings.<sup>6</sup>

To better understand the nature and prevalence of high-speed boat injuries among SWCC, researchers conducted an internet-based survey of retired SWCC.<sup>7</sup> The survey was given to 360 members of the Combatant Craft Crewman Association online user group. Participants answered questions on demographics, service branch, boat type, and years of service and capacity, as well as injury-specific questions on types of events, injury location, severity, pain, disability, and need for treatment. In this survey, the average age of respondents was 50, and 97% of respondents indicated that they were retired SWCC. The median time served aboard a high-speed boat was nine years.

The 31-question survey included the following questions relevant to TBI:<sup>7</sup>

- On which boat type did you sustain an injury and to which part of the body? Please specify how many injuries.
- Can you describe the type(s) of injury—fracture, dislocation, disc rupture, strain, tear, fracture, dislocation, concussion, etc.?
- Were you ever knocked unconscious while underway on board a high-speed boat? If yes, indicate the number of times unconscious.
- Did you ever experience mental capacity impairments because of exposure to an impact?

The respondents reported 2,460 impact-related injuries over 2,318 person-years of service as SWCC, during which respondents reported:

- Temporary loss of consciousness as a result of wave-slamming (33%)
- Impact injuries that ultimately impaired their capacity to perform their job aboard (70%)
- One or more injuries (90%), for which
  - 39% needed surgery for the injury while serving
  - 34% needed surgery after retirement

The most common types of injuries were back (32%), neck (21%), and head (16%).<sup>7</sup> After retiring from active duty, most respondents had chronic pain issues, and only 17% reported their general health to be excellent or very good. In an updated systematic review of studies published from 1980 to 2022, researchers found two prospective longitudinal and three cross-sectional cohort studies that reported on 804 cases with 3,312 injuries sustained during 3,467 person-years exposed to high-speed boats.<sup>8</sup> Again, the most common injuries were musculoskeletal injuries of the lower back (26%) and neck (16%), and head injuries (12%). The pooled prevalence of chronic pain was 74%, and 60% of the cohort used analgesics.

Most studies to date have focused on the musculoskeletal injuries among SWCC but have not provided details related to TBI, such as post-concussion symptoms, balance difficulties or cognitive impairment. A medical record review of 210 Navy SEALs found that the frequency of high-speed boat injuries was 0.025 per operator per month.<sup>9</sup> Most injuries involved the upper extremity (38.1%). Frequent anatomic sublocations of the shoulder (23.8%) and lumbopelvic region of the spine (12.7%) were reported, as well as various types of strain (20.6%), pain/spasm/ache (19.0%), fracture (11.1%), and sprain (11.1%). This report did not mention any TBI in these operators, however.<sup>9</sup> A subsequent study also emphasized the frequency of musculoskeletal injuries, particularly among students undergoing Crewman Qualification Training, but again did not mention TBI.<sup>10</sup> By using anonymous questionnaires to assess injuries sustained by French special forces high-speed boat crews (n=84), researchers found that 67% had at least one injury in the past 12 months and 71% reported chronic pain.<sup>11</sup> In a separate study, researchers found that Marines who travel in high-speed boats, especially in rough seas, can have measurable physiologic changes, increased blood levels of creatine kinase (a sign of muscle damage), and reduced physical capabilities.<sup>12</sup>

Prevention of high-speed boat injuries may include adapting the boat speed to sea conditions; training and vetting boat operators based on their driving skills; adapting training and operational routines; and designing boats with hull shapes offering acceptable ride quality and suspension seats scientifically proven to mitigate injurious impacts.<sup>7</sup> On high-speed boats, seat position (upright or reclined) does not appear to affect overall comfort or safety,<sup>13</sup> but suspension seats may be preferable to fixed seats.<sup>4</sup> In a small study of 12 naval personnel, cognitive performance was tested before and after a three-hour trip on a high-speed boat, with half the subjects in fixed seats and half in suspension seats.<sup>14</sup> After

the trip, those in suspension seats performed better on some cognitive tests, and reported less fatigue and sleepiness compared to those in fixed seats. Of note, wave slamming may still cause sleep disturbances even when experienced during operation of marine vessels that are not the typical high-speed craft operated by SWCC.<sup>15</sup>

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