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Guidance on Fishing Vessel Risk Assessments and Accounting for Safety at Sea in Fishery Management Design

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U.S. Department of Commerce
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ABBREVIATIONS AND ACRONYMS

ACL............................Annual Catch Limit
BSAI ....Bering Sea/Aleutian Islands
CFID ....Commercial Fishing Incident Database
CFR............................Code of Federal Regulations
Councils ....Regional Fishery Management Councils
DAS............................Days-at-sea
FMP............................Fishery Management Plan
FR...............................Federal Register
ft.................................feet
FTE ....Full-time Equivalent Employee
GMFMC.....................Gulf of Mexico Fishery Management Council
IFQ ....Individual Fishing Quota
LAGC.........................Limited Access General Category
lbs...............................pounds
LLP ....License Limitation Program
MISLE........................Marine Information for Safety and Law Enforcement
MSA...........................Magnuson-Stevens Fishery Conservation and Management Act
NEFMC......................New England Fishery Management Council
NGOM ....Northern Gulf of Maine
NIOSH ....National Institute for Occupational Safety and Health
NM ....Nautical Miles
NMFS.........................National Marine Fisheries Service
NOAA........................National Oceanic and Atmospheric Administration
NPFMC......................North Pacific Fishery Management Council
NS10 ....National Standard 10
SAFMC......................South Atlantic Fishery Management Council
US ....United States
USCG.........................United States Coast Guard
VMS...........................Vessel Monitoring System

EXECUTIVE SUMMARY

Commercial fishing is one of the most dangerous occupations in the United States. A number of factors can either positively or negatively influence fishing vessel safety, such as: fishing vessel safety regulations, characteristics of the vessel (e.g., age, condition, and maintenance), human competency, weather conditions, and fishery regulations. Several federal agencies have an obligation and interest in promoting fishing vessel safety. NOAA's National Marine Fisheries Service (NMFS) and the eight Regional Fishery Management Councils (Councils) manage federal fisheries under the authority of the Magnuson-Stevens Fishery Conservation and Management Act (MSA).

National Standard 10 of the MSA requires that conservation and management measures shall, to the extent practicable, promote the safety of human life at sea (MSA section 301(a)(10)). The National Standard 10 guidelines are the primary source of guidance for the consideration of safety issues in fishery regulations. The National Institute for Occupational Safety and Health (NIOSH) conducts scientific research and makes evidence-based recommendations to prevent workplace injury and illness. NIOSH maintains the Commercial Fishing Incident Database (CFID), which contains information about fatalities and other safety incidents that have occurred in commercial fisheries. The U.S. Coast Guard (USCG) has authority for establishing and enforcing fishing vessel safety regulations, responding to casualties or accidents at sea, and investigating major accidents. The USCG also maintains the Marine Information for Safety and Law Enforcement (MISLE) system, which contains information on, among other things, fatalities, injuries, and accidents in the commercial fishing industry.

Recent work by NIOSH, USCG, NMFS, and the Councils have illustrated that the fishery management process can more explicitly address safety by analyzing information about the adverse outcomes (e.g., fatalities, non-fatal injuries, vessel losses, and vessel casualties) that have occurred in a fishery, learning from them, and implementing policies that may facilitate increases in safety. Based on these experiences, this document was prepared to provide guidance on methods to evaluate safety within fisheries. The goal is to promote the consideration of safety issues within fisheries management. Two specific tools are described: a safety checklist and a risk assessment.

The safety checklist, described in section 3, is a tool that can be used by fishery managers when developing new fishery management measures. It contains a series of questions intended to help identify whether a proposed management measure may create a safety concern. If a proposed measure does create a safety concern, then the managers should consider whether alternative measures are appropriate or develop mitigation measures to address the concern. The goal of the checklist is to encourage the consideration of fishing safety issues within the fishery management context.

A risk assessment is a tool to help identify trends and major safety hazards that may exist within a fishery. It involves analyzing information about safety incidents and other aspects of fisheries to identify those experiencing high risks. The risk assessment can be used by fishermen, fishery managers, and safety professionals to develop solutions for reducing risks and improving safety, such as targeted safety training programs, accident prevention programs, or changes in management approaches. A procedure for conducting a risk assessment is provided in section 4 and an example of a risk assessment is provided in Appendix A.

1.0 INTRODUCTION

Commercial fishing remains one of the most dangerous occupations in the United States, ranking among the top three occupations with the highest work-related fatality rate since 1992.[1] During 2000–2013, 665 fishermen died, an annual average of 47 deaths nationally (NIOSH, CFID analysis 2014). Approximately half of the fatalities (336, 51 percent) occurred after a vessel disaster. Another 198 (31 percent) fatalities occurred when fishermen fell overboard. Other fatalities were due to injuries on board such as falls or poisonings, and the remaining fatalities occurred while diving or from on-shore injuries.

In response to concerns about fishing safety, Congress added National Standard 10 (NS10) to the Magnuson-Stevens Fishery Conservation and Management Act (MSA) in 1996. This standard states that *"Conservation and management measures shall, to the extent practicable, promote the safety of human life at sea"* (MSA section 301(a)(10)). There are 10 national standards in the MSA, and all fishery management plans (FMPs)—including their amendments and implementing regulations—must be consistent with the national standards. Under section 301(b) of the MSA, the Secretary of Commerce is required to *"establish advisory guidelines (which shall not have the force and effect of law), based on the national standards to assist in the development of fishery management plans."* NOAA's National Marine Fisheries Service (NMFS) published guidelines for NS10 in 1998 (63 FR 24212; May 1, 1998).

The NS10 guidelines at 50 CFR 600.355 are the primary source of guidance for the consideration of safety issues in fishery regulations. The current NS10 guidelines have five sections containing:

a) A statement listing National Standard 10. (50 CFR 600.355(a))
b) A general statement that fishing is a dangerous occupation and recommendation that Regional Fishery Management Councils (Councils) reduce safety risks when developing management measures; an explanation of the qualifying phrase "to the extent practicable" in NS10; and an explanation that the phrase "safety of human life at sea" refers to both the safety of a fishing vessel and the safety of persons aboard the vessel. (50 CFR 600.355(b))
c) A list of safety issues to consider when evaluating management measures. (50 CFR 600.355(c))
d) A recommendation that during the preparation of any FMP, FMP amendment, or regulation that might affect safety of human life at sea, a Council should consult with the U.S. Coast Guard (USCG) and the fishing industry as to the nature and extent of any adverse impact. (50 CFR 600.355(d))
e) A list of mitigation measures that could be considered when management measures are developed. (50 CFR 600.355(e))

Fisheries management and fishing vessel safety science have evolved since the NS10 guidelines were first implemented in 1998. The current NS10 guidelines do not contain guidance on analytical methods to evaluate safety. Recent work by NIOSH, USCG, NMFS, and

[1] U.S. Department of Labor, Bureau of Labor Statistics. Injuries, illnesses, and fatalities: Census of Fatal Occupational Injuries—current and revised data. Washington, DC: U.S. Department of Labor, Bureau of Labor Statistics; 1992-2013. Available at http://www.bls.gov/iif/oshcfoi1.htm/#2012.

the Councils has shown that the fishery management process can more explicitly address safety at sea by collecting and analyzing information about the adverse outcomes (e.g., fatalities, non-fatal injuries, vessel losses, and vessel casualties) that have occurred in the fishery (Table 1). In addition, incident rates based on workforce estimates can be calculated to compare risk over time or to other fisheries. These safety statistics allow for the assessment of safety performance of a fishery, identification of risks, identification of trends over time, comparisons of fisheries across regions, and potential identification of adverse or positive safety outcomes that may result from major changes to fishery management regimes. A review of personnel casualties (fatalities and injuries) and vessel casualties (vessel losses and other incidents) will help fishery managers and safety professionals identify the factors that contributed to the incidents, and subsequently identify and implement risk mitigation measures in fisheries.

The safety performance of U.S. fisheries has been analyzed in a number of studies, particularly within the context of fishery management reviews (Table 1). For example, NIOSH and the USCG have partnered to provide in-depth analyses of fatality and safety information for some fisheries in the North Pacific, including the Bering Sea/Aleutian Islands (BSAI) crab fishery, the non-pollock groundfish cooperatives (i.e., the Amendment 80 fishery), and the freezer longline license limitation program fishery (Lincoln and Woodley 2010; NMFS 2012; NPFMC and NMFS 2013; Northern Economics, Inc. 2014). Knapp (1999) documented fishermen's perceptions of safety regarding the implementation of the quota based management system for Alaskan halibut. Lincoln et al. (2007) evaluated and documented improvements in safety after implementation of quota based management systems for Alaskan halibut and sablefish and the BSAI American Fisheries Act Pollock fishery. In addition, a five year review of the Gulf of Mexico red snapper individual fishing quota (IFQ) program and a review of the Atlantic scallop General Category IFQ fishery also examined safety performance of those fisheries (GMFMC 2013; NMFS 2014). The studies highlighted in Table 1, as well as others, provide examples of how fishery managers and staff can evaluate safety in their fisheries and provide the basis for some of the guidance provided in this paper.

The literature on fishing safety has identified a number of factors that either positively or negatively influence fishing vessel safety (National Research Council 1991; USCG 1999, 2011; Kite-Powell et al. 2001; Acheson 2002; Lincoln and Lucas 2010; NIOSH 2010a, 2010b, 2010c, 2010d; National Transportation Safety Board 2011). Generally, those factors include:

- Safety regulations.
- Vessel safety standards and equipment (e.g., vessels examinations, emergency lifesaving equipment, safety drills).
- Vessel characteristics (e.g., age, size, design, construction, maintenance, stability, watertight integrity).
- Human causes (e.g., operator/crew training and competency, fatigue, navigational error).
- Weather conditions.
- Insurance.
- Social and economic environment of a fishery.
- Fisheries management practices.

Often, a combination of factors is at play and may contribute to a vessel accident. Because the first six factors listed above are beyond the regulatory authority of NMFS, this report will not discuss them in depth. The purpose of this document is to assist fishery managers and NMFS and Council staff who work on FMPs, by providing some tools on how to analyze safety issues within their fisheries. This document provides background on how the economic and social environment of fisheries may influence fishing safety; describes a safety checklist that can be used to identify whether a proposed management measure may create a safety concern; explains procedures for conducting a risk assessment of a fishery; and provides an example of a risk assessment. Readers should feel welcome to modify these tools as appropriate for their fisheries of interest. The tools contained here can be applied to state-managed fisheries as well.

2.0 ECONOMIC AND SOCIAL ASPECTS OF FISHING SAFETY

The economic and social environment of a fishery may influence fishing safety and is important to consider when developing policies to improve safety. Economic conditions underlying a fishery may affect decisions made by fishing vessel captains and crew in a number of ways. In a survey of British Columbia fishermen, Acheson (2002) found that economic pressures (e.g., needing to pay for new gear, bills, and crew) were noted as being at least one cause of accidents by 10 of 12 fishermen interviewed. A relationship between accident risk and poor economic conditions resulting from increasingly stringent management controls designed to address declining fishery resources was also noted by Murray (2002) and Kaplan and Kite-Powell (2000). When economic conditions of a fishery are poor, vessel operators may have a diminished capacity to avoid fishing opportunities that exhibit significant risk due to the need to generate income to cover their base expenditures for the year. Similarly, investments in the vessel required to maintain safe, adequate working conditions may be less feasible. In such conditions some vessel operators may be inclined to take greater risks—such as fishing in poor weather when other vessels have tied up—in order to make ends meet or to take advantage of higher prices at the dock when fish are in short supply. This does not necessarily mean that a clear directional, causal relationship exists between economic health and safety, or that the relationship can be completely disentangled from the management regime. For example, targeted safety intervention programs have been used to improve safety conditions. Woodley et al. (2009) documented reductions in fatalities in the Bering Sea crab fishery even when the fishery was under economic stress. NIOSH found that between 1990–1999 and 2000–2006, there was a 60 percent reduction in the fatality rate in this fishery (Lincoln and Lucas 2008); this reduction has been attributed to the implementation of the "At the Dock Stability and Compliance Check" program in 1999 by the USCG and Alaska Department of Fish and Game. Woodley et al. (2009) noted a further reduction in fatalities in the crab fishery after 2005 when the fishery began operating under a rationalization program. Coincidentally, the economic performance of the crab fishery has also improved.

Economic conditions alone may not be a reliable indicator of vessel safety, support for increased safety regulations, or compliance with existing regulations for a variety of reasons. Investments in safety equipment tend to be viewed as costly, and increased risk-taking may be due to a divergence between subjective and objective assessments of risk, as well as differences in tolerance or acceptance of risk. Bergland and Pedersen (1997) provide a theoretical model of accident risk that illuminates some of these factors in terms of how they may influence fishing decisions. In their model, the optimal investment in safety-improving inputs is determined by the relationship between the cost of safety equipment, for example, and the marginal reduction in the expected loss from an accident. However, Bergland and Pedersen note that the total cost of vessel accidents includes both private and public costs (e.g., search and rescue, increased insurance premiums to the fleet as a whole, and social and economic dislocations caused by fatalities or permanent disability). These public costs are external to a fishing firm's profit calculus, resulting in a divergence between total and private costs. This externality means that the firm will use fewer safety-improving inputs and more safety-worsening ones than would otherwise be socially optimal. This may partially explain the resistance to increasing regulatory requirements for safety equipment, which would be one way to internalize the public cost externality. Factors affecting risk preferences and subjective assessment of accident risks are further explored below.

Compared to the general public, fishermen have been described as risk lovers; they deliberately seek out danger (Hall-Arber and Mrakovcich 2008; Davis 2012), and there is ample evidence that fishing as an occupation tends to select for personality traits that are predisposed to operate under higher levels of risk than the general public (Binkley 1991; Poggie et al. 1995; Pollnac et al. 1995; Kaplan and Kite-Powell 2000; Bye and Lamvik 2007; Pollnac and Poggie 2008; Davis 2012). This does not necessarily mean that fishermen do not understand the injury or fatality risks involved with their chosen occupation.

It is important to note that, although fishermen may accept higher risk than the general public, they have been found to be risk-neutral or risk-averse with respect to financial risk (Eggert and Martinsson 2004) and risk-averse to both financial and accident risk (Smith and Wilen 2005). In terms of accident risk, risk neutrality means that choices are based only on the expected value of financial returns and expected loss associated with an accident. Risk aversion means that choices are influenced by variability in returns and accident loss. In the context of Bergland and Pedersen's model, a risk-averse fisherman would invest in more risk-decreasing inputs as compared to a risk-neutral fisherman. Jin and Thunberg (2005) found that fishermen are less likely to start a fishing trip under relatively poor weather conditions, but will do so if expected returns are sufficiently high. These studies demonstrate that fishermen avoid uncompensated risk, where acceptance of higher risk must be accompanied by higher reward. In this context fishermen make tradeoffs between financial gains and accident risk, although the propensity to accept risk varies among fishermen. This means that an understanding of any systematic tendencies in risk acceptance or awareness may be an important element to consider when conducting a risk assessment of a fishery.

Factors such as age, experience, position, kinship, and investment have been identified as affecting the level of "comfort" or perception of risk. It is important to acknowledge the various perceptions of risk, as they may influence how fishermen respond to safety intervention programs. Age and experience have generally been found to be correlated, but those effects may differ by fishery or the context for the study. For example, for a study in New Bedford, Massachusetts, and Point Judith, Rhode Island, fishermen were asked to rate accident severity; more experienced fishermen were found to rate accidents as less severe than the actual accident outcomes based on USCG data (Pollnac et al. 1995). When combined with age, the authors attribute this finding to habituation with exposure to risky conditions resulting in desensitization to accident risk. By contrast, Davis (2012) found that accident risk was rated higher among older, more experienced lobstermen in Maine than by younger lobstermen. Whether the difference between the finding of Davis (2012) and that of Pollnac et al. (1995) is unique to each fishery or to some other social or demographic factors is uncertain.

Occupational position on a vessel (e.g., deckhand, first mate, captain) has been shown to influence perceptions of safety and accident risk. However, as noted by Binkley (1991) these perceptions may also be related to age and experience, as the position one has a boat (and hence exposure to risk) is often a function of experience. For example, Binkley (1991) found that crew members that are more exposed to dangerous working conditions (e.g., deckhands) tended to be less satisfied with safety conditions than individuals in positions that are less exposed. Pollnac et al. (1995) found that fishermen with greater responsibility on a vessel had perceptions of accident risk were more closely aligned with actual accident outcomes based on USCG data. In addition to the factors noted above, Pollnac et al. (1998) noted that individuals operating out of New Bedford, Massachusetts, with prior experience with events that create the conditions for accidents (e.g., engine failure, lost electronics, fog, low visibility) expressed less concern with these types of incidents than others. The authors also noted that of the 44 fishermen interviewed in New Bedford, those identifying themselves as ethnic Norwegians and ethnic Portuguese tended to have a lower threshold for danger than those who did not specify any specific ethnic group.

In summary, vessel operating and investment decisions are complicated and motivated by myriad factors that may relate to vessel safety. In addition, fishermen’s perception of risk may vary based on age, experience, and position on vessel. Ultimately, fishery management analysts should be aware that the economic and social environment has a potential impact on fishing vessel safety and consider the ways in which fishery management decisions are likely to affect the incentives facing vessel owners, operators, and crew, and the ways in which both operating and investment decisions may be skewed either toward or away from safe operating conditions. Additionally, as noted by several authors (Binkley 1991; Pollnac et al. 1995, 1998; Davis 2012), individuals involved in conducting safety training programs should acknowledge that awareness and perceptions of risk may vary among fishermen.

3.0 SAFETY CHECKLIST

There are many inherent risks to fishing. The work is conducted in a dangerous environment with heavy equipment, often far from help if something goes wrong. In addition to safety issues, fisheries managers face immense challenges in working to achieve multiple and often conflicting goals, while addressing a diversity of stakeholder viewpoints, with limited funding and data. And other agencies, particularly the USCG, have primary responsibility for the regulations that most directly affect safety, such as those regarding vessels, gear, examinations, and training. Nevertheless, a wide and growing body of evidence indicates that how fisheries are managed can and does affect safety, often in indirect but still important ways. Multiple studies suggest that, although fisheries management policies are not meant to regulate safety at sea, they do sometimes contribute to safety problems (Jensen 1997; Kaplan and Kite-Powell 2000; Wiseman and Burge 2000; Petursdottir et al. 2001; Windle et al. 2008).

The safety checklist (Table 2) is a tool that can be used by fishery managers when developing new fishery management measures. The 13 questions are intended to help identify if a proposed management measure creates a safety concern. If a proposed measure does create a safety concern, then the managers should consider whether alternative measures are appropriate or develop mitigation measures to address the concern. The goal of the checklist is to encourage the consideration of fishing safety issues within the fishery management context.

How the checklist is used may depend on the type of FMP amendment or regulation being developed. The fishery management process is dynamic and adaptive. If a Council is undertaking an FMP amendment that is expected to fundamentally change how a fishery operates, they may want to consider using the checklist early in the process to revise or remove potential alternatives. If a Council is undertaking an FMP amendment that will make minor changes to the fishery, they may want to use this checklist later in the process. The response to the questions would not necessarily dictate making a particular management decision. If a management measure does create a safety concern, it does not mean that it cannot be selected. Councils need to balance the various objectives of the MSA when establishing conservation and management measures. Mitigation measures can be developed to reduce potential impacts on safety at sea. The last column of the checklist includes a space to document potential mitigation measures.

The questions in the checklist were derived based on the following sources of information: the current NS10 guidelines; stakeholder concerns regarding fishing safety; NMFS' experiences with addressing fishing safety; and the USCG's Commercial Fishing Safety Advisory Committee. In 2010, the USCG's Commercial Fishing Safety Advisory Committee created a list of fishery management measures that, in their opinion, have created safety risks. The questions in the checklist are not arranged in any particular order. Further background on each question and corresponding safety concern is provided below.

<u>Operating environment (Questions 1–3)</u>

Where and when a fishing vessel operates is partially a function of the location of the target species, fishery regulations, economics, size of the vessel, climate, and weather. Some environments may be more dangerous to operate in than others and can play a significant factor in operational and survivability risk. For example, vessels that fish far offshore may face more risks than those that fish closer to shore because they spend more time on the water, may have longer transit times to seek shelter, and could be far away from assistance and from USCG search and rescue assets. A general understanding of the distance between the vessel operations and search and rescue assets is prudent in voyage planning and fishery management plan development, as it can identify potential concerns associated with the time needed to respond to incidents should they occur. Alternatively, those who fish inshore may be more susceptible to changing tides, currents, and bathymetry and may experience greater vessel traffic. A general understanding of the weather and conditions that may arise during the time period that the fishery operates could identify potential safety risks.

Crews who operate on cold water are at greater risk for death at sea than those who operate in warmer water, because if an individual were to enter the water due to a fall overboard or vessel disaster, there is an added risk of experiencing cold shock, swimming failure, and eventually hypothermia. "Cold water" is defined in the USCG regulations as water where the monthly mean low water temperature is normally 59 °F (15 °C) or less (46 CFR 28.50). Cold water immersion can cause hypothermia and may result in unconsciousness and possibly death. The survival time of an individual immersed in cold water is much shorter than it is in warm water.

Transit provisions (Question 4)

When areas are closed to fishing, the issue of transiting through the closed area is often raised. Allowing vessels to transit through closed areas, thereby reducing travel time, can help mitigate safety concerns. Fishing vessels are usually allowed to transit through a closed area, but may be required to stow fishing gear in a particular manner. For example, gear stowage regulations for fishing vessels operating in the Northeast are primarily contained in 50 CFR 648.2 under the definition for "not available for immediate use." In the past, trawl gear stowed on the net reel was required to be covered with a "canvas or similar opaque material." This requirement raised safety concerns, as gear stowage is often done while at sea and crew members often had to climb on the net reel or surrounding parts of the vessel to cover the net. To address safety concerns, the New England Fishery Management Council worked with the industry and the USCG to develop alternative methods to stow gear. As a result, NMFS revised the gear stowage regulations in order to improve safety of fishing operations at sea (79 FR 52578; 9/4/14).

Incentives to work for prolonged periods of time (Question 5)

It is important to consider how incentives to fish may change under new fishing regulations. Some fishery management measures may lead fishermen to fish longer than they would otherwise. For example, day or trip limits may entice fishermen to continue to fish in poor weather so that they can obtain their full limit without missing out on fishing opportunities. This is particularly an issue when fishing seasons or fishing opportunities are limited. Fishing for long periods of time without rest can lead to fatigue, which can be a contributing factor to accidents and injuries occurring on vessels.

Some fishermen have expressed a concern that regulations limiting the number of crew allowed on a vessel could potentially impact crew fatigue and overall safety. An example where a crew size limit has been increased partially due to safety concerns can be found in the Gulf of Mexico reef fish fishery. Vessels with both a charter for-hire permit and a commercial reef fish permit (referred to as dual-permitted vessels) were previously limited to a three-person crew when fishing commercially, unless a USCG certificate of inspection required a larger crew. When these vessels were conducting commercial spear fishing trips, this regulation prevented them from having two divers in the water and two crew onboard, which is considered a safe diving practice by the U.S. Coast Guard Diving Policies and Procedures Manual (USCG 2009). Amendment 34 to the Gulf Council's Reef Fish FMP increased the maximum crew size for dual-permitted vessels from three to four to improve the safety at sea for these vessels (GMFMC 2012). For the same reason, in December 2013 the South Atlantic Fishery Management Council (SAFMC) increased the crew size limit from three to four for dual-permitted vessels in the South Atlantic (SAFMC 2013).

Independent of regulatory limits, crew size may be reduced to save costs in fisheries that are under financial stress. This has the same potential effect on crew fatigue as that of a regulatory limit on crew size.

Stability (Question 6)

A fishing vessel operates in a very dynamic environment. Moving loads or gear while underway or in rough sea conditions can create a dangerous situation on a vessel. Carrying an excessive amount of gear can also significantly reduce the stability of a fishing vessel, making it prone to capsizing. Fishery managers should consider the safety and stability of fishing vessels when requiring specific gear or considering gear-carrying limits, requiring the removal of gear from the water, or requiring fishing gear to be disconnected or covered. Management measures should reflect sensitivity to these stability issues and provide methods of mitigation of these situations wherever possible. Mitigation measures could include tailoring gear requirements to provide for smaller or lighter gear for smaller vessels or allowing for pre- and post-season "soak time" to deploy and pick up fixed gear, so as to avoid overloading vessels with fixed gear.

Economic pressure may motivate fishermen to use unsafe stability practices. For example, due to perceived economic gain, fishermen may deck load fish or carry excessive gear to reduce the number of fishing trips and save fuel. These types of practices can increase the vessel's center of gravity, push the vessel lower in the water, and decrease the vessel's ability to right itself from external heeling forces. If fishery managers recognize that vessels are using unsafe stability practices, they should consult with the USCG on ways to address the issue. For example, unsafe stability practices were at one time commonplace in the BSAI crab fishery as fishermen overloaded their vessels with pots. However, the Dockside Stability and Safety Compliance Check program established by the USCG and other partners in 1999 provided a mechanism for USCG officials to review stability and safety issues with vessel masters and prevent overloading, resulting in a 60 percent reduction in the fatality rate of the BSAI crab fleet (Woodley et al. 2009).

Short Fishing Seasons (Questions 7 and 8)

Having short fishing seasons could provide an incentive to race to fish, whereas longer seasons could allow fishermen more flexibility to avoid hazardous weather conditions. To participate fully in a fishery that has a short season or a limited number of fishing days, fishermen may feel compelled to fish in bad weather and overload their vessel with catch and/or gear so that fishing opportunities are not lost. When fishing opportunities are limited, day or trip limits may entice fishermen to continue to fish in poor weather so they can obtain their full limit without missing out on fishing opportunities.

Section 303(a)(6) of the MSA states that FMPs shall consider temporary adjustments regarding access to the fishery for vessels otherwise prevented from harvesting because of weather or ocean conditions. When fishing opportunities are limited, the following mitigation measures could be applied to address safety concerns: setting seasons to avoid hazardous weather; spreading effort over time and area to avoid potential gear and/or vessel conflicts, as well as to reduce the race to fish; allowing some compensation in the number of allowable fishing days for a vessel when a fishing trip is cut short due to safety concerns; delaying the start of a fishing season if bad weather conditions exist so that fishing opportunities are not lost; and allowing for fishing seasons to be extended so that quotas may be reached. This approach has been used by some Councils. For example, the Pacific Fishery Management Council in 1992 approved an operating procedure to provide guidance for making weather-related adjustments to salmon fisheries.[2] Similarly, in the mid-1990s NMFS set the season (which was relatively short) for the non-trawl sablefish component of the Pacific Coast groundfish limited entry fishery to start at a time when weather conditions were considered the safest (60 FR 11062; March 1, 1995).

Vessel size, upgrades, and replacement (Question 9)

In some fisheries, NMFS and the Councils have implemented measures to limit the potential size of replacement vessels in order to promote conservation of the resource and limit increases in fishing capacity. Limiting the length or horsepower of vessels that can operate within a fishery could encourage the design and use of vessels that are poorly equipped to handle ocean conditions. Measures that limit one dimension of size or power but not others may skew the vessels into suboptimal configurations from a safety perspective, even if they help maximize harvesting volumes or rates. Prohibiting vessel upgrades or replacement can impede building newer and potentially safer vessels. Allowing older vessels to be replaced by newer ones could improve safety because newer vessels will have to meet more stringent construction standards and can incorporate advances in marine design that improve a vessel's safety. For example, the Coast Guard Authorization Act of 2010 and the Coast Guard and Maritime Transportation Act of 2012 established new safety requirements for commercial fishing vessels, including vessel construction standards, and survey, classification, and loadline requirements for certain new vessels.

Research has shown an association between vessel age and the probability of a negative safety event. Talley et al. (2005) reviewed USCG accident investigations from 1991 through 2001 of incidents of non-fatal crew injuries, fatal crew injuries, and missing crew (i.e., when a crew member is missing after an incident and is not found) on freight ship, tanker, and tugboat vessels. They found that fatal injuries on freight ships increased with vessel age; however non-fatal injuries declined with vessel age (Talley et al. 2005). Additionally, missing crew in a freight ship accident was shown to increase with vessel age (Talley et al. 2005). Another study by Meek et al. (1985) concluded that, in general, a positive correlation exists between ship loss rates and ship age. Jin et al. (2001) found that an increase in vessel age increases the probability of a total loss due to a collision, fire/explosion, material/equipment failure, capsizing, sinking, and grounding; however it was found that the likelihood for total vessel loss is lower for older vessels in a flooding accident. Jin (2014) developed a model to examine the determinants of fishing vessel accident severity in the Northeast and found that vessel damage is positively associated with vessel age.

NMFS and the Councils have addressed or are in the process of addressing vessel replacement provisions. For example, in 2012 NMFS published a final rule to implement Amendment 97 to the North Pacific Fishery Management Council's (NPFMC) Groundfish of the BSAI FMP (NMFS 2012) to allow vessel replacement for BSAI Amendment 80 vessels (77 FR 59852; 10/1/2012). Briefly, "Amendment 80 vessels" are catcher/processor trawl vessels that are

[2] Pacific Fishery Management Council, Council Operating Procedure 16. http://www.pcouncil.org/council-operations/operating-procedures/

part of a catch share fishery (established in 2008 by Amendment 80 to the FMP) for non-pollock (non-American Fisheries Act) groundfish. Previously, the 28 vessels in the Amendment 80 sector could not be replaced. Amendment 97, among other things, allows Amendment 80 vessels to be replaced for any reason at any time**.** The amendment was considered necessary to promote safety at sea by allowing Amendment 80 vessel owners to replace aging vessels with newer, larger, and safer ones and by requiring replacement vessels to meet certain USCG vessel safety standards.

Similarly, the NPFMC developed Amendment 99 to the BSAI Groundfish FMP to allow owners of BSAI freezer longline vessels that fish for Pacific cod to replace their vessels to a length greater than that specified under the restrictions of the License Limitation Program (LLP) and the American Fisheries Act (NPFMC and NMFS 2013). Originally implemented in 2010, the LLP limited the number, size, and specific operation of vessels fishing for groundfish and crab in the BSAI and Gulf of Alaska, based on historical participation. Each LLP license had a specified maximum length overall that was based on the length of the vessel initially receiving the license. Amendment 99 adjusted the maximum length overall to 220 ft on the LLP license assigned to freezer longline vessels, to accommodate larger replacement vessels.

NMFS and the New England and Mid-Atlantic Fishery Management Councils are considering changes to regulations that would simplify vessel baselines. In June 2015, NMFS published a proposed rule that would eliminate the one-time limit on vessel upgrades and remove gross and net tonnages from the vessel baseline specifications that are considered when determining a vessel's baseline for replacement purposes (80 FR 31343; 6/2/2015). This rule, if implemented, will provide flexibility to vessel owners in the selection of replacement vessels and upgrades to existing vessels.

<u>Landing requirements (Question 10)</u>

Some fisheries have regulations regarding where and/or when fish products are to be delivered or landed. The regulations could require catch to be landed in a particular state, or require that fish products be delivered to particular processors. Environmental conditions (e.g., ice) or safety incidents on a vessel may create impediments to delivering fish to the required location. Councils may want to consider developing a process that allows exemptions from landing requirements to mitigate safety risks. NMFS and the Councils have implemented exemptions to landing requirements and other measures in some regions to mitigate safety concerns.

For example, under the Crab Rationalization program in Alaska, NMFS issues quota shares to eligible harvesters and processor shares to eligible processors. For six of the crab fisheries, regional delivery regulations (established to preserve the historic geographic distribution of deliveries) require that a portion of crab harvested be delivered and processed within the boundaries of the North or South Region. However, weather conditions or other circumstances can increase safety risks or create obstacles to regional deliveries. In 2013, NMFS implemented Amendment 41 to the BSAI Crab FMP to establish a process whereby holders of regionally designated individual fishing quota and individual processor quota in these six fisheries may receive an exemption from regional delivery requirements in the North or South

Region (78 FR 6278; January 30, 1013). This rule helped promote the safety of human life at sea and mitigate disruptions in the fishery.

Another example of an exemption from landing requirements can be found in the Pacific coast salmon fishery. In that fishery, the coasts of Washington, Oregon, and California are divided up for management purposes. There are specific quotas for each area and there are specific landing requirements; typically fishermen have to land in the same management area where they caught the fish. However, the Pacific Council and NMFS have allowed boats to seek safe harbor provided they contact authorities before crossing management lines (75 FR 24482; 5/5/2010).

Another example of a safety exception can be found in Amendment 5 to the Atlantic Herring FMP. Amendment 5 established measures to enhance sampling of catch at sea and required that limited access vessels, with limited exceptions, bring all catch aboard the vessel and make it available for sampling by an observer. However, the amendment allowed catch to be slipped (discarded before being brought aboard a vessel) if bringing the catch aboard will compromise safety.

Fishery observers (Questions 11 and 12)

NMFS deploys fishery observers to collect catch and bycatch data from U.S. commercial fishing and processing vessels. The data collected by observers supports the conservation and management of fisheries, protected species, and ecosystems. FMPs may require vessels to carry an observer, except when "the facilities of the vessel for the quartering of an observer, or for carrying out observer functions, are so inadequate or unsafe that the health or safety of the observer or the safe operation of the vessel would be jeopardized" (see 16 USC 1853(d)(8)).

Regulations governing the health and safety of observers are contained in 50 CFR 600.725 and 600.746. A vessel is inadequate for observer deployment if it: 1) does not comply with the applicable regulations regarding observer accommodations (see 50 CFR parts 229, 285, 300, 600, 622, 635, 648, 660, and 679); or 2) has not passed a USCG Commercial Fishing Vessel Safety Examination, or for vessels less than 26 ft in length, has not passed an alternate safety equipment examination (see 50 CFR 600.746(c)). A vessel that would otherwise be required to carry an observer, but is inadequate for observer deployment (as described in 50 CFR 600.746(c)), is prohibited from fishing without observer coverage.

If regulations governing observer programs cause concerns about the health and safety of the observer, or the safe operation of the vessel (as indicated in questions 11 and 12), managers could consider providing regulatory authority for observer programs to release vessels from the observer requirement and require corrective actions (e.g., repair deficiencies, obtain larger life rafts, etc.). For example, in Alaska, regulations at 50 CFR 679.51(a)(1)(iii) allow vessels to be released from observer coverage on a case-by-case basis.

Other safety concerns (Question 13)

It is quite possible that the USCG, Council members, or members of the public may express concerns about safety over a proposed management measure. Question 13 in the safety checklist is meant to capture any safety concerns that have not been identified by a review of questions 1 through 12.

4.0 RISK ASSESSMENTS

Risk assessments are a useful tool to help identify trends and major safety hazards that may exist within a fishery. The identification of safety hazards is a critical piece of information that can be used by fishermen, fishery managers, and safety professionals to develop solutions for reducing risk and improving safety, such as targeted safety training programs, accident prevention programs, or changes in management approaches. We provide procedures for conducting risk assessments in sections 4.1 to 4.7 and a conceptual diagram is illustrated in Figure 1.

Fishery managers and analysts will want to consider when it is appropriate or prudent to conduct a risk assessment. It may not be appropriate to assess every fishery or to assess at a frequent interval. For example, analysts may want to prioritize their efforts by assessing those fisheries that are known to experience a high number of safety incidents or have significant safety concerns. Also, analysts may want to consider conducting risk assessments before and after implementing major changes to their fishery management regime (especially if the objective of those changes is to address safety concerns), to assess safety performance.

The format of a risk assessment may vary depending on the particular needs and interests of fishery managers. For example, a risk assessment could be a stand-alone analysis, such as the scallop fishery risk assessment in Appendix A. Risk assessments could also be incorporated into a stock assessment and fishery evaluation report, the analysis of an FMP amendment, a fishery impact statement, or an overall review of the performance of a fishery management regime (e.g., such as the 5- or 7-year review of catch share programs). The studies listed in Table 1 are good examples of ways that risk assessments can be incorporated into FMP amendments or fishery performance reviews.

4.1 Identify the fishery

The first step of a risk assessment is to determine the appropriate scale of the fishery to assess. Some FMPs may contain multiple fishery sectors (e.g., user groups, gear types) that may be managed under different regimes and may target different fish stocks. Other FMPs may be more narrowly focused and include only one user group and target stock (e.g., Deep Sea Red Crab FMP). A risk assessment could be conducted at the level of all the fishery sectors managed under an FMP. However, if there is a known safety concern about a particular fishery sector, it may be appropriate to discreetly analyze that sector if data are available to do so. By examining the different sectors of a fishery, it may be possible to identify whether some sectors experience greater risks than others and focus the analysis on those that have greater risks. The scale of the fishery that is assessed will also be influenced by the type of information that is available. For example, it may not be possible to code all marine and personnel casualties by fishery (see section 4.3 for more information on this). Once the scope of the risk assessment has been defined, it is useful to include a brief description of how the fishery is managed and any known safety concerns. This information will help provide the context for the risk assessment.

4.2 Conduct literature reviews

During the development of a risk assessment, analysts should conduct a literature review to identify studies that examine safety risks or concerns relevant to the fishery under review. Websites like PubMed (http://www.ncbi.nlm.nih.gov/pubmed) or SafetyLit (http://www.safetylit.org/index.htm) provide searchable databases for health and safety literature. The websites of federal agencies, such as the USCG (http://www.fishsafe.info/) and NIOSH (http://www.cdc.gov/niosh/topics/fishing/default.html), also contain literature on fishing safety. The literature review could also include relevant economic studies that examine the relationship between management regimes and economic factors or incentives that may increase or reduce risk-taking. Additionally, the social and cultural literature could be consulted to identify any factors that may explain differences in perceptions of risk among fishing sub-populations. This literature may also inform the design of programs for safety training or behavior modification.

4.3 Describe vessels and work environment

A risk assessment should include a general description of the vessels in the fishery and of the work environment to help identify potential safety concerns. For example, a description of the vessels and work environment could include information on:

- Active number of vessels within the fishery.
- Age, tonnage, and length of vessels in the fishery.
- Time and location of where the fishery operates (distance from shore, distance from search and rescue assets).
- Water temperature.
- Average crew size.
- Description of fishing gear and any known safety hazards associated with using the gear.
- How fish are stored or processed.
- Type of loading, loads, any typical load transfers.
- Navigational challenges (e.g., river bar crossings, currents).
- Other operational characteristics of the fishery (e.g., duration and number of work shifts).

This descriptive information is helpful, as risks will vary greatly depending on a number of factors. For example, fisheries that use stationary gear like pots and traps tend to have more fatalities from falls overboard than fisheries that use mobile gear. Also, vessels that carry stationary gear tend to have stability problems due to the load of pots and traps. Winches on deck used on vessels that pull nets through the water pose entanglement hazards. Vessels that both catch and process fish to some extent also have hazards in the processing line that are not present on other vessels. Fisheries that use power blocks and winches might experience crushing injuries, while hook-and-line fisheries will have more cut and puncture-type injuries (Dzugan 2010).

A fishery that operates in cold water, far from search and rescue resources, and that carries a large crew could be considered as operating in a high-risk environment. Fishery managers should consider these safety concerns when designing management measures. An understanding of these safety concerns would help fishery managers and safety professionals identify whether targeted safety programs are needed to address the concerns. If search and rescue assets are located far away, temporary pre-deployment of search and rescue assets and/or mandatory safety training for participating vessels may be options to consider. Consultations with industry advisory panels would aid in developing a solid understanding of the work environment and the potential safety concerns. In fisheries that experience a large number of fatalities or other types of accidents, it would be appropriate to conduct further research, such as comprehensive surveys of captains and crew, to better understand the safety risks.

4.4 Analyze marine and personnel casualties

The most important part of a risk assessment is the analysis of available information on marine casualties[3] that have occurred in the fishery, such as: fatalities, non-fatal injuries, vessel losses (e.g., when a vessel sinks or burns and is no longer capable of transportation by water), vessels capsizing, sinking, grounding, burning, failure of vessel components, and other activities such as USCG search and rescue missions. The goal of this analysis is to examine trends and patterns, and identify the major contributing factors or characteristics of the casualties experienced in the fishery. Trends and changes can be examined in a given region across all fisheries, within particular fisheries, or, where data allow, for a given company or vessel operator. Marine casualties and serious marine incidents[4] are required to be reported to the USCG (see 46 CFR 4.05-1). Non-fatal injuries are required to be reported if: "it requires professional medical treatment (treatment beyond first aid) and, if the person is engaged or employed on board a vessel in commercial service, that renders the individual unfit to perform his or her routine duties" (see 46 CFR 4.05-1(a)(6)). It is possible that marine casualties are under-reported, due to a lack of knowledge that they should be reported and to whom.

As mentioned above, marine casualties also include failures of vessel components or systems that result in problems such as the loss of main propulsion, loss of steering, flooding, and fire. Some marine casualties may be leading indicators of larger issues with a vessel that could trigger a future vessel loss and/or fatalities.

Fatalities and vessel disasters (defined by NIOSH as "a catastrophic marine casualty which forces the crew to abandon the vessel because it is no longer safe to remain on-board") are the most critical pieces of information that should be reported in the risk assessment. There are two sources for this information: NIOSH's Commercial Fishing Incident Database (CFID), which is maintained by staff of the NIOSH Commercial Fishing Safety Research and Design Program, and the USCG's Marine Information for Safety and Law Enforcement (MISLE) system. The authors recommend contacting NIOSH first for data requests.

[3] Defined at 46 CFR 4.03-1.
[4] Defined at 46 CFR 4.03-2.

NIOSH developed CFID to collect and analyze data on fatalities that have occurred in the entire U.S. commercial fishing industry since 2000. The purpose of CFID is to identify high-risk fisheries in the United States and to identify the risk factors that contribute to fatal incidents. Data for CFID are collected from multiple sources, including the USCG, law enforcement agencies, death certificates, news media, and state-based occupational fatality surveillance programs. CFID includes information specific to each incident including vessel characteristics, the fishery it was operating in, environmental factors, and victim demographic data. The database contains almost 100 variables for each fatality in the U.S. fishing industry and currently holds data from 2000 to 2013. In addition to occupational deaths in the fishing industry, CFID also contains data on survivors of fishing vessel disasters. This enables epidemiologists to study survival factors by comparing survivors to decedents of such incidents. CFID is housed and managed at the NIOSH Alaska Pacific Office and data requests can be submitted directly to that office (907-271-2382). A NIOSH epidemiologist will review the request and work with the requester to meet the need as much as possible.

The incidents captured in CFID are coded by fishery. NIOSH uses multiple methods and data sources to identify which fishery each vessel was participating in at the time of the incident. In some cases, NMFS staff can help identify what fishery a vessel was participating in at the time of an incident. In other cases, the USCG investigation report will mention what species was being targeted at the time of the incident, or have other details that allude to the fishery. When the fishery cannot be determined by reading the USCG report or by making a request to NMFS, other sources are sometimes fruitful (news media, internet searches, contacts with locals, etc.). Finally, in some cases when all other methods and sources fail to identify the fishery, there will be enough related information about the case (location, date, gear type) that the fishery can be accurately estimated.

As mentioned above, the USCG maintains the MISLE system, which contains information on all official USCG activities including search and rescue missions, vessel losses, number of marine casualties or fatalities, and injuries for the commercial fishing industry as well as other incidents. However, the system can be difficult to query without intimate understanding of the system, and USCG activities are not coded by fishery.

Information from MISLE may be obtained from three sources. First, the entire system, which includes data from MISLE and earlier accident reporting systems, are available for purchase from the National Technical Information Service.[5] Data are included for all marine accidents—not just those involving commercial fishing accidents. The data are organized into multiple tables that must be joined by an activity ID. Incidents are added on an ongoing basis, but not available until an investigation has been completed, which may take a year or more. Information on the type of fishing vessel, location, and fishing activity (gear) is not available in MISLE, therefore additional information will need to be collected when using this data source.

Second, information on marine incidents may also be obtained from the USCG's Marine Information eXchange, which is a web-based query system.[6] A number of types of queries can

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[5] http://www.ntis.gov/products/marine-casualty/
[6] https://cgmix.uscg.mil/IIR/Default.aspx

be done to identify incident investigation reports, but it provides limited information on cases and does not provide download capabilities.

Third, it may be possible to get some information from MISLE by partnering with the local USCG office or possibly with the USCG Fishing Vessels Division office in Washington, DC, under the 2004 Memorandum of Agreement on Observer Safety between NMFS and the USCG. It may require extra work to collect, code, and clean the data but, even with these data limitations, it may be possible to get high-quality data for specific fleets and fisheries if one is willing to review cases.

One of the challenges of using data from MISLE is that it needs to be coded by fishery. In order to identify what fishery a vessel was participating in at the time of an incident, the analyst may need to examine a variety of data sources. State and federal permit data can help to identify which fishing permits the vessel had at the time of the incident, and therefore which fisheries the vessel would have been allowed to participate in at a given time. However, vessels can often hold multiple permits simultaneously, and some fishing activities do not require permits. A compilation of fishery and fishing sector season openings and closings may help narrow the possibilities. An analyst will likely need to further examine fishing vessel trip reports, logbook data, VMS data, or observer data to identify the activity of the vessel at the time of the incident, although the existence of such data is variable and access to such data may be restricted by confidentiality provisions within the MSA. In some cases, it may be impossible to determine with the available data which fishery a vessel was participating in at the time of the incident.

4.5 Calculate casualty rates

Casualty rates (e.g., fatality rates, vessel loss rates) are important because they account for the number of workers and exposure time on the water and provide a way to compare risk using a common denominator across years. These rates can help identify whether safety is improving or declining in a fishery. In order to calculate rates, an estimate of the amount of fishing effort in the fishery is needed. A number of different measures of fishing effort (i.e., the denominator in the casualty rate) can be used and the decision to use one method over another will depend on the data that are available to the user. In order to be able to compare rates across fisheries, the methods used to derive the denominator would have to be applied consistently for all fisheries. The following section describes four measures of fishing effort: full-time equivalent employees (FTEs); number of hours fished; number of vessel days; and number of individuals or active vessels involved in commercial fishing. The measures are listed in order of decreasing complexity and precision in terms of accounting for exposure time.

4.5.1 Full-time equivalent employees (FTEs)

Equation 1: $$\frac{\text{\# of fatalities}}{\text{\# of FTEs}} \times 100{,}000 \text{ FTEs} = \text{fatality rate (per 100,000 FTEs)}$$

NIOSH compares rates across fisheries by estimating FTEs. They use three pieces of information to estimate FTEs:

- Number of Active Vessels: The number is estimated by fish tickets or reporting logs to identify active vessels with documented catches and landings rather than vessels permitted to fish. A vessel is considered "active" in a fishery if at least one landing occurred in a particular year.
- Average Number of Operational Days per Vessel: This includes transit days to and from fishing grounds, preparation days, gear trials, fishing days, and at-sea weather loss days.
- Average Crew Size for vessels in the fishery.

Averages, rather than actual numbers, are used for the number of operational days and crew size, because that information is available to NIOSH across more fisheries

Values for those three parameters are multiplied to calculate the number of "fishermen days." The number of fishermen days is then divided by the number of regular work days in a year (250). Fisheries having seasons shorter than 15 days are weighted by a factor of three to give credit for longer hours worked and increased time at risk per day. Seasons lasting between 16 and 50 days are weighted by a factor of two, and seasons lasting longer than 50 days are not weighted. The result is the number of FTE fishermen.

This method accounts for fishermen working around the clock and is advantageous from a national perspective because rates are standardized and can be compared across fisheries and industries. This method of calculating FTEs is documented in Thomas et al. (2001), NIOSH (2002), Lucas and Lincoln (2007), and Lincoln et al. (2007). In addition, Lincoln and Lucas (2010) estimated fatality rates for a number of fisheries and found that the Northeast multispecies groundfish fishery had the highest rate, followed by the Atlantic scallop fishery and the West Coast Dungeness crab fishery (Table 3).

4.5.2 Number of hours fished

Equation 2: $\frac{\text{\# of fatalities}}{\text{\# of hours fished}} \times 100{,}000 \text{ hours} = \text{fatality rate (per 100,000 hrs)}$

The number of hours fished could be obtained by examining data from vessel monitoring systems (VMS) or fishery observer programs. VMS is a satellite surveillance system primarily used to monitor the location and movement of commercial fishing vessels. The system uses satellite-based communications from on-board transceiver units, which certain vessels are required to carry. The transceiver units send position reports that include vessel identification, time, date, and location, and are mapped and displayed on the end user's computer screen. Vessels typically send position reports once every hour, although the interval can vary. One of the advantages of VMS data is that they adequately account for exposure time on the water.

Depending on the research question, there may be interest in distinguishing between the time actively fishing versus the time steaming to fishing locations. Calculation of active fishing time relies on an algorithm based on distance traveled between VMS polls, which provides an estimate of speed to distinguish between when a vessel may be fishing and when a vessel may be steaming from one location to another. For trawl vessels that tend to tow in longer straight lines, VMS should provide a reasonable estimate of active fishing time. For vessels engaged in fixed gear fisheries that may stop and start to retrieve gear, VMS may provide a reliable estimate of total time spent at sea, but may not be a reliable estimator for active fishing time.

Calculating hours fished from VMS data and then using that value as the denominator to calculate fatality rates is an approach that has been used in the New England multispecies and scallop fisheries. At the New England Fishery Management Council's September 2010 meeting, the USCG representative to the Council presented data on fatalities in terms of hours fished for those fisheries.[7]

As mentioned above, in fisheries that have observer coverage, observer data could also be used to estimate hours fished. The precision of estimating hours fished will depend on the rate of observer coverage. In fisheries with 100 percent observer coverage, fishing time may be better estimated using observer data even if VMS data are available for the same fishery.

4.5.3 Number of vessel days

Equation 3: $$\frac{\text{\# of fatalities}}{\text{\# of vessel days}} \times 1{,}000 \text{ days} = \text{fatality rate (per 1,000 days)}$$

In fisheries where VMS are not required, fishing effort may be measured by the number of vessel days or days absent from port, including the time vessels spend fishing and transiting to and from fishing locations. This can be obtained from landings data that identify the start and end dates of a fishing trip. The number of "vessel days" for all vessels in a fishery over the course of a year can be summed to obtain the annual number of vessel days. This approach was used to obtain the denominator for accident rates in Jin and Thunberg (2005).

The precision with which vessel days may be estimated will depend on whether and how trip-level data are reported. For fisheries where the date and time for both the start and end of a trip must be reported for all trips (e.g., via a declaration or call-in, logbook, or trip ticket), it may be possible to obtain an estimate of vessel days in hours. If only the start and end dates of the trip are recorded, days absent would need to be measured in terms of calendar days.

For fisheries where trip-level data are available, but the start and end dates of each trip are not reported or where trip-level reporting is not required at all, an inferential method to estimate vessel days will be required. If observer data are available and total trips are known, an estimate of vessel days may be obtained by multiplying average trip duration on observed trips by total trips. In fisheries with 100 percent observer coverage, it is possible to know the actual trip duration for each trip. Absent any other available data, vessel days could be estimated by multiplying the number of active vessels by an average trip duration obtained through expert knowledge, literature review of past studies, or some other informed means.

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[7] http://www.nefmc.org/press/council_discussion_docs/Sept%202010/list_of_sept2010_discussion_docs.html

In estimating vessel days, it is important to note that the start and end of a trip may not be defined the same way in all fisheries. For example, in some fisheries, the start of a fishing trip is defined as when a vessel leaves the dock, while in others the trip starts when active fishing commences. In the latter case, steaming time to the location where active fishing commences is not counted. The end of a trip is often defined as when fish are sold and offloaded. This may or may not coincide with the actual end of a trip if the location that the vessel is tied up differs from the offload site, if the vessel does not offload on the same day that it returns to port, or if the vessel makes multiple deliveries to different ports.

4.5.4 Number of individuals or active vessels involved in commercial fishing

Equation 4: $$\frac{\text{\# of fatalities}}{\text{\# of fishermen}} \times 100{,}000 \text{ fishermen} = \text{fatality rate (per 100,000 fishermen)}$$

Equation 5: $$\frac{\text{\# of fatalities}}{\text{\# of active vessels}} \times 1{,}000 \text{ active vessels} = \text{fatality rate (per 1,000 active vessels)}$$

Fishing effort can also be based on the number of fishermen or number of active vessels involved in a fishery, which could be based on observer program data, vessel log books, permit data, or expert judgement. For example, in Alaska the number of fishermen has been derived by obtaining data on the number of individuals who purchased fishing permits from the Commercial Fishing Entry Commission and the number of commercial crew licenses sold by the Alaska Department of Fish and Game (Thomas et al. 2001). The Alaska Department of Fish and Game requires that persons engaged in commercial fishing obtain a commercial crewmember license. Since the crewmember licenses are not fishery-specific, the number of individuals involved in commercial fishing is identified for the state as a whole, rather than for a specific fishery. While equations four and five account for the universe of people involved in commercial fishing and the universe of vessels involved, respectively, they do not account for exposure time, and therefore are less precise measures of fishing effort. However, these metrics do provide a way to examine trends over time in a particular fishery. Analysts will need to determine which measure of fishing effort to use based on the data available to them.

4.6 Describe safety regulations

A risk assessment should also include a brief summary of the safety regulations and safety programs that apply to the fishery to identify some of the known safety concerns. The USCG is the federal agency with primary authority and responsibility for establishing and enforcing fishing vessel safety regulations. The Commercial Fishing Industry Vessel Safety Act of 1988 gave the USCG authority to issue regulations for safety equipment standards. These regulations vary depending on vessel size, date vessel was built, number of persons on board, the type of vessel (fishing, fish tender, and fish processing vessels), and location of operation (miles from shore, or cold water vs. warm water). Regulations for commercial fishing vessels are contained in 46 CFR Part 28.

The Coast Guard Authorization Act of 2010 and the Coast Guard and Maritime Transportation Act of 2012 established additional safety and equipment requirements for U.S. commercial fishing vessels. Some of the major requirements established by these Acts include:

- Uniform safety standards and equipment requirements for all commercial fishing vessels operating beyond three nautical miles (NM).
- Commercial fishing vessels operating beyond three NM must carry approved survival craft applicable to their vessel that ensures that no part of an individual is immersed in water.
- Commercial fishing vessels operating beyond three NM must be examined dockside at least once every five years.
- Individuals in charge of a commercial fishing vessel that operates beyond three NM must pass a training program.
- New commercial fishing vessels, built after January 1, 2010, that are less than 50 feet in overall length must be constructed in a manner that provides a level of safety equivalent to the minimum standards established for recreational vessels.
- New commercial fishing vessels, built after July 1, 2013, that are 79 ft or greater in length must be load lined.
- New commercial fishing vessels, built after July 1, 2013, that are at least 50 ft overall in length and operate beyond three NM must be designed, constructed, and maintained to the standards of a classification society.
- USCG must develop Alternate Safety Compliance Programs for certain older vessels and certain vessels that undergo a major conversion.

For more information on fishing vessel safety, visit www.fishsafe.info.

4.7 Summarize results

The overarching goal of the risk assessment is to help identify trends and major safety hazards that may exist within a fishery. As mentioned previously, the identification of known safety hazards is the first step in developing recommendations and solutions for reducing risk and improving safety, such as targeted safety training programs, accident prevention programs, or changes in management approaches. The ability to calculate casualty rates that are standardized by the number of workers and exposure time on the water allows analysts to examine trends and identify whether safety is improving or declining in a fishery. If a fishery has experienced major changes in the management regime, analysts may be able to infer whether the change helped promote positive or negative safety outcomes. It may not be possible to code all safety casualties to a particular fishery or to calculate casualty rates for all fisheries due to data limitations. However, when the information is available, we believe it will be useful to better understand safety concerns.

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Table 1. Examples of studies that have examined the safety performance of a fishery, particularly within the context of a fishery management action or change in fishery management regime.

Fishery	Safety Analysis	Management Context	Reference
Bering Sea/Aleutian Islands (BSAI) Crab Fisheries	• Reviewed fatalities in fishery. • Examined the impact of the Dockside Stability and Safety Compliance Check program. • Examined impact of rationalization program on safety. • Provided recommendations.	Five year review of crab rationalization program.	Lincoln and Woodley 2010
BSAI non-pollock groundfish cooperatives (i.e., Amendment 80 fishery)	• Examined personnel casualties from 2001-2012. • Describe fatalities and series injury events. • Provided rates of fatal and non-fatal injuries. • Quantified injuries by job task. • Identified the number and type of vessel casualties. • Described safety regulations. • Provided recommendations.	Five year review of the Amendment 80 fishery.	Northern Economics, Inc. 2014
Gulf of Mexico reef fish fishery	• Examined changes in the number of fatalities in the fishery before and after implementation of the red snapper individual fishing quota (IFQ) program.	Five year review of the red snapper IFQ program.	GMFMC 2013
BSAI non-pollock groundfish cooperatives (i.e., Amendment 80 fishery)	• Characterized operational risks. • Identified number of fatalities and fatality rate. • Review safety regulations. • Discussed safety implications of vessel replacement.	Amendment 97 to FMP for groundfish of the BSIA. This amendment established a process to allow vessel replacement in the Amendment 80 fishery.	NMFS 2012
Freezer longline license limitation program (LLP) vessels	• Characterized operational risks. • Identified number of fatalities and fatality rate. • Reviewed safety regulations.	Amendment 99 to FMP for groundfish of the BSIA. This amendment increased the maximum size limit for freezer longline LLP vessels, to accommodate larger replacement vessels.	NPFMC and NMFS 2013
Alaska halibut IFQ program	• Survey fishermen about the effects of IFQ management on safety.	Assessment of whether safety improvements occurred after	Knapp 1999

		establishment of a quota-based management system.	
Alaskan halibut and sablefish IFQ program; and BSAI American Fisheries Act Pollock fishery	• Identified the number of fatalities and fatality rates. • Identified the number of search and rescue missions. • Identified number of serious non-fatal injuries.	Assessment of whether safety improvements occurred after establishment of a quota-based management system.	Lincoln et al. 2007
Limited access general category (LAGC) IFQ scallop fishery	• Identified the number of vessel casualties for the LAGC IFQ scallop fishery.	The New England Fishery Management Council (NEFMC) requested a performance review of this fishery.	NMFS 2014

Table 2: Safety Checklist. This list of questions can be used to identify if proposed management measures create a safety concern.

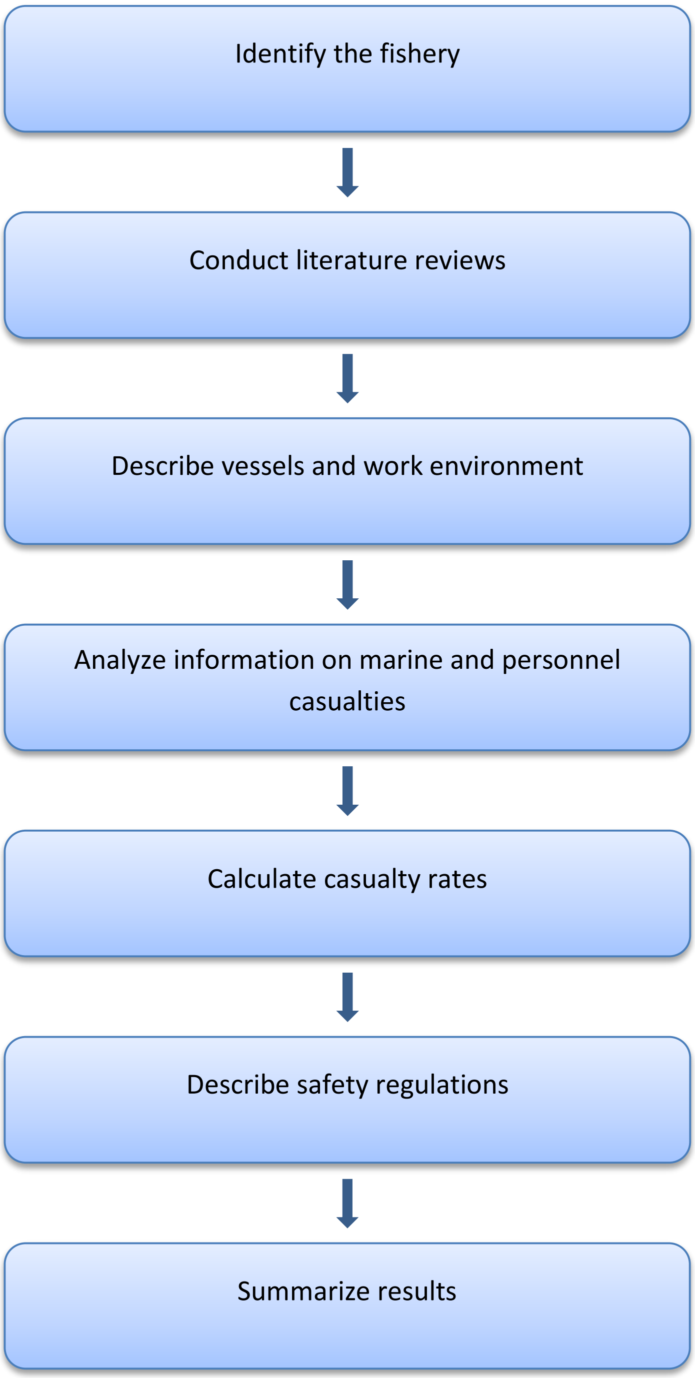
#	Will the proposed management measure:	Response	Likely impact on safety	Potential mitigation measure
1	Cause vessels to operate substantially further offshore?			
2	Increase the distance between where vessels operate and search and rescue assets?			
3	Shift fishing operations to occur when weather and ocean conditions are typically more hazardous?			
4	Restrict transit through closed areas?			
5	Create incentives for vessel operators or crew to work for prolonged periods of time? (e.g., day or trip limits, limiting size of crew)			
6	Encourage unsafe stability practices such as deck loading of fish, extensive deck sorting or catch, or carrying excessive amounts of gear?			
7	Increase the intensity of the fishing season? (e.g., shorten the season; create derby-style conditions)			
8	Prevent the adjustments of fishing seasons in the event of poor weather conditions?			
9	Place restrictions on vessel size, vessel upgrades, or vessel replacement?			
10	Require the delivery of fish products to ports or other strict measures without exceptions for safety concerns?			
11	Deploy an observer where the facilities of the vessel for quartering the observer or for carrying out observer functions would be so inadequate or unsafe that the health or safety of the observer would be jeopardized? (e.g., data collection areas that may pose an extreme hazard to an observer, observer deployment into a sector with comparatively high safety risk)			
12	Cause the addition of an observer to a vessel which would impact the safe operation of the vessel? (e.g., increasing the number of persons on board would exceed life raft capacity or exceed vessel weight capacity)			
13	Create other safety concerns, not described above but known from input from U.S. Coast Guard, Council discussions, or public comment?			

Table 3: Commercial fishing fatalities and fatality rates[*] for full-time equivalent (FTE) employee, by fishery type — United States, 2000–2009. (Lincoln and Lucas, 2010)

Fishery	Fatalities	FTEs	Annual rate per 100,000 FTEs
Groundfish			
Northeast Multispecies Groundfish	26	4,340	600
Atlantic snapper/grouper	6	3,622	170
Alaska halibut	10	7,519	130
Alaska cod	26	21,327	120
Alaska sole	21	–[ǂ]	–
Gulf of Mexico snapper/grouper	10	–	–
Shellfish			
Atlantic scallop[§]	44	10,384	425
West Coast Dungeness crab[¶]	25	8,092	310
Bering Sea and Aleutian Island crab	12	4,658	260
Gulf of Mexico shrimp	55	–	–
Northeast lobster	18	–	–
Gulf of Mexico oyster	11	–	–
Pelagic Fish			
Alaska Salmon	39	34,287	115
West Coast tribal salmon	10	–	–
Other fisheries[**]	165	–	–
Unspecified	26	–	–

[*]Rates were calculated by dividing the total number of fatalities for the 10-year period by total annual FTEs.
[ǂ] Unknown.
[§]Includes the Northeast and Mid-Atlantic regions.
[¶] Excludes two Washington tribal crab fatalities, which are not included in the FTE count.
[**]Fisheries with < 10 fatalities each.

Figure 1. Conceptual diagram of a fishery risk assessment.



Appendix A. Atlantic Scallop Fishery Risk Assessment – 2000 to 2010.

1.   Introduction.

This risk assessment was prepared to accompany the technical guidance and provide an example of how a risk assessment could be conducted. We chose to prepare a risk assessment for the Atlantic scallop fishery because it is known to have a high number of fatalities and a high fatality rate. Through this assessment, we hope to identify potential safety hazards that may exist in the Atlantic scallop fishery. The identification of safety hazards is a critical piece of information that can be used by fishermen, fishery managers, and safety professionals to develop solutions for improving safety at sea. This assessment includes an overview of the fishery and how it is managed, a description of the vessels in the fishery and the work environment, a summary of safety regulations that apply to the fishery, and a review of fishing fatalities that occurred in the fishery from 2000 to 2010. A description of how the fishery is managed and the vessels in the fishery could have been incorporated by reference, but we have chosen to include those descriptions here for completeness.

One of the goals of this assessment was to show that completing a risk assessment can be conducted relatively easily by reviewing and compiling existing information. However, 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. If a relatively simple risk assessment suggests a high level of safety concern and risk in the fishery, fishery managers may be interested in engaging stakeholders in a more comprehensive analysis.

2. Review of studies that have examined safety in the scallop fishery.

While a number of studies have examined safety aspects or perceptions of safety issues within New England fisheries (Poggie et al. 1995, Poggie et al. 1996, Hawkes et al. 1997, Pollnac et al. 1998, Jin and Thunberg 2005, Hall-Arber and Mrakovich 2008, Day et al. 2010, Davis 2011), only a few have focused specifically on the scallop fishery (Kaplan and Kite-Powell 2000, Ciampa et al. 2002, Howard 2010, NMFS 2014). Lincoln and Lucas (2010) analyzed and reported fatality rates for a number of U.S. fisheries and found that of fisheries for which average annual fatality rates could be calculated, the Atlantic scallop fleet (including the Northeast and Mid-Atlantic regions) had the second highest rate; the fishery experienced 44 fatalities between 2000 to 2009 which results in an annual rate of 425 deaths per 100,000 full-time equivalent employees. A USCG report of fishing vessel casualties includes short narratives on some selected vessel casualties, including three scallop vessels (USCG 2011).

Howard (2010) provided a presentation on vessel casualties that occurred from January 2008 to June 2010, in the sea scallop fishery at the National Transportation Safety Board's Fishing Vessel Safety Forum in October 2010. "Vessel casualties" included the following types of accidents: disabled vessel, running aground, allision, collision, capsizing, sinking, flooding, man overboard, medevac, injury, and fire. NOAA's VMS data were used to calculate hours fished which was then used to calculate casualty rates for vessels with different age and size characteristics. Howard reported that when considering vessel age, scallop vessels built between

1970-1979, had the highest reported vessel casualty rate (6.7 reported casualties per 100,000 hours fishing). When considering vessel size, scallop vessels between 30-39 feet had the highest reported vessel casualty rate (121.1 reported casualties per 100,000 hours fishing). Vessels of this size are predominately in the general category component of the fishery. NMFS (2014) examined vessel casualties in the Limited Access General Category (LAGC) Individual Fishing Quota (IFQ) component of the scallop fishery from 2007-2012, and found that this component of the fishery generated 10-15 percent of the number of casualties that the USCG responded to in the Northeast. Since 2007, the number of vessel casualties has declined in this component of the fishery, however, it is difficult to conclude from this information whether safety has improved since the IFQ program was fully implemented in 2010.

Ciampa et al. (2002) documented an effort by the USCG and the Harvard School of Public Health to address safety problems affecting the inshore scallop fishery occurring in coastal waters of Maine. The occurrence of vessel capsizing and acute injuries was high in this fishery compared with other fisheries. They characterized the circumstances that lead to capsizing as either being dynamic (where the vessel's propulsion contributed to the capsizing) or static (where propulsion did not play a role). They identified nine distinct vessel equipment designs that were used in the fishery and found a relationship between the equipment design used on a vessel and the types of accidents that occurred. They found that vessels towing from points aloft in their rigging experienced most of the dynamic stability incidents, while vessels towing and lifting equipment from the sides experienced most of the static stability incidents. They also found that most of the serious occupational type of injuries (e.g., entanglement) occurred on vessels designed to handle equipment over the side of the hull. By demonstrating a relationship between incident type and vessel-equipment design, fisheries safety personnel were able to involve the affected community in identification of risk and development of preventative solutions.

Pollnac et al. (1998) examined individual and cultural factors that influence thresholds to danger among fishermen from New Bedford, MA. They interviewed 44 fishermen (20 Americans, 14 Portuguese, and eight Norwegians) to gauge their perceptions of risk. They noted that younger less experienced individuals with low capital investment had comparatively lower concern for risk, and noted that this group tends to be comprised of American-born scallopers.

Kaplan and Kite-Powell (2000) examined fishermen's perception of safety issues by interviewing 22 boat owners, captains, and crew, all of which had a minimum of 10 years experience in the commercial fishing industry and were from New Bedford, MA. Almost all of the participants were scalloping at the time of the study. Over two-thirds stated they feel comfortable with risk in their lives; two expressed serious concern about their personal risk. Approximately two-thirds rated fisheries management regulations as an important factor that affected safety at sea. Fishermen attributed several safety issues to management regulations; the safety issues mentioned most often were: "…*(1) reduced crew size regulations created overworked and tired crew and prevented bringing new, inexperienced crewmen to learn the trade since "every man needs to pull his full weight"; (2) tightly limited or short-term fishing periods pressured fishermen to go out (or stay out) in bad weather or when there may be problems with their boats; (3) transiting around marine protected areas caused unnecessary dangers in various weather conditions (Fishermen often seemed unsure about the conditions in* *which they might be allowed to transit closed areas.); (4) limiting areas for fishing often caused congestion among boats (especially within shipping lanes).”*

3. Summary of the Atlantic scallop fishery and management measures.

The range of the sea scallop (*Placopecten magellanicus)* extends from North Carolina to the Gulf of St. Lawrence. The scallop fishery occurs year round and extends from Maine to North Carolina. The principal resource areas are the Northeast Peak of Georges Bank, westward to the Great South Channel, and southward along the continental shelf of the Mid-Atlantic. The Atlantic scallop fishery in Federal waters is managed by the New England Fishery Management Council (Council) under the Scallop Fishery Management Plan (FMP). The Council established the Scallop FMP in 1982 and a number of Amendments and Framework Adjustments have been implemented since then to adjust the original plan. Regulations for the fishery are contained in 50 CFR Part 648 subpart D. The fishing year for this fishery is from March 1st to February 28th. A relatively small amount of scallop fishing does occur in state waters of Maine and Massachusetts (NEFMC and NMFS, 2014). Because only a small portion of catch occurs in state waters (less than one percent), this risk assessment will focus on the management and operation of the Federal fishery for Atlantic scallops.

The scallop fishery is managed with a variety of measures including a limited access program, annual catch limits (ACLs), accountability measures, possession limits, gear restrictions, crew size restrictions, a rotational area management program, and essential fish habitat closed areas. Under the rotational management program, there are three types of areas: Rotational Closed Areas; Sea Scallop Access Areas; and Open Areas. These areas are defined and will be closed and reopened to fishing on a rotational basis, depending on the condition and size of the scallop resource in the areas. Figure A1 shows the scallop access areas, closed areas, and essential fish habitat closed areas as of fishing year 2014. Two types of scallop permits exist in the fishery: limited access permits and limited access general category (LAGC) permits. The fishing gears used in this fishery are scallop dredge and trawl.

There are eight categories of limited access permits; categories are based on whether the vessel is a full-time, part-time, or occasional vessel and the fishing gear used (dredge, small dredge, or bottom trawl; see Table A1). The majority of limited access permits are issued to full-time vessels that use dredge gear (Category 2). Ninety-four and a half (94.5) percent of the total ACL for the scallop fishery is allocated to limited access vessels. On an annual basis, vessels with limited access permits are assigned days-at-sea (DAS) to use in open areas as well as an allocation of scallops (in pounds) that can be caught in specific controlled access areas. For example, in 2015, all full time limited access vessels were allocated 30.86 DAS to use in open areas, and 51,000 lbs. of scallops that could be fished in the Mid-Atlantic Access Area. Vessels could take their poundage allocation in the access area in as many trips as needed, as long as they did not exceed the trip possession limit of 17,000 lbs.

The general category scallop fishery was historically an open access fishery allowing any vessel to fish for up to 400 lbs. of scallops per trip, provided the vessel has been issued a general category or limited access scallop permit. This open access fishery was established in 1994 by

Amendment 4 to the FMP to allow vessels fishing in non-scallop fisheries to catch scallops as incidental catch, and to allow a small-scale scallop fishery to continue outside of the limited access and effort control programs that applied to the larger-scale scallop fishery. Over time, participation in the general category fishery increased. Out of concern about growth in the level of fishing effort, the Council developed and adopted Amendment 11 in 2007 to create three categories of LAGC permits. LAGC vessels use both dredge and trawl gear.

The three categories of LAGC permits are: LAGC individual fishing quota (IFQ) vessels; LAGC Northern Gulf of Maine (NGOM) vessels; and LAGC incidental catch vessels. For all three LAGC permits, VMS is required to be installed, activated, and a) transmitting a positional signal, or b) declared into a scallop power down activity code, or c) issued a VMS 'Letter of Exemption' from NMFS to power down the vessel's VMS unit.

Of the remaining 5.5 percent of the total ACL for the scallop fishery, five percent is allocated to LAGC IFQ vessels and translated into IFQs; and 0.5 percent to LAGC IFQ vessels that also have a limited access scallop permit (i.e., scallop DAS), and translated into IFQs for such vessels. Vessels with LAGC incidental catch scallop permits are managed under an annual target total allowable catch and possession limits. There is an annual hard total allowable catch for the Northern Gulf of Maine management area and vessels with LAGC NGOM permits are subject to possession limits.

LAGC IFQ vessels are subject to possession limits of 600 lbs. on any IFQ trip. LAGC IFQ vessels and limited access vessels with LAGC IFQ permits also receive a fleet-wide allocation of access area trips, giving them the option to fish their IFQ in access areas, rather than open areas, so long as the trips have not been fully taken.

4. Management measures that address safety issues.

The NEFMC and NMFS have implemented a number of measures that in part, address safety issues within the scallop fishery. Although these measures may not have been implemented solely for safety reasons, they may indirectly improve safety in the fishery. A few examples are provided below.

Carry-over provisions

There are carry-over provisions in both the limited access and LAGC IFQ fisheries (see 50 CFR 648.53(d) and (v)). Limited access vessels that have unused open area DAS at the end of the fishing year may carry over a maximum of 10 DAS, not to exceed the total open area DAS allocation by permit category, into the next year. LAGC IFQ vessels that have unused IFQ at the end of the fishing year may carry over up to 15 percent of the vessel's original IFQ into the next fishing year. These carry-over provisions provide a safety mechanism for vessel owners, in that it allows them to avoid fishing in bad weather at the end of the fishing year, while retaining some of their unused quota or DAS.

Compensation for broken trips

Previously, limited access vessels were allocated a certain number of trips that could be taken in a Sea Scallop Access Areas. If a vessel terminated a Sea Scallop Access Area trip before catching the allowed possession limit, the vessel could be authorized to fish an additional trip in the same Sea Scallop Access Area based on certain broken trip notification and compensation trip requirements. As noted in Framework Adjustment 17, this provision was intended to improve safety, as it allowed vessels facing inclement weather or other adverse conditions that might compromise safety to make a decision that favors a safer course of action. Under Framework Adjustment 26, the New England Fishery Management Council and NMFS provided additional flexibility to the fishery by removing the requirement that fishermen send in broken trip and compensation trip forms (76 FR 22119; April 21, 2015). Vessels are now allocated a number of pounds that can be taken from an access area and can harvest that allocation in as many trips as needed, as long as they do not exceed trip possession limits. For example, a vessel could harvest 54,000 lbs. of scallops from an area in three trips of 18,000 lbs., or several more trips with less pounds per trip. This provides each vessel owner and captain more flexibility in their harvest and would allow more vessel operator discretion in the face of hazardous or life-threatening situations. Framework Adjustment 26 also allows all unharvested scallop pounds from an access area to automatically carry over into the first 60 days of the next year. This eliminates the requirement for vessels to have to break a trip in the last 60 days of a fishing year in order to carry them over to the next. This measure also makes the access area fisheries more flexible and allows more owner and operator discretion.

Gear stowage provision

When vessels transit through particular areas, regulations may require that fishing gear be "not available for immediate use" (i.e., stowed) (50 CFR 648.2). For example, while outside a Sea Scallop Access Area on a Sea Scallop Access Area trip, vessels must have fishing gear stowed, unless there is a compelling safety reason to be transiting without gear stowed (50 CFR 648.60(a)(7)). In the final rule to Framework Adjustment 15 (68 FR 9580; 2/28/2003), NMFS modified the gear stowage provision for scallop dredges to improve safety. The new provision eliminated the need for vessel operators to disconnect towing wires and reel them fully onto the winch in order for the gear to be considered properly stowed. Reconnecting the wire at sea was determined to be dangerous, particularly in rough seas. This provision improved the safety on board vessels that were required to stow gear.

Start-of-trip notification provision

As of May 2012, scallop vessels are able to declare a scallop trip anywhere shoreward of the vessel monitoring system (VMS) Demarcation Line, rather than from a designated port (50 CFR 648.10(e)(f)). As explained in Framework Adjustment 23, the rational for this provision was to improve safety by eliminating the previous requirement that at times resulted in scallop vessels steaming into unfamiliar ports to declare their scallop trips before being able to fish.

Vessel Replacement

NMFS and the New England and Mid-Atlantic Fishery Management Councils are considering changes to regulations that would simplify vessel baselines. In June 2015, NMFS published a proposed rule that would eliminate the one-time limit on vessel upgrades and remove gross and net tonnages from the vessel baseline specifications that are considered when determining a vessel's baseline for replacement purposes (80 FR 31343; 6/2/2015). This rule, if implemented, will provide flexibility to vessel owners in the selection of replacement vessels and upgrades to existing vessels. Providing more flexibility in the ability to replace older vessels with newer vessels could improve safety because newer vessels will have to meet more stringent construction standards and can incorporate advances in marine design that improve a vessel's safety. For example, the Coast Guard Authorization Act of 2010 and the Coast Guard and Maritime Transportation Act of 2012 established new safety requirements for commercial fishing vessels, including vessel construction standards, and survey, classification, and loadline requirements for certain new vessels.

5. Description of the vessels in the Atlantic scallop fishery.

Number of vessels in the fishery

The limited access fishery is primarily full-time, with a small number of part-time permits (Table A2). Of these permits, the majority are dredge vessels, with a small amount of full-time small dredge and full-time trawl vessels.

There was considerable growth in the general category fishery in the early 2000's, although not all vessels with general category permits were active (Table A3). From 2000 to 2007, the number of general category permits ranged from 2263 to 2950. The number of general category permits declined considerably after 2007 as a result of the Amendment 11 provisions. In 2010, 740 vessels had permits in the LAGC fishery, but only 267 were active.

Vessel Horsepower

In the limited access fishery, the horsepower of permitted vessels ranges from <500 hp to greater than 1000 hp (NEFMC 2010). The majority of the limited access vessels have a horsepower of 500 or greater. In contrast, the general category scallop vessels are relatively smaller vessels and most have a horsepower less than 500 hp (NEFMC 2010).

Vessel Length and Tonnage

Limited access vessels are generally larger than general category vessels. The majority of limited access vessels are greater than 70 ft, while the majority of general category vessels are less than 50 ft (NEFMC 2007). The majority of limited access vessels are also greater than 100 gross tons, while the majority of general category vessels are less than 50 gross tons (NEFMC 2007).

Safety Examinations

Both the limited access and general category components of the scallop fishery are subject to an industry-funded observer program managed by the Northeast Fisheries Observer Program. Scallop fishermen must call-in to NMFS before an intended trip, and NMFS will then determine if an observer must be hired for the trip. Vessels that carry a fisheries observer must display or show proof of a valid USCG Commercial Fishing Vessel Safety Examination decal. Because this fishery has observer coverage, it is likely that a high percentage of vessels in this fishery possess a USCG Commercial Fishing Vessel Safety Examination decal and are therefore meeting USCG safety regulations. Observer coverage rates for the access and open areas are determined at the start of each fishing year. In FY 2012, the coverage rates range from 15 percent in open areas to 23 percent in access areas. Scallop vessels are also subject to observer coverage beyond the industry-funded observer program. Those trips are random intercepts consistent with similar requirements for all other FMPs, and are subject to the same vessel safety decal requirement.

6. Description of the work environment.

Time and location of operation

For management purposes, a fishing year for this fishery is from March 1st to February 28th. Fishing typically occurs year around. The Atlantic sea scallop fishery is prosecuted in concentrated areas in and around Georges Bank and off the Mid-Atlantic coast, in waters extending from the near-coast out to the continental shelf. Although all sea scallops in the U.S. EEZ are managed as a single stock, four regional components and six resource areas are recognized. Major aggregations occur in the Mid-Atlantic from Virginia to Long Island (Mid-Atlantic component), Georges Bank, the Great South Channel (South Channel component), and the Gulf of Maine (Hart and Rago 2006, NEFMC 2010). These four regional components are further divided into six resource areas: Delmarva (Mid-Atlantic), New York Bight (Mid-Atlantic), South Channel, southeast part of Georges Bank, northeast peak and northern part of Georges Bank, and the Gulf of Maine (NEFMC 2010). Georges Bank and the Mid-Atlantic contain the largest concentrations of sea scallops (NEFMC 2010).

Water temperature

Mean sea surface water temperature off the Northeastern U.S. ranges from around 3ºC in March to 23ºC in August.[8] Given the cold water conditions, if an individual were to fall overboard, they would be at risk of experiencing immersion hyperthermia.

Crew size

Regulations related to crew size are contained in 50 CFR 648.51(c) and (e). Full-time limited access vessels fishing under DAS and full-time limited access vessels fishing in the Delmarva Access Area may have no more than seven people aboard when not docked or moored in port. However, there is no restriction on the number of crew for vessels participating in the scallop area access program, other than the Delmarva Access Area. Based on observer data, between 2002 and 2005, the average crew size was 3.1 for general category vessels and seven for limited access vessels (NEFMC 2007).

Fishing gear

As indicated previously, the primary fishing gears used in this fishery are the scallop dredge and trawl, and the regulations on fishing gear are contained in 50 CFR 648.51. Generally, for all vessels issued limited access and LAGC scallop permits and fishing with scallop dredges (except for those with a "small dredge" permit), the combined dredge width in use by or in possession on board the vessels shall not exceed 31 ft measured at the widest point in the bail of the dredge. Limited access vessels with "small dredge" permits (categories five and six) must fish exclusively with one dredge no more than 10.5 ft. Vessels that use trawl nets to fish for scallops are subject to requirements on mesh size and maximum trawl sweep (not to exceed 144 feet).

[8] http://nefsc.noaa.gov/ecosys/advisory/current/sst.html

7. Safety regulations.

The USCG's safety regulations for commercial fishing vessels are contained in 46 CFR Part 28. The regulatory requirements vary depending on vessel size, date vessel was built, number of persons on board, the type of vessel (fishing, fish tender, and fish processing vessels), and location of operation (miles from shore, or cold water vs. warm water). Because the scallop fishery operates in cold water, the vessels would have to comply with the specific regulations for survival craft and would be required to carry immersion suits. The Coast Guard Authorization Act of 2010 and the Coast Guard and Maritime Transportation Act of 2012 established additional safety and equipment requirements for U.S. commercial fishing vessels. Some of the major requirements established by these Acts include:

- Uniform safety standards and equipment requirements for all commercial fishing vessels operating beyond three nautical miles (NM).
- Commercial fishing vessels operating beyond three NM must carry approved survival craft applicable to their vessel that ensures that no part of an individual is immersed in water.
- Commercial fishing vessels operating beyond three NM must be examined dockside at least once every five years.
- Individuals in charge of a commercial fishing vessel that operates beyond three NM must pass a training program.
- New commercial fishing vessels, built after January 1, 2010, that are less than 50 ft in overall length must be constructed in a manner that provides a level of safety equivalent to the minimum standards established for recreational vessels.
- New commercial fishing vessels, built after July 1, 2013, that are 79 ft or greater in length must be load lined.
- New commercial fishing vessels, built after July 1, 2013, that are at least 50 feet overall in length and operate beyond three NM must be designed, constructed, and maintained to the standards of a classification society.
- USCG must develop Alternate Safety Compliance Programs for certain older vessels and certain vessels that undergo a major conversion.

For more information on fishing vessel safety, visit www.fishsafe.info.

8. Review of fishing fatalities in the Atlantic Scallop fishery.

Safety information for the scallop fishery from years 2000 to 2010 was obtained from the Commercial Fishing Incident Database (CFID) that is maintained by the National Institute for Occupational Safety and Health (NIOSH). NIOSH developed CFID to collect and analyze data on fatalities in the entire U.S. commercial fishing industry and contains information on fatalities since 2000. The purpose of CFID is to identify high-risk fisheries in the U.S. and to identify the risk factors that contribute to fatal incidents. Data for CFID are collected from multiple sources, including the U.S. Coast Guard's (USCG) Marine Information for Safety and Law Enforcement (MISLE) database, law enforcement agencies, and state-based occupational fatality surveillance programs. CFID includes information specific to each incident including vessel characteristics, environmental factors, and victim characteristics.

Two of the variables included in CFID are the general category of fish (e.g., shellfish, groundfish, pelagic) and the species of fish that a fishing vessel was targeting at the time of the incident. The values for these variables are usually determined by reviewing information within the MISLE database and the USCG's investigation report of an incident. The species that the vessel was targeted at the time of the incident is used to determine which fishery the vessel was participating in. For this report, we analyzed fatal incidents on vessels that were targeting scallops in the Atlantic Ocean at the time of the incident. Only fatal incidents that occurred while a vessel was fishing or transiting were included in the analysis; two fatalities that occurred due to non-fishing related causes (e.g., drugs, alcohol, suicide) and two fatalities that occurred from falling off a dock, were excluded from this analysis.

From 2000 to 2010, 41 commercial fishing deaths occurred to fishermen in the scallop fishery (Figure A2). Those fatalities occurred in 23 separate fatal incidents, therefore some incidents resulted in more than one fatality. Between zero and four fatal incidents occurred a year during the 2000 to 2010 time period (Table A2).

There were three types of fatal incidents; 30 fatalities occurred due to vessel disasters, eight fatalities occurred due to falls overboard, and three occurred due to on-board injuries. For the purposes of CFID, a vessel disaster is defined as “a catastrophic marine casualty which forces the crew to abandon the vessel because it is no longer safe to remain on-board.” Vessel disasters often result in multiple fatalities and are usually caused by a sequence of events, starting with an initiating event. In the scallop fishery, the 30 fatalities that occurred due to vessel disasters during 2000-2010 took place in 12 separate incidents. The initiating events that led to those disasters were: flooding, instability, collision, gear getting caught on the bottom, and a large wave striking the vessel (Figure A3). Of the eight fatalities that occurred due to a fall overboard, four were not witnessed, two were due to entanglement, one was due to vessel motion, and one was due to leaning over the side. Of the three fatalities that occurred due to an on-board injury, one was due to gear entanglement, one was due to a fall from height, and one was due to being struck by gear/object.

Of the 23 fatal incidents that occurred from 2000-2010, Table A4 indicates the type of fishing permit that the fishing vessel had at the time of the incident and what type of incident occurred (fall overboard, vessel disaster, or on-board injury). Thirteen of the fatal incidents occurred on vessels participating in the limited access component of the scallop fishery, nine occurred in the general category component (including LAGC), and one occurred on a vessel that did not have a Federal scallop permit at the time of the incident and it is expected that it was participating in a state scallop fishery. When factoring in the number of active vessels for each of the two major sectors of the fishery, the limited access fishery experienced an average of 6.9 fatalities per 1000 active vessels, while the general category/limited access general category fishery experienced an average of 3.7 fatalities for 1000 active vessels (Table A5). The limited access full-time dredge vessels had the highest number of fatal incidents out of all the limited access vessels (10 out of 13), which was not surprising as full-time dredge vessels make up the vast majority of limited access vessels (around 71 percent; Table A2).

Note that of the permits listed in Table A4, the General Category and the General Category (VMS required) permits are no longer issued. The General Category fishery existed from 1994 to 2008 before it became categorized as Limited Access General Category. In 2005, NMFS implemented Framework Adjustment 17 to the scallop FMP which required general category vessels that land, or intended to land, more than 40 lbs. of shucked, or five bushels unshucked scallops, to install and operate a VMS onboard the vessel, hence the "General Category (VMS required)" permit type.

Most of the fatal incidents (74 percent) occurred while vessels were fishing (Table A6). When considering vessel length, vessels between 70 to 79 ft experienced the most fatalities (46 percent) and fatal incidents (43 percent) (Table A7). Vessel disasters occurred on relatively smaller vessels (of length between 30-79 feet), whereas fall over boards occurred on relatively larger vessels (of length between 70-99 feet; Table A7). When considering vessel age, most fatal incidents (52 percent) occurred on vessels built between 1970 to 1989; there does not appear to be any relationship between vessel age and the type of fatal incident experienced on the vessel (Table A8). Nineteen of the fatal incidents occurred on vessels that were using dredge gear, while the remaining four occurred on vessels using trawl gear. This was not surprising as most of the fishing effort occurs with dredge gear. Fourteen of the fatal incidents occurred on vessels that had a current USCG safety decal at the time, whereas the remaining nine incidents occurred on vessels that had an expired safety decal or no decal at all.

Of the 23 fatal incidents most (65 percent) of the incidents occurred on vessels located between 10 and 50 miles from shore at the time of the incident (Table A9). Figure A4 illustrates the locations where fatal incidents occurred. There does not appear to be any seasonality to the number of fatal incidents, as fatal incidents occurred consistently throughout the year; either five or six fatal incidents occurred during each season (winter, spring, summer, and fall; Table A10).

9. Discussion.

The Atlantic scallop fishery experienced 41 fatalities during 23 separate fatal incidents between 2000 and 2010. Of fisheries for which average annual fatality rates have been calculated, the Atlantic scallop fishery has the second highest rate, with an annual rate of 425 deaths per 100,000 full-time equivalent employees (Lincoln and Lucas 2010). This report analyzed the available safety data for the scallop fishery and did not identify a consistent contributing factor or characteristic of the fatalities experienced in this fishery.

There were three main types of fatal incidents: 30 fatalities occurred due to a vessel disaster, eight fatalities occurred due to a fall overboard, and three occurred due to an on-board injury. As described above, a vessel disaster is defined as "a catastrophic marine casualty which forces the crew to abandon the vessel because it is no longer safe to remain on-board." The fact this fishery operates in cold water and that 38 of the 41 fatalities had something to do with entering the water, either as a result of falling overboard or during an event that caused individuals to abandon the vessel, highlights the importance of survival gear, training, and knowing what to do in the event of an emergency or fall overboard.

The limited access sector of the fishery experienced 24 fatalities, while the general category/limited access general category sector of the fishery experienced 16 fatalities. When factoring in the number of active vessels for each of the two sectors, the limited access fishery experienced an average of 6.9 fatalities per 1000 active vessels, while the general category/limited access general category fishery experienced an average of 3.7 fatalities for 1000 active vessels (Table A5). We calculated a fatality rate based on number of active vessels, because that information was readily available to the authors. Further research should examine whether the limited access fishery does in fact experience greater risks and if so, attempt to mitigate those risks.

When considering vessel length, the number of fatalities and fatal incidents was highest on vessels between 70-79 ft (Table A7); and when considering vessel age, most of the fatal incidents occurred on vessels built between 1970-1989 (Table A8). Fatalities due to vessel disasters occurred on relatively smaller vessels (of length between 30-79 feet), whereas fatalities due to falls overboard occurred on relatively larger vessels (of length between 70-99 feet; Table A7). It is important to note the limitations of these data, as they were not adjusted by fishing effort, so we are not able to draw specific conclusions about the observed trends. However, given that fatal falls overboard tend to occur on relatively larger vessels (between 70-99 feet), crew that operate on vessels of that size may want to seek training on how to prevent falls overboard and how to respond to a fall overboard event.

Howard (2010) reported that when considering vessel age, vessels built between 1970 and 1979, had the highest reported vessel casualty rate; and when considering vessel size, scallop vessels between 30 and 39 ft had the highest reported vessel casualty rate. Further research into the fatalities and accidents on these categories of vessels may identify opportunities for accident prevention. Additionally, a better understanding of scallop fishermen's perception of safety issues would aid in developing solutions to promote safety at sea in this fishery.

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Table A1. Limited Access Permit Categories in the Atlantic Scallop Fishery.[9]

Category	Type
2*	Full-Time: This category includes all gear types except bottom trawl.
3*	Part-Time: This category includes all gear types except bottom trawl.
4	Occasional: This category includes all gear types except bottom trawl.
5*	Full-Time Small Dredge: Category 3 (Part-Time) vessel may elect this category for the entire year if the vessel uses one dredge no larger than 10.5 ft and with no more than five people on board. This category is limited to dredge gear only.
6*	Part-Time Small Dredge: Category 4 (Occasional) vessel may elect this category for the entire year if the vessel uses one dredge no larger than 10.5 ft and with no more than five people on board. This category is limited to dredge gear only.
7*	Full-Time: Authorized to use trawl nets: This category in limited to bottom trawl nets only.
8*	Part-Time: Authorized to use trawl nets: This category in limited to bottom trawl nets only.
9	Occasional: Authorized to use trawl nets: This category in limited to bottom trawl nets only.

*A vessel monitoring system (VMS) is required to be installed and in continuous operation onboard the vessel, unless the vessel is issued a VMS 'Letter of Exemption' from NMFS to power down the VMS unit.

[9] Table from the Initial Federal Northeast Region Fishing Vessel Permit Application, available at: http://www.nero.noaa.gov/permits/forms.html.

Table A2. Number of Limited Access Vessels in the Atlantic Scallop Fishery by Permit Category and Gear Type.[10] (NEFMC 2012)

Permit Category	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
Full-time	220	224	234	238	242	248	255	256	254	259	252
Full-time small dredge	3	13	25	39	48	57	59	63	56	55	54
Full-time net boat	17	16	16	16	15	19	14	12	11	11	11
Total full-time	240	253	275	293	305	324	328	331	321	326	317
Part-time	16	14	14	10	4	3	3	2	2	2	2
Part-time small dredge	4	6	8	19	26	30	34	35	32	34	34
Part-time trawl	20	18	10	8	3						
Total part-time	40	38	32	37	33	33	37	37	34	37	38
Occasional	4	5	4	3	3	1	2	1	1		
Occasional trawl	16	19	15	8	5	5					
Total Occasional	20	24	19	11	8	6	2	1	1	0	0
Total Limited Access	300	315	326	342	346	363	367	369	356	361	353
Number of active[11] limited access vessels	258	281	292	303	315	327	340	353	348	353	351

[10] Note that the permit numbers in the table include duplicate entries because replacement vessels receive new permit numbers and when a vessel is sold, the new owner would get a new permit number.
[11] "Active" vessels are ones that have at least one dealer report connected to the vessel.

Table A3. Number of General Category Permits in the Atlantic Scallop Fishery Before and After Amendment 11 Implementation. (NEFMC 2012)

Year	General category permit (up to 2008)	Number of limited access general category permits: IFQ permit (A)	NGOM permit (B)	Incidental catch permit (C)	Grand Total	Number of active vessels[12]
2000	2263				2263	208
2001	2378				2378	280
2002	2512				2512	299
2003	2574				2574	337
2004	2827				2827	446
2005	2950				2950	618
2006	2712				2712	639
2007	2493				2493	485
2008		342	99	277	718	439
2009		344	127	301	772	317
2010		333	122	285	740	267

[12] Note that the number of active vessels may include duplicate records for replaced vessels with different permit numbers.

Table A4. Number of Fatal Incidents in the Atlantic Scallop Fishery from 2000 to 2010 by Permit and Incident type.[13]

Type of Scallop Permit	Type of Fatal Incident: Vessel Disaster	On-board Injury	Fall Overboard	Total # of Fatal Incidents
Limited Access - Full-Time: Authorized to use trawl nets			1	1
Limited Access - Full-Time (dredge)	3	2	5	10
Limited Access - Full-Time small dredge	1			1
Limited Access - Part-Time small dredge			1	1
General Category	4			4
General Category (VMS required)	3		1	4
Limited Access General Category IFQ Permit	1			1
No Federal Permit (assume participating in state scallop fishery)		1		1
			sum	23

[13] Information on fatal incidents was obtained from NIOSH Commercial Fishing Incident Database. Information on permit type for each vessel that experienced a fatal incident was obtained from the NMFS Northeast Regional Permit Office.

Table A5. Number of Fatalities and Fatal Incidents in the Atlantic Scallop Fishery as a whole, and for the two main sectors of the fishery – Limited Access and General Category/General Category Limited Access.[14]

	Scallop Fishery		Limited Access Fishery				General Category & GC Limited Access			
Year	# of fatalities	# of fatal incidents	# of fatalities	# of fatal incidents	# of active vessels	# of fatalities per 1000 active vessels	# of fatalities	# of fatal incidents	# of active vessels	# of fatalities per 1000 active vessels
2000	3	3	2	2	258	7.75	1	1	208	4.81
2001	1	1	1	1	281	3.56			280	0.00
2002	1	1	1	1	292	3.42			299	0.00
2003	10	4	4	2	303	13.20	6	2	337	17.80
2004	6	2	6	2	315	19.05			446	0.00
2005	3	3	2	2	327	6.12	1	1	618	1.62
2006	5	4	1	1	340	2.94	4	3	639	6.26
2007	2	1			353	0.00	2	1	485	4.12
2008	0	0			348	0.00			439	0.00
2009	10	4	7	2	353	19.83	2	1	317	6.31
2010	0	0			351	0.00			267	0.00
Total=	**41**	**23**	**24**	**13**			**16**	**9**		
					average rate=	6.90			average rate=	3.72

[14] Information on fatal incidents was obtained from NIOSH Commercial Fishing Incident Database. Information on permit type for each vessel that experienced a fatal incident was obtain from the NMFS Greater Atlantic Regional Fisheries Office. The number of active vessels was obtained from Appendix 1 of Framework 24 to the Scallop FMP (NEFMC 2012).

Table A6. Activity of Vessel at Time of Fatal Incident.[15]

Activity at time of fatal incident	# of Fatalities	# of Fatal Incidents
Fishing	31	17
Transit Inbound or Outbound	6	5
Unknown (either fishing or transiting)	4	1
Total	**41**	**23**

Table A7. Length of Vessel for those Vessels that Experienced Fatal Incidents in the Atlantic Scallop Fishery.[16]

Vessel Length	# of Fatalities	Type of Incident			# of Fatal Incidents
		Vessel Disaster	On-board Injury	Fall Overboard	
0-29	0				0
30-39	2	1			1
40-49	9	3	1		4
50-59	3	3			3
60-69	5	2			2
70-79	19	3	2	5	10
80-89	2			2	2
90-99	1			1	1
Total	**41**	**12**	**3**	**8**	**23**

[15] Information on fatal incidents was obtained from NIOSH Commercial Fishing Incident Database.
[16] Information on fatal incidents was obtained from NIOSH Commercial Fishing Incident Database.

Table A8. Number of Fatalities and Fatal Incidents by Year Vessel was Built and Incident Type.[17]

Year Built	# of Fatalities	Type of Fatal Incident			# of Fatal Incidents
		Vessel Disaster	On-board Injury	Fall Overboard	
1940-1949	1			1	1
1950-1959	5	2			2
1960-1969	9	2		1	3
1970-1979	12	3	1	2	6
1980-1989	6	3	1	2	6
1990-1999	0				0
2000-2009	6	2		1	3
unknown	2		1	1	2
Total	**41**	**12**	**3**	**8**	**23**

Table A9. Distance to the Closest Point of Land during Fatal Incidents in the Atlantic Scallop Fishery.[18]

Miles from shore	# of Fatalities	# of Fatal Incidents
0	0	0
>0 to 3	2	2
>3 to 10	2	1
>10 to 30	11	6
>30 to 50	16	9
>50 to 70	8	3
>70 to 140	2	2
total	**41**	**23**

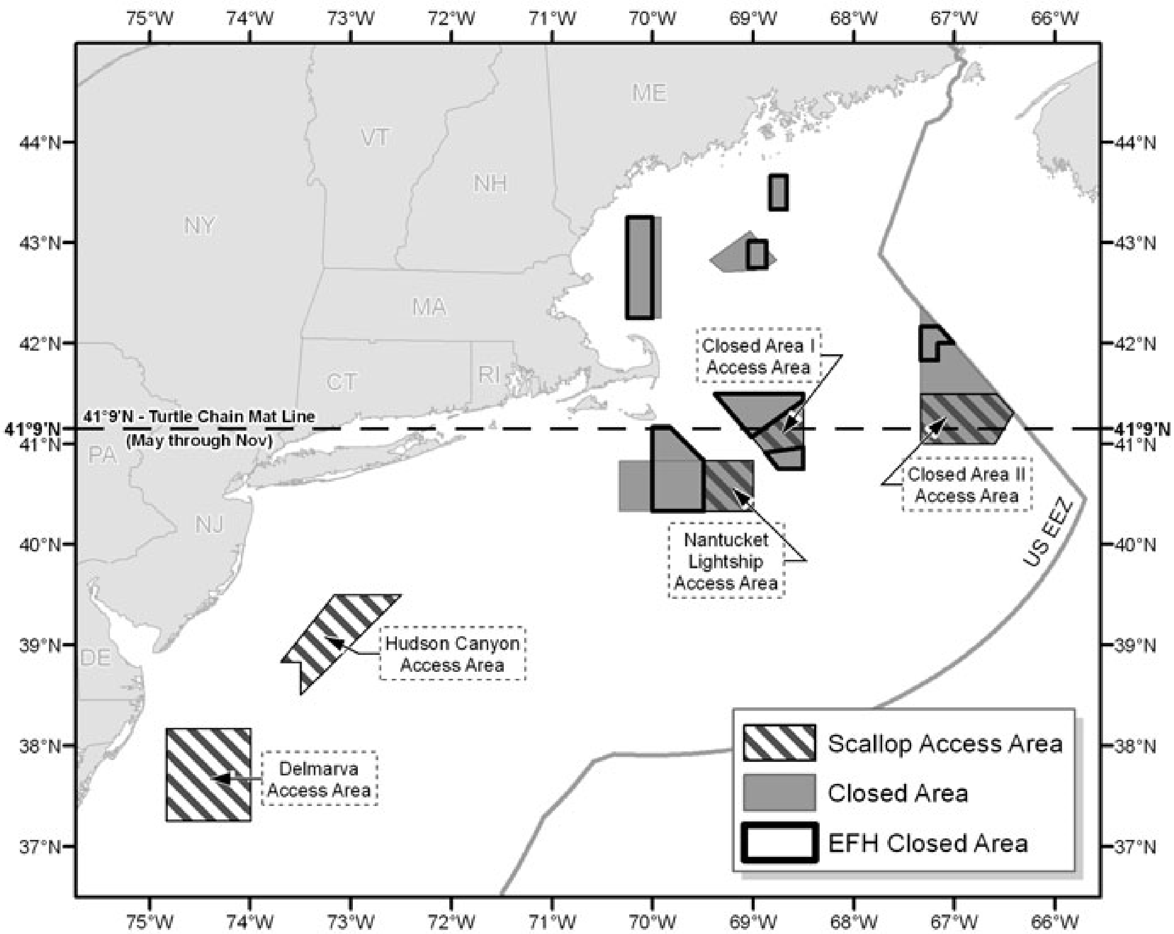
[17] Information on fatal incidents was obtained from NIOSH Commercial Fishing Incident Database.
[18] Information on fatal incidents was obtained from NIOSH Commercial Fishing Incident Database.

Table A10. Number of Fatalities and Fatal Incidents in the Atlantic Scallop Fishery by Month and Season.[19]

Month	# of Fatalities	# of Fatal Incidents	# of Fatal Incidents per Season
December	11	4	6
January	2	2	
February	0	0	
March	7	2	6
April	1	1	
May	4	3	
June	4	3	5
July	0	0	
August	2	2	
September	3	2	6
October	7	4	
November	0	0	
Total	**41**	**23**	

[19] Information on fatal incidents was obtained from NIOSH Commercial Fishing Incident Database.

Figure A1. Atlantic Scallop Fishery Management Areas.[20]



[20] NMFS Northeast Regional Office, http://www.nero.noaa.gov/nero/fishermen/charts/scal4.html, obtained on 12/11/14

Figure A2. Number of Fatalities and Fatal Incidents that Occurred in the Atlantic Scallop Fishery from 2000 – 2010.[21]

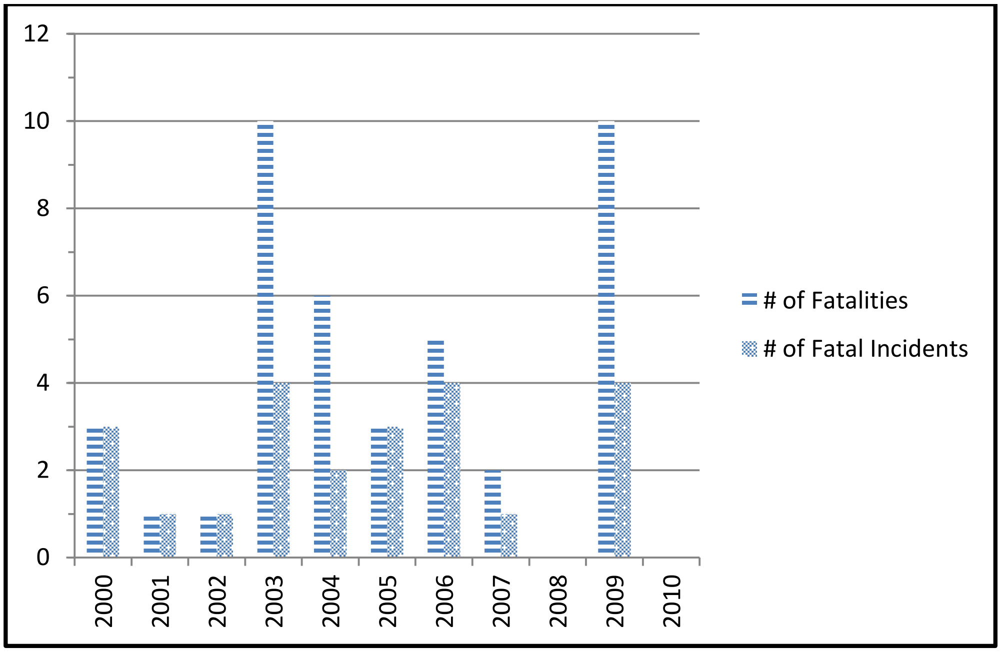
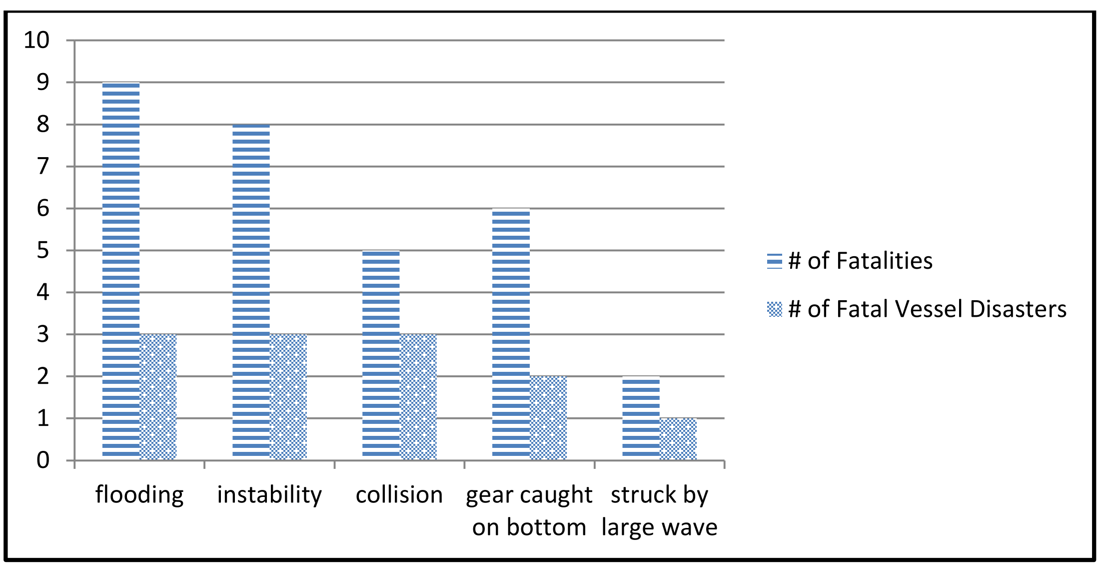
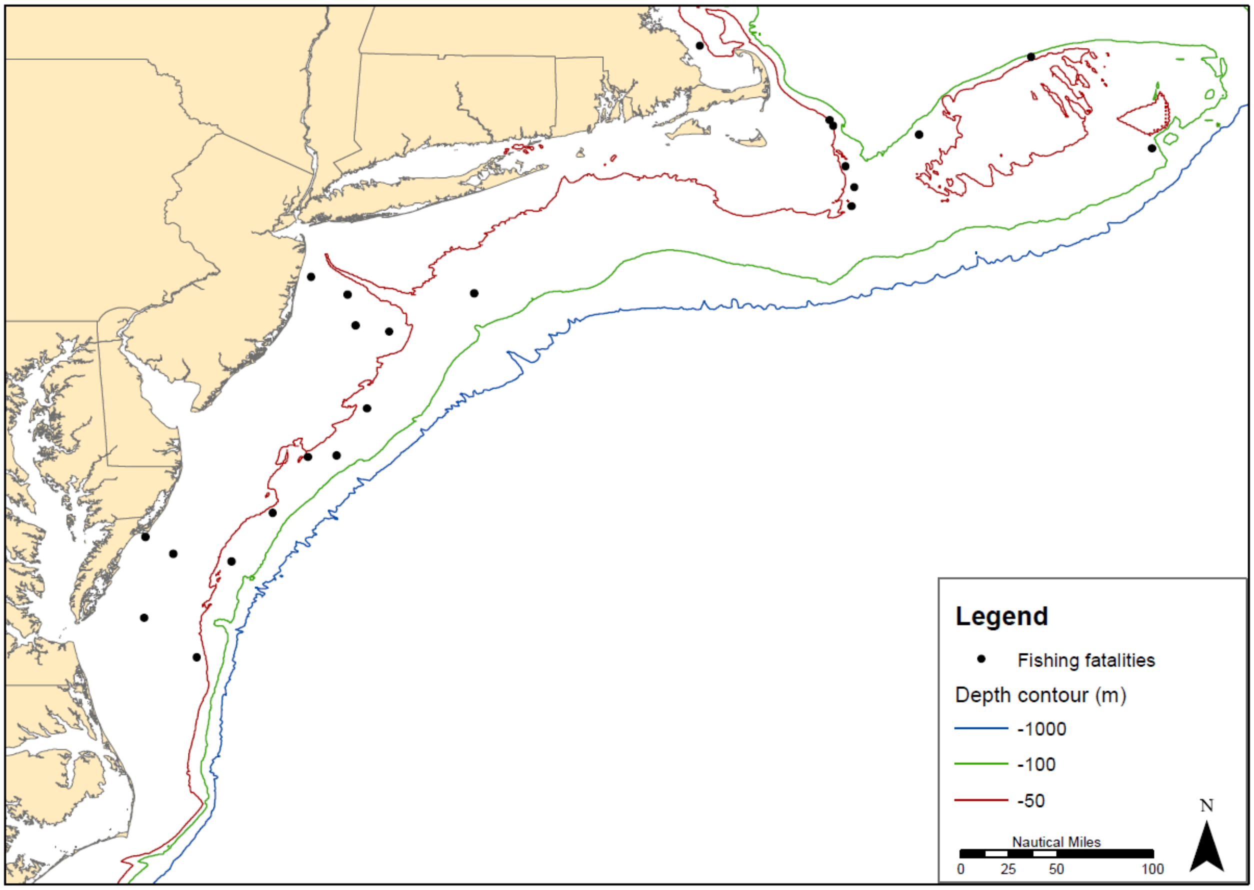


Figure A3. Initiating Event that Lead to a Fatal Vessel Disaster in the Atlantic Scallop Fishery, 2000-2010.[22]



[21] Information on fatal incidents was obtained from NIOSH Commercial Fishing Incident Database.
[22] Information on fatal incidents was obtained from NIOSH Commercial Fishing Incident Database.

Figure A4. Location of Fatal Vessel Incidents in the Atlantic Scallop Fishery.[23]



[23] Information on fatal incidents was obtained from NIOSH Commercial Fishing Incident Database.