HHS Public Access
Author manuscript
J Safety Res. Author manuscript; available in PMC 2021 December 01.

Published in final edited form as:
J Safety Res. 2020 December ; 75: 51–56. doi:10.1016/j.jsr.2020.07.005.

Predicting Commercial Fishing Vessel Disasters Through a Novel Application of the Theory of Man-Made Disasters

Samantha L. Case, MPH[a], **Devin L. Lucas, PhD**[a]

[a]Western States Division, National Institute for Occupational Safety and Health, 4230 University Drive Suite 310, Anchorage, AK 99508

Abstract

Vessel disasters (e.g., sinkings, capsizings) are a leading contributor to fatalities in the US commercial fishing industry. Primary prevention strategies are needed to reduce the occurrence of vessel disasters, which can only be done by developing an understanding of their causes and risk factors. If less serious vessel casualties (e.g., loss of propulsion, fire, flooding) are predictors of future disasters, then reducing vessel casualties should in turn reduce vessel disasters and the accompanying loss of life. This case-control study examined the association between vessel casualties and disasters using fishing vessels in Alaska during 2010–2015. The findings show that vessels that experienced casualties within a preceding 10-year period were at increased odds of disaster. Other significant predictors included safety decal status and hull material. The results of this analysis emphasize the importance of implementing vessel-specific preventive maintenance plans. At an industry level, specific prevention policies should be developed focusing on high-risk fleets to identify and correct a wide range of safety deficits before they have catastrophic and fatal consequences.

Keywords

Occupational safety; maritime; disaster incubation; drift

1. Introduction

> *"On the afternoon of April 21, 2015, a fire broke out in the forepeak machinery space on the uninspected fishing vessel* Northern Pride *while underway in the vicinity of Portlock Bank, Alaska. Smoke and fire spread quickly to the main cabin and wheelhouse, prompting the captain to broadcast a Mayday alert. The captain then ordered his crew to don their immersion suits and abandon ship into the vessel's inflatable life raft …. Shortly after rescue, the* Northern Pride *capsized."* (National Transportation Safety Board [NTSB], 2016)

Author Contact Information: Case (corresponding author): scase@cdc.gov; (907)-271-1569.

Disclaimer
The findings and conclusions in this report are those of the authors and do not necessarily represent the views of the National Institute for Occupational Safety and Health.

> *"About 0300 local time on June 10, 2015, the uninspected commercial fishing vessel* Kupreanof *began taking on water while transiting from Juneau to Bristol Bay, Alaska. About two and a half hours later, the vessel sank in 420 feet of water. All four crewmembers were rescued without injury by the Coast Guard soon after abandoning ship."* (NTSB, 2017)

> *"About 1600 on July 23, 2016, the commercial fishing vessel* Ambition *started taking on water in its lazarette while transiting in the Bering Sea near the northern entrance to False Pass off the Alaska Peninsula. The vessel began sinking by the stern, and efforts by the crew to determine the source of the flooding were unsuccessful. After the captain transmitted a distress call over VHF radio at 1832, the five crewmembers donned immersion suits and abandoned the vessel into the water and onto a good Samaritan vessel."* (NTSB, 2018)

Vessel casualties are consequences of failures within vessel-specific components or systems that may result in the loss of electrical power, propulsion, and steering. These failures, as well as human error, may also cause flooding, fires, and groundings. Vessel casualties are often resolved at sea or in port and do not cause loss of life or property. However, as shown in the above excerpts from fishing vessel sinking investigations, sometimes these failures are not immediately resolved, initiating chains of events that lead to vessel disasters (e.g., sinkings, capsizings) and associated fatalities.

Catastrophic vessel disasters are the leading contributor to occupational fatalities in the United States (US) commercial fishing industry, which is consistently one of the most hazardous industries nationwide (Bureau of Labor Statistics, 2018). During 2000–2014, 204 separate fatal vessel disasters resulted in 344 worker deaths in US fisheries, representing 50% of all fishing industry fatalities (Lucas & Case, 2018). Fishing vessel disasters involve a sequence of events that results in a final catastrophic event, such as a vessel sinking (Lucas & Case, 2018). Fatal vessel disasters in the US during 2000–2014 most frequently began with flooding (25%), instability (19%), struck by a large wave (19%), and collision (12%) (Lucas & Case, 2018).

As the leading cause of occupational fatalities, vessel disasters are a vital area to target prevention efforts. Prevention of vessel disasters has the potential to save many lives, especially since a single disaster can place multiple workers in danger at the same time. For most fishing vessels in the US, there are no safety requirements concerning their construction, maintenance, and watertight integrity. Current regulations vary based on vessel size, year built, and area of operation, but largely focus on secondary prevention of death through the carriage of lifesaving equipment used during vessel emergencies (United States Coast Guard [USCG], 2009). Primary prevention strategies are needed to reduce the occurrence of vessel disasters, which can only be done by first understanding their causes and risk factors.

Given the potential for vessel casualties to directly initiate a disaster, the broader role of vessel casualties in fishing vessel safety needs to be better understood. If a vessel experiences casualties over time, then that history of casualties may be a leading indicator of larger problems with the vessel that could trigger a future vessel disaster. This hypothesis is supported by the theory of man-made disasters developed by Turner (1978), which states that disasters involving complex man-made systems, such as fishing vessels, are not chance events. Instead, a sequence of events, often starting years prior to the disaster, occurs and escalates to the eventual disaster (Pidgeon & O'Leary, 2000; Turner, 1978; Turner & Pidgeon, 1997). In this sequence of events, a disaster incubation period exists in which unnoticed, misunderstood, or ignored events accumulate. Instead of recognizing these precursor events as warning signs of an impending disaster, workers fail to perceive the warning events as such or fail to adequately assess the risk (Pidgeon & O'Leary, 2000; Turner, 1978; Turner & Pidgeon, 1997). This results in a drift toward failure over time in which the tolerance for safety threats, perhaps subconsciously, increases (Dekker, 2011; Dekker & Pruchnicki, 2014). This can occur as safety, productivity, and other goals compete, reducing safety margins. Until a catastrophic failure occurs, workers and organizations believe hazards are adequately controlled (Dekker, 2011; Dekker & Pruchnicki, 2014; Pidgeon & O'Leary, 2000; Turner, 1978; Turner & Pidgeon, 1997).

If vessel casualties are indeed a predictor of a future vessel disaster, then reducing vessel casualties should in turn reduce vessel disasters and the accompanying loss of life. This association has not been previously examined. The purpose of this study was to test the novel hypothesis that fishing vessel casualties are leading indicators of future vessel disasters using data from fishing vessels operating in Alaskan waters during 2010–2015.

2. Methods

2.1 Study Design

A case-control study design was used. Cases were identified from the Commercial Fishing Incident Database (CFID), a system managed by the National Institute for Occupational Safety and Health (NIOSH) that stores data on marine casualties in the US commercial fishing industry (Lucas & Case, 2018). A commercial fishing vessel was included as a case in this study if it was involved in a vessel disaster in Alaskan waters during 2010–2015. A vessel disaster was defined as any catastrophic event that occurred to a vessel resulting in the entire crew abandoning the vessel, such as a sinking or capsizing.

Cases were limited to decked catcher and tender vessels. Catcher vessels are those that are used to harvest fish and shellfish, whereas tender vessels transport fish from the catcher vessels to port. Processing vessels (i.e., vessels that include onboard factories for production and packaging) were excluded from the study, in part because there were no vessel disasters involving processing vessels during the study period. Skiffs were also excluded as cases in this study because they are small (typically under 26' in length) and undecked, a considerable contrast to catcher and tender vessels. In rare instances where a vessel experienced more than one disaster during the study period (e.g., vessel capsized or grounded in 2011 but was salvaged; later sank in 2014), the vessel was only included as a case once, at the time of the first disaster.

Controls were defined as commercial fishing vessels that were active in Alaskan waters during 2010–2015 and did not experience a vessel disaster during that time, in Alaska or elsewhere. Because fisheries landings data were confidential and therefore not available, a

Author Manuscript
Author Manuscript
Author Manuscript

list of unique commercial fishing vessels most likely to be active in Alaska was developed for each year in the study period using two other data sources: 1) annual lists of commercial fishing vessels licensed to operate in Alaskan waters obtained from the State of Alaska Commercial Fisheries Entry Commission (CFEC) Commercial Vessel Database (State of Alaska, n.d.); and 2) annual lists of vessels with federal fishery permits obtained from the National Oceanic and Atmospheric Administration (NOAA) Fisheries Alaska Region (NOAA, n.d.). These two data sources provided the best publicly available proxy for active vessels. Alaska statutes AS 16.05.475 and AS 16.43.150(d) indicate that vessel licenses must be renewed whenever a vessel is to be used in a particular year for commercial fishing in state waters, whereas state limited entry permits must be renewed annually irrespective of whether the permits are actually used in a particular season (Registration of Fishing Vessels, 2007; Terms and Conditions of Entry Permit; Annual Renewal, 2007). Federal fishery permits were used to include a small number of vessels that could potentially operate solely in federal waters and would not otherwise be included in the CFEC list. The two lists were merged, and duplicate vessels were dropped before control selection. Skiffs and processing vessels were excluded from the sampling frame to align with cases as described above.

For each case, three control vessels were randomly selected from the list of all vessels active during the same year. For example, there were 10 cases in 2010; therefore, 30 control vessels were randomly selected from the list of vessels active in 2010. This process was repeated for each year of the study period. Cases and controls were incorporated into a master dataset for additional data collection and analysis.

2.2 Data Collection on Exposure Variables

Vessel casualty history was the primary risk factor of interest in this study. Vessels that are federally documented and/or have any interaction with the US Coast Guard can be found in their Marine Information for Safety and Law Enforcement (MISLE) system. Vessel casualties are required to be reported to the Coast Guard (Notice of Marine Casualty, 1994). When reported, casualty data are associated with the vessel within its activity history in MISLE. NIOSH researchers with access to MISLE reviewed activity histories for each vessel to identify any reported casualties within 10 years prior to the disaster or when the control was selected (i.e., inclusion year) (Table 1). Casualty history was only collected for vessels built at least 10 years prior to the study inclusion year.

In addition to vessel casualty history, documentation status was determined for each based on its registration number. Commercial fishing vessels at least five net tons are required to be federally documented (Vessels Requiring Documentation, 1993). A vessel was classified as federally documented if it had an official number assigned (e.g., 123456). In contrast, a state registered vessel only had a registration number with the State of Alaska (e.g., AK0001K).

Fishing vessel safety decal status was obtained from MISLE. A fishing vessel safety decal is issued after a successful dockside examination by the Coast Guard or an approved third-party organization, showing compliance with federal regulations, including carriage of lifesaving equipment (USCG, 2007). Safety decal status was recorded as current or expired if the vessel had a safety decal on or prior to the disaster date (cases), or anytime during or prior to the inclusion year (controls).

Other vessel characteristics included in this study were vessel age, length, and hull material. Due to the high correlation of length and tonnage, length was included as the preferred variable given the emphasis on vessel length in commercial fishing vessel safety regulations. Data on these characteristics were obtained from the original CFID, CFEC, or NOAA source as applicable. Vessel age was determined for each vessel as the difference between the inclusion year and year built.

2.3 Analysis

Data analysis was performed using Stata SE v15.1 (StataCorp, 2017). A descriptive analysis of the sampling frame, cases, and controls was conducted to explore characteristics of each. Logistic regression was used to calculate odds ratios (OR) and 95% confidence intervals (CI) to measure the association between the exposure variables and the outcome (disaster). Unadjusted ORs were calculated for casualty history (one or more casualties / no casualties), documentation (federally documented / state registered), fishing vessel safety decal status (current / expired / none), vessel age (<25 years / ≥25 years), vessel length (<50’ / 50–78’ / ≥79’), and hull material (fiberglass / aluminum / steel / wood). The categories for length and age were chosen based on current or proposed fishing vessel safety regulations. The multivariable model included all variables. Post-regression diagnostics including goodness of fit and variance inflation factors were performed to assess model fit and multicollinearity. Because 10-year casualty history was not applicable for vessels less than 10 years of age, those vessels were excluded from models examining casualty history.

3. Results

3.1 Characteristics of Sampling Frame, Cases, and Controls

Characteristics of the sampling frame, cases, and controls are described below. Table 2 also presents cases and controls for comparison.

3.1.1 Sampling Frame—Based on CFEC and NOAA records, 7,309 total unique decked catcher and tender vessels operated in Alaska during 2010–2015, with 5,956 active vessels per year on average. Most fishing vessels were federally documented (5,584, 76.4%). Vessels were a mean 42’ in length (26–194’) and built in 1979 (1907–2015). Over half of vessels were fiberglass (3,798, 52.0%), followed by aluminum (1,794, 24.5%), steel (879, 12.0%), and wood (810, 11.1%).

3.1.2 Cases—Seventy fishing vessels were identified as cases during the six-year study period, averaging nearly 12 vessel disasters per year in Alaska. Of these, the majority were nonfatal events (66, 94.3%). Three types of initiating events caused the majority of disasters: running aground (21, 30.0%), flooding (12, 17.1%), and instability (10, 14.3%). Most vessel disasters were sinkings (45, 64.3%), followed by groundings (18, 25.7%). In seven other disasters (10.0%), the vessels capsized, burned, or otherwise experienced severe damage but remained afloat.

Most cases were federally documented (59, 84.3%). On average, cases were 48’ in length (26 – 110’) and were built in 1973 (1927 – 2011). At the time of disaster, vessels were a mean 40 years old (1 – 84 years), with three vessels less than 10 years. Hull material was most often fiberglass (29, 41.4%), steel (18, 25.7%), wood (16, 22.9%). Cases were nearly evenly distributed among the three decal status categories. Twenty-four vessels (34.3%) had a valid decal at the time of disaster, with an additional 22 (31.4%) operating with an expired decal.

Seventeen of the 67 cases that were ≥ 10 years old at the time of disaster (25.4%) had a history of vessel casualties within the preceding 10 years. Of these, the most common initiating event for disasters was running aground (7, 41.2%), followed by engine failure, fire, flooding, and instability, resulting in two disasters each. Overall, the 17 cases reported 24 total casualties, ranging from 1–3 casualties per vessel. The leading prior casualty types were grounding (8, 33.3%), loss of power (6, 25.0%), flooding (3, 12.5%), and loss of steering (3, 12.5%). For five vessels, the initiating event of the disaster was the same type as at least one of its prior casualties: grounding (4) and fire (1).

3.1.3 Controls—In total, 210 controls were randomly selected. Controls were predominantly federally documented (181, 86.2%). Vessels were a mean 41’ in length (26–149’) and, on average, built in 1978. The mean vessel age of controls based on inclusion year was 34 years (0–94 years). Thirteen vessels were less than 10 years old. The majority of controls were fiberglass (121, 57.6%) or aluminum (45, 21.4%). Most controls had either a valid (84, 40.0%) or expired (47, 22.4%) decal during their inclusion year.

Eighteen of the 197 controls that were ≥ 10 years old at the time of inclusion (9.1%) reported 24 total casualties within the preceding 10-year period, with individual vessels reporting 1–3 casualties. The leading types of casualties among controls were grounding (7, 29.2%), loss of propulsion (5, 20.8%), and collision (5, 20.8%).

3.2 Predictors of Disaster

In the unadjusted models, the significant predictors of disaster were: having one or more casualties within 10 years (OR = 3.38; 95% CI = 1.62–7.04); vessel length of 50–78’ (OR = 2.70; 95% CI = 1.43–5.10) or ≥79’ (OR = 3.47; 95% CI = 1.11 – 10.86), and a steel (OR = 4.42; 95% CI = 2.03–9.61) or wood hull (OR = 2.47; 95% CI = 1.18–5.18) (Table 3). The multivariable model showed that casualty history and steel hull remained significant. In addition, having an expired decal was significantly associated with increased risk of disaster (OR = 2.41; 95% CI = 1.09 – 5.30). Post-regression diagnostic tests found no evidence for poor model fit (Pearson χ^2 = 58.4; p=0.253) or multicollinearity (Mean VIF = 1.76).

4. Discussion

The Commercial Fishing Industry Vessel Safety Act (CFIVSA) of 1988 was the first US legislation to establish safety standards for the fishing industry (Hiscock, 2002). The regulations, implemented in the early 1990s, require most fishing vessels to carry survival equipment, such as personal flotation devices (PFDs), immersion suits, life-rafts, throwable flotation devices, distress signals, emergency position indicating radio beacons (EPIRBs), and fire extinguishers (USCG, 2009). Access to this lifesaving equipment resulted in increasing case-survivor rates for vessel disasters in Alaska, from 78% in 1991–1993, to 92% in 1994–1996, to 94% in 1997–1999 (NIOSH, 2002), and research has shown that immersion suit and life-raft use improves chances of survival when immersed in cold water after fishing vessel sinkings (Lucas et al., 2018). While this is a remarkable improvement in survivability, vessel disasters continue to occur and contribute to the high rate of fatalities in the fishing industry (Lucas & Case, 2018). In addition to ensuring crewmembers have the skills and equipment needed to survive, there is a clear need for prevention of fishing vessel disasters altogether.

While other studies have described the more direct causes and risk factors of fishing vessel disasters (Jin et al., 2002; Lincoln & Lucas, 2010; Lucas & Case, 2018), this is the first to explore historical patterns of vessel safety problems that may be less directly associated with the onset of disaster. The theory of man-made disasters suggests that disasters are the result of failure of foresight; that is, the inability to recognize and mitigate warning signs and safety threats (Pidgeon & O'Leary, 2000; Turner, 1978; Turner & Pidgeon, 1997). The theoretical framework for this study posited that vessel casualties are safety threats that are often ignored, or even considered successes through no loss of life or property. Vessel casualties may not be merely mechanical failures; rather, they may be indicative of breakdowns in the larger systems and demands in place that affect decision-making. The findings support our hypothesis and show an elevated risk of disaster when a vessel has experienced casualties within a preceding 10-year period, even after adjusting for a host of other factors. As vessel casualties occurred in the disaster incubation period, competing demands related to money, time, and compliance with regulations may have led to a misinterpretation of, or increased tolerance for, risk. In most cases, there was no apparent link between the prior casualty type(s) and the initiating events of the vessel disaster (e.g., a prior flooding issue is not fully resolved or repaired, resulting in progressive flooding and sinking), lending more support to the theory that these events often arise through decreasing safety margins rather than more direct associations.

In a more immediate and practical sense, vessel owners and operators should be cognizant of the association between casualties and disasters, and work to establish a strong safety management system on their vessels that emphasizes risk assessments and preventive maintenance. Different strategies are needed to address the variety of casualty types, such as fire, flooding, steering failure, and loss of propulsion and power. For instance, fire prevention includes inspecting and maintaining fuel lines and ventilation systems, identifying leaks in hoses and piping systems, practicing good housekeeping, and repairing electrical wiring that could serve as potential ignition sources (USCG, 2006). Flooding prevention includes in-depth inspection and maintenance of the vessel hull and through-hull fittings, inspection and testing of high-water alarms and bilge pumps before each trip, and stocking a damage control kit (USCG, 2006). All vessel owners and operators should formalize a maintenance plan for their vessel and systems, and adhere to the established maintenance schedule (NIOSH, 2016). Being proactive, rather than reactive, improves vessel safety and may reduce lost days at sea.

The concept of preventing vessel casualties, and thus disasters, is not new. In the early 2000s, the Coast Guard determined that some fishing vessels operating in the Bering Sea were also conducting processing activities but failed to meet the classification and load line standards required for processing vessels (USCG, 2015). The Coast Guard engaged industry members and used its regulatory authority to develop the Alternate Compliance and Safety Agreement (ACSA) for some factory trawlers and freezer longliners (USCG, 2015). This program includes specific safety standards that participating vessels must comply with to conduct minimal processing activities. ACSA focuses on primary prevention of vessel disasters by addressing vessel stability, propulsion, vital piping systems, fire prevention, and electrical generation machinery (USCG, 2015). Lucas et al. (2014) conducted an evaluation of ACSA and found that the rate of serious casualties decreased after vessels complied with ACSA requirements.

More recently, the Coast Guard Authorization Act of 2010 and the Coast Guard and Marine Transportation Act of 2012 included a provision for the Coast Guard to develop an Alternative Safety Compliance Program (ASCP) for commercial fishing vessels ≥50’ in length and ≥25 years of age (USCG, 2017). The ASCP was suspended during development in lieu of a voluntary program (Voluntary Safety Initiatives and Good Marine Practices) (USCG, 2017). However, like ACSA, the guidance includes prevention measures involving firefighting equipment, machinery and electrical safety, flooding control, stability standards, and material condition (USCG, 2017). While our study did not find evidence of elevated risk based on length or age after controlling for other factors, it is likely that compliance with these guidelines would result in reductions in vessel casualties and disasters, similar to ACSA. Regardless of whether the ASCP is revived in future rulemaking efforts, specific prevention programs should be developed to target high-risk fleets and their safety problems, based on quantitative risk assessments.

The findings of this study also support the Coast Guard’s dockside examination program, as vessels with expired decals had higher odds of disaster than those with current decals. The dockside examination and safety decal are not equivalent to vessel inspections and thus do not focus on the condition of the vessel itself, but rather on the carriage and maintenance of lifesaving equipment, and functionality of critical systems (e.g., navigation, communication, firefighting, alarms) (USCG, 2007). However, the examinations provide an opportunity for Coast Guard personnel to meet with fishing vessel owners, operators, and crewmembers to educate them on fleet-specific risks and good marine practices. The Coast Guard has found that, within a given year, as dockside examination activity increases, vessel losses decrease (USCG, 2006). Like vessel casualty history, decal status could be a proxy for beliefs and behavior around safety on fishing vessels.

Documentation status is a determining factor in which regulations apply. There are additional requirements for documented vessels operating beyond the boundary lines, which, according to the regulations, “follow the trend of the seaward high-water shorelines and cross entrances to small bays, inlets, and rivers” (Requirements for Commercial Fishing Industry Vessels, 1991). These requirements include CPR and first aid training, emergency drills, safety orientation, high water alarms, bilge pumps, and some machinery guards (Requirements for Commercial Fishing Industry Vessels, 1991). Our analysis did not reveal evidence to indicate any difference in risk between federally documented and state registered vessels.

Vessels with steel hulls were more likely to experience a vessel disaster than vessels with fiberglass hulls. It is possible that this finding has little to do with the actual hull material and more to do with different exposures typically experienced by vessels of various sizes and configurations. For instance, steel vessels tend to be larger than fiberglass vessels and fish farther off shore for longer periods of time, often year-round. These exposures to more hazardous conditions for longer duration may explain why steel hulled vessels were more likely to experience vessel disasters than smaller fiberglass vessels operating in protected waters during summer months. In this analysis, it was not possible to control for differences in exposures between vessels. Future research may find new ways to measure and control for varying levels of exposure to hazards.

Aging of the fleet is a concern in the commercial fishing industry. Vessels in the North Pacific fleet, for example, are 40 years old on average, with many built in the 1970s (McDowell Group, 2016). This is consistent with the age of vessels included in this study. Increased vessel age was not found to be a significant risk factor for disaster, but this is most likely because the age of cases and controls were similar, with most vessels in both groups ≥25 years. Therefore, we cannot rule out increased age as a risk factor. Newer vessels may provide a host of benefits, including improved safety by meeting the modern build standards for new construction (McDowell Group, 2016). However, vessel replacement costs and obtaining the financing for new builds may be a barrier, particularly for vessel owners that are not associated with large seafood companies (McDowell Group, 2016).

5. Conclusions

Vessel disasters are the leading cause of work-related fatalities among commercial fishermen in the US. Although the likelihood of surviving these events has increased since the introduction of safety standards in 1988, their continued occurrence is a concern. This is the first study to identify vessel casualties as a predictor of future disasters. Vessel casualties are just one of many risks in commercial fishing vessel safety. Additional research applying the man-made disaster theory and drift (toward failure) should focus on identifying other threats and ways to explain and control drift in the fishing industry. Efforts should be made by the Coast Guard, marine safety trainers, and researchers to work collaboratively with industry members to voluntarily enhance preventive policies and procedures onboard fishing vessels.

Several study limitations should be considered. As of this writing, no historical data are readily available on all active fishing vessels in the US. Landings data are confidential on state and federal levels, and federal documentation records were determined to be an unreliable proxy for activity. Therefore, only Alaskan vessels were included in this study, leaving the generalizability of the findings outside of Alaska unknown. However, a joint project by NOAA Fisheries, the Coast Guard, and NIOSH to consolidate and track active vessels in federal fisheries is underway. These vessel data may be used in future research. Further, vessels were not included based on landings, which could mean that some non-operational vessels were inadvertently included in the population from which the controls were selected. The impact of this was minimized by primarily using licensed vessels, which better represent an intent to operate compared to vessel permits that automatically renew. In addition, it is possible that vessel casualties were underreported to the Coast Guard, particularly in situations where the casualty was resolved at sea or when Coast Guard assistance was not required. This could result in nondifferential misclassification of the 10-year casualty history. Lastly, examining the role of vessel systems and characteristics is only one component of understanding and preventing catastrophic disasters. Although vessel casualties may be indicative of other failures, such as inadequate maintenance schedules or operating in dangerous conditions, this study does not explicitly account for or quantify other factors that may also contribute to disasters, including fatigue, inattention, seasonality, weather, operating region, fishery, or policies. Future safety research in the fishing industry should explore these issues to determine to what extent each contributes to adverse events. Because of the considerable differences in how fishing operations are conducted, such research should be specific to fisheries and regions to ensure that safety solutions have the maximum effect as they are appropriately tailored.

Acknowledgements

The authors thank Jennifer Lee for assisting with data collection for the study.

Funding Sources

This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

References

Bureau of Labor Statistics. (2018). Fatal occupational injuries, total hours worked, and rates of fatal occupational injuries by selected worker characteristics, occupations, and industries, civilian workers, 2017 [Data file]. Retrieved from https://www.bls.gov/iif/oshcfoi1.htm#rates.

Dekker S (2011). Drift Into Failure Farnham, Surrey: Ashgate.

Dekker S, Pruchnicki S. (2014). Drifting into failure: theorizing the dynamics of disaster incubation. Theor Issues Ergon Sci; 15(6): 534–544.

Hiscock RC. (2002). Fishing vessel safety in the United States: The tragedy of missed opportunities. In: Paper presented at the International Fishing Industry Safety and Health Conference, Woods Hole, MA.

Jin D, Kite-Powell HL, Thunberg E, Solow AR, Talley WK. (2002). A model of fishing vessel accident probability. J Saf Res; 33: 497–510.

Lincoln JM, Lucas DL. (2010). Occupational fatalities in the United States commercial fishing industry, 2000–2009. J Agromedicine; 15(4): 343–350. [PubMed: 20954029]

Lucas DL, Case SL. (2018). Work-related mortality in the US fishing industry during 2000–2014: New findings based on improved workforce exposure estimates. Am J Ind Med; 61(1): 21–31. [PubMed: 28833290]

Lucas DL, Case SL, Lincoln JM, Watson JR. (2018). Factors associated with crewmember survival of cold water immersion due to commercial fishing vessel sinkings in Alaska. Saf Sci; 101: 190–196. [PubMed: 29861549]

Lucas DL, Kincl LD, Bovbjerg VE, Branscum AJ, Lincoln JM. (2014). Primary prevention of fishing vessel disasters: Evaluation of a United States Coast Guard policy intervention. Mar Policy; 50: 67–73.

McDowell Group. (2016). Modernization of the North Pacific Fishing Fleet: Economic Opportunity Analysis [PDF file]. Prepared for Port of Seattle and Washington Maritime Federation. Retrieved from https://www.portseattle.org/sites/default/files/2018-03/Fleet%20Modernization%20Final%2011_11.pdf.

NIOSH. (2002). Surveillance and Prevention of Occupational Injuries in Alaska: A Decade of Progress, 1990–1999 OH: US Department of Health and Human Services, Centers for Disease Control and Prevention, National Institute for Occupational Safety and Health DHHS (NIOSH) Publication No. 2002–15.

NIOSH. (2016). Assessment of Safety in the Bering Sea/Aleutian Island Crab Fleet By Lucas D, Case S, Teske T, DeLeon A, Kloczko D. OH: US Department of Health and Human Services, Centers for Disease Control and Prevention, National Institute for Occupational Safety and Health DHHS (NIOSH) Publication No. 2016–112.

NOAA. (n.d.). Federal Fisheries Permits [Date file]. Available from https://alaskafisheries.noaa.gov/permits-licenses.

Notice of Marine Casualty, 46 CFR § 4.05–1 (1994, as most recently amended Mar. 19, 2018).

NTSB. (2016). Marine Accident Brief: Fire on board Fishing Vessel Northern Pride, with Subsequent Capsizing (NTSB/MAB-16/12).

NTSB. (2017). Marine Accident Brief: Sinking of Fishing Vessel Kupreanof (NTSB/MAB-16/23).

NTSB. (2018). Marine Accident Brief: Flooding and Sinking of Fishing Vessel Ambition (NTSB/MAB-18/04).

Pidgeon N, O'Leary M. (2000). Man-made disasters: why technology and organizations (sometimes) fail. Saf Sci; 34(1–3): 15–30.

Registration of Fishing Vessels, AS 16.05.475 (2007).

Requirements for Commercial Fishing Industry Vessels, 46 CFR Part 28 (1991).

StataCorp. (2017). Stata Special Edition [computer software] College Station: StataCorp LLC.

State of Alaska. (n.d.). CFEC Public Search Application: Vessels Yearly Download [Data file]. Available from https://www.cfec.state.ak.us/plook/#downloads.

Terms and Conditions of Entry Permit; Annual Renewal, AS 16.43.150(d) (2007).

Turner BA. (1978). Man-Made Disasters London: Wykeham Publications.

Turner BA, Pidgeon NF. (1997). Man-Made Disasters (Second Edition). London: Butterworth-Heinemann.

USCG. (2006). Vessel maintenance can reduce vessel risk – United States Coast Guard Fishing Vessel Safety Program, issue 6E [PDF File]. Retrieved from http://www.fishsafewest.info/PDFs/HQSafetyFlyers/6E-MaintenanceProblems.pdf.

USCG. (2007). Dockside Safety Examinations - United States Coast Guard Fishing Vessel Safety Program Flyer, issue 8E [PDF file]. Retrieved from https://www.dco.uscg.mil/Portals/9/DCO%20Documents/5p/CG-5PC/CG-CVC/CVC3/notice/flyers/8E-Dockside_Exams.pdf.

USCG. (2009). Federal Requirements for Commercial Fishing Industry Vessels [PDF file]. Retrieved from https://www.fishsafe.info/FederalRequirementsCFV2009.pdf.

USCG. (2015). Guidance for the Alternate Compliance and Safety Agreement Program (ACSA) [PDF file]. Retrieved from http://www.fishsafewest.info/acsa/ACSA_Guide_24Mar_2016.pdf.

USCG. (2017). Voluntary Safety Initiatives and Good Marine Practices for Commercial Fishing Industry Vessels [PDF file]. Retrieved from http://www.fishsafewest.info/News/VoluntarySafetyInitiativesAndGoodMarinePractices.pdf.

Vessels Requiring Documentation, 46 CFR § 67.7 (1993, as most recently amended Sept. 25, 2009).

Table 1.

Distribution of cases and controls by year with casualty history parameters.

Inclusion Year	Cases (n=70)	Controls (n=210)	10-Year Casualty History Timeframe
2010	10	30	2001–2010
2011	14	42	2002–2011
2012	14	42	2003–2012
2013	12	36	2004–2013
2014	10	30	2005–2014
2015	10	30	2006–2015

Author Manuscript

Author Manuscript

Author Manuscript

Table 2.

Characteristics of case and control vessels.

	Cases (n=70)		Controls (n=210)	
	n	**%**	**n**	**%**
10- Year Casualty History				
No Casualties	50	74.6	179	90.9
One or More Casualties	17	25.4	18	9.1
Not applicable (<10 years old)	3	-	13	-
Documentation				
Federally Documented	59	84.3	181	86.2
State Registered	11	15.7	29	13.8
Fishing Vessel Safety Decal				
Current	24	34.3	84	40.0
Expired	22	31.4	47	22.4
None	24	34.3	79	37.6
Age (years)				
<25	13	18.6	45	21.4
≥25	57	81.4	165	78.6
Length (feet)				
<50	42	60.0	170	81.0
50–78	22	31.4	33	15.7
≥79	6	8.6	7	3.3
Hull Material				
Fiberglass	29	41.4	121	57.6
Aluminum	7	10.0	45	21.4
Steel	18	25.7	17	8.1
Wood	16	22.9	27	12.9

Table 3.

Factors associated with fishing vessel disasters.

	Unadjusted OR (n=280*)	95% CI	Adjusted OR (n=264)	95% CI
10-Year Casualty History				
No Casualties	1	-	1	-
One or More Casualties	**3.38**	**1.62–7.04**	**2.98**	**1.29–6.89**
Documentation				
Federally Documented	1	-	1	-
State Registered	1.16	0.55–2.47	2.15	0.83–5.53
Fishing Vessel Safety Decal				
Current	1	-	1	-
Expired	1.64	0.83–3.23	**2.41**	**1.09–5.30**
None	1.06	0.56–2.02	1.59	0.74–3.42
Age (years)				
<25	1	-	1	-
≥25	1.20	0.60–2.38	0.56	0.23–1.38
Length (feet)				
<50	1	-	1	-
50–78	**2.70**	**1.43–5.10**	1.37	0.56–3.34
≥79	**3.47**	**1.11–10.86**	1.23	0.28–5.54
Hull Material				
Fiberglass	1	-	1	-
Aluminum	0.65	0.27–1.59	0.42	0.13–1.28
Steel	**4.42**	**2.03–9.61**	**3.29**	**1.12–9.68**
Wood	**2.47**	**1.18–5.18**	2.26	0.92–5.58

* Unadjusted models included all 280 vessels except for 10-year casualty history (n=264), due to the exclusion of the vessels <10 years in that model.