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Risk Assessment of the Northeast Limited Access Multispecies (Groundfish) Fishery

US DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
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Northeast Fisheries Science Center
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Editorial Notes

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ABC = acceptable biological catch
ACE = annual catch entitlement
ACL = annual catch limit
AM = accountability measure
BSA = broad stock area
CC/GOM = Cape Cod/Gulf of Maine
CFID = Commercial Fisheries Incident Database
CFR = Code of Federal Regulations
CPH = confirmation of permit history
CPR = cardiopulmonary resuscitation
DAS = days at sea
DMV = Department of Motor Vehicles
DSC =digital selective calling
EPIRB = emergency position indicating radio beacon
FCC = Federal Communications Commission
FMP = Fishery Management Plan
FTE = full-time equivalent employee
FY = fishing year
GB = Georges Bank
GOM = Gulf of Maine
GRT = gross registered tonnage
HP = horsepower
IVQ = individual vessel quota
LOA = length overall
MISLE = Marine Information for Safety and Law Enforcement
MMSI = Maritime Mobile Service Identity
MSA = Magnuson-Stevens Fishery Conservation and Management Act
NEFMC = New England Fishery Management Council
NEFSC = Northeast Fisheries Science Center
NIOSH = National Institute for Occupational Safety and Health
NM = nautical miles
NMFS = National Marine Fisheries Service
NOAA = National Oceanic and Atmospheric Administration
NTSB = National Transportation Safety Board
PFD = personal flotation device
PSC = potential sector contribution
RA = Regional Administrator
SCBA = self-contained breathing apparatus
SOPEP = Ship Oil Pollution Emergency Plan
SNE/MA = Southern New England/Mid-Atlantic
TAC = total allowable catch
USCG = United States Coast Guard
VMS = vessel monitoring system
VTR = vessel trip report

INTRODUCTION

Commercial fishing has long been one of the most dangerous occupations in the United States, despite the development of regulatory and voluntary initiatives aimed at making it safer. National Standard 10 of the Magnuson-Stevens Fishery Conservation and Management Act (MSA) requires that federal regulations be designed in such a way to "promote the safety of human life at sea" without compromising conservation objectives (National…1998). In this context, "safety of human life" includes protecting fishing vessels and protecting the welfare of the individuals onboard those vessels (National…1998). There are a multitude of environmental, physical, regulatory, and social factors that contribute to fishermen's level of safety at sea; these risk factors can vary across fisheries or across groups within the same fishery. Specific characteristics of fishing vessels (e.g., length, age, tonnage), the natural environment in which fishing occurs (e.g., water temperature, presence of navigational hazards), fishing operations (e.g., gear used, crew size), crew, and fishing regulations may all impact the amount of risk fishermen are exposed to at sea (Poggie et al. 1995; Bergland and Pedersen 1997; Kaplan and Kite-Powell 2000; Dyer 2000; Jin et al. 2001; Jin and Thunberg 2005; Windle et al. 2008; Byard 2013; Lambert et al. 2015; Weil et al. 2015). One way to identify any major safety trends and hazards present in a fishery is to conduct a risk assessment of that fishery.

Here, we apply guidance published by the National Marine Fisheries Service (NMFS; Lambert et al. 2015) to complete a risk assessment for the limited access northeast multispecies groundfish fishery. The northeast groundfish fishery is one of 16 federally managed catch share fisheries in the U.S. The National Oceanic and Atmospheric Administration (NOAA) defines catch shares as "fishery management strategies that allocate a specific portion of the total allowable fishery catch to individuals, cooperatives, communities, or other entities. Each recipient of a catch share is directly accountable to stop fishing when its exclusive allocation is reached" (NOAA 2010). In the case of the groundfish fishery, the majority of the commercial groundfish sub-annual catch limit (ACL) is allocated to self-selected groups of limited access groundfish permit holders known as "sectors," and the members of these sectors are jointly responsible for assuring that the group's collective catch limits are not exceeded. The remaining portion of the commercial groundfish sub-ACL is allocated to a small component of the fishery that does not participate in sectors (the common pool) and which is managed by effort controls in the form of days-at-sea (DAS) allocations, gear restrictions, and area closures. Evidence from studies on catch share fisheries suggests that, compared to traditional open access approaches to management, adopting this type of regulatory program may lead to improvements in environmental, economic, and social outcomes in the affected fisheries, including improved safety outcomes (Gauvin et al. 1994; McCay 2004; Heizer 2000; McCay 2004; Hughes and Woodley 2007; Grimm et al. 2012; Brinson and Thunberg 2016; Pfeiffer and Gratz 2016). For example, data from the geoduck fishery in British Columbia shows that the number of vessel incidents and diving accidents associated with the fishery declined after the implementation of individual vessel quotas (IVQs) in 1989 (Heizer 2000). Research on 3 catch share fisheries in Alaska (Pacific halibut (*Hippoglossus stenolepis*) and sablefish (*Anoplopoma fimbria*) longline, Bering Sea pollock (*Gadus chalcogrammus*) trawl, and Bering Sea king (*Paralithodes camtschaticus*) and tanner crab (*Chionoecetes baridi*)) indicates that the shift to catch share management helped alleviate the proverbial "race to fish" in these fisheries, improving safety by affording fishermen more flexibility to avoid fishing in bad weather (Hughes and Woodley 2007). Similar improvements in operational flexibility were reflected in a 2016 study on the sablefish fishery when researchers found that the probability of a fisherman choosing to start a trip in poor weather decreased by approximately 79% after the implementation of an IFQ program (Pfeiffer and Gratz 2016).

This risk assessment was conducted as an accompaniment to the New England Fishery Management Council's (NEFMC) 5-year review of catch share management in the northeast groundfish fishery. This report is divided into 8 major components:

1. Identification of the fishery
2. Literature review
3. Description of vessels and work environment
4. Description of fatalities and injuries
5. Calculation of fatality rates
6. Review of safety-related regulations
7. Interviews with industry experts
8. Discussion of results

Seven of these components (Sections 1-6 and 8) are based directly on the "conceptual diagram of a fishery risk assessment" contained in the Lambert et al. (2015) guidance document (Figure 1). The final component (Section 7: Interviews with industry experts) was added based on a comment in the Atlantic scallop fishery risk assessment which states that "this assessment could have been greatly enhanced by engaging industry through interviews or surveys to identify their views on risks and safety concerns in the fishery" (Lambert et al. 2015).

By compiling data on fleet characteristics, fishing behavior, and fishing vessel safety incidents, we aim to (1) identify major risk factors and hazards impacting limited access groundfish fishermen, and (2) determine whether certain sub-groups within the fishery tend to be exposed to more risk than others. The qualitative data gathered through informational interviews with safety trainers, commercial fishermen, and fishery observers is used to further develop these analyses and to identify any risk factors or safety hazards that may not have been evident in other data sources. The goal of this assessment is to provide fishery managers and regulators with additional insight on fishing safety that could be used to inform the development of management alternatives for the groundfish fishery. Furthermore, the trends and hazards identified through this risk assessment may also help fishermen, managers, and safety professionals develop tools, programs, or occupational practices to further reduce risk and improve safety at sea.

1. IDENTIFICATION OF THE FISHERY

Lambert et al. (2015) state that the first step of any fishery risk assessment is to define the scope of the assessment; that is, to determine (1) which fishery to assess; (2) which portion of that fishery to focus on; and (3) what information is available on the fleet in question. We chose to focus this risk assessment on the limited access portion of the northeast groundfish fishery. Section 1.1 of this report provides background information on how the northeast groundfish fishery is managed, while Section 1.2 explains the rationale behind focusing on the limited access portion of the fleet.

1.1 The northeast groundfish fishery

The groundfish fishery is federally managed under the Northeast Multispecies Fishery Management Plan (FMP), one of 10 management plans administered by the NEFMC.[1] Thirteen large mesh groundfish species, known as the groundfish complex, are regulated through the Northeast Multispecies FMP:

- Atlantic cod (*Gadus morhua*)
- Haddock (*Melanogrammus aeglefinus*)
- Yellowtail flounder (*Limanda ferruginea*)
- Pollock (*Pollachius virens*)
- American plaice (*Hippoglossoides platessoides*)
- Witch flounder (*Glyptocephalus cynoglossus*)
- White hake (*Urophycis tenuis*)
- Windowpane flounder (*Scophtalmus aquosus*)
- Winter flounder (*Pseudopleuronectes americanus*)
- Acadian redfish (*Sebastes fasciatus*)
- Atlantic halibut (*Hippoglossus hippoglossus*)
- Atlantic wolffish (*Anarhichas lupus*)
- Ocean pout (*Zoarces americanus*)

The groundfish complex is comprised of 22 distinct stocks, 17 of which are allocated under the groundfish FMP.[2] Three transboundary Georges Bank (GB) stocks (GB cod, GB haddock, and GB yellowtail flounder) are managed jointly with Canada under the US/CA Resource Management Understanding. Fishermen use a variety of different gear types, including bottom trawls, sink gillnets, bottom longlines (tub trawls), and rod-and-reel/jigs (handlines) to target groundfish species from Maine to North Carolina.

The Northeast Multispecies FMP was first implemented in 1986. For several decades, fishing activity in the groundfish fishery was regulated using traditional effort controls such as mesh size limits, gear restrictions, area closures, and DAS constraints in order to limit fishing mortality and conserve fish stocks. Amendment 13 to the Northeast Multispecies FMP, implemented at the start of fishing year[3] 2004 (FY2004), contained a number of significant revisions to existing groundfish regulations. Among other changes, Amendment 13 reduced baseline DAS allocations, established the DAS transfer and DAS leasing programs, and introduced sector management to the groundfish fishery. Under sector management, northeast multispecies permit holders were given the option to voluntarily organize themselves into self-governing groups called "sectors" which would each be allocated a hard annual total allowable catch (TAC) for each

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[1] Additional information on these management plans can be found on the NEFMC website.

[2] *Allocated stocks*: Gulf of Maine (GOM) cod, GB cod, GOM haddock, GB haddock, Cape Cod (CC)/GOM yellowtail flounder, GB yellowtail flounder, Southern New England/Mid Atlantic (SNE/MA) yellowtail flounder, pollock, American plaice, witch flounder, white hake, GOM winter flounder, GB winter flounder, SNE/MA winter flounder, and redfish. *Non-allocated stocks*: GOM/GB (northern) windowpane flounder, SNE/MA (southern) windowpane flounder, Atlantic halibut, Atlantic wolfish; and ocean pout.

[3] In the northeast multispecies fishery, fishing years begin on May 1 of one calendar year and end on April 30 of the following calendar year. For example, FY2010 spans May 1, 2010-April 30, 2011.

requested groundfish stock based on the fishing history of the permits collectively enrolled in that sector. In return for agreeing to abide by hard TACs, each sector was also permitted to request exemptions from many existing effort controls such a trip limits or gear restrictions. The GB Cod Hook Gear Sector was the first sector to be authorized in 2004[4], and the GB Fixed Gear Sector became the second in 2007[5]. These 2 sectors later merged into one, the GB Cod Fixed Gear Sector, in 2010.

Six years after the implementation of Amendment 13, Amendment 16 set acceptable biological catches (ABCs), ACLs, and accountability measures (AMs) for all 20 stocks managed under the groundfish FMP. Amendment 16 also expanded sector management into a larger catch share management program. Under this new system, each groundfish sector is allocated a share of 17 groundfish stocks[6] on an annual basis. These sector allocations, called annual catch entitlements (ACEs), represent the percentage of the total ACL for each groundfish stock that the members of a sector can collectively harvest during each fishing year. A sector's ACE allocation is determined based on the fishing permits that are enrolled in that sector during a given fishing year. Each limited access groundfish permit is assigned a potential sector contribution (PSC) based on that permit's fishing history from 1996-2006. This PSC represents the percentage of each stock's ACL that the permit is allowed to catch; a sector's ACE is calculated by summing the PSCs of all the permits enrolled in that sector. Both landings and discards by sector vessels count against a sector's ACE. The members of each sector are jointly responsible for ensuring that the sector's collective ACE is not exceeded for any stock.

Amendment 16 specified that any northeast multispecies permit holders that held a limited access groundfish permit as of May 1, 2008, were eligible to join a sector; importantly, this included inactive permits that were held in confirmation of permit history (CPH). Permits not enrolled in a sector are said to be in the "common pool." Common pool fishing effort is still primarily managed using traditional input controls such as DAS restrictions and trip limits, while sectors are exempt from many of these effort controls. Seventeen groundfish sectors operated during the first year of catch share management in FY2010; this increased to 19 sectors in FY2015.

Amendment 16 also included provisions enabling ACE to be traded between members of the same sector, or between members of different sectors, on an annual basis. Intra-sector ACE transfers are handled internally within the sector and do not need NMFS approval to be finalized. Inter-sector ACE transfers, on the other hand, must be approved by NMFS before being finalized; however, details about the amount of ACE being traded, compensation for the ACE, and acceptable trade partners are established by the participating sectors. Sectors can trade ACE at any point during the fishing year, up to 2 weeks after the close of the fishing year on April 30.

1.2 Risk assessment scope

Amendment 5 to the Northeast Multispecies FMP implemented a moratorium on new northeast multispecies permits in 1993.[7] Following this moratorium, northeast multispecies permits were divided into open access and limited access categories. There are currently 10 federal

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[4] For additional details on the authorization of the Georges Bank Cod Hook Gear Sector, see 69 Fed. Reg. 22905

[5] For additional details on the authorization of the Georges Bank Cod Fixed Gear Sector, see 72 Fed. Reg. 26563.

[6] Northern windowpane flounder, southern windowpane flounder, ocean pout, wolfish, and Atlantic halibut were not allocated from FY2010-FY2015. GOM winter flounder was not allocated from FY2010-FY2012.

[7] For additional details about the moratorium on northeast multispecies permits, please see Amendment 5 to the Northeast Multispecies FMP.

northeast multispecies permit categories. Four of these permit categories are open access: Handgear B (HB); Charter/Party (I); Scallop Multispecies Possession Limit (J); and Open Access Multispecies (K). The remaining 6 permit categories are limited access: Days-at-Sea (A); Small Vessel Exemption (C); Hook Gear (D); Combination Vessels (E); Large Mesh Individual DAS (F); and Handgear A (HA) (Table 1).

We focused this risk assessment on the active limited access portion of the northeast groundfish fishery. Throughout this report, a "limited access vessel" refers to a vessel that held a valid limited access groundfish permit (category A, C, D, E, F, or HA) in FY2015. A vessel is described as being "active" if it took at least 1 groundfish trip in FY2015. For the purposes of this risk assessment, we define a "groundfish trip" as any commercial fishing trip taken under a limited access groundfish permit where at least 5% of total fish kept (by weight, in live pounds) is attributed to any of the 9 allocated large mesh groundfish species. These allocated species are: cod, haddock, yellowtail flounder, pollock, American plaice, witch flounder, white hake, winter flounder, and Acadian redfish. In order to be classified as a groundfish trip that was completed during FY2015, a trip had to begin on or after May 1, 2015, and had to land on or before April 30, 2016.

We opted to focus our analysis on the limited access portion of the fleet because (1) vessels fishing under limited access permits are responsible for the bulk of commercial landings of allocated groundfish, and (2) limited access groundfish permit holders are the individuals who are most heavily impacted by the majority of the regulations being analyzed in the 5-year review of the groundfish catch share management program. We chose to profile the limited access groundfish fleet during FY2015 because (1) we wanted to use the most recent data possible while still ensuring that our analyses overlapped with the FY2007-FY2015 timeline used in the 5-year review, and (2) FY2015 was the most recent year for which data on fishing-related fatalities and injuries were available. Finally, we decided to include data solely from targeted groundfish trips because we wanted our descriptions of fishing effort and operational practices to reflect the fishing trips that are primarily regulated by the provisions contained in the Northeast Multispecies FMP. Limited access groundfish fishermen often hold other federal and state fishing permits which enable them to participate in multiple fisheries at various points throughout the year. While there may be regulatory overlap between the groundfish fishery and some other fisheries (e.g., dogfish, monkfish, skate), fishing activity on trips targeting these alternative fisheries is also largely managed through management measures contained in other FMPs. Therefore, we chose to exclude those trips from our analysis since many of the rules constraining fishing effort on these trips fall outside the regulatory purview of the groundfish FMP.

As such, for the remainder of this report, it is important to remember that the fleet characteristic data (e.g., vessel length, vessel horsepower, vessel age) presented in this assessment only reflect the attributes of the limited access groundfish vessels that took at least 1 groundfish trip in FY2015. Vessels without a limited access groundfish permit, or vessels with a limited access groundfish permit that did not take a groundfish trip in FY2015, are not reflected in these data. Additionally, data on fishing activity (e.g., trip timing, trip location, gear used) specifically describe commercial groundfish trips taken by the limited access groundfish fleet in FY2015. The limited access groundfish vessels described in this risk assessment may have taken additional non-groundfish trips during FY2015; however, data on these trips are not included in this analysis.

2. LITERATURE REVIEW

Fishing is an inherently dangerous occupation, and commercial fishermen are often exposed to many occupational and environmental hazards. Fishermen routinely work with dangerous equipment, in harsh weather conditions, and in isolated settings in order to catch and process their fish (Davis 2011). Data published by the National Institute for Occupational Safety and Health (NIOSH) show that 725 commercial fishermen died while fishing in the U.S. from 2000-2015 (NIOSH 2017a). This represents a fatality rate of 117 deaths per 100,000 workers in the commercial fishing industry, a rate which is 29 times higher than the national average of 4 deaths per 100,000 workers for all U.S. industries during that same time period (NIOSH 2017a). The largest proportion of these commercial fishing fatalities were attributed to vessel disasters[8] (49%), while the remainder resulted from falls overboard (30%), onboard injuries (12%), and accidents while onshore or while diving (9%) (NIOSH 2017a).

There are many environmental, operational, regulatory, economic, and cultural factors which influence the amount of risk and types of hazards fishermen are exposed to while at sea (Poggie et al. 1995; Bergland and Pedersen 1997; Kaplan and Kite-Powell 2000; Dyer 2000; Jin et al. 2001; Jin and Thunberg 2005; Windle et al. 2008; Byard 2013; Lambert et al. 2015; Weil et al. 2015). Many of these variables differ across fisheries, across fishery sub-groups, and across regions.

In order to understand more about the factors that may impact risk and safety in northeastern fisheries, we conducted a review of existing literature on safety at sea and commercial fishing. Section 2.1 summarizes findings from research on risk exposure, safety hazards, and perceptions of safety in the northeastern U.S. commercial fishing industry. Section 2.2 highlights studies that have touched specifically upon factors influencing safety in the groundfish fishery. Jin et al. (2001) found that the number of crew injured in a vessel disaster is directly proportional to vessel damage severity. Therefore, this review includes studies on the factors influencing vessel accident probability and severity, as well as factors directly influencing safety of human life at sea.

2.1 Studies on safety in northeastern U.S. commercial fisheries

Aspects of the physical environment in which fishing activity occurs can impact the types of risks and hazards fishermen are exposed to while at sea. Interviews with 121 commercial fishermen from New Bedford, MA, and Point Judith, RI, revealed that this group ranked 3 characteristics of the physical environment—sea conditions, wind speed, and visibility—as being strong contributing factors in fishing vessel accidents (Poggie et al.1996). A 2000 study by Dyer on vessel casualties in the northeastern U.S. reported that severe weather was the leading environmental cause of commercial fishing vessel accidents from 1993-1997. This is largely due to the fact that severe weather can cause waves to overtop and downflood fishing vessels, compromising vessel stability and increasing the likelihood of capsize (Dyer 2000). Subsequent research on fishing vessel accidents in the region found direct correlations between fishing vessel accident probability and wind speed (Jin et al 2002; Jin and Thunberg 2005), accident severity and wind speed, and accident severity and barometric pressure (Jin 2014). For example, Jin (2014) analyzed U.S. Coast Guard (USCG) data on commercial fishing vessel accidents from 2001-2008 and found that the probability of total vessel loss increased by 0.0009 for every 1 m/s increase in

[8] NIOSH defines vessel disasters as "sinkings, capsizings, groundings, fires, or other events that force crews to abandon ship" (NIOSH 2017b).

daytime wind speed, and the probability of total vessel loss increased by 0.0012 for every 10 hPa increase in barometric pressure. Water temperature is another environmental attribute that may impact fishermen's safety. Cold water (< 45 °F), coupled with high wind speeds (> 18 knots) and cold air temperatures (0-28 °F) can cause sea spray to freeze and build up on fishing vessels (Chatterton and Cook 2008). The additional weight from this accumulated ice may compromise vessel stability, increasing chances that the vessel will capsize (Chatterton and Cook 2008). Additionally, according to the USCG, the majority of immersion-related fatalities in the U.S. commercial fishing industry from 1992-2007 occurred in the northeast and the northwest, where water temperatures tend to be colder and survival time is shorter (Dickey 2008).

Operational characteristics of certain fisheries, such as when and where fishing activity occurs, may also impact the level of risk fishermen are exposed to at sea. In terms of fishing location, research has shown that distance from shore may impact the likelihood of a commercial fishing vessel accident occurring. In their investigation of commercial fishing vessel accidents in the northeast from 1981-2000, Jin and Thunberg (2005) discovered that accidents involving commercial fishing vessels are more likely to occur as distance to shore decreases. This could be partly due to the fact that there are more physical hazards and currents to navigate near shore (Dyer 2000; Jin and Thunberg 2005). It may also be partly due to the fact that crew are tired and vessels are weighed down with fish as they steam toward shore at the end of a fishing trip, which may increase the likelihood of human error or stability issues (Jin and Thunberg 2005). Research has also found that accidents are less likely to occur in the southwestern portion of the northeast region and more likely to occur in Georges Bank and the Gulf of Maine (Jin et al. 2002; Jin and Thunberg 2005). Jin (2014) found that commercial fishing vessel accident severity increases as distance from shore increases, with probability of total vessel loss increasing by 0.0007 with each additional kilometer from shore. In terms of fishing trip timing, Poggie et al. (1996) found that fishermen cite "visibility" as being one of the leading causes of vessel accidents, suggesting that trips taken at night may be more hazardous than those taken during the day. Interviews with commercial fishermen also revealed that this group perceives "time of year" to be a major contributing factor to fishing vessel accidents (Poggie et al. 1996). This was reiterated when Jin and Thunberg (2005) found that the probability of a commercial fishing vessel accident occurring varied throughout the year, being higher in the winter and summer months and lower during the spring and fall months. Additionally, Chatterton and Cook (2008) found that in the northeastern region of the U.S., icing events are most likely to occur between November and April. Therefore, fishing trips taken during this time of year may be more likely to experience stability issues which could cause vessels to capsize.

Physical attributes of individual fishing vessels, such as length, tonnage, or age, may impact fishermen's level of safety at sea. In terms of vessel size, studies show that medium-sized commercial fishing vessels (those in tonnage classes 2 and 3; 5-150 gross registered tons) are more likely to experience accidents in the northeast compared to vessels in other tonnage classes (Jin et al. 2002; Jin and Thunberg 2005). Additionally, Jin (2014) found that vessel size is indirectly proportional to vessel damage severity; that is, for every 10 gross-ton increase in vessel size, probability of total vessel loss decreases by 0.0101. In terms of vessel age, research has shown that vessel damage severity increases as vessels grow older, with probability of total vessel loss increasing by 0.0026 for every additional year (Jin 2014). Vessel construction and condition also impact a vessel's general level of seaworthiness, which in turn impacts crew safety. Dyer (2000) reviewed 102 commercial fishing vessel casualties in the northeast from 1993-1997 and found that 53 of these accidents (52%) resulted from vessels taking on water. The majority of cases where vessel hulls were breached occurred on vessels with wooden hulls, suggesting that vessels with this type of construction may be particularly susceptible to hull integrity issues (Dyer 2000). Additional issues that caused vessels to take on water included pump failures, insufficient or broken bilge alarms, compromised bulkheads, poorly engineered deck openings, and fishing gear puncturing or wearing through the hull (Dyer 2000). This last issue may be particularly problematic when an operator redirects their fishing effort into a new fishery because their vessel may not be configured to accommodate different gear (Dyer 2000).

Fishing regulations designed to conserve fish stocks and protect the environment may also directly or indirectly impact safety at sea. Financial strain resulting from strict regulations may impact fishermen's decisions to take trips in poor weather, to postpone vessel maintenance, to redirect into new fisheries, or to fish with fewer crew on their vessels (Dyer 2000). Interviews with 22 commercial fishermen in New Bedford, MA, revealed that the majority of all respondents (2/3) felt that fishing regulations have a significant impact on safety at sea (Kaplan and Kite-Powell 2000). When asked to provide specific examples of safety issues stemming from fishing regulations, respondents mentioned that crew size restrictions were contributing to increased fatigue and decreased hiring and training on their vessels (Kaplan and Kite-Powell 2000). Respondents also felt that fishing regulations reduced their trip planning flexibility, forcing them to either stay out or start trips in poor weather or when their vessels were not seaworthy (Kaplan and Kite-Powell 2000). Some respondents reported that regulations restricting transit through closed areas compromised safety, particularly in situations where those transit restrictions forced them to travel farther or stay out longer in hazardous weather (Kaplan and Kite-Powell 2000). Finally, some respondents mentioned that closing certain areas to fishing can lead to increased crowding and conflict in the remaining areas (Kaplan and Kite-Powell 2000).

Even when regulations and equipment are designed specifically to mitigate occupational hazards, there are a number of external factors that may compromise fishermen's ability or willingness to comply with those regulations or invest in that technology. A 2011 study on compliance with fishing safety regulations conducted surveys on 259 commercial fishing vessels during at-sea boardings by the USCG off the coast of Maine (Davis 2011). During each boarding, researchers collected data on what pieces of safety equipment were present on each vessel and compared this with the applicable list of required safety equipment for each vessel (Davis 2011). Results indicated that almost half of the vessels (42%) boarded were not in compliance with the safety regulations applicable to their vessel characteristics and/or area of operation (Davis 2011). Fishermen tended to carry the required pieces of "basic" safety equipment on their vessels (e.g., life preservers, fire extinguishers, anchors), but compliance rates began to drop as equipment got more expensive to purchase and maintain (e.g., immersion suits, life rafts) (Davis 2011). Additionally, vessels fishing farther from shore exhibited lower compliance rates (41%) than vessels fishing closer to shore (64%), as safety equipment regulations become costlier and more complicated farther offshore (Davis 2011). It is important to note that simply having safety equipment onboard a vessel does not necessarily imply that this equipment would be effective in an emergency. Many of the captains interviewed during this project could not locate their equipment quickly, did not know how to use their equipment, or carried broken or expired equipment (Davis 2011). Additionally, interviews conducted with commercial lobster fishermen in 2016 revealed that respondents rarely wear personal flotation devices (PFDs) while at sea (Weil et al. 2015). When asked why they chose not to wear a PFD, some respondents explained that PFDs are too costly, too restrictive, or too hazardous to work in (Weil et al. 2015). Others believed they would be negatively judged by their peers if they wore a PFD, or they believed in the superstition that wearing a PFD would invite an accident to happen (Weil et al. 2015).

Human factors, such as experience, fatigue, and attitude toward risk, can also impact fishermen's level of safety at sea and willingness to invest in safety equipment and/or training. Dyer (2000) reported that "human factors" were the primary cause of the majority of serious vessel accidents (59%) in the northeastern U.S. from 1993-1997. Human factors cited to negatively impact vessel safety included poor emergency response preparedness, lack of situational awareness, inexperience with commercial fishing, small crews, and increased fatigue (Dyer 2000). Similarly, a series of interviews with 121 commercial fishermen in New England found that respondents ranked "captain/crew error" as one of the leading causes of fishing vessel accidents (Poggie et al. 1996). Davis (2012) interviewed 233 commercial fishermen operating off the coast of Maine and found that 12% of respondents did not know how to swim, and 17% reported that they regularly fish alone (Davis 2012). Less than 25% of the fishermen interviewed had recent training in first aid or CPR, and the majority of respondents had never enrolled in a marine safety training program (Davis 2011).

The way fishermen perceive the risks associated with commercial fishing can have important implications for safety because risk perception may impact the extent to which fishermen address occupational hazards (Poggie et al. 1995). Interviews with commercial fishermen in New England suggest that, as a group, these individuals often cope with the dangerous nature of their profession by trivializing risk, adopting fatalistic attitudes toward risk, and denying the dangers associated with their profession (Poggie et al. 1995). Data suggest that witnessing or surviving an accident at sea may help to reinforce risk denial or trivialization and decrease fishermen's level of concern for danger (Pollnac et al. 1998). Similarly, interviews with 233 commercial fishermen off the coast of Maine found that respondents tended to underestimate the level of occupational risk they were exposed to, despite the fact that the mortality rate amongst commercial fishermen far exceeds the national average (Davis 2012). A 2015 study by Weil et al. on risk perceptions and PFD usage amongst commercial lobstermen in Maine revealed that very few respondents reported that they wore PFDs while fishing even though most of them had fallen overboard or lost friends or family at sea in the past. When asked why this was the case, many respondents explained that they accept risk as an unavoidable part of their job (Weil et al. 2015). Some respondents explained that they do not choose to wear PFDs because they do not allow themselves to think about risk while they fish, and others stated that they used other methods or tools to address safety on their boats (Weil et al. 2015).

2.2 Studies on safety in the northeast groundfish fishery

Trends in safety data suggest that the northeast multispecies groundfish fishery may be particularly dangerous. In a 2017 report titled "Commercial Fishing Fatality Summary: East Coast Region (2010-2014)," NIOSH calculated fatality rates for 15 commercial fishing fleets[9] across the U.S. from 2005-2014. Analyses show that of all the fisheries for which fatality rates could be calculated, the fatality rate in the East Coast groundfish trawl fishery was the highest at 30 deaths

[9] Fatality rates were calculated for the following U.S. commercial fishing fleets: northeast multispecies groundfish trawl; Atlantic clam/quahog dredge; Atlantic snapper/grouper; West Coast multispecies groundfish trawl; Alaska salmon set gillnet; West Coast non-tribal Dungeness crab; Atlantic squid; Atlantic scallop; Atlantic flounder/scup/black sea bass; Alaska Bering Sea crab; Alaska halibut/sablefish longline; Alaska salmon tender; Alaska salmon drift gillnet; Alaska groundfish freezer trawl (A80); and Gulf of Mexico shrimp.

per 10,000 full-time equivalent employees (FTEs)[10] during this period (NIOSH 2017b). While a number of studies have examined the factors impacting risk exposure and safety in commercial fishing in the northeast, relatively few have specifically highlighted the northeast commercial groundfish fleet.

A 2001 report by Olson and Clay presented results from a NOAA socioeconomic survey which was distributed to groundfish vessel owners and groundfish crew who received funds from the Northeast (Gulf of Maine) Multispecies Fishery Disaster Assistance Program in 2000. While these surveys did not focus solely on safety at sea, many of the responses provided mention factors that may directly and/or indirectly influence fishermen's safety. In total, survey responses were received from 286 groundfish vessel owners and 181 groundfish crew members (Olson and Clay 2001). When asked about changes in their fishing practices over the past 5 years (1995-1999), the majority of vessel owners reported that they deferred vessel maintenance (66.1%), postponed purchasing new fishing gear (71.3%), and hired fewer crew (67.5%) during this period (Olson and Clay 2001). Survey responses from crew members indicated that many respondents (29.8%) worked on vessels that experienced crew turnover during the fishing year (Olson and Clay 2001). In terms of changes in time spent on the water, almost half of crew respondents (44.8%) reported spending more time at sea than they did 5 years before, partly because they had to travel longer and farther offshore to fish (Olson and Clay 2001). More than half of vessel owners (54.2%) reported that their vessels needed assistance at sea on at least one occasion from 1995-1999, and a number of owners had to postpone fishing trips because of mechanical or electrical issues on their vessels during 1999 (Olson and Clay 2001). Many of these factors—deferred maintenance, postponed gear replacement, reduced crew, and more time spent at sea—could potentially increase the level and type of risk fishermen are exposed to at sea.

A 2010 study by Lincoln and Lucas compiled data from the NIOSH Commercial Fishing Incident Database (CFID) to calculate incidence rates from commercial fishing fatalities across the U.S. during the decade spanning 2000-2009. The purpose of this study was to identify safety hazards and risk factors present in U.S. commercial fishing and to provide recommendations on how to potentially reduce the high fatality rate characterizing this industry (Lincoln and Lucas 2010). Findings revealed that there were 504 commercial fishing fatalities across the U.S. from 2000-2009 (Lincoln and Lucas 2010). One quarter of these fatalities (124) occurred in the northeastern region of the country (Lincoln and Lucas 2010). When the data was aggregated by fishery, results indicated that the northeast groundfish fishery and the Alaska salmon fishery were tied for the most fatal vessel disasters (12 incidents) during the 2000-2009 period (Lincoln and Lucas 2010). The northeast groundfish fishery also exhibited the highest annual average fatality rate (600 deaths per 100,000 FTEs) during this period (Lincoln and Lucas 2010).

In 2010, Holland et al. conducted a series of telephone interviews with 542 northeast multispecies permit holders shortly before catch share management was implemented in the fishery. The purpose of these interviews was to collect initial information about social capital and attitudes toward fishery management amongst groundfish permit holders. Results from these surveys showed that 33% of respondents felt dissatisfied with their level of physical safety on the job (Holland et al. 2010). Additionally, the majority (64%) of respondents believed fishing regulations had negatively impacted the safety of their crew on at least 1 occasion (Holland et al.

[10] For an explanation of how these fatality rates were calculated, see Section 6 of this report or the Commercial Fishing Fatality Summary: East Coast Region.

2010). When asked specifically how fishing regulations compromised crew safety, respondents explained that there were times when they were forced to fish in poor weather to keep from sacrificing their fishing days (Holland et al. 2010). Some respondents also indicated that rolling area closures forced them to fish farther from port than they normally would (Holland et al. 2010). Fishing farther from port could increase fishermen's travel time and potentially put them farther from shore and lifesaving services.

During the 2010 National Transportation Safety Board's (NTSB) Fishing Vessel Safety Forum, Howard (2010) presented research on fishing safety incidents in the northeast scallop and groundfish fisheries from January 2008-June 2010. Data on safety incidents came from the USCG's reported casualty data (Howard 2010). The types of casualties contained in these records include: disabled vessels, groundings, collisions, capsizings, sinkings, floodings, man overboard events, MEDEVAC events, injuries, and fires (Howard 2010). Findings show that at the time of this presentation, the majority of the groundfish fleet (64% of vessels) were at least 20 years old, built in or before 1989 (Howard 2010). These older vessels were responsible for the majority of fishing effort (80% of total hours fished by the fleet) during this period (Howard 2010). Trends in reported casualty data showed that for both the scallop fleet and the groundfish fleet, casualty rates are directly proportional to vessel age; as vessels grow older, casualty rates increase (Howard 2010). Additionally, groundfish vessels in the 70'-79' length class which operate offshore experienced a higher casualty rate than other groundfish vessels from January 2008-June 2010 (Howard 2010). For both the scallop fleet and the groundfish fleet, fatalities were primarily attributed to events where vessel stability was lost and events where there was a man overboard (Howard 2010). Howard (2010) concluded by suggesting that current operator licensing and vessel inspection requirements were not adequate in helping to reduce casualty rates in the northeast.

Last, a NOAA technical memorandum presenting responses from the 2012-2013 "Survey on the Socio-Economic Aspects of Commercial Fishing Crew in the Northeast and Mid-Atlantic" included data from several questions relating to safety at sea. In total, 401 crew members completed the survey at least partially, one-quarter of whom identified themselves as groundfish crew (Henry and Olson 2014). These groundfish respondents reported that they worked an average of 16.4 hours per day during fishing trips (Henry and Olson 2014). When asked about job safety, one-third of groundfish crew (33%) indicated they were dissatisfied with the physical safety of their jobs, and 35% of groundfish crew reported being dissatisfied with their level of physical exhaustion while fishing (Henry and Olson 2014). Additionally, just over half of groundfish crew (54%) indicated they did not have any health insurance coverage (Henry and Olson 2014). Research has suggested a link between health insurance, risk exposure, and safety (Tuler et al. 2008). Financial stress—which could be caused or exacerbated by the absence of health insurance—in an individual's personal life can lead to increased feelings of stress at work (Tuler et al. 2008). Increased work stress may lead individuals to engage in riskier behavior, which may in turn increase the likelihood of accidents and injuries (Tuler et al. 2008).

3. DESCRIPTION OF VESSELS AND WORK ENVIRONMENT (FY2015)

The type and amount of risk a given group of vessels is exposed to varies based, in part, on the physical and operational characteristics of those vessels. Therefore, in order to understand more about the factors that may impact safety within the limited access groundfish fleet, we first had to examine the characteristics of those vessels and their fishing activity. We compiled data from permit applications and vessel trip reports (VTRs) in order to build a profile of the active limited access groundfish fleet as it was in FY2015. Details on fishing vessels, such as their age, length, and tonnage, were available in the Northeast Fisheries Science Center (NEFSC) permit database. Details on fishing activity, such as trip length, gear used, and crew size, were available in the NEFSC VTR database.

In order to determine whether a vessel met the criteria to classify as an active groundfish vessel in 2015, we first checked to see if that vessel had a limited access groundfish permit that was valid as of May 1, 2015. If so, we pulled data on the fishing trips that vessel completed under its limited access groundfish permit during FY2015. For each fishing trip, we calculated the ratio of groundfish landed to total fish landed (by weight, in live pounds); if the ratio of groundfish landed to total fish landed was greater than or equal to 5%, we classified that trip as a groundfish trip and retained it for analysis. If the ratio of groundfish landed to total fish landed was less than 5%, we classified that trip as a non-groundfish trip, and it was subsequently dropped from the data set. In several instances, VTR data showed that a fishing trip we had designated as a groundfish trip using the "5% rule" used gear that is not typically used to target groundfish (e.g., lobster traps, scallop dredges). When this happened, we removed these trips from the data set.

We chose 5% of total fish landed by weight as the threshold for defining a groundfish trip because this number is consistent with regulations pertaining to incidental bycatch standards for regulated multispecies. The regulations set at 50 CFR 648.80(a)(8) state that exemptions from Northeast multispecies gear restrictions may be added in other fisheries, provided that the percentage of regulated species[11] caught as bycatch is, or can be reduced to, less than 5%, by weight, of total catch. Therefore, a trip with a total catch composed of less than 5% groundfish by weight may be an exempted fishery trip and not a targeted groundfish trip. While we tried our best to isolate groundfish trips, it is worth noting that using this "5% rule" to define a groundfish trip may have been overly inclusive in some cases. For example, this threshold may have resulted in us pulling some non-groundfish trips such as those targeting monkfish, spiny dogfish, or skates into our data set because these fisheries are also subject to groundfish effort controls to a degree. However, this overlap complements this work in that the fishing operations and safety hazards present on these trips are similar to those on groundfish trips.

3.1 Fleet size

In total, 254 active vessels operated in the limited access groundfish fleet in 2015. The bulk of these active vessels (77.2%, 196 vessels) were enrolled in groundfish sectors, while the remainder of the active vessels (22.8%, 58 vessels) were enrolled in the common pool. The vast majority of the active vessels (89.8%, 228 vessels) in the limited access groundfish fleet fished under category A permits while on groundfish trips in 2015, while the remainder operated under category HA permits (6.3%, 16 permits), category E permits (2.0%, 5 permits), and permits in other limited access categories (2.0%, 5 permits; Figure 2).

3.2 Fishing activity and gear type

In total, the 254 active vessels in the limited access groundfish fleet took 5,686 groundfish trips in 2015. The vast majority of these groundfish trips (87.9%, 4,996 trips) were taken by vessels

[11] "Regulated species" refers specifically to large mesh groundfish species (Atlantic cod, witch flounder, American plaice, yellowtail flounder, haddock, pollock, winter flounder, windowpane flounder. Redfish, white hake, Atlantic halibut, and Atlantic wolfish; Definitions…1996).

enrolled in sectors, while the remainder of the trips (12.1%, 690 trips) were taken by vessels enrolled in the common pool (Figure 3). Bottom trawl gear was used on more than half of the groundfish trips (69.7%, 3,964 trips) completed by the fleet in 2015. The remainder of the groundfish trips taken during 2015 used sink gillnet gear (25.0%, 1,420 trips), handline gear (4.6%, 262 trips), and bottom longline gear (0.7%, 40 trips) (Figure 4). In total, 174 limited access vessels fished with bottom trawl gear, 51 vessels fished with sink gillnet gear, 8 vessels fished with bottom longline gear, and 28 vessels fished with handline gear on groundfish trips in FY2015 (Figure 5).

In terms of gear size, the average sweep length of the bottom trawl nets used on FY2015 groundfish trips was 111.7'. The average length of the sink gillnets used on groundfish trips was 299.1', and limited access vessels fished with an average of 28 nets per string. Limited access vessels fishing with handline gear fished with an average of 3 hooks per line on groundfish trips in FY2015, while limited access vessels fishing with bottom longlines fished with an average of 1,046 hooks per line. The average length of the mainlines on this bottom longline gear use was 2.7 nautical miles (NM) in FY2015.

3.3 Vessel home port

More than half of the active vessels (55.9%, 142 vessels) in the limited access groundfish fleet were home ported in Massachusetts in 2015. The rest of the active vessels in the fleet hailed from Rhode Island (14.6%, 37 vessels), Maine (10.2%, 26 vessels), New York (9.8%, 25 vessels), New Hampshire (5.9%, 15 vessels), Connecticut (2.4%, 6 vessels), and New Jersey (1.2%, 3 vessels). Common pool vessels were generally distributed farther south relative to sector vessels; in 2015, the number of common pool vessels homeported in New York, New Jersey, and Connecticut outnumbered the number of sector vessels hailing from these states (Figure 6).

Data show that all of the limited access vessels that fished with bottom longline gear on groundfish trips in 2015 hailed from either Massachusetts or Maine. Limited access vessels that fished with handline gear on groundfish trips were homeported in Maine, New Hampshire, Massachusetts, and New York. Limited access vessels using sink gillnet gear on groundfish trips hailed primarily from Massachusetts, Maine, and New Hampshire, and limited access vessels that fished with bottom longlines on groundfish trips hailed primarily from Massachusetts, Rhode Island, New York, and Maine.

3.4 Vessel age

In 2015, the average age of all the active vessels in the limited access groundfish fleet was 29.9 years. The youngest active vessel in the fleet was less than 1 year old (built in 2015), while the oldest active vessel in the fleet was 81 years old (built in 1934). When binned into age brackets, the largest proportion of the active vessels (49.6%, 126 vessels) in the limited access groundfish fleet fell into the 30- to < 40-year age category. Sector vessels were generally older than common pool vessels. The average age of active sector vessels was 30.7 years, while the average age of common pool vessels was 27.4 years (Figure 7).

When broken down by gear type, data show that on average, the limited access vessels that took bottom trawl trips were older than the limited access vessels that took trips using other fishing gears in 2015. Records indicate that the average age of vessels that took bottom trawl trips in 2015 was 32.3 years. In contrast, the average age of vessels that took sink gillnet trips was 26.5 years, the average age of vessels that took bottom longline trips was 22.3 years, and the average age of vessels that took handline trips was 23.3 years (Figure 8).

3.5 Vessel size (length and tonnage)

The active vessels in the limited access groundfish fleet varied in size, ranging from a minimum of 23' to a maximum of 88.4' in length. The average length of all the active vessels in the fleet as a whole was 54.8'. When binned according to length, the largest proportion of active limited access vessels (42.1%, 107 vessels) fell into the 30- to < 50-foot category. Sector vessels were generally larger than common pool vessels; the average length of sector vessels was 58.1', while the average length of common pool vessels was 43.6'. Furthermore, there were no active sector vessels that were less than 30' in length in 2015, and there were only 2 active common pool vessels that were 75' or longer (Figure 9).

The average gross tonnage of the active vessels in the limited access groundfish fleet was 99.8 tons in 2015. Vessel gross tonnages ranged from a minimum of 2 tons to a maximum of 199 tons. More than half of the active vessels (53.1%, 135 vessels) in the limited access groundfish fleet were less than 50 gross tons. Common pool vessels tended to be smaller than sector vessels; the average gross tonnage of common pool vessels was 35.5 tons, while the average gross tonnage of active sector vessels was 76.1 tons. None of the common pool vessels active in 2015 weighed more than 150 gross tons (Figure 10).

In general, limited access vessels that fished with bottom trawl gear in 2015 tended to be larger than limited access vessels fishing with other gear types in terms of both length and tonnage. On average, groundfish vessels that took at least 1 trip with bottom trawl gear in 2015 were 62' in length and had a gross tonnage of 87.5 tons. Vessels that fished with handline gear had an average length of 32.8', but the average gross tonnage of these vessels was only 15.1 tons. Groundfish vessels that fished with bottom longline gear had an average length of 43.3'and an average gross tonnage of 27.4 tons. Similarly, groundfish vessels that fished with sink gillnet gear had an average length of 43.2' and an average gross tonnage of 27.9 tons (Figure 11 and Figure 12).

3.6 Vessel horsepower (HP)

In 2015, the average HP of the active limited access groundfish vessels was 435 HP. The minimum reported HP for a limited access groundfish vessel was 120 HP, while the maximum reported HP was 1,380 HP. Sector vessels were generally more powerful than common pool vessels; the average HP of sector vessels was 458 HP, while the average HP of common pool vessels was 359 HP. Vessels that fished with bottom trawl in 2015 tended to be more powerful than vessels that fished with other gear types, which is consistent with the fact that the length and tonnage of these vessels also tended to be greater. The average HP of bottom trawl vessels in 2015 was 487 HP, the average HP of sink gillnet vessels was 328 HP, the average HP of bottom longline vessels was 408 HP, and the average HP of handline vessels was 297 HP (Figure 13).

3.7 Hull material

The largest proportion of the active vessels (47.2%, 120 vessels) in the limited access groundfish fleet had fiberglass hulls in 2015. The remainder of the vessels in the active limited access groundfish fleet were constructed with steel hulls (46.1%, 117 vessels), wooden hulls (6.3%, 16 vessels), or hulls made from other materials (0.4%, 1 vessel). The majority of the active vessels enrolled in the common pool (65.5%, 38 vessels) were fiberglass-hulled, while the bulk of the active vessels enrolled in groundfish sectors (51.0%, 100 vessels) were steel-hulled (Figure 14). When broken down by gear type, data show that the majority of the vessels that fished with bottom trawl gear in 2015 were steel-hulled. Conversely, the majority of the vessels that fished with handline gear, sink gillnet gear, and bottom longline gear had fiberglass hulls.

3.8 Crew size

In 2015, the average crew size (including captains) on all groundfish trips taken by limited access vessels was 2.8 individuals. Captains fished alone (crew size of 1) or with a single deckhand (crew size of 2) on almost half of the groundfish trips (44.2%, 2,511 trips) taken during 2015. In general, sector vessels operated with larger crews on groundfish trips than common pool vessels. The average groundfish trip crew size for sector vessels was 2.9 individuals, while the average groundfish trip crew size for common pool vessels was 2.3 individuals (Figure 15).

When broken down by gear type, data show that vessels fishing with sink gillnets and vessels fishing with bottom trawl nets tended to operate with the largest crews. Limited access vessels fishing with sink gillnets operated with an average crew size of 2.9 individuals on groundfish trips in 2015, while vessels fishing with bottom trawl gear operated with an average crew size of 2.8 individuals. Vessels fishing with handline gear had an average crew size of 2.4 individuals on groundfish trips, and vessels using bottom longline gear had an average crew size of 1.8 individuals (Figure 16).

3.9 Trip length

On average, limited access vessels spent 2.26 days absent from port per groundfish trip in 2015. More than half of the limited access groundfish trips (61.0%, 3,468 trips) were day trips, meaning vessels spent less than 24 hours absent from port on those trips. Sector vessels tended to take much longer trips than common pool vessels; sector vessels spent an average of 2.5 days absent from port per groundfish trip, while common pool vessels spent an average of 0.7 days absent per groundfish trip (Figure 17).

Limited access vessels fishing with bottom trawl gear and sink gillnet gear were the only vessels that spent multiple days absent per groundfish trip, on average, in 2015. Vessels fishing with bottom trawl gear spent an average of 2.7 days absent per groundfish trip, and vessels fishing with sink gillnet gear spent an average of 1.4 days absent per groundfish trip. Vessels fishing with handline gear spent an average of 0.75 days absent per groundfish trip, and vessels fishing with bottom longline gear spent an average of 0.6 days absent per groundfish trip (Figure 18).

3.10 Trip timing and location

VTR data indicate that limited access vessels took groundfish trips during every month in 2015. May was the busiest month in terms of number of groundfish trips taken (11.5%, 654 trips), and February was the slowest month (5.2%, 294 trips). The fact that the largest percentage of groundfish trips were taken in May is likely due in part to the fact that the groundfish fishing year starts on May 1. Therefore, the amount of sector ACE and common pool TAC that is available for harvest is still relatively high, and limited access permit holders are likely less constrained by catch caps or lack of quota. Limited access vessels took the most groundfish trips during the spring months (March-May, 27.2%, 1,544 trips) and the fewest groundfish trips during the winter months (December-February, 23.0%, 1,307 trips) (Figure 19).

When broken down by gear type, VTR data show that trip timing varied between vessels fishing with different types of fishing gear. For example, limited access vessels fishing with bottom trawl gear took the most groundfish trips in April and May (23.9%, 947 trips), while vessels fishing with sink gillnet gear took the most groundfish trips in August and September (28.9%, 410 trips). Additionally, vessels fishing with bottom longline gear were most active in April (72.5%, 29 trips). In terms of seasonality, vessels fishing with bottom trawls took the most groundfish trips during the spring and winter months (56.8%, 2,253 trips), while vessels fishing with sink gillnet (67.2%, 954 trips) and handline gear (64.1%, 168 trips) were most active during summer and fall (Figure 20).

In terms of distance from shore, more than half of the groundfish trips (56.3%, 3,203 trips) taken by limited access vessels in 2015 were taken within 3 miles of the shore. The rest of the groundfish trips taken this year were taken between 3 and 12 miles offshore (14.6%, 832 trips) or more than 12 miles offshore (27.8%, 1,582 trips) (Figure 21). In terms of area fished, the majority of the groundfish trips (56.7%, 3,221 trips) taken by the limited access fleet occurred in the Gulf of Maine. The rest of the limited access groundfish trips occurred in Georges Bank (22.4%, 1,276 trips) and in Southern New England (21.0%, 1,189 trips). Sector vessels tended to operate farther north than common pool vessels. The largest proportion of sector groundfish trips (58.9%, 2,941 trips) occurred in the Gulf of Maine, while the largest proportion of common pool groundfish trips (55.6%, 384 trips) occurred in Southern New England (Figure 22).

Data show that the largest percentage of groundfish trips taken using bottom trawl gear (49.1%, 1,945 trips), bottom longline gear (92.5%, 37 trips), sink gillnet gear (76.3%, 1,084 trips), and rod-and-reel gear (59.2%, 155 trips) occurred in the Gulf of Maine in 2015. The second largest proportion of bottom longline trips (7.5%, 3 trips), sink gillnet trips (20.3%, 288 trips), and rod-and-reel/jig trips (27.5%, 72 trips) were taken in Georges Bank, while the second largest proportion of bottom trawl trips (27.9%, 1,106 trips) were taken in Southern New England (Figure 23).

3.11 Water temperature

In order to understand more about the physical environment in which groundfish fishing occurs, we obtained coastal water temperature data from the NOAA National Centers for Environmental Information website. Data show that water temperatures in coastal areas around the Northeast (from Maine to North Carolina) vary by location and time of year. For example, the water temperature at Bergin Point, NY, was 26 °F in January, while the water temperature at Money Point, VA, was 86.5 °F in July. Unsurprisingly, monthly mean water temperatures are higher in the southern portion of the region (New Jersey to North Carolina) and cooler in the northern portion of the region (Maine to New York). Throughout the Northeast, the coldest water temperatures are typically observed from December-March while the hottest temperatures usually occur from June-September (Table 2).

NIOSH explains that hypothermia can result from immersion in water that is below 70 °F (NIOSH 2022). It is worth noting that all of the limited access vessels we included for analysis in this report are homeported in ports from Maine to New Jersey. Data show that the monthly mean water temperatures in many areas in these states fall below this 70 °F threshold for “cold water” during many months of the year. Therefore, the fatality risk for limited access groundfish fishermen who enter the water may be relatively high. This may be especially true for crew on bottom trawl vessels that tend to take a large percentage of their groundfish trips during in the winter months when water temperatures are at their lowest.

3.12 Operating environment on limited access groundfish vessels

The specific operational practices followed during a commercial fishing trip may vary by fishery, port, vessel, trip, and individual. However, after interviewing members of the commercial groundfish industry, we were able to identify the “basic stages” that generally occur during most limited access commercial groundfish trips in the Northeast. Below, we present a description of the standard operating procedures used on typical groundfish trips in the region and highlight some differences between vessels fishing with bottom trawl, sink gillnet, bottom longline, and rod-and-reel gear. It is important to acknowledge that the steps illustrated throughout the rest of this section may not reflect the full suite of fishing practices and techniques used on all limited access groundfish vessels; instead, these descriptions are intended to broadly illustrate some of the common processes that occur on typical vessels in the fleet.

3.12.1 Boarding the vessel

Before starting any trip, groundfish fishermen must first climb from the dock onto their vessels, sometimes carrying duffel bags, groceries, or other supplies with them. According to the respondents we spoke with, boarding the vessel can be one of the most dangerous parts of a commercial fishing trip because the risk of fishermen slipping and falling into the water is relatively high. Respondents noted that the risk associated with boarding a vessel is higher under certain conditions, such as when the wind is blowing the vessel farther from the dock, when the tide is low, when a vessel is rafted with other vessels, and when it is dark or icy.

3.12.2 Prepping and transiting

After boarding, groundfish fishermen must prepare their vessels for the impending trip. Tasks to be completed during this time vary between vessels and between trips, but in general, they may include: giving safety briefings to crew; ensuring communications and navigation equipment is running smoothly; monitoring the weather; purchasing fuel, ice, or bait; and onboarding fishery observers (when a trip is selected for one). Fishermen on vessels configured with below-deck holds must also prepare this area before the start of a fishing trip. Typically, this requires crew to climb into the hold and use wooden boards to divide the area into a series of compartments to contain ice and fish. These compartments are designed to keep loads from shifting dramatically during transit and to ensure that weight is evenly distributed across the vessel. Once underway, groundfish fishermen typically spend the majority of their transit time resting, cooking, or preparing the rest of the fishing gear. For crew on vessels fishing with bottom longlines with snap-on gangions, this normally includes baiting the hooks.

3.12.3 Setting and hauling bottom trawls

According to respondents, the exact steps fishermen go through to set and haul their gear vary greatly based on the type of gear being used. Vessels fishing with bottom trawl gear usually store their nets on large drums located near the stern of the vessel. The trawl doors (otter boards), which are used to hold the mouth of the net open as it's being towed through the water, are typically secured with chains to the frame of the vessel to keep them from swinging around while the vessel is in motion. When it is time to deploy the net, 1 or 2 crew members position themselves in the stern of the vessel (the "sternmen"). First, the sternmen release the chains attaching the trawl doors to the vessel, allowing them to be lowered into the water. Next, the crew members help guide the net out over the stern of the vessel, making sure it gets deployed without the cables twisting or the doors crossing. These crew members typically stay in the stern of the vessel until the net is fully deployed and retreat to a safer position while it is being towed. Fishermen try to stay away from trawl cables, blocks, and winches while the gear is in motion because these components are under extreme tension and a mechanical failure could result in serious injury or death to anyone standing nearby.

When the time comes to haul the net back in, the sternmen resume their positions on either side of the net drum. The sternmen help guide the net evenly onto the drum, and they secure the trawl doors to the vessel once they break the surface of the water. Crew are careful not to stand directly behind the net drum during haulback in order to avoid being hit by rocks, buoys, or other objects that may fly out of the net as it is being wound. Once the codend of the trawl net reaches the surface, the crew wrap a chain or cable around the net, hook it to the cargo wire, and use the gantry to haul the full codend up the stern ramp onto the deck. Alternatively, this may be done by hand if the vessel does not have a mechanized cargo hauling system. Fish are then released from the codend into a checker pen or partitioned deck, and fishermen can commence sorting and processing their catch.

3.12.4 Setting and hauling sink gillnets

Sink gillnets are typically stored in large open pens in the sterns of groundfish vessels. The buoys and buoy lines attached to the nets are also typically kept in the rear of the vessel. When fishermen are ready to set sink gillnets, 1 or more crew typically stand in either corner of the stern of the vessel. These crew first deploy the anchor, buoy line, and buoy used to mark the beginning of the gillnet string. Next, the mesh panels of the gillnet are deployed over the stern of the vessel, where they pass over a spreader bar. This structure is designed to ensure that the net is flat and fully open when it enters the water. The sternmen continuously monitor the net as it is being deployed to ensure that it does not get tangled or slip off the spreader. After the mesh panels have all been set, a second anchor, buoy line, and buoy are deployed to mark the end of the string. Some groundfish fishermen opt to let their gillnets soak overnight, while others haul them back later the same day.

Sink gillnets are typically retrieved with hydraulic haulers located on either the port or starboard side of the vessel. Fishing captains typically man the haulers while the other crew members handle the catch and the net. After the gillnet comes up over the side of the vessel and through the hauler, it is passed over a table where crew members stand and pick the fish out. Once all the fish have been removed from the net, the net is passed to another crew member at the rear end of the table who guides it up and over another roller. The net is flaked (folded back and forth like a fan) into the net pen in the stern where it is stored until the next time it is set.

3.12.5 Setting and hauling bottom longlines

In the northeast, fishermen primarily use bottom longlines called “tub trawls” to target groundfish species. This gear gets its name because of the fact that when the lines are not in use, they are coiled up and stored in containers (tubs) on the deck of the vessel. On average, a typical groundfish trip uses 3 or 4 tubs’ worth of gear; each tub typically contains approximately three-tenths of a mile of line equipped with about 300 hooks. Most of the bottom longline gear used in in the groundfish fishery has gangions that are tied directly to the mainline, so the hooks are not removed when the gear is stowed in tubs. However, several vessels (particularly those in the southern end of the region) fish with longlines that have snap-on gangions. In this case, each gangion (and the accompanying hook) is unclipped from the mainline when the gear is not in use.

Much like sink gillnets, bottom longlines are typically deployed over the stern of the boat and hauled back over the port or starboard side. Most bottom longline vessels are equipped with a chute or a large PVC pipe in the stern. When it is time to set the gear, 1 or 2 crew members typically stand in the stern of the vessel on either side of the chute. First, an anchor and buoy are deployed to mark the start of the string. Next, the mainline is deployed directly from the tubs over the stern of the vessel. The lines in each tub are connected to one another in 1 continuous piece; once one of the tubs has been emptied, crew move it out of the way to make room for the next one. On vessels fishing with gear with attached gangions, crew simply need to monitor the line’s progress to make sure it does not get snagged. On vessels fishing with longlines with snap-on gangions, crew must snap the individual hooks onto the moving mainline as it is being set over the stern.

After all the line has been set and all the tubs are empty, a final anchor and buoy are deployed to mark the end of the string, and the gear is left to soak for 2-3 hours. Occasionally during setting, one of the longline hooks will become snagged on the stern of the vessel. When this happens, the safest thing for crew to do is to simply cut the hook free from the mainline

Once the gear is done soaking, fishermen use a gaff to retrieve the buoy marking the start of the string. Once the buoy is brought onboard, the mainline is fed up over the roller on the side of the boat, through the crucible, and into the hydraulic hauler. As the rest of the line is being brought in, 1 crew member stands beside the crucible and waits for hooked fish to come to the surface. When this happens, crew grab the fish (sometimes using a gaff), guide it up over the side of the vessel, and unhook it. Sometimes a net is held under the fish as it is being unhooked, just in case it drops overboard when it is released. After the fish have been unhooked from the gear, another crew member removes the snap-on gangions (if necessary) and coils the mainline back into the tubs for transit back to port.

3.12.6 Setting and hauling handlines

In the northeast, groundfish fishermen typically use rods and reels or automatic jigging machines (auto-jigs) to target groundfish species. Vessels that fish with rod-and-reel gear typically fish with 4-6 rods at once. The line attached to each rod is usually equipped with 1-3 unbaited hooks. Each hook is decorated with a colorful coating designed to attract fish. Additionally, a heavy lure is usually secured to the end of the line below the hooks. Not only does this lure help attract fish, it also helps weigh down the line to make sure the hooks remain near the bottom.

When it is time to set rod-and-reel gear, fishermen drop the lines attached to each fishing rod over the side of the vessel and allow the hooks to sink until they reach the bottom. Once the hooks are positioned accordingly, each rod is mounted into one of the holders built into the side of the vessel, and the gear is left to soak. When a fisherman senses there is a fish caught on one of the hooks, they reel the line in manually, brings the fish onboard, and unhooks it. Once the fish has been removed, the line is dropped back over the side of the vessel and the process is repeated. Auto-jigs work in a similar fashion to traditional rods and reels, but in this case, the lines are set and hauled mechanically rather than by hand.

3.12.7 Sorting, processing, and storing fish

Once fish are brought onboard commercial groundfish vessels, the crew need to sort, process, and store the fish. This process varies slightly depending on the type of fishing gear being used, the configuration of the vessel, and the species being handled. On bottom trawl vessels, fish are typically released from the codend of the net into one or more checker pens on the deck of the vessel. Some vessels have on-deck conveyor belts that move fish up and out of the checker pens, enabling fishermen to sort fish while standing in a more ergonomic, upright position. However, on most vessels, fishermen typically work their way through the pile of fish while stooping or on their hands and knees, using fish picks to sort the catch into totes by species and size. Fish that are not kept are thrown overboard as discards, while fish to be landed are retained for processing. Crew on gillnet vessels typically sort fish as they remove them from the gear, as do crew on longline, rod-and-reel, and jig vessels.

The amount of processing required for each fish depends on the species and the market it is destined for. For example, roundfish (e.g., pollock, haddock, cod) designated for human consumption must be gutted and gilled before being transported back to shore. On the other hand, skates destined for the bait market (e.g., for the lobster fishery) are left intact. Once the fish are processed accordingly, they are loaded into totes and stored on deck or in the hold, depending on the configuration of the vessel and the duration of the trip. For vessels with below-deck holds, 1 crew member (the "hold man") generally descends into the hold, receives the fish totes as they are lowered down, and distributes the fish across the hold compartments. These fish totes are sometimes lowered into the hold with a crane, but more frequently, they are simply handed down by other fishermen up on the deck.

3.12.8 Transiting, offloading, and disembarking

The return journey to port is generally riskier than the initial trip out to the fishing grounds because there is a lot more weight on the vessel at the end of a trip and fishermen are fatigued after working long shifts. Upon arrival, fishermen must start the process of unloading their catch. In some locations, fishermen are able to use dockside cranes to lift their totes of fish off of the vessel or out of the hold. In areas without such infrastructure, fishermen must manually move the fish from the vessel to the shore. Once the hold is empty, crew must inspect the bilges and clean out any fish that may have gotten caught in them. If fish or other organic material is left to rot in the bilges, it could release poisonous fumes that could harm or kill the fishermen next time they enter the hold.

4. ANALYSIS OF MARINE AND PERSONNEL CASUALTIES

In order to illuminate potential patterns or trends in safety outcomes within the limited access groundfish fleet, we compiled data on the occupational fatalities and fishing-related injuries that occurred in the fishery from FY2006-FY2015. While we do not expect that these data represent a complete record of all the safety incidents that occurred in the fishery during this time, they do help us to better understand (1) whether certain segments of the fleet are particularly at-risk and (2) how certain hazards and risk factors may directly impact fishermen's safety and survivability in the event of an emergency. Section 4.1 presents data on the fishing-related fatalities that occurred on limited access groundfish vessels from FY2006-FY2015, and Section 4.2 provides details on nonfatal occupational injuries sustained on limited access groundfish vessels during this same period.

4.1 Occupational fatalities in the limited access groundfish fishery, 2006-2015

Data on fatal vessel disasters[12] and other occupational fatalities involving vessels targeting groundfish from 2006-2015 were obtained from the NIOSH CFID database. The CFID database is maintained by the NIOSH Commercial Fishing Safety Research and Design Program, and it contains information on vessel disasters, fatalities, and other occupational safety incidents which occur in commercial fisheries across the U.S. dating back to 2000 (Lambert et al. 2015). CFID data are collected from a variety of sources including USCG investigation reports, death records, news stories, law enforcement agencies, and other occupational health and safety monitoring agencies (Lambert et al. 2015). Detailed data on occupational fatalities can help researchers identify trends in safety outcomes for different segments of the fleet, and they can also help to illuminate the hazards and other contributing factors that impact those outcomes.

[12] NIOSH defines vessel disasters as "sinkings, capsizings, groundings, fires, or other events that force crews to abandon ship" (NIOSH 2017b).

CFID records indicate that there were 9 fatal incidents involving limited access groundfish vessels from FY2006-FY2015; these 9 incidents resulted in the deaths of 14 commercial groundfish fishermen (Table 3). There were no more than 3 fatal incidents annually during each year of this time series, but FY2006 was particularly deadly in terms of fishermen fatalities (7 fatalities) (Table 3). Both the total number of fatal incidents and the total number of occupational fatalities in the groundfish fishery decreased after the transition to sector management in FY2010. There were 6 fatal incidents and 11 fatalities in the limited access groundfish fishery from FY2006-FY2009; this dropped to 3 fatal incidents and 3 fatalities from FY2010-FY2015 (Table 3).There are many factors that may have contributed to the observed decline in casualties from 2010-2015; however, this trend is likely due in part to the fact that the total number of active vessels and the total number of groundfish trips taken during this period dramatically declined. Fewer vessels taking fewer trips means fewer opportunities for safety incidents to occur.

When broken down by incident type, data show there were 5 fatal vessel disasters, 2 fatal falls overboard, 1 fatal onboard injury, and 1 fatal onshore injury in the groundfish fleet from FY2006-FY2010 (Table 3). Vessel disasters were the only incident type that resulted in multiple fatalities per incident, and all 5 of the vessel disasters occurred before FY2010 (Table 3). Records indicate the initiating events that led to these vessel disasters were instability (4 events) and flooding (1 event) (Table 4). All 5 of the affected vessels ultimately sank as a result of these disasters. Both fatal falls overboard were witnessed by other crew members who were on the deck at the time of the incident. The cause of one of the fatal falls overboard was unknown, but the second fall occurred when a fisherman tripped over unsecured gear on the deck. The fatal onboard injury was the result of a winch entanglement, and the fatal onshore injury occurred after a fisherman fell from a pier into the water.

Most of the occupational fatalities (10 fatalities) that occurred in the groundfish fishery from FY2006-FY2015 happened during the winter months (Table 5). January saw the highest number of fatal incidents (4 incidents) and fisherman fatalities (9 fatalities) of any single month during the study period (Table 5). The fact that the majority of the groundfish fatalities occurred during the winter months likely reflects the fact that prevailing environmental conditions during this time of year present many hazards for commercial fishermen. For example, rough seas and ice accretion can compromise vessel stability, and cold air and water temperatures can increase the risk for hypothermia should a fisherman enter the water.

More than half of the fatal incidents (5 incidents) that occurred in the limited access groundfish fishery from FY2006-FY2015 occurred in or adjacent to the state of Massachusetts, while the rest occurred in and around Maine (1 incident) and New Jersey (1 incident) (Table 6). Massachusetts also experienced the highest total number of fishermen fatalities (9 fatalities) during this time series, followed by Maine (4 fatalities) and New Jersey (1 fatality) (Table 5). The bulk of the active vessels in the limited access groundfish fleet hailed from ports in the state of Massachusetts during FY2015, so it is unsurprising that a large proportion of the fatal incidents and fatalities occurred in this geographic area. The vast majority of the fatal incidents (8 incidents) and occupational fatalities (13 fatalities) in the limited access groundfish fishery occurred within 50 miles of shore, and the largest proportion of fatal events (4 incidents) and fatalities (9 fatalities) occurred between 10 and 30 miles from shore (Table 7).

The majority of the limited access groundfish vessels (6 vessels) involved in fatal incidents from FY2006-FY2010 were actively fishing at the time of the incident (Table 8). The remainder of the fatal incidents that occurred during this time period happened while the affected vessels were transiting in from the fishing grounds (1 vessel), transiting out to the fishing grounds (1 vessel), or moored (1 vessel) (Table 8). Half of the total fatalities (7 fatalities) that occurred from FY2006-FY2015 occurred on vessels that were actively fishing at the time of the incident (Table 8). Furthermore, all 14 of the fatalities that occurred during this period involved vessels that were fishing with bottom trawl gear at or around the time of the incident (Table 9). In other words, none of the fishing-related deaths in the groundfish fishery from FY2006-FY2015 occurred while vessels were fishing with sink gillnets, bottom longlines, or rod-and-reel gear (Table 9). All 9 of the groundfish vessels involved in fatal incidents from FY2006-FY2015 held Category A limited access multispecies permits at the time of the incident. Additionally, all 3 of the groundfish vessels involved in fatal incidents during or after 2010 were enrolled in a groundfish sector at the time of the incident; none were enrolled in the common pool. The fact that all of the vessels held Category A permits at the time of the incident is not surprising since the vast majority of the vessels in the limited access groundfish fleet (89.8% of vessels in FY2015) operate under this permit category. Additionally, the bulk of the vessels in the fleet (77.2% of vessels in FY2015) were enrolled in sectors, so it is more likely that a fatal incident will involve a sector vessel as opposed to a common pool vessel.

In terms of the physical characteristics of the vessels involved in fatal incidents from 2006-2015, the majority of the affected limited access groundfish vessels (7 vessels) were steel-hulled (Table 10).The remaining vessels were wooden-hulled (1 vessel) or the construction of the vessel was unknown (1 vessel) (Table 10). Vessels in the 30' to < 50' size category experienced the most fatalities (7 fatalities) of any size class from FY2006-FY2015 (Table 11). Both of the fatal falls overboard that occurred during this period involved vessels in the 2 largest size classes (50' to < 75' and 75' and longer) (Table 11). This may suggest that fishermen on larger vessels may be more susceptible to this type of accident; however, it is difficult to draw any strong conclusions without more data on the subject. There does not appear to be a clear relationship between vessel size and any of the other incident types, as vessels in all but the smallest size category were involved in at least 1 vessel disaster (Table 11).

Regarding vessel age, the majority of the fatal incidents (7 incidents) and fishermen fatalities (11 fatalities) that occurred in the groundfish fishery from FY2006-FY2015 involved vessels that were between 20 and 49 years old (Table 12). Interestingly, data show that none of the vessels involved in fatal vessel disasters during this period were in the 2 highest age brackets (40-49 years and 50-59 years) (Table 12). However, all of the fatal falls overboard, fatal onboard injuries, and fatal onshore injuries involved vessels in these age categories (Table 12). This pattern may indicate that vessels of different ages are prone to different types of accidents, but we cannot draw any firm conclusions on this subject without additional data.

In total, 14 groundfish fishermen lost their lives in fatal occupational incidents from 2006-2015 (Table 13). Almost half of the decedents worked as deckhands (6 decedents) or skippers (6 decedents) at the time of their deaths, while the remaining decedents (2 decedents) were owner-operators. Data suggest that deckhands were more susceptible to falls overboard than skippers or owner-operators during this period (Table 13). Both of the individuals who died in fatal falls overboard were handling gear (1 individual) or hauling gear (1 individual) at the time of the incident (Table 14). The fact that almost half of the decedents were deckhands, coupled with the fact that all of the fatal falls overboard involved individuals working as deckhands, may be partly because deckhands typically spend more time exposed on deck handling the gear than captains do.

All the limited access groundfish fishermen killed in occupational incidents were between 20 and 69 years old (Table 15). The largest proportion of decedents (6 decedents) were 50-59 years old at the time of the incident (Table 15). All of the decedents who died as a result of falls overboard, onboard injuries, or onshore injuries were 40-69 years old (Table 15). In total, 4 fishermen survived vessel disasters from FY2006-FY2015 (Table 16). All 4 of these survivors entered the water during these incidents, as did the vast majority of the decedents (13 out of 14) (Table 16). Almost all (3 out of 4) of the survivors were wearing PFDs at the time of the incident, while none of the decedents were wearing PFDs.

In addition to the occupational fatalities described above, there were 2 non-fishing related fatalities that occurred in the groundfish fishery during the study period. Both of these fatalities were the result of drug overdoses while the vessels were moored and the victims were alone onboard. For ease of analysis, we chose to keep those 2 fatalities separate from the occupational fatality tallies in Tables 3-16, since those incidents were not strictly fishing-related. Additionally, those 2 overdose fatalities were not included in the occupational fatality rate calculations in Section 6. However, we felt it was important to still acknowledge the existence of these 2 incidents in this risk assessment. We feel that data pertaining to non-fishing related fatalities can still provide insight into the overall condition of the fishery and its participants, as well as the broader social issues impacting safety in the fleet. Additionally, the fact that both of these non-fishing related fatalities were attributed to drug overdoses directly reflects concerns mentioned in interviews with industry experts, as substance use disorders were cited multiple times as factors impacting fishing safety. Therefore, we felt it was essential not to exclude data about issues industry experts felt were important enough to inform us about during their interviews. Finally, conversations with industry members and health professionals suggest that commercial fishermen may turn to substance use as a coping mechanism to deal with the uncertain, physically demanding, isolated, and stressful nature of their profession. Therefore, while substance use issues cannot be solely attributed to commercial fishing, it is likely that some elements of commercial fishing contribute to these issues amongst fishermen.

4.2 Nonfatal injuries in the groundfish fishery, 2006-2015

We analyzed data pulled from the USCG's Marine Information for Safety and Law Enforcement (MISLE) database in order to identify and describe some of the nonfatal safety incidents that occurred in the limited access groundfish fishery from 2006-2015. The MISLE database contains details from USCG investigation reports about marine casualties around the U.S.; these details include the names of the vessels involved, the types of incidents that occurred, the locations of the incidents, the causes of the incidents, the number of persons involved, and the nature of any injuries sustained through each incident. Parts of these incident reports are available online at the USCG online incident investigation report website.

In order to determine whether a safety incident occurred on a limited access groundfish trip from 2006-2015, we first isolated the marine casualties that involved U.S.-flagged commercial fishing vessels off the northeastern coast of the U.S. during this time period. Next, we cross-referenced the hull ID numbers and vessel names contained in the list of incidents pulled from the MISLE database to those contained in the list of vessels that participated in the limited access groundfish fleet from 2006-2015. Once we determined that a vessel in the MISLE database matched a vessel in our groundfish fleet data, we examined the rest of the details attached to that MISLE record. If the MISLE entry specified that the vessel was participating in the northeast multispecies fishery at the time of the incident, we included that incident in our list of nonfatal incidents in the limited groundfish fishery from 2006-2015. If details about that vessel's fishing activity were not recorded in the MISLE database, we examined VTR data to see what kinds of fishing trips that vessel had taken in the days prior to and after the incident. If that vessel had been taking groundfish trips around the time of the incident, we assumed it was likely that the vessel had been on a groundfish trip at the time of the incident and included that incident in our data set. Using this technique, we identified 13 nonfatal safety incidents that occurred in the limited access groundfish fishery from 2006-2015 (Table 17).

It is important to note that we do not expect that the 13 incidents pulled from the MISLE database represent all the nonfatal safety incidents that occurred in the limited access groundfish fishery during this time period. The MISLE database only contains records of the incidents investigated by the USCG; therefore, accidents and injuries that were not serious enough to require emergency assistance are largely underreported in this database. For example, USCG data would not contain details about the relatively minor injuries fishermen routinely sustain and treat themselves, such as cuts, sprains, and puncture wounds. There are also financial disincentives in place, such as insurance penalties, that may encourage fishermen not to report every safety incident that occurs on their vessel. Finally, the USCG would not have records of chronic injuries (e.g., back, knee, and shoulder conditions) that arise from years of heavy lifting and physical labor unless those injuries culminate in a sudden severe injury. Therefore, while the data presented throughout the remainder of this section help to illustrate the types of injuries and accidents that may occur on commercial groundfish vessels, it should not be interpreted as a complete record of all the accidents and injuries that have occurred in the fishery over the past 15 years.

In total, MISLE data indicate that 13 nonfatal occupational injuries occurred on limited access groundfish vessels from 2006-2015 (Table 17). Almost half of these injuries occurred during 2011 (3 injuries) and 2012 (3 injuries) (Table 17). The largest proportion of injuries (5 injuries) occurred during the winter months; this may be because of the fact that weather and environmental conditions make it particularly risky to fish during this time of year (Table 18). The second largest proportion of injuries (4 injuries) occurred in the summer months (Table 18). This is likely in part because of the fact that the largest percentage of groundfish trips are taken during the summer months, so the chance of an injury occurring during this time of year are higher. The average size of the vessels on which nonfatal injuries occurred was 66.5’ (Table 19), which is slightly longer than the fleet-wide average size of 54.8’. This may be partly due to the fact that 7 out of the 13 vessels on which an injury occurred were bottom trawl vessels, which tend to be larger than vessels fishing with other gear types. Eleven of the injuries occurred on trips with otter trawl gear, and two were gillnet vessels. Of the injuries on otter trawl vessels, 5 of 11 occurred while operating the towing gear (laceration by winch, caught in tow wire, caught in gear, tangled in net, broken safety chain hit crewmember in the face). The other otter trawl injuries were caused by ice buckets, collisions, fish spines, fainting, and fixing the vessel. The gillnet injuries were caused by a collision and a slip on a wet deck.

Although there were only 13 injuries that required USCG response during this time period, we can relate this data to several risk trends discussed in this assessment. Crew members were injured more frequently than captains or vessel owners from 2006-2015; 10 crew members sustained nonfatal injuries during this time period, while only 2 captains and 1 vessel owner were injured (Table 20). These differences could be due to crew being more exposed to on-deck hazards and having more contact with the gear than captains or vessel owners. It may also be partly because crew outnumber captains and vessel owners in the groundfish fleet, making it more likely that they are the ones to get injured. Through interviews with fishermen, detailed in section 7, we learned that many captains reported feeling safer and having better safety outcomes with a more experienced crew. The majority of the injuries (7 injuries) reported in MISLE involved encounters with fishing gear or other related equipment (e.g., net, winch, ice bucket, safety chain) (Table 21). We similarly learned through the interviews that crew are particularly vigilant around gear as they see gear as a safety hazard. The remaining 6 injuries resulted from vessel collisions (3 injuries), slips and falls (2 injuries), and a fainting spell (1 injury) (Table 21). From 2006-2015, MISLE records indicate that 3 fishermen sustained nonfatal wounds to their head and/or face (Table 21). Two fishermen sustained leg wounds, 2 fishermen injured their hands and/or fingers, 1 fisherman injured their arm, 1 fisherman sustained a torso wound, and 1 fisherman injured their shoulder (Table 21). Because of a lack of information, we do not know if these injuries are weather-related (fog or ice), fatigue-related, or experience-related.

5. CALCULATION OF FATALITY RATES

The level of participation in a fishery, such as the number of vessels operating in that fishery, the number of fishermen working in that fishery, and the amount of effort directed into that fishery, can fluctuate dramatically over time. Because of these variations, simply tracking changes in the absolute number of occupational fatalities in a fishery annually does not allow us to adequately gauge improvements or declines in safety. Instead, we use standardized fatality rates to measure fatality risk within fisheries (NIOSH 2017b). Risk is defined as "the probability of a fatality occurring" (NIOSH 2017b). A calculated decline in fishery fatality rates shows that the probability of a fatality occurring in that fishery is decreasing, which may indicate an improvement in safety. Conversely, an increase in fishery fatality rates indicates that the probability of a fatality occurring in that fishery is increasing.

NIOSH developed an approach for calculating fatality rates per 10,000 FTEs within fisheries. These rate calculations can be used to track changes in risk over time within a given fishery, and they can also be used to compare risk between different fishing fleets. The fatality rate per 10,000 FTEs provides an estimate of "how many fatalities would have occurred in [fishing] fleets if they all had 10,000 fishermen working regular 40-hour weeks throughout the year" (NIOSH 2017b). In order to calculate the fatality rate per 10,000 FTEs in a fishery, you need to first know (1) how many fatalities occurred within that fishery in a given year, and (2) how many FTEs were in that fishery in a given year (NIOSH 2017b).

In order to estimate the number of FTEs in the limited access groundfish fleet, we first calculated the number of "fishermen days" in the fleet (Lambert et al. 2015). Fishermen days were calculated by multiplying the total number of active groundfish vessels, the average crew size per groundfish vessel, and the average number of operational days per groundfish vessel for a given year (NIOSH 2017b; Lambert et al. 2015). This total was then adjusted to reflect a standard 40-hour work week, and the resulting number was the estimate of the number of FTEs in the limited access groundfish fleet (NIOSH 2017b):

$$\frac{\#\ \text{vessels} \times \#\ \text{crew per vessel} \times \#\ \text{operating days per vessel} \times 24\ \text{hours}}{2{,}000\ \text{hours}} = \#\ \text{FTEs}$$

By incorporating the number of active vessels, average crew size per vessel, and average number of operating days per vessel into this equation, we were able to control for changes in fleet size and fishing effort over time. Once the number of FTEs was calculated, we divided the total number of annual fatalities by the total number of annual FTEs in the limited access groundfish fleet to calculate annual fatality rates per 10,000 FTEs:

$$\frac{\#\ \text{fatalities}}{\#\ \text{FTEs}} \times 10{,}000 = \#\ \text{fatalities per } 10{,}000\ \text{FTEs}$$

Other methods for calculating fatality rates include calculating fatalities per 1,000 active vessels, fatalities per 1,000 vessel days[13], fatalities per 100,000 fishermen, and fatalities per 100,000 hours fished (Lambert et al. 2015). We chose to use the fatalities per 10,000 FTEs calculation method because this is the standard method by which NIOSH reports risk in U.S. fisheries and in other U.S. industries. Therefore, this rate is most comparable to other studies on occupational safety and health. In addition, we chose not to calculate nonfatal incident rates as part of this research since data on nonfatal occupational injuries within the fishery are scarce and often underreported. Therefore, the only incident rate calculations found within this report refer to occupational fatalities.

The annual number of estimated FTEs in the limited access groundfish fleet declined overall from 2006-2015, dropping from 691.1 FTEs in FY2006 to 434.8 FTEs in FY2015 (-37.1%, -256.3 FTEs) (Figure 24). The annual occupational fatality rate fluctuated dramatically from year to year, ultimately declining during this time series. The annual occupational fatality rate in the limited access groundfish fishery peaked in FY2006 at 101.28 fatalities per 10,000 FTEs (Figure 25). The limited access fleet experienced no occupational fatalities in FY2007, FY2009, FY2011, FY2012, FY2014, or FY2015; therefore, the annual occupational fatality rate during those years was 0.00 fatalities per 10,000 FTEs (Figure 25).

The 10-year average occupational fatality rate in the groundfish fishery from FY2006-FY2015 was 21.89 fatalities per 10,000 FTEs (Figure 25). Calculations indicate that the average occupational fatality rate in the period pre-catch share implementation (FY2006-FY2009) was higher than the average occupational fatality rate in the period post-catch share implementation (FY2010-FY2015). The average occupational fatality rate in the limited access groundfish fishery from FY2006-FY2009 was 39.85 fatalities per 10,000 FTEs; this dropped to an average rate of 9.92 fatalities per 10,000 FTEs in FY2010-FY2015 (Figure 25).

Changes in occupational fatality rates suggest that fatality risk within the limited access groundfish fleet may have improved since catch shares were implemented in 2010. However, we do not attribute this trend solely to the change in management regime; there are a variety of other factors that may have also contributed to these findings. For example, the likelihood of a fatality occurring in the limited access groundfish fleet may have declined as the fleet contracted over time. Fewer vessels taking fewer trips may mean less risk exposure and reduced opportunity for fatalities within the fleet. Additionally, conversations with commercial fishermen and safety trainers suggest that a "culture of safety" has been growing within the New England commercial fishing industry in recent years. As emergency response training and other safety resources became more widely available, groundfish fishermen may have started operating more safely. Finally, "less safe" operators may have dropped out of the limited access groundfish fleet over time, leaving only the "safer" operators remaining.

When assessing whether or not safety has improved in the limited access groundfish fleet, it is important to remember that the casualty rate calculations presented in this section are based solely on occupational fatality data. Therefore, we cannot gauge whether or not the probability of

[13] Vessel days are days absent from port; this includes fishing time and transit time (Lambert et al. 2015).

nonfatal accidents or injuries has increased or decreased over time. Additionally, the only fatal occupational incidents included in these calculations were the incidents that occurred on groundfish vessels taking groundfish trips. These calculations did not include fatal occupational incidents on groundfish vessels while they were engaged in other fisheries.

6. REVIEW OF FEDERAL REGULATIONS

Many of the regulations governing the commercial fishing industry may impact fishermen's ability to operate safely at sea, even if those regulations were not designed specifically with safety in mind. In order to better understand how federal fishing regulations may affect safety within the limited access groundfish fleet, we reviewed Federal Register publications, amendments to the groundfish FMP, and framework adjustments to the groundfish FMP from FY2006-FY2015 and identified instances where safety at sea was mentioned. In Section 6.1, we provide a brief overview of some of the USCG safety regulations that pertain broadly to U.S. commercial fishing industry vessels. In Section 6.2, we describe how various types of federal fishing regulations may impact safety in the limited access groundfish fleet, and we illustrate these points using examples of regulations that were effective during our study period.

6.1 Federal fishing industry safety regulations

The USCG is primarily responsible for implementing and enforcing safety regulations for commercial fishing vessels in the U.S. Over the past decade, safety regulations pertaining to the commercial fishing industry have been revised through a series of federal Acts. First, the Coast Guard Authorization Act of 2010 (Coast Guard Authorization…2010) implemented several revisions designed to clarify regulatory language, streamline safety requirements, and revise safety equipment and training standards. Specifically, these changes included:

- removing the distinction between federally-documented and state-registered fishing vessels so all vessels operating in the same waters are subject to the same safety requirements;
- replacing the term "boundary line" with "3 NM from the baselines from which the territorial sea of the United States is measured or 3 NM from the coastline of the Great Lakes" when describing fishing vessel operating areas;
- setting new performance standards for survival craft and eliminating life floats and buoyant apparatus from the list of acceptable survival craft for fishing vessels operating beyond 3 NM;
- requiring all fishing vessels operating beyond 3 NM to maintain a safety log that describes the safety equipment on the vessel, maintenance done to this equipment, and instructions and drills given to the crew;
- requiring all fishing vessels operating beyond 3 NM to pass a dockside safety exam and receive a safety certificate every 2 years;
- requiring the individuals in charge on fishing vessels operating beyond 3 NM to complete a competency training program;
- implementing new construction standards for fishing vessels < 50' that were built after January 1, 2010;
- implementing new classing standards for fishing vessels $\geq$ 50' that were built after July 1, 2012;

- and implementing new load line requirements for fishing vessels $\geq$ 79' that were built after July 1, 2012.

The Coast Guard and Maritime Transportation Act of 2012 (Coast Guard and Maritime…2012) further updated the safety requirements for commercial fishing vessels, some of which were prescribed in the Coast Guard Authorization Act of 2010 (Coast Guard Authorization…2010). Changes to the regulations under the Coast Guard and Maritime Transportation Act of 2012 (Coast Guard and Maritime…2012) included:

- requiring commercial fishing vessels operating beyond 3 NM to undergo a dockside vessel safety examination at least once every 5 years(existing regulations required these examinations to be completed at least once every 2 years);
- implementing new classing standards for fishing vessels $\geq$ 50' that were built after July 1, 2013 (existing regulations stated that these new classing standards applied to fishing vessels $\geq$50' that were built after July 1, 2012);
- and implementing new load line requirements for fishing vessels $\geq$ 79' built after July 1, 2013 (existing regulations stated that these new load line requirements applied to fishing vessels $\geq$79' that were built after July 1, 2012).

The USCG safety regulations for commercial fishing industry vessels are codified in the Code of Federal Regulations (CFR) at 46 CFR 28. The specific certifications and pieces of safety equipment that a given vessel must possess vary based on several physical and operational characteristics of that vessel, including the waters in which the vessel operates (cold waters vs. warm waters), the distance from shore the vessel operates at (within vs. beyond 3 NM of the baseline), the type of registration the vessel holds (federal documentation vs. state registration), vessel length, vessel tonnage, and the number of persons onboard. The vessels in the limited access groundfish fleet primarily operate beyond 3 NM of the baseline in cold waters, which the USCG defines as "waters where the monthly mean low water temperature is normally 59 °F/15 °C or colder" (USCG 2009). Additionally, the vessels comprising the fleet are between 23' and 88.4' in length and between 2 and 199 gross tons. Based on these criteria, these vessels are generally required to carry the following pieces of lifesaving and safety equipment on commercial groundfish trips:

- Immersion suits
- Survival craft (inflatable life raft, inflatable buoyant apparatus, buoyant apparatus)
- Throwable flotation devices (cushions, ring life buoys)
- Emergency Position Indicating Radio Beacons (EPIRBs)
- Distress signals (flares, smoke signals)
- Fire extinguishers (B-I, B-II, A-II, C-I, C-II)
- First aid kits

It is important to note that this list provides examples of some, but not all, of the equipment that limited access groundfish vessels may be required to carry. For more details on the specific types of certifications, documentations, and safety equipment that may be required on different limited access groundfish vessels in the Northeast, please see Appendix A of this report.

Alternatively, you may visit the Fish Safe website, which is maintained by the USCG and contains links to a variety of forms, guides, and regulations related to commercial fishing vessel safety.

6.2 Federal fishing regulations

There are many federal fishing regulations that may directly or indirectly impact safety at sea within a given fishery. In order to determine what types of fishing regulations may have impacted safety in the limited access groundfish fleet during our study period, we reviewed management actions implemented in the groundfish fishery from FY2006-FY2015. For each management action identified, we reviewed (1) the corresponding Federal Register announcement, (2) the public comments attached to the action, and (3) the full-text of the action, then we scanned them for keywords related to safety (e.g., safe, risk, hazard, weather). In some cases, the regulations we examined pertained broadly to commercial fishing vessels in the Northeast, while others applied specifically to the groundfish fishery. Once we compiled a list of safety-related regulations, we sorted them into "general fishing regulations" and "groundfish-specific fishing regulations," then we grouped them by "type" (e.g. regulations pertaining to DAS, gear stowage, landing limits, safe harbor provisions).

Throughout the remainder of Section 6.2, we present the results of this regulatory review and explain the potential safety implications associated with each type of regulation identified. We supplement these discussions with examples of specific regulations implemented from FY2006-FY2015 to better illustrate how each type of regulation may potentially impact safety. We do not expect that this regulatory review yielded a comprehensive list of all the types of management measures that could affect safety within the limited access groundfish fleet, since any regulation that impacts fishermen's operating decisions could conceivably have ramifications for safety. However, we do believe that the list contained in this risk assessment provides valuable insights into the social impacts associated with various types of regulations. It is important to note that some of the specific regulations we cite as examples of measures that may impact safety are no longer in effect. However, we believe understanding the safety implications associated with past regulations can help researchers, managers, and policy analysts better anticipate the social impacts resulting from future management actions.

6.2.1 General regulations governing federally-permitted commercial fishing vessels

6.2.1.1 Gear stowage requirements

Federal regulations allow commercial fishing vessels to transit closed areas for safety reasons, as long as their fishing gear is stowed properly so it is "not available for immediate use." Stowage requirements vary based on the type of gear a vessel is carrying. For example, operators of vessels fishing with bottom trawl nets may opt to stow their nets on deck, on net reels, or below deck while transiting closed areas; if operators choose to stow the nets on deck, they must be fan-folded, tied around the middle, and attached to the deck or rail of the vessel. If bottom trawl nets are being stored on net reels, the nets must be covered with canvas or highly visible yellow or orange mesh incapable of catching fish, the cover must be securely fastened to the vessel, and the codend of the net must be removed and stowed below deck. Alternatively, if bottom trawl nets are stowed below deck during transit, operators must ensure that they are fan-folded and tied around the middle. In order for sink gillnet vessels to transit closed areas, the nets must be folded, covered with a canvas or tarp, and fastened to the deck or rail of the vessel during transit. In addition, all of the buoys, high flyers, and anchors must be detached from the net during transit. Finally, vessels fishing with hook gear must ensure that all gear is covered and all buoys and anchors are secured before the vessel may transit a closed area (Definitions…1996).

Allowing vessels to transit through closed areas may positively impact safety at sea by not forcing commercial fishing vessels to spend extra time circumventing these areas in adverse weather. However, public comments on these types of gear stowage requirements suggest that these regulations may also have negative safety ramifications for fishermen's safety. For example, several public comments that were submitted on the proposed rule for Framework Adjustment 48 explained that requiring operators to fold, secure, and cover their gear before transiting forces fishermen to spend more time maneuvering around on deck, which is especially dangerous in rough weather (Magnuson-Stevens…2013a). From FY2006-FY2015, the NEFMC sought to address some of these safety concerns by proposing changes to the gear stowage regulations. For example, the Council included a provision in Framework Adjustment 48 (Magnuson-Stevens…2013a)) that would eliminate gear stowage requirements for bottom trawl fishermen on a groundfish trip. While NMFS acknowledged that this measure may reduce the amount of risk bottom trawl operators are exposed to when transiting closed areas, they failed to approve the measure because it would not be fair to address safety concerns on bottom trawl vessels and not on vessels fishing with other gear types.

Instead, in 2014, NMFS approved regulations (Magnuson-Stevens…2014a) revising, but not eliminating, on-reel stowage requirements for bottom trawl nets. The revised regulations specified that fishermen no longer needed to cover net reels with canvas or tarps when transiting closed areas; instead, they could use highly visible colored mesh to demonstrate that their gear was properly stored. This action also eliminated the measure requiring towing wires to be detached from nets while they are stowed on reels for transit. Industry comments on this rule said these revisions to stowage requirements would have positive impacts on safety. One commenter explained that covering net reels with canvas is extremely dangerous because fishermen must crawl up and over the reels while wrestling to secure the covering, exposing them to the elements as well as any additional hazards on deck. Also, detaching the towing wires from the net during transit leaves the trawl doors free to swing around, a scenario that could easily result in damage to vessels or injuries to fishermen.

6.2.1.2 Vessel upgrade and replacement restrictions

In 1994, Amendment 5 implemented regulations limiting the extent to which vessels holding federal limited access multispecies permits[14] may be upgraded over time. These regulations were primarily designed to control effort and limit overcapacity within limited access fisheries by restricting potential future increases in fleet harvesting capacity. Under these regulations, limited access permit holders were permitted a one-time opportunity to upgrade the size and HP of the vessel their permit was issued for; "upgrading" included either modifying the existing vessel or replacing the vessel altogether. If a permit holder chose to modify their vessel, they had to ensure that the length overall (LOA) of the modified or replacement vessel was not more than 10% longer than the baseline LOA of the vessel originally granted their limited access permit. Similarly, a permit holder could increase the baseline gross registered tonnage (GRT) and net tonnage by no more than 10%. Each vessel was also eligible for one additional upgrade in which the HP could be increased by no more than 20% from the vessel's baseline HP specifications. In 2015, the Omnibus Amendment to Simplify Vessel Baselines (Magnuson-

[14] In 1999, similar upgrade regulations were implemented for most other types of federal limited access permits.

Stevens…2015c) removed the regulation limiting permit holders to a single upgrade and eliminated the tonnage requirements for vessel upgrades.

While limitations on vessel upgrades may help to address issues related to overcapacity in the groundfish fishery, public comments on these types of regulations suggest that restricting fishermen's ability to upgrade or replace their vessels may negatively impact safety at sea by restricting operators' ability to adapt to changing conditions. For example, one individual who submitted public comment on the Omnibus Amendment to Simplify Vessel Baselines (Magnuson-Stevens…2015b) explained that restrictions on vessel upgrades have prevented fishermen from being able to switch to larger vessels as new closed area and access area restrictions compelled them to take longer trips to fish farther offshore. As a result, some operators of smaller inshore vessels had been forced to fish in offshore areas their vessels were not designed for, which poses safety concerns. A second commenter similarly noted that restrictions on vessel upgrades have prevented some vessel owners from being able to purchase vessels large enough to safely support their current fishing operations. Finally, another commenter on this rule pointed out that lifting restrictions on vessel upgrades would give owners of older vessels the flexibility to switch to newer and safer vessels that better complied with new USCG regulations.

6.2.1.3 At-Sea monitoring and observer requirements

The regulations contained at 50 CFR 648.11 (At-sea…1996) state that at any point during the fishing season, the NOAA Northeast Regional Administrator (RA) may request that vessels fishing under a federal groundfish permit[15] must carry an NMFS-certified fishery observer or at-sea monitor. Fishery observers and at-sea monitors collect a variety of biological, economic, and operational data when accompanying a vessel on a fishing trip. This data is used to better inform science and resource management in the northeast multispecies fishery, and to aid in regulatory compliance within the fishery. Prior to starting any fishing trip, fishery observers and monitors are required to complete a walkthrough safety inspection of the vessel they are assigned to. During these inspections, an observer or monitor checks for any major hazards or deficiencies onboard the vessel and ensures that the vessel's safety equipment is properly documented, stored, and maintained. Some of the items reviewed as part of these safety inspections include:

- PFDs and immersion suits;
- ring life buoys;
- distress signaling devices;
- fire extinguishers;
- EPIRBs; and
- survival craft.

Additionally, any vessel selected to carry a fishery observer or monitor must possess a valid USCG Commercial Fishing Vessel Safety Examination Decal. A fishery observer or monitor is authorized to refuse to embark on a fishing trip if they complete their pre-trip safety inspection and find that a vessel does not have a current safety decal or if crucial safety equipment is non-

[15] The groundfish fishery is not the only federal fishery subject to these observer/at-sea monitor requirements. For more details on the other affected fisheries, please see the regulations set forth in 50 CFR 648.11.

functional, insufficient, expired, or missing. When this occurs, the owner/operator of that vessel is required to correct the deficiencies before embarking on its next fishing trip.

Feedback on federal observer and at-sea monitoring requirements suggests that these regulations may have had a positive impact on safety at sea within the commercial groundfish fleet. The fact that vessels must meet certain safety standards in order to carry fishery observers has forced groundfish permit holders to ensure that their vessels are always properly equipped and documented for safety. This additional layer of oversight may have helped to ensure that the vessels in the commercial groundfish fleet are prepared to deal with emergencies at sea, reducing the likelihood of negative safety outcomes within the fishery. Furthermore, fishery observers and at-sea monitors may be able to alert captains and crew to safety issues that would otherwise have gone undetected. However, some members of the fishing industry feel that the presence of an observer or monitor on commercial groundfish vessels can negatively impact the safety of the crew on those vessels. Some industry members said that being forced to carry an observer or monitor on a trip increases crowding on their vessel, making it more difficult for crew to maneuver safely and efficiently on deck. Other industry members have explained that many observers and monitors have little experience working at sea or working on specific vessels. As a result, fishing crew may become distracted making sure the observers are not placing themselves in harm's way, increasing the crew's likelihood of making a mistake and getting injured. Lack of experience on a specific vessel may also mean that observers and monitors are unfamiliar with the emergency protocols on that vessel, which can impact their personal safety as well as the safety of others onboard in the event of a crisis. For example, public comments expressing these concerns were submitted in response to Framework Adjustment 48 to the Northeast Multispecies FMP (Magnuson-Stevens…2013a), which included measures increasing observer coverage levels within the groundfish fleet.

6.2.1.4 Vessel monitoring system (VMS) requirements

Framework Adjustment 42 to the Northeast Multispecies FMP (Magnuson-Stevens…2006b) implemented a requirement that all limited access groundfish DAS vessels fishing under a groundfish DAS must be equipped with an approved VMS. While this regulation was primarily designed to improve monitoring of fishing activity, social impacts analyses in the FW42 Environmental Assessment indicated that this measure may also indirectly improve safety within the fleet because an approved VMS can act as an additional means of communication or distress signaling in the event of an emergency. Additionally, VMS technology records a vessel's position on an hourly basis, creating a data stream the USCG could use when directing rescue missions and locating vessels in distress.

6.2.2 Effort control regulations in the Northeast groundfish fishery

Fishing activity in the commercial groundfish fleet was largely managed through the use of traditional effort control measures until Amendment 16 transitioned primary management of the fishery to a catch share program in 2010. Since then, limited access permit holders who opt to enroll their permit in a groundfish sector have been granted exemptions from many of these effort control regulations. The specific management measures that a given sector vessel is exempt from depend, in part, on which sector that operator is enrolled in. Exemptions from certain groundfish regulations are considered "universal"; that is, these exemptions are automatically granted to members of all approved groundfish sectors each year. Specifically, in FY2015, all sector members were exempt from:

- trip limits for all allocated groundfish stocks for which a sector receives an ACE;
- portions of the GOM Cod Protection Closure Areas;
- portions of the GB Seasonal Closure Area;
- Northeast multispecies DAS restrictions (except those required to comply with effort control measures in the monkfish, dogfish, and skate fisheries);
- minimum codend mesh size restrictions for vessels that fish in the GB Regulated Mesh Area, provided that these vessels used a haddock separator trawl or a Ruhle trawl with minimum 6” mesh; and
- the at-sea monitoring coverage rate for sector vessels fishing in a monkfish DAS in the Southern New England (SNE) Broad Stock Area (BSA) with extra-large mesh gillnets.

In addition to these universal exemptions, individual sectors may also apply annually for exemptions from additional groundfish regulations. As a result, the members of one sector may be exempt from certain groundfish management measures during a given fishing year, while the members of another sector may still be subject to those measures. For example, in FY2015, members of the GB Cod Fixed Gear Sector were exempt from the regulation prohibiting one sector vessel from hauling another sector vessel’s hook gear; members of the Maine Coast Community Sector, however, did not receive this exemption and therefore still had to abide by this measure.[16] In total, sectors applied for 22 exemptions in FY2015, and NMFS granted 19 of these exemptions (Magnuson-Stevens…2015a).

While sector fishermen are largely exempt from many of the effort control measures in the groundfish fishery, common pool fishermen are subject to these regulations. Because of the difference in the way these 2 components of the fleet are managed, many of the safety concerns associated with effort control-based regulations described in Section 6.2.2 primarily impact common pool vessels. However, it is important to note that sector vessels are still subject to certain effort control regulations under certain circumstances, and therefore, they are not immune to these risks. Throughout the remainder of Section 6.2.2, we explain how various types of effort control regulations may impact safety at sea for limited access groundfish vessels, with a focus on vessels in the common pool.

6.2.2.1 TACs and the common pool trimester TAC system

While sector members’ fishing activity is primarily constrained through the use of quotas, common pool fishing activity is constrained through the use of fleet-wide TACs for each allocated groundfish stock. For most stocks[17], common pool fishermen are only permitted to harvest a certain percentage of common pool sub-ACL during a given point in the fishing year. Starting in FY2012, the common pool sub-ACL for most stocks has been divided into 3 trimester TACs; a trimester TAC represents the proportion of the sub-ACL for that stock that can be harvested during a given point in the fishing year.[18] For example, Framework Adjustment 47 to the Northeast

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[16] For more detail on which sectors received specific exemptions in a given fishing year, please reference that sector’s Sector Operations Plan and Contract for the fishing year in question.

[17]SNE/MA winder flounder did not become an allocated stock until 2013. This is the only allocated stock where the common pool sub-ACL is not divided by trimester and is instead managed annually.

[18] Trimester 1 lasts from May 1-August 31, Trimester 2 lasts from September 1-December 31, and Trimester 3 lasts from January 1-April 30.

Multispecies FMP (Magnuson-Stevens…2012) specified that common pool vessels were permitted to catch 27% of the common pool sub-ACL for GOM cod in Trimester 1, 36% in Trimester 2, and 37% in Trimester 3. Once 90% of the trimester TAC has been caught for a particular stock, the trimester TAC area for that stock is closed to all vessels fishing with gear capable of catching that stock until the start of the next trimester. Additionally, if a percentage of the Trimester 1 or Trimester 2 TAC for a given stock is not harvested during that trimester, it may be rolled over and caught in Trimester 2 or Trimester 3, respectively.

Relying on hard TACs to manage fishing mortality may have negative impacts on safety at sea because fishermen may be inclined to race against one another to catch as much of the TAC as they can, as quickly as they can (NEFMC 2003). If the TACs for certain commercially important species are particularly low, or if additional restrictions are put in place limiting how many DAS are available for the fleet, this derby fishing behavior may be further exacerbated (NEFMC 2003). The trimester TAC system was expected to have mixed impacts on safety at sea for common pool fishermen. Analyses in the Amendment 16 Environmental Impact Statement (EIS) explain that breaking the common pool sub-ACL into 3 different trimesters may help to avoid the formation of the derby at the beginning of each fishing year (NEFMC 2009). If fishermen know they will have multiple opportunities to target groundfish stocks throughout the fishing year (i.e., at the start of each trimester), they may be less inclined to race to fish when each new fishing year starts in May (NEFMC 2009). Also, including provisions enabling portions of a Trimester 1 or 2 TAC to be rolled over at the end of the trimester could help to ensure that fishermen do not feel pressure to engage in unsafe behavior to harvest the remaining TAC near the end of the trimester. However, by forcing fishermen to wait until Trimester 2 or Trimester 3 to harvest portions of the common pool sub-ACL for a stock, the trimester TAC system may indirectly limit fishermen's flexibility to avoid fishing during the time of year when the weather is typically the most hazardous. Additionally, if fishermen anticipate that an in-season closure of a trimester TAC area may occur, they may engage in derby fishing behavior prior to that closure being implemented. Therefore, while the trimester TAC system may help discourage the formation of a race to fish at the start of each fishing year, it may lead to the formation of multiple smaller derbies at other points during the fishing year (NEFMC 2009).

6.2.2.2 Possession and landing limits

In addition to limiting the total amount of each stock that may be harvested annually by vessels fishing in the common pool, there are also regulations in place limiting the total amount of fish (by weight) that common pool vessels holding various types of permits may possess and land per trip and/or per DAS. For example, Framework Adjustment 53 to the Northeast Multispecies FMP (Magnuson-Stevens…2015a) set the initial FY2015 common pool trip limit for GOM cod at 50 live pounds per DAS, up to 200 live pounds per trip, for Category A-permitted vessels. Trip limits may be adjusted between fishing years based on changes in stock specifications and catch rates from the previous year, and they may also be adjusted within a fishing year based on current catch information. For example, a 2015 temporary rule (Magnuson-Stevens…2015b) reduced the common pool possession and landing limits for GOM cod to zero in order to avoid exceeding the common pool allocation for this stock during FY2015.

While possession and landing limits are primarily designed to protect and conserve fish stocks, they may also help to promote safety within the common pool by constraining fishing effort and preventing the formation of a derby fishery. Limiting the amount of fish a vessel may possess and land during a given time may reduce the incentive for that vessel to engage in risky fishing practices in order to race to harvest fish as quickly as possible. Conversely, the fact that possession and trip limits may be adjusted in-season could indirectly encourage fishermen to race to fish ahead of an anticipated possession limit reduction. Additionally, the existence of possession and landing limits may also negatively impact safety by indirectly encouraging fishermen to stay at sea for long enough to account for their catch, sometimes in rough weather (see Section 7 for more details).

It is worth noting that, while sector vessels are primarily regulated using quotas, these vessels are still subject to trip and possession limits for certain species. For example, all vessels issued a federal groundfish permit (whether in a sector or in the common pool) may not possess or land more than 1 Atlantic halibut per trip. Additionally, sector vessels may be subject to possession restrictions while targeting other species (e.g., monkfish) on sector trips. Therefore, the safety implications associated with trip or possession limits described above may also apply to sector vessels, though likely to a lesser extent than they do for common pool vessels.

6.2.2.3 DAS restrictions

All limited access groundfish vessels receive annual groundfish DAS allocations. The number and type of DAS a particular vessel is allocated depends on the fishing history attached to that vessel's permit. There are 3 categories of groundfish DAS: Category A DAS, Category B DAS, and Category C DAS. There are certain restrictions in place that dictate when certain types of DAS can be used: Category A DAS can be used at any time to target allocated groundfish, Category B DAS can be used on set-only gillnet trips or to target healthy stocks through Special Access Programs, and Category C DAS cannot currently be used. Fishing effort in the common pool is largely constrained through the use of DAS restrictions. That is, the total number of days common pool vessels are permitted to spend on groundfish trips during each fishing year are limited. In general, sector vessels are less constrained by DAS restrictions than common pool vessels because sector vessels are exempt from the requirement to use a groundfish DAS to land allocated groundfish stocks.[19]

Amendment 16 to the Northeast Multispecies FMP (Magnuson-Stevens…2010) included provisions updating the way groundfish DAS are allocated to common pool vessels only, ultimately reducing each vessel's FY2010 DAS allocation by 32% compared to FY2009. While limitations on the number of DAS that may be fished are designed primarily to protect fish stocks, social impacts analyses and comments from members of the public indicate that these measures may indirectly impact safety at sea for affected fishermen by compromising flexibility and reducing earning opportunities. For example, the Amendment 13 Final Supplemental Environmental Impact Statement (SEIS) explained that reducing the number of DAS available to groundfish fishermen may make it more difficult for some vessels to remain economically viable (NEFMC 2003). Some operators may choose to engage in riskier behavior in order to capitalize on their remaining opportunities to fish (NEFMC 2003). For example, some vessels may attempt to maximize profits from their remaining DAS by fishing primarily during the winter, when fish prices are typically higher but weather also tends to be more extreme and less predictable (NEFMC 2003). Additionally, comments received on Amendment 13 suggest that, when faced with declining revenues, vessel owners often skip purchasing safety equipment and opt to forgo vessel maintenance (NEFMC 2003). While reductions in DAS may mean vessels spend less time on the water and are therefore exposed to fewer hazards, skipping maintenance and failing to purchase

[19] Under certain circumstances, sector vessels may need to use groundfish DAS while participating in other fisheries that require the concurrent usage of groundfish DAS (e.g., monkfish).

safety equipment may contribute to an increase in the number of accidents that occur on some vessels (NEFMC 2003). Spending less time on the water could also lead to reduced fishing experience for operators and crew, which may negatively impact safety (NEFMC 2003). Finally, DAS reductions may make it more difficult for vessels to find and retain crew members (NEFMC 2003), or it may lead vessel owners to reduce their operating costs by reducing the number of crew they fish with (NEFMC 2003). This may lead some vessel operators to fish alone for all or part of the fishing year (NEFMC 2003).

In addition to changing the number of DAS available during a fishing year, fishery managers may also implement measures altering the way DAS are counted in order to control common pool fishing effort. Differential DAS counting areas, or areas in which groundfish DAS are counted at a rate different than 1:1, may be implemented in order to adjust fishing effort to align with stock conservation goals. For example, a 2006 Emergency Secretarial Action (Fisheries…2006) implemented measures in which northeast multispecies Category A DAS were counted at a rate of 1.4:1 in all areas except the U.S./Canada Management Area. Therefore, a common pool vessel fishing under a northeast multispecies Category A DAS that spent 5 days at sea would be charged for 7 DAS (5 x 1.4) unless that vessel fished exclusively in the U.S./Canada Management Area. Impact analyses and public feedback on differential DAS counting have indicated that the use of this type of management measure may negatively impact safety within the common pool by indirectly encouraging fishermen to travel farther offshore outside of differential DAS areas to fish (Magnuson-Stevens…2010). Additionally, counting DAS at a differential rate during part of the fishing year may indirectly lead vessels to fish during other times of year when DAS are counted at a lower rate. If this results in vessels taking more trips during the winter when the weather is typically more extreme and unpredictable, the safety of those vessels may be compromised (NEFMC 2003).

Similar to differential DAS counting, some groundfish management actions have relied on adjustments to DAS counting increments to curb common pool fishing effort. For example, Amendment 16 to the Northeast Multispecies FMP (Magnuson-Stevens…2010) revised the way northeast multispecies DAS were counted for the common pool portion of the fishery, making it so each partial DAS used by these vessels was counted as a minimum of 24 hours. Therefore, a common pool vessel that fished for 5 hours would be charged for 24 hours' worth of DAS, and a common pool vessel that fished for 30 hours would be charged for 48 hours' worth of DAS (and so forth). In contrast, sector vessels are charged DAS at the rate they are used and not in 24-hour increments. Therefore, a sector vessel that fished for 5 hours would only be charged for 5 hours' worth of DAS. Impact analyses have revealed that these types of DAS-counting regulations may indirectly compromise safety by creating a perverse incentive for fishermen to spend more time at sea in order to take advantage of the full 24-hour DAS charge being imposed upon them (NEFMC 2003). This may exacerbate fatigue onboard these vessels, especially on smaller vessels that typically take partial day trips with minimal crew onboard (NEFMC 2003).

While there are many ways in which DAS regulations may encourage groundfish fishermen to make safety tradeoffs, there are also several measures in place designed to alleviate this pressure. For example, there is a "good Samaritan credit" measure in place that says that a limited access DAS vessel will not be charged any DAS for time spent helping with a USCG search and rescue mission or towing operation. This measure helps to encourage operators to assist other vessels in distress by eliminating the fear of wasting allocated DAS. Additionally, there are also regulations in place that allow limited access DAS vessels to request "canceled trip DAS credits" if they end a trip prior to setting and/or hauling their fishing gear. These provisions may help encourage operators to stop a trip early if they have concerns over the weather, their crew, the physical condition of their vessel, or anything else related to safety.

6.2.2.4 DAS leasing and transfer provisions

Amendment 13 to the Northeast Multispecies FMP (Magnuson-Stevens…2004) implemented DAS transfer and DAS leasing provisions for the groundfish fishery. The DAS transfer program allows limited access groundfish permit holders to permanently transfer groundfish DAS to other limited access groundfish permit holders. The DAS leasing program allows limited access multispecies permit holders to temporarily lease Category A DAS to other limited access groundfish permit holders on an annual basis. All leased DAS must be used within the same fishing year in which they were leased; in other words, leased DAS cannot roll over from one fishing year to another. There are some restrictions in place limiting DAS transfers and DAS leases between certain vessels. For example, a sector vessel may lease DAS to another sector vessel and a common pool vessel may lease DAS to another common pool vessel, but DAS leasing between sector and common pool vessels is prohibited. Additionally, a vessel may only transfer or lease DAS out to another vessel as long as the baseline LOA of the recipient vessel is not more than 10% greater than the baseline LOA of the transferor/lessor vessel. Similarly, a vessel may only transfer or lease DAS out to another vessel as long as the baseline HP of the recipient vessel is not more than 20% greater than the baseline HP of the transferor/lessor vessel. Sector vessels are largely exempt from the length and HP DAS leasing restrictions, but DAS leasing between common pool vessels is still constrained by these provisions.

The DAS leasing and transfer programs was designed to enhance the economic viability of the fishery and to increase fishermen's flexibility to adopt to the other management measures being proposed through Amendment 13 (NEFMC 2003). These programs were expected to indirectly impact safety at sea in several ways. First, impact analyses determined that the ability to lease or transfer DAS would likely help some vessels remain economically viable, which would help to offset some of the negative economic impacts resulting from DAS reductions as described in the previous section of this report (NEFMC 2003). This, in turn, could help mitigate some of the potential safety concerns associated with reductions in DAS. Additionally, public comments received during the development of Amendment 13 indicated that the ability to transfer DAS from one vessel to another could allow owners of multiple vessels to fish their DAS with fewer vessels, which would reduce their operating costs and enable their remaining active vessels to operate more safely (NEFMC 2003).

We should note that the vessel upgrade restrictions constraining DAS transfers and leases may limit the potential safety-related benefits associated with these programs for certain groups of vessels, especially if they are enrolled in the common pool and therefore not exempt from any of these restrictions. Analyses in the Amendment 13 SEIS indicated that DAS is likely to move from larger vessels to smaller vessels, in part due to the length and HP restrictions placed on DAS transfers and leases (NEFMC 2003). If larger vessels have a difficult time finding suitable lease or transfer partners, their ability to participate in, and therefore benefit from, these programs may be relatively limited.

6.2.2.5 DAS Carryover

Amendment 13 also established provisions for DAS carryover. These provisions allow limited access vessels with unused Category A or B DAS on the last day of the fishing year (April 30) to carry a maximum of 10 DAS over for use in the following year, with some restrictions. The ability to carry over DAS from one fishing year to another may have positive impacts on safety because it may discourage operators from fishing in unsafe conditions solely to avoid wasting

DAS. Instead, if a vessel was unable to fish its full DAS allocation due to poor weather or other factors, that vessel would have the ability to fish a portion of its DAS during the following fishing year when conditions were more favorable (NEFMC 2009).

6.2.2.6 Trip limits in Special Access Programs (SAP)

Some groundfish vessels have the ability to participate in SAPs, which are designed to provide vessels with additional opportunities to target healthy groundfish stocks while avoiding stocks of concern and minimizing impacts on essential fish habitat (Magnuson-Stevens…2004). For example, Amendment 13 (Magnuson-Stevens…2004) implemented the Closed Area II (CA II) Yellowtail Flounder SAP to allow for increased opportunities to harvest GB yellowtail flounder. Framework Adjustment 40B to the Northeast Multispecies FMP (Fisheries…2005) contained provisions requiring the RA to determine the total number of trips that may be declared into the CA II Yellowtail Flounder SAP annually to target yellowtail flounder based on the GB yellowtail founder TAC and the catch of GB yellowtail flounder outside of the SAP. The RA determines how many trips should be allocated to the CA II Yellowtail Flounder SAP using the following formula:

$$Trips\ in\ the\ SAP = \frac{GB\ yellowtail\ flounder\ TAC - 1{,}947\ mt}{4.54\ mt}$$

If the calculations result in less than 150 trips (with a 15,000 lb. trip limit for GB yellowtail flounder) or less than 1,202 mt of GB yellowtail flounder allocated to the CA II Yellowtail Flounder SAP in a given fishing year, the RA has the authority to allocate zero trips to the SAP during that year.

Allocating a low number of trips to a SAP may indirectly lead vessels to engage in derby fishing behavior (Magnuson-Stevens…2006a). Therefore, giving the RA the authority to allocate zero trips to the CA II Yellowtail Flounder SAP if calculations show that certain thresholds are not met may improve safety by avoiding creating a situation in which vessels may race to fish. Public comment on Framework Adjustment 40B (Fisheries…2005) revealed that some industry members felt that giving the RA the authority to authorize zero trips under the CA II Yellowtail Flounder SAP would increase vessel safety.

6.2.2.7 Time and area restrictions

Regulations restricting when and where fishing may occur are used to constrain effort in the limited access groundfish fishery. These measures take various forms and may impact different groups of vessels fishing with specific types of gear. For example, a 2009 temporary action (Fisheries…2009) closed the Western U.S./Canada Management Area to all vessels not using haddock separator trawl gear or Ruhle trawl gear for the remainder of FY2009. Other times, management measures closed certain areas to all commercial and recreational fishing during various points in the season. For example, a 2014 emergency action (Magnuson-Stevens…2014b) implemented a series of seasonal interim closure areas in the Gulf of Maine; commercial and recreational fishing with any gear capable of catching GOM cod was strictly prohibited in these areas during the effective period. Finally, sometimes time and area restrictions prohibit fishermen from fishing in different management areas during the same fishing trip. For example, Framework Adjustment 40B (Fisheries…2003) dictated that limited access groundfish vessels could not fish in the Eastern U.S./Canada Management Area and in another management area during the same fishing trip, while a 2014 emergency management action (Magnuson-Stevens…2014b) prohibited groundfish fishermen from fishing in the Gulf of Maine BSA and any other BSA during the same trip. Members of groundfish sectors are exempt from many of these time and area restrictions, but common pool fishermen are still subject to these effort controls.

Reviews of time and area restrictions suggest that these management measures may result in indirect negative impact to safety at sea. Closing select areas to fishing, either altogether or with certain gear types, may force some operators to travel farther offshore or farther from their port of departure in order to fish. This can expose these operators to a greater degree of risk, particularly if they fish on smaller vessels that traditionally operate much closer to shore. For example, public comment on the 2014 emergency management action (Magnuson-Stevens…2014b) suggests that the GOM closures implemented through this action caused major concerns for the safety of smaller operators. Several industry commenters noted that the timing and placement of these closed areas left very few spots available for fishing within 50 miles of many ports in the Gulf of Maine, which would force smaller operators to fish much farther from shore, especially in the winter. Similarly, outreach conducted during the development of Amendment 13 revealed that area closures in the Gulf of Maine had forced fishermen to fish farther offshore in areas their vessels are not designed for, which becomes especially hazardous in poor weather conditions (NEFMC 2003). When vessels travel farther offshore to reach open fishing grounds, they may end up spending more time at sea than they normally would, which can result in increased fatigue, increased exhaustion, and a higher incidence of accidents and injuries (NEFMC 2003).

Feedback on regulations prohibiting fishermen from fishing in multiple management areas in 1 trip suggests that these regulations may also compromise safety by reducing fishermen's ability to react to weather conditions at sea. For example, one comment on the 2014 emergency management action (Magnuson-Stevens…2014b) said vessels fishing on Georges Bank often seek shelter in the Gulf of Maine if the weather starts to deteriorate; however, preventing fishermen from fishing in the Gulf of Maine BSA and any other BSA in the same trip would prevent them from being able to do this.

Over the years, several regulations have been implemented in order to mitigate some of the negative safety impacts associated with time and area restrictions. For example, a 2006 Emergency Secretarial Action (Fisheries…2006) implemented Eastern U.S./Canada Management Area flexibility provisions that permitted limited access groundfish vessels to fish inside and outside of the Eastern U.S./Canada Management Area in the same fishing trip. This measure made it possible for vessels fishing in the Eastern U.S./Canada Management Area to fish closer to shore in worsening weather without having to cut their trip short, reducing the incentive to ride out dangerous weather at sea. Additionally, Framework Adjustment 45 to the Northeast Multispecies FMP (Magnuson-Stevens…2011) included a measure allowing Handgear A- and Handgear B-permitted vessels to operate in seasonal closed areas. This provision was designed to help ensure that these smaller vessels have continuing access to the inshore waters where it is safest for them to fish.

6.2.3 Catch share regulations in the groundfish fishery

While members of the common pool are still regulated through effort controls such as those discussed in Section 6.2.2, sector members are exempt from many of these regulations. Instead, their fishing activity is primarily constrained through the use of hard TACs and ACE. At the start of every fishing year, each groundfish sector receives allocations for 17 groundfish stocks; these allocations are known as sector ACE. A sector's ACE represents the percentage of the total ACL for each groundfish stock the members of that sector can collectively harvest during each fishing year. Both landing and discards by sector vessels count against their sector's ACE, and the members of each sector are held jointly responsible for ensuring that the sector's collective ACE is not exceeded for any stock.

The transition to catch share management in the groundfish fishery was expected to result in broad improvements in safety within the limited access groundfish fleet. In 2005, the NEFMC conducted a series of public outreach meetings focused on safety at sea within the groundfish fishery. During one of these meetings, the Council suggested that "if the [Groundfish Oversight Committee] truly wished to address safety concerns, it may be necessary to consider alternatives to effort control management" (NEFMC 2005). Amendment 16 to the Northeast Multispecies FMP (Magnuson-Stevens…2010) noted that the implementation of sector management may help to alleviate many of the safety concerns associated with effort control regulations noted in Section 7.2.2. For example, constraining fishing activity through quotas rather than DAS may help eliminate incentives to race to fish, which results in derby conditions in the fishery. Additionally, exempting sector fishermen from trip limits or daily possession limits may help reduce the likelihood of fishermen riding out bad weather at sea in order to take full advantage of catch limits. Throughout the remainder of Section 6.2.3, we discuss several specific aspects of the sector management program and explain their implications for safety.

6.2.3.1 Sector exemptions from effort control measures

Many of the exemptions granted to sectors are designed to improve operational flexibility; in some cases, this may result in positive impacts to safety within the sector fleet. However, over the years, several sector exemptions have raised safety concerns. For example, in FY2010, NMFS approved requests for exemptions to 9 different effort control regulations. Included in this list were several exemptions to regulations pertaining to sink gillnet gear. Specifically, sector vessels fishing with sink gillnet gear were exempted from the following management measures:

- prohibition preventing one gillnet vessel from hauling another gillnet vessel's gear;
- limit on the number of gillnets a vessel can haul while fishing under a groundfish/monkfish DAS on Georges Bank; and
- limit on the number of gillnets that a day-trip gillnet vessel may fish with.

NMFS granted these exemptions in order to give sector gillnet fishermen more operational flexibility, enabling them to reduce some of their operating costs and fish more efficiently. However, feedback from members of the industry revealed that these sector exemptions raised safety concerns for some individuals. Specifically, public comments submitted on the interim final rule approving FY2011 sector operations plans (Magnuson-Stevens…2001) said granting gillnet fishermen exemptions to these regulations could lead to increased crowding in some areas. Commenters felt that the extra gillnet gear in the water, coupled with increased fishing pressure, could create hazardous fishing conditions that may result in negative safety outcomes, such as gear conflicts, entanglements, and safety pressure.

Another exemption that raised concerns for safety was a measure that permitted sector fishermen to fish in parts of the Southern New England Nantucket Lightship Closed Area for the remainder of FY2013. This exemption, which was approved through a 2013 interim final rule (Magnuson-Stevens…2013c), was designed to better enable sector fishermen to harvest healthy groundfish stocks such as monkfish, dogfish, and skates. Increased access to these stocks was expected to help offset some of the negative socioeconomic impacts that resulted from steep reductions in regulated groundfish catch limits in FY2013. While this management measure may have given fishermen additional flexibility to target a broader array of stocks, several public comments on this action revealed that allowing sector fishermen to access the Nantucket Lightship Closed Area may also have negative ramifications for safety. Several comments explained that offshore lobster fishermen traditionally fish in the areas that would be opened to sector fishermen. These commenters feared that the potential for gear conflicts and other safety issues was very high in these areas, and they were concerned because NMFS did not appear to have a plan in place to address these potential issues.

Finally, one sector exemption that was designed in part to improve safety within the sector fleet is the exemption from discard prohibitions. Amendment 16 to the Northeast Multispecies FMP required sector vessels to retain all legal-sized allocated groundfish. As part of the interim final rule approving and implementing FY2011 sector operations plans and contracts (Magnuson-Stevens…2001), NMFS approved a partial exemption to this discard provision that would allow sector vessels to discard legal-sized fish as long as they are deemed "unmarketable." NMFS defines "unmarketable" as "any legal-sized fish the vessel owner/captain elects not to retain because of poor quality as a result of damage prior to, or from, harvest" (Magnuson-Stevens…2001). Sectors initially requested this exemption because forcing fishermen to retain and land unmarketable fish creates extra work for fishermen, uses more deck and storage space, and contributes to unsafe work environments on groundfish vessels (Magnuson-Stevens…2001). By approving a partial exemption to the discard provision, NMFS sought to alleviate some of these operational and safety concerns while still ensuring that sector ACE usage could be accurately monitored.

6.2.3.2 ACE leasing

Amendment 16 to the Northeast Multispecies FMP (Magnuson-Stevens…2010) included provisions allowing ACE to be leased between members of the same sector or between members of different sectors. Unlike the DAS leasing program, members of sectors are exempt from the length and HP restrictions placed on partner trade vessels. However, there are other measures in place limiting sector fishermen's ability to participate in ACE leasing outside of their own sector. Most sectors have chosen to adopt "right of first refusal" provisions in their operations plans. These provisions enable members of a sector to match the terms of a proposed lease that would otherwise take ACE out of the sector, effectively "blocking" the transaction and keeping the ACE within the sector. For example, if a member of NEFS IX wanted to lease ACE out to a member of NEFS III, the other members of NEFS IX may match the trade and keep the ACE within NEFS IX.

Much like DAS leasing, the ability to lease ACE may help to improve safety at sea for sector vessels by giving fishermen more operational flexibility and increased earning potential. Leasing out unused ACE provides fishermen with an additional source of revenue, which could make it easier for these fishermen to afford vessel maintenance, crew pay, and safety equipment. However, right of first refusal provisions may prevent some operators from being able to get the ACE they need to run their businesses, so these individuals may not benefit from the increased flexibility leasing could provide. Also, the price of leasing in ACE can be very high, sometimes exceeding the ex-vessel value of the fish being landed. These additional expenses may put fishermen under more financial strain, making it harder to afford maintenance, crew, or other safety-related expenses.

6.2.3.3 ACE carryover provisions

Amendment 16 to the Northeast Multispecies FMP (Magnuson-Stevens…2010) permitted each sector to carry over up to 10% of its unused ACE for each allocated groundfish stock (except GB yellowtail flounder) from one fishing year to another. Initially, carryover was not counted against a sector's ACE or a stock's ACL for the fishing year in which it was harvested; however, this resulted in sectors potentially being able to harvest fish in excess of a stock's ACL without triggering any AMs. This practice was deemed to be a violation of National Standard 1 of the MSA, and subsequent management actions began taking steps to correct this practice. Framework 50 to the Northeast Multispecies FMP (Magnuson-Stevens…2013b) first introduced the concept of *de minimus* carryover. This action explained that, in the future, sectors would be permitted a *de minimus* amount of carryover from one year to another that would not be counted against sector ACEs or stock ACLs. However, any additional carryover in excess of the *de minimus* amount would be counted against sector ACEs and stock ACLs for catch accounting purposes. Framework 50 (Magnuson-Stevens…2013b) also reduced the amount of GOM cod that sectors could carry over in FY2013, lowering it from 10% of uncaught FY2012 ACE to 1.85%; this was done in order to avoid overfishing on this stock in FY2013. A 2014 management action (Magnuson-Stevens…2014c) set *de minimus* carryover amounts at 1% of the sector sub-ACL for each eligible stock. Sectors were still permitted to carry over up to 10% of their unused sector ACE for a stock from one year to another, but any carryover above the *de minimus* amount would count against that stock's ACE and ACL. For example, if a sector carried over 8% of its unused GB winter flounder ACE from FY2014 to FY2015, 7% of that would be counted against the sector's ACE and the GB winter flounder ACL in FY2015 (8% carryover – 1% *de minimus* carryover).

The ability to carry over ACE from one fishing year to the next was originally included in Amendment 16 (Magnuson-Stevens…2010) in order to promote safety within the sector fishing fleet. If sectors were not permitted to carry over any ACE from one year to another, sector members may feel compelled to engage in rushed and risky fishing behavior at the end of the fishing year in order to avoid "wasting" unused ACE. Allowing some unused ACE to be harvested after the fishing year has ended gives fishermen more flexibility to fish when it is safest, enabling them to take trips when the weather is favorable and their vessels are in good working order.

6.2.3.4 Approved landing ports and safe harbor provisions

When Amendment 13 to the Northeast Multispecies FMP (Magnuson-Stevens…2004) first introduced the concept of sectors in the groundfish fishery in FY2004, it specified that each sector must prepare a formal contract and operations plan for each fishing year in which the sector wished to operate. Amendment 13 provided guidance on the information that must be contained in a sector operations plan; for example, every sector operations plan must include a full roster of participant vessels, a plan for monitoring landings and discards, and rules for entering or leaving the sector. Amendment 16 to the Northeast Multispecies FMP (Magnuson-Stevens…2010) expanded on the requirements detailed in Amendment 13, requiring sectors to add more detail to their operations plans. One of the new requirements contained in Amendment 16 stated that each sector operations plan must include a list of approved landing ports where sector members are permitted to land their fish, as well as a description of the circumstances under which members may land in non-approved ports.

These landing port exemptions, often called "safe harbor protocols," are included in sector operations plans in order to promote safety at sea on sector vessels. Enabling sector fishermen to land in non-approved ports for reasons related to weather, mechanical failure, crew illness, or other safety-related concerns helps to ensure that fishermen are not forced to compromise safety by remaining at sea to transit to an approved landing port. Giving fishermen the flexibility to get off the water when they deem that to be the safest course of action can help avoid accidents, injuries, and fatalities within the sector fleet.

7. INTERVIEWS WITH INDUSTRY EXPERTS

In order to better understand day-to-day operations on commercial groundfish vessels, and in order to better recognize the hazards and risk factors that may impact fishermen's safety onboard these vessels, we conducted a series of interviews with industry experts who have experience with the northeast commercial groundfish fishery. Using convenience sampling, we completed interviews with 14 commercial groundfish captains (across 9 ports in 3 states), 16 current and former groundfish fishery observers, and 2 commercial fishing safety training professionals. Through these conversations, we were able to identify a number of hazards that may be dangerous for commercial groundfish fishermen, as well as additional risk factors that may contribute directly or indirectly to safety at sea. This section presents a summary of the information we learned through these interviews, organized by theme and aggregated across all respondents.

7.1 Physical hazards

7.1.1 Physical hazards onboard groundfish vessels

During the course of their interviews, we asked respondents to describe the physical hazards that exist on and around commercial groundfish vessels, and to explain what types of accidents or injuries are associated with those hazards. Some of the hazards mentioned by respondents are port- or gear-specific, while others exist broadly across various groundfish vessels.

7.1.1.1 General hazards on groundfish vessels

Respondents explained that many of the everyday tools fishermen use to sort and process their catch can pose serious safety hazards to commercial fishermen. Fishermen on most groundfish vessels typically use metal fish picks to sort their catch after it is brought onboard and fish knives to gut and gill the fish before they are stored for transport. Respondents noted that handling these tools is like second nature for most crew, but occasional slips with fish picks or knives can result in serious lacerations or puncture wounds. For example, one respondent described an instance in which a crew member on his vessel slipped while cutting fish, slicing 4 of his fingers down to the bone and requiring emergency medical treatment. Many respondents agreed that the likelihood of an accident such as this increases when the weather is rough or when crew are inexperienced.

Many respondents noted that other pieces of equipment found the deck of most groundfish vessels can also negatively impact safety under certain conditions. For example, most respondents mentioned that the rubber hoses used to power the hydraulics on groundfish vessels wear out and break fairly frequently since they are constantly exposed to sunlight and salt water. When this happens, hydraulic fluid sprays all over the deck of the vessel, covering the area in an extremely slippery, hard-to-remove coating. As a result, crew members working in the affected areas are at increased risk for slips, trips, and falls, which may result in broken bones, head injuries, or other physical trauma. Several respondents also said the conveyors used for sorting and processing catch on some vessels can be very dangerous to work around. Specifically, these respondents explained that fishermen's fingers or hands may get caught in the head of the conveyor if they are not careful, which can result in serious crushing injuries or broken bones.

In addition to the tools and equipment used to harvest fish, multiple respondents reported that fish themselves can be hazardous for commercial groundfish fishermen to handle. Respondents explained that crew may get bitten by fish, sustain puncture wounds from fish spines, or slip on fish on the deck of the vessel. Bites and puncture wounds caused by fish become infected relatively easily, so respondents said these types of injuries can be especially serious. Respondents also mentioned that totes full of fish are often very heavy; as a result, crew may strain their shoulders or backs while attempting to move them around the vessel. Finally, respondents explained that sometimes, fish can get stuck in the bilges in the hold; as these fish rot, they release poisonous hydrogen sulfide gas. Hydrogen sulfide gas is denser than air, so if left unventilated, it can build up to dangerous levels. Fishermen climbing down into the hold may be overcome by the poisonous fumes, leading them to lose consciousness, fall, and/or asphyxiate. Several of the respondents we interviewed mentioned that incidents such as this have occurred in their ports before; one interviewee from Rhode Island mentioned that a young crewman had passed away for this reason recently.

7.1.1.2 Dangers associated with bottom trawl gear

Respondents generally agreed that there are more hazards associated with bottom trawl gear than with any of the other major gear types used to target groundfish. According to respondents, fishing with bottom trawl gear is particularly dangerous because (1) the gear is large and extremely heavy, (2) catch volumes are high, and (3) many components of the vessel are under extreme tension while the net is deployed. Therefore, the potential for catastrophic mechanical failures and traumatic injuries is relatively high.

Numerous respondents said the trawl net itself represents a significant safety hazard for commercial groundfish fishermen, both when it is empty and when it is full. Respondents explained that as the net is being set, crew may become entangled in the mesh and dragged overboard. As a result, affected individuals could sustain physical injuries, become hypothermic, or drown. Respondents also explained that it is fairly common for a bottom trawl net to become "hung up" on obstacles on the seafloor while it is being towed. This can compromise the stability of the vessel and limit maneuverability until the net is freed, compromising the safety of those onboard.

Hauling back bottom trawl gear puts many parts of a fishing vessel under extreme strain. As a result, the cargo wires suspending the net above the deck may snap, sending the contents crashing down with enough force to injure or kill anyone standing underneath. One respondent who witnessed such an event on a groundfish trip said the weight of the net hitting the deck was enough to "explode the floorboards'"; luckily, nobody was injured in that case. Even if the cargo wires remain intact, crew may still be injured or knocked overboard if they are hit as the bag of fish swings above the deck of the vessel; this risk is especially high if the gear is being hauled in rough weather. Finally, multiple respondents said fishermen may get hit by rocks, floats, or other objects that are expelled from the net as it is wound back onto the drum. Crew are careful not to work directly behind the net as it is being hauled in to avoid these types of injuries, but one respondent estimated that his crew are still hit by objects from the net at least 3 or 4 times each year.

Several respondents believed that the trawl doors (or otter boards) attached to either side of a bottom trawl net are some of the most hazardous items onboard a groundfish vessel. When the gear is not in use, these trawl doors are typically secured to the frame of the boat; however, when the net is being set or hauled, the doors are released and able to swing around. Respondents explained that trawl doors are typically made of steel, and that each door can weigh hundreds or thousands of pounds. Several respondents said if a fisherman were to get hit by one of those doors, they could easily be knocked overboard, sustain crushing injuries, or be killed. For example, one respondent remembered a fishing trip during which a crew member on his vessel was pinned between one of the trawl doors and the frame of the vessel when the vessel changed direction unexpectedly. The respondent said the crew member sustained a broken collarbone and 6 broken ribs, but he had no doubt that this individual could easily have been killed if the door had hit his head instead. Another respondent said the moment when the trawl doors break the surface of the water during haulback is the most hazardous part of a fishing trip because they sometimes burst 10-15 feet into the air, landing near the stern of the vessel.

There are many other pieces of equipment on the deck of a bottom trawl vessel that could cause serious harm to commercial fishermen. Many respondents stated that the winches used to set and hoist fishing gear are some of the most dangerous pieces of machinery onboard bottom trawl vessels. Respondents explained that there is typically no emergency stop mechanism built into these powerful machines; if a fisherman was to get entangled in a winch, most respondents felt certain this would almost always result in amputation, decapitation, or death. Trawl wires, cables, and cargo wires are also major hazards onboard groundfish trawl vessels. Whenever the gear is in motion, these cables and wires are all under extreme tension. When one of these cables or wires snaps, the broken ends often whip across the deck of the vessel, potentially hitting one of the fishermen onboard. Respondents said this can cause serious lacerations, amputations, head injuries, or death. Similarly, respondents also said the blocks at the tops of the davits used to haul gear can sometimes break under tension and come crashing down to the deck below. When this occurs, crew working on deck are at risk of getting hit by the falling equipment and sustaining serious injuries. For example, one respondent said a crewman on a nearby vessel was killed when a block snapped, swung to the deck, and hit him in the head.

7.1.1.3 Dangers associated with sink gillnet gear

One respondent noted that some fishermen minimize the hazards associated with gillnet gear because, at a glance, it seems less dangerous than bottom trawl gear or bottom longline gear. However, this respondent said this is a grave mistake, as many of the injuries and accidents that occur on gillnet vessels happen because fishermen are lulled into a false sense of security. Respondents explained that sink gillnet gear can be hazardous to work around for a variety of reasons. First, respondents said the risk of entanglement in sink gillnets is relatively high because fishermen tend to have a lot of contact with the gear as they work, especially while it is being set. Groundfish fishermen may become entangled in nets or the buoy lines as they set them over the stern of the vessel. Entangled crew members may sustain broken bones, lacerations, or be dragged overboard where they could drown. Several respondents mentioned that wearing PFDs can greatly increase the risk of entanglement on gillnet vessels because the straps and buckles on a PFD are easily snagged in the mesh of the nets.

The monofilament line used to construct the mesh panels on sink gillnets is very sharp; therefore, fishermen may sustain lacerations or degloving injuries if their hands or fingers are snagged in the net. Knowing this, respondents said they and their crew are careful not to touch the net as it is being set. Finally, respondents explained that sink gillnets are typically hauled back into the vessel using hydraulic haulers. Fishermen must take care not to let their hands or fingers get caught in these haulers, as this could result in crushing injuries or broken bones. Sink gillnet gear sometimes gets snagged on the seafloor or on another nearby vessel's fishing gear as it is being hauled back in. When this happens, the gillnet can get yanked off the hauler, and any fishermen who were in contact with the net are at risk of getting cut or knocked overboard.

7.1.1.4 Dangers associated with longline gear

Many of the dangers associated with sink gillnets are also present on vessels fishing with bottom longlines since both gear types are examples of fixed bottom gear. For example, respondents explained that fishermen must use caution while setting bottom longline gear because they may become entangled and dragged overboard as the gear is being deployed. Bottom longline gear is particularly hazardous because it is rigged with hundreds, or thousands, of fish hooks. Should a fisherman become entangled in a bottom longline, these hooks could get caught in their clothing or flesh, making it extremely difficult to break free. Additionally, several respondents noted that the anchors attached to longline gear sometimes fly across the deck of the vessel as the gear is being deployed. Fishermen may get hit by these heavy anchors, which could result in broken bones, crushing injuries, or falls overboard. Respondents also explained that attaching snap-on gangions to mainlines during setting can be extremely dangerous because the gear is moving very fast. If a fisherman's hand or finger was to become impaled on a hook they had just snapped onto the mainline, it could pull them overboard or cause extreme physical trauma to their hands.

Finally, several respondents reported that one of the biggest dangers on longline vessels is sharks. Respondents explained that sharks frequently become hooked on longlines as they attempt to prey on the fish caught on that gear. To further complicate matters, many sharks roll their bodies in an attempt to free themselves, which often results in them becoming even more entangled. Unhooking these sharks is extremely dangerous because groundfish fishermen may (1) get bitten, hit, or otherwise injured by the thrashing animals as they attempt to free them or (2) become entangled in the gear themselves.

7.1.1.5 Dangers associated with handline gear

Overall, respondents reported that the hazards associated with handline gear are relatively minimal compared to other gear types. Much like bottom longline gear, fishermen working around jig gear or rod-and-reel gear may sustain puncture wounds while baiting hooks or unhooking fish. Additionally, several respondents also noted that sharks represent a serious safety hazard for fishermen working with handlines, as well, especially if they become heavily wrapped up in the gear.

7.1.2 Navigational hazards in the Northeast

Several respondents talked about physical hazards in the natural environment that make navigating the waters in the Northeast region more dangerous. Most of the time, respondents focused on "bar crossings," which are areas of sediment accumulation where rivers meet up with the ocean. Tides, currents, winds, and shifting sediment deposits make these areas highly unstable and very difficult to navigate, and vessels can easily run aground or capsize if the crossing is not executed properly. Respondents mentioned the following 3 bar crossings by name when citing coastal hazards in the region: the Chatham bar (Chatham, MA), the Newburyport bar (Newburyport, MA), and the Hampton bar (Hampton, NH). In addition, several respondents mentioned that some of the channels in ports around the Northeast are relatively shallow and/or narrow, making it difficult to navigate around other vessel traffic. Respondents cited Hampton, NH, and Point Judith, RI, as examples.

7.2 Risk factors impacting safety within the groundfish fleet

7.2.1 Human risk factors

During the course of their interviews, the vast majority of respondents cited human risk factors—such as crew size, fatigue, and substance use disorders—as the primary issues currently impacting safety within groundfish fleet. Many respondents spoke broadly about human decision-making, explaining that most accidents and injuries are avoidable as long as fishermen use common sense, maintain situational awareness, and avoid becoming complacent on their vessels. Phrases such as "fishing doesn't have to be dangerous unless you make it dangerous," "you'd need to have a real brain cramp [to get hurt]," and "a lot of safety is just common sense" were repeated frequently, particularly during interviews with fishing captains. While most respondents emphasized the importance of human decision-making and awareness in safety at sea, they also acknowledged that there are many additional human factors that can compromise safety outcomes.

7.2.1.1 Common sense and situational awareness

Many of the respondents we interviewed said one of the most important things fishermen can do to reduce the level of risk they face at sea is use common sense and maintain situational awareness. Respondents explained that many of the accidents and injuries that occur on commercial groundfish vessels are preventable as long as fishermen stay away from moving equipment, make realistic judgments about their boat and their abilities, and refrain from getting complacent on the job. One respondent summed up the importance of constant vigilance when he stated that "luck is a lot of hard work."

While many respondents agreed that common sense and awareness are crucial for preserving safety at sea, several individuals also admitted that external pressures can sometimes lead fishermen to make decisions that seem to contradict this principle. For example, several respondents said economic strain can drive fishermen to make risky decisions, such as deferring vessel maintenance, fishing in poor weather, fishing alone, or ignoring persistent health problems. Several other respondents said that on company-owned boats, pressure from vessel owners can sometimes force hired captains to make fishing decisions that go against their better judgment, such as starting or prolonging a trip in bad weather.

7.2.1.2 Fatigue and crew size

The majority of respondents mentioned that groundfish vessels have been forced to operate shorthanded in recent years, with many respondents specifying that this has become more common since catch shares were implemented in the fishery. Fishing with reduced manning is dangerous because it puts increased strain on the remaining crew members, who are frequently forced to work longer shifts with less rest to compensate. This can exacerbate fatigue, which is commonly cited as a contributing factor in personal injuries, navigational mistakes, and other errors in judgment involving commercial fishing vessels (Schilling 1971; Smith et al. 2006; Allen et al. 2010; Jensen et al. 2014). Many respondents spoke to the dangers associated with reduced crew and/or fatigue during their interviews, citing instances where these conditions have or could compromise safety for groundfish fishermen. Multiple respondents mentioned that fishing vessels often fail to post wheel watches when operating with reduced crew because they need all hands on deck to help handle the gear and process the catch. Other respondents mentioned that the increased fatigue associated with reduced manning often leads the individual on wheel watch to fall asleep. Both of these scenarios increase the risk of a fishing vessel being involved in a collision, grounding, or other accident. Respondents also spoke about how fatigued crew are often less aware of their surroundings and more susceptible to accidents. For example, one respondent remembered a time when a deckhand was knocked overboard by a moving trawl cable because he dozed off while standing in the stern of the vessel. Several other respondents mentioned that fatigue can increase the risk of a fisherman falling into the water and drowning while disembarking from their vessel at the end of a fishing trip since tired fishermen are more likely to slip or misjudge their footing.

Respondents provided several explanations as to why groundfish crew sizes have declined over time. First, some respondents explained that the increased costs associated with fishing under sector management (e.g. sector membership fees, quota leasing costs, at-sea monitoring costs) have made it impossible to pay as many crew members as they used to and still earn a living. Others said crew sizes have gotten smaller simply because there are fewer people available and willing to work on groundfish vessels than there used to be. Some respondents attributed this shortage to the fact that many crew members have left the fishery in order to work on vessels participating in other more lucrative fisheries, such as sea scallops or lobster. Others explained that new entrants are no longer joining the groundfish fishery as crew because they no longer see opportunities for long-term growth and personal advancement. In the past, crew members on groundfish vessels had the opportunity to work their way up the ranks, eventually becoming part or sole owners of their own vessels. Now, permits are so expensive and the long-term outlook on the fishery is so uncertain that these incentives have largely vanished. One respondent echoed this sentiment, explaining "nobody sees a future in fishing anymore." Another respondent reflected on his own experiences, noting that "90% of the opportunities I had are gone now."

7.2.1.3 Crew experience and training

Many respondents explained that the individuals who are still willing and available to work as groundfish crew members often have little to no experience with commercial fishing, and therefore they do not have the skills or training necessary to perform their jobs safely or efficiently. For example, several respondents explained that captains and/or boat owners frequently round out their crews by hiring friends, family members, or random strangers they encounter at the dock, regardless of whether they had ever fished before. Another respondent noted that his only current deckhand used to work in a restaurant and has no prior experience with fishing. Respondents largely agreed that the prevalence of inexperienced crew within the groundfish fishery is largely due to the fact that only inexperienced crew, or crew that cannot find work on other vessels, are willing to accept the relatively low pay and short seasons that characterize this fishery. Additionally, many respondents explained that turnover rate on groundfish vessels is so high that many crew leave before gaining much familiarity with their vessels and fishing practices.

Fishing with inexperienced crew is dangerous for a number of reasons. As one respondent explained, experience helps fishermen develop the ability make sound judgment calls when it comes to safety. This individual stated that "experience really makes a difference" in terms of deciding, for example, whether or not to push your luck in a risky situation. Without this practice, fishermen may be more likely to make decisions that inadvertently compromise their safety, as well as that of their fellow crew members. Respondents also mentioned that crew who are new to fishing, new to the groundfish fishery, or new to a specific vessel often lack a basic operational knowledge of the vessel's mechanics. As a result, new crew members may not know how to avoid cables and winches, how to safely handle fishing gear, or where to position themselves out of harm's way. According to many respondents, having inexperienced fishermen onboard a groundfish vessel can be distracting for the captain and other crew members who feel the need to divert attention away from their own tasks in order to supervisor the newcomer. Finally, respondents also noted that inexperienced fishermen have likely never completed a safety training program or participated in a safety drill, so these individuals may not know how to locate or deploy lifesaving equipment in the event of an emergency.

7.2.1.4 Substance use disorders

Many of the industry experts we interviewed cited substance use disorders as one of the main factors impacting safety in the groundfish fleet, explaining that, in their experience, it can be very difficult to "find clean crew" in some ports around the Northeast. Most of these comments referred specifically to drug use, but several respondents also mentioned alcohol consumption. Some respondents spoke about the inherent dangers associated with substance use, explaining that there had been multiple fatal overdoses in their ports in recent years. Speaking specifically about fishing safety, respondents also explained that drug and alcohol use on commercial fishing vessels is extremely dangerous because these substances compromise the user's situational awareness and inhibit their ability to perform their job, which can increase the likelihood of that individual injuring themselves or another crewmember. One respondent elaborated on the importance of being able to trust fellow fishermen for safety, noting that the relationships between crew on a boat are "closer than a marriage because you're all responsible for one another's lives." In light of these risks, a number of respondents said they have developed "zero tolerance policies" when it comes to drugs and alcohol on their vessels.

While it is true that substance use disorders may impact fishing safety, it is extremely important to remember that these types of disorders are not confined to commercial fishermen or fishing communities alone. Substance use disorders pose a growing health and safety concern across the U.S. For example, over 63,000 people across the country died as a result of a drug overdose in 2016 (Walter et al. 2018). The majority of these overdose deaths were attributed to the use of "synthetic opioids such as fentanyl, fentanyl analogs, heroin, and opioid pain relievers" (Walter et al. 2018, p. 1).

7.2.1.5 Health and chronic injuries

Fishing is an extremely stressful and demanding job, and as a result, many commercial fishermen suffer from chronic physical and mental health issues. A number of the respondents we interviewed explained that years of hard labor on commercial groundfish vessels often leads fishermen to develop physical ailments such as bad backs, shoulders, and knees. These long-term injuries make it painful and challenging for fishermen to safely and efficiently complete their work, leaving them vulnerable to further injuries or accidents. Several other respondents mentioned that stress associated with fishing has contributed to high blood pressure, anxiety, depression, and substance use issues amongst many groundfish fishermen. Stress and anxiety over earnings or fishing regulations can drive fishermen to make risky decisions that increase the chances of injuries or accidents occurring (Tuler et al. 2008). For example, one respondent explained that anxiety over being able to pay his bills caused him to continue fishing instead of seeking medical treatment for a minor injury he had sustained. As a result, the injury became infected and the respondent almost lost his life.

7.2.1.6 Additional human risk factors

Several additional human risk factors came up during respondent interviews, albeit less frequently than the 3 major themes detailed above. One respondent mentioned that, in their experience, language barriers can impact safety on commercial groundfish vessels. This respondent explained that sometimes, all of the individuals working on a commercial groundfish vessel are not fluent in a common language. This can make it difficult to convey instructions, concerns, or information about hazards onboard the vessel. Several other respondents mentioned that a fisherman's age may impact how they think about safety at sea. Some respondents explained that over the years, they have observed that older fishermen seem more accepting of the dangers associated with fishing. This means that these individuals may be less likely than younger fishermen to engage in safety trainings, adopt new technologies, or wear safety equipment. Others felt that older fishermen are more careful and conscientious than younger fishermen, making them more safety-conscious overall. Finally, several respondents spoke about the use of PFDs on groundfish vessels. All but one of these respondents reported that fishermen typically do not wear PFDs while they work. Some respondents presented this as a factor that negatively impacts safety, explaining that wearing a PFD can help increase a fisherman's chances of surviving a fall overboard. However, several other respondents explained that choosing not to wear a PFD can actually help to improve fishermen's safety at sea in some regards. These individuals argued that the buckles and straps on the outside of a PFD can easily get caught on fishing gear, entangling and potentially injuring fishermen in the process.

7.2.2 Vessel condition and deferred maintenance

According to most respondents, conducting routine maintenance on vessels and equipment is one of the most important practices fishermen can follow to reduce the amount of risk they are exposed to at sea. Keeping a vessel clean, free of clutter, and in good working order can help to minimize the chances of accidents or injuries occurring at sea. One respondent illustrated this point when he said "[maintaining your vessel] could save your life and save the boat." While the majority of respondents broadly agreed that preventative maintenance is crucial for protecting safety at sea, they also admitted it has gotten more difficult for groundfish fishermen to afford vessel maintenance as fishing costs increased and the fleet became less profitable over time.

A number of respondents provided us with specific examples of deferred maintenance items they have observed on their own vessels or on other groundfish vessels. One respondent mentioned that he should be replacing the hydraulic hoses on his vessel every 4 years, but his current hoses are 6-7 years old because he cannot afford new ones. Another respondent mentioned that he was supposed to rebuild or replace his engine after 8 years, but he skipped that maintenance, and his engine is now 9 years old. A third respondent mentioned that has been putting off purchasing new winches, new valves, a new pull shaft, and a new rudder for his vessel. Other specific deferred maintenance items mentioned by respondents included rusty ladders; broken railings; cracked and shattered windows; holes in decking; leaking hatches, doors, and windows; broken alarm systems; parting cables; broken outriggers; expired flares; fraying wires; broken pumps; and leaky hydraulic hoses.

In order to illustrate exactly how expensive maintenance can be, several respondents provided us with estimate of what it costs to repair, replace, or inspect a variety of items on their vessels. One respondent anticipated that shortly after his interview, he would have to spend $75,000-$80,000 to rebuild his engine. Two other respondents estimated that it costs $25,000-$30,000 each time a vessel is hauled out for a hull inspection. Another respondent mentioned that he pays $3,000 per year to repair wear and tear on the conveyor on the deck of his boat, and another said he pays $800 per year to service and re-pack his life raft. One respondent's vessel contains 50 different hydraulic hoses, each of which costs $400-$500 to replace. Another respondent said the towing wires on his trawl vessel cost $2,500, and the 3 sets of ground cables on his net cost $1,500 per set. Finally, one respondent who fishes with rod-and-reel gear said each of his poles contain about $20-$25 worth of line that needs to be replaced periodically when it snaps or starts tearing, and sometimes he loses $400-$500 worth of tackle in a day to sharks breaking his lines.

7.2.3 Crowding and overlap with other fisheries

Several respondents cited crowding and spatial conflict as issues impacting safety in the Northeast groundfish fleet, particularly in regard to overlap with other commercial fisheries. The lobster fishery was mentioned most frequently in this context, with many respondents saying they frequently encounter lobster gear while at sea. One respondent said he has been displaced from his traditional fishing grounds because now there is too much lobster gear there for him to safely maneuver the area. Multiple other respondents mentioned that groundfish bottom trawl vessels routinely get snagged on lobster traps, especially ghost traps that are not visible at the water's surface. This poses several safety risks to both the vessel and to the individual fishermen onboard. First, when a vessel's trawl net gets hung up on lobster gear, the vessel must immediately stop fishing until the gear is freed. During this time the captain often goes down to the deck to assist the crew, leaving the vessel to drift without a wheel watch. This can increase the likelihood of a vessel collision or other accident during this time. Once the traps are free, groundfish fishermen will sometimes stack them on the deck of their vessel to take them back to port. This added weight can compromise the stability of the vessel, particularly if the traps are not secured adequately and they shift during the trip. Furthermore, stopping to detangle lobster traps forces fishermen to haul their gear more frequently than they normally would, prolonging time spent at sea, exacerbating fatigue, and increasing the chances of a mechanical failure or malfunction occurring while the gear is under tension. Fishermen working to free heavy lobster traps from their nets are at increased risk of falling overboard, getting crushed by heavy equipment, getting entangled in the net, and sustaining shoulder and back injuries. Finally, multiple respondents also mentioned that they, or others on their boats, have gotten cut or stabbed by broken traps, the pieces of which one respondent likened to “rusty daggers.” This same respondent once contracted a staph infection after being stabbed by a rusty lobster trap he freed from a trawl net.

Several respondents also mentioned that groundfish vessels occasionally get into conflicts with scallop vessels fishing. One respondent recounted an instance when their vessel’s bottom trawl net got tangled with a nearby scallop dredge. In this case, both vessels were set adrift until crews were able to cut the trawl net free. Several other respondents mentioned conflicts between sink gillnets and scallop dredges, explaining that gillnets are sometimes caught and dragged by passing scallop dredges. When this happens, the gillnet is wrenched off the hauler and dragged rapidly down into the water. Groundfish fishermen who were working on hauling the net when this happens are at risk of getting knocked overboard, getting entangled and dragged overboard, sustaining broken fingers, or getting cut by the monofilament mesh. Finally, one respondent said inexperienced recreational boaters pose a safety hazard because they frequently maneuver incorrectly and unpredictably around other vessels, particularly in highly trafficked areas near ports and harbors. He feels that this hazard has become more common as the waterfront in his area becomes increasingly gentrified.

7.2.4 Environmental conditions

Many respondents explained that environmental conditions, such as wave height, wind speed, wind direction, air temperature, and water temperature, can all impact the amount of risk groundfish vessels and individual fishermen are exposed to at sea. In terms of wave height, respondents explained that fishing in heavy seas is dangerous because large waves can compromise vessel stability and/or lead to down-flooding issues, increasing the chances of a vessel capsizing or sinking. Many respondents also mentioned that routine tasks, such as hauling gear or cutting fish, are much riskier in heavy seas, making fishermen more likely to fall overboard, cut themselves, or get hit by moving gear. Several respondents were able to provide us with specific examples of the conditions under which they will not fish. One respondent who fishes on a 37’ boat said he will not leave port if the waves are greater than 6’, while another respondent who works on a 72’ boat said he will not fish in waves greater than 10’.

When talking about weather and safety, respondents said it is also important to consider wind speed and wind direction in trip decisions because these variables are closely linked to wave height. Respondents explained that in the northeast region, northeasterly winds[20] typically result in larger waves than winds that originate over land and blow offshore. Additionally, higher wind

[20] Winds that blow from the northeast toward the southwest.

speeds typically generate larger waves. Several respondents who operate smaller vessels (between 35' and 45') said they typically will not take a fishing trip if the wind is blowing more than 15-20 knots, while a couple of respondents with larger vessels (between 50' and 75') said they do not fish if the wind is blowing more than 35-40 knots. Several of these same respondents noted that if the wind is blowing from the northeast, they will lower the wind speed threshold they use when judging whether or not it is safe to start a fishing trip. For example, one respondent said he will typically fish in 12 knot northeasterly winds and 20 knot winds blowing from a different direction.

In addition to wave height, wind speed, and wind direction, respondents also mentioned that the presence of fog makes operating fishing vessels riskier because it reduces visibility, increasing the likelihood of collisions, groundings, or other navigational accidents. Several respondents noted that heavy fog can be particularly dangerous while fishermen are operating close to port because these conditions may obscure navigational buoys marking the edges of safe travel lanes. Respondents also largely agreed that fishing during the winter months is particularly risky because the weather tends to be stormier, seas are rougher, vessels are icy, and air and water temperatures are colder. Ice buildup on fishing vessels can contribute to stability issues and increase the likelihood of fishermen slipping and falling, and cold air and water temperatures put fishermen at increased risk for hypothermia should they enter the water. Finally, multiple respondents mentioned that low tides make boarding and disembarking from fishing vessels particularly risky because the vessels sit lower in the water relative to the dock at this point in the tidal cycle. This means that fishermen need to cross a wider gap while moving between the boat and the dock, increasing their risk of falling. This is particularly true in ports with fairly large tidal ranges, such as Scituate, MA (approximately 10' range, on average).

7.2.5 Federal and state regulations

During the course of their interviews, respondents talked about how many different types of federal regulations impact commercial groundfish fishermen's safety at sea. Some of these management measures are designed specifically to address risk exposure on commercial fishing vessels, while others geared toward resource conservation have indirect impacts on safety.

7.2.5.1 USCG commercial fishing vessel safety regulations

Overall, respondents spoke positively about the fishing safety standards implemented and enforced by the USCG, agreeing that these measures have helped improve safety within the fishery over time. Some respondents cited specific regulations that they feel have improved safety within the fleet. For example, several respondents said the USCG regulations requiring operators to conduct periodic safety drills with their crew have helped fishermen become better prepared to respond to emergencies onboard their vessels. Other respondents spoke positively about the USCG Commercial Fishing Vessel Safety Examination Decals, saying that maintaining these decals has helped them ensure their vessels are outfitted with the equipment, documentation, and instruction necessary for safe operation. These respondents were referring to the decals awarded to vessels that successfully demonstrate compliance with the commercial fishing industry vessel safety regulations during a dockside safety examination. These decals are valid for 5 years, and any vessel selected to carry a fishery observer must display a valid decal.

While most of the feedback we received about USCG safety regulations was positive, a few respondents expressed concerns over existing requirements. A couple of respondents felt that the 5-year inspection cycle for USCG Commercial Fishing Vessel Safety Examination Decals is too long, explaining that emergency equipment and vessel infrastructure can fall into disrepair during this time period. These respondents thought a 2-year inspection cycle would be more appropriate, especially since safety decals are issued to fishing vessels free-of-charge. Several other respondents said compliance with some of the USCG safety regulations is very expensive, leaving fishermen with less money left over to pay for vessel maintenance and crew. To illustrate this point, one respondent told us it costs $800 annually to re-pack his life raft per USCG specifications.

7.2.5.2 Sector exemptions from effort-control regulations

When asked whether the transition to catch shares had impacted safety within the groundfish fleet, respondents provided mixed feedback. A number of respondents felt that, in their experience, catch share management has contributed to improved safety within the sector-portion of the fleet. Respondents explained that exemptions from many traditional effort control regulations has given sector fishermen more flexibility to choose when to fish, enabling them to harvest their allocations when weather conditions and fish prices are favorable. For example, respondents felt that exemptions from DAS restrictions have largely alleviated sector fishermen's incentives to remain at sea and continue fishing in bad weather. One respondent explained that, prior to joining a sector, if he leased DAS for a fishing trip, he would almost never terminate the trip early due to weather because he would lose the DAS he paid for. Now, under sector management, if he pays to lease in quota from another permit holder and chooses to end a trip early, he will still have that quota available to use at a later date and his money will not be "wasted." Respondents also said that prior to joining sectors, they used to rush back to port as quickly as possible in order to cross the DAS demarcation line and preserve their remaining DAS. Rushing during this stage of a trip is dangerous because fishermen are tired and vessels are laden with fish, increasing the likelihood of injuries or stability issues. Under catch share management, respondents said sector fishermen can afford to take their time and operate more carefully.

Numerous respondents mentioned that before they enrolled in sectors, they used to feel forced to spend prolonged periods "riding time out" at sea once they finished fishing in order to satisfy landing limits for various groundfish stocks. For example, if a vessel had been at sea for 2 days, but had 3 days' worth of fish onboard, the operator would stay at sea for an additional day in order to be able to land their full catch. These types of regulations are dangerous because they force fishermen to spend more time exposed on the water, sometimes in stormy weather. Since enrolling in sectors, respondents report that they no longer need to worry about riding out DAS clocks before returning to port, reducing the amount of time they spend exposed at sea. Similarly, several respondents said the small annual allocations they receive under sector management have reduced their risk exposure simply because they take fewer trips and spend less time on the water, leaving them with fewer opportunities to get injured.

While most respondents agreed that sector management has improved flexibility for sector members, a number of respondents explained that other aspects of catch share management have negatively impacted safety for sector fishermen. For example, multiple respondents reported that the mix of stocks in their ACE portfolios have forced them to travel farther and operate farther offshore than they did previously. These respondents explained that quota for inshore stocks is very expensive to lease, so they cannot afford to fish in their preferred areas close to port. Instead, they need to travel more than 65 miles offshore to target pollock and other, cheaper stocks. Additionally, one respondent said he can only afford to lease in groundfish quota during the winter months when ex-vessel prices are relatively high and lease prices are relatively low. Therefore, he feels that sector management has forced him to take all of his groundfish trips during bad weather months (February-April).

Many respondents also explained that the additional costs associated with catch share management, such as sector fees and quota leasing costs, have made it very difficult for sector fishermen to afford to pay for crew and vessel maintenance. As a result, many groundfish vessel operators are forced to defer maintenance and operate shorthanded, increasing the likelihood for mechanical failures and fatigue-related incidents. In order to illustrate just how difficult these costs can be to bear, one respondent told us he paid $200,000 last year to lease fish, and another respondent said he paid $22,000 in sector and leasing fees on his last fishing trip alone. Financial strain can also drive fishermen to take fishing trips in bad weather simply because they cannot afford to forgo the income. Therefore, even though sector fishermen may not feel regulatory pressure to fish in bad weather, they do feel economic pressure to do so.

When considering how catch share management may have impacted safety within the fleet, it is important to remember that most of the catch-share related safety gains and compromises described by respondents are likely confined to the sector portion of the fishery. Common pool fishermen are still subject to many of the effort-control regulations that sector members are exempt from, so common pool operators are still largely constrained by the DAS restrictions and landing limits. Therefore, this group of operators likely still feels the same regulatory pressures to fish in poor weather, preserve DAS, or delay their landing time that sector fishermen used to feel before the transition to catch share management.

7.2.5.3 Groundfish fishery time and area closures

Several respondents explained that time and area closures can impact fishermen's operating decisions in ways that compromise safety. Respondents said closing certain areas to fishing, or closing them to certain gear types, displaces vessels and often forces fishermen to travel longer and farther from port in order to fish. Prolonging the amount of time fishermen spend at sea increases the amount of risk they are exposed to, as does forcing them into less familiar waters that may be farther from shore.

7.2.5.4 Regulations governing other overlapping fisheries

Several respondents noted that groundfish fishermen's fishing activity is not only constrained by the provisions found in the groundfish FMP; they also must abide by regulations governing other overlapping fisheries. At times, these "other" fishery regulations can also impact groundfish fishermen's ability to operate safely at sea. For example, one respondent mentioned incidental catch limits for lobster, explaining that the 100 lobster-per-day (500 lobster-per-trip) limit can force groundfish fishermen to ride out stormy weather at sea until enough time has passed to cover their lobster landings. This same respondent said monkfish landing policies are much safer because they do not force fishermen to physically spend multiple days at sea in order to land multiple DAS' worth of monkfish. Instead, fishermen wishing to land 1 additional days' worth of monkfish may call in prior to landing and request to be charged with enough DAS to cover their landings. Another respondent spoke at length about fluke regulations, explaining that restrictive state-mandated landing limits (1,000 lbs. per-trip, per-state) compromise his safety by forcing him take multiple smaller trips, spend more time on the water, and navigate in and out of the highly trafficked waters near port more frequently.

7.2.5.5 Fishery observer requirements

According to respondents, carrying a fishery observer onboard a groundfish vessel may negatively or positively impact safety depending on the characteristics of the vessel and the individuals onboard. Some respondents felt that the safety requirements necessary to carry an observer, such as possessing a valid USCG Commercial Fishing Vessel Safety Decal, have helped reduce risk in the fishery by ensuring that vessels stay up-to-date on their safety equipment. Other respondents felt that fishery observers can help to improve safety by serving as an additional set of eyes onboard a vessel, sometimes noticing safety hazards busy fishermen may miss. However, not all respondents agreed that observers positively impact safety onboard groundfish vessels. Some respondents said observers serve as distractions for captains and crew, who feel like they constantly need to make sure observers are not placing themselves in harm's way. Other respondents mentioned that observers can contribute to crowding on commercial fishing vessels, making it riskier for the individuals onboard to maneuver around machinery and other equipment. Finally, a couple of respondents explained that observers who are unfamiliar with specific fishing vessels may not know where to locate lifesaving equipment in an emergency. This means these individuals may not be equipped to react quickly or appropriately in a crisis, which could be especially dangerous if the fishermen onboard are incapacitated and unable to assist.

7.2.6 Safety solutions adopted by groundfish fishermen

Groundfish captains and vessel owners use a number of strategies to account for safety onboard their vessels that go above and beyond the standards which are required by law. Some owners have adapted the physical structure of their vessels in order to reduce risk exposure. These modifications include: building up the sides of the vessel to reduce the risk of falls overboard; installing overhead weather decking to better protect crew from the elements; building holding containers for ropes and nets to reduce the risk of entanglement; and installing slip-resistant mats to reduce the likelihood of slips and falls. Other groundfish fishermen have invested in specialized machinery to help improve efficiency and minimize some of the hazards associated with commercial fishing. Many groundfish vessels, particularly those that also participate in high-volume fisheries such as herring or squid, have on-deck conveyors to help fishermen sort catch. Respondents explained that without these conveyors, fishermen typically sort fish on deck on their hands and knees, leaving them vulnerable to waves and ergonomic injuries. Conveyors enable fishermen to sort their catch while standing, which is more comfortable and affords them more protection. Additionally, one respondent mentioned that many fishermen have gas detectors installed in their vessels' holds that alert them to a buildup of toxic gasses, reducing their risk of asphyxiation.

In addition to modifying their vessels, respondents explained that many fishermen work vigilantly to create a "culture of safety" amongst their crew. Many captains and vessel owners are particularly harsh on new crew members, yelling at them for standing in the wrong places or handling gear incorrectly. Respondents said this strict approach helps to impress the importance of safe work practices on new crew, and it also helps captains to "weed out" the individuals who may not be well-suited to fishing. Several respondents mentioned that they always inspect each of their crew members before they head out to deploy or haul gear, checking them for loose jewelry, hair, or clothing. These respondents said they even go so far as to cut off any snaps, straps, or strings that dangle from their crew's clothing in order to minimize the chances of them getting entangled. Some operators require their crew to wear protective gear, such as PFDs and hard hats, at all times when they are on deck, while others feel it is safer for their crew to operate without these items. Finally, several respondents said many groundfish captains and crew take advantage of the safety training resources available in the Northeast, participating in voluntary safety training events when possible.

CONCLUSIONS

In this risk assessment, we discussed the multitude of environmental, physical, regulatory, and social factors that contribute to fishermen's level of safety at sea in the limited access portion of the northeast groundfish fishery. We detailed how these risk factors can vary across fisheries and across groups within the same fishery, and how other factors, including specific characteristics of fishing vessels (e.g., length, age, tonnage), the natural environment in which fishing occurs (e.g. water temperature, presence of navigational hazards), fishing operations (e.g., gear used, crew size), crew characteristics, and fishing regulations may all impact the amount of risk that fishermen are exposed to at sea.

Casualty data from the NIOSH CFID database revealed that 9 fatal incidents involving limited access groundfish vessels occurred from FY2006-FY2015. These 9 fatal incidents resulted in the deaths of 14 commercial groundfish fishermen. Our research shows that of the 14 fatalities, 11 occurred from FY2006-FY2009, and 3 occurred from FY2010-FY2015. While changes in the absolute number of fatalities is informative, translating this data into a fatality rate is helpful because it provides a standardized measure of risk per unit of exposure. The average annual fatality rate in the limited access groundfish fleet from FY2006-FY2015 was 21.89 fatalities per 10,000 FTEs. The average occupational fatality rate during the period pre-sector management (FY2006-FY2009) was 39.85 fatalities per 10,000 FTEs, while the fatality rate during the post-sector management period (FY2010-FY2015) dropped to 9.92 fatalities per 10,000 FTEs. While this decline in the occupational fatality rate indicates that the probability of a death occurring in the limited access groundfish fleet declined after the sector management program was implemented, it is not possible to attribute this decline solely to the change in regulatory regime. There are a variety of other confounding factors, including changes in the number of vessels participating in the fishery and changes in the number of trips being taken in the fishery, which likely also contributed to this trend.

It is also important to remember that occupational fatality rates represent only one method through which to assess relative safety. These rates do not indicate whether the probability of nonfatal safety incidents, which are often not reported or underreported, changed over time or whether fishermen's overall level of risk exposure changed. Interviews with fishermen, observers, and safety professionals indicate that, while there have been a number of safety-related improvements over time, the fleet's overall level of risk exposure may have increased or at least remained unchanged. During these conversations, we learned that some individuals feel that increased opportunities for emergency response training, and increased accessibility of other safety-related resources, has fostered a stronger "culture of safety" within the fleet over time. Multiple interviewees explained that this culture of safety is often enforced by the groundfish vessel captains, and several interviewees provided examples of ways that some captains implement safety protocols for their crew that go above and beyond those that are required through regulation. However, despite this perceived cultural shift, interviewees explained that there are a number of other factors that contribute negatively to groundfish fishermen's level of risk exposure. The most common factor described by interviewees was financial strain. Almost every individual that we spoke with explained that changes in fishing regulations, resource status, and reductions in vessel profits has led to significant financial strain for a large percentage of the fleet. This has contributed to vessel deterioration due to inability to pay for regular repair and maintenance. Interviewees also explained that uncertainty over the future of groundfish resources and concern over the long-term economic viability of the fishery have led to decreased human capital in the fleet. This has resulted in less stable work, greater turnover, and fewer experienced crew. As a result, many vessels are operating with reduced or inexperienced crew, which could lead to increased fatigue and a greater probability of an accident occurring. Data from limited access groundfish fishing trips indicated that, on almost half of all trips taken in FY2015, captains fished alone or with only one crew member, which may reflect the crew availability issues described by interviewees.

Fishery data and interview data indicate that certain portions of the limited access groundfish fleet may be more exposed to some types of risk than others. For example, interviews with industry suggest that owners of multiple vessels, or owners of vessels that are diversified into other fisheries, may be more profitable and experience less financial strain than owners of single vessels, or owners of vessels that direct their effort primarily on the groundfish fishery. As a result, smaller less diversified vessel owners may have less capital available to invest in maintenance and safety equipment, which means that these vessels may be exposed to more risk. Additionally, interviews with key stakeholders revealed that, while there are many serious safety hazards associated with all types of fishing gear, trawl gear may be particularly dangerous to work around. Interviewees cited the weight of the catch, the amount of strain that the net is under, the risk of entanglement in the deck winches or net mesh, and the swinging of the net as it is brought onto the vessel as major hazards associated with trawl gear. CFID data also revealed that all 14 fatalities from FY2007-FY2015 occurred on vessels fishing with bottom trawl gear, which further suggests that crew on trawl vessels experience relatively high risk. Finally, data from FY2015 indicate that common pool vessels tend to be smaller (in terms of length and tonnage) and have lower HP than sector vessels, which could indicate that these vessels are less suited to fishing farther from shore and therefore may be exposed to more risk if they feel forced to operate farther offshore.

Overall, it is clear that there are a number of factors that influence safety at sea and risk exposure in the limited access groundfish fleet and not all components of the fleet are exposed to the same amount of type of risk. Future research should focus on how economic strain impacts safety-related decisions, and what types of trade-offs are made when monetary resources are limited. Additionally, because CFID data revealed that 15 out of 16 of the individuals that were killed in fatal incidents entered the water, and none of these individuals were wearing PFDs, future research should investigate the factors that influence fishermen's choices to wear (or not wear) safety gear. This information could be used to tailor safety-related outreach to the fleet, or to guide the development of new safety equipment that may better suit fishermen's safety needs and operational practices. Finally, because CFID data showed that the majority of the individuals who were killed in fatal incidents from FY2007-FY2015 worked as deckhands at the time of the incident, and that both individuals involved in fatal falls overboard worked as deckhands, safety training and outreach should try to target this group.

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Table 1. Northeast multispecies permit categories and permit types.

Permit category	Abbreviation	Permit type
Day-at-sea (DAS)	A	Limited access
Small vessel exemption	C	Limited access
Hook gear	D	Limited access
Combination vessels	E	Limited access
Large mesh individual DAS	F	Limited access
Handgear A	HA	Limited access
Handgear B	HB	Open access
Charter/party	I	Open access
Scallop multispecies possession limit	J	Open access
Open access multispecies	K	Open access

Table 2. Monthly mean water temperatures in coastal areas throughout the northeastern U.S. (Source: NOAA National Centers for Environmental Information).[21]

Port	Jan	Feb	March	April	May	June	July	Aug	Sept	Oct	Nov	Dec
Bar Harbor, ME	38.0	36.0	38.0	43.5	49.0	55.0	59.0	61.5	57.5	54.0	52.0	44.0
Eastport, ME	40.0	37.0	38.0	40.0	43.5	46.0	50.5	51.0	51.5	49.5	45.0	45.0
Portland, ME	34.0	33.0	37.0	40.0	49.0	55.5	60.5	61.5	58.5	52.0	47.0	39.0
Portsmouth Harbor, NH	40.0	35.0	37.0	43.0	50.0	55.0	60.0	61.5	58.5	52.0	48.0	41.0
Boston, MA	40.0	36.0	41.0	47.0	56.0	62.0	66.5	68.0	64.5	57.0	51.0	42.0
Fall River, MA	37.0	36.0	41.0	49.0	57.5	64.0	72.5	75.0	69.5	56.5	52.0	44.0
Woods Hole, MA	34.0	35.0	37.0	45.5	55.0	63.0	71.0	71.5	67.5	59.0	50.0	41.0
Conimicut Light, RI	38.0	37.0	41.0	48.5	58.0	67.0	74.0	75.5	71.0	62.0	52.0	43.0
Quonset Point, RI	38.0	37.0	40.0	47.0	52.0	64.5	76.5	71.5	65.0	59.5	51.0	43.0
Newport, RI	37.0	36.0	37.0	46.0	54.5	62.0	68.5	70.0	66.5	60.0	52.0	44.0
Providence, RI	39.0	37.0	41.0	48.5	57.0	63.5	69.5	70.5	67.5	60.0	50.0	43.0
New Haven, CT	42.0	36.0	40.0	48.0	57.5	67.5	72.5	75.0	72.5	63.0	53.0	47.0
New London, CT	37.0	37.0	40.0	49.0	56.5	64.0	70.0	71.5	68.5	59.5	52.0	42.0
Bergen Point, NY	26.0	26.0	32.0	49.0	58.0	67.5	73.5	75.5	71.5	62.0	52.0	39.0
Kings Point, NY	37.0	36.0	40.0	47.5	57.0	65.0	69.5	73.5	71.0	63.0	54.0	43.0
Montauk, NY	36.0	35.0	38.0	44.0	52.0	60.5	68.5	70.0	67.5	59.5	56.0	43.0
The Battery, NY	38.0	36.0	41.0	47.0	57.0	65.5	71.5	73.5	70.0	60.5	53.0	43.0
Willets Point, NY	35.0	34.0	39.0	47.0	56.5	64.5	70.5	73.0	70.5	61.5	54.0	42.0
Sandy Hook, NJ	37.0	36.0	40.0	46.0	55.0	61.5	69.0	72.0	68.0	59.0	51.0	43.0
Atlantic City, NJ	37.0	35.0	42.0	48.0	56.0	63.0	69.5	72.5	69.5	60.5	53.0	44.0
Cape May, NJ	37.0	37.0	42.0	49.5	59.0	68.0	72.5	73.5	71.5	60.5	52.0	42.0
Ship John Shoal, NJ	37.0	37.0	44.0	54.5	64.5	75.5	81.5	80.5	74.0	58.0	52.0	44.0

26°F 56°F 86°F

[21] Water temperatures depicted here represent monthly averages calculated across all years for which a given station collected data. For more information about the availability of historical water temperature data for a given location, please see the NOAA National Buoy Data Center website..

Table 2 (continued). Monthly mean water temperatures in coastal areas throughout the northeastern U.S. (Source: NOAA National Centers for Environmental Information).[22]

Port	Jan	Feb	March	April	May	June	July	Aug	Sept	Oct	Nov	Dec
Tacony-Palmyra Bridge, NJ	36.0	37.0	45.0	55.0	63.5	75.5	80.5	79.0	72.0	60.5	49.0	41.0
Brandywine Shoal Light, DE	38.0	38.0	45.0	54.0	65.0	75.0	82.0	81.5	74.5	64.0	52.0	43.0
Delaware City, DE	38.0	38.0	45.0	54.0	65.0	75.0	82.0	81.5	74.5	64.0	52.0	43.0
Lewes, DE	37.0	36.0	41.0	51.0	60.0	67.5	72.5	75.5	71.5	61.5	52.0	44.0
Reedy Point, DE	37.0	37.0	44.0	54.0	64.0	76.0	81.0	80.5	75.0	64.0	52.0	43.0
Annapolis, MD	36.0	35.0	42.0	52.0	60.5	71.5	77.0	77.5	73.0	63.0	53.0	45.0
Baltimore, MD	40.0	37.0	43.0	54.0	64.0	72.5	77.5	79.0	74.5	63.5	54.0	43.0
Chesapeake City, MD	36.0	36.0	44.0	55.0	66.5	77.0	82.0	82.0	75.0	63.5	52.0	41.0
Ocean City, MD	37.0	34.0	42.0	49.5	55.5	62.5	68.5	71.0	70.0	62.0	53.0	44.0
Solomons Island, MD	37.0	37.0	43.0	52.5	63.5	73.5	80.0	83.0	76.0	63.5	57.0	45.0
Tolchester Beach, MD	37.0	36.0	44.0	54.0	64.5	74.0	80.0	79.5	73.5	62.5	51.0	41.0
Washington DC	37.0	37.0	46.0	57.5	67.5	76.5	81.5	82.0	75.0	61.0	52.0	41.0
Chesapeake Bay Bridge Tunnel, VA	46.0	42.0	44.0	56.5	64.0	72.5	77.5	78.5	76.5	64.0	56.0	49.0
Kiptopeke, VA	36.0	39.0	46.0	53.5	63.0	69.5	76.5	77.5	75.0	63.5	54.0	44.0
Lewisetta, VA	39.0	40.0	48.0	58.5	68.5	78.5	82.0	82.0	75.5	62.5	53.0	44.0
Money Point, VA	49.0	49.0	55.0	63.0	72.5	81.5	86.5	86.0	80.0	66.0	60.0	54.0
Virginia Beach, VA	55.0	53.0	48.0	51.5	59.0	71.5	77.0	80.5	73.5	68.5	60.0	60.0
Yorktown, VA	42.0	42.0	49.0	57.5	69.0	76.5	81.5	82.5	77.5	68.5	56.0	47.0
Cape Hatteras, NC	49.0	46.0	52.0	59.0	68.0	73.5	77.5	80.0	76.5	70.0	58.0	55.0
Duck, NC	45.0	44.0	46.0	59.0	67.0	73.5	71.0	74.0	75.0	68.5	59.0	52.0

26°F 56°F 86°F

[22] Water temperatures depicted here represent monthly averages, calculated across all years for which a given station collected data. For more information about the availability of historical water temperature data for a given location, please see the NOAA National Buoy Data Center website..

Table 3. Annual number of occupational fatalities in the limited access groundfish fishery from FY2006-FY2015.

Year	Total # of fatalities	Total # of fatal incidents	# of falls overboard	# of onboard injuries	# of onshore injuries	# of vessel disasters
2006	7	3	0	0	0	3
2007	0	0	0	0	0	0
2008	4	3	0	1	0	2
2009	0	0	0	0	0	0
2010	1	1	1	0	0	0
2011	0	0	0	0	0	0
2012	0	0	0	0	0	0
2013	2	2	1	0	1	0
2014	0	0	0	0	0	0
2015	0	0	0	0	0	0
Grand total	**14**	**9**	**2**	**1**	**1**	**5**

Table 4. Initiating events leading to fatal vessel disasters in the limited access groundfish fishery from FY2006-FY2015.

Initiating event	# of vessel disasters	# of fatalities
Flooding	1	2
Instability	4	8
Grand total	**5**	**10**

Table 5. Occupational fatalities in the limited access groundfish fishery by month and season from FY2006-FY2015.

Month and season	# of fatal incidents	# of fatalities
December	1	1
January	4	9
February	0	0
Winter total	**5**	**10**
March	0	0
April	0	0
May	0	0
Spring total	**0**	**0**
June	1	1
July	0	0
August	0	0
Summer total	**1**	**1**
September	0	0
October	1	1
November	2	2
Fall total	**3**	**3**

Table 6. Occupational fatalities in the limited access groundfish fishery by state in or adjacent to which they occurred from FY2006-FY2015.

State	Total # of fatalities	Total # of fatal incidents	# of falls overboard	# of onboard injuries	# of onshore injuries	# of vessel disasters
Maine	4	3	0	0	1	2
Massachusetts	9	5	2	0	0	3
New Jersey	1	1	0	1	0	0
Grand total	**14**	**9**	**2**	**1**	**1**	**5**

Table 7. Occupational fatalities in the limited access groundfish fishery by distance from shore from FY2006-FY2015.

Distance from shore (miles)	Total # of fatalities	Total # of fatal incidents	# of falls overboard	# of onboard injuries	# of onshore injuries	# of vessel disasters
0	1	1	0	0	1	0
> 0-3	0	0	0	0	0	0
> 3-10	1	1	0	1	0	0
> 10-30	9	4	1	0	0	3
> 30-50	2	2	1	0	0	1
> 50-70	0	0	0	0	0	0
> 70-140	1	1	0	0	0	1
Grand total	**14**	**9**	**2**	**1**	**1**	**5**

Table 8. Occupational fatalities in the limited access groundfish fishery by activity at the time of the incident from FY2006-FY2015.

Vessel activity	Total # of fatalities	Total # of fatal incidents	# of falls overboard	# of onboard injuries	# of onshore injuries	# of vessel disasters
Fishing	7	6	2	1	0	3
Moored	1	1	0	0	1	0
Transit (inbound)	4	1	0	0	0	1
Transit (outbound)	2	1	0	0	0	1
Grand total	**14**	**9**	**2**	**1**	**1**	**5**

Table 9. Occupational fatalities in the limited access groundfish fishery by gear type from FY2006-FY2015.

Gear type	Total # of fatalities	Total # of fatal incidents	# of falls overboard	# of onboard injuries	# of onshore injuries	# of vessel disasters
Sink gillnet	0	0	0	0	0	0
Bottom longline	0	0	0	0	0	0
Bottom trawl	14	9	2	1	1	5
Rod and reel	0	0	0	0	0	0
Grand total	**14**	**9**	**2**	**1**	**1**	**5**

Table 10. Occupational fatalities in the limited access groundfish fishery by vessel hull construction from FY2006-FY2015.

Hull construction	Total # of fatalities	Total # of fatal incidents	# of falls overboard	# of onboard injuries	# of onshore injuries	# of vessel disasters
Unknown	1	1	1	0	0	0
Steel	12	7	1	0	1	5
Wood	1	1	0	1	0	0
Grand total	**14**	**9**	**2**	**1**	**1**	**5**

Table 11. Occupational fatalities in the limited access groundfish fishery by vessel size category from FY2006-FY2015.

Vessel size category (feet)	Total # of fatalities	Total # of fatal incidents	# of falls overboard	# of onboard injuries	# of onshore injuries	# of vessel disasters
Less than 30	0	0	0	0	0	0
30 to < 50	2	2	0	0	1	1
50 to < 75	7	5	1	1	0	3
75 and longer	5	2	1	0	0	1
Grand total	**14**	**9**	**2**	**1**	**1**	**5**

Table 12. Occupational fatalities in the limited access groundfish fishery by vessel age from FY2006-FY2015.

Vessel age category (years)	Total # of fatalities	Total # of fatal incidents	# of falls overboard	# of onboard injuries	# of onshore injuries	# of vessel disasters
10-19	2	1	0	0	0	1
20-29	7	3	1	0	0	2
30-39	2	2	0	0	0	2
40-49	2	2	1	1	0	0
50-59	1	1	0	0	1	0
Grand total	**14**	**9**	**2**	**1**	**1**	**5**

Table 13. Decedents' positions onboard limited access groundfish vessels from FY2006-FY2015.

Position	Total # of fatalities	# of falls overboard	# of onboard injuries	# of onshore injuries	# of vessel disasters
Deckhand	6	2	0	1	3
Skipper	6	0	1	0	5
Owner operator	2	0	0	0	2
Grand total	**14**	**2**	**1**	**1**	**10**

Table 14. Activities decedents were engaged in at the time of a fatal incident from FY2006-FY2015.

Activity	Total # of fatalities	# of falls overboard	# of onboard injuries	# of onshore injuries	# of vessel disasters
Handling gear on deck	1	1	0	0	0
Hauling the gear	4	1	1	0	2
Not classified or unclassifiable	9	0	0	1	8
Grand total	**14**	**2**	**1**	**1**	**10**

Table 15. Age of decedents from FY2006-FY2015.

Decedent age (years)	Total # of fatalities	# of falls overboard	# of onboard injuries	# of onshore injuries	# of vessel disasters
20-29	2	0	0	0	2
30-39	2	0	0	0	2
40-49	3	2	0	0	1
50-59	6	0	1	0	5
60-69	1	0	0	1	0
Grand total	**14**	**2**	**1**	**1**	**10**

Table 16. Number of decedents and number of survivors by incident type from 2006-2015.

Incident type	# of decedents	# of survivors	# of individuals who entered the water
Vessel disaster	10	4	14
Fall overboard	2	0	2
Onshore injury	1	0	0
Onboard injury	1	0	1
Grand total	**14**	**4**	**17**

Table 17. Annual number of nonfatal occupational injuries sustained by limited access groundfish fishermen (2006-2015).

Year	# of injuries
2006	1
2007	1
2008	2
2009	1
2010	1
2011	3
2012	3
2013	0
2014	1
2015	0
Grand total	**13**

Table 18. Number of nonfatal occupational injuries sustained by limited access groundfish fishermen by season (20062015).

Season	# of injuries
Spring	2
Summer	4
Fall	2
Winter	5
Grand total	**13**

Table 19. Size of the limited access groundfish vessels on which nonfatal injuries occurred (2006-2015).

Vessel size category (feet)	# of incidents
30-39	1
40-49	1
50-59	1
60-69	3
70-79	4
80-89	2
Unspecified	1
Grand total	**13**

Table 20. Number of nonfatal occupational injuries sustained by crew in various positions on limited access groundfish vessels (2006-2015).

Crew position	# of injuries
Crew member	10
Captain/Master	2
Owner	1
Grand total	**13**

Table 21. Incident types and resulting nonfatal injuries in the limited access groundfish fleet (2006-2015).

Incident type	Resulting injury	# individuals injured
Slip and fall onto winch	Leg laceration	1
Hit in head by ice bucket	Head injury	1
Vessel collision	Hand laceration	1
Hit by slack towing wire	Head injury; knocked over	1
Arm caught in trawl gear during haul-back	Arm fracture	1
Vessel collision	Torso injury	1
Vessel collision	Broken leg	1
Tangled in net	Unspecified	1
Slip and fall on wet deck	Shoulder injury	1
Fainting spell	Unspecified	1
Slip and fall onto fish spine	Infected wound	1
Hit by broken safety chain	Face laceration; broken jaw	1
Injured while repairing broken steering equipment	Finger injury	1
Grand total		**13**

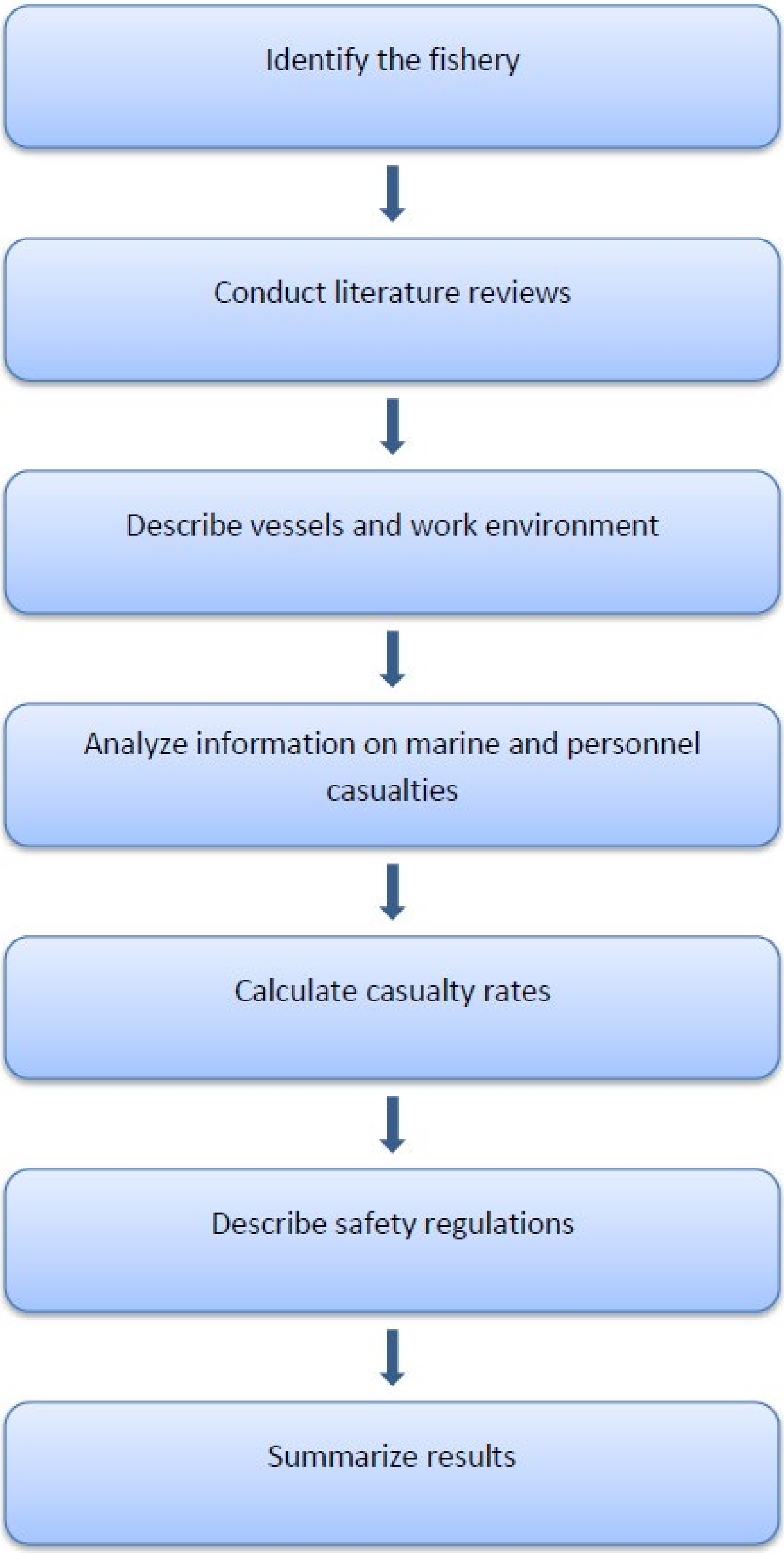

Figure 1. Conceptual diagram of a fishery risk assessment (Source: Lambert et. al 2015).

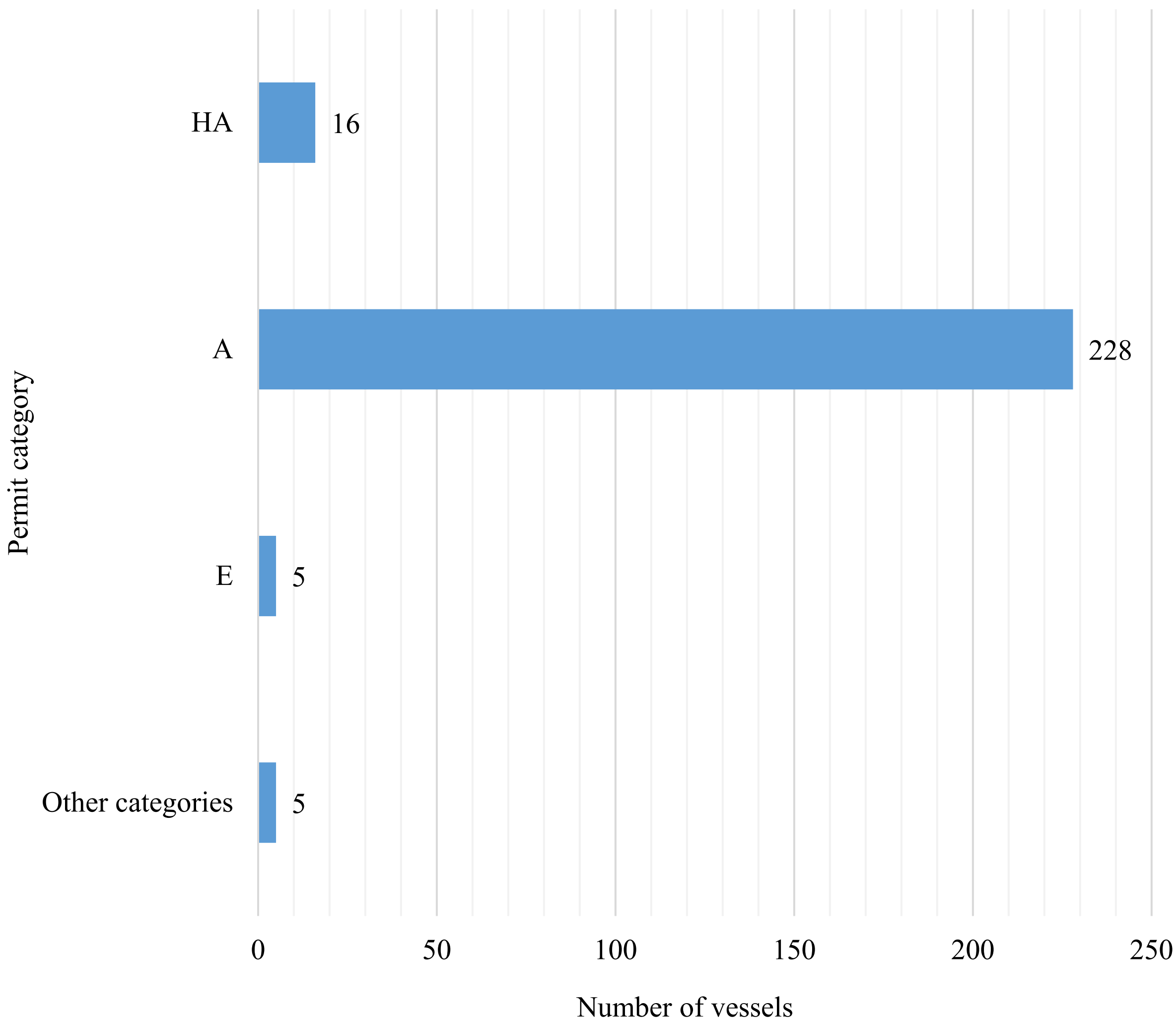

Figure 2. Number of active groundfish vessels fishing under various limited access permit categories in FY2015.

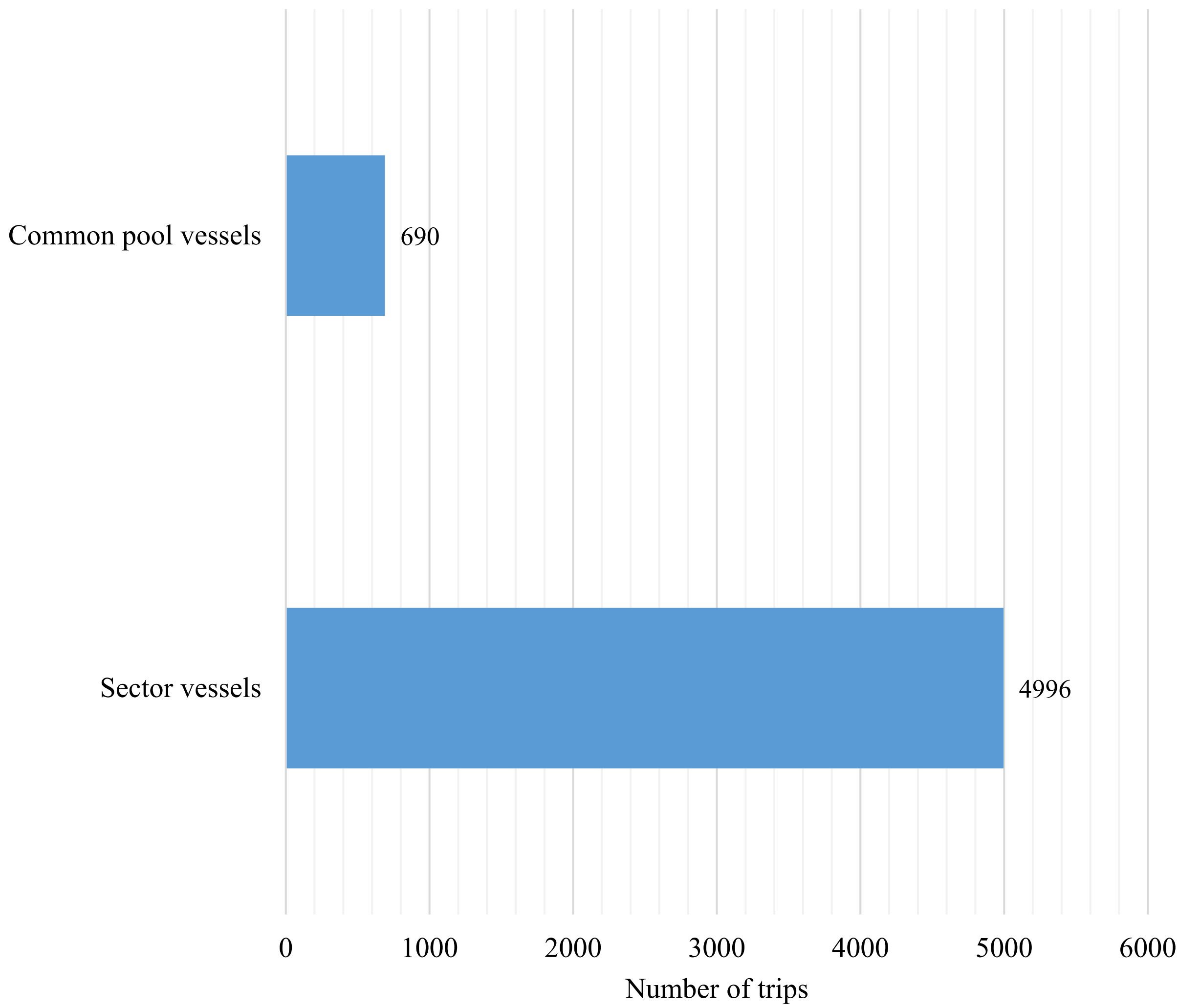

Figure 3. Number of limited access groundfish trips taken by sector vessels and common pool vessels in FY2015.

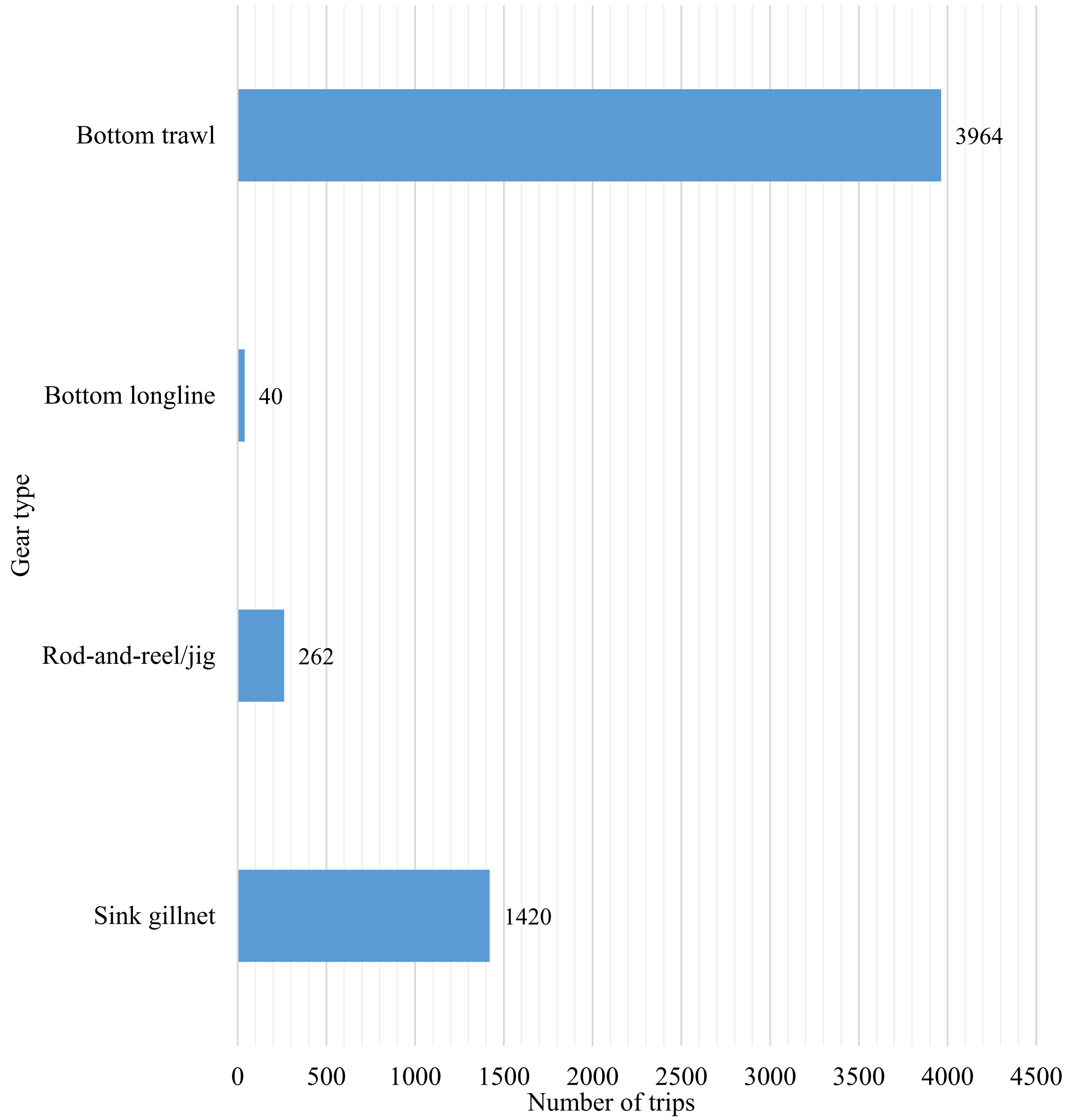

Figure 4. Number of limited access groundfish trips taken with various gear types in FY2015.

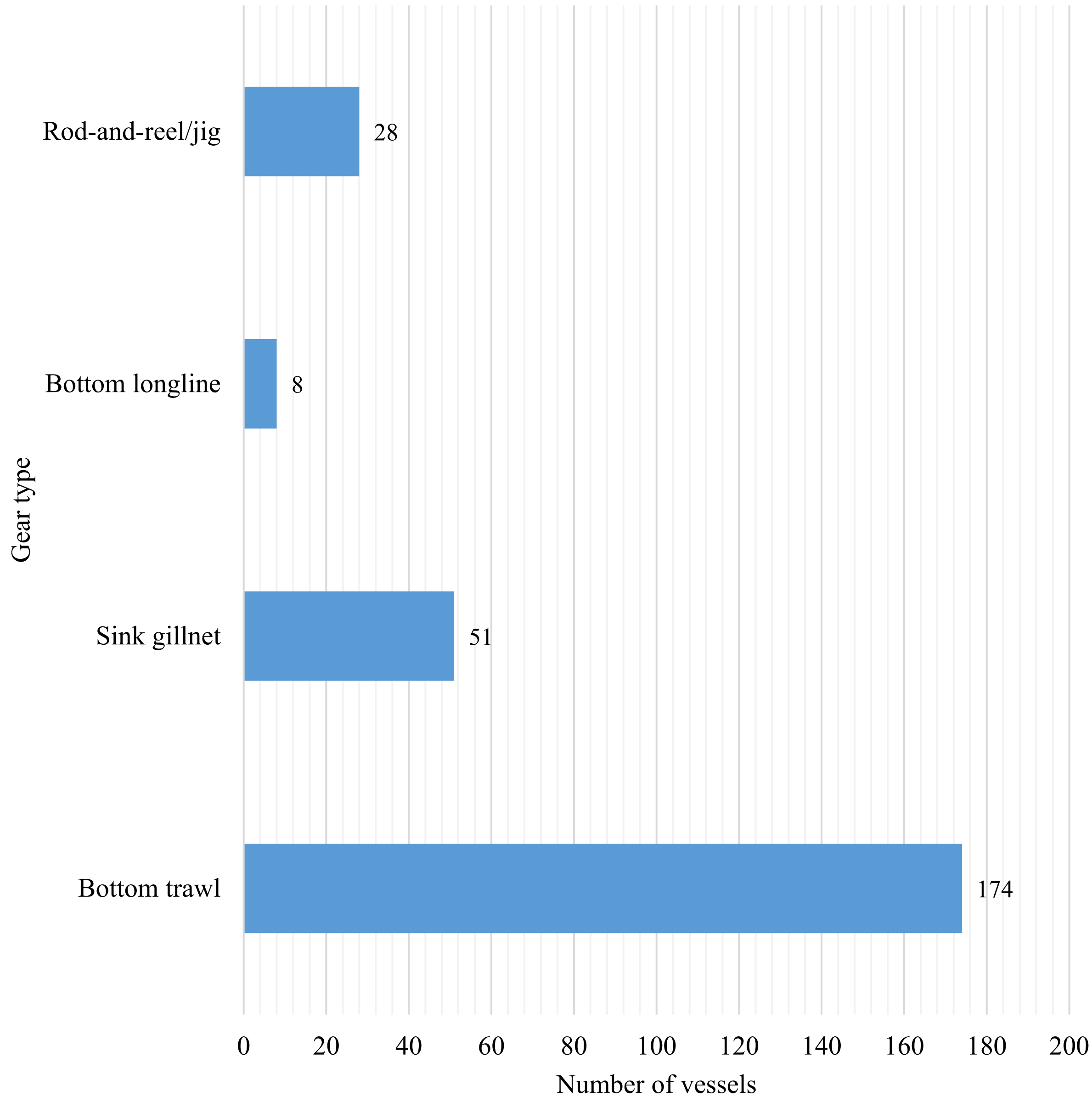

Figure 5. Number of limited access vessels that fished with various gear types on groundfish trips in FY2015.

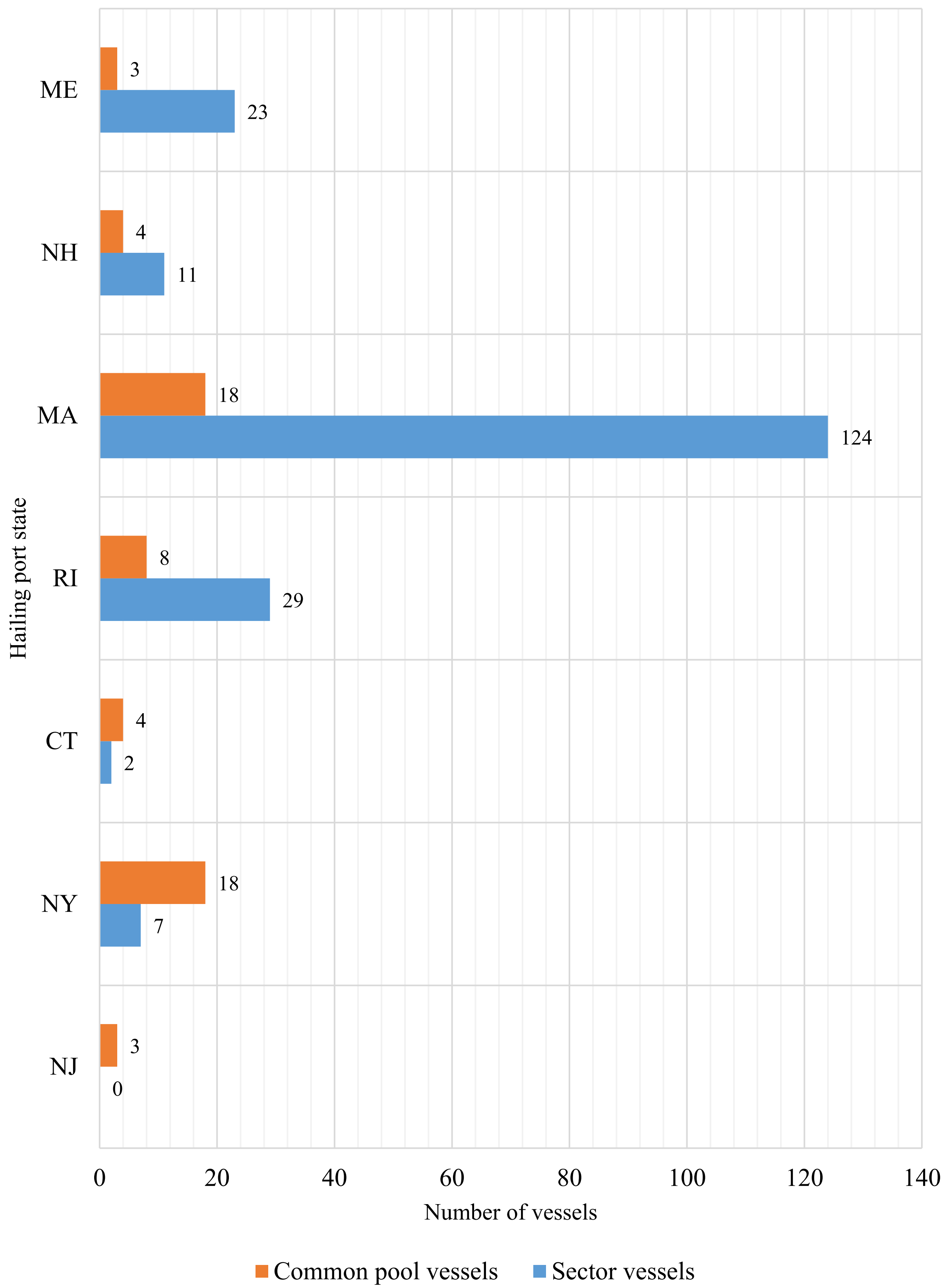

Figure 6. Number of active limited access groundfish vessels by hailing port state in FY2015.

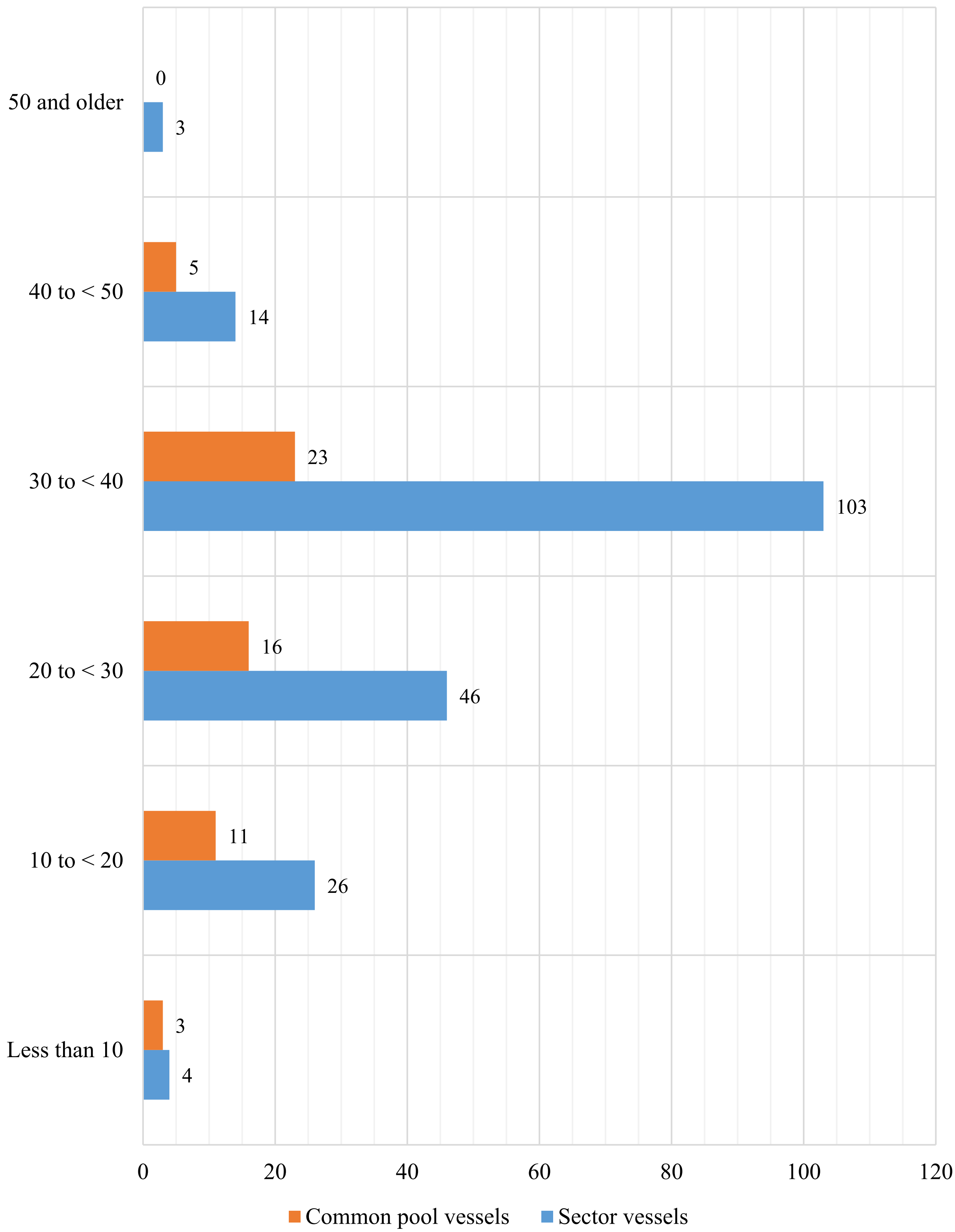

Figure 7. Number of active limited access groundfish vessels by age category (years) in FY2015.

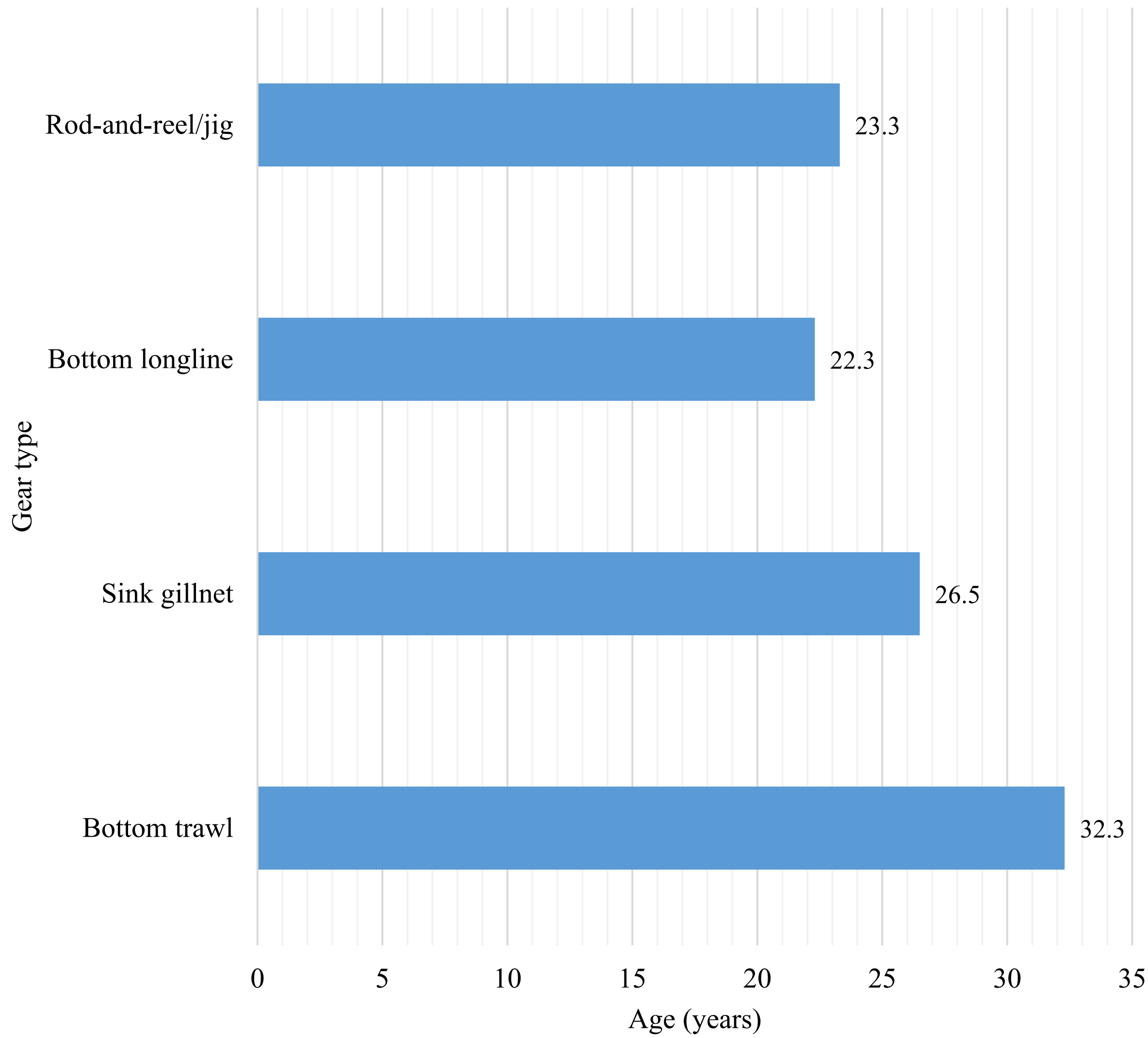

Figure 8. Average age of active limited access groundfish vessels by gear type used in FY2015.

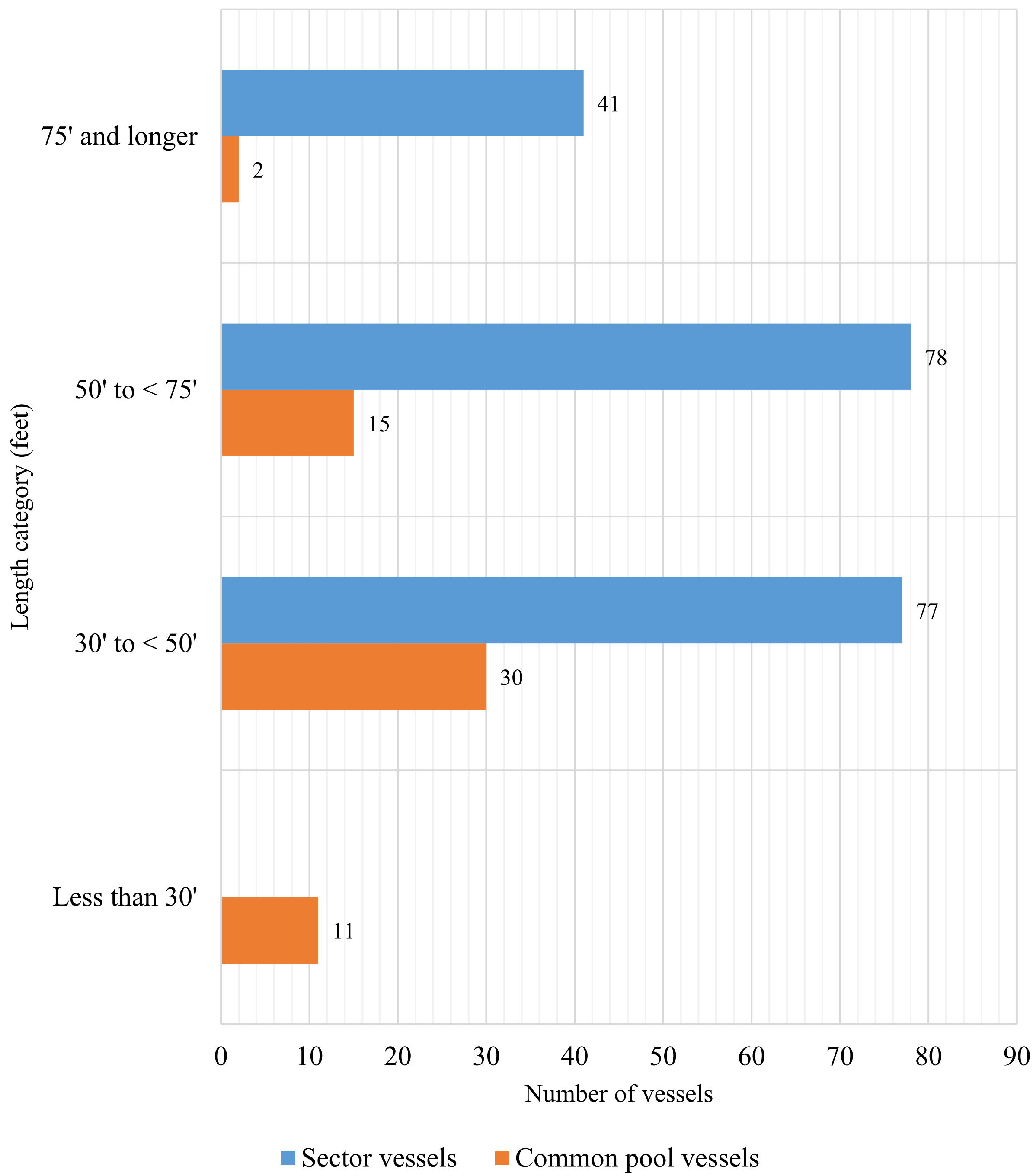

Figure 9. Number of active limited access groundfish vessels by length category (feet) in FY2015.

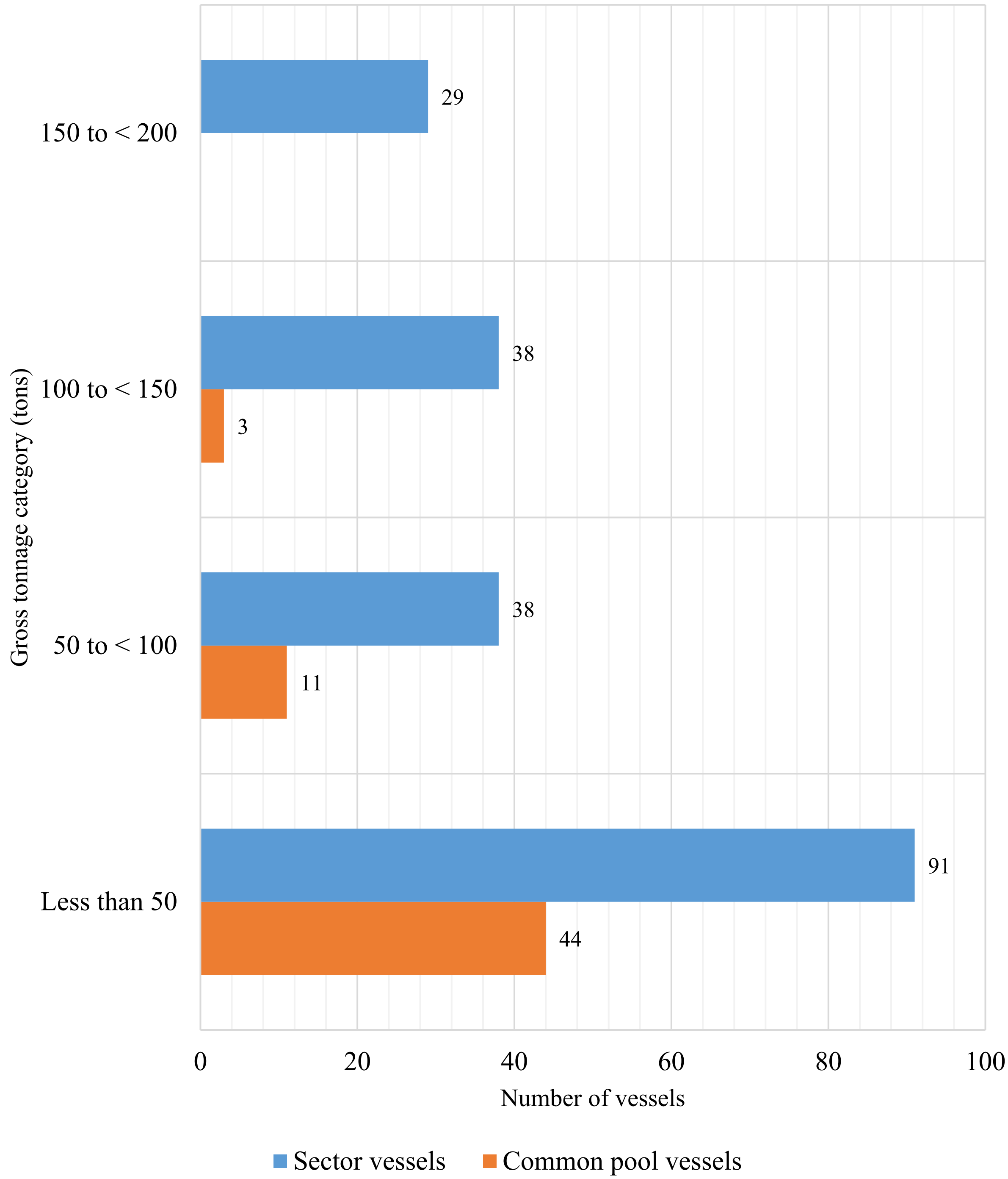

Figure 10. Number of active limited access groundfish vessels by gross tonnage category (tons) in FY2015.

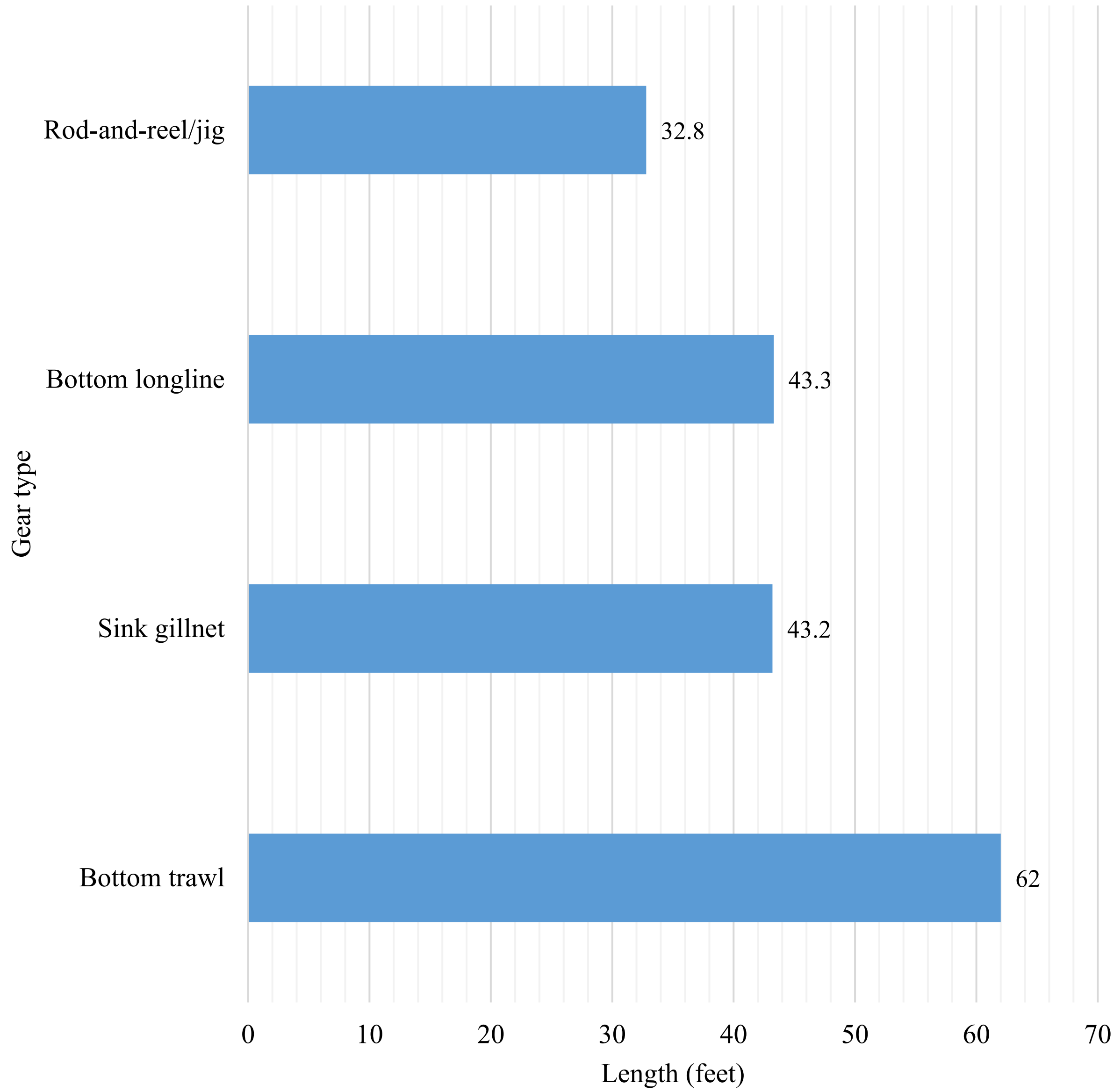

Figure 11. Average length (feet) of active limited access groundfish vessels by gear type used in FY2015.

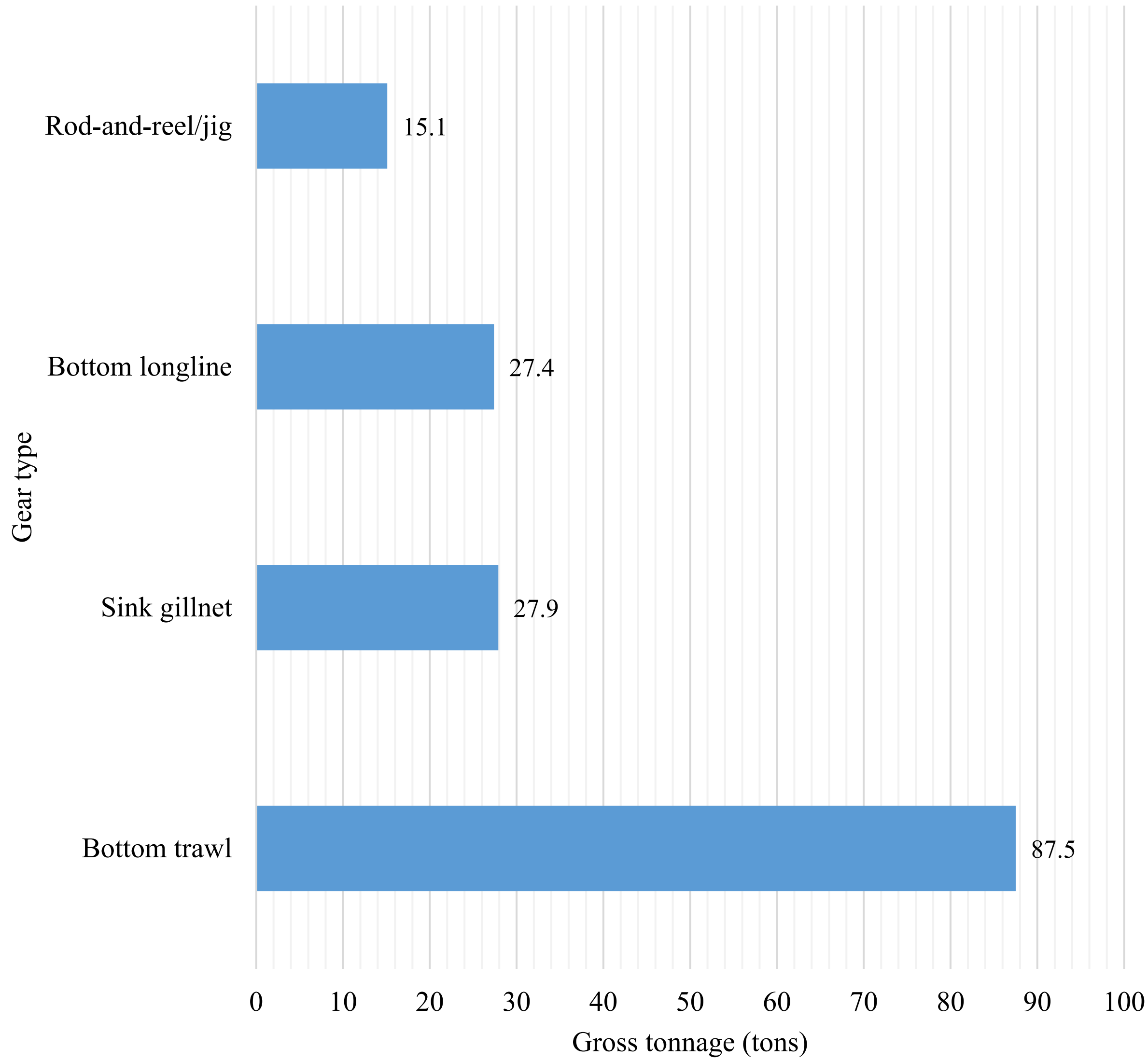

Figure 12. Average gross tonnage (tons) of active limited access groundfish vessels by gear type used in FY2015.

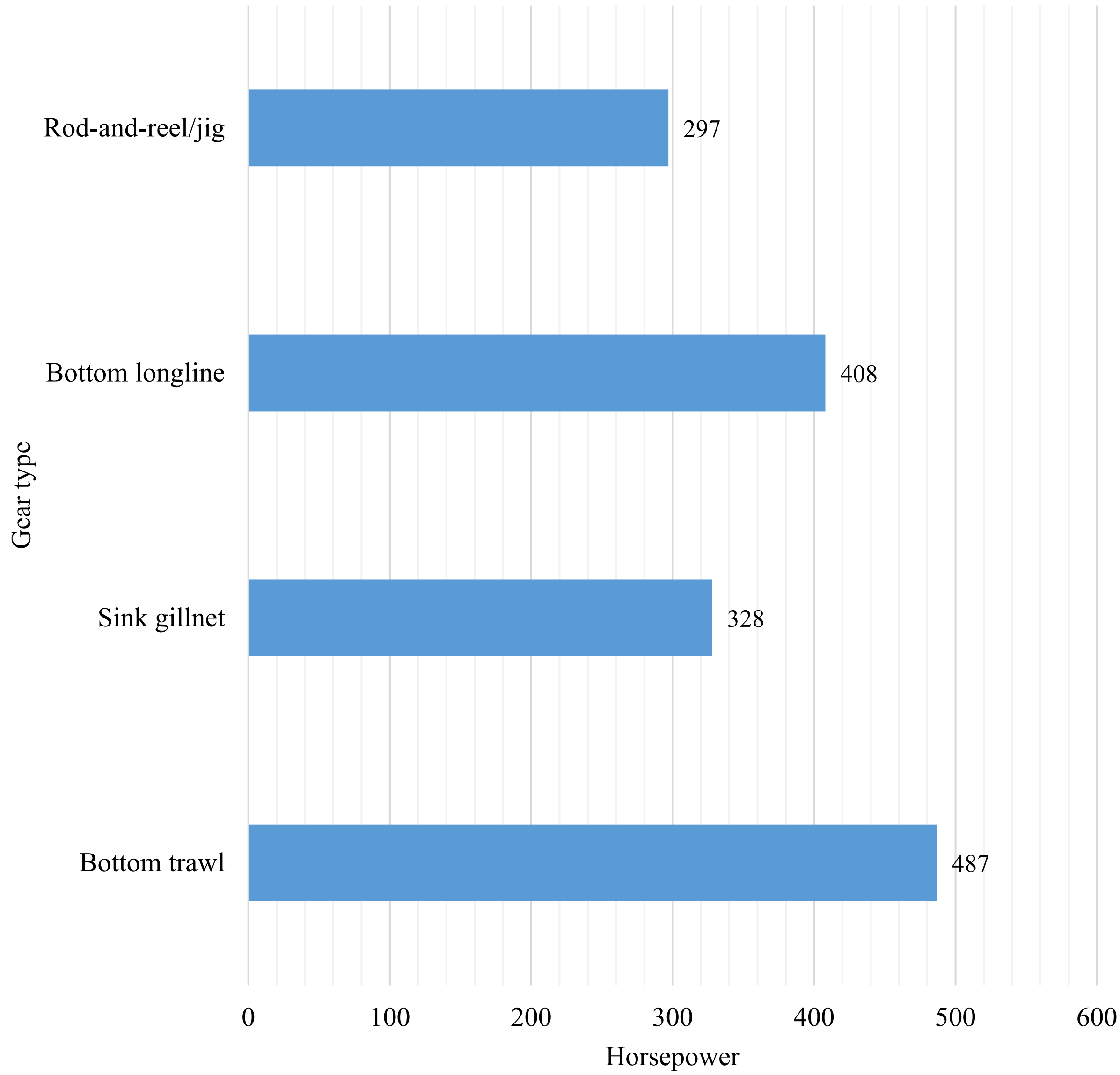

Figure 13. Average horsepower (HP) of active limited access groundfish vessels by gear type used in FY2015.

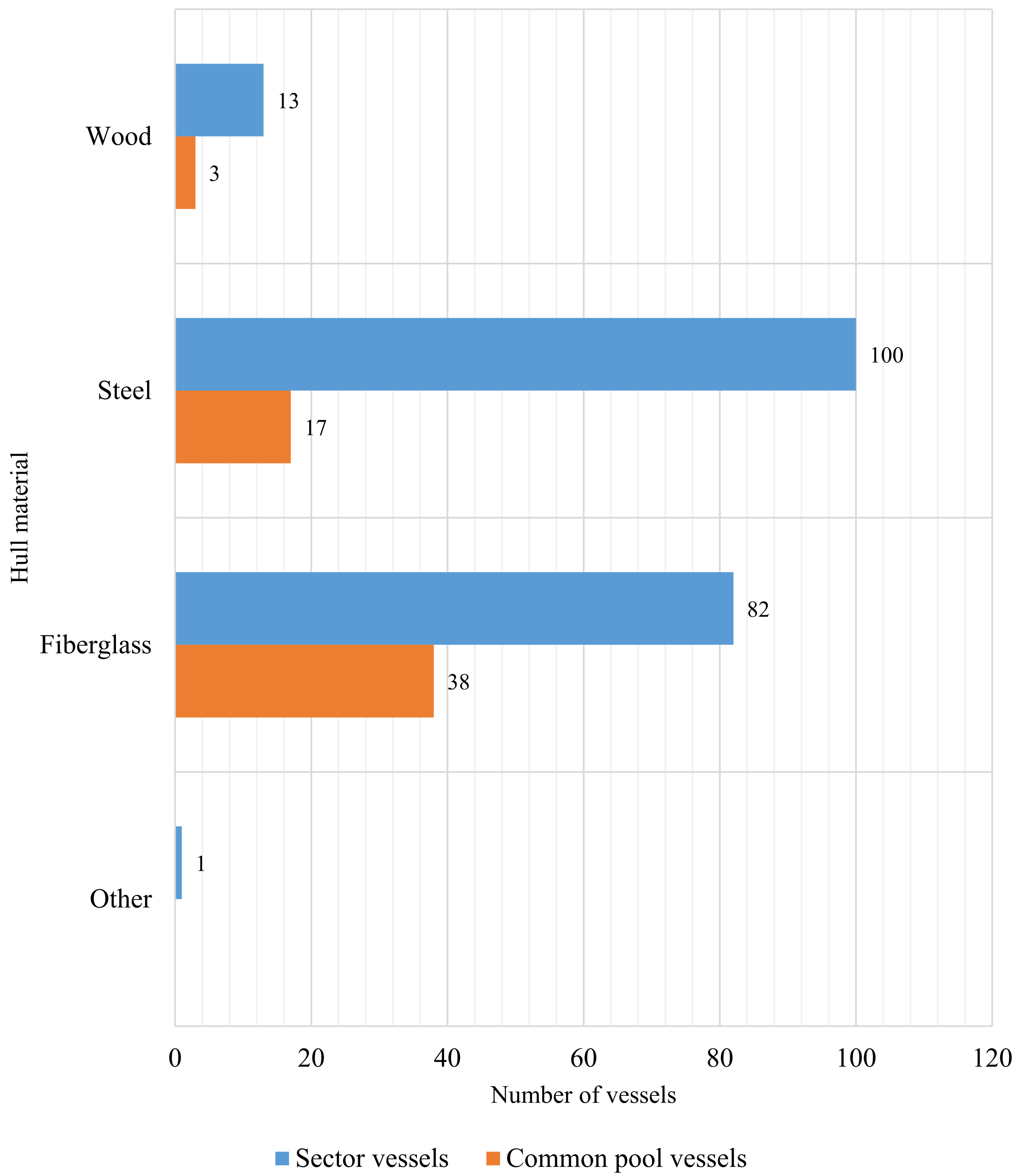

Figure 14. Number of active limited access groundfish vessels by hull material in FY2015.

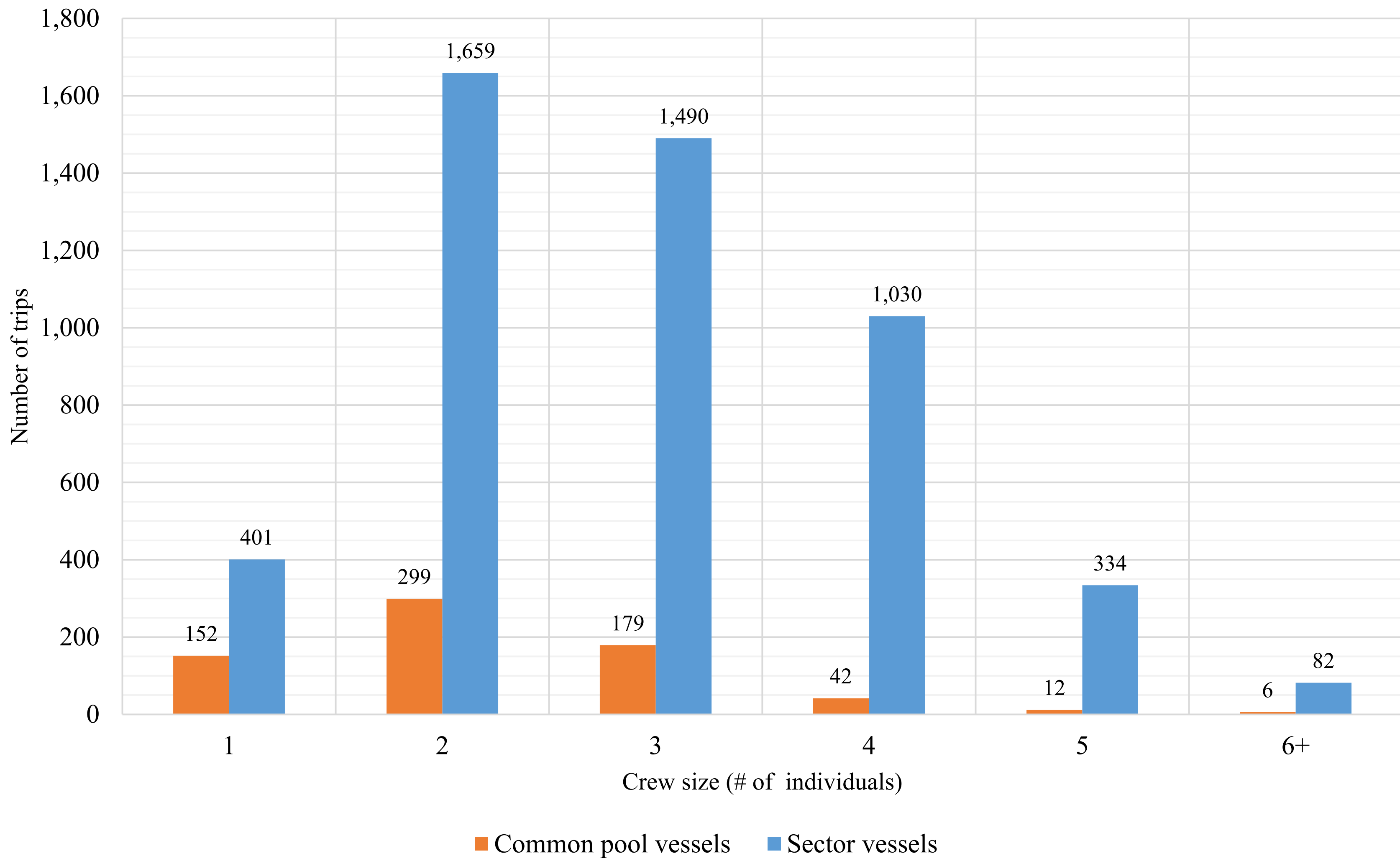

Figure 15. Number of groundfish trips by crew size (individuals) in FY2015.

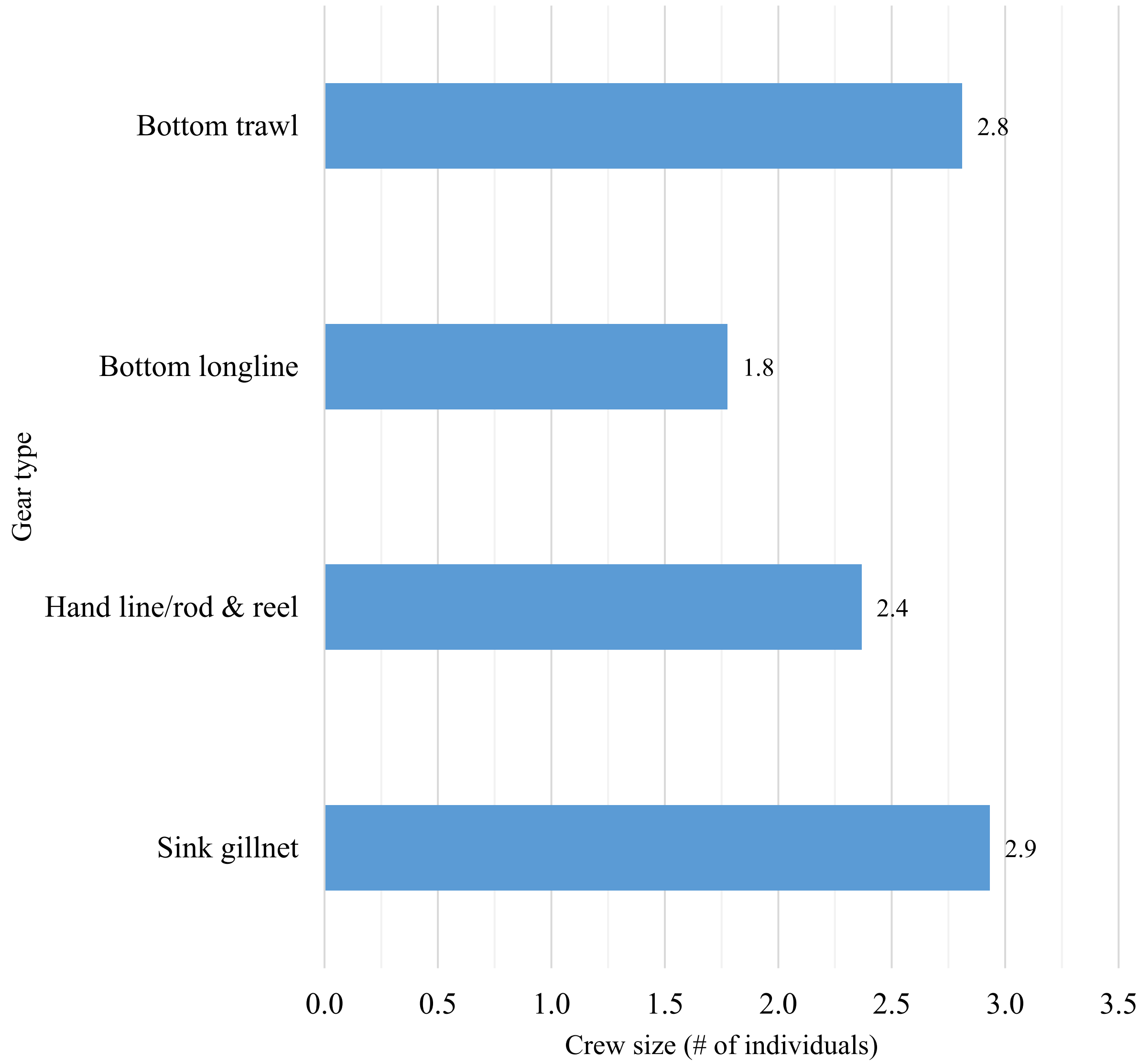

Figure 16. Average crew size by gear type in FY2015.

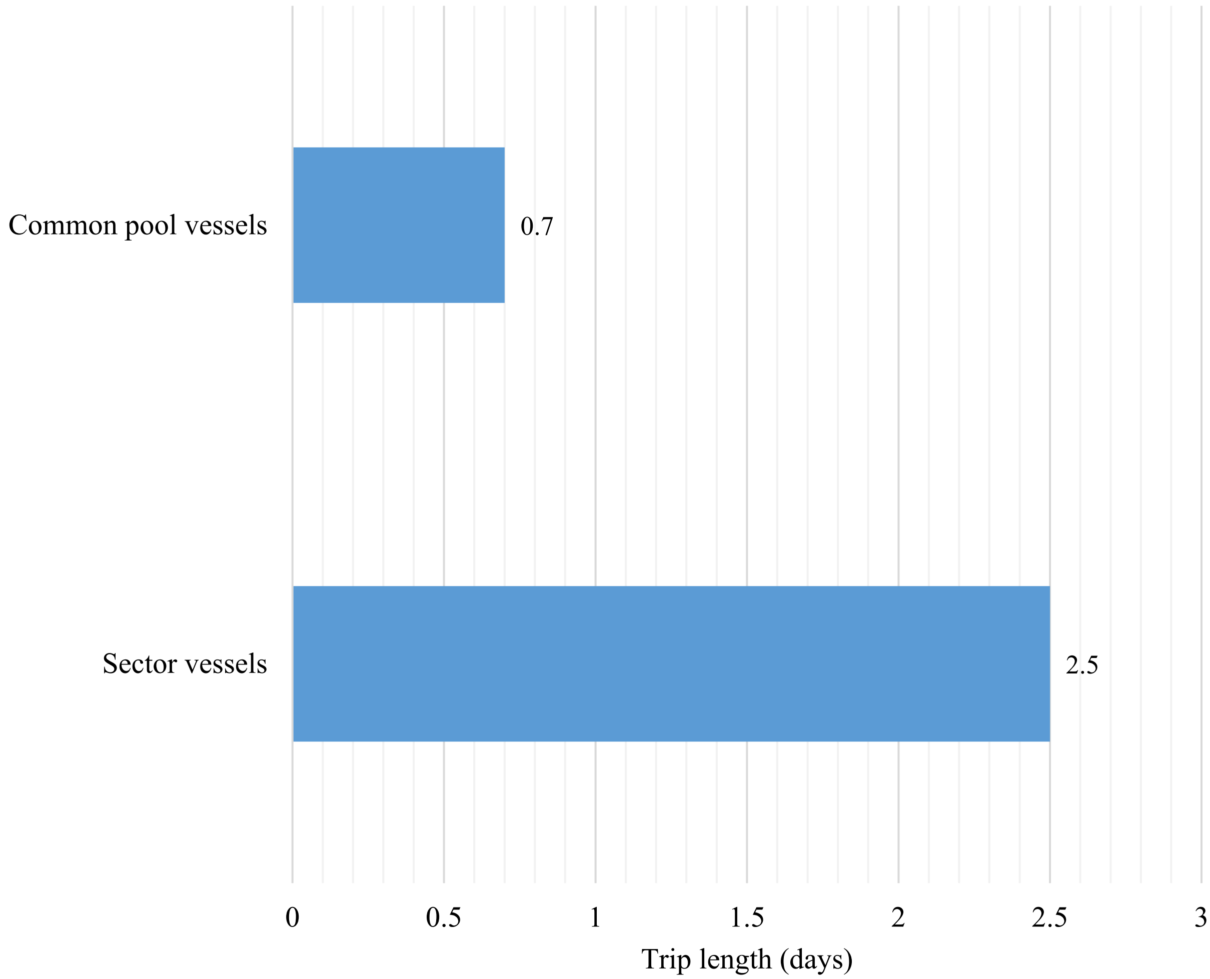

Figure 17. Average groundfish trip length by sector vessels and common pool vessels in FY2015.

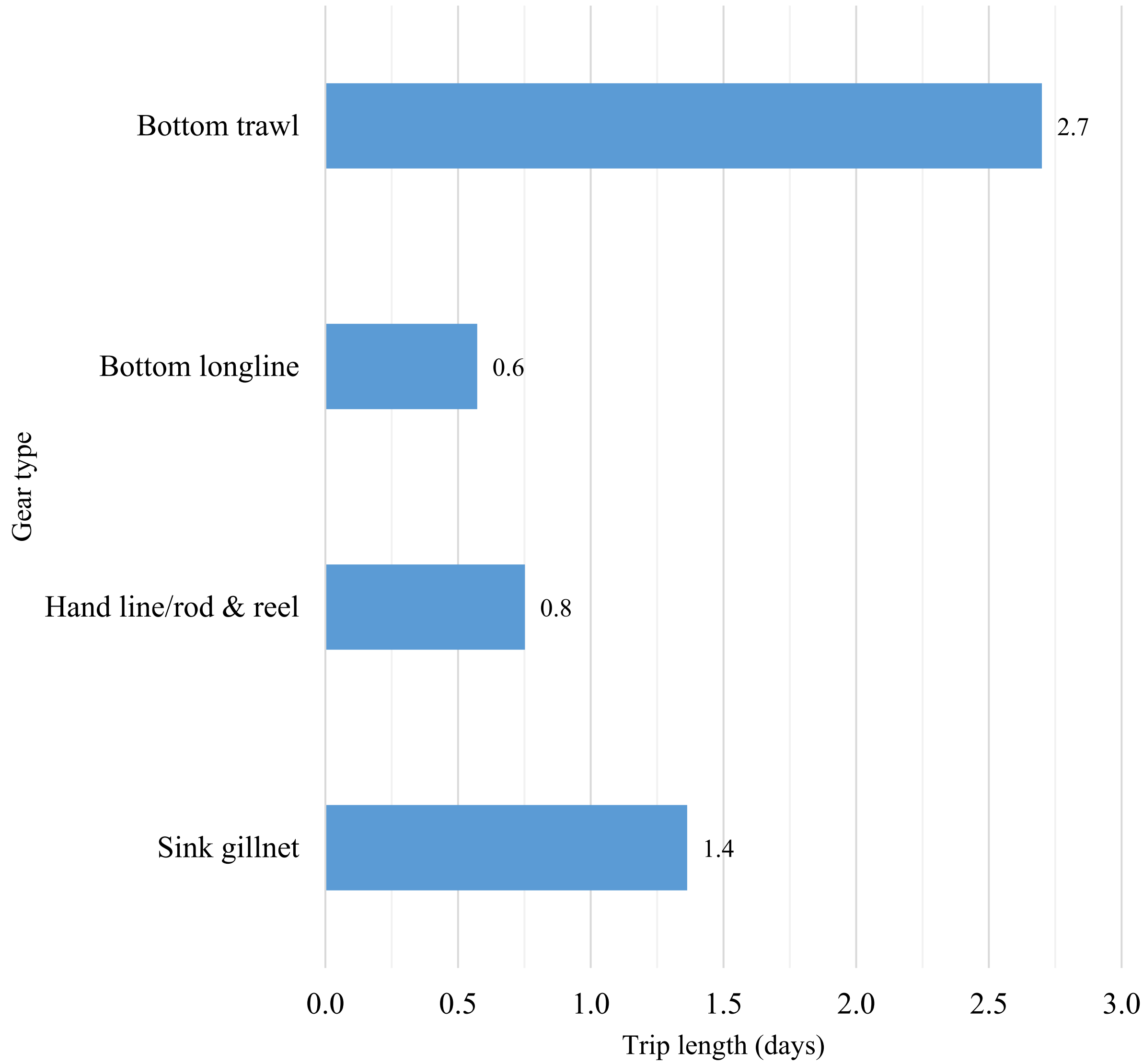

Figure 18. Average groundfish trip length by vessels using various gear types in FY2015.

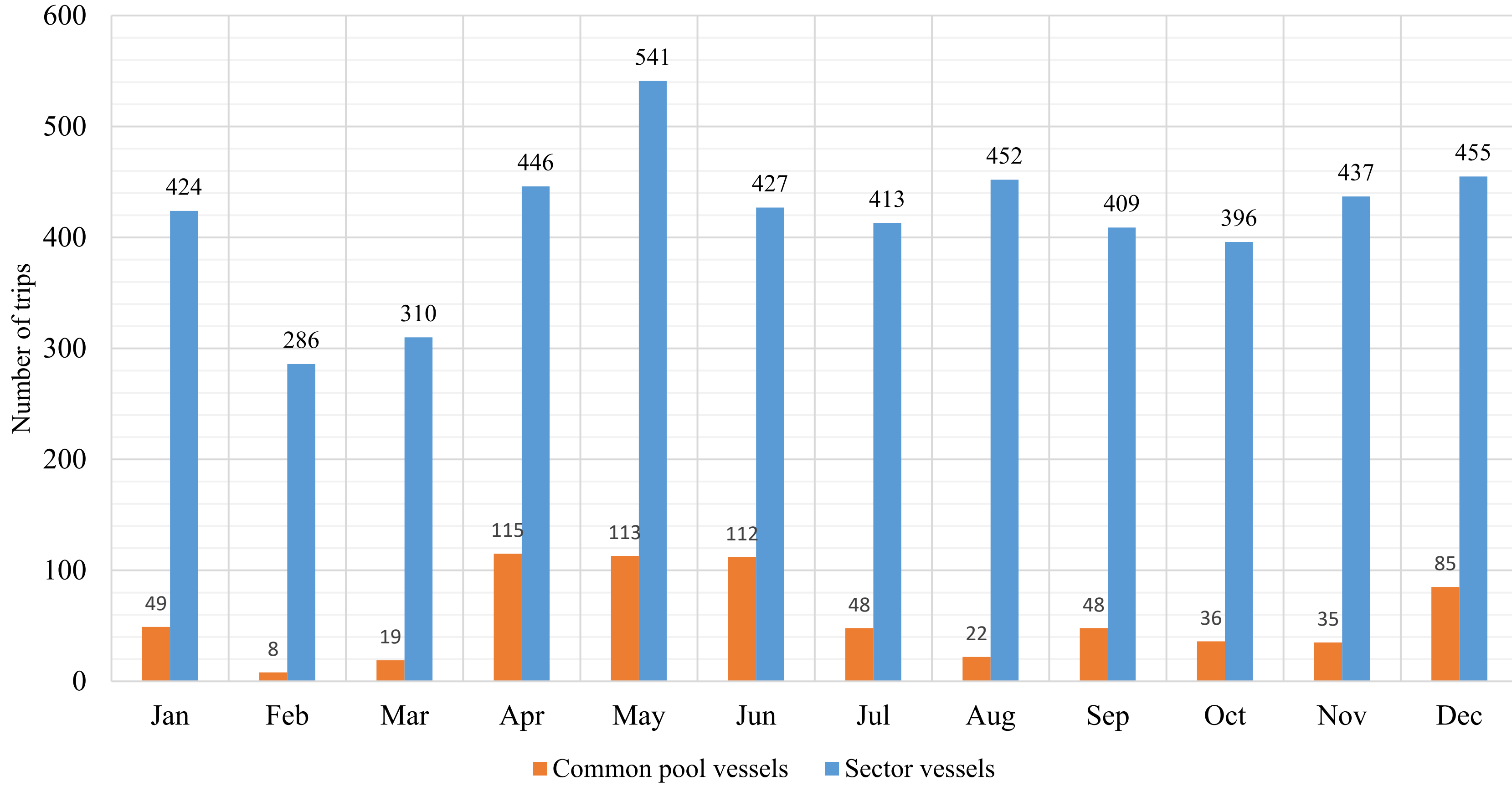

Figure 19. Number of groundfish trips per month in FY2015.

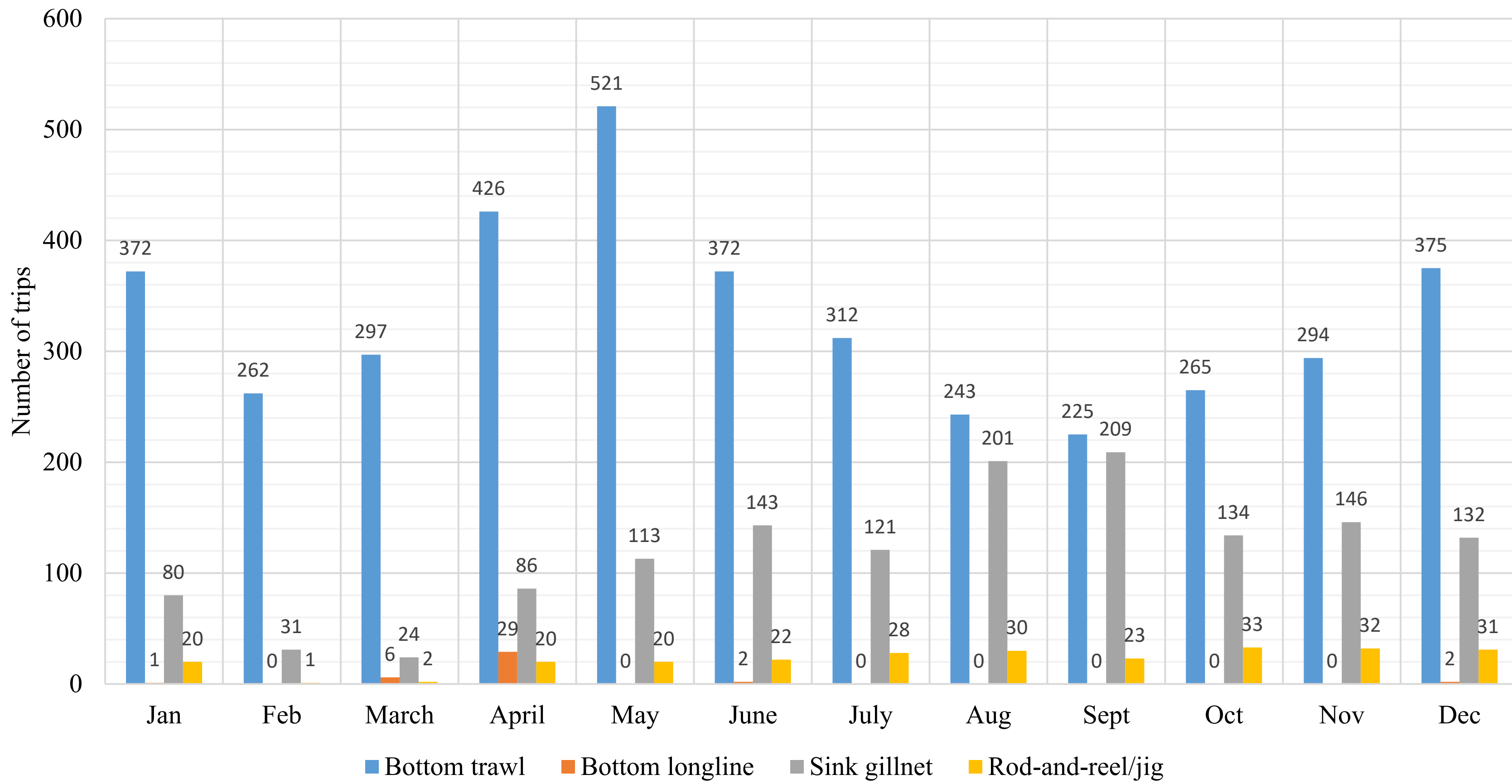

Figure 20. Number of groundfish trips taken with various gear types by month in FY2015.

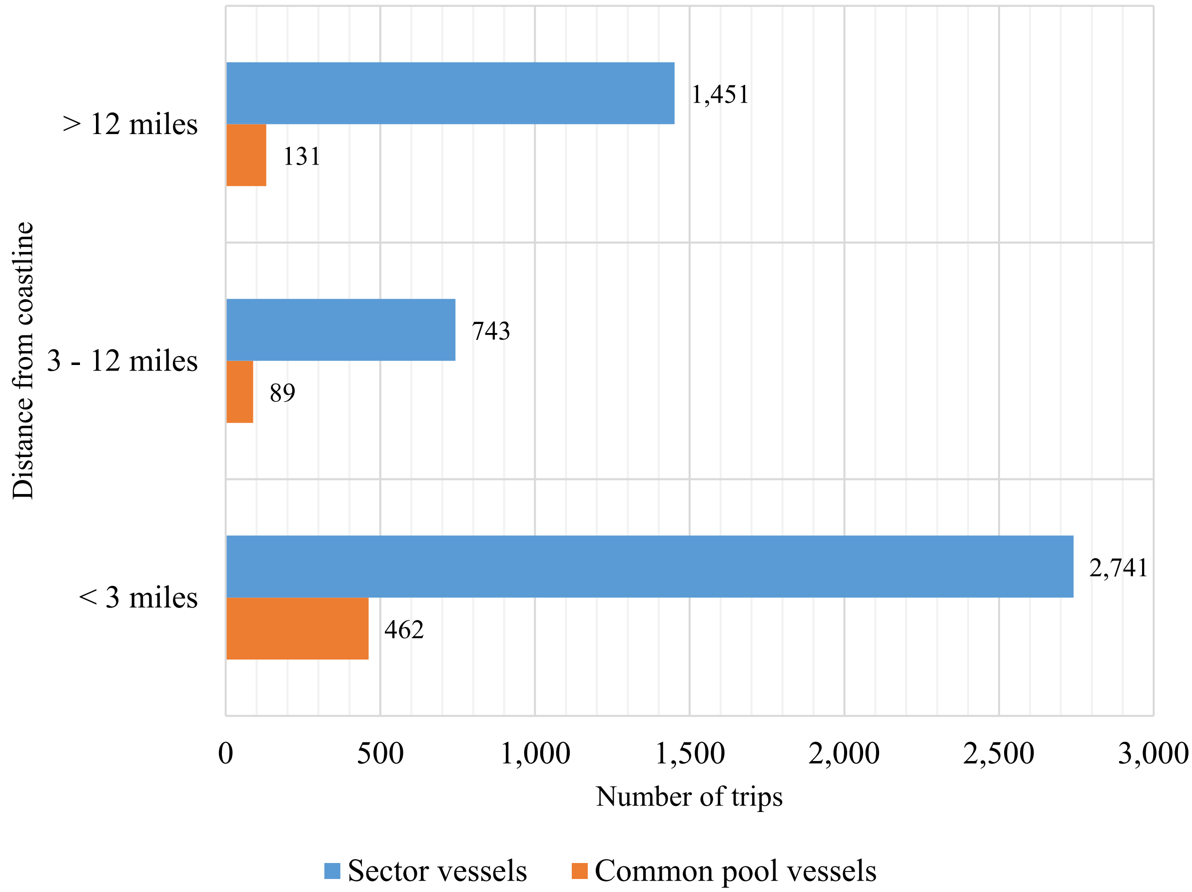

Figure 21. Number of groundfish trips by fishing zone (miles from coastline) in FY2015.

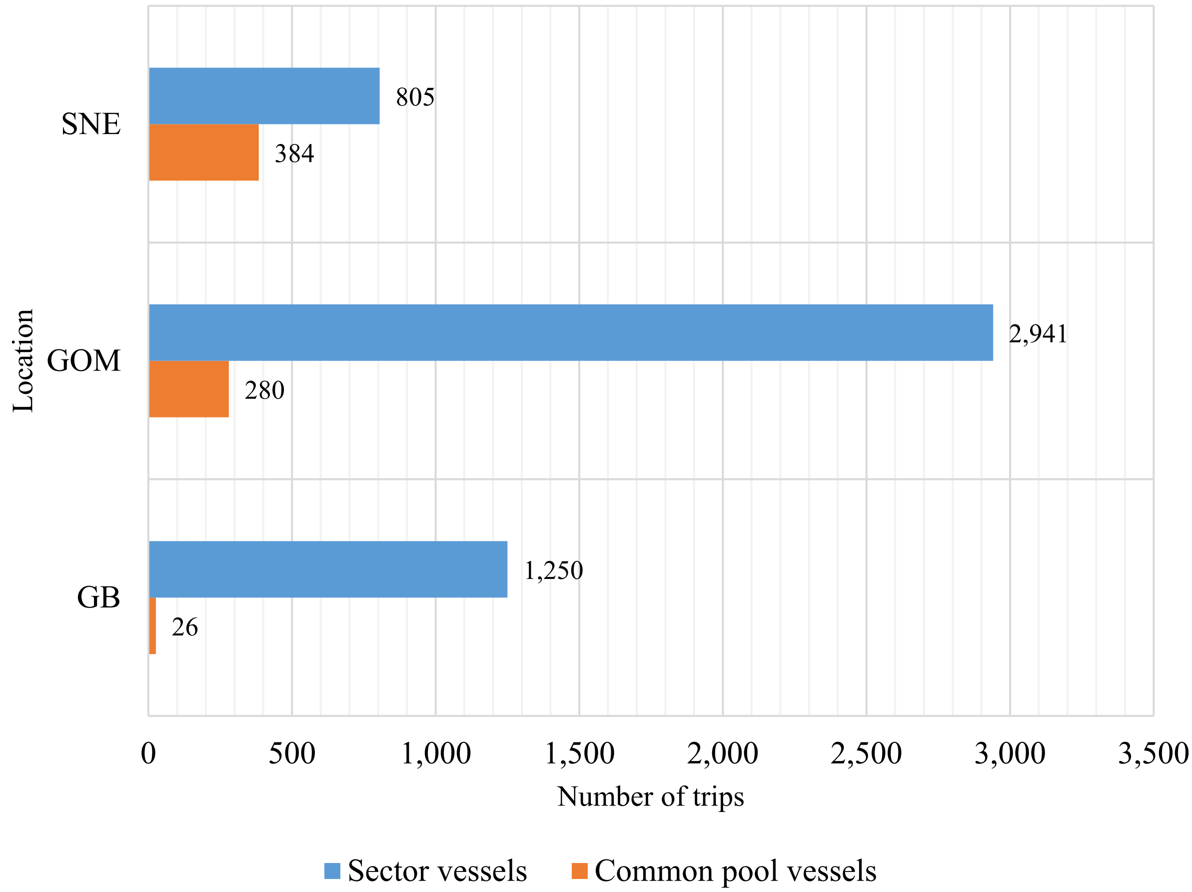

Figure 22. Number of groundfish trips by location in FY2015.

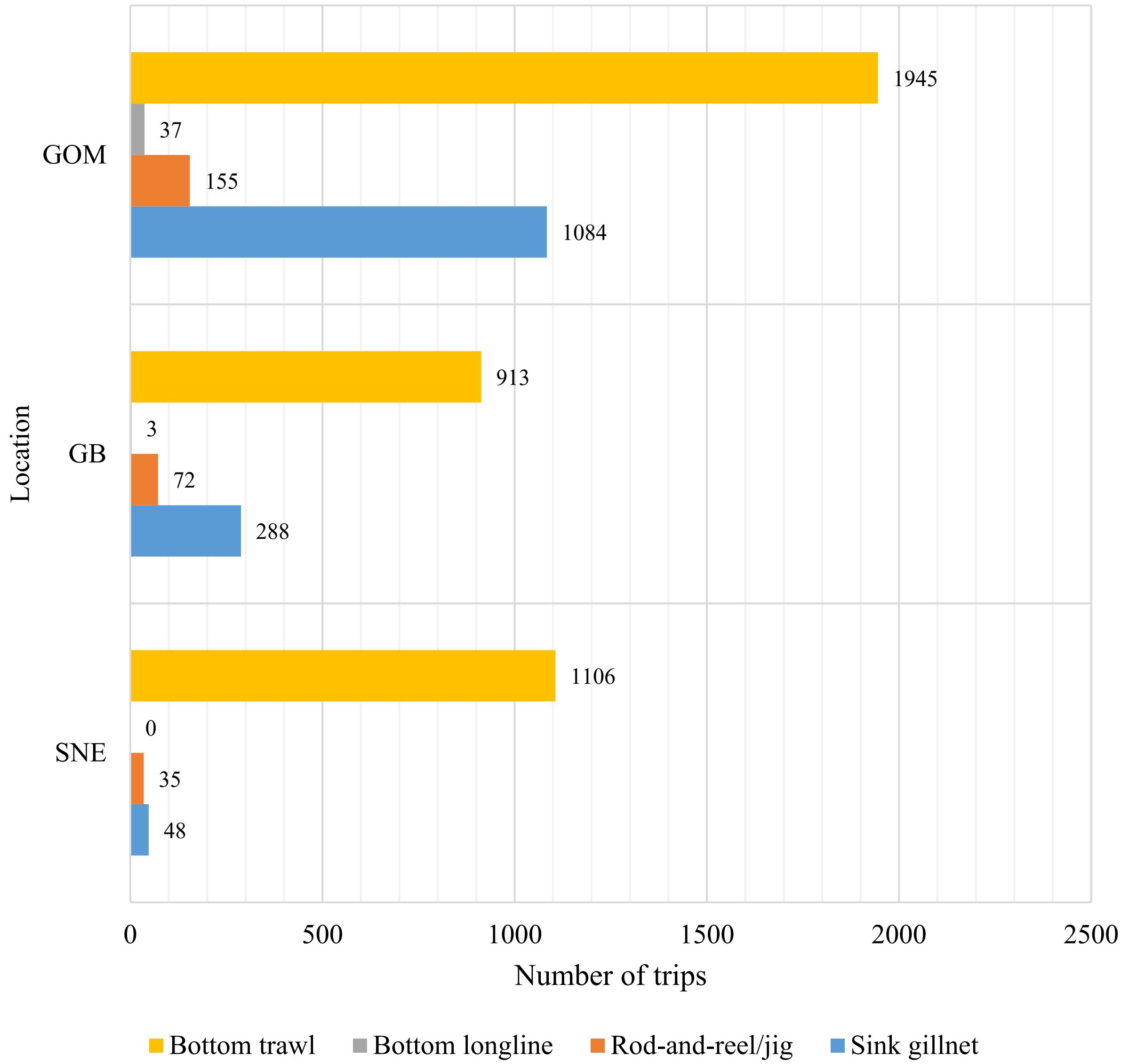

Figure 23. Number of groundfish trips taken with various gear types by location in FY2015.

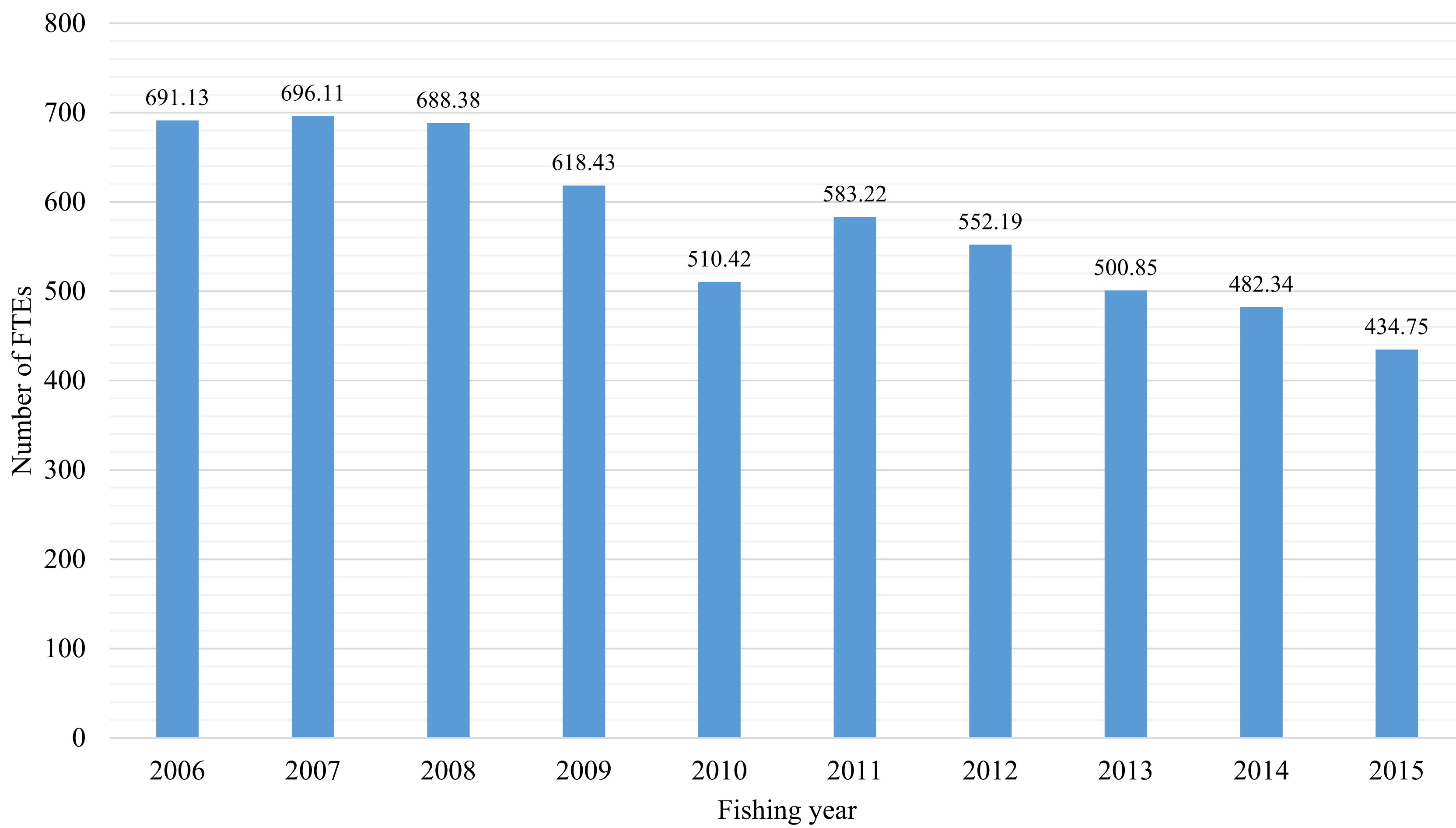

Figure 24. Estimated annual number of full-time equivalent employees (FTEs) in the limited access groundfish fleet from FY2006-FY2015.

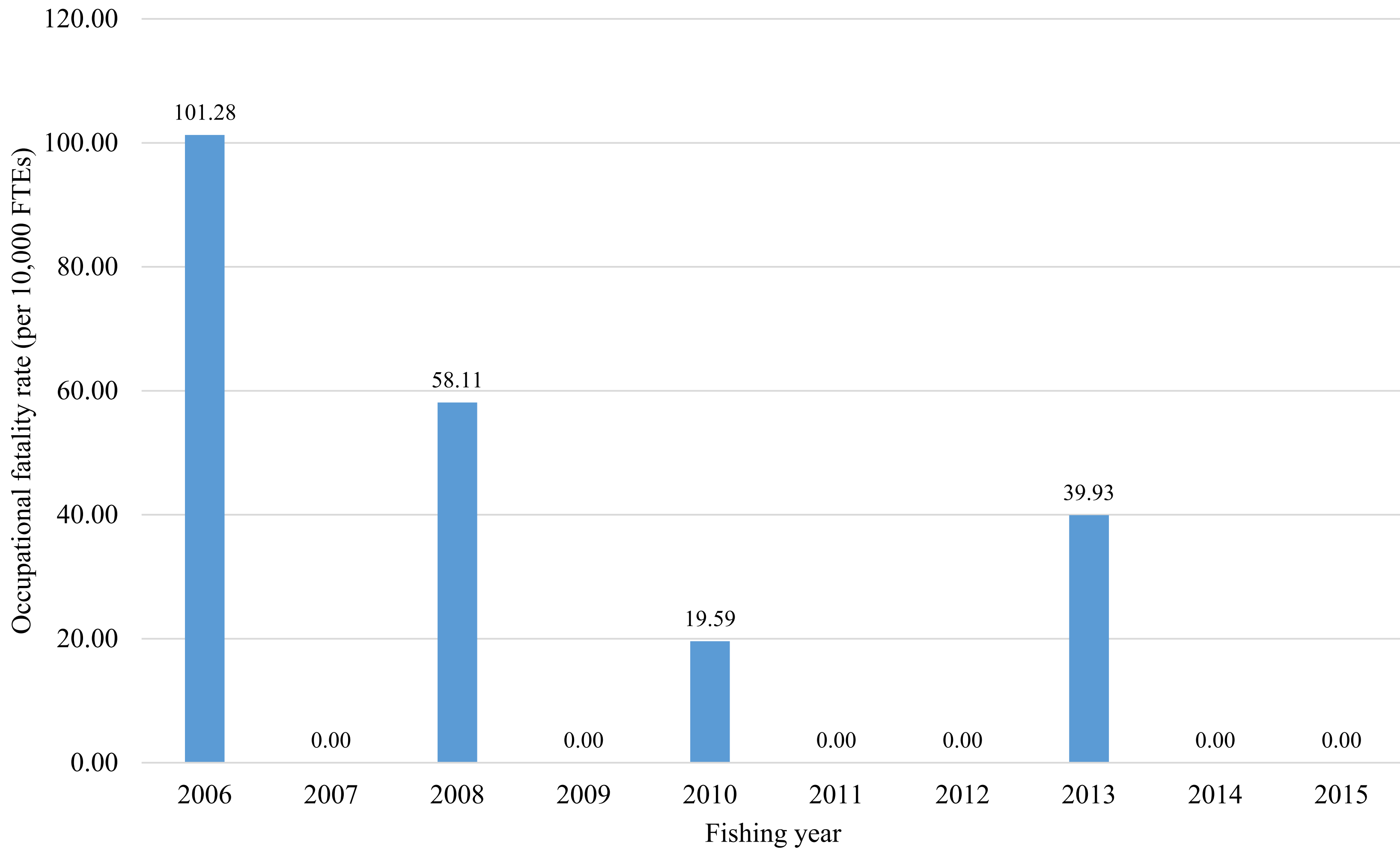

Figure 25. Annual occupational fatality rates (number of fatalities per 10,000 FTEs) in the limited access groundfish fleet from FY2006-FY2015.

APPENDIX A: REQUIREMENTS FOR COMMERCIAL FISHING INDUSTRY VESSELS

The USCG is primarily responsible for implementing and enforcing safety regulations for US commercial fishing industry vessels. Appendix A provides additional details about specific safety-related USCG regulations, with a focus on those regulations that apply to limited access groundfish vessels. Many of the regulations identified in Appendix A specify the type and quantity of safety and lifesaving equipment (such as PFDs, survival craft, and EPIRBs) that is required on various commercial fishing vessels. Other regulations describe requirements for crew training, first aid training, and safety documentation onboard commercial fishing vessels. Some of the requirements described in Appendix A apply broadly to all commercial fishing industry vessels, while others are dependent on vessel size, vessel construction, number of persons onboard, area of operation, timing of operation, or type of documentation.

Throughout this Appendix A, a "documented" vessel refers to a vessel that holds a Certificate of Documentation from the U.S. Coast Guard (46 CFR 67.3). All commercial fishing vessels with a net tonnage ≥ 5 tons must be federally documented with a fishery endorsement (46 CFR 67.7). Commercial fishing vessels that do not meet these tonnage requirements are "undocumented" and may instead be registered with their state's Department of Motor Vehicles (DMV). Regulations that are said to apply to "all" vessels apply to documented and undocumented vessels alike. Additionally, fields marked with "N/A" indicate that certain criteria are not used as determining factors in deciding whether or not a requirement applies to a specific vessel or group of vessels. For example, Table A1 indicates that documented vessels operating seaward of the Boundary Line north of 32°N or south of 32°S must carry one immersion suit for each individual onboard; the "vessel length" field is filled in with "N/A" in that instance. This means that this immersion suit requirement applies to all documented vessels operating in this area regardless of the size of the vessel.

It is important to note that the regulations described throughout Appendix A do not represent an exhaustive list of all the USCG regulations governing US commercial fishing industry vessels. Rather, the regulations contained in Appendix A were chosen for inclusion in this report because they broadly apply to the vessels that fish under Northeast Multispecies limited access permits. For example, in order to pass a USCG commercial fishing vessel safety exam, vessels ≥ 400 gross tons that transit international waters must have a Ship Oil Pollution Emergency Plan (SOPEP) in place. However, since the largest groundfish vessel described in this risk assessment is 199 gross tons, we did not include the SOPEP requirements in any of the Appendix A tables. It is also important to note that the limited access groundfish vessels described in this report may be subject to additional regulations not contained in Appendix A if they engage in other fisheries or other trades in addition to groundfishing. Additionally, while we strived to present the requirements in this Appendix as completely and accurately as possible, it should not be relied on as a comprehensive source of regulatory information. The hyperlinks provided throughout Appendix A will direct readers to copies of the CFR entries that were current at the time that this report was written; as such, most of the regulatory information linked in this Appendix was last updated on October 1, 2018.[23] Anyone wishing to learn more about current or past USCG regulations, or anyone wishing to learn more about whether certain regulations apply to specific vessels, should reference the Federal Register directly through the Code of Federal Regulations website. Additionally, while Appendix A provides general information about the types of equipment that are required on various vessels, it does not provide examples of specific products that are approved by the USCG to meet these requirements. For more information about the types, brands, and models of equipment that are approved for use by the USCG, please see the USCG approved equipment online database.

[23] Revisions to portions of the CFR are staggered throughout each year: titles 1 – 16 are updated as of January 1; titles 17 – 27 are updated as of April 1; titles 28 – 41 are updated as of July 1; and titles 42 – 50 are updated as of October 1. Please visit the Code of Federal Regulations website to see when each title was last revised.

Table A1. Immersion suit and personal flotation device (PFD) requirements for commercial fishing industry vessels (Sources: 46 CFR 28.105; 46 CFR 28.110).

Device	Vessel type	Area of operation	Vessel length (ft.)	Minimum # of devices required	Approved alternatives*	Pertinent regulations
Immersion suit	Documented	Seaward of the boundary line north of 32°N or south of 32°S; Lake Superior	N/A	1 per individual onboard	Exposure suit	46 CFR 28.105; 46 CFR 28.110; 46 CFR 28.135; 46 CFR 28.140; 46 CFR 25.25
Immersion suit	All	Coastal waters north of Point Reyes, CA; beyond coastal waters in cold water; Lake Superior	N/A	1 per individual onboard	Exposure suit	46 CFR 28.105; 46 CFR 28.110; 46 CFR 28.135; 46 CFR 28.140; 46 CFR 25.25
Immersion suit	All	All other waters (including all Great Lakes except Lake Superior)	≥ 40’	1 per individual onboard	Type I PFD; Type V commercial hybrid PFD; exposure suit	46 CFR 28.105; 46 CFR 28.110; 46 CFR 28.135; 46 CFR 28.140; 46 CFR 25.25
Immersion suit	All	All other waters (including all Great Lakes except Lake Superior)	< 40’	1 per individual onboard	Type I PFD; Type II PFD; Type III PFD; Type V commercial hybrid PFD; exposure suit	46 CFR 28.105; 46 CFR 28.110; 46 CFR 28.135; 46 CFR 28.140; 46 CFR 25.25

*Type V PFDs may be substituted for Type I, II, or III PFDs when used in agreement with USCG regulations.

Table A2. Throwable PFD requirements for commercial fishing industry vessels (Sources: 46 CFR 28.115).

Device	Vessel type	Area of operation	Vessel length (ft.)	Minimum # of devices required	Approved substitutes	Pertinent regulations
Orange 24” life ring w/ 60’ of line	All	N/A	16 to < 26	1	Throwable cushion; white 20” life ring*	46 CFR 28.115; 46 CFR 28.135
Orange 24” life ring w/ 60’ line	All	N/A	26 to < 65	1	White 20” life ring*	46 CFR 28.115; 46 CFR 28.135
Orange 24” life ring w/ 60’ line	All	N/A	≥ 65	2	N/A	46 CFR 28.115; 46 CFR 28.135
Orange 24” life ring w/ 90’ line	All	N/A	≥ 65	1**	N/A	46 CFR 28.115; 46 CFR 28.135

*May substitute 1 orange 24” life ring for 1 white 20” life ring if the white life ring was installed prior to September 15, 1991.

**A minimum of 1 out of 3 of the 24” orange life rings required on vessels ≥ 65’ must have 90’ of line attached.

Table A3. Survival craft requirements for commercial fishing industry vessels operating in cold waters (Source: 46 CFR 28.120).

Device	Vessel type	Area of operation	Vessel length (ft.)	Minimum # of devices required*	Approved substitutes	Pertinent regulations
Buoyant apparatus	Documented	Inside Boundary Line; lakes, bays, sounds; or rivers; Great Lakes	< 36	1**	Inflatable buoyant apparatus; life float; inflatable liferaft with coastal service pack, SOLAS B pack, or SOLAS A pack	46 CFR 28.120; 46 CFR 28.125; 46 CFR 28.130; 46 CFR 28.135; 46 CFR 28.140
Inflatable buoyant apparatus	Documented	Beyond Boundary Line, within 12 miles of coastline; Great Lakes	≥ 36	1	Inflatable liferaft with coastal service pack, SOLAS B pack, or SOLAS A pack; buoyant apparatus***	46 CFR 28.120; 46 CFR 28.125; 46 CFR 28.130; 46 CFR 28.135; 46 CFR 28.140
Inflatable liferaft with coastal service pack	Documented	Beyond Boundary Line, between 12 and 20 miles of coastline	N/A	1	Inflatable liferaft with SOLAS B pack or SOLAS A pack	46 CFR 28.120; 46 CFR 28.125; 46 CFR 28.130; 46 CFR 28.135; 46 CFR 28.140
Inflatable liferaft with SOLAS B pack	Documented	Between 20 and 50 miles of coastline	N/A	1	Inflatable liferaft with SOLAS A pack	46 CFR 28.120; 46 CFR 28.125; 46 CFR 28.130; 46 CFR 28.135; 46 CFR 28.140
Inflatable liferaft with SOLAS A pack	Documented	Beyond 50 miles of coastline	N/A	1	N/A	46 CFR 28.120; 46 CFR 28.125; 46 CFR 28.130; 46 CFR 28.135; 46 CFR 28.140

*Aggregate survival craft capacity must adequately accommodate all persons onboard a vessel in the event of an emergency. A lifeboat may be substituted for any survival craft provided that it is properly equipped (see 46 CFR 199 for details).

**Vessels < 36’ in length, with 3 or fewer persons onboard, that operate within 12 miles of the coastline do not need to carry a survival craft. Vessels < 36’ in length that meet the flotation criteria in 33 CFR 183 do not need a survival craft while operating on rivers or within 12 miles of the coastline.

***Vessels ≥ 36’ with 3 or fewer persons onboard which operate within 12 miles of the coastline may substitute a buoyant apparatus for an inflatable buoyant apparatus.

Table A3 (continued). Survival craft requirements for commercial fishing industry vessels operating in cold waters (Source: 46 CFR 28.120).

Device	Vessel type	Area of operation	Vessel length (ft.)	Minimum # of devices required*	Approved substitutes	Pertinent regulations
Inflatable buoyant apparatus	Undocumented with ≤ 16 persons onboard	Beyond 20 miles of coastline	N/A	1	Inflatable liferaft with coastal service pack, SOLAS B pack, or SOLAS A pack	46 CFR 28.120; 46 CFR 28.125; 46 CFR 28.130; 46 CFR 28.135; 46 CFR 28.140
Inflatable buoyant apparatus	Undocumented with ≤ 16 persons onboard	Beyond Boundary Line, between 12 and 20 miles of coastline	N/A	1	Inflatable liferaft with coastal service pack, SOLAS B pack, or SOLAS A pack	46 CFR 28.120; 46 CFR 28.125; 46 CFR 28.130; 46 CFR 28.135; 46 CFR 28.140
Buoyant apparatus	Undocumented with ≤ 16 persons onboard	Beyond Boundary Line, within 12 miles of coastline	≥ 36	1	Inflatable buoyant apparatus; life float; inflatable liferaft with coastal service pack, SOLAS B pack, or SOLAS A pack	46 CFR 28.120; 46 CFR 28.125; 46 CFR 28.130; 46 CFR 28.135; 46 CFR 28.140
Buoyant apparatus	Undocumented with ≤ 16 persons onboard	Beyond Boundary Line, within 12 miles of coastline	< 36	1**	Inflatable buoyant apparatus; life float; inflatable liferaft with coastal service pack, SOLAS B pack, or SOLAS A pack	46 CFR 28.120; 46 CFR 28.125; 46 CFR 28.130; 46 CFR 28.135; 46 CFR 28.140

Device	Vessel type	Area of operation	Vessel length (ft.)	Minimum # of devices required*	Approved substitutes	Pertinent regulations
Buoyant apparatus	Undocumented with ≤ 16 persons onboard	Inside Boundary Line; lakes, bays, sounds; or rivers	≥ 36	1	Inflatable buoyant apparatus; life float; inflatable liferaft with coastal service pack, SOLAS B pack, or SOLAS A pack	46 CFR 28.120; 46 CFR 28.125; 46 CFR 28.130; 46 CFR 28.135; 46 CFR 28.140

*Aggregate survival craft capacity must adequately accommodate all persons onboard a vessel in the event of an emergency. A lifeboat may be substituted for any survival craft provided that it is properly equipped (see 46 CFR 199 for details).

**Vessels < 36' in length, with 3 or fewer persons onboard, that operate within 12 miles of the coastline do not need to carry a survival craft. Vessels < 36' in length that meet the flotation criteria in 33 CFR 183 do not need a survival craft while operating on rivers or within 12 miles of the coastline.

Table A3 (continued). Survival craft requirements for commercial fishing industry vessels operating in cold waters (Source: 46 CFR 28.120).

Device	Vessel type	Area of operation	Vessel length (ft.)	Minimum # of devices required*	Approved substitutes	Pertinent regulations
Buoyant apparatus	Undocumented with ≤ 16 persons onboard	Inside Boundary Line; lakes, bays, sounds; or rivers	< 36'	1**	Inflatable buoyant apparatus; life float; inflatable liferaft with coastal service pack, SOLAS B pack, or SOLAS A pack	46 CFR 28.120; 46 CFR 28.125; 46 CFR 28.130; 46 CFR 28.135; 46 CFR 28.140
Buoyant apparatus	Undocumented with ≤ 16 persons onboard	Great Lakes	N/A	1**	Inflatable buoyant apparatus; life float; inflatable liferaft with coastal service pack, SOLAS B pack, or SOLAS A pack	46 CFR 28.120; 46 CFR 28.125; 46 CFR 28.130; 46 CFR 28.135; 46 CFR 28.140
Inflatable liferaft with SOLAS A pack	Undocumented with > 16 persons onboard	Beyond 50 miles of coastline	N/A	1	N/A	46 CFR 28.120; 46 CFR 28.125; 46 CFR 28.130;

Device	Vessel type	Area of operation	Vessel length (ft.)	Minimum # of devices required*	Approved substitutes	Pertinent regulations
						46 CFR 28.135; 46 CFR 28.140
Inflatable liferaft with SOLAS B pack	Undocumented with > 16 persons onboard	Between 20 and 50 miles of coastline	N/A	1	Inflatable liferaft with SOLAS A pack	46 CFR 28.120; 46 CFR 28.125; 46 CFR 28.130; 46 CFR 28.135; 46 CFR 28.140
Inflatable liferaft with coastal service pack	Undocumented with > 16 persons onboard	Beyond Boundary Line; between 12 and 20 miles of coastline	N/A	1	Inflatable liferaft with SOLAS B pack or SOLAS A pack	46 CFR 28.120; 46 CFR 28.125; 46 CFR 28.130; 46 CFR 28.135; 46 CFR 28.140

*Aggregate survival craft capacity must adequately accommodate all persons onboard a vessel in the event of an emergency. A lifeboat may be substituted for any survival craft provided that it is properly equipped (see 46 CFR 199 for details).

**Vessels < 36' in length, with 3 or fewer persons onboard, that operate within 12 miles of the coastline do not need to carry a survival craft. Vessels < 36' in length that meet the flotation criteria in 33 CFR 183 do not need a survival craft while operating on rivers or within 12 miles of the coastline.

Table A3 (continued). Survival craft requirements for commercial fishing industry vessels operating in cold waters (Source: 46 CFR 28.120).

Device	Vessel type	Area of operation	Vessel length (ft.)	Minimum # of devices required*	Approved substitutes	Pertinent regulations
Inflatable buoyant apparatus	Undocumented with > 16 persons onboard	Beyond Boundary Line; within 12 miles of coastline	≥ 36	1	Inflatable liferaft with coastal service pack, SOLAS B pack, or SOLAS A pack	46 CFR 28.120; 46 CFR 28.125; 46 CFR 28.130; 46 CFR 28.135; 46 CFR 28.140
Buoyant apparatus	Undocumented with > 16 persons onboard	Beyond Boundary Line; within 12 miles of coastline	< 36	1**	Inflatable buoyant apparatus; life float; inflatable liferaft with coastal service pack, SOLAS B pack, or SOLAS A pack	46 CFR 28.120; 46 CFR 28.125; 46 CFR 28.130; 46 CFR 28.135; 46 CFR 28.140
Inflatable buoyant apparatus	Undocumented with > 16 persons onboard	Inside Boundary Line; lakes, bays, sounds, or rivers; Great Lakes	≥ 36	1	Inflatable liferaft with coastal service pack, SOLAS B pack, or SOLAS A pack	46 CFR 28.120; 46 CFR 28.125; 46 CFR 28.130; 46 CFR 28.135; 46 CFR 28.140
Buoyant apparatus	Undocumented with > 16 persons onboard	Inside Boundary Line; lakes, bays, sounds, or rivers; Great Lakes	< 36	1**	Inflatable buoyant apparatus; life float; inflatable liferaft with coastal service pack, SOLAS B pack, or SOLAS A pack	46 CFR 28.120; 46 CFR 28.125; 46 CFR 28.130; 46 CFR 28.135; 46 CFR 28.140

*Aggregate survival craft capacity must adequately accommodate all persons onboard a vessel in the event of an emergency. A lifeboat may be substituted for any survival craft provided that it is properly equipped (see 46 CFR 199 for details).

** Vessels < 36' in length that meet the flotation criteria in 33 CFR 183 do not need a survival craft while operating on rivers or within 12 miles of the coastline.

Table A4. Distress signal requirements for commercial fishing industry vessels (Source: 46 CFR 28.145).

Device	Vessel type	Timing of operation	Area of operation	Vessel length (ft.)	Minimum # of devices required	Approved substitutes	Pertinent regulations
Distress flag	All	Daytime	Ocean coastal waters; within 3 miles of the coastline on Great Lakes	N/A	1	3 flares*; 3 smoke signals	46 CFR 28.145; 46 CFR 160.072
Electric distress light	All	Nighttime	Ocean coastal waters; within 3 miles of the coastline on Great Lakes	N/A	1	3 flares*	46 CFR 28.145; 46 CFR 161.013
Parachute flare	All	N/A	Between 3 and 50 miles from the coastline on the ocean; more than 3 miles of the coastline on Great Lakes	N/A	3	N/A	46 CFR 28.145; 46 CFR 160.036
Hand flare	All	N/A	Between 3 and 50 miles from the coastline on the ocean; more than 3 miles of the coastline on Great Lakes	N/A	6	N/A	46 CFR 28.145; 46 CFR 160.021
Smoke signal	All	N/A	Between 3 and 50 miles from the coastline on the ocean; more than 3 miles of the coastline on Great Lakes	N/A	3	N/A	46 CFR 28.145; 46 CFR 160.022; 46 CFR 160.037
Parachute flare	All	N/A	More than 50 miles of the coastline on the ocean	N/A	3	N/A	46 CFR 28.145
Hand flare	All	N/A	More than 50 miles of the coastline on the ocean	N/A	6	N/A	46 CFR 28.145
Smoke signal	All	N/A	More than 50 miles of the coastline on the ocean	N/A	3	N/A	46 CFR 28.145

*The same 3 flares may be used as the daytime and nighttime signaling devices on a vessel.

Table A5. Emergency Position Indicating Radio Beacon (EPIRB) requirements for commercial fishing industry vessels (Source: 46 CFR 28.150).

Device	Vessel type	Area of operation	Vessel length (ft.)	Minimum # of devices required	Approved substitutes	Pertinent regulations
Category 1 406 MHz EPIRB (automatic; float-free)	All	High seas; more than 3 miles of coastline on Great Lakes	≥ 36	1	N/A	46 CFR 28.150; 46 CFR 25.26
Category 2 406 MHz EPIRB (manual)	All with certified buoyancy*	High seas; more than 3 miles of coastline on Great Lakes	< 36	1	Category 1 406 MHz EPIRB (automatic; float-free)	46 CFR 28.150; 46 CFR 25.26

*Builder's Certificate must indicate that the vessel was built with material buoyant enough to keep the vessel afloat in the event of flooding (46 CFR 25.26-5(b)).

Table A6. Portable fire extinguisher requirements for commercial fishing industry vessels (Source: 46 CFR 28.160).

Fire extinguisher rating	Vessel length (ft.)	Area of operation	Device location	Minimum # of devices required	Approved substitutes	Pertinent regulations
2-A portable	$\geq$ 65	N/A	Safety areas & communication corridors	1 per main corridor, no more than 150' apart	Extinguisher with higher numerical rating or double-letter designation	46 CFR 28.155; 46 CFR 28.160; 46 CFR 25.30
20-B:C portable	$\geq$ 65	N/A	Pilothouse	2 near the exit	Extinguisher with higher numerical rating or double-letter designation	46 CFR 28.155; 46 CFR 28.160; 46 CFR 25.30
40-B:C portable	$\geq$ 65	N/A	Service spaces & galleys	1 per 2,500 ft^2 (or fraction thereof)	Extinguisher with higher numerical rating or double-letter designation	46 CFR 28.155; 46 CFR 28.160; 46 CFR 25.30
40-B portable	$\geq$ 65	N/A	Paint lockers	1 outside of the paint locker, near the exit	Extinguisher with higher numerical rating or double-letter designation	46 CFR 28.155; 46 CFR 28.160; 46 CFR 25.30
2-A portable	$\geq$ 65	N/A	Accessible baggage & storerooms	1 per 2,500 ft^2 (or fraction thereof*) near the exit	Extinguisher with higher numerical rating or double-letter designation	46 CFR 28.155; 46 CFR 28.160; 46 CFR 25.30
2-A portable	$\geq$ 65	N/A	Workshops & similar spaces	1 outside of the space near the exit	Extinguisher with higher numerical rating or double-letter designation	46 CFR 28.155; 46 CFR 28.160; 46 CFR 25.30
40-B:C portable	$\geq$ 65	N/A	Machinery spaces; internal combustion propelling machinery	Minimum of 2; maximum of 6; 1 per 1,000 brake HP or fraction thereof**	Extinguisher with higher numerical rating or double-letter designation	46 CFR 28.155; 46 CFR 28.160; 46 CFR 25.30

* For example, a vessel with 3,000 ft^2 of galley and service space must be equipped with two 40-B:C portable fire extinguishers.

**For example, a vessel with 1,000 brake HP must be equipped with two 40-B:C portable fire extinguishers. A vessel with 2,000 brake HP must also be equipped with two 40-B:C portable fire extinguishers.

Table A6 (continued). Portable fire extinguisher requirements for commercial fishing industry vessels (Source: 46 CFR 28.160).

Fire extinguisher rating	Vessel length (ft.)	Area of operation	Device location	Minimum # of devices required	Approved substitutes	Pertinent regulations
40 –B:C portable	≥ 65	N/A	Electric propulsion motors; open-type generator unit	1 per propulsion motor generator unit	Extinguisher with higher numerical rating or double-letter designation	46 CFR 28.155; 46 CFR 28.160; 46 CFR 25.30
40 –B:C portable	≥ 65	N/A	Auxiliary spaces	1 outside the space near the exit	Extinguisher with higher numerical rating or double-letter designation	46 CFR 28.155; 46 CFR 28.160; 46 CFR 25.30
40 –B:C portable	≥ 65	N/A	Internal combustion machinery	1 outside the space near the exit	Extinguisher with higher numerical rating or double-letter designation	46 CFR 28.155; 46 CFR 28.160; 46 CFR 25.30
40 –B:C portable	≥ 65	N/A	Electric emergency motors & generators	1 outside the space near the exit	Extinguisher with higher numerical rating or double-letter designation	46 CFR 28.155; 46 CFR 28.160; 46 CFR 25.30

Table A7. Additional fire extinguishing requirements for motor vessels (Source: 46 CFR 25.30).

Fire extinguisher rating	Vessel gross tonnage (tons)	Area of operation	Device location	Minimum # of devices required	Approved substitutes	Pertinent regulations
20-B portable	≤ 50	N/A	N/A	1	Extinguisher with higher numerical rating or double-letter designation	46 CFR 28.155; 46 CFR 28.160; 46 CFR 25.30
20-B portable	50-100	N/A	N/A	2	Extinguisher with higher numerical rating or double-letter designation	46 CFR 28.155; 46 CFR 28.160; 46 CFR 25.30
20-B portable	100-500	N/A	N/A	3	Extinguisher with higher numerical rating or double-letter designation	46 CFR 28.155; 46 CFR 28.160; 46 CFR 25.30
20-B portable	500-1,000	N/A	N/A	6	Extinguisher with higher numerical rating or double-letter designation	46 CFR 28.155; 46 CFR 28.160; 46 CFR 25.30
20-B portable	1,000	N/A	N/A	8	Extinguisher with higher numerical rating or double-letter designation	46 CFR 28.155; 46 CFR 28.160; 46 CFR 25.30
20-B portable	N/A	N/A	Machinery space	1 per 1,000 brake HP of the main engines (or fraction thereof); maximum of 6*	Extinguisher with higher numerical rating or double-letter designation	46 CFR 28.155; 46 CFR 28.160; 46 CFR 25.30
160-B semi-portable	> 300	N/A	Machinery space; frame must be welded to bulkhead or deck	1	Fixed fire extinguishing system; extinguisher with higher numerical rating or double-letter designation	46 CFR 28.155; 46 CFR 28.160; 46 CFR 25.30

* For example, a vessel with 1,000 brake HP must be equipped with one 20-B portable fire extinguishers. A vessel with 7,000 brake HP must be equipped with six 20-B portable fire extinguishers.

Table A8. Fireman's outfit and self-contained breathing apparatus (SCBA) requirements for commercial fishing industry vessels (Source: 46 CFR 28.205).

Device	Vessel type	Operating criteria	Vessel length (feet)	Minimum # of devices required	Approved substitutes	Pertinent regulations
Fireman's suit*	Documented	Operating beyond the Boundary Lines *OR* operating with > 49 persons onboard	N/A	2	N/A	46 CFR 28.205
Spare air bottle	Documented	Operating beyond the Boundary Lines *OR* operating with > 49 persons onboard	N/A	2**	N/A	46 CFR 28.205
SCBA with full facepiece	All	Operating with ammonia-based refrigerant onboard	N/A	2	N/A	46 CFR 28.205
Spare air bottle	All	Operating with ammonia-based refrigerant onboard	N/A	2**	N/A	46 CFR 28.205

*Each fireman's suit must consist of: one SCBA with attached lifeline, full facepiece, and extra air bottle; one flashlight; one rigid helmet; one pair of boots; one pair of gloves; one set of protective clothing; and one fire axe.

**Need one spare air bottle with 30-minute air supply for each SCBA onboard the vessel.

Table A9. First aid equipment requirements for commercial fishing industry vessels (Source: 46 CFR 28.210).

Device	Vessel type	Operating criteria	Minimum # of devices required*	Pertinent regulations
First aid manual	Documented	Operating beyond the Boundary Lines *OR* operating with > 16 persons onboard	1	46 CFR 28.210
Medicine chest	Documented	Operating beyond the Boundary Lines *OR* operating with > 16 persons onboard	1	46 CFR 28.210

*Each medicine chest must be adequately sized and stocked according to the number of persons onboard a vessel.

Table A10. First aid training requirements for commercial fishing industry vessels (Source: 46 CFR 28.210).

Certification*	Vessel type	Operating criteria	# persons onboard (individuals)	Minimum # of certified (individuals)**	Pertinent regulations
First aid certification	Documented	Operating beyond the Boundary Lines	> 2	1	46 CFR 28.210
First aid certification	Documented	Operating beyond the Boundary Lines	> 16	2	46 CFR 28.210
First aid certification	Documented	Operating beyond the Boundary Lines	> 49	4	46 CFR 28.210
CPR certification	Documented	Operating beyond the Boundary Lines	> 2	1	46 CFR 28.210
CPR certification	Documented	Operating beyond the Boundary Lines	> 16	2	46 CFR 28.210
CPR certification	Documented	Operating beyond the Boundary Lines	> 49	4	46 CFR 28.210)

*Approved first aid certifications include: an American Red Cross "Standard First Aid and Emergency Care" course; an American Red Cross "Multi-media Standard First Aid" course; or d another USCG-approved course. Approved CPR certifications include: an American National Red Cross training course; an American Heart Association training course; or another USCG-approved course.

**The same individual may hold a first aid certification and a CPR certification. For example, a documented vessel operating beyond the Boundary Lines with > 2 persons onboard must have (1) one individual onboard who is certified in first aid and one individual onboard who is certified in CPR, or (2) 1 individual onboard who is certified in both first aid and CPR.

Table A11. Navigational requirements for commercial fishing industry vessels (Source: 46 CFR 28.225; 46 CFR 28.230).

Navigational item	Produced by	Vessel Type	Operating criteria	Vessel size (feet)	Area covered	Pertinent regulations
Marine charts	National Ocean Service; National Geospatial-Intelligence Agency; U.S. Army Corps of Engineers; or river authority	Documented	Operating beyond the Boundary Lines *OR* operating with > 16 persons onboard	N/A	Areas being transited	46 CFR 28.225
U.S. Coast Pilot publication	NOAA	Documented	Operating beyond the Boundary Lines *OR* operating with > 16 persons onboard	N/A	Areas being transited	46 CFR 28.225
Coast Guard Light List	USCG	Documented	Operating beyond the Boundary Lines *OR* operating with > 16 persons onboard	N/A	Areas being transited	46 CFR 28.225
Tide tables	National Ocean Service	Documented	Operating beyond the Boundary Lines *OR* operating with > 16 persons onboard	N/A	Areas being transited	46 CFR 28.225
Tidal current tables	National Ocean Service	Documented	Operating beyond the Boundary Lines *OR* operating with > 16 persons onboard	N/A	Areas being transited	46 CFR 28.225
River current tables	U.S. Army Corps of Engineers; or river authority	Documented	Operating beyond the Boundary Lines *OR* operating with > 16 persons onboard	N/A	Areas being transited	46 CFR 28.225
Inland Navigation Rules	USCG	Documented	Operating shoreward of the COLREG Demarcation Lines*	≥ 39.4	N/A	46 CFR 28.225; 33 CFR 83
Magnetic steering compass	N/A	Documented	Operating beyond the Boundary Lines *OR* operating with > 16 persons onboard	N/A	N/A	46 CFR 28.230
Compass deviation table	N/A	Documented	Operating beyond the Boundary Lines *OR* operating with > 16 persons onboard	N/A	N/A	46 CFR 28.230

*For more details about COLREGS, see 33 C.F.R 80.

Table A12. Emergency alarm requirements for commercial fishing industry vessels (Source: 46 CFR 28.240; 46 CFR 28.250).

Alarm type	Vessel Type	Operating criteria	Vessel size (feet)	Alarm location	Alarm characteristics	Pertinent regulations
General alarm*	Documented with accommodation or work space not adjacent to operating station	Operating beyond the Boundary Lines *OR* operating with > 16 persons onboard	N/A	Contact-maker at operating station	Capable of notifying an individual in any accommodation space or work space where they may normally be located. Flashing red lights must be installed in work spaces with enough background noise to make an audible alarm difficult to hear. Each bell and flashing light must be labeled with half-inch red lettering	46 CFR 28.240
High water alarm	Documented	Operating beyond the Boundary Lines *OR* operating with > 16 persons onboard	≥ 36	Visible and audible alarm at operating station	Must indicate high water levels in the following types of spaces: • Spaces with through-hull fittings below the deepest load waterline; • Machinery space bilges, bilge wells, shaft alley bilges, or other spaces prone to flooding by sea water being piped through; • Spaces with non-watertight closures	46 CFR 28.250

*A public address system or other means of alert may be used in place of a general alarm system as long as it complies with the criteria specified in 46 CFR 28.240(b)(c)(e) and can be activated from the operating station.

Table A13. Communications requirements for commercial fishing industry vessels (Source: 46 CFR 28.245).

Equipment*	Vessel type	Operating criteria	Vessel size (feet)	Approved substitutes*	Pertinent regulations
156-162 MHz band VHF radiotelephone	Documented	Operating beyond the Boundary Lines *OR* operating with > 16 persons onboard	N/A	N/A	46 CFR 28.245; 46 CFR 28.375
156-162 MHz band VHF radiotelephone	Documented	Operating more than 20 miles from the coastline	N/A	N/A	46 CFR 28.245; 46 CFR 28.375
2-4 MHz band radiotelephone transceiver	Documented	Operating more than 20 miles from the coastline	N/A	Satellite communications equipment; cellular telephone	46 CFR 28.245; 46 CFR 28.375
156-162 MHz band VHF radiotelephone	Documented	Operating more than 100 miles from the coastline	N/A	N/A	46 CFR 28.245; 46 CFR 28.375
2-27.5 MHz band radiotelephone transceiver	Documented	Operating more than 100 miles from the coastline	N/A	Satellite communications equipment; cellular telephone; 4-20 MHz band radiotelephone transceiver installed before September 15, 1991	46 CFR 28.245; 46 CFR 28.375
156-162 MHz band VHF radiotelephone	Documented	Operating in waters contiguous to Alaska	N/A	N/A	46 CFR 28.245; 46 CFR 28.375
2-27.5 MHz band radiotelephone transceiver	Documented	Operating in waters contiguous to Alaska	N/A	Satellite communications equipment; cellular telephone; 4-20 MHz band radiotelephone transceiver installed before September 15, 1991	46 CFR 28.245; 46 CFR 28.375
FCC Ship Radio Station License	Documented	Using radio equipment to meet communications requirements	N/A	N/A	46 CFR 28.245; 47 CFR 80

*Any equipment used to meet the communications requirements contained in 48 CFR 28.245 must be capable of communicating with a public coast station or a USCG station in the area in which the vessel is operating. Any VHF radios with digital selective calling (DSC) capabilities must ensure that the Maritime Mobile Service Identity (MMSI) is properly programmed.

Table A14. Bilge and dewatering requirements for commercial fishing industry vessels (Source: 46 CFR 28.255).

Equipment	Vessel type	Operating criteria	Vessel size (feet)	Equipment capabilities	Pertinent regulations
Bilge pump*	Documented	Operating beyond the Boundary Lines *OR* operating with > 16 persons onboard	N/A	Capable of draining watertight compartments (except tanks and small buoyancy compartments) under all service conditions	46 CFR 28.255; 33 CFR 151; 33 CFR 155
Bilge piping**, ***	Documented	Operating beyond the Boundary Lines *OR* operating with > 16 persons onboard	N/A	Capable of draining watertight compartments (except tanks and small buoyancy compartments) under all service conditions. Large spaces need multiple suction lines.	46 CFR 28.255; 33 CFR 151; 33 CFR 155
Dewatering system***	Documented	Operating beyond the Boundary Lines *OR* operating with > 16 persons onboard	N/A	Capable of dewatering the space used to sort and process fish at the same rate as water is introduced under normal conditions. Must be connected to the pump(s) used for supplying water to the space.	46 CFR 28.255; 33 CFR 151; 33 CFR 155
Fixed bilge pump connected to bilge manifold	Documented	Operating beyond the Boundary Lines *OR* operating with > 16 persons onboard	≥ 79	Must be self-priming and powered	46 CFR 28.255; 33 CFR 151; 33 CFR 155

*If the bilge pump used to meet these requirements is portable, it must be connected to (1) a suction hose long enough to reach the bilges of each compartment it serves, and (2) a discharge hose long enough to ensure overboard discharge. A portable pump must be able to dewater each compartment it serves at a rate ≥ 2 inches of water depth per minute.

**Each individual suction line must lead to a manifold with a stop valve at the manifold unless (1) a single pump is used for a separate space or (2) unless a portable pump is used. Each suction line must also have a check valve somewhere along the line to prevent unintended flooding.

***Each bilge suction line and dewatering system suction line must be fitted with a strainer capable of preventing clogging of the line.

Table A15. Additional equipment requirements for commercial fishing industry vessels (Source: 46 CFR 28.260; 46 CFR 28.235; 46 CFR 28.215).

Required equipment	Vessel type	Operating criteria	Vessel size (feet)	Minimum # of devices	Device or equipment details	Pertinent regulations
Electronic position fixing device	Documented	Operating beyond the Boundary Lines *OR* operating with > 16 persons onboard	≥ 79	1	Must be capable of providing accurate position fixes for the vessel's area of operation (e.g. GPS, SATNAV, etc.)	46 CFR 28.260
Anchor	Documented	Operating beyond the Boundary Lines *OR* operating with > 16 persons onboard	N/A	1	Must be attached to a chain, cable, or rope appropriate for the vessel and the waters in which it operates.	46 CFR 28.235
Radar reflector	Documented with non-metallic hull	Operating beyond the Boundary Lines *OR* operating with > 16 persons onboard	N/A	1	Vessels rigged with gear that provides a radar signature from a distance of 6 miles do not require radar reflectors.	46 CFR 28.235
Guards for exposed hazards	Documented	Operating beyond the Boundary Lines *OR* operating with > 16 persons onboard	N/A	Based on # hazards onboard vessel	Machinery that may cause injury to personnel must have hand covers, guards, or railings installed that help protect personnel without restricting access to fishing equipment. Exhaust pipes from internal combustion engines that may injury to personnel must be insulated or guarded against burns.	46 CFR 28.215

Table A16. Injury placard and emergency instruction requirements for commercial fishing industry vessels (Source: 46 CFR 28.165; 46 CFR 28.265)/

Informational material	Vessel type	Operating criteria	Vessel size (feet)	Minimum # required	Location of information	Information presented	Pertinent regulations
Injury placard (5 x 7 inches)	All	N/A	N/A	1	Highly visible location; accessible to crew	Injury placard must instruct all persons onboard to report all injuries, disabilities, or illnesses suffered onboard the vessel within 7 days after the date that the injury, disability, or illness arose (as required by public law)*	46 CFR 28.165
Posted emergency instructions	Documented	Operating beyond the Boundary Lines *OR* operating with > 16 persons onboard	N/A	1	Conspicuous location; accessible to crew**	Emergency instructions must identify the following information (tailored to the specific vessel): • Survival craft embarkation stations and survival craft assignments for all persons onboard • Fire and emergency signal • Abandon ship signal • Location of immersion suits and illustrated instructions for donning (if required on the vessel) • Procedures for making distress calls • Actions that must be taken by each individual during an emergency • Procedures for rough weather at sea, crossing hazardous bars, flooding, and anchoring*** • Procedures for when an individual falls overboard*** • Firefighting procedures***	46 CFR 28.265

*For details about the specific language required on the injury placard, please see 46 CFR 28.165.
**Vessels operating with < 4 persons onboard may keep emergency instructions readily available rather than being posted.
***Instructions on these specific scenarios may be kept readily available rather than being posted.

Table A17. Instruction, drill, and training requirements for commercial fishing industry vessels[24] (Source: 46 CFR 28.270; 46 CFR 28.275).

Training type	Vessel type	Operating criteria	Frequency	Participants	Information presented	Pertinent regulations
Safety orientation	Documented	Operating beyond the Boundary Lines *OR* operating with > 16 persons onboard	Once per individual onboard	Any persons who have not received instruction or participated in a drill	Must cover the emergency instructions required under 46 CFR 28.265 (see Table A16) and the safety instructions required under 46 CFR 28.270 (see below)	46 CFR 28.270; 46 CFR 28.275
Safety instruction	Documented	Operating beyond the Boundary Lines *OR* operating with > 16 persons onboard	Once per month	All persons onboard	Explain the following procedures? • Abandoning the vessel; • Fighting fires on the vessel; • Recovering men overboard; • Mitigating effects of unintentional flooding; • Launching survival craft and recovering lifeboats/rescue boats; • Donning immersion suits and other wearable PFDs; • Donning a fireman's outfit and SCBA (if required on the vessel); • Using distress signals and making distress calls; • Activating the general alarm; • Reporting inoperative alarms and fire detection systems	46 CFR 28.270; 46 CFR 28.275
Safety drills	Documented	Operating beyond the Boundary Lines *OR* operating with > 16 persons onboard	Once per month	All persons onboard	Execute the procedures above as if in a real emergency. This includes breaking out and using equipment, testing alarm and detection systems, donning protective clothing, and donning immersion suits (if required)	46 CFR 28.270; 46 CFR 28.275

[24] The individual conducting drills and instructions must be trained in the proper procedures for conducting training activities (see 46 CFR 28.275 for details about approved instructors and courses). The do not need to be a master, individual in charge, or member of the crew on the vessel.

REFERENCES CITED

Allen P, Wellens B, Smith A. 2010. Fatigue in British fishermen. Int Marit Health. 62(3):154-158.

At-sea sea sampler/observer coverage, 50 CFR Sect. 648.11 (1996).

Bergland H and Pedersen PA. 1997. Catch regulation and accident risk: The moral hazard if fisheries' management. Mar Resour Econ. 12(4): 281-292.

Brinson AA and Thunberg EM. 2016. Performance of federally managed catch share fisheries in the United States. Fish Res. 179:213-223.

Byard R. 2013. Commercial fishing industry deaths - Forensic issues. J Forensic Leg Med. 20(3): 129-132.

Chatterton M and Cook JC. 2008. The effects of icing on commercial fishing vessels [interactive qualifying project report]. [Washington (DC)]: Worcester Polytechnic Institute. Project No. 47-CXP-0805. Available from: https://digitalcommons.wpi.edu/cgi/viewcontent.cgi?article=1512&context=iqp-all.

Coast Guard Authorization Act of 2010, Pub. L. No. 111-281, 124 Stat. 2905 (Oct. 15, 2010).

Coast Guard and Maritime Transportation Act of 2012. Pub. L. No. 112-213, 126 Stat. 1540 (Dec. 20, 2012).

Cold Stress - Cold Water Immersion. The National Institute for Occupational Safety and health (NIOSH). [December 13, 2022]. https://www.cdc.gov/niosh/topics/coldstress/coldwaterimmersion.html

"Commercial Fishing Safety: National Overview." The National Institute for Occupational Safety and Health (NIOSH). [accessed 2017]. https://www.cdc.gov/niosh/topics/fishing/nationaloverview.html.

Davis ME. 2011. Occupational safety and regulatory compliance in US commercial fishing. Arch Environ Occup Health. 66(4):209-216.

Davis ME. 2012. Perceptions of occupational risk by US commercial fishermen. Mar Pol. 36(1):28-33.

Definitions, 46 CFR Sect. 67.3 (1993).

Definitions, 50 CFR Sect. 648.2 (1996).

Dickey DH. 2008. Analysis of fishing vessel casualties: A review of lost fishing vessels and crew fatalities, 1992-2007. Washington (DC): United States Coast Guard Compliance Analysis Division (CG-5452). Available from: http://www.fishsafe.info/FVStudy_92_10.pdf.

Dyer MG. 2000. Hazard and risk in the New England fishing fleet. Mar Technol SNAME N. 37(1):30-49.

Fisheries of the Northeastern United States; Northeast Multispecies Fishery; Emergency Secretarial Action. 2006. Fed Regist. 71(71):19347-19390.

Fisheries of the Northeastern United States; Northeast (NE) Multispecies Fishery; Framework Adjustment 40B. 2005. Fed Regist. 70(104):31323-31342.

Fisheries of the Northeastern United States; Northeast Multispecies Fishery; Gear Restriction for the U.S./Canada Management Area. 2009. Fed Regist. 74(222):59917-59918.

Gauvin JR, Ward JM, Burgess EE. 1994. Description and evaluation of the wreckfish (*Polyprion americanus*) fishery under individual transferable quotas. Marine Resource Economics. 9(2):99-118.

Grimm D, Barkhorn I, Festa D, Bonzon K, Boomhower J, Hovland V, Blau J. 2012. Assessing catch shares' effects evidence from federal United States and associated British Columbian fisheries. Mar Pol. 36(3):644-657.

Heizer S. 2000. The commercial geoduck (*Panopea abrupta*) fishery in British Columbia, Canada – an operational perspective of a limited entry fishery with individual quotas. J Shellfish Res. 19:621.

Henry A, Olson J. 2014. An overview of the survey on the socio-economic aspects of commercial fishing crew in the Northeast. Woods Hole (MA): National Marine Fisheries Service. Tech Memo NMFS-NE-230. Available from: https://repository.library.noaa.gov/view/noaa/4862.

Holland DS, Pinto da Silva P, Wiersma J. 2010. A survey of social capital and attitudes toward management in the New England groundfish fishery. US Dept Commer, Northeast Fish Sci Cent Ref Doc. 10-12; 13 p. Available from: National Marine Fisheries Service, 166 Water Street, Woods Hole, MA 02543-1026; or online at https://repository.library.noaa.gov/view/noaa/3740.

Howard P. 2010. Presentation to the National Transportation Safety Board's Fishing Vessel Safety Forum.

Hughes SE and Woodley C. 2007. Transition from open access to quota based fishery management regimes in Alaska increased the safety of operations. Int Marit Health. 58(1-4):33-45.

Instruction, drills, and safety orientation, 46 CFR Sect. 28.270 (1991).

Jensen OCC, Petursdottir G, Holmen IM, Abrahamsen A, Lincoln J. 2014. A review of fatal accident incidence rate trends in fishing. Int Marit Health. 65(2):47-52.

Jin D. 2014. The determinants of fishing vessel accident severity. Accid Anal Prev. 66:1-7.

Jin D, Kite-Powell HL, Talley WK. 2001. The safety of commercial fishing: Determinants of vessel total losses and injuries. J Safety Res. 32(2):209-228.

Jin D, Kite-Powell HL, Thunberg E, Solow AR, Talley WK. 2002. A model of fishing vessel accident probability. J Safety Res. 33(4):497-510.

Jin D and Thunberg E. 2005. An analysis of fishing vessel accidents in fishing areas off the northeastern United States. Saf Sci. 43(8):523-540.

Kaplan IM and Kite-Powell HL. 2000. Safety at sea and fisheries management: Fishermen's attitudes and the need for co-management. Mar Pol. 24(6):493-497.

Lambert DM, Thunberg EM, Felthoven RG, Lincoln JM, Patrick WS. 2015. Guidance on fishing vessel risk assessments and accounting for safety at sea in fishery management design. Woods Hole (MA): National Marine Fisheries Service. Tech Memo NMFS-OSF-2. DOI: 10.7289/V58P5XJQ.

Lincoln JM and Lucas DL. 2010. Occupational fatalities in the United States commercial fishing industry, 2000-2009. J Agromedicine. 15(4):343-350.

Magnuson-Stevens Act Provisions; Fisheries of the Northeastern United States; Northeast Multispecies Fishery; 2011 Sector Operations Plan and Contracts, and Allocation of Northeast Multispecies Annual Catch Entitlements. 2001. Fed Regist. 76(79):23076-23108.

Magnuson-Stevens Act Provisions; Fisheries of the Northeastern United States; Northeast Multispecies Fishery; Final Rule to Allow Northeast Multispecies Sector Vessels Access to Year-Round Closed Areas. 2013c. Fed Regist. 78(241):76077-76091.

Magnuson-Stevens Fishery Conservation and Management Act Provisions; Fisheries of the Northeastern United States. 2014a. Fed Regist. 79(171):52578-52583.

Magnuson-Stevens Fishery Conservation and Management Act Provisions; Fisheries of the Northeastern United States; Northeast Multispecies Fishery; 2007 Georges Bank Cod Fixed Gear Sector Operations Plan and Agreement and Allocation of Georges Bank Cod Total Allowable Catch. 2007. Fed Regist. 72(90):26563-26566.

Magnuson-Stevens Fishery Conservation and Management Act Provisions; Fisheries of the Northeastern United States; Northeast Groundfish Fishery; Fishing Year 2014; Emergency Gulf of Maine Cod Management Measures. 2014b. Fed Regist. 79(219):67362-67376.

Magnuson-Stevens Fishery Conservation and Management Act Provisions; Fisheries of the Northeastern United States; Northeast (NE) Multispecies Fishery; Allocation of Trips to

Closed Area (CA) II Yellowtail Flounder Special Access Program (SAP). 2006a. Fed Regist. 71(98):29256-29257.

Magnuson-Stevens Fishery Conservation and Management Act Provisions; Fisheries of the Northeastern United States; Northeast (NE) Multispecies Fishery; Amendment 13. 2004. Fed Regist. 69(81):22905-22988.

Magnuson-Stevens Fishery Conservation and Management Act Provisions; Fisheries of the Northeastern United States; Northeast (NE) Multispecies Fishery; Amendment 16. 2010. Fed Regist. 75(68):18261-18353.

Magnuson-Stevens Fishery Conservation and Management Act (Magnuson-Stevens Act) Provisions; Fisheries of the Northeastern United States; Northeast Multispecies Fishery, Framework Adjustment 42; Monkfish Fishery, Framework Adjustment 3. 2006b. Fed Regist. 71(204):62155-62196.

Magnuson-Stevens Fishery Conservation and Management Act Provisions; Fisheries of the Northeastern United States; Northeast (NE) Multispecies Fishery; Framework Adjustment 45. 2011. Fed Regist. 76(79):23042-23076.

Magnuson-Stevens Fishery Conservation and Management Act Provisions; Fisheries of the Northeastern United States; Northeast Multispecies Fishery; Framework Adjustment 47. 2012. Fed Regist. 77(85):26104-26128.

Magnuson-Stevens Fishery Conservation and Management Act Provisions; Fisheries of the Northeastern United States; Northeast (NE) Multispecies Fishery; Framework Adjustment 48. 2013a. Fed Regist. 78(86):26117-26169.

Magnuson-Stevens Fishery Conservation and Management Act Provisions; Fisheries of the Northeastern United States; Northeast Multispecies Fishery; Framework Adjustment 50. 2013b. Fed Regist. 78(86):26171-26209.

Magnuson-Stevens Fishery Conservation and Management Act Provisions; Fisheries of the Northeastern United States; Northeast Multispecies Fishery; Framework Adjustment 53. 2015a. Fed Regist. 80(84):25110-25143.

Magnuson-Stevens Fishery Conservation and Management Act Provisions; Fisheries of the Northeastern United States; Northeast Multispecies Fishery; Possession Limit Adjustments for the Common Pool Fishery. 2015b. Fed Regist. 80(117): 34841-34842.

Magnuson-Stevens Fishery Conservation and Management Act Provisions; Fisheries of the Northeastern United States; Northeast Multispecies Fishery; Unused Catch Carryover; Emergency Action. 2014c. Fed Regist. 79(124):36433-36436.

Magnuson-Stevens Fishery Conservation and Management Act Provisions; Fisheries of the Northeastern United States; Omnibus Amendment to Simplify Vessel Baselines. 2015c. Fed Regist. 80(165):51754-51757.

McCay B. 2004. ITQs and community: An essay on environmental governance. AgricResour Econ Rev. 33(2):162-170.

National Standard 10 – safety of life at sea, 50 CFR Sect. 600.355 (1998).

[NEFMC] New England Fishery Management Council. 2003. Final Amendment 13 to the Northeast Multispecies Fishery Management Plan Including a Final Supplemental Environmental Impact Statement and an Initial Regulatory Flexibility Analysis, Volume I: Management Alternatives Impacts. NEFMC. 1,728 p. Available from: https://s3.amazonaws.com/nefmc.org/Final-Amendment-13-SEISVol.-I-II.pdf.

[NEFMC] New England Fishery Management Council. 2005. Groundfish Oversight Committee Meeting Summary. 13 January 2005. NEFMC. 6 p. Available from: http://archive.nefmc.org/nemulti/index.html.

[NEFMC] New England Fishery Management Council. 2009. Final Amendment 16 to the Northeast Multispecies Fishery Management Plan Including an Environmental Impact Assessment and Initial Regulatory Flexibility Analysis. NEFMC. 931 p. Available from: https://s3.amazonaws.com/nefmc.org/091016_Final_Amendment_16.pdf.

[NIOSH] National Institute for Occupational Safety and Health. 2017b. Commercial Fishing Fatality Summary: East Coast Region (2010-2014). DHHS (NIOSH) Publication No. 2017-173. 6 p. Available from: https://www.cdc.gov/niosh/docs/2017-173/pdf/2017-173.pdf?id=10.26616/NIOSHPUB2017173.

[NOAA] National Oceanic and Atmospheric Administration. 2010. NOAA Catch Share Policy. Silver Spring (MD): National Marine Fisheries Service. 26 p. Available from: https://www.fisheries.noaa.gov/.

Olson J and Clay PM. 2001. An overview of the social and economic survey administered during round II of the Northeast Multispecies Fishery Disaster Assistance Program. Woods Hole (MA): National Marine Fisheries Service. Tech Memo NMFS-NE-164. Available from: https://repository.library.noaa.gov/view/noaa/3238.

Pfeiffer L and Gratz T. 2016. “The effect of rights-based fisheries management on risk taking and fishing safety.” Proc Natl Acad Sci U S A. 113(10):2615-2620.

Poggie J, Pollnac R, Jones S. 1995. Perceptions of vessel safety regulations: A southern New England fishery. Mar Policy. 19(5):411-418.

Poggie JJ, Pollnac RB, Van Dusen C. 1996. Intracultural variability in the cognition of danger among southern New England fishers. Marine Resource Economics. 11(1):23-30.

Pollnac RB, Poggie JJ, Cabral SJ. 1998. Thresholds of danger: Perceived risk in a New England fishery. Hum Organ. 57(1):53-59.

Requirements for commercial fishing industry vessels, 46 CFR 28 (2004).

Schilling RSF. 1971. Hazards of deep-sea fishing. Occup Environ Med. 28(1):27-35.

Smith A, Allen P, Wadsworth E. 2006. Seafarer fatigue: The Cardiff Research Programme. [Project Report]. MCA Research Report, vol. 464. Cardiff: Centre for Occupational Health Psychology, Cardiff University. Available at: https://orca.cardiff.ac.uk/id/eprint/48167/1/research_report_464.pdf.

Tuler S, Agyeman J, Pinto da Silva P, Roth LoRusso K, Kay R. 2008. Assessing vulnerabilities: Integrating information about driving forces that affect risks and resilience in fishing communities. Human Ecology Review. 15(2):171-184.

[USCG] United States Coast Guard. 2009. Federal Requirements for Commercial Fishing Industry Vessels. Washington, DC: Commandant (CG-543-3), Office of Vessel Activities, Fishing Vessel Safety Division. Pamphlet.

United States Coast Guard (USCG). "Commercial Fishing Industry Vessel Safety." *Fish Safe*, United States Coast Guard, 2010, http://www.fishsafewest.info/.

Vessels requiring documentation, 46 CFR Sect. 67.7 (1993).

Walter AW, Morocho C, King L, Bartlett J Jr., Kelsey D, DeSousa M, Biesecker G, Punnett L. 2018. Preventing opioid use disorders among fishing industry workers. Int J Environ Res Public Health. 15(4):648.

Windle M, Neis B, Bornstein S, Binkley M, Navarro P. 2008. Fishing occupational health and safety: A comparison of regulatory regimes and safety outcomes in six countries. Mar Pol. 32(4): 701-710.

Weil R, Pinto K, Lincoln J, Hall-Arber M, Sorensen J. 2015. The use of personal flotation devices in the Northeast lobster fishing industry: An examination of the decision-making process. Am J Ind Med. 59(1):7380.

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