# Commercial Fishing Morbidity and Mortality U.S. Distant Water Tuna Fleet 2006-2012

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On the Front Cover: 15-foot tall net piles on the decks of two distant water tuna vessels in American Samoa (NIOSH)

One the Back Cover: A school of tuna (NOAA)

# About this report

The National Institute for Occupational Safety and Health (NIOSH) is the federal government agency responsible for conducting research and making recommendations for the prevention of work-related injury and illness. Commercial fishing is consistently one of the most dangerous occupations in the US, with a rate of 117 fatalities per 100,000 workers reported during 2012, 36 times higher than the average workplace fatality rate of 3.2 per 100,000 [BLS 2013].

NIOSH maintains the Commercial Fishing Incident Database (CFID) and has published a series of reports on commercial fishing fatalities from 2000 to 2009 in four US regions: Alaska, West Coast, East Coast, and the Gulf of Mexico [NIOSH 2010a,b,c,d]. These reports outline the hazards of particular fisheries located within the regions and highlight the need to create interventions that focus on problems found in these specific fleets. However, these reports do not include the US Distant Water Tuna Fleet (DWTF), which operates far from the US West Coast in the Pacific Ocean.

The Distant Water Tuna Fleet (also known as the US Purse Seine Fleet) is licensed under the South Pacific Tuna Act of 1988, which has since been amended and reaffirmed [16 USC[1] 973]. The number of vessels operating in the fleet has increased from 14 in 2006 to a total of 39 vessels operating in 2012. Compared with other US commercial fishing catcher vessels, the DWTF vessels are the largest in terms of both vessel size (average length: 214.5 ft, range: 174–260 ft) and number of crew (28 members average, range: 20–40). The fleet is also the only US fishing fleet allowed to have licensed foreign officers (other than the master) to occupy key leadership positions such as that of mate and chief engineer on the vessel [CGMTA 2006]. Since March 2007, the United States Coast Guard (USCG) and the National Marine Fisheries Service (NMFS) have submitted annual reports to Congress on the activities of the DWTF, as required by the Coast Guard and Maritime Transportation Act of 2006 (Public Law 109-241, Section 421). These reports enumerate active vessels, fish landings (amount of fish caught), foreign crew officer exemptions, and known vessel disasters and fatalities [Department of Homeland Security, 2007, 2008, 2009, 2010, 2011, 2012, 2013]. In 2012, the USCG asked NIOSH to conduct a systematic review of DWTF fatal and non-fatal traumatic injuries similar to the regional analyses of other US fleets previously mentioned in order to make a baseline assessment, compare mortality rates with other US fisheries, and to provide recommendations to prevent future injuries and fatalities.

[1] United States Code

# Methods

The USCG Marine Information for Safety and Law Enforcement (MISLE) system was used as the primary source for fatality and injury data. MISLE is used to record information reported by fishing companies to the USCG on injuries, fatalities, and vessel incidents such as allision, collision, fire, flooding, and sinking events. Federal law requires companies that operate fishing vessels to report marine casualties (death, "serious injury," material loss of property, vessel damage affecting seaworthiness or efficiency, or significant harm to the environment) to the USCG [46 USC 6101]. For standardization of findings, a case was defined as any crewmember who suffered a non-fatal or fatal traumatic injury reported to the USCG. Incident data were extracted from reports found in MISLE and entered into an Access database.

Denominator data were calculated with the following information. Annual DWTF congressional reports were used as a basis for crew size estimates for each vessel. When unknown, crew size for each vessel was assumed to be the same size as the most recently reported year for that vessel, or (when never reported for that vessel) the average crew size of other vessels during that same year. Annual National Oceanic and Atmospheric Administration (NOAA) observer program aggregate data were obtained for DWTF vessel days at sea per year. Workforce full-time equivalents (FTEs) were calculated by multiplying average crew size by annual fleet vessel days at sea and adjusting to a standard 250-day work year. This methodology has been used previously by NIOSH to compare fishing vessel mortality rates among fleets [CDC 2010]. Mortality for the latter half of the investigation period was compared with the earlier half by calculating risk ratio, p-value, and confidence interval by mid-p exact test in OpenEpi software.

# Results

During 2006–2012, a total of 14 fatal and 20 non-fatal traumatic injuries were reported by the DWTF and recorded in MISLE (Figure 1). Three additional fatalities were reported from this fleet, but not included in our analysis because two involved non-crewmembers (one stevedore crushed and one marine pilot fell overboard) and one other crewmember death was related to medical illness and thus did not meet the standard case definition discussed in the methods section. There were no fatalities in 2006, and 11 of the 14 fatalities occurred between 2010 and 2012. In part, this is explained by a 70% increase in the average annual FTE workforce from the earlier to the latter part of the period.

The work-related mortality rate in the DWTF was 226 deaths per 100,000 FTE for the period 2006–2012. The rate of fatal injuries increased during the study period (Table 1).

Figure 1 - U.S. Distant Water Tuna Fleet Morbidity/Mortality, 2006–2012 (N=34)

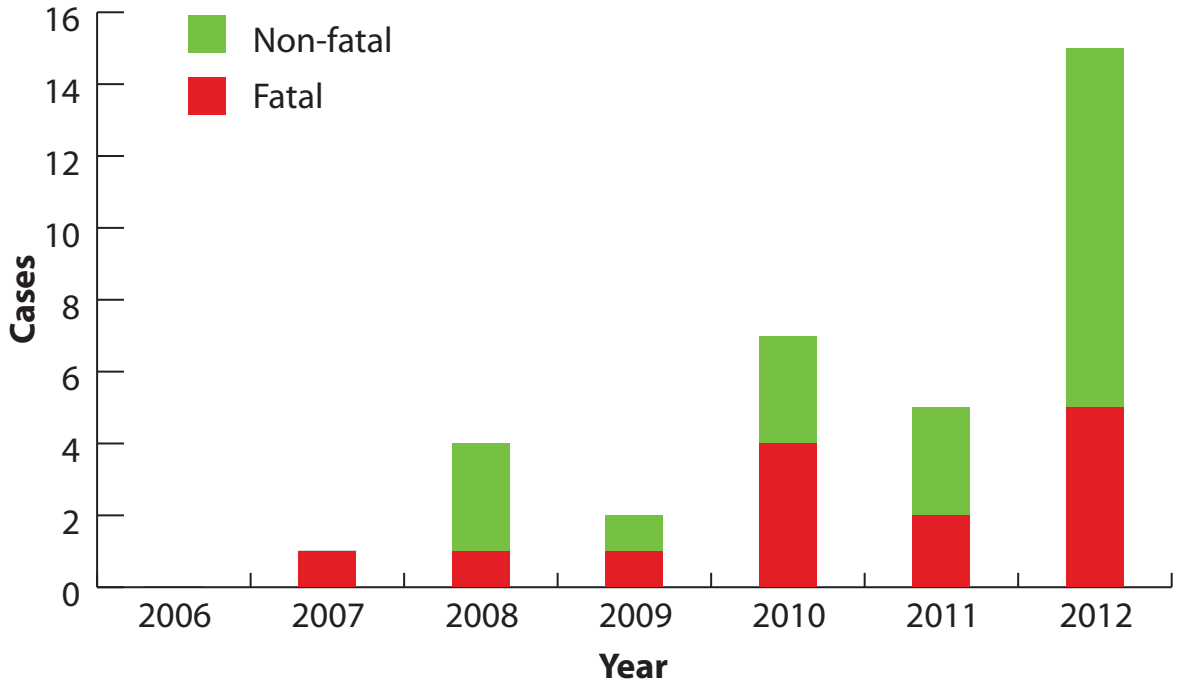


Table 1: Fishing Injury Fatality Rates for Full-time Equivalent (FTE) Workers, DWTF, 2006-2012

| Time Interval | Injury Fatalities | FTEs | Annual Mortality Rate per 100,000 FTEs* |
|---|---|---|---|
| **2006-2012** | **14** | **6196** | **226** |
| 2006-2009 | 3 | 2720 | 111 |
| 2010-2012 | 11 | 3476 | 316 |

* Risk ratio of fatality in 2010-2012 compared with 2006-2009 = 2.9 [CI: (0.8, 10); p=0.09]

A variety of events led to fatalities and injuries in the fleet (Figure 2). Nearly half of all fatalities (n=6; 43%) were caused by falls overboard. Five of the fatal falls were witnessed, and in all these cases the victim was either working with a line or climbing on the net immediately prior to the fall. Three crewmembers experienced non-fatal falls overboard and were recovered by crew with varying levels of injury. In none of the falls overboard did the victim wear a personal flotation device (PFD). Improper footwear (e.g., open-toed shoes without heel support) was noted to have contributed to some of these falls overboard.

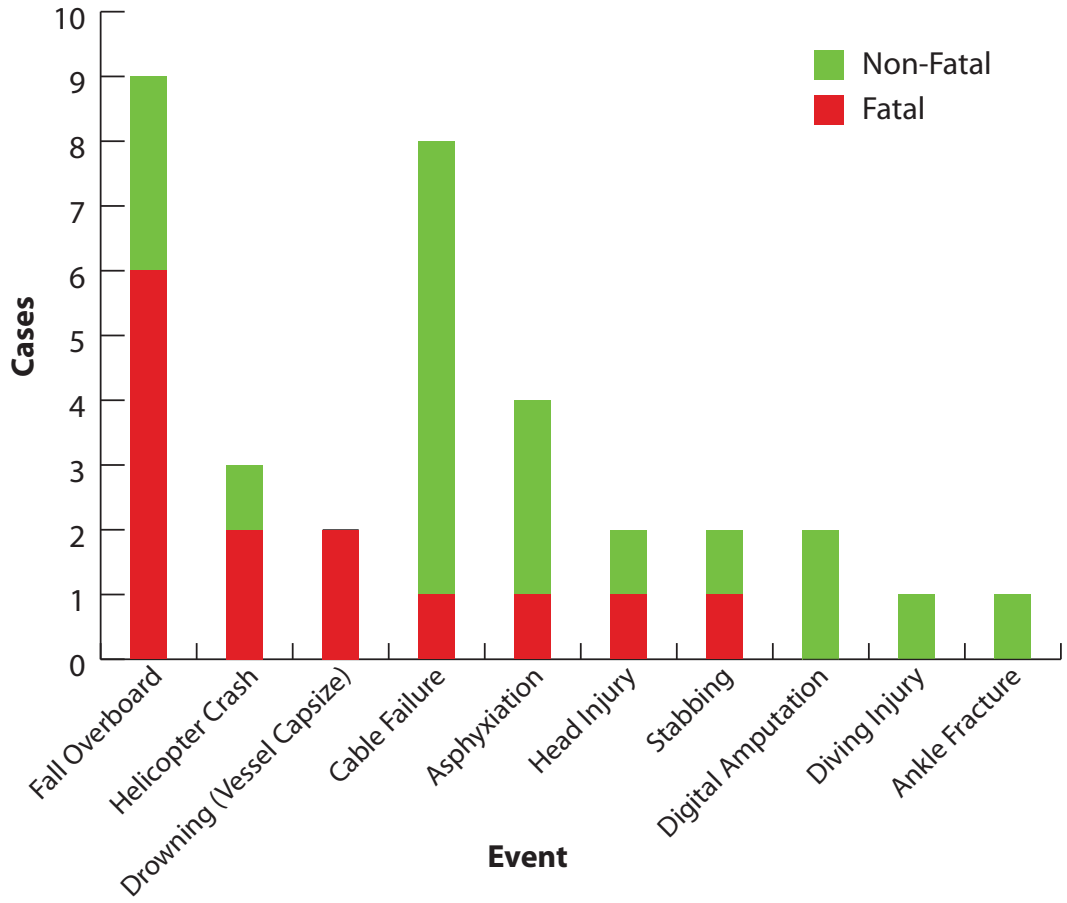
Four additional drowning deaths occurred (Figure 2). In separate incidents, two helicopter pilots died after crashing into the ocean. As helicopters are used by some vessels for fish-spotting, we considered pilots to be part of the crew. The helicopter passengers in these incidents survived, but one sustained skull and pelvic fractures. A vessel disaster caused the other two drowning deaths. Both the captain and the chief engineer (who were wearing PFDs) sank with their vessel after it catastrophically flooded and capsized. An investigation of the sinking revealed that several watertight doors had been left open and that crew coordination for disaster response was impaired by inexperience and language barriers.

Worn or overloaded cables accounted for the most morbidity, with one crew fatality and seven non-fatal injuries (Figure 2). These were associated with two catastrophic mast and boom failures, one causing a fatal crush injury and a non-fatal injury, the other causing six non-fatal injuries.

One death from asphyxiation and three serious poisonings resulted from exposure to hydrogen sulfide in a holding tank with decaying fish biomass. Two crewmembers were sent to clean the tank without training in confined-space entry or proper personal protective equipment. Both lost consciousness. Two additional crewmembers then attempted to rescue these men and also lost consciousness. Both inexperience and language barriers were noted as contributing factors during the USCG investigation.

Head injuries occurred after a crewmember was struck by a chunk of ice and another was struck by a single frozen 80 pound tuna during offloading. The frozen tuna struck the crew member in the head, breaking his hard hat resulting in a fatal injury.

Figure 2 - U.S. Distant Water Tuna Fleet Morbidity/Mortality, 2006–2012 (N=34)

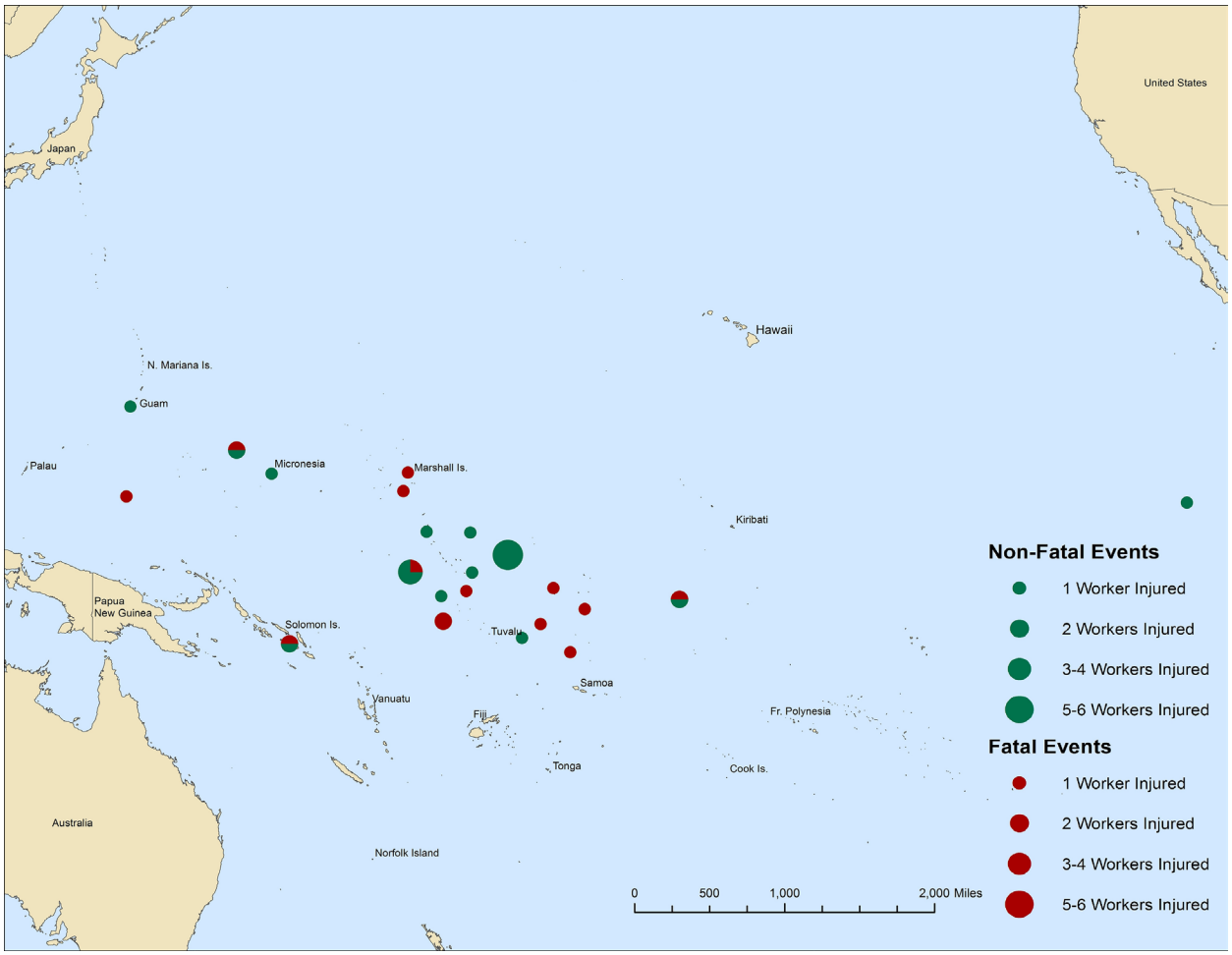



The final DWTF death was an intentional stabbing. Three crewmen were drinking in port and returned to the ship; one man stabbed the other two, resulting in one death and one nearly fatal injury.

A non-fatal injury type that merits discussion is digital amputation, which occurred in two separate incidents. One crewman lost four fingers when he accidentally placed his hand in a blower fan blade while trying to maintain his balance as the vessel rocked. In an unrelated incident, a crewman was lubricating a winch drum; a crewmate unknowingly began operating the controls of the winch, which resulted in the severing of three of the first crewman's fingers. These amputation injuries were attributable to unguarded equipment and to lack of lockout/tagout procedures, respectively.

The geographic locations where fatal and non-fatal injuries occurred are plotted in Figure 3. These remote locations reflect where the DWTF operates, and illustrate how challenging rescue or medical assistance can be for this fleet.

Figure 3 - Locations of Fatal and Non-Fatal Injuries in the Distant Water Tuna Fleet, 2006–2012 (N=34)



## Discussion, limitations, and recommendations

This was the first systematic evaluation of injury morbidity and mortality in the DWTF. The DWTF annual mortality rate during 2006–2012 was 226 per 100,000 FTE (Table 1). The annual mortality rate rose during the second half of the investigation period to 316 per 100,000 FTE during 2010–2012. NIOSH has identified only three other fleets with similar or higher mortality rate. During 2000–2009 fisheries with the highest fatality rates were the Northeast Groundfish (600/100,000 FTE/year), Atlantic scallop (425/100,000 FTE/year) and West Coast Dungeness Crab (310/100,000 FTE/year) [CDC 2010]. The elevated mortality rate found for the DWTF supports the concerns of the USCG that workers in the DWTF are at high-risk for fatal injuries.

Unlike many other US fleets, only a small number of fatalities in the DWTF resulted from a vessel disaster (two drowning deaths when a vessel capsized). The single leading cause of death, accounting for 43% of injury mortality, was falls overboard. Making modifications to the vessel (under the direction of a naval architect or engineer) to prevent falls overboard could include raising gunnels or installing rails, and creating more enclosed workspaces [Lucas and Lincoln 2007]. Crews should continue to conduct monthly emergency drills that include the recovery of a fall overboard victim. Since the majority of these incidents were witnessed, the deaths were most likely preventable with a PFD. During a visit to a DWTF port by our team, crewmembers cited a few reasons for lack of PFD use during our conversations—discomfort in the warm environment, bulk getting in the way during fishing operations, and not perceiving the need. Research has been completed with other fishing fleets to identify PFDs that fishermen can use comfortably while working [Lucas et al 2012]. In order to increase the use of PFDs in the DWTF, the industry must understand the risk of falling overboard and devices must be identified that overcome crew discomfort in their particular environment. DWTF crewmembers we spoke to showed interest in finding PFDs that would be more comfortable to wear in their tropical fishing environment and would permit them to engage in deck work unhindered. At least one company reported purchasing PFDs for all crews [Harper 2013]. Appropriate footwear (closed-toed shoes with heel support) also could have prevented slips that resulted in falls overboard and other injuries, as inadequate footwear was documented in at least two USCG investigations and was observed commonly during our field investigation.

PFD use may also have prevented the helicopter pilots' drowning deaths (in each case, a passenger survived). In other industries where helicopters are used, pilots and passengers complete helicopter underwater escape training and wear inflatable PFDs during flights over water. Helicopters in other industries are also fitted with flotation gear that automatically inflates on impact with water supporting the helicopter on the surface of the water [International Association of Oil and Gas Producers 2011]. For multiple reasons — cost, safety, and availability of superior fish-finding methods such as fish-aggregating devices — many vessels in the fleet do

not employ helicopters. For those vessels that continue to use helicopters in fishing operations, both equipment checks/maintenance and PFDs are important.

Properly maintaining, safeguarding, loading, and operating vessel and fishing equipment are also crucial to preventing injuries, just as in any industry. Two crew deaths, a stevedore death, and several injuries could have been prevented with appropriate crane maintenance, avoidance of overloading equipment, and avoidance of walking under suspended loads. Application of occupational safety best practices is as important during dockside offloading as it is onboard the vessel. Some companies have begun to place more emphasis on safety measures, including one company employing a fleet safety officer who manages an extremely detailed list of the maintenance and inspection needs for the riggings of each vessel in its fleet and prioritizes maintenance activities when the vessels come to port (Figure 4).

Finger amputations could have been prevented with equipment guards (e.g., over the blades of a fan) and with lockout/tagout procedures, which is not a common practice in the industry. The OSHA lockout/tagout standard—a regulatory standard in other industries- requires practices and procedures to shut down equipment, isolate it from its energy source, and prevent release of energy during maintenance or service activities [OSHA 2002; 29 CFR 1910.147]. It can be adapted to meet the needs of different industries, and would be beneficial on DWTF vessels and other commercial fishing vessels.

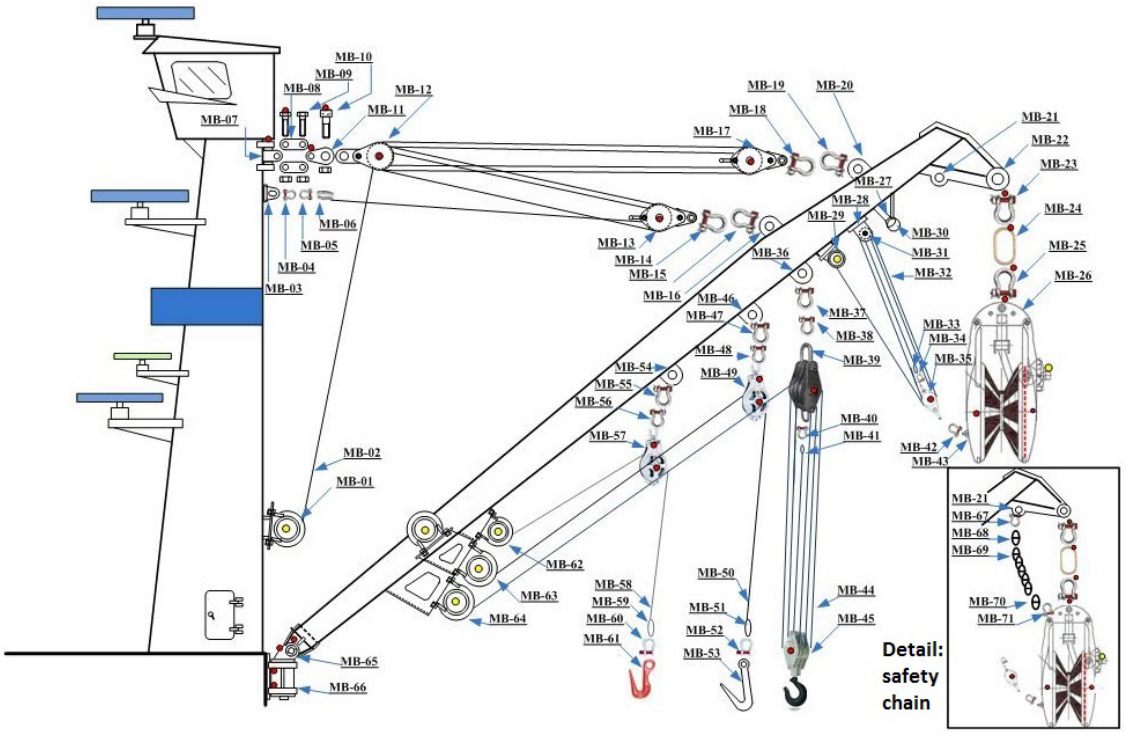
The fatal event involving a confined space entry illustrated the need for the development of proper procedures when entering a tank for cleaning or maintenance. OSHA has developed a fact sheet explaining the serious hazards confined spaces on fishing vessels pose and explaining how they can be properly identified, tested, and ventilated to keep crewmembers safe [OSHA 2011].

The DWTF operates in warmer water than most other US fishing fleets, which should improve the odds of surviving a fall overboard or a vessel disaster. However, this is outweighed by several disadvantages. The vast and remote fishing area (Figure 3) makes medical evacuation or search and rescue operations daunting. Language barriers among the crew were also cited numerous times in the USCG investigative reports as being a problem during emergencies at sea, including the confined-space entry asphyxiation and the vessel flooding and capsizing. Multiple languages are spoken on these vessels among the crew and among senior personnel. This can limit the effectiveness of safety training and impair response to complex emergencies at sea by impairing on-board and radio communications.

There are several limitations to this study. The USCG MISLE database is assumed to have complete fatality data, but we believe (on the basis of discussions with USCG and industry, as well as the wording of 46 USC 6101) that many non-fatal injuries are not reported to the USCG and therefore are not recorded in MISLE. The workforce denominator data were adjusted for

vessel days at sea, which were only available on a fleet aggregate and not an individual vessel basis, requiring assumptions to be made that each vessel had the same number of days at sea in a given year. However, the assumptions were based on the best information available through the annual DWTF reports, MISLE, and interviews with vessel crews, and would be unlikely to skew fleet mortality rates substantially. Finally, the small size of the DWTF means that even one event has a significant impact on the mortality statistics, making trend analyses difficult for the short study period and reducing statistical significance. Nevertheless, as intuited by the USCG in the setting of a rapid expansion of the fleet, there appeared to be evidence of an increase in injury mortality in the latter half of the investigation period. A follow up report should be completed to review incidents occurring during 2013–2017. This report could see if PFD policies and rig maintenance programs have made an improvement in the safety of the fleet. Language and cultural differences should also be better documented in causality investigations so that practical solutions can be implemented to overcome these communication problems that occur during emergencies at sea.

Figure 4 - Schematic of the Maintenance/Inspection Points of the Riggings for one Vessel's Mast and Main Boom




*Source: Rigging Technician, Samoa Fishing Management, Tri Marine, Sept. 10, 2013*

A summary of recommendations can be found on the following page (Table 2). This investigation offers a baseline assessment of injury mortality in the DWTF during 2006–2012, in the hopes that observations and recommendations herein will highlight key areas where serious injuries can be prevented and will help further a culture of safety through smart fleet safety practices.

Table 2: Recommendations for Injury Prevention in the DWTF [NIOSH 1997; NIOSH 2010a,b,c,d; NIOSH 2012; OSHA 2011]*

| | |
|---|---|
| Crewmember Safety | We recommend that Owners and Operators:<br>1. Set vessel-specific policies regarding the use of personal flotation devices<br>2. Ensure that there are persons in the crew who can interpret for non-officers that speak different languages. In addition, ships officers must be able to communicate in a single language to adequately respond to emergencies at sea to minimize the effect of language barriers.<br>3. Provide a marine safety class and conduct monthly emergency drills for all crew as required by regulation.<br>4. Post clear pictorial signs by all operating and safety equipment to minimize the effect of language barriers.<br><br>We recommend that Crewmembers:<br>5. Wear a personal flotation device (PFD) at all times while on deck, while in a work boat, or while in a fishing operation-related helicopter.<br>6. Wear appropriate closed-toed footwear at all times while working on deck.<br>7. Use fall restraints when working from heights to perform maintenance activities.<br>8. Do not attempt confined-space entry without adequate training. Follow proper procedures and wear appropriate personal protective equipment.<br>9. Avoid standing underneath suspended loads.<br>10. Use man-overboard alarms to alert other crew members when a fall into the water has occurred. |
| Equipment Safety | To improve equipment safety:<br>1. Identify and do not exceed the safe loading limits of all cranes. This includes the mast and boom.<br>2. Complete and document periodic crane, mast, boom (rigging and gear) inspections.<br>3. Install guards over potentially hazardous equipment, such as fan blades.<br>4. Develop and maintain a proper lockout/tagout program for each vessel to prevent the unintended release of energy.<br>5. Keep all vessel equipment maintained regularly per manufacturer's guidelines. Track this effectively for each vessel and/or company fleet.<br>6. Follow the previously cited OSHA guidance on how to properly identify, test, and ventilate confined spaces prior to entry. |
| Vessel Safety | To improve vessel safety:<br>1. Continue to receive US Coast Guard annual dockside safety exams.<br>2. Conduct monthly emergency drills to practice recovering victims of falls overboard as well as proper procedures to abandon ship<br>3. Maintain/monitor watertight doors to keep closed.<br>4. Keep all helicopters on a regular maintenance schedule.<br>5. Consider vessel modifications to raise gunnels, install rails, and create more enclosed workspaces where possible to minimize the risk of falling overboard. |

*Recommendations are based on review of specific morbidity and mortality patterns for the DWTF during the investigation period, supplemented by previous NIOSH recommendations for other commercial fishing fleets.

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