Occupational Safety and Regulatory Compliance in US Commercial Fishing

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ABSTRACT

This study explored occupational safety practices and regulatory compliance in a representative sample of Maine commercial fishing vessels. Data were collected on demographic characteristics, safety equipment and training, and regulatory compliance during at sea boardings of working commercial fishing vessels (n=259). Trends in safety and compliance were explored using standard comparison tests and principal component analysis. More than 40% of vessels were not in compliance with applicable safety regulations. That rate was lower for fishermen subjected to more stringent and costly safety requirements. The vast majority of fishermen were not safety trained, and many were not familiar with the proper use and maintenance of life-saving equipment. There is a clear need for better safety training in this industry. Educational efforts should be targeted at the local level at minimal cost to fishermen to encourage participation.

INTRODUCTION

Commercial fishing is consistently ranked as one of the most dangerous occupations in the United States.[1] In a recent report by the Bureau of Labor Statistics,[2] the fatality rate for fishermen was over three times higher than the second most dangerous occupation, logging. Fishing vessel crews work through dangerous weather and fatigue, using complex and hazardous deck machinery to haul, sort, and store their catch at sea.[3] These workers are vulnerable to marine hazards such as vessel sinking, capsizing, fire, grounding, and collision, as well as occupational hazards related to the harvesting and processing of fish onboard. Based on a recent review of fishing vessel accidents by the US Centers for Disease Control and Prevention,[4] more than half of the fishing-related fatalities over the last decade were caused by vessel disasters (52%), attributed primarily to vessel flooding and instability, as well as impact with rogue waves. Another third of the fishermen fatalities were the result of falls overboard; of those deaths, more than half were working alone and none were wearing personal flotation devices. Falls overboard represent a particular problem in the lobster fishery, as these workers commonly operate alone and there is a high risk of entanglement with lobster gear and slick deck conditions.[3]

The Northeast fisheries face the additional hazard of severe environmental conditions and cold water temperatures compared to other regions of the US.[5] Not surprisingly, this region accounts for 25% of the commercial fishing fatalities nationally over the last decade (narrowly surpassed only by the Alaskan region with 26%).[4] Due to extreme wind and tidal forces along the rocky New England coastline, accident rates are highest in the small-scale fleet (<79 feet) operating close to shore.[3,6]

US commercial fishing vessels are subject to occupational safety regulations, but the applicable standards vary based on vessel and crew size, fishing location and fishery, registration status, etc., and the resources necessary for the enforcement of these standards is limited.[3] However, the fishing industry has made strides in improving safety practices since the 1988 passage of the Commercial Fishing Vessel Safety Act.[3] Despite these improvements nationally, fishing fatalities have continued to rise in the US Northeast region.[4-5]

Fishermen typically acquire their occupational skills on the water without any formal job training. Many fishermen come from families with a strong fishing heritage, and workers in this occupation are known for their independence and sense of cultural identity.[7-9] The rate of self-employment in the fishing industry is among the highest in the US workforce.[10] As independent operators, commercial fishing boat captains are economically vulnerable to the fluctuating price of their catch as well as the cost of inputs such as bait and fuel. In addition, much of the fishing activity is seasonal and income levels are generally not stable throughout the year. From a safety perspective, individual fishermen have the primary responsibility for maintaining proper safety practices on their vessels, as they are not served by industry or union training and safety protocols.[11] This is especially true in the small-scale fishing fleet (<79ft), where the applicable state and federal safety requirements are limited to basic lifesaving, communication, and portable firefighting equipment.[3] Additional investments in safety equipment and training represent a significant cost to this self-employed workforce; although they enjoy the full benefit of additional safety precautions, they must also absorb 100% of the cost of enhanced safety onboard.

To reduce the rate of injury and death in the fishing industry, it is essential to understand how fishermen mitigate the occupational hazards of fishing, whether or not these mitigation strategies are government mandated. From a regulatory perspective, it is informative to explore compliance rates with existing federal and state safety regulations to better inform training and enforcement efforts, as well as to understand the potential impact of increasing safety requirements. This latter objective especially relevant in the small-scale fishing fleet that is not currently subject to stringent safety standards, but where increasing safety regulations are imminent based on the currently ongoing review of the 1988 Act in the US Congress.

MATERIALS AND METHODS

A comprehensive survey of commercial fishermen is challenging because they often work across a broad geographic area, and are not centrally located in a factory or similar work environment that would facilitate a population survey. This is evident in the generally low sample sizes available from previous studies exploring risk and safety in the industry.[7,9,11-12] Although it is possible to construct a list of licensed commercial fishermen and administer a mail survey, these lists would be fishery-specific and limited to the geographic reach of the licensing agencies. Also, a simple licensing list would not be representative of the fishermen actively engaged in the trade. To complicate matters, the probability of a widespread response from this cohort to a mail survey is low, and fishermen would be unlikely to respond truthfully to questions regarding compliance with safety regulations.

To overcome these problems, a study was designed to directly solicit information on safety practices during the boarding of working commercial fishing vessels at sea. The boardings were conducted in cooperation with the Maine Marine Patrol, and funding for this work was provided by the National Oceanic and Atmospheric Administration and Maine Sea Grant. Commercial fishing captains across the entire stretch of Maine coastline from Kittery to Eastport were recruited to participate in this study during their normal at sea operations. Due to the feasibility of locating working commercial fishing vessels on the water and project budget considerations, the survey was limited to inshore fisheries and primarily consisted of vessels operating within three miles of the Maine coastline. However, the majority of the US fishing fleet is represented by small-scale vessels similar to those targeted in this study,[3] and as such the results should provide valuable insight into occupational safety in this region and more generally across the US commercial fishing fleet.

A brief safety questionnaire was administered to the captains that took approximately five to ten minutes to complete. This questionnaire was a simplified version of the *Commercial Fishing Vessel Safety Examination Checklist* and was developed in collaboration with Kevin Plowman, the US Coast Guard (USCG) Commercial Fishing Vessel Safety Examiner for Northern New England. The current survey focused on cataloguing the existence of the equipment onboard, and excluded a detailed examination of equipment quality. This would have taken too much of the fishermen's time to be feasible for the current study, and would have required the participation of USCG safety personnel (as opposed to Maine Marine Patrol) on each boarding. To ensure the confidentiality of the study participants, individually identifiable

information was not recorded, i.e. no name, license number, or vessel identification. The sampling protocol was approved by the University of Maine's Institutional Review Board for the Protection of Human Subjects

Commercial fishing vessels were selected from those operating in the study area on the days the survey was conducted. All vessels operating within the vicinity of the Marine Patrol vessel were approached to complete the survey, and 100% of those fishermen solicited to participate in the study agreed to do so. After obtaining consent for participation, the fishing vessel captains were asked the series of questions about safety equipment, training, vessel and captain characteristics. A list the data collected on safety equipment is provided in Table 1, along with a description of each item and an estimate of the cost of acquisition and maintenance. Where necessary, their responses were confirmed with a brief check of the visible safety equipment onboard. For example, captains were asked to show the location of their survival suits, to test the horn, to display the contents of their first aid kit, etc. In addition to noting the existence of a piece of safety equipment, information on quality and accessibility were noted in narrative form on the questionnaires.

One of the primary goals of this study was to inventory existing equipment uniformly across the occupational group, and to assess the extent to which strengthening the safety regulations would impact those vessels currently subjected to only minimal standards. The question of regulatory impact is very relevant to the ongoing policy debate and legislative efforts to increase safety requirements, i.e. vessels not currently required to carry certain safety equipment may soon be required to do so under pending legislation. Therefore, the survey questions were applied uniformly across all vessels

sampled, and were not limited to the existing regulatory requirements that varied by characteristics such as fishing location, vessel and crew size, and licensing status. However, this is not to suggest that all vessels should be required to have all of the equipment on the checklist. In this study, the actual regulatory compliance reported for each of the surveyed vessels was judged based on the applicable regulations specific to that individual vessel. For example, a vessel not required to have a life raft was not judged 'out of compliance' for the purposes of this study, despite the fact that these data were part of the uniform safety questionnaire.

The survey data were analyzed using STATA 10.1 (College Station, TX). Statistically significant comparisons were explored using the appropriate chi-square or t test statistics, and principal component analysis was used as an exploratory tool to identify trends among the safety equipment data.

RESULTS

Summary of the Study Population

A total of 259 vessels were surveyed for this project during an approximate two-year period between October 2007 and August 2009. A map of the at sea boarding locations is provided in Figure 1A, and includes the regulatory boundary line delineating safety requirements. Also provided is a second map of the home ports of the participating captains (Figure 1B), where the size of the home port circle reflects the number of fishing vessels from each location. These maps provide evidence of a broad sampling of fishermen across the Maine coastline, and a survey population that is geographically representative of Maine coastal waters. The captain and vessel

characteristics of the population of lobstermen sampled were also consistent with a recent large-scale survey of the New England lobster fishery,[13] providing further evidence of the representativeness of the current study population.

A breakdown of the boarding data by fishery and season is provided in Table 2. The surveyed vessels are generally representative of the inshore fisheries in the state, with some underrepresentation of the primary inshore fishery, lobster. Although lobster is by far the largest fishery in terms of dollar value in Maine, the study disproportionately focused on smaller fisheries operating in the northern half of the Maine coastline (known as Downeast) to obtain a more geographically diverse picture of the industry.

A summary of the surveyed captain and vessel characteristics is provided in Table 3. The typical commercial fishing vessel was owner operated, 35 feet long, and nearly 20 years old. The typical crew consisted of two middle-aged Caucasian men out on a single day fishing trip. Nearly half of the captains reported engaging in multiple fisheries depending on the season and economic viability of the individual fisheries. This appeared to be an increasing trend as fishermen cope with declining fish stocks and increasing fisheries regulations. Women were present on 12% of the vessels, but the majority of those women were related to the captain. One-third of the crews were biologically related in some way and most captains reported to have been raised in a fishing family. Most fishermen were highly experienced, with nearly 30 years of fishing on average. Many reported fishing with family members as toddlers, and 75% were full-time fishermen by the age of 21. Nearly one-third reportedly pursued some post-secondary education, although that typically did not include graduation from college.

Nearly half of the vessels sampled in this study were federally documented, which is above average for the small-scale fleet (29% federally documented nationwide[3]). Based on a comparison of the sampled Maine lobstermen to a recent survey of the lobster industry in New England,[13] the Maine lobstermen were younger on average (by five years) and therefore slightly less experienced. Less Maine lobstermen were observed fishing alone than what was reported overall for the region (20% compared to 31%), and slightly less engaged in multiple fisheries in Maine (38% compared to 41%).

Less than 25% of fishermen had recent safety training in First Aid or CPR, and most reported not having been exposed to these training courses since high school. The majority of fishermen had never participated in any organized marine safety training, which included training in the use of survival suits and life rafts, as well as cold water survival and the drill instructor course. Of those captains that had received marine safety training in the past, around half were expired (certification more than five years old).

Exploring differences across fisheries, captains in the urchin and scallop industries were less experienced (5 years on average; t-test $p<0.05$), were less likely to come from a family history of fishing (74% compared to 87%; chi-square test $p<0.05$), and were less likely to own their vessels (76% compared to 98%; chi-square test $p<0.01$) when compared to the other captains, which primarily consisted of lobstermen.

Safety Equipment and Training

Table 1 provides an inventory of the safety equipment observed onboard the fishing vessels, along with a description of the equipment and purchase price estimates. Nearly all fishing boats had the following basic safety equipment: life preservers, radio,

compass, ring buoy, flares, fire extinguisher, and bilge pump. Over 85% also had a first aid kit, anchor, horn, functioning navigation lights, and GPS unit. The majority of these items are relatively inexpensive to maintain and represent a one-time cost to the fishermen. Less common onboard were survival suits (75%), emergency beacons (54%), and survival craft (36%), equipment that is comparatively more expensive. Nearly 25% of the vessels surveyed had participated in the voluntary USCG safety inspection program, which provides fishermen with a free safety exam and sticker certifying regulatory compliance. However, half of those safety stickers were expired.

Despite the existence of the safety equipment noted above, in many cases the captains were unfamiliar with the proper use of that equipment or had a difficult time locating it. Although present onboard, the safety equipment would neither have been accessible nor useful during the emergency situations for which they were intended. There was also a problem with broken or expired safety equipment, such as leaky survival suits, malfunctioning flares and horns, and first aid kits with few useable items left in them.

Compliance

The actual safety equipment required on each vessel is determined based on a complicated matrix of where a vessel fishes, whether they are documented with the federal government or registered with the state, and the size of the vessel and crew. Larger vessels that venture farther from shore are required to have relatively more equipment than a small vessel that stays closer to shore, and federally documented vessels are generally required to maintain more safety equipment than state registered

vessels. In this study, compliance was similarly determined based on the actual requirements of the individual fishing vessels observed, taking into account the fishing location at the time of boarding and other relevant vessel and crew characteristics. The results suggest that 58% of the sampled vessels were technically 'in compliance' with their vessel-specific safety regulations.

There were no observable trends in compliance status across demographic or vessel characteristics, nor were there any statistically significant differences in compliance rates across the sampled fisheries. However, there was a statistically significant difference in the compliance rate across vessels observed fishing further from shore compared to those observed closer to shore, as delineated by an artificial boundary line used by regulators to determine applicable vessel safety requirements (See Figure 1-A). Outside of the regulatory boundary line where the safety requirements are more stringent and therefore more costly, the compliance rate observed was much lower (41%) than that observed inside the boundary line where safety regulations are more relaxed (64%). The difference in compliance rates across the boundary line was statistically significant (chi-square $p<0.01$), suggesting that cost plays an important role in the individual decision by fishermen to comply with existing safety regulations.

Trend Analysis of Safety Equipment Data

The safety equipment data were explored for trends using principal component analysis and the results are provided in Table 4. There were four distinguishable equipment patterns from this exploratory analysis, although slightly more than half of the variability in these data remained unexplained. The first factor consisted of the relatively

more expensive life-saving equipment, including an emergency beacon (EPIRB), survival craft, survival suit, GPS, and the USCG safety decal. The second factor consisted of more inexpensive equipment including the PFD, ring buoy, and horn. The third factor contained the radio, first aid kit, and fire extinguisher, and the fourth factor included compass, anchor, and flares. There was no discernable trend between these factor loadings and the other variables and groupings in the survey. However, the exploratory analysis supports the more intuitive assumption that safety equipment acquisition tends to cluster by cost characteristics, with the more expensive equipment grouping together.

DISCUSSION

The dangers associated with commercial fishing are well documented, and fishermen consistently face one of the highest job-related mortality risks of all US occupations.[1] In the vast majority of fatal fishing accidents where causes were identified, casualties could have been prevented with the proper safety equipment and training.[1,5,14] Therefore, improving safety practices in the industry would provide a clear benefit to fishermen by reducing the rate of injury and death. However, fishermen face a trade-off between the costs and benefits of improved safety practices, since the acquisition of life-saving equipment and training represent a significant economic cost to this largely self-employed workforce. While fishermen derive the full benefit from enhanced onboard safety practices, they absorb the entirety of the costs of the added safety measures. Fishermen also face growing pressure on their livelihood from fisheries regulations and catch limits. These fisheries regulations have been linked to lapses in safety precautions, since they reduce the overall pool of resources available to invest in safety and encourage

more risk-taking behaviors.[1,12] The fishermen observed in this study supported these observations, blaming fisheries regulations for a decline in safety practices.

The results of this study suggest that more than 40% of vessels in the Maine inshore fishing fleet were not compliant with applicable safety regulations. This number would have likely been much higher had a full-scale USCG safety exam been conducted. The results also support the intuitive assumption that compliance rates are lower when the cost of complying with those regulations is higher.

In general, fishermen did not have the proper safety education that would be required in case of an emergency, such as marine safety training or basic First Aid and CPR. However, despite this general lack of safety training in the industry, there was a pattern of strong safety education in coastal locations where the USCG had conducted organized training sessions in the local area, generally free of charge. Also, a newly instituted lobster apprentice program in the state that requires new lobstermen to have adequate safety training has made a large impact in the younger generation, with some evidence of spillover to other crewmembers who attended the training alongside apprentice.

Although most fishermen had the basic low cost safety equipment onboard, this was not the case with the more expensive life-saving equipment that would be necessary in an emergency situation such as a vessel capsizing or sinking. Safety equipment such as survival suits and life rafts are especially important in the cold waters of Maine; fishermen are twice as likely to survive when cold water equipment are used properly.[5] Also, there were many cases in which, despite having the necessary equipment onboard, the captains were not familiar with the proper use of that safety equipment. Much of the

equipment was buried under fishing gear in the hull and took some time to locate, and would not be readily accessible in an emergency situation. There was also a problem with broken or expired safety equipment, such as leaky survival suits, malfunctioning flares and horns, and first aid kits with few useable items left in them. These results suggest that further safety equipment mandates will only be effective if they are followed by safety training and education efforts targeted at their proper use and maintenance.

There is also a clear evidence of the importance of family ties in the fishing industry. In many cases, crew members are related, and most workers acquire their skills based on interacting and working with family members starting at a very young age. This strong sense of family or clan identity presents both a unique challenge and an opportunity for safety enhancement in the industry. Based on the results of this survey, safety education and awareness would be more effective if targeted at the local level, taking advantage of the sub-culture that exists within these fishing communities. Localized training of all fishermen, not just those obtaining new licenses, would ensure that vital safety skills are passed down to subsequent generations.

A federal review of the Commercial Fishing Industry Vessel Safety Act of 1988 is now pending in Congress. If successful, the new safety regulations would strengthen safety requirements for equipment and training, as well as fund additional research and training efforts. The legislation also seeks to shift the regulatory boundary delineating safety requirements, in effect requiring fishermen that are now subject to only minimal safety requirements to comply with the stricter and more costly safety regulations. Given the already low compliance rate in this industry as shown in this study, it is clear that more stringent safety regulations will require a strong education and enforcement effort

on the part of regulators to ensure that fishermen comply with the enhanced regulations. Subsidies for the initial purchase as well as long-time maintenance of more expensive equipment pieces may also be necessary to maintain the economic vitality of the industry and ensure participation.

Limitations

These study results do not necessarily align with the results that would have come from an official USCG safety examination of the same vessel, which would have included a detailed check of all safety equipment for malfunctions and expiration. Therefore, the compliance rate reported here is an overestimate of the true level of industry-wide compliance.

Most of the observations made in this study were from small vessels operating within 3-miles of the coastline, and therefore the results reported here can only be reliably extended to small-scale inshore fisheries. However, small vessels represent the vast majority of those operating in US waters (>99%),[3] and these results are therefore widely applicable. Although fatalities occur at a higher rate for larger vessels, there is evidence to suggest that accident rates are higher for inshore fishing vessels operating in this region.[6] Although it was not feasible to sample fishing vessels operating far from the shore in the current study, this topic represents an important area of future research.

CONCLUSIONS

The results of a detailed safety survey of the Maine commercial fishing industry highlighted a number of important safety concerns. More than 40% of the surveyed

vessels were not in compliance with existing federal and/or state safety regulations, a number that likely understates the true number of delinquent vessels. Based on the results of this survey, it is clear that any attempt to strengthen the safety regulations that apply to this industry should be coupled with the appropriate training and education efforts. Equipment mandates will only be successful at limiting occupational accidents and fatalities if fishermen understand how to use and maintain the equipment. Educational efforts should be targeted at the local level at minimal cost to fishermen to encourage participation. Since much of the fishing culture is passed down from generation to generation at the local or clan level, it is important that these factors are accounted for when designing educational safety programs.

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Table 1. Safety Equipment Surveyed on Fishing Vessels

Safety Equipment	**Equipment Description**	**Approximate Cost of Equipment (Routine Servicing Costs)**	**Percentage of Vessels with Equipment**
PFD (Personal Flotation Device)	Life preserver	$38-$130	99%
Survival Craft[1]	Small craft lowered into water in case of emergency	$3,060 (annual service cost $650-$950)	36%
EPIRB (Emergency Position Indicating Radiobeacons)	Emit emergency distress signals	$650 (2-year service cost $150; 5-year service cost $200)	54%
Radio	Communication equipment, ranging from standard AM/FM antennas to advanced wireless and digital technology	$52-$400	99%
Compass	Navigational instrument	$330	98%
First Aid Kit[2]	Emergency medical supplies	$78	89%
Survival Suit[3]	Waterproof body suit to protect from hypothermia	$318	75%
Anchor	Prevent vessel from moving	$438-$773	94%
Ring Buoy	Flotation device	$49	99%
Flares	Produce bright light for warning and identification	$50-300 (replaced every 3 years)	99%
Fire Extinguisher	Manually operated device for putting out small fires	$190	99%
Horn	Noisemaking device	$20-$238	90%
Working Navigation Lights	Lights indicating course, position, and vessel type	$180-$412	90%
Bilge Pump	Remove water from hull	$145-$223	99%
GPS (Global Positioning System)	Navigational system to determine geographic location	$270-$3,000	96%
USCG Safety Decal[4]	Voluntary and free safety inspection provided by USCG	Free	24%
In Compliance with Safety Regulations	Individually determined based on characteristics of sampled vessel		57.6%

[1]84% of survival craft were packed with the proper lifesaving equipment (typical cost $53)
[2]Only 35% of first aid kits included appropriate manual
[3]97% of survival suits had the required reflective tape
[4]51% of USCG decals were expired

Table 2: Summary of Boarding Data by Fishery

Fishery	Number of Boardings	% of Total Boardings	% of Actual In-Shore Fishery
Lobster	206	79.5%	96.8%
Scallop	9	3.5%	0.4%
Shrimp	4	1.5%	1.0%
Urchin and Sea Cucumber	37	14.3%	1.8%
Other	3	1.2%	-
Total	259	100%	100%
Season			
Summer	96	37%	
Fall	73	28%	
Winter	20	8%	
Spring	70	27%	

Table 3. Vessel and Captain Characteristics

Variable	Summary Statistics
Vessel Year of Construction	Median: 1992; SD: 12
Vessel Length	Median: 35 feet; SD: 5.9
Engine Horsepower	Median: 300 ; SD: 144
Size of Crew	Median: 2; SD: 0.6
Federally documented	49%
Single Day Trip	98%
Owner Operated	93%
Engaged in Multiple Fisheries	49%
Fishing Alone	17%
Relatives Onboard	33%
Female Onboard	12%[1]
Years Fishing	Median: 27; SD 13.2
Age	Median: 45; SD: 13.4
Family History of Fishing	85%
Some College or Technical Training Beyond High School	31%
Female Captain	<1%
Caucasian Captain	>99%
First Aid Certified	24% (42% expired training; 34% never trained)
CPR Certified	24% (50% expired training; 26% never trained)
Drill Conductor Course	13% (9% expired training; 78% never trained)
Life Raft Training	17% (17% expired training; 66% never trained)
Survival Suit Training	19% (22% expired training; 59% never trained)
Cold Water Training	13% (11% expired training; 76% never trained)

[1]73% of the females onboard were related to the captain

Table 4. Principal Component Analysis of Safety Equipment

Component	Eigenvalue	Difference	Proportion	Cumulative
1	2.27	0.56	0.16	0.16
2	1.71	0.39	0.12	0.29
3	1.32	0.09	0.10	0.38
4	1.24	0.11	0.09	0.47
Eigenvectors				
Variable	Component 1	Component 2	Component 3	Component 4
PFD	-0.04	**0.41**	-0.22	-0.31
Survival Craft	**0.47**	0.08	-0.10	0.04
EPIRB	**0.55**	0.03	-0.04	-0.01
Radio	0.14	0.07	**0.50**	-0.25
Compass	-0.02	0.33	0.09	**0.49**
First Aid Kit	0.11	0.36	**0.56**	-0.15
Survival Suit	**0.50**	-0.10	0.05	-0.01
Anchor	0.01	0.35	0.17	**0.48**
Ring Buoy	-0.004	**0.42**	-0.26	-0.47
Flares	-0.02	0.15	0.10	**0.26**
Fire Extinguisher	-0.05	0.05	**0.36**	-0.18
Horn	-0.04	**0.50**	-0.30	0.10
GPS	**0.26**	-0.07	-0.19	0.15
USCG Safety Decal	**0.35**	0.02	-0.11	-0.002