Atlantic States Marine Fisheries Commission

Healthy, self-sustaining populations for all Atlantic coast fish species or successful restoration well in progress by the year 2015

Report of the Fishing Gear Technology Work Group to the Management and Science Committee

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Executive Summary

Introduction

The Commission's Interstate Fisheries Management Program Policy Board requested the Management and Science Committee (MSC) investigate the need to reconvene the Conservation Engineering Committee (CEC). The CEC was active in the 1990s and contributed to the evaluation and implementation of new gear technology, including Bycatch Reduction Devices (BRDs) in South Atlantic fisheries. Following the Board's request, in 2006, the MSC recommended the formation of the Fishing Gear Technology Work Group (FGTWG). The Group was instructed to focus on fishery-dependent aspects of gear conservation (e.g., BRDs and other gear modifications). The Policy Board approved the formation of the FGTWG to begin work in 2007. The charge given to the FGTWG was to identify and evaluate studies of fishing gear selectivity, bycatch reduction, gear effects on habitat, and impacts of a single gear used in multispecies fisheries (ecosystem planning); develop a comprehensive report of gear work along the coast; evaluate the work to see if it is ready to be implemented in the management process, develop research recommendations, and determine the transferability of completed research to other species and geographical areas. This includes identifying relevant studies from outside the Atlantic Coast and evaluating their findings for possible application to ASMFC species. Based on a prioritization matrix of ASMFC managed fisheries, the group identified ten fisheries to be comprehensively investigated in 2008. Individual fishery summaries are listed below in no particular order of importance.

Trawl Fisheries

A considerable body of research has been conducted on the size selection characteristics of trawl codends for summer flounder, winter flounder, and scup. Bycatch of non-target finfish species in the scup fishery remains a problem in need of better documenting through at-sea sampling. Protected species bycatch in the trawl fisheries is problematic. The National Marine Fisheries Service is considering seasonal regulations requiring Turtle Excluder Devices (TEDs) in trawls operating south of Cape Cod. Small cetacean bycatch in the trawl fisheries is also problematic, although these fisheries have not been identified as Category 1. Additional research is needed to minimize effects on catch rates of target species that may occur with the introduction of TEDs into trawl nets, as well as developing new technologies to reduce small cetacean interactions with trawls.

Lobster Pot Fisheries

Solutions to catches of sublegal lobster, finfish, and ghost gear have been partially resolved by the addition of escape vents and biodegradable panels. Questions exist about the effectiveness of escape vents and biodegradable panels in the field. Solutions to some problems conflict with management reality (such as decreasing the number of pots fished), and some solutions reduce one problem, but increase others (e.g. sturdier gear to reduce pot loss vs. avoiding protected, endangered, and threatened species entanglement and habitat impact through the use of lighter gear). The work of Estrella and Glenn (2006) on pot selectivity, while valuable, is limited in its ability to predict actual capture of sublegal lobster because lobster retention as a function of size in a trap is a result of physical dimensions and lobster behavior. Evaluations of escape vent selectivity should be revisited so that results can lead to more accurate field implementation. Additional information on escape vent and biodegradable panel location can be obtained through surveys of pots in use in the fishery. Thorough investigation of capture, discard, and predation mortality of sublegal and other lobsters should be prioritized if capture cannot be avoided. At a minimum, existing data sources should be explored to define sublegal discard patterns. Further, investigation of development of RAMP methodology (Davis and Ottmar 2006) for lobsters should be initiated. The Atlantic Large Whale Take Reduction Team (ALWTRT) summary of potential solutions to large whale interactions appears complete, some of the modifications have been implemented, and they may be effective: it has been informally reported that entanglement rates are declining. One of the most important gear related research needs in the area of whale entanglement as referred to, although not a part of, the 2007 NMFS and ALWTRT working draft matrix was the development of a technological device for the purpose of marking gear (e.g. bar code, electronic tagging). Any additional information about the nature of the gear involved in an entanglement and the area it is from would play a great role in evaluating gear modifications. Research in this area should focus on gear marking technology that can be easily affixed to the gear but also handle everyday fishing activities. Until there is a way to mark gear, the best direction for future gear research in this area is to follow the matrix established by NMFS and ALWTRT.

Northern Shrimp Trawl Fishery

The Gulf of Maine northern shrimp fishery is an important fishery for inshore fishermen from downeast Maine to northern Massachusetts with trawling as the main method supplemented by shrimp potting. The fishery provides a good fishing opportunity at the time when the groundfishery is faced with ever increasing restriction. The implementation of the Nordmøre grate in 1992 greatly reduced finfish bycatch in the fishery, ranging from 90 to 95% in one report to about 60% in another. There are still bycatch issues in the fishery, but recent development on the modification to the Nordmøre grate and new designs of trawls may provide further reductions in finfish bycatch. One concern is small shrimps caught in the fishery. Further research is needed to devise systems to reduce the catch of small shrimps. There are no reports on serious interactions of shrimp trawls with protected species. Shrimp trawling affects the seabed both physically and biologically. There are attempts to reduce impacts of shrimp trawling on the seabed, but more efforts are needed to find solutions for efficient harvesting of the shrimp resource while minimizing impacts on habitat.

Southern Shrimp Trawl Fishery

Despite concerted efforts by government agencies and fishermen, some intractable problems remain with achieving levels of bycatch reduction in the shrimp trawl fishery that may improve stock levels of species such as weakfish. The use of bycatch reduction devices (BRDs) has not had an apparent effect on weakfish abundance, as landings are at historically low levels. The stock status of Atlantic croaker in the south Atlantic is unknown, but has been at a high level of abundance from North Carolina to the north since 1996. The status of spot is also unknown, but efforts to reduce bycatch should protect the stocks until assessments can be made. The current shrimp trawl fishery is currently under severe economic hardship (Nance *et al.* 2006; SAFMC

Shrimp Amendment 6, 2004). New requirements for BRDs must continue to account for shrimp loss, in addition to finfish reduction, and the cost and availability of new gear. For the southeast Atlantic, we recommend additional testing of newer devices that reduce finfish bycatch, such as the Composite Panel BRD. NMFS should be encouraged by ASMFC to take the lead role in additional BRD and TED testing, which is a continuation of ongoing studies on bycatch characterization, gear development, and outreach to fishermen for proper usage of BRDs and TEDs.

Pound Net Fisheries

The selectivity of pound nets in the Chesapeake Bay can be vastly improved by using bycatch reduction panels (BRPs) in the gear's head. Currently, only the Potomac River Commission actively encourages such use. These techniques have not been widely employed in pound nets coastally or even within the neighboring waters of Maryland and Virginia. Many of the undersized commercially and recreationally important species escaping through panels in the Potomac may be captured later as adults in Maryland or Virginia waters. Bycatch reduction panels have not been tested in Northeast pound nets. Because many species taken in these nets are also taken in the Chesapeake, culling characteristics are likely similar. Further investigations might be warranted to determine potential effects for dissimilar species. Because marine turtles are protected by the Endangered Species Act, federal regulations forced alterations to Virginia's pound net leaders to reduce such interactions in the lower Chesapeake Bay. It remains to be seen if this leader design will also reduce interactions with bottlenose dolphin or sturgeon. The stationary trap design of pound nets has an inherently low mortality of entrapped fish until harvest. Therefore, if regionally appropriate Bycatch Reduction Panels are used and the gear modified to reduce protected, endangered, and threatened species interactions, pound nets can be an ecologically sound method of selective and thus sustainable harvest.

Gillnet Fisheries for Coastal Sharks, Spiny Dogfish, and Striped Bass

Gillnets are known to be among the most highly size selective fishing gears available to capture fishery resources. Generally, sublegal target individuals can be avoided where the relationship between fish size and mesh size is known. There are considerable size selectivity data available for coastal sharks and striped bass. Where this information is absent (dogfish), gillnet selectivity studies should be conducted to determine appropriate mesh sizes. However, size selectivity characteristics of dogfish gillnets could be estimated based on available data for similar species. Appropriate matching of minimum landing sizes or desired market sized target fish to mesh sizes can then be implemented in regulations or adopted as good practices by fishermen. Improving species selectivity of gillnets in these fisheries is a more complex issue potentially requiring a combination of time and area closures and modifications to the gear so as to reduce bycatch. Some research suggests modification of the height of gillnets, either through the use of tie-downs, reduced meshes, or floatline modifications, can reduce catches of similar sized, undesired non-target species. Where net modifications are not practical or possible, information on the separation of target and bycatch species by season, area, or depth should be employed. If this information is unknown, further investigation of spatial and temporal distributions of target and non-target species should be conducted. Knowledge obtained on the avoidance of non-targets should be widely distributed.

Atlantic Herring Mid-water Trawl Fishery

Mid-water trawl fisheries are generally considered to be relatively 'clean', as bycatch rates are low in comparison to many other fisheries, although there is concern about bycatch of regulated and protected species. The schooling nature of the targeted catch and the relative efficiency of the fishing operation allow for effective targeting of schools of fish. Because the fishing occurs mainly off the bottom, the habitat effects from this fishery are considered minimal. Although there is a documented bycatch of marine mammals, mainly pilot whales and the Atlantic white-sided dolphins, neither of these species are considered strategic (i.e., endangered). At this time sea turtle bycatch has not been observed by NMFS in this fishery in the northwest Atlantic.

From the information contained in this report, we recommend the ASMFC does not give this fishery a high priority relative to other more problematic fisheries in regards to the examination of new mitigation strategies to reduce bycatch. If the fishery changes or the bycatch increases, the further assessment of this fishery and bycatch mitigation strategies might be warranted. Although we do not suggest this fishery is a high priority relative to other more problematic fisheries, our understanding of the bycatch issues in this fishery would be improved with a higher level of observer coverage.

Croaker Fly Net Trawl Fishery

The catch of this fishery should continue to be monitored under ACCSP protocols to determine the magnitude of catch of ASMFC managed species and account for their removals in stock assessments. NEAMAP and SEAMAP fishery-independent trawl surveys are useful in examining the take of flynet fisheries from a sustainability perspective. Progress on flexible TED testing and implementation should continue. Field testing and quantitative analyses of codend mesh size retention should continue, specifically on mesh sizes ranging from 3-5 inch hung in square and diamond shapes.

Atlantic Menhaden Purse Seine Fishery

The Atlantic menhaden fishery continues to generate concern and its legality in Virginia's waters is currently being debated by Virginia's legislature. However, its importance with regard to non-targeted species bycatch is minor even when considering the magnitude of the fishery. In addition, negative impacts on protected, endangered and threatened species are not documented in the published literature. Due to the size of the fishery, bycatch does not have to be a very large portion of the catch in order to potentially be biologically significant for management. If further bycatch research is warranted in the future, a regulatory-enforcement type sampling scheme that incorporates unannounced inspections/sampling efforts conducted during off loading and on-board during harvesting is suggested. Significant differences in bycatch percentages have been observed between dockside and at-sea sampling regimes with at-sea always exceeding dockside (Austin *et al.* 1994).

Recreational Striped Bass Fishery

Discarding and the resulting mortality is an important problem in both the commercial and recreational fisheries for striped bass. In the recreational striped bass fishery increasing the use of circle hooks is recommended. An additional recommendation is to continue and expand angler education efforts to encourage the use of circle hooks and the careful play and handling of fish, and explain the implications of high-grading (*see* Lockwood 2008). The Mid-Atlantic Fishery Management Council (MAFMC) is developing an ethical angling brochure. It is recommended the ASMFC collaborate with the MAFMC on this brochure and its distribution to the recreational fishing community and general public. Although angler education is not a direct gear technology solution, it is related to the use of gear by recreational fishermen and how they can contribute to promoting the survival of fish returned to the water. The issues and potential solutions related to the striped bass recreational fishery apply to other species caught recreationally. Although striped bass is evaluated here, results should be explored for possible implementation in other recreational fisheries.

Conclusions

Of the ten fisheries identified during the prioritization process, nine are commercial and one is recreational. In all of the fisheries investigated, the committee identified issues related to ecosystem impacts from the capture process, and evaluated previous research that addressed issues related to selectivity, bycatch reduction, and habitat impact. In most of the fisheries investigated, previous research was directed at providing an understanding of size selection characteristics of a particular gear type for a particular species; attempts to reduce the bycatch of unwanted, unmarketable, or protected species by making technological changes to the gear; or the results of studies addressing an increase in the survival of captured animals that are released or discarded after capture. The northern shrimp trawl fishery provides an example of the introduction of Bycatch Reduction Technology (BRT), in this case the Nordmøre Grate, which successfully reduced finfish bycatch and improved the quality of target species catch. The technology was introduced based on the results of cooperative research conducted by fishermen and scientists, and subsequently integrated into the regulatory process based on this research. The primary issue associated with the recreational striped bass fishery is the survival of released fish, and the results of previous research suggest the greater use of circle hooks will reduce hooking mortality. The trawl fisheries, the lobster pot fishery, the southern shrimp trawl fishery, the pound net fishery, the gillnet fisheries, the herring mid-water trawl fishery, and croaker fly-net fishery all have problems with finfish bycatch and protected species interactions (sea turtles, marine mammals, and sturgeon), and these problems potentially threaten the future of these fisheries. The menhaden purse seine fishery was found to have no documented problems associated with the capture process,

The primary gear research needs at present are related to reducing finfish bycatch and protected species interactions in the trawl fisheries, the lobster pot fishery, the southern shrimp trawl fishery, the pound net fishery, the gillnet fisheries, the herring mid-water trawl fishery, and croaker fly-net fishery. The FGTWG found that all gears that have been adequately researched and tested have been implemented into management. FGTWG also found that for the fisheries considered, there are many gear modifications that research has been shown to be promising, but have not been adequately tested under a variety of conditions, and therefore have not been implemented into management. The FGTWG advises the ASMFC to support further research and testing of gear modifications so as to reduce finfish bycatch and protected species interactions, by urging its member states to provide the resources required to conduct these activities.

In general improved communication between fishery managers, fishing gear scientists, and fishermen, is needed to address ecosystem impacts associated with the capture process. The NMFS, NEFSC, Protected Species Branch has established a process for developing, testing, and evaluating modifications to fishing gear that will reduce both interactions with protected species while attempting to minimize effects on commercial fishing operations and efficiency. The FGTWG recommends that ASMFC support a similar process. As existing technological modifications to fishing gear that have proven successful in testing and evaluation are integrated into management, ASMFC and other fishery management organizations should anticipate the continuing development and modification of fishing gear and develop policies for their development, evaluation, and implementation. The goal of any technological modification to fishing gear should be to reduce the ecosystem impacts of fishing, while minimally affecting the efficiency of the gear for the target species. This goal can only be accomplished after adequate testing and evaluation of the gear modification in the fishery. The best approach facilitates and conducts cooperative research between fishermen and scientists.

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I. INTRODUCTION

I.1 Addressing Gear Issues in Atlantic Coast Fisheries

The Commission's Interstate Fisheries Management Program Policy Board requested the Management and Science Committee (MSC) investigate the need to reconvene the Conservation Engineering Committee (CEC). The CEC was formed in the mid-1980s to provide recommendations to the states regarding bycatch technology and other clean gear modifications. The committee was instrumental in the development of the Nordmøre Grate, TEDs, and BRDs. The committee also conducted survey design workshops and produced an annual report of gear-related activities along the coast.

In 2006, the MSC recommended the formation of the Fishing Gear Technology Work Group (FGTWG). The Group is to focus on fishery-dependent aspects of gear conservation (e.g., BRDS and other gear modifications), rather than also addressing fishery-independent conservation projects (e.g., fish passage, impingement, and entrainment). The Policy Board approved the formation of the FGTWG to begin work in 2007.

I.2 Charge and Objectives

The Fishing Gear Technology Work Group was given the following charge from the ASMFC Management and Science Committee (MSC):

- Identify and evaluate studies of fishing gear selectivity, bycatch reduction, gear effects on habitat, and impacts of a single gear used in multispecies fisheries (ecosystem planning).
- Develop a comprehensive report of gear work along the coast, evaluate the work to see if it is ready to be implemented in the management process, and provide recommendations for future research.
- Determine the transferability of such studies to other species and geographical areas. This includes identifying relevant studies from outside the Atlantic Coast and evaluating their potential application to ASMFC species.

I.3 Terms of Reference

1. Develop a matrix of fisheries by area, commercial and recreational gear types, and contribution to landings, that addresses and prioritizes bycatch, species and size selectivity, encounter and discard mortality, ghost fishing, and habitat issues for ASMFC managed species:
    - The matrix will be used to prioritize problematic fisheries and gears in terms of overall ecosystem impacts; the highest priority fisheries will be addressed in the first year report.

- The matrix will utilize the ACCSP bycatch matrix, other gear effects prioritization matrices, and expert opinions of Work Group members.
- Bycatch issues are understood to include protected, endangered, and threatened species.
- The prioritization will be completed by the end of November 2007, and distributed to the MSC for comment.

2. Having identified priority fisheries, the Work Group will collect and evaluate relevant gear related research, and also make suggestions for further research needs or identify possible research directions.
    - The Work Group will hold its second meeting in the spring of 2008 to evaluate the research collected for high priority fisheries.
    - Individual Work Group members will be assigned to lead the collection and review of specific fisheries based on experience and interest. Each lead individual will be responsible for collecting available reports, and presenting a review of reports to the Work Group at its spring meeting.
    - The Work Group report evaluations will be based on spring meeting discussions.
    - At the spring meeting, a report will be outlined/drafted summarizing the evaluations of gear research, the potential for gear adaptations to be implemented into management, and recommendations for future research.

3. Based on the Work Group's findings and work group review of the draft summary report, a Final Report will be prepared and presented to the MSC in early fall of 2008. This report will include the initial prioritization matrix and results of the evaluation of studies relevant to fisheries determined to have the highest ecosystem impacts.

I.4 Development of Fishery Gear Matrix and List of Priority Fisheries

The FGTWG matrix (Table I-4.1) evaluates all fisheries and their gears targeting species managed by the Atlantic States Marine Fisheries Commission. Values for each species-fishery are determined within several categories, summed together, and then weighted by the magnitude of the fishery (annual metric tons landed). Gear interaction categories include:

- Bycatch of Sub-legal Target Species
- Bycatch of Other Finfish Species
- Protected Species or Bird Interactions
- Ghost Gear
- Habitat Impacts

Table I-4.1. Gear matrix by fishery. Qualitative and quantitative values are assigned for each category – major (3.0), moderate (2.0), minor (1.0), and none (0.0).

Fishery	Proportion of Total Landings	Bycatch of Sub-legal Target Species	Bycatch of Other Finfish Species	Protected Spp Interactions	Ghost Gear	Habitat Impact	Total Value	MT	MTxValue	Ranking
Atl. Herring trawl	major, 0.841	major, 3.0	major, 3.0	major, 3.0	none, 0.0	minor, 1.0	8.4	75487	**634991**	**1**
Menhaden purse seine	major, 0.985	minor, 1.0	minor, 1.0	minor, 1.0	none, 0.0	none, 0.0	3.0	177105	**523330**	**2**
Lobster pot	major, 0.988	minor, 1.0	minor, 1.0	moderate, 2.0	minor, 1.0	none, 0.0	5.9	38299	**226970**	**3**
Striped Bass rec	major, 0.734	major, 3.0	minor, 1.0	minor, 1.0	none, 0.0	none, 0.0	3.7	8793	**32269**	**4**
Summer Flounder trawl	major, 0.541	moderate, 2.0	moderate, 2.0	minor, 1.0	none, 0.0	minor, 1.0	3.2	5919	**19214**	**5**
Winter Flounder trawl	major, 0.920	moderate, 2.0	moderate, 2.0	minor, 1.0	none, 0.0	minor, 1.0	5.5	2716	**14992**	**6**
Atl. Herring purse seine	minor, 0.159	moderate, 2.0	moderate, 2.0	minor, 1.0	none, 0.0	none, 0.0	0.8	14251	**11316**	**7**
No. Shrimp trawl	major, 0.900	moderate, 2.0	moderate, 2.0	none, 0.0	none, 0.0	minor, 1.0	4.5	2046	**9205**	**8**
Scup trawl	major, 0.491	moderate, 2.0	moderate, 2.0	minor, 1.0	none, 0.0	minor, 1.0	2.9	1979	**5830**	**9**
Croaker trawl	minor, 0.321	minor, 1.0	minor, 1.0	minor, 1.0	none, 0.0	minor, 1.0	1.3	4258	**5469**	**10**
Dogfish & Sharks gillnet	major, 0.780	moderate, 2.0	moderate, 2.0	moderate, 2.0	minor, 1.0	none, 0.0	5.5	795	**4338**	**11**
Bluefish rec	major, 0.704	minor, 1.0	no problem, 0.0	none, 0.0	none, 0.0	none, 0.0	0.7	6095	**4288**	**12**
Summer Flounder rec	minor, 0.361	moderate, 2.0	minor, 1.0	none, 0.0	none, 0.0	none, 0.0	1.1	3954	**4286**	**13**
Spot gill net	minor, 0.446	minor, 1.0	minor, 1.0	moderate, 2.0	minor, 1.0	none, 0.0	2.2	1593	**3554**	**14**
Dogfish gill net	major, 0.740	minor, 1.0	moderate, 2.0	moderate, 2.0	minor, 1.0	minor, 1.0	5.2	626	**3242**	**15**
Croaker gill net	minor, 0.180	moderate, 2.0	moderate, 2.0	moderate, 2.0	minor, 1.0	none, 0.0	1.3	2384	**2999**	**16**
Striped Bass gill net	minor, 0.162	moderate, 2.0	moderate, 2.0	major, 3.0	minor, 1.0	none, 0.0	1.3	1942	**2518**	**17**

Fishery	Proportion of Total Landings	Bycatch of Sub-legal Target Species	Bycatch of Other Finfish Species	Protected Spp Interactions	Ghost Gear	Habitat Impact	Total Value	MT	MTxValue	Ranking
Bluefish gill net	minor, 0.199	moderate, 2.0	moderate, 2.0	moderate, 2.0	minor, 1.0	none, 0.0	1.4	1727	**2410**	**18**
American Eel pot	major, 0.992	moderate, 2.0	no problem, 0.0	moderate, 2.0	moderate, 2.0	none, 0.0	6.0	384	**2285**	**19**
Shad & River Herring gillnet	major, 0.764	moderate, 2.0	moderate, 2.0	moderate, 2.0	minor, 1.0	none, 0.0	5.3	312	**1668**	**20**
Croaker rec	minor, 0.322	minor, 1.0	none, 0.0	none, 0.0	none, 0.0	none, 0.0	0.3	4276	**1378**	**21**
Black Sea Bass pot/trap	minor, 0.355	moderate, 2.0	minor, 1.0	minor, 1.0	moderate, 2.0	none, 0.0	2.1	572	**1219**	**22**
Spanish Mackerel gillnet	minor, 0.304	moderate, 2.0	moderate, 2.0	moderate, 2.0	minor, 1.0	none, 0.0	2.1	532	**1131**	**23**
Shad gillnet	major, 0.800	minor, 1.0	minor, 1.0	moderate, 2.0	minor, 1.0	none, 0.0	4.0	269	**1076**	**24**
Tautog rec	major, 0.907	minor, 1.0	none, 0.0	none, 0.0	none, 0.0	none, 0.0	0.9	984	**893**	**25**
Black Sea Bass trawl	minor, 0.285	moderate, 2.0	moderate, 2.0	minor, 1.0	none, 0.0	minor, 1.0	1.7	459	**784**	**26**
Croaker pound net	minor, 0.097	moderate, 2.0	moderate, 2.0	moderate, 2.0	none, 0.0	none, 0.0	0.6	1287	**749**	**27**
Shark long line	major, 0.515	moderate, 2.0	moderate, 2.0	moderate, 2.0	none, 0.0	none, 0.0	3.1	193	**597**	**28**
Spotted Seatrout rec	major, 0.871	minor, 1.0	none, 0.0	none, 0.0	none, 0.0	none, 0.0	0.9	571	**497**	**29**
Sharks gillnet	minor, 0.450	moderate, 2.0	minor, 1.0	moderate, 2.0	minor, 1.0	none, 0.0	2.7	169	**455**	**30**

NOAA Fisheries' Office of Protected Resources classifies fisheries based on their level of interaction with marine mammals. Category descriptions are as follows (NMFS/CFR 2007):

- **Category I:** Annual mortality and serious injury of a stock in a given fishery is greater than or equal to 50 percent of the PBR (Potential Biological Removal) level.
- **Category II:** Annual mortality and serious injury of a stock in a given fishery is greater than 1 percent and less than 50 percent of the PBR level.
- **Category III:** Annual mortality and serious injury of a stock in a given fishery is less than or equal to 1 percent of the PBR level.

The fisheries addressed in this report are listed in the following categories:

Fishery	Category
Otter trawl fisheries for summer flounder, winter flounder, and scup	2
American lobster pot fishery	1
Northern shrimp trawl fishery	3
Southern shrimp trawl fishery	3
Pound net fisheries	2
Gillnet fisheries for coastal sharks, spiny dogfish, and striped bass	1
Atlantic herring mid-water trawl fishery	2
Croaker fly net trawl fishery	2
Atlantic menhaden purse seine fishery	2
Recreational striped bass fishery	3

II. Priority Fisheries

II.1 Otter Trawl Fisheries for Summer Flounder, Winter Flounder, & Scup

II.1.1 Introduction

a. Background

The otter trawl fisheries for summer flounder, winter flounder, and scup were identified as fisheries of concern for the following reasons: 1) catch and discarding of sub-legal target finfish species, 2) catch and discarding of other finfish species, 3) interactions with protected species, including marine mammals and sea turtles, and 4) potential benthic habitat impacts from interactions with the seabed. This section will treat fisheries individually in terms of target species size selectivity investigations, fishery species selectivity, discard rate, and discard survival. Joint evaluation of interactions with protected species and habitat impact will be described.

b. Life History and Status of Resource

Summer flounder

Summer flounder are found in inshore and offshore waters from Nova Scotia, Canada to the east coast of Florida. In the U.S., they are most abundant in the Mid-Atlantic region from Cape Cod, Massachusetts to Cape Fear, North Carolina.

A recent stock assessment update indicated that the summer flounder stock is no longer overfished and that overfishing is not occurring (NEFSC 2008). Spawning stock biomass (SSB) was estimated 95.6 million pounds, which is above the SSB target of 66.2 million pounds but below the target of 132.4 million pounds. The current estimate of fishing mortality (0.288) is below the threshold fishing mortality rates of 0.310 but above the target level of 0.255. The abundance at age for most age classes has continued to increase over the last ten years, and the 2007 year class (40.0 million fish) is estimated to be only slightly below the 1982-2007 arithmetic average recruitment of 41.6 million fish.

Winter flounder

The 2005 stock assessment update concluded the Gulf of Maine winter flounder stock is not overfished and overfishing is not occurring. Fishing mortality (F) in 2004 was well below the estimate of F_{MSY}, and spawning stock biomass in 2004 was estimated to be about 67 percent above the estimate of spawning stock biomass (SSB) threshold. Recruitment to the stock has been above or near average since 1995.

The 2005 update concluded the Southern New England/Mid-Atlantic winter flounder stock is overfished and overfishing is occurring. Fishing mortality in 2004 was 0.38, 19% higher than the

$F_{threshold}$. Spawning stock biomass in 2004 was only 26% of the threshold value of 33.2 million pounds SSB. The average recruitment from 1981 to 2001 was 23.9 million age-1 fish. Recruitment to the stock has been below average since 1989. The 2002 year class, with only 4.4 million fish, is the smallest in the 22-year time series. A new assessment is being conducted in 2008 but results are not yet available for inclusion in this report.

Scup

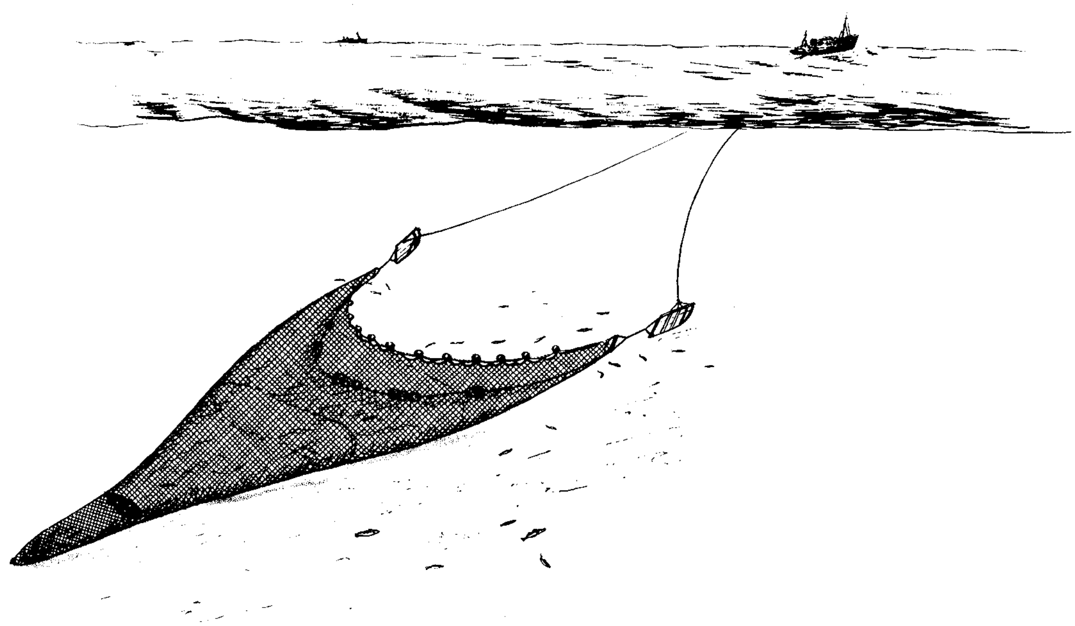
Scup are a migratory, schooling species found on the continental shelf of the Northwest Atlantic, commonly inhabiting waters from Cape Cod, Massachusetts to Cape Hatteras, North Carolina.

The 2000 stock assessment indicated scup were overfished and overfishing was occurring. The primary concerns identified by the assessment were excessive discarding of scup and near collapse of the stock. In 2002, the Northeast Regional Stock Assessment Review Committee changed the status of scup to no longer overfished but could not determine if overfishing was occurring due to a lack of information on fishing mortality. The change in stock status is a result of a high survey index in 2002 and its inclusion in the 3-year moving average calculation. The 2002 survey was considered highly uncertain because the abundance of all age groups increased substantially from the 2001 survey, suggesting that increased availability of scup to the survey gear was an important determinant in the 2002 survey results. Despite an incomplete picture of fishing mortality and concerns about the 2002 survey, more recent surveys indicate strong recruitment and some rebuilding of age structure. Using a statistical catch at age model, the Northeast Data Poor Stocks Working Group determined in 2008 that the scup stock is rebuilt and that overfishing is not occurring (NDPSWG 2008).

c. The Fishery and Gear

The summer flounder and scup trawl fisheries can each be divided in two seasonally and geographically distinct components: the summer-inshore fishery and the winter-offshore fishery. The winter flounder fishery can also be similarly divided in two components: a winter-inshore fishery and a summer-offshore fishery. Previous studies of trawl performance have demonstrated that the within-species size selection process occurs primarily in the extension and codend sections of the trawl, while species selection can occur in the net mouth or in the extension and codend, especially if it is influenced by species-specific size differences.

Figure II-1.1.1. Otter trawl (From DeAlteris, 1998).



d. Management and Regulations

The fisheries for winter flounder, summer flounder, and scup are managed with a variety of technological restrictions and effort controls to control fishing mortality on target and bycatch species. Technologically, minimum mesh size restrictions are used to control bycatch of sublegal individuals, and bycatch reduction technologies including Turtle Excluder Devices (TEDs) are being introduced to minimize mortality of protected species. Effort controls include spatial and temporal closures and limited days at sea.

II.1.2 Bycatch

II.1.2.1 Summer flounder

a. Size selectivity, discard rate and discard mortality

A 30.5-35.5 cm (12-14 in) TL minimum landing size (MLS) has been implemented for summer flounder in the otter trawl fishery, depending on the state of landing. To balance the capture and retention of legal-sized flounder with the escape of sub-legal fish, regulations require a minimum mesh size of 14.0 cm (5.5 in) diamond or 15.2 cm (6.0 in) square throughout for trawls used to target this species (MAFMC 1992). Four studies have quantified summer flounder codend selectivity (Table II-1.2.1.1). Using data collected off Long Island, NY, Lange (1984) determined a 14.0 cm (5.5 in) diamond mesh has an L_{50} of 34.3 cm (13.5 in) TL for summer flounder, meaning 50% of 34.3 cm (13.5 in) TL flounder encountering 14.0 cm (5.5 in) diamond mesh are retained. Similar results were reported from a study of the North Carolina winter trawl fishery (Gillikin *et al.* 1981). DeAlteris *et al.* (1999) calculated L_{50} values for summer flounder of 41.2 cm (16.2 in) TL for both 15.2 in (6.0 in) diamond and 16.5 cm (6.5 in) square codend mesh. More recently, Beutel *et al.* (2004) investigated four codend mesh sizes 16.5 cm (6.5 in) diamond, 17.8 cm (7.0 in) square, 17.8 cm (7.0 in) diamond, and 20.3 cm (8.0 in) square. Only slight variations in L_{50} values for the 16.5 cm (6.5 in) diamond (L_{50} = 43.9 cm (17.3 in)), 17.8 cm (7.0 in) square (L_{50} = 43.4 cm (17.1 in)), and 17.8 cm (7.0 in) diamond (L_{50} = 45.0 cm (17.7 in)) meshes were observed. The 20.3 cm (8.0 in) square mesh had an L_{50} value of 51.9 cm (20.4 in) for summer flounder. While length at retention values were greater than the legal minimum size for each of these experimental mesh sizes, the 20.3 cm (8.0 in) square mesh significantly reduced the catch of legal-size summer flounder.

Additional mesh selectivity studies may be warranted should increases in commercial MLS be desired. For example, if the commercial MLS was set at 38.1 cm (15.0 in), quantifying selectivity for mesh sizes between 14.0 cm (5.5 in) and 15.2 cm (6.0 in) would become necessary. Such and increase in commercial MLS may prove to be counterproductive from both a biological and an economic perspective, however. Larger fish tend to be breeding females as well as less marketable than the smaller fish.

Information regarding discards and discard survival of summer flounder prior to 1989 is sparse. Before this time, no minimum mesh sizes or minimum landing sizes were mandated in Federal waters and a market existed for small summer flounder (Terceiro 2002). Annual discard estimates from the National Marine Fisheries Service, Northeast Fisheries Science Center domestic observer program, suggest 5-10% of the summer flounder catch from the otter trawl fishery is discarded (ASMFC 2004). Kennelly *et al.* (1997) reported a summer flounder discard rate of 12.6% from the summer flounder otter trawl fishery operating in Southern New England and the Mid Atlantic Bight and concluded the gear and operations used for catching summer flounder in this fishery were efficient.

Reported discard rates include sublegal and legal-sized summer flounder. The reasons for discarding trawl-caught summer flounder have changed through time. Between 1989 and 1995, the capture of undersized summer flounder was the main reason for discarding on 90% of observed tows. In 1999, discards due to the minimum size limit occurred on only 61% of tows, while the majority of remaining discards resulted from reaching a quota or trip limit (26% of tows) or high-grading (11% of tows) (Terceiro 2002, ASMFC 2003).

Discard survival of summer flounder in the otter trawl fishery is assumed to be 20% (i.e., 80% mortality) based on the recommendations of an Industry Advisory Committee to the Mid-Atlantic Fishery Management Council (MAFMC 1992). Handling practices have changed in this fishery, however, and the assumption of an 80% discard mortality rate has been challenged recently by the industry (ASMFC 2004). Hasbrouck (New York Sea Grant, unpublished data) initiated a study in 2007 in an attempt to refine this estimate. Rhode Island Sea Grant will also develop and validate a Reflex Action Mortality Predictor (RAMP) and visual marker index for discard mortality of summer flounder in 2008.

b. Bycatch of finfish species

It is likely that adequate information is available to assess the appropriate minimum mesh size needed to manage the summer flounder fishery. Inherent imprecision in trawl selectivity (sub-legals) and management practices (legal-sized fish) are primary impediments to further reductions of discards. Improvements in fish handling and understanding of discard mortality are welcome additions to the gaps in understanding of the impact of discarding.

Little information is available in the literature (primary or gray) regarding the discard of non-target finfish in the summer flounder otter trawl fishery. Documentation of the magnitude of these discards would result in a more comprehensive understanding of this fishery and, depending on the scale, may give rise to studies designed to reduce the capture of these non-target fishes (i.e., species selectivity studies).

c. Interactions with protected species

The bottom trawl fisheries of the northeast and mid-Atlantic incidentally take many species of small cetaceans including common dolphin, white-sided dolphin, harbor porpoise, and short and long finned pilot whales, and one pinniped species, the harp seal. As a result of these documented interactions, both fisheries are listed as Category Two in the List of Fisheries published by NMFS in 2007. These fisheries also interact with sea turtles (Rossman *et al.* 2006), including the loggerhead sea turtle (*Caretta caretta*) where the annual bycatch has been estimated to be 616 individuals (Murray 2006). NMFS is considering requiring the use of Turtle Excluder Devices (TEDs) at particular times of the year in many bottom trawl fisheries south of Cape Cod.

II.1.2.2 Winter flounder

a. Size selectivity, discard rate, and discard mortality

The winter flounder otter trawl fishery accounts for 98% of landings of winter flounder from the southern New England and the mid-Atlantic stock, and about 80-90% of landings in Gulf of Maine stock (Mayo and Terceiro 2005). A minimum landing size of 30.5 cm (12 in) is current mandated. Many studies of the size selectivity of trawl codends for winter flounder have been conducted (Table II-1.2.2.1). Smolowitz (1983) determined the L_{50} of a 13.3 cm (5.25 in) diamond mesh codend for winter flounder was 29.2 cm (11.5 in) TL; Simpson (1989) estimated the L_{50} of a 12.7 cm (5.0 in) diamond mesh codend was 28.4 cm (11.2 in) TL; and DeAlteris and Riefsteck (1992) estimated the L_{50} of a 11.9 cm (4.7 in) diamond and square mesh codends to be 24.7 and 21.6 cm (9.7 and 8.5 in) TL, respectively. More recently, DeAlteris and Chosid (2004) determined the L_{50}s of 16.5 and 17.8 cm (6.5 and 7.0 in) square and diamond mesh codends to be 38.1, 42.9, 38.1, and 43.3 cm (15.0, 16.9, 15.0, and 17.0 in) TL, respectively. DeAlteris and Chosid (2004) also integrated the results of these selectivity patterns into Yield per Recruit (YPR) and Spawning Stock per Recruit (SSBPR) models and determined the current minimum mesh size required in the groundfish fishery of 16.5 cm (6.5 in) produced about 95% of the maximum YPR, while retaining 18-21 % of the virgin spawning stock biomass. The current minimum mesh size for winter flounder of 16.5 cm (6.5 in) retains about 5% undersized or sub-legal fish (less than 30.5 cm (12 in)) and appears appropriate for the fishery based on experimental results.

Reported observed rates of winter flounder discards vary across multiple studies and data sources. In southern New England and the mid-Atlantic from 1981-2004, discards were 9.3% of landings by weight, and 15.3% of landings by number based on discard estimates based on Vessel Trip Reports. In the Gulf of Maine, the discard rate averaged 4.3% from 1994-2004 based on Vessel Trip Reports. Howell and Langan (1987) reported a mean discard percent per tow of 5% by weight and 12% by number for winter flounder in 112 commercial trawl tows in the Gulf of Maine. Kennelly *et al.* (1997), using observer data from July 1990 to June 1994 for a variety of species, found winter flounder had a 20% discard rate.

Not all of these discards are sublegal fish. Murawski (1996) investigated factors influencing non-target catch and discard rates based on analyses from multi-species and multi-fishery sea sampling data (4533 tows) from 1989 to 1992 from Georges Bank and southern New England. Winter flounder were found to have a mean discard rate of 13.6% when mesh size ranged from 4-6 inches. Based on this observation, the author describes discards in the winter flounder directed fishery as clearly regulatory in nature.

Howell *et al.* (1992) reported a discard mortality rate estimate of 50% for commercial fisheries in the inshore fisheries of the Gulf of Maine. Ross and Hokensen (1997) estimated the mortality of winter flounder 9-28 cm in length due to air exposure was less than 10% for all air exposure time periods tested (15, 30, 45, and 60+ minutes). Further, they found limited predation of discarded winter flounder by seabirds, most likely because winter flounder sank or swam to the bottom quickly. They also found higher survival rates from this study than those predicted for the fishery, possibly due to the fishery taking place in winter and early spring (cooler temps). Further investigation of winter flounder discard mortality is planned by Rhode Island Sea Grant in 2008 using a Reflex Action Mortality Predictor (RAMP) and visual marker index.

b. Bycatch of finfish

ASMFC (2006), in a review of the winter flounder fishery management plan, called for expanded sea sampling for estimation of commercial discards, an increase in intensity of commercial fishery discard length sampling, and a study to determine selectivity of 6-inch diamond and square mesh sizes on winter flounder. This latter request appears inappropriate due to the large number of size selectivity studies conducted with 5-8 inch mesh, and the relatively low rate of sub-legal discarding. As with summer flounder, reduction of winter flounder discarding is limited by trawl selectivity and regulations that tolerate discarding of legal-sized fish. Further investigation is needed and is underway to assess discard mortality.

c. Interactions with protected species

As noted previously, the bottom trawl fisheries of the northeast and mid-Atlantic incidentally take many species of small cetaceans including common dolphin, white-sided dolphin, harbor porpoise, and short and long finned pilot whales, and one pinniped species, the harp seal. As a result of these documented interactions both fisheries are listed as Category Two in the List of Fisheries published by NMFS in 2007. These fisheries also interact with sea turtles (Rossman *et al.* 2006), including the loggerhead sea turtle (*Caretta caretta*), where annual bycatch has been estimated at 616 individuals (Murray, 2006). NMFS is considering requiring the use of Turtle Excluder Devices (TEDs) at particular times of the year in many bottom trawl fisheries south of Cape Cod.

II.1.2.3 Scup

a. Size selectivity, discard rate, and discard mortality

Scup landed by the commercial otter trawl fishery must be at least 22.9 cm (9 in) TL. Regulations establish varying minimum codend 11.4 or 12.7 cm (either 4.5 or 5.0 inches) and net body mesh sizes dependent on net size and daily landing limits, as determined by seasonal quotas (ASMFC 2006). The size selectivity of 12.0 cm (4.7 in) square and diamond mesh codends was investigated by DeAlteris and Riefsteck (1992). The L_{50}s of the square and diamond mesh codends were found to be 21.3 and 21.0 cm (8.4 and 8.3 in) respectively, based on total length, and the selection curves had steepness values of 0.74 and 0.71. Based on a mean selection factor (SF) of 1.76 for the 12.0 cm (4.7 cm) codends, and assuming the girth to length ratio remains constant for fish in the 17.8-22.9 (7-9 in) size range, the L_{50}s of 11.4, 12.7, 14.0 cm (4.5, 5.0, 5.5 in) codends were estimated by DeAlteris and Lazar (2004) to be 20.1, 22.4, 24.6 cm (7.9, 8.8 and 9.7 in) TL, respectively. Given the current minimum mesh in the fisheries targeting scup in either the codend or the extension section is 12.7 cm (5.0 in) and the L50 of this mesh is 22.4 (8.8 in) TL, there is strong agreement between the minimum mesh size and the minimum fish size, balancing the discarding of retained sub-legal scup with the escape of legal size scup from the codend. The 11.4 cm (4.5 in) codend retains 90% of the 22.9 cm (9 in) TL scup, resulting in excessive discards of sub-legal size fish.

However, current restrictions do not provide for adequate escapement for undersized scup (Bochenek *et al.* 2001, Bochenek *et al.* 2005). Kennelly *et al.* (1997) reported scup retention and discard rates in the trawl fishery between July 1990 and June 1994 were 10.4 kg/hr and 8.3 kg/hr, respectively, indicating approximately 44.5% (by weight) of scup caught by the commercial trawl fisheries were discarded due to small size. These data were then used to identify spatial and temporal trends in the discarding of scup. The highest discard rates were shown to generally occur over a range of depths between the eastern end of Long Island and the northern portion of the Delmarva Peninsula (Kennelly 1999). Most of this discarding took place in the late summer and fall months, while lesser peaks also occurred in the spring. Highest average discard rates (145 kg/hr) were observed in NMFS statistical area 613 (i.e., eastern Long Island) between 30-40 fm during November and December. These results were incorporated by the ASMFC into time-area closures in an attempt to minimize catch of sub-legal scup.

More recently, Powell *et al.* (2003) analyzed observer data collected from commercial trawl fisheries between 1997 and 2002 and noted that scup discards can exceed landings in some years. In particular, discards of scup (by weight) were 1.91 times larger than scup landings in 2001. The directed scup fishery accounted for 56% of these discards, followed by butterfish (18.7%), black sea bass (12.1%), *Loligo* squid (6.8%), and silver hake (4.7%) fisheries.

Bochenek *et al.* (2005) investigated the use of codends with two different mesh sizes to reduce black sea bass catch and sublegal scup catch in scup fisheries. They analyzed the length frequencies of scup caught using both millionaire and large box-style otter trawls fitted with a variety of codends (i.e., composite with 30 meshes of 10.2 cm (4.0 in) mesh at the very end of the bag preceded by 45 meshes of 11.4 cm (4.5 in) mesh, a 12.7 cm (5.0 in) mesh codend, the legal 11.4 cm (4.5 in) mesh codend, a 10.2 cm (4.0 in) mesh codend, and with and without a composite with one of the sections having meshes $\geq$ 12.7 cm (5.0 in)) and found no significant difference in the length frequency distributions of scup captured by these gears. Scup discards were either greater than or equal to scup landings for most tows.

While the directed scup fishery has been shown to account for more than half of scup discards (Powell *et al.* 2003), the quantification and reduction of scup discards in the *Loligo* squid fishery have also received a large amount of attention. McKiernan and Pierce (1995) documented the discarding of scup in the southern New England inshore *Loligo* squid trawl fishery, but concluded the impact of this discarding on the abundance of scup was probably less than that of the offshore trawl fishery. This study recommended quantifying the discard rate in the offshore fishery as well as developing gear solutions to the discard problem. Several trawl gear modifications were developed and tested.

By placing a 45 mesh section of 14.0 cm (5.5 in) square mesh webbing ahead of the codend, Glass *et al.* (1999) was able to reduce the bycatch and discarding of small scup with little effect of the catch of *Loligo* squid. While this modification appeared to work well in this experimental setting, its performance was less consistent when applied to the commercial fishery (Powell *et al.* 2004). Variations on the aforementioned design, including the addition of a dark tunnel behind the square mesh band and the addition of a 11.4 cm (4.5 in) diamond mesh extension top (Glass *et al.* 2001, Pol and Carr 2000, Pol 2001), have also been investigated. In 2002, vee and ring excluders were tested as a means of reducing scup bycatch in the southern New England inshore *Loligo* squid fishery (Pol *et al.* 2002). Both types of excluders released scup at mean rates of 87-100% but were tested when squid catches were low; the vee excluder appeared to release more squid. None of these latter modifications has moved beyond the experimental stage.

The discard mortality of scup for the commercial trawl fisheries is currently assumed to be 100%, as no known studies of scup discard mortality exist (NEFSC 2000). The ASMFC Stock Assessment Review Committee for this species has recently called for the characterization of gear-specific scup discard mortalities (ASMFC 2006). Encounter mortalities (i.e., mortality of scup that interact with, but are not collected by, the gear) are believed to be low, based on field and tank experiments conducted by DeAlteris and Riefsteck (1992) and DeAlteris and La Valley (1999).

b. Bycatch of finfish

Catch of sublegal scup continues to be high. Mandatory minimum mesh sizes and experimental configurations have not demonstrated adequate selectivity. Use of data to define spatio-temporal separation may be an area for further investigation. Continued research into other means of separating small scup should be pursued.

c. Interactions with protected species

As noted previously, the bottom trawl fisheries of the northeast and mid-Atlantic incidentally take many species of small cetaceans including common dolphin, white-sided dolphin, harbor porpoise, and short and long finned pilot whales, and one pinniped species, the harp seal. As a result of these documented interactions, both fisheries are listed as Category Two in the List of Fisheries published by NMFS in 2007. These fisheries also interact with sea turtles (Rossman *et al.* 2006), including the loggerhead sea turtle (*Caretta caretta*), where the annual bycatch has been estimated at 616 individuals (Murray, 2006). NMFS is considering requiring the use of Turtle Excluder Devices (TEDs) at particular times of the year in many bottom trawl fisheries south of Cape Cod.

II.1.3 Ghost Fishing

Ghost fishing by lost or discarded fishing nets is a problem in all fisheries. Trawl nets are unintentionally lost on wrecks, hangs, and in soft mud bottoms, and are sometimes discarded at sea. These gears are referred to as derelict fishing gears, and as they are made of synthetic material may persist for a long time in the marine environment. Lost gear will continue to capture fishery resources, and result in unaccounted mortality and a waste of resource. There are no studies documenting the number of lost trawl nets in these fisheries, or estimating the number of fish lost due to ghost trawl fishing gear.

II.1.4 Habitat impact

The effects of mobile fishing on benthic habitats have been well documented and reviewed in numerous reports and papers (Jennings and Kaiser, 1998; Kaiser *et al.* 2006; and many others) and books (Hall, 1999; Kaiser and deGroot, 2000, Løkkeborg 2005). Løkkeborg (2005) concluded the most noticeable physical effect of otter trawling is the furrows (up to 20 cm deep) created by the doors, whereas other parts of the trawl create only faint marks. The most serious biological impacts of otter trawling on hard bottom habitats that are dominated by large sessile fauna were demonstrated when vertical epifaunal organisms such as sponges and corals were shown to decrease considerably in abundance at the passing of the ground gear. Experimental trawling on sandy bottoms of high sea (offshore) fishing grounds caused declines in some taxa. However, such disturbances did not produce large changes in benthic assemblages, and these habitats may be resistant to trawling, owing to natural disturbances and large natural variability. Studies of the impacts of shrimp trawling on clay-silt bottoms have not demonstrated clear and consistent effects, but potential changes may be masked by the more pronounced temporal variability in these habitats. Trawling disturbance caused no effects in areas exposed to natural disturbances (e.g., wave action, fluctuations in salinity).

In essence, the issues are the severity of the disturbance to the habitat, the frequency of the trawl disturbance relative to natural disturbance, and the recovery time of the habitat to the natural condition (DeAlteris *et al.* 1999; DeAlteris 2005). The severity of disturbance is a function of gear type and complexity of the habitat. The frequency of trawl disturbance is related to the intensity of fishing. The frequency of natural disturbance is related to water depth, and ocean wave and current climate. Finally, the recovery time of the habitat is a function of both re-colonization and growth rates. There are no specific studies of effects of the summer flounder, winter flounder, and scup trawl fisheries on habitats. However, for the most part these fisheries are prosecuted on relatively smooth, sand to mud bottoms with nets using cookie sweeps. These gears minimally disturb the seabed, despite rather intense levels of fishing in some areas, so the habitat impact is minimal as compared to the habitat impact of a scallop dredge on a gravel-cobble bottom with vertically developed epifuana. He (2007) reviewed worldwide modifications to trawl gear that have been adopted or have been examined with the intent of reducing bottom contact of trawl gear. It can also be concluded that knowledge of the impacts of towed fishing gear is still rather rudimentary. The difficulty in conducting impact studies that produce clear conclusions is due primarily to the complexity and natural variability of benthic communities (Løkkeborg 2005).

II.1.5 Summary and Recommendations

A considerable body of research has been conducted on the size selection characteristics of trawl codends for summer flounder, winter flounder, and scup. Bycatch of non-target finfish species in the scup fishery remains a problem in need of better documenting through at-sea sampling. The magnitude of non-target bycatch in the summer flounder fishery is unclear, as little information is available in the literature, and future investigations into this topic (also through at-sea sampling) would be welcomed. Information regarding fleet dynamics and its impacts on sub-legal target and non-target bycatch may also prove useful. Protected species bycatch in these trawl fisheries is problematic. The National Marine Fisheries Service is considering seasonal regulations requiring Turtle Excluder Devices (TEDs) in trawls operating south of Cape Cod. Small cetacean bycatch in the trawl fisheries is also problematic, although these fisheries have not been identified as Category 1. Additional research is needed to minimize effects on catch rates of target species that may occur with the introduction of TEDs into trawl nets, as well as developing new technologies to reduce small cetacean interactions with trawls.

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Table II-1.2.1.1. Summer flounder trawl codend selectivity results.

Mesh size (in.)	Mesh shape	L50 (TL in.)	Reference
5.5	diamond	13.5	Lange (1984); Gilliken *et al.* (1981)
6.0	diamond	16.2	DeAlteris *et al.* (1999)
6.5	square	16.2	DeAlteris *et al.* (1999)
6.5	diamond	17.3	Beutel *et al.* (2004)
7.0	square	17.1	Beutel *et al.* (2004)
7.0	diamond	17.7	Beutel *et al.* (2004)
8.0	square	20.4	Beutel *et al.* (2004)

Table II-1.2.2.1. Winter flounder trawl codend selectivity results.

Mesh size (in.)	Mesh shape	L_{50} (TL in.)	Reference
4.7	diamond	9.7	DeAlteris and Riefsteck (1992)
4.7	square	8.5	DeAlteris and Riefsteck (1992)
5.0	diamond	11.2	Simpson (1989)
5.25	diamond	11.5	Smolowitz (1983)
6.5	diamond	15.0	DeAlteris and Chosid (2004)
6.5	square	16.9	DeAlteris and Chosid (2004)
7.0	diamond	15.0	DeAlteris and Chosid (2004)
7.0	square	17.0	DeAlteris and Chosid (2004)

II.2 American Lobster Pot Fishery

II.2.1 Introduction

a. Background

The American lobster *Homarus americanus* pot fishery was identified as a fishery of concern primarily because of the fishery's magnitude. It is estimated that up to 4,000,000 lobster pots are actively fished in the United States Exclusive Economic Zone, resulting in yearly landings of over 38,000 MT. The primary problem identified for this fishery was interactions with protected species, particularly marine mammals; sub-legal discarding, non-target finfish catches, ghost gear, and habitat impacts were cited as minor problems. However, the number of pots magnifies the small individual impact of each pot. Therefore, all of these factors are considered.

b. Life History and Status of Resource

The American lobster is found in the Northwest Atlantic from Labrador to Cape Hatteras, from coastal waters out to depths of 700 m (400 fathoms). Highest abundances are found along the coast within the Gulf of Maine and southern New England, and three separate stocks are defined within this area (i.e., Gulf of Maine, Georges Bank, and southern New England). Lobsters have a complex life cycle with mating following molting of the female. Eggs (7,000 to 80,000) are extruded and carried under the female's abdomen during a 9 to 11 month incubation period and hatch during late spring or early summer. Larvae are pelagic and undergo four molts before becoming adults and settling to the ocean floor. Lobsters molt approximately 20 times (in 5 to 8 years) before reaching minimum legal size.

Landings of lobsters have increased steadily since 1990. The Gulf of Maine and Georges Bank stocks are currently in favorable condition (not depleted and overfishing is not occurring relative to the reference points used in the assessment), with the exception of Area 514. The southern New England stock has been determined to be depleted. Overfishing of this stock is not occurring, however (McKown *et al*. 2009).

c. The Fishery and Gear

Lobster pots are the primary gear type employed in the U.S. commercial lobster fishery. Between 1981 and 2003 commercial pots accounted for an average of 98% of the total landings. All other gear types (otter trawl, gill net, dredge, SCUBA) accounted for the remaining 2% of the total landings (Correia *et al.* 2005). The size, shape, construction, and rigging of lobster pots vary across the fishery. Construction material is predominantly coated wire, but certain areas, such as outer Cape Cod, prefer wooden pots. Inshore pots are typically rectangular, 36 in (92 cm) in length, approximately 21 in (54 cm) wide, and 14-16 in (36-41 cm) high; offshore traps are usually longer, approximately 48 in (122 cm). In many areas, pots are strung together: inshore strings are typically 10 pots long; offshore ones can be 40 pots long. In the inshore Maine fishery, pots fished singly or doubly are common. Pots are typically constructed with two entrances leading to a parlor, with one opening from the parlor into the kitchen (R. Glenn, Mass. DMF, pers. comm.). Bait preferences vary by region, practice, and supply.

Figure II-2.1.1. Traditional wood frame and netting lobster trap (From DeAlteris, 1998).

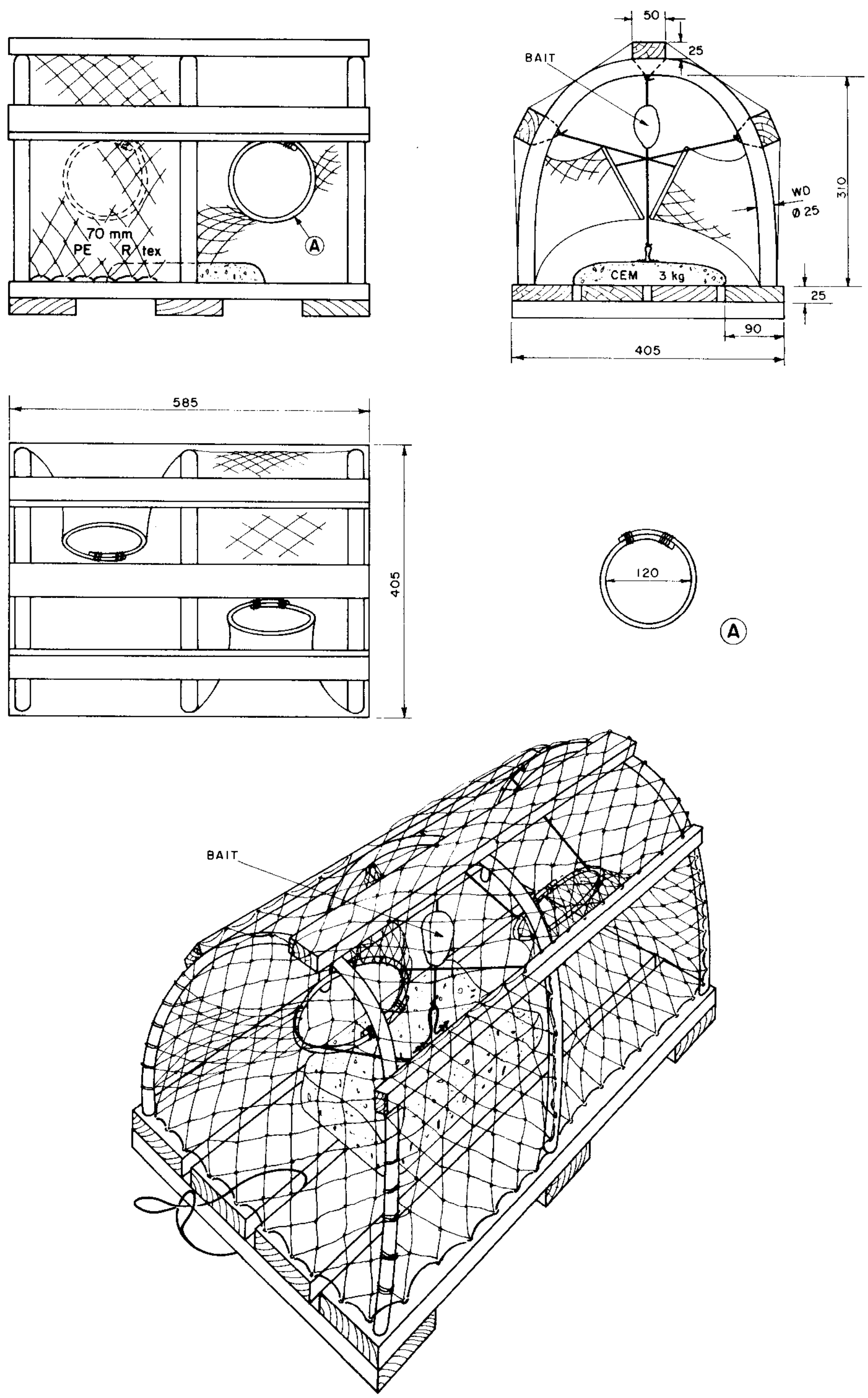
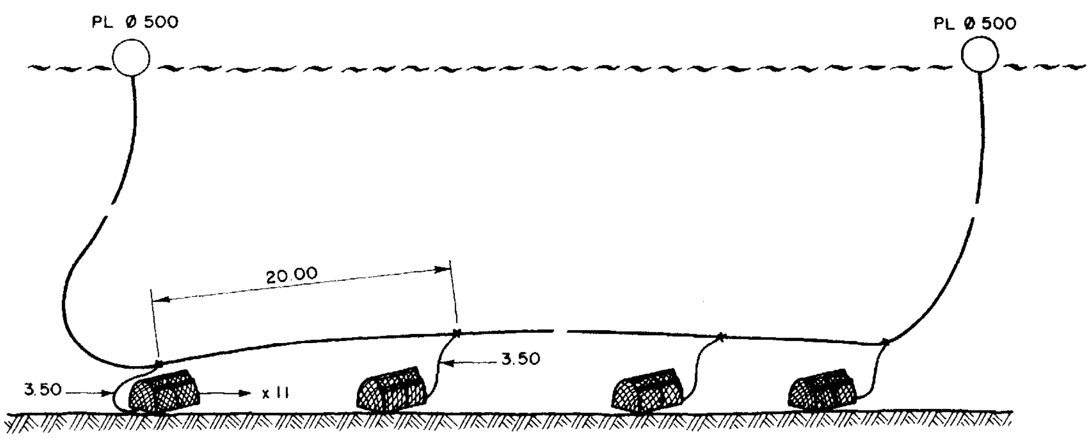


Figure II-2.1.2. Lobster trap set (From DeAlteris, 1998).



d. Management and Regulations

As noted above, lobsters are managed under a three-stock structure (Gulf of Maine, Georges Bank, southern New England). A sub-committee of the ASMFC Lobster Technical Committee is responsible for assessing each of these stocks, and these assessments are subjected to an external peer review as well as a review by the ASMFC Lobster Board. Regulation of U.S. lobster fishing from the Hague Line to Cape Hatteras is divided into seven Lobster Conservation Management Areas (LCMAs), each with a Lobster Conservation Management Team (LCMT) of appointed industry members (McKown *et al*. 2009). In many instances, these LMCAs cut across stock boundaries. The LCMTs are responsible for proposing preferred management measures for their respective LCMAs to the Lobster Board. They are also responsible for facilitating the implementation of FMP provisions and informing industry members as to the status of the lobster stocks.

In order for a change in the lobster FMP to occur, the proposed amendment or addendum to the Plan goes to public hearings and is then voted on by the Board. If approved, the states adopt conforming regulations or legislation. NMFS is also required to adopt 'complementary' regulations for Federal waters (R.B. Allen, pers. comm.). Pot limits, minimum and maximum landing sizes, escape vent dimensions, and v-notch definitions and requirements vary among LMCAs; area-by-area management measures are available at www.asmfc.org.

II.2.2 Bycatch

a. Bycatch of sublegal target species

The primary gear modification used to limit catch of sublegal lobsters is an escape vent, an opening deliberately introduced in a pot to facilitate escape. Effective escape of sublegal lobsters was established using lath spacing in wooden lobster pots over a century ago (Templeman 1958). In 1972, informal agreement to require escape vents was reached by the states (Thunberg 2007). Mandatory use of escape vents based on research by Krouse and Thomas (1975) and Smolowitz (1978b) was initiated in 1987 under the New England Council's management plan (Thunberg 2007).

More recently, Estrella and Glenn (2006) generated selectivity curves using laboratory and field observations for both rectangular (2, 2 1/16th, 2 1/8th, 2 3/16th inches (50.8, 52.4, 54.0, 55.6 mm) x 5 ¾-in (146 mm)) and circular (2 ½, 2 9/16th, 2 5/8th, 2 11/16th inches diameter (63.5, 65.1, 66.7, 68.3 mm) escape vents that corresponded with potential increases by the ASMFC in minimum legal carapace lengths for American lobster. Laboratory experiments in sea-water raceways observed escape by lobsters of known size from pots with varying vent sizes, attracted by baits outside the pots. Field observations were generated from 10-pot trawls of alternating vented and unvented pots, with vent size consistent within trawls. Proportions of lobster escape by carapace lengths in millimeter increments were fitted with logistic curves. Raceway results in general resulted in smaller L_{50}s and more narrow selection ranges in comparison to field results. Field results were deemed not useful for management purposes by the authors due to inadequate sample sizes and limited size ranges of lobsters due to heavy exploitation in Cape Cod Bay, Massachusetts. Results from this research were used by the ASMFC to adjust circular to rectangular vent equivalencies, and to establish circular and rectangular vent sizes that correspond to minimum gauge sizes (ASMFC 2007).

The vent sizes selected by the ASMFC are chosen so that the minimum legal carapace length is above the L_{100} determined by Estrella and Glenn (2006), resulting in a 'conservation buffer' from the minimal escapement of legal-sized lobsters. This conservation buffer is incorporated into the fishery management plans of several lobster management areas. While harvesters report displeasure at escape of legal size lobsters through escape vents, substantial capture of sublegal lobsters in commercial pots continues. DMF commercial sea sampling lobster pot data for the last five years drawn from 84 sampling trips per year show sublegal discard rates as high as 53% of all lobsters caught (Table II-2.2.1). Stock-to-stock differences in discard rates are attributed to size-related differences in habitat use with larger lobsters on Georges Bank. While escape vents have not eliminated sublegal capture, their impact can be seen in Table II-2.2.1. A minimum legal lobster size without an escape vent increase was put into effect in 2003. The subsequent drop in discard rates probably reflects the implementation of a larger mandatory escape vent in 2004 (R. Glenn, pers. comm.).

Reportedly, some vents are placed within the pot to inhibit escape of legal-sized lobsters, and high sublegal capture rates may reflect that inhibition. Due to the nature of the original Estrella and Glenn (2006) study design, the impact of lobster behaviors (resource guarding, within-trap competition, and others) on escape could not be included. Increasing the vent size therefore may not further reduce sublegal catches. Lobsters physically capable of escaping through a vent may not be enticed or willing to escape regardless of how large an opening is (R. Glenn, pers. comm.).

Capture and release of sublegal lobster can cause damage, exposure and displacement that lead to immediate mortality and delayed mortality. This subject does not appear to have been substantially investigated for *Homarus americanus*. Pecci *et al.* (1978) found 9% of all-sized lobsters to be damaged after entry into the pot. Smith and Howell (1987) found immediate and delayed mortality in pot-caught lobsters to be zero. Comparatively, immediate mortality in otter trawls ranged from 0-2.2% and delayed mortalities of trawl-caught tank-held lobsters with CL <81 mm (3.2 inches) ranged from 1.0-19.2%. Moriyasu *et al.* (1995) reported pot-caught untagged lobsters had a mortality rate of 2.5% (3/120) after being held for 5 days in tanks. Tagged lobsters similarly held had a mortality rate of 10% (26/260). While sizes were measured in this study, they were not reported with respect to mortality rates.

Before discarding, American lobsters are typically held on deck for only a short time - <30 min in inshore operations, longer in offshore lobster operations (M. Syslo, Mass. DMF, pers. comm.). While the effect of this exposure on American lobsters appears to be unstudied, DiNardo *et al.* (2002) demonstrated that poor handling, including lengthy (>1 h) exposure of spiny and slipper lobsters (*Panulirus marginatus* and *Scyllarides squammosus*) common in that fishery, led to mortalities ranging from 25-77%. Brown and Caputi (1979) found exposures as short as 15 minutes increased mortalities of western rock lobster (*Panulirus cygnus*). Generally, increasing exposure led to increasing mortality whether from direct mortality or from predation. Additionally, Brown and Caputi (1983) implied mortality due to lower recaptures of displaced tagged rock lobsters, compared to non-displaced tagged rock lobsters.

Near-surface predation of discarded sublegal lobsters by fish, particularly striped bass, is reportedly high and may be a learned behavior. An examination of predation on discarded spiny lobsters indicated variation between sites, from zero to near total predation on discarded individuals by white ulua *Caranx ignobilis* (Gooding 1985). No published reports were found describing predation on discarded American lobsters.

Avoiding capture and mortality of sublegal lobsters would reduce wastage and could improve abundance of stocks. Innovations to allow lobster release at depth were described at the 2008 Maine Fishermen's Forum by Blue Water Concepts (Eliot, ME). A lobster trap is fitted with a small compartment with a low-cost, adjustable pressure sensitive release that allows fish and lobsters to be released at depth, where they will be presumably less vulnerable. The modification is still in the developmental stage.

b. Bycatch of non-target species

Finfish bycatch in lobster pots has not been widely studied. However, it is well known that Atlantic cod and other groundfish are routinely captured in lobster pots. Limited observer data indicates median catch of Atlantic cod from offshore lobster trips for 2000-2005 was 0.22 lb/pot (0.10 kg/pot). The Georges Bank lobster fishery includes an estimated 100,000 pots (NMFS, unpubl. data). The assumption that discard mortality is low from lobster pots has been cited as a motivation for lack of interest in the subject. Additionally, escape vents mandated for sub-legal lobster protection also provide egress for smaller non-target individuals. Miller (1996) described two primary areas for investigation for reduction of non-target catch: repellent baits, possibly formed from conspecifics; and adjustments to the shape, size, location, and construction material of entrances and escape panels. For example, he proposed plastic skirts inside a pot that present a crawling barrier to crustaceans, but allow fish to escape. The location of escape vents is not regulated, except that they cannot be on the bottom of the pot. Recent research in Canada found that escape vent locations low on the pot exterior wall increased escape attempts in crab pots (Winger and Walsh 2007). Other Canadian investigation of the use of plastic collars as barriers in crab pots concluded collars were ineffective (Winger *et al.* 2006; Hiscock and Grant 2008). Other than these efforts with crab pots, the directions suggested by Miller (1996) remain largely uninvestigated.

c. Protected species interactions

The primary protected species interaction for lobster gear has been Atlantic large whales (McKiernan *et al.* 2002). The National Marine Fisheries Service identified the lobster pot fishery as a Category 1 fishery. Nelson *et al.* 2007 summarized all reported baleen and unidentified whale events along the Northern Gulf of Mexico coast, United States East Coast, and adjacent Canadian Maritimes from 2001-2005. Of 417 events reported for Atlantic large whales, 151 were entanglements in all fishing gear with 133 being confirmed. From 2001-2005, confirmed entanglements in lobster gear resulted in 4 mortalities and 0 serious injuries (Table II-2.2.2). Analysis of 31 right whale and 30 humpback whale entanglements where gear could be identified showed 89% of entanglements were attributable to pot and gill net gear (Johnson *et al.* 2005). Pot gear was recovered from both species equally and 81% of the entanglements were in buoy line and/or groundlines.

The NMFS Atlantic Large Whale Take Reduction Team (ALWTRT 2007) developed a working draft matrix, intended to be updated annually, comprehensively identifying and prioritizing gear research to reduce whale takes. The matrix identifies, prioritizes, and assesses current or potential strategies to reduce entanglement risk. The current version of the matrix includes 30 gear modifications, with modifications broken down into four categories: surface system of the buoy line, buoy line, reducing the number of vertical lines, and ground line.

High priority gear modifications of surface buoy systems (SBS) looked at or in place already are ‘weak links’, ‘surface system weak links’, and reducing the separation between buoys in the surface system. The ‘weak link’ is a technique or device used to reduce the breaking strength at a particular point in the gear to a predetermined maximum value that is usually considerably less than the strength of the line it is placed in. Requiring a surface system weak link for some offshore fisheries involves the placement of additional weak links at the connection of the SBS and buoy line, providing an increased measure of protection in the event of an entanglement while not compromising the weak link configuration currently required. The concept of reducing the separation between buoys in the surface system works by holding the highflier and the tide ball close to each other until it is time to haul the gear, reducing the horizontal lines at the surface between the buoys and the surface system.

High priority gear modifications in the buoy line section of the matrix include composition of the buoy line, thwartable bottom links, lipid-soluble rope, and a time tension line cutter bottom release. The composition of the buoy line modification allows for the top two-thirds of a buoy line to be sinking rope while the bottom third of a buoy line is floating rope. The bottom third of floating rope reduces the chance of the buoy line fouling and chafing on the bottom while the top two-thirds of sinking rope allow a buoy line to exhibit a profile similar to a buoy line comprised completely of neutrally buoyant line in most conditions. The concept of a thwartable bottom link is that a device located at the bottom of a buoy line will act as a weak link until the gear is ready to be hauled. At that time the device switches from a weak link mode to a strong link mode allowing the gear to be hauled. Another gear modification, in the concept stage, is lipid-soluble rope. It would have characteristics suitable for use by the fishing industry that upon contact with an entangled whale would rapidly deteriorate. The time tension line cutter bottom release is another high-priority gear modification. This device cuts the buoy line away from the bottom gear if a load is exerted on the buoy line for a time longer than the device is set to accommodate. If in normal fishing conditions it takes 5 minutes to haul the gear, the device could be set to trigger the cut after a 10 minute time period. Thus, a whale entangled in the buoy line would be released from the bottom gear after pulling on the buoy line for 10 minutes.

Reduction of the number of vertical lines is suggested through acoustic releases and increasing the number of pots per trawl. Acoustic releases hold the buoy and buoy line on the bottom until an acoustic signal releases them so the pot can be hauled.

Ground line high-priority gear modifications include the type of rope and reduced profile. The type of rope modification would replace traditional floating rope ground lines with sinking or neutrally buoyant rope replacing floating rope between pots which has been shown to rise up to 25 feet (7.6 m) or more above the bottom. The reduced profile modification relies on an adaptation to the already existing floating rope ground lines which would lower its profile in the water column (such as by adding weight at intervals).

II.2.3 Ghost Gear

Ghost fishing occurs when lost fishing gear continues to catch and kill animals, including lobsters and finfish such as tautog and black sea bass, generating unaccounted fishing mortality. This mortality may persist through ‘self-baiting’ as dead individuals act as an attractant for both target and non-target species. Additional impacts of ghost fishing gear include adding to marine debris, interference with trawl surveys, and habitat alteration, which may be negative or positive. It is estimated that a minimum of 400,000 pots are lost per year. Smolowitz (1978a) cites anecdotal estimates of the annual loss of pots as 20-30% of all pots along the Atlantic seaboard. The catch rates of ghost pots were found to be 10% of that of hauled traps (Pecci *et al.* 1978). Twenty-five percent of lobsters caught in ghost pots died. Causes identified by Smolowitz (1978b) include pot warp parting, buoy separation, buoy break up caused by propellers, gear conflicts, damage by sea gulls, and even fish biting. Operational mistakes were also identified such as excessive ballast in pots. Environmental influences such as storm surges, rolling up of gear, and substrate burial were also identified. Smolowitz suggested several solutions including effort reduction, and improvements in pot shape, ballast, warp, buoys, and greater use of multipot trawls, as well as degradable sections and sublegal escape vents (Smolowitz 1978b). The higher durability of coated wire lobster pots (95% of lobster pot construction type in Massachusetts (Dean *et al.* 2007)) exacerbates the ghost pot problem (Fogarty 1995; Pol and Carr 2000). In some areas, an equal number of ghost and active lobster pots have been observed. A recent ghost trap removal project in the Cape Cod Canal found 50% of lobster pots encountered by divers were ghost gear, and half of these were irretrievable, in some cases due to encrusting growth (McClintock and Churchill, 2007).

Sidescan sonar has been found to be an effective means of detecting ghost pots (Stevens *et al.* 2000, AUSS 2006) and could potentially be used in recovery efforts. Images of pots using sidescan sonar, including one reportedly of ghost gear, can be viewed at: http://www.l-3klein.com/image_gallery/image_gallery.html.

Ghost fishing is primarily mitigated by mandatory panels attached with biodegradable fasteners (‘escape panels’ or ‘biodegradable panels’) that create larger escape openings if the panel falls open after time. The development of the appropriate materials for panels was the subject of considerable research (B. Estrella, pers. comm.; Blott 1978). Panels were mandated by ASMFC Amendment 3 (Lockhart and Estrella 1997) for all non-wooden pots. Effectiveness of escape panels in lobster pots has not been assessed since implementation. However, the location of the panel is not regulated (other than a prohibition on placing the panel on the bottom of the pot) and reportedly, panels are intentionally placed to prevent them falling open when attachments biodegrade. Also, stainless steel or other non-degrading rings may be used, as replacement of biodegradable rings is a nuisance. Some underwater observations indicate panels are not falling off within 1 year. Enforcement of ring material is difficult as the materials are hard to distinguish in the field.

II.2.4 Habitat Impact

Pots, groundlines, and anchors can affect substrate or organisms they settle upon or are pulled across during setting and retrieval (Rose *et al.* 2000). Bottom habitats with higher relief such as reefs are more vulnerable to pot damage. Smolowitz (1978a) reports banning of pots in an Australian snapper fishery due to pots scraping along the sea bottom and killing corals. Others contend lobster gear poses no threat to the sea floor (Morrell 1998). Eno *et al.* (2001) found surprisingly little immediate impact to sea pens from *Nephrops* pots, although they could not discount cumulative impacts. They suggested snagging of lines and pots and dragging during recovery may cause more severe damage.

Recommendations to minimize adverse effects of pots and traps include effort reduction, exclusion from sensitive habitats, lighter pots, minimizing the amount of line on bottom, and fewer pots per string (Northeast Region Essential Fish Habitat Steering Committee 2002). Reducing the number of pots per string without effort reduction will increase the amount of vertical lines. Increased vertical lines and less line on bottom both increase risk of large whale entanglement and injury. Additionally, lighter pots may move around more, potentially increasing habitat damage (Melville-Smith *et al.* 2007).

II.2.5 Summary and Recommendations

Solutions to catches of sublegal lobster, finfish, and ghost gear have been partially resolved by the addition of escape vents and biodegradable panels. Questions exist about the effectiveness of escape vent biodegradable panels in the field. Solutions to some problems conflict with management reality (such as decreasing the number of pots fished), and some solutions reduce one problem, but increase others - e.g., sturdier gear to reduce pot loss vs. avoiding protected, endangered, and threatened species entanglement and habitat impact through the use of lighter gear.

The work of Estrella and Glenn (2006) on pot selectivity, while valuable, is limited in its ability to predict actual capture of sublegal lobster because lobster retention as a function of size in a trap is a result of physical dimensions and lobster behavior. Evaluations of escape vent selectivity methodology should be revisited so that results can lead to more accurate field implementation. Additional information on escape vent and biodegradable panel location can be obtained through surveys of pots in use in the fishery. Thorough investigation of capture, discard, and predation mortality of sublegal and other lobsters should be prioritized if capture cannot be avoided. At a minimum, existing data sources should be explored to define sublegal discard patterns. Further, investigation of development of RAMP methodology (Davis and Ottmar 2006) for lobsters should be initiated.

The ALWTRT summary of potential solutions to large whale interactions appears complete. Some modifications have been implemented and they may be effective. It has been informally reported that entanglement rates are declining. One of the most important gear related research needs in the area of whale entanglement, as referred to but not a part of the 2007 NMFS and ALWTRT working draft matrix, was the development of a technological device for the purpose of marking gear (e.g., bar code, electronic tagging). Any additional information about the nature of the gear involved in an entanglement and the area it is from would play a great role in evaluating gear modifications. Research in this area should focus on gear marking technology that can be easily affixed to the gear but also handle everyday fishing activities. Until there is a way to mark gear, the best direction to go for the future of gear research in this area is to follow the matrix established by NMFS and ALWTRT.

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Table II-2.2.1. Annual sublegal lobster discards as a percentage of total numbers of lobster caught by sampling region (from Massachusetts DMF, unpublished sea sampling data).

Year	Area 514 (Gulf of Maine stock)	Outer Cape Cod (Georges Bank stock)	Buzzards Bay (southern New England stock)
2003	51.3	10.6	73.3
2004	45.7	9.5	46.2
2005	48.0	12.5	35.3
2006	49.6	14.1	37.9
2007	46.3	13.4	53.2

Table II-2.2.2. The number of whale entanglements, injuries, and mortalities due to lobster gear interactions from 2001-2005 along the Atlantic and Gulf coasts (from Nelson *et al.* 2007).

	Events	Confirmed Entanglements	Mortalities Due to Entanglements	Serious Injury Due to Entanglements	Confirmed Mortality Due to Lobster Gear
Right Whale	51	24	3	4	1
Humpback Whale	162	70	8	6	1
Fin Whale	47	8	3	1	0
Minke Whale	86	25	11	0	2
Blue Whale	1	1	0	0	0
Sei Whale	6	0	0	0	0
Brydes Whale	1	1	1	0	0
Unidentified Whale	63	4	0	0	0
Totals	417	133	26	11	4

II.3 Northern Shrimp Trawl Fishery

II.3.1 Introduction

a. Background

Northern shrimp, or pink shrimp, *Pandalus borealis* is widely distributed in the northern waters of the Pacific and Atlantic, and in the Arctic (Schumway *et al.* 1985). The Gulf of Maine marks the southern limit of their distribution in the Northwest Atlantic (Haynes and Wigley 1969). The fishery began in the 1930s using primarily shrimp trawls. Shrimp trawls landed almost 90% of total northern shrimp landings in recent years while shrimp pots landed the rest. This section therefore will only deal with shrimp trawl issues.
The major issues related to shrimp trawling include bycatch of finfish and small shrimps, and potential impact to the seabed. Before 1992, large quantities of juvenile groundfish were discarded by small mesh shrimp trawlers in the Gulf of Maine (Table II-3.1.1, Howell and Langan 1992). The use of the Nordmøre grate became mandatory in 1992 in the fishery and has since significantly reduced finfish bycatch and discards (Kenny *et al*. 1992; Clark *et al*. 2000). However, a Nordmøre grate cannot exclude small fish that can pass through the 1 in (2.5 cm) spacing between the grate bars (Clark *et al*. 2000). Small fish such as Atlantic herring, silver hake, juvenile cod, haddock, red hake, and flounders are often bycatch in various quantities.

b. Life History and Status of Resource

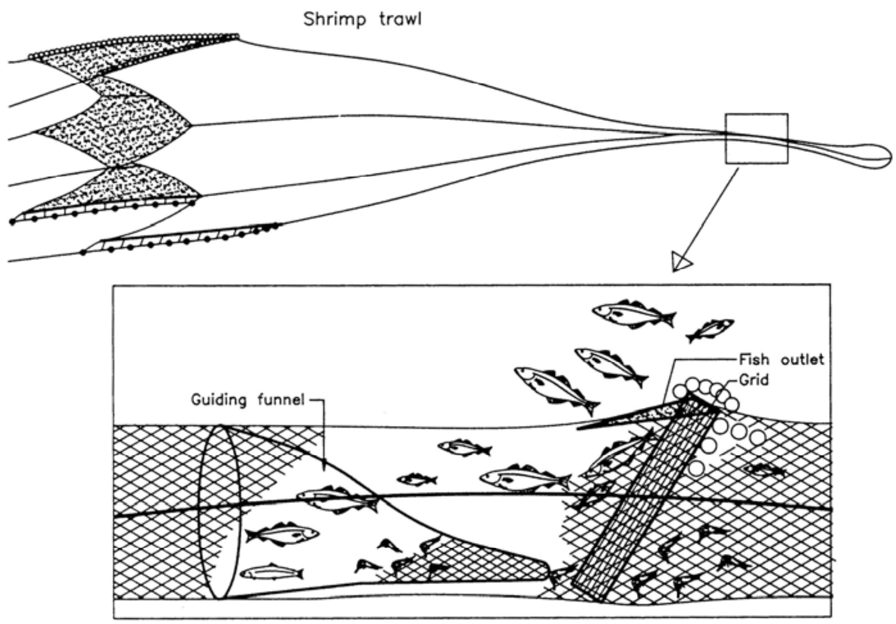
The biology of the northern shrimp in the Gulf of Maine has been extensively studied and reviewed (Haynes and Wigley 1969; Apollonio *et al*. 1986; Clark *et al*. 2000). Northern shrimp are protandric hermaphrodites, maturing first as males at around 2-½ years of age, and then transforming to females when they are about 3-½ years old. In the Gulf of Maine, spawning takes place in offshore waters in late July. Egg-bearing females move to inshore shallow waters in late fall and early winter for the purpose of hatching their eggs. Hatching of larval shrimp typically occurs in late winter or early spring. Larvae and juveniles may stay inshore for a year or more before they migrate into deeper waters offshore. The females who survived will again migrate offshore after egg hatch, to return the following season with a new brood to hatch. The winter fishery in the western Gulf of Maine off the states of Maine, New Hampshire, and Massachusetts primarily targets mature females before or just after their eggs hatch.

c. The Fishery and Gear

The Gulf of Maine commercial shrimp fishery formally began in 1938 and during the 1940s and 1950s almost all of the landings were by Maine vessels from Portland and smaller Maine ports to the east (Scattergood 1952). The fishery reached a peak of 264 tons in 1945, but then declined into the 1950s and during 1954-1957 no commercial landings were recorded. In the late 1950s, the fishery began to recover and experienced a rapid expansion in landings, leading to all time highs of 13,000 MT in 1969, but declined to about 400 MT in 1977 (Figure II-3.1.1). The total landings have been less than 4,000 MT since 1998.

Traditional shrimp trawls resemble groundfish trawls except that small mesh sizes are used throughout the net and the Nordmøre grate (Figure II-3.1.2) is required at all times. Nordmøre grates are made of stainless steel, aluminum, or more recently, high density polyethylene. They are either oval or rectangular in shape. The size of the grate is determined by the size of the gear and net drum. The grate is installed either with the fish exit on the top or on the bottom. The minimum mesh size for the net and the codend is 1-¾ in (4.5 cm).

Figure II-3.1.3: Shrimp trawl with Nordmøre grate (From DeAlteris, 1998).



d. Management and Regulations

The northern shrimp fishery is managed by the Interstate Fisheries Management Program (ISFMP) of the Atlantic States Marine Fisheries Commission (ASFMC). The Northern Shrimp Technical Committee (NSTC) provides stock assessment and other related technical information to the ASMFC's Northern Shrimp Section (NSS). NSS, with consideration of NSTC's assessment and with input from Northern Shrimp Advisory Panel, set management regimes. Currently, NSS manages the fishery through season length and gear restrictions.

The primary management measure of the fishery is the season length, with the entire fishery closed during summer and fall. The season length has varied from a total closure in 1978, to 25 days in 2001, and 151 days in 2007. In the 2008 fishing season, the season started on December 1, 2007 and ended on April 30, 2008, a 152-day fishing season.

Gear restrictions on shrimp trawls include the minimum codend mesh and the use of Nordmøre grate. The minimum mesh size regulation has been implemented since 1973, with the minimum mesh sizes in the body and codend not less than 1-¾ in (4.5 cm). The netting must be one layer except for a codend strengthener or chaffing gear attached to the bottom half of the codend. Since 1992, the Nordmøre grate has been required for all shrimp trawls. The bar spacing in the grate must be less than 1 in (2.5 cm) with a fish exit opening on the top or on the bottom depending on the orientation of the grate. The use of a size sorting grate is optional in the fishery. To reduce groundfish bycatch, the lower bridle connecting the wingend and the trawl door must be less than 15 fm (27 m) in length, and must be bare wire with no coverings such as rubber cookies. No regulated groundfish bycatch is permitted to be retained.

II.3.2 Bycatch

a. Bycatch of sublegal target species

No minimum landing size is mandated for northern shrimp. The catch of small shrimp in shrimp trawls can vary from year to year and month to month. Maine port sampling data show that since 2000 small shrimp (all species of shrimp with less than a 22 mm (0.9 in) carapace length) have made up as little as 20.9% of the total shrimp catch in the 2005 shrimp season and as much as 40.3% of the total shrimp catch in the 2001 shrimp season (Table II-3.2.1). The data also show that for the eight year period, February was the month with lowest small shrimp catch at 24.6% of the total shrimp catch. April had the highest percentage of small shrimp at 58.3% of the total shrimp catch (Table II-3.2.1).

<u>Small shrimp bycatch reduction technologies</u>

Several attempts have been made to devise a size sorting grate to sieve out small shrimps both for resource protection and a better price for larger size shrimps. A dual-grate system was tested in Newfoundland and in the Gulf of Maine for northern shrimp (DFO 1995; 1998; Schick *et al*. 1999). In these systems, the smaller spacing (11-12 mm (0.4-0.5 cm)) size sorting grate was installed after the main Nordmøre grate. The success of sorting was limited due to lowered flow rate at the second grate (FTU 1996), especially during large catch tows in which shrimps were observed to "sit" on the size sorting grate.

Schick *et al*. (2006) reported a size/species combination grate which replaces the Nordmøre grate. One of the grates had a fish exit on the bottom and with half of its length on top with 7/16-inch (1.1 cm) spacing allowing small shrimps to escape and the remaining half length with ¾ inch (1.9 cm) bar spacing leading to the codend. When compared with the regular Nordmøre grate, this design showed a 57% reduction in the number of small shrimp (<22 mm (0.9 in) carapace length) but with a 16% reduction in marketable (≥ 22 mm CL) shrimp. Another grate had only ¼ of length for the 7/16 inch bar spacing size sorting section. This grate showed a 30% reduction in the number of small shrimp, and with a loss of 13%, but not statistically significant, reduction in marketable shrimp.

He and Balzano (2007) used a small spacing (11 mm (0.4 in)) size sorting grate installed in front of the main Nordmøre grate. They tested two variations of the design, one without a funnel (SGNF) and another with a funnel (SGWF) (Figure II-3.2.1). Comparative fishing trials indicated small shrimps (<22 mm CL) escaped from the size sorting grate. The SGNF design reduced count per pound by 17 with a loss of shrimp by 16%. The SGWF design reduced count by 20 per pound, but resulted in 43% loss of shrimp. Clearly, more work needs to be done on the size sorting grate design before commercial adoption.

There have also been many square mesh codend studies for *Pandalus* shrimp fisheries around the world but with mixed results. Thorsteinsson (1992) reported a drastic reduction using square mesh codends for the Icelandic shrimp fishery to reduce bycatch of 0-group fish and small shrimp. The reduction was associated with a 10-20% reduction in total shrimp catch, but the reduction was considered acceptable as it was mainly the small shrimp that could not be utilized. All boats in the inshore shrimp fishery are now using square mesh codends to reduce the manual work of sorting and to increase the value of their quota by landing larger shrimp. A 45 mm (1.8 in) diamond mesh codend and a 45 mm square mesh codend were compared in Greenland waters (Lehmann *et al*. 1993). This study, however, showed no significant difference in the length composition of the catch for the two codends for the *Pandalus* shrimps. A study carried out in Canada comparing 43 mm (1.7 in) diamond mesh codends and 43 mm square mesh codends off of northeast Newfoundland and southern Labrador (Hickey *et al*. 1993) revealed the square mesh codend caught slightly larger shrimps than diamond mesh codend (55 vs. 59 shrimp/lb).

In the Gulf of Maine, Schick and Brown (1997) tested three different sizes of square mesh codends (1-1/4, 1-1/2, and 1-3/4 inch mesh sizes (3.2, 3.8, and 4.5 cm) in combination with the Nordmøre grate. They compared these codends with a 1-3/4 inch diamond mesh codend with and without a Nordmøre grate. The results showed the 1-1/2 inch square mesh codend provided a size selection curve very similar to the 1-3/4 in diamond mesh codend. The 50% selection length was 22 mm (0.9 in) CL, which is about the size when male shrimps change to females. The 1-1/4 in square mesh codend had a 50% selection length of about 16 mm (1.7 in) CL and the 1-3/4 in square mesh codend had a 50% selection length of about 27 mm (1.1 cm) CL. The study showed the square mesh codends provided sharper selection curves than the diamond mesh codend.

Square and diamond mesh were also tested in different combinations in the lengthener and codend (Schick *et al*. 2006). The best combination was 7/16 inch bar space bent grate with a diamond lengthener and a square mesh codend. This combination showed a 47% (statistically significant) reduction in small shrimp over the standard Nordmøre grate but with a 34% reduction in marketable shrimp.

b. Bycatch of non-target species

Before implementation of the Nordmøre grate in the fishery (prior to 1992), bycatch of finfish in the fishery was a major problem (Howell and Langan 1992). For the 50 tows for which finfish bycatch was monitored, 11.0 MT of finfish were caught, while shrimp landings were 7.8 MT, a finfish bycatch rate of 59%. American plaice and silver hake were the two major bycatch species by weight. Winter flounder comprised 2.5% of total catch. Richards and Hendrickson (2006) reported similar rates, comparable to 45-50% bycatch, in 1991 and 1992 in the same fishery.

The Nordmøre grate became mandatory in April 1992. Bycatch rates for the following four years (1993, 1994, 1995 and 1996), as analyzed by Richards and Hendrickson (2006) from observer data, were much lower, between 12-16% of the total catch for these four years. Of those bycatch species, bycatch rates of regulated roundfish were between 3.9-10%, while those of regulated flatfish were between 2.3-3.1% of the total catch.

Atlantic herring can be a major bycatch species during certain times of the year. He *et al*. (2007) reported 26.3% of herring bycatch during February of 2006. Mean bycatch rates for other species (by weight) from ten tows were 2.1% for blueback herring, 1.2% for silver hake, 0.5% for winter flounder and 0.4% for American plaice. Silver hake can sometimes dominate the shrimp trawl catch, especially later in the season.

Finfish bycatch reduction technologies

The Nordmøre grate (Figure II-3.1.2) has been proven to reduce bycatch of finfish species in the Gulf of Maine northern shrimp fishery (Kenny *et al.* 1992; Richards and Hendrickson 2006). Kenny *et al.* (1992) documented a reduction of regulated groundfish species by 95% for a ¾ inch spacing grate and 91% for a 1 inch spacing grate. Almost no flounders less than 29 cm in length were caught in either 1 inch or ¾ inch spacing grate, but a large number of these fish were caught when no grates were used. Richards and Hendrickson (2006) reported about 60% reduction of regulated species comparing four years (1993-1996) when grates were used in the fishery with proceeding two years (1991-1992) when grates were not used. They also reported an increase in shrimp catch rates when grates were used.

He and Balzano (unpublished) tested a modified Nordmøre grate with most of the netting around the grate removed and strengthened by ropes. The rationale behind the design is that finfish and other bycatch species may more easily get off a grate with large open spaces on the sides and on the top. As a result, less finfish may pass through the grate as well as allowing more efficient passing (less blocking) of shrimps. While there was a slight increase in the catch of shrimps (31%), all major bycatch finfish were reduced by 21 to 79%. While these data are preliminary, they indicate room for improvement of the Nordmøre grate to further reduce bycatch, without loss of shrimps.

He *et al*. (2007) tested a shrimp trawl without an overhang square and the top netting immediately following the square. The net resembles an upside-down version of a regular trawl (Figure II-3.2.2). The net is called a 'topless trawl' as the majority of the top netting has been removed. A similar trawl without an overhang square targeting Norway lobster was tested in the English Channel and proved successful in reducing the bycatch of haddock, whiting, and other finfish species (Revill *et al*. 2006). The topless trawl performed very well in reducing the amount of bycatch. In the 10 pairs of comparative tows, the overall bycatch was reduced from 30.5% to 9.4% with a moderate increase in shrimp catch. The major finfish bycatch species was Atlantic herring.

Schick and Brown (1997) tested a 1-1/4 inch square mesh codend with a Nordmøre grate against a 1-3/4 inch diamond mesh codend with and without a Nordmøre grate to determine the effectiveness of finfish release. The results showed a 32% decrease in silver hake bycatch when using the 1-1/4 inch square mesh codend compared with the 1-3/4 inch diamond mesh codend without the grate. The 1-3/4 inch diamond mesh codend with the Nordmøre grate showed only 1% decrease in silver hake bycatch compared with the same codend without a grate. The 1-1/4 inch square mesh codend was either less effective or ineffective at reducing the bycatch of all other finfish when compared to the 1-3/4 inch diamond mesh codend with a grate.

c. Protected Species Interactions

There are some reports of Atlantic sturgeon and one report of shortnose sturgeon blocking the fish escape hole, being caught in shrimp otter trawls, and then being released alive. Even though marine mammals (mainly harbor porpoise) are often spotted following shrimp trawls, no documented bycatch or mortality has been reported.

II.3.3 Ghost Gear

Loss of shrimp trawls is not common and ghostfishing from lost trawls is not considered to be a significant problem.

II.3.4 Habitat Impact

Shrimp trawls, like other bottom trawls, alter seabed structure and may impact benthic organisms living in or on the seabed. While physical alterations of the seabed by towed gears are evident, the effects of the alterations on benthic organisms and recovery rates of the alterations vary depending on location, depth, and natural disturbance in the area. Researchers are making efforts to quantify the effects and to devise means to reduce alterations and their impact on the ecosystem (He 2007). Simpson and Watling (2006) did a study on the effect of commercial shrimp trawling on mud-bottom fishing grounds in the Gulf of Maine. In this study, surface burrow densities, porosity, excess ^{210}PB activity, and sediment macrofauna were examined in active and non-active trawling areas. The results showed commercial shrimp trawling did not appear to have a cumulative or lasting impact on overall habitat or macrofaunal community structure, though significant short-term changes in macrofaunal communities were clearly apparent on fishing grounds within 3 months of trawling.

The authors felt factors contributing to the rapid recovery rate were the low intensity and low frequency of trawling over the course of the study. They also suggested there was evidence of high levels of biological sediment disturbance, probably caused by large, predatory megafauna, maintained macrofaunal communities in a disturbed, low successional state that may have minimized the impact of shrimp trawling on both habitat and community structure. Another study by Sparks-McConkey and Watling (2001) showed similar results in that there were significant reductions in surface porosity, and no significant difference in subsurface porosity immediately following experimental shrimp trawling on mud bottom in the Gulf of Maine. Three months later, surface porosity had rebounded to ambient levels, indicating a rapid recovery following disturbance. Shrimp trawls are generally similar to groundfish trawl designs except that mesh sizes are much smaller. Rockhopper gears are often used in shrimp trawls, indicating these trawls are often operating on hard sand and rocky bottom even though most shrimps are reported to reside in silt and muddy bottom. Fishing on hard bottom is believed to have more impact than on soft bottom.

Studies on bottom trawling in other areas revealed various physical and biological impacts. The impact varies with many factors, such as seabed type, natural variations, and community structure, among other factors (Løkkeberg 2005).

He (2007) reviewed various means and methods to reduce impact of trawls and dredges on the seabed. Seabed impact may be reduced through a reduction in effort, change of fishing strategy (e.g., midwater trawling instead of bottom trawling), and modification to the groundgear and the door.

In groundfish trawls, sand clouds stirred up by the doors, sweeps, and bridles are known to herd fish toward the mouth of the trawl. Shrimps (such as the northern shrimp), on the other hand, are not herded by sand clouds and bridles due to their poor swimming and inability to react to fast-moving trawl components. Therefore, a semi-pelagic trawl with the doors off the bottom and therefore no sand clouds should not reduce the capture efficiency of the gear for northern shrimp, but would reduce the disturbance of the seabed by the doors and bridles.

A project to test the feasibility of a semi-pelagic shrimp trawling system was conducted in the Gulf of Maine (He and Littlefield 2006; He 2007). In the experiment, the primary control of the door height off the seabed was achieved through the shortening of warps and monitored in real time through the use of door height monitoring devices of the NetMind system. High lift-coefficient and high lift-to-drag ratio Poly-Ice® El Cazador doors which could be operated on or off bottom were used. After 38 tows in the western Gulf of Maine in 2003, only about one-third of the door shoes were polished, indicating very light and intermittent bottom contact during turning and changes in depth. The amount of shrimp caught by the experimental trawl operating in semi-pelagic mode was comparable to catches by similar vessels fishing commercially with regular shrimp trawls on the same grounds, suggesting the possibility of using such a trawling system in that fishery. However, most of the vessels fishing for shrimp in the Gulf of Maine are not equipped with a gear monitoring system and independently controlled winch system. The application of this technology is limited at this time.

II.3.5 Summary and Recommendations

The Gulf of Maine northern shrimp fishery is an important fishery for inshore fishermen from downeast Maine to northern Massachusetts with trawling as the main method supplemented by shrimp potting. The fishery provides a good fishing opportunity at a time when the groundfishery is faced with ever increasing restriction. Implementation of the Nordmøre grate in 1992 has greatly reduced finfish bycatch in the fishery, ranging from 90-95% in one report to about 60% in another. There are still bycatch issues in the fishery, but recent modifications to the Nordmøre grate and new designs of trawls may provide further reductions in finfish bycatch. One concern is the catch of small shrimps in the fishery. Further research is needed to devise systems to reduce the catch of small shrimps. There are no reports on serious interactions of shrimp trawls with protected species. Shrimp trawling affects the seabed both physically and biologically.

There are attempts to reduce impacts of shrimp trawling on the seabed, but more efforts are needed to find solutions for efficient harvesting while minimizing impacts on habitat.

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Table II-3.1.1. Bycatch of regulated finfish in Gulf of Maine shrimp trawls (50 tows) between 1985 and 1989. No Nordmøre grates were used in the fishery at that time (From Howell and Langan, 1992).

Species	Weight (lbs)	Bycatch rate*
silver hake (*Merluccius bilinearis*)	11328	27.4%
American plaice (*Hippoglossoides platessoides*)	6380	15.4%
Atlantic cod (*Gadus morhua*)	4340	10.5%
winter flounder (*Pseudopleuronectes americanus*)	1053	2.5%
monkfish (*Lophius americanus*)	453	1.1%
witch flounder (*Glyptocephalus cynoglossus*)	403	1.0%
yellowtail flounders (*Limanda ferruginea*)	343	0.8%
all finfish	24300	58.7%
shrimp (*Pandalus borealis*) - target species	17080	
total fish and shrimp	41380	

* bycatch rate = weight of bycatch species divided by total weight of all fish and shrimp

Table II-3.2.1. Maine port sampling data from 2000 to 2007 showing for each month the percentage of the total trawled shrimp less than 22 mm (0.9 in) carapace length.

	December	January	February	March	April	Average
2000		14.3	17.6	44.4	61.1	23.7
2001		39.8	31.6	48.5		40.3
2002			26.5	35.1		29.4
2003		35.9	34.9			35.4
2004		21.9	24.4	20.1		22.6
2005	17.0	21.9	23.2	17.0		20.9
2006	19.3	18.6	8.9	48.6	41.9	26.5
2007	33.6	28.8	20.4	44.8	62.4	34.9
Average	27.3	28.5	24.6	35.9	58.3	30.2

Figure II-3.1.1. Historical landings of the northern shrimp, *Pandalus borealis* (From ASMFC 2007).

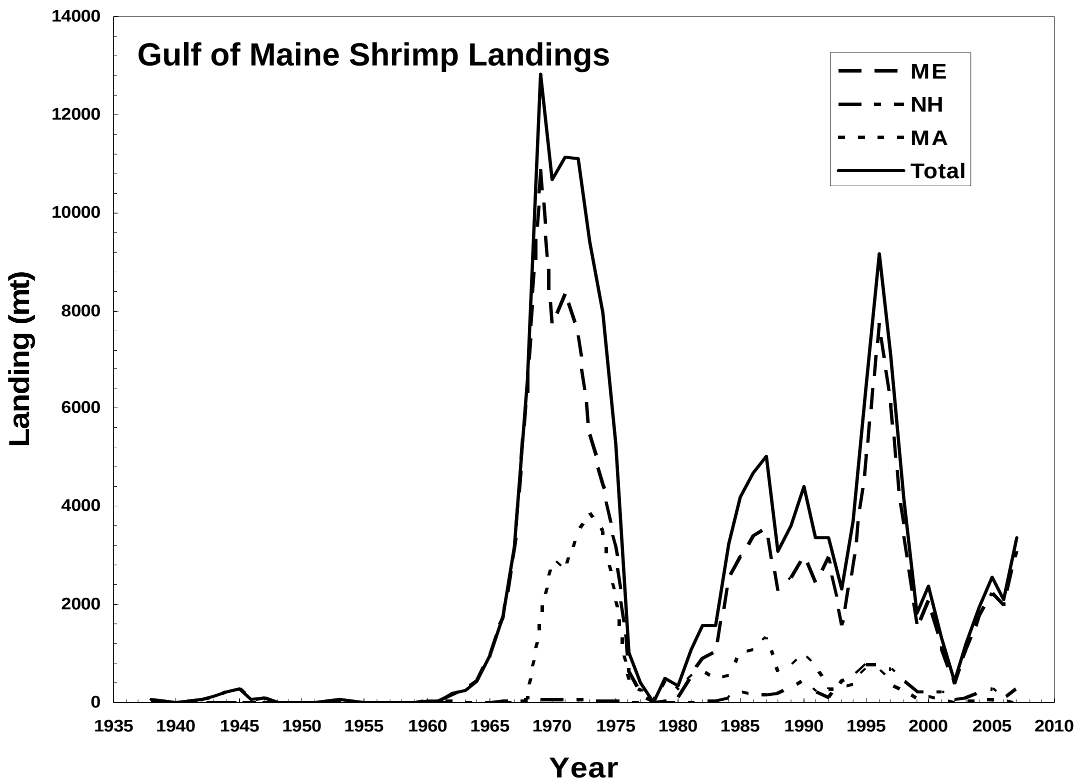


Figure II-3.1.2. An artist's impression of a Nordmøre grate.

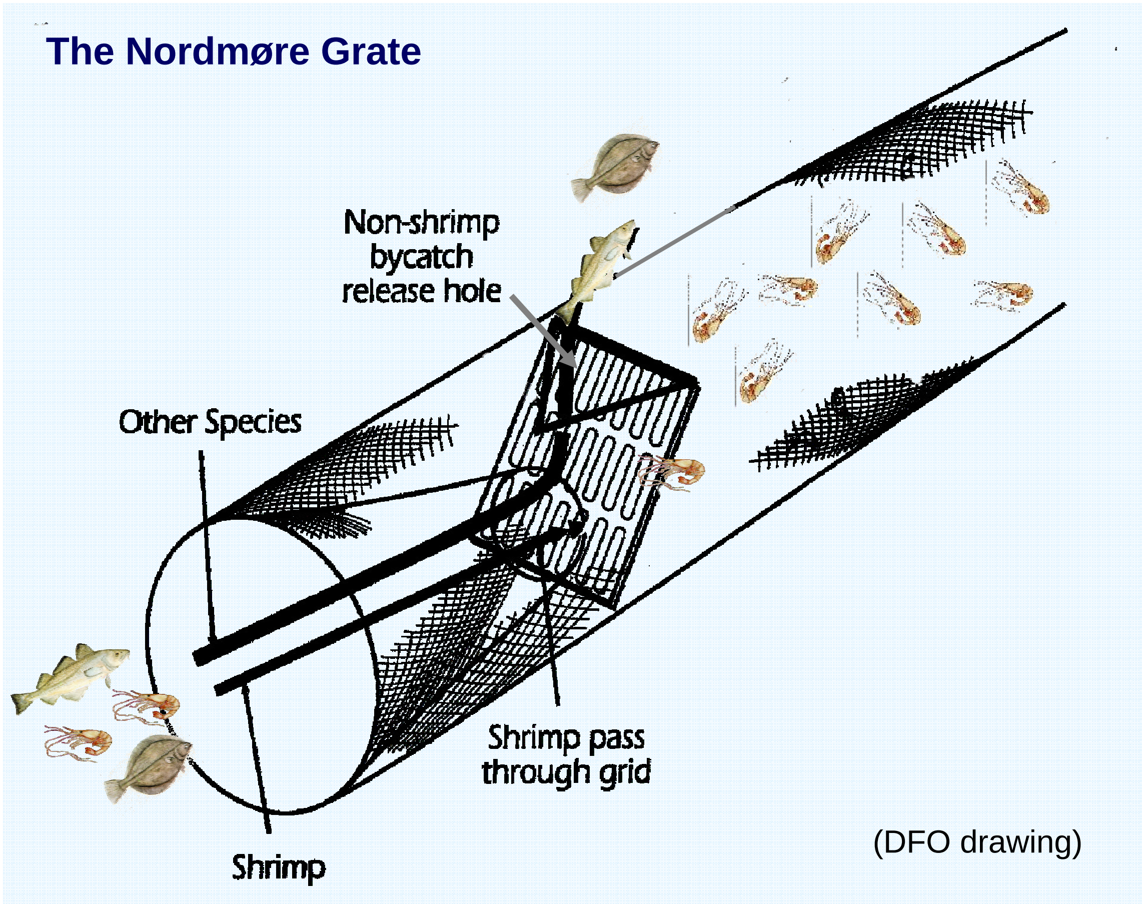


Figure II-3.2.1. Two designs of size sorting and bycatch reduction combination grates. A) Size Grid No Funnel (SGNF) and B) Size Grid With Funnel (SGWF) (He and Balzano 2007).

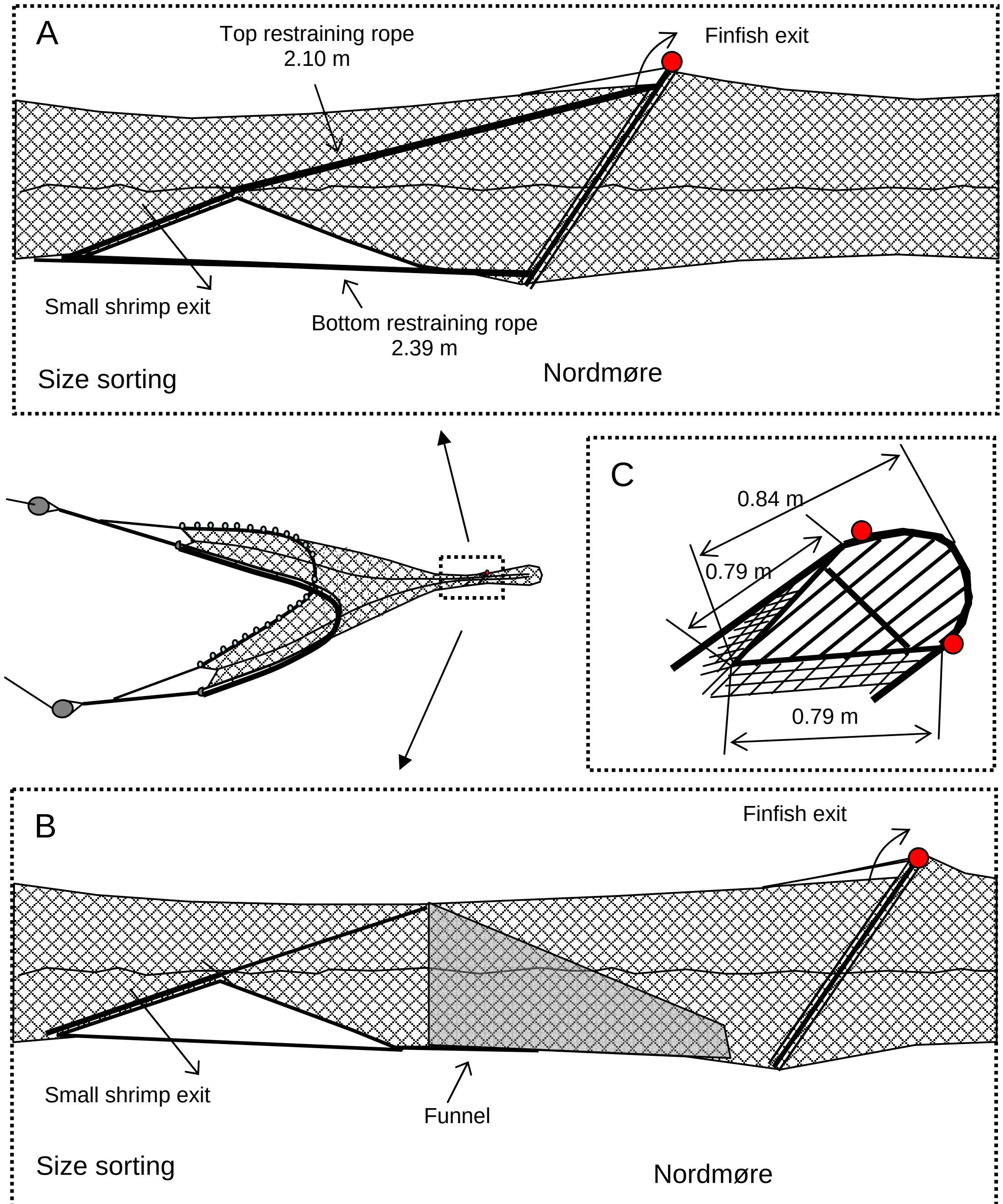
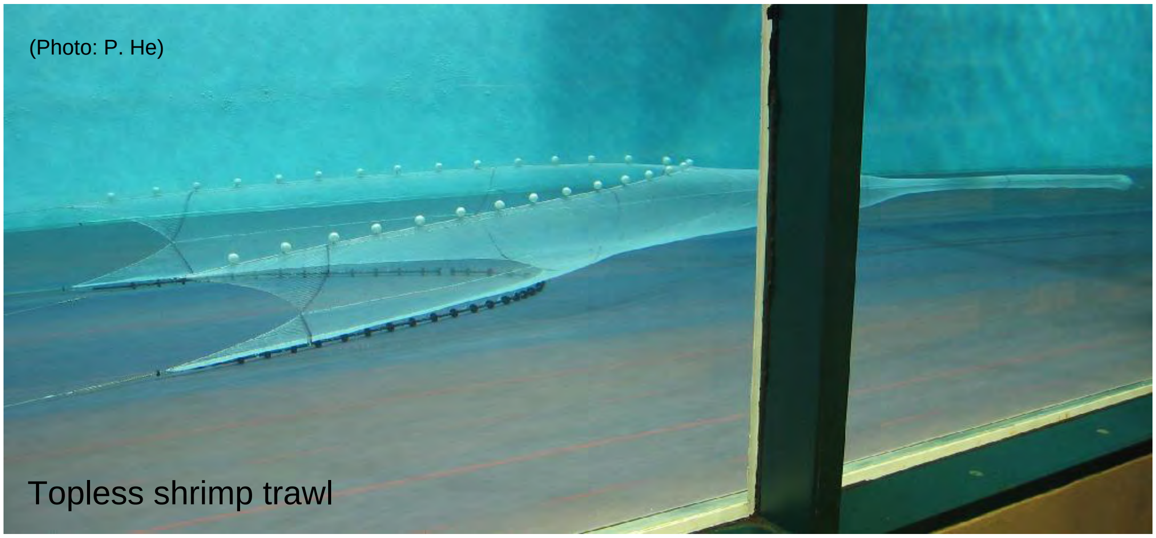


Figure II-3.2.2. The topless shrimp trawl model as seen in a flume tank (He *et al*. 2007).



II.4 Southern Shrimp Trawl Fishery

II.4.1 Introduction

a. Background

The penaeid shrimp trawl fishery conducted in the states of North and South Carolina, Georgia, and Florida consistently ranks as one of the most valuable in that region in terms of earnings by fishermen (approximately $30-70 million annually). The impacts of this fishery on the environment are well known and include bycatch of many finfish species managed by ASMFC, and bycatch of threatened and endangered sea turtles (Peuser 1996). Recent research on finfish bycatch reduction by NMFS in the Gulf of Mexico is presented as it may have application along the southeastern Atlantic.

b. Life History and Status of Resource

The three commercially important penaeid shrimp species taken in the southeastern U.S. are: the white shrimp, *Litopenaeus setiferus,* brown shrimp, *Farfantepenaeus aztecus,* and the pink shrimp, *Farfantepenaeus duorarum.* More brown shrimp are taken in North Carolina, while white shrimp are generally taken in greater quantities in South Carolina, Georgia, and the east coast of Florida. Pink shrimp are taken chiefly in North Carolina and Florida. All three species spawn in offshore oceanic waters, with larvae progressing through several naupliar, protozoeal, and mysis stages before metamorphosis to the postlarva, which recruit into estuarine habitats in shallow creek and marsh areas (Williams, 1955; 1984). The timing of spawning and estuarine recruitment varies among the species, with brown shrimp spawning in spring and fall, and subsequent recruitment occurring primarily in spring. White and pink shrimp spawn in spring and summer with recruitment progressing from spring through early fall.

According to NMFS FISHWATCH, population levels of pink shrimp in the south Atlantic is stable, but low, and is considered overfished. However, overfishing is not occurring. Population levels of white and brown shrimp are also high, and overfishing is also not occurring in these stocks either. Landing of these three species of penaeid shrimp comprise almost 99% of the landings of shrimp. Landings of shrimp vary greatly on an annual basis, primarily due to environmental considerations. In the south Atlantic annual landings have been stable, and are dominated by brown and white shrimp.

c. The Fishery and Gear

The trawl fishery targets subadult and adult shrimp as they move into lower estuaries and the ocean. Trawls are generally nylon mesh of less than 2 inch (5.1 cm) stretch mesh ranging in headrope length from 30-80 ft (9.1-24.2 m) (towed on the bottom for one to 6 hours. One to four nets are fished from each vessel, with 2-seam “flat” trawls utilized for brown shrimp and 4-seam “Mongoose” for white shrimp which occur further off the bottom. Vessel lengths range from 20+ to 100+ ft (SAFMC Shrimp FMP Amendment 6, 2004).

Because of declining economic conditions, numbers of licensed trawlers and coinciding effort have fallen dramatically since 2000. In South Carolina, for example, the number of trawler licenses fell from 913 in the year 2000 to 369 in 2008 (SC DNR License Office).

d. Management and Regulations

The individual states manage time and area trawl season openings and closures within state territorial waters, while the SAFMC prosecutes regulations in Federal waters (McKenzie 1981; SAFMC Shrimp Fishery Management Plan, 1993). In North Carolina, most shrimp trawling effort takes place in the major sounds and inlets, but regulations limit effort from some inshore areas in South Carolina to beyond one nautical mile offshore of Florida as one moves south.

II.4.2 Bycatch

a. Bycatch of sublegal target species

Currently the bycatch of small shrimp is not believed to be a problem associated with this fishery.

b. Bycatch of non-target species

The catch and discard of unwanted bycatch from penaeid shrimp trawls in the U.S. and elsewhere has been a concern since the large scale expansion of the fishery beginning in the 1930s (NMFS 1991). Estimates of 3-20 pounds of discarded finfish per pound of shrimp harvested were reported in the 1970s (Juhl *et al.* 1976 in Watson and McVea 1987). More recent observations ranged from 2.3-4.3 pounds of fish per pound of shrimp (NMFS 1995). This apparent decline in finfish bycatch could be due to numerous factors such as larger sample sizes of observed trawl catches, the use of TEDs, and changes in populations of bycatch species.

The first studies to reduce finfish bycatch in the shrimp trawl fishery in the Gulf of Mexico were conducted by the National Marine Fisheries Service (NMFS) in the 1960's (Seidel 1969; Seidel 1975; Watson 1976; Watson and McVea 1977; and Seidel and Watson 1978). Beginning in the 1980s, state agencies and the NMFS conducted studies on bycatch exclusion and shrimp retention rates for various TEDs (Watson *et al.* 1986; NCDMF unpublished data, 1985–1986; NMFS unpublished data. 1988–1989; DeLancey *et al.* 2000), and started work on identifying means to reduce finfish bycatch in the shrimp trawl fisheries (Pearce *et al*. 1988; Holland 1988) in the South Atlantic. The grid style TED, the most widely used version, may have negligible finfish reduction capabilities (S. Branstetter, NMFS, 2005; L. Parker, U. Ga. Mar. Ext., 2008, pers. comm.).

In 1991, Amendment 1 to the ASMFC Weakfish Fishery Management Plan (FMP) was adopted. This amendment recommended South Atlantic states implement programs to reduce bycatch mortality of weakfish in their shrimp trawl fisheries by 40% by January 1, 1994. State and

Federal agencies including SeaGrant and the Gulf and South Atlantic Fisheries Development Foundation, Inc. sponsored testing of many different BRDs in a variety of waterbodies, seasons, and under various tidal and environmental conditions (Whitaker *et al.* 1992; McKenna and Monaghan 1993; McKenna *et al.* 1996; Branstetter 1997; NMFS 1999; Univ. of Georgia Mar. Ext. unpub. Rep.). The goal of the testing was to find devices which maximized finfish reduction, minimized shrimp loss, and met the requirements of Amendments 1 and 2 of the weakfish FMP.

Shrimp trawl catch characterization conducted by NMFS from 1992-94 listed spot (9%), Atlantic menhaden (9%), Atlantic croaker (6%), southern kingfish (4%), and star drum (3%) as the most abundant finfish caught per hour of towing in the south Atlantic. The ratio of finfish to shrimp was 2.3:1 by weight (NMFS, 1995); however previous estimates of finfish bycatch in the southern shrimp trawl fisheries estimated the ratio to finfish to shrimp to be as high as 20:1. This latter estimate is considered very wasteful, and resulted is considerable unfavorable attention directed to this fishery. Based on results obtained during North Carolina development work in 1990 and 1991 on DMF research vessels and operational testing conducted aboard a commercial trawler in 1992, the DMF required all shrimp trawlers working in state waters to equip their nets with functional fish excluders in October 1992. However, North Carolina was the only state that required finfish excluders. On October 20, 1994 Amendment 2 of the weakfish FMP was passed. This amendment required all South Atlantic states (NC-FL) to implement management measures to achieve the 40% reduction in bycatch of weakfish in the shrimp trawl fisheries by the start of the 1996 shrimping season.

Two Bycatch Reduction Devices (BRDs), the Florida Fisheye and the Large Mesh Extended Funnel are currently certified for Federal waters in the South Atlantic. Individual states recognize additional BRDs in respective state waters that have been shown to reduce bycatch of weakfish by 40%. While the bycatch of weakfish was mandated to be reduced by the use of approved BRDs by the ASMFC Weakfish Management Plan, weakfish and Spanish mackerel were required to be reduced by Amendment 2 of the SAFMC Shrimp Fishery Management Plan (1997). The latter plan listed requirements for the certification of new BRDs.

Gear Research to reduce finfish bycatch

Trawl minimum mesh size regulations are the principal method used to regulate fishing mortality on fish stocks (Smolowitz 1983). The control of net selectivity is the preferred management tool in lieu of other more stringent regulations such as temporal and spatial closures, quotas, or limited entry. The underlying principle of mesh size regulations is that undersized fish will escape from the codend, survive, and become part of the future spawning biomass. Studies on the survival of fish escaping from codends (Main and Sangster 1988; Simpson 1990) support the use of minimum mesh sizes as a means of reducing fishing mortality on juvenile fish.

In 1949 Roelofs (1950) tested three codend sizes (2, 2 ¼, and 2 ½ inches (5.1, 5.7, 6.4 cm)) in Pamlico Sound, North Carolina. Reduction rates were reported for spot, Atlantic croaker, and shrimp. Reduction rates for spot were 12.2% (2 in), 42.8% (2 ¼ in), and 50.5% (2 ½ in). Atlantic croaker reductions were 24.8% (2 in), 59% (2 ¼ in), and 38% (2 ½ in). Overall shrimp reduction rates were 5.6% (2 in), 14.9% (2 ¼ in), and 9.2% (2 ½ in). In all cases, reduction rates were influenced by the size of the fish and shrimp.

The NCDMF conducted some preliminary tests on diamond codend mesh size in 1991, and square mesh codends in 2000. The two codends tested in 1991 were 1-5/8 inch (4.1 cm) stretched mesh (13/16 inch bar (2.1 cm)), and 2 inch (5.1 cm) stretched mesh (1 inch bar (2.5 cm)) tested against a 1 ½ inch (3.8 cm) standard stretched mesh codend. In 2000 a 1 ½ inch stretched square mesh codend was tested against a 1 ½ inch stretched mesh diamond codend. Results of the 1991 tests indicated that there was no apparent difference between the catches in the control net and the 1 5/8 inch codend. Tests with the 2 inch stretched mesh codend did show a difference between catch rates of spot (-46%), Atlantic croaker (-22%), total fish (-37%) and total catch (-18%). However as was the case with the 1 5/8 inch codend not enough tows were made to test for significance differences. Tests conducted in 2000 with the 1 ½ inch square mesh codend showed a significant reduction in the catch of young of the year (YOY) weakfish (-51%).

An original intent in the development of BRDs was to reduce the unwanted bycatch of red snapper in the Gulf of Mexico. The use of BRDs by commercial shrimp vessels operating in federal waters became mandatory in 1998 under amendment 9 to the Gulf of Mexico shrimp fishery management plan. Under this amendment, BRDs were required to reduce the bycatch mortality of juvenile red snapper by a minimum of 44% from the average level of mortality for the years 1984–1989. Three BRDs were certified under these criteria: the Fisheye, Gulf Fisheye, and Jones-Davis BRDs.

In February of 2008, NMFS issued a final rule to consolidate and make modifications to the Bycatch Reduction Device Testing Manual for the Gulf of Mexico and the South Atlantic regions (NMFS 1999). The rule revised the bycatch reduction device certification criteria for the western Gulf of Mexico and certified additional BRDs. The intended effect of the rule was to improve bycatch reduction in the shrimp fishery.

Under the new certification criteria, the candidate BRD must demonstrate a 30 percent reduction in total weight of finfish bycatch to be certified. The new rule also provides a secondary benchmark by which BRDs can be provisionally certified, i.e. at least 25 percent reduction in total weight of finfish bycatch. A provisional certification applies to an experimental BRD not quite meeting the criteria for certification, but deemed likely to meet the criteria with further testing. A provisional certification of a BRD is effective for two years from the date of publication in the Federal Register. This time period allows additional wide scale industry evaluation of the BRD candidate. The intent is to further refine the design or application of the experimental BRD so it could eventually meet the certification requirements. Placement of the Gulf Fisheye would be restricted under the new criteria.

Based on the results of recent certification tests three BRD designs, the Extended Funnel, the Modified Jones-Davis, and Composite Panel BRDs have been certified under the new criteria (Table II-4.2.1). The Modified Jones-Davis was certified for use in the federal waters of the Gulf of Mexico and South Atlantic, while the Extended Funnel and Composite Panel BRDs exceeded 25% in finfish reduction but failed to reach 30%, and were provisionally certified. The Jones- Davis and Composite Panel BRDs should be thoroughly evaluated in the South Atlantic.

c. Protected species interactions

Capture of threatened and endangered sea turtles by shrimp trawls encouraged the development of turtle excluder devices (TEDs) by NMFS and shrimp fishermen (Watson *et al.* 1986; NMFS 1991; Renaud *et al.* 1992). Beginning in the fall of 1987, NMFS required TEDs seasonally in shrimp trawls on most vessels operating in ocean waters off the southeastern U.S. (Federal Register 1987). Initially, vessels operating in inshore waters were allowed to use tow time limits in lieu of TEDs. However, subsequent evidence of sea turtle bycatch in these inshore areas provided sufficient justification for NMFS to expand TED requirements to all areas at all times with full implementation of these requirements achieved by December 1994 (Federal Register 1992a, 1992b). Federal publications estimated at least 97% of sea turtles escape through TEDs, a great improvement from the time period before they were required (Henwood *et al.* 1992).

However, significant mortality of sea turtles continues to occur. Annual estimates of mortality due to all bottom trawling activity in Atlantic and Gulf of Mexico U.S. waters are equivalent to 9,417 adult female loggerheads (http://www.fws.gov/northflorida; NMFS and USFWS 2008). Continued stranding of mature loggerhead sea turtles (*Caretta caretta*) prompted the NMFS Turtle Expert Working Group (TEWG) to recommend an investigation to compare the size of stranded sea turtles to the size of TED escape openings (TEWG 1998). Epperly and Teas (2002) found that 33-47% of stranded loggerheads and a small proportion of stranded green sea turtles (*Chelonia mydas*) were too large to fit through the minimum-size required TED opening. This study prompted NMFS to require enlarged TED escape openings throughout the shrimp fishery to allow for the exclusion of leatherback (*Dermochelys coriacea*) and large loggerhead and green sea turtles (Federal Register 2003).

In addition to sea turtle captures, there have been reports of occasional captures of bottlenose dolphins in shrimp trawls, particularly on 'lazy lines'. These takes have been investigated but the rarity of their occurrence precludes intensive research. Seabirds feed heavily on discarded bycatch, and may occasionally be caught in trailing lines before nets are set (J. Gearhart, NMFS, personal observation).

II.4.3 Habitat Impacts

Physical disturbance impacts on soft (mud and sand) bottom communities by shrimp trawling in the south Atlantic are thought to be relatively short in duration (Van Dolah *et al.*, 1991) or indistinguishable from natural fluctuations of benthic populations (Cahoon *et al*., 2001).

II.4.4 Summary and Recommendations

Despite concerted efforts by government agencies and fishermen, some intractable problems remain with achieving levels of bycatch reduction in the shrimp trawl fishery that may improve stock levels of species such as weakfish in the Atlantic and red snapper in the Gulf of Mexico. The use of BRDs has not had an apparent effect on weakfish abundance, as landings are at historically low levels (http://www.asmfc.org/). The stock status of Atlantic croaker in the south Atlantic is unknown, but has been at a high level of abundance from North Carolina north since 1996. The status of spot is also unknown, but the ASMFC states that efforts to reduce bycatch should protect the stocks until assessments can be made.

The current shrimp trawl fishery is under severe economic hardship (Nance *et al.* 2006; SAFMC Shrimp Amendment 6, 2004). New requirements for BRDs must continue to account for shrimp loss, in addition to finfish reduction and the cost and availability of new gear. For the southeast Atlantic, we recommend additional testing of newer devices that reduce finfish bycatch, such as the Composite Panel BRD (Figure II-4.2.3), the continuation of ongoing studies on bycatch characterization, other gear development, and outreach to fishermen for proper usage of BRDs and TEDs.

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Table II-4.2.1. NOAA Fisheries 2007 Gulf of Mexico finfish and shrimp reduction estimates with 95% confidence intervals for the Modified Jones/Davis, Extended Funnel, and Composite Panel BRDs (From Foster, 2008).

	n	% Finfish Reduction	Finfish 95% C.I.	% Shrimp Reduction	Shrimp 95% C.I.
Modified Jones Davis	464	33.1	30.3 – 36.0	3.2	1.4 - 4.9
Extended Funnel*	56	26.6	21.7 - 31.6	2.2	-1.7 – 6.0
Composite Panel*	146	25.1	20.9 - 29.4	5.4	1.7 – 9.1

* Provisional Certification

Figure II-4.2.1. Florida fish excluder with bottom opening Hard Ted. (NMFS)

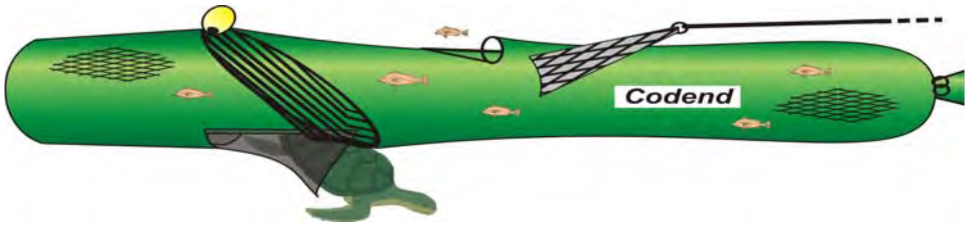


Figure II-4.2.2. Diagram of the Modified Jones-Davis BRD, which consists of two panels of webbing sewn diagonally across the trawl extension immediately behind the TED to form a funnel of small mesh webbing. The panels make a channel for shrimp to pass into the codend while creating an area of reduced water flow to allow for fish escapement through four openings (two on each side) cut into the trawl extension. A webbing cone is installed into the trawl extension behind the funnel in order to stimulate fish escapement. (NMFS)

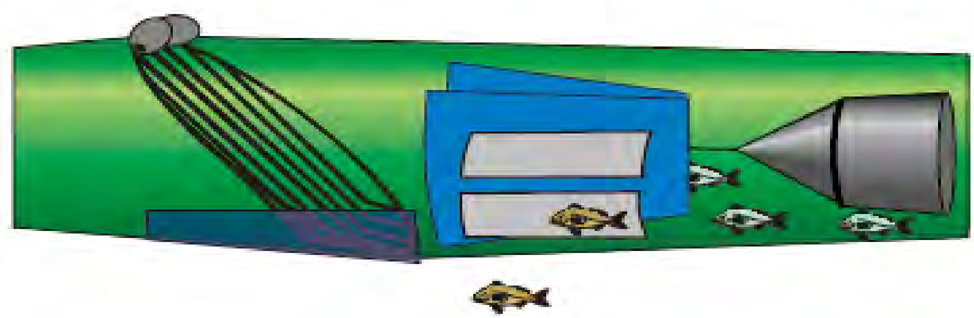
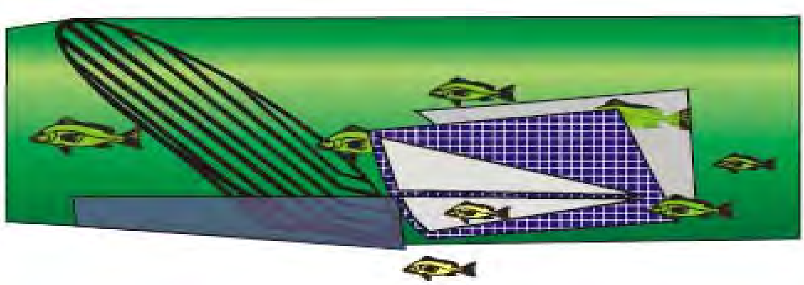


Figure II-4.2.3. Diagram of the Composite Panel BRD, which consists of two panels installed in the lower part of the extension. The panels taper inward creating a slow flow area that allows escapement of fish through two triangular escape openings cut into the extension on each side of the trawl. Each composite panel is comprised of two overlapping panels, a diamond mesh panel (interior) and a square mesh exterior panel. The inner panel reduces the water flow creating the slow flow necessary for fish escapement. The outer square mesh panel provides support, preventing the panels from billowing outward and closing off the escape openings. (NMFS)



II.5 Pound Net Fisheries

II.5.1 Introduction

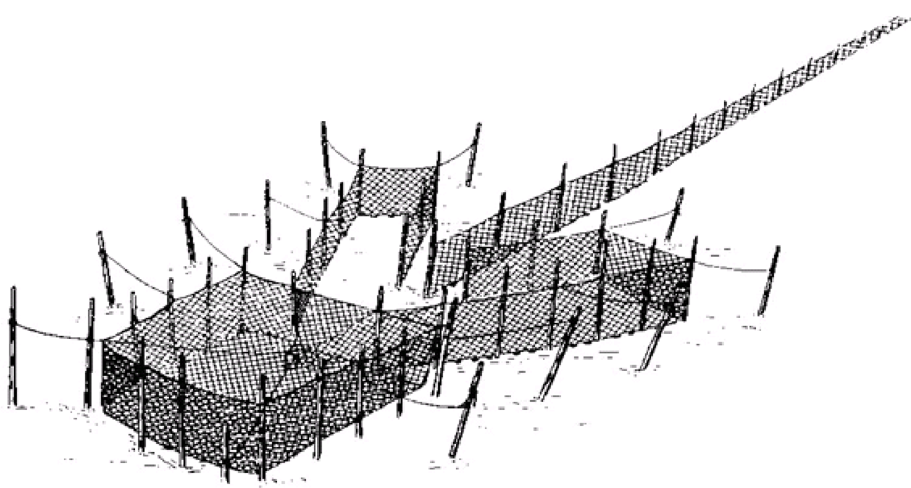
a. Background

The pound-net fishery was identified as a fishery of primary concern based on retention of undersized targeted fishes, non-targeted species and interactions with protected and endangered species. The primary protected and endangered species interactions are with marine turtles and mammals though there may be concern over intentional killing of some migratory birds. Ghost gear and habitat impacts were not cited as problems. Pound nets are a traditional fixed fishing gear that is widely used in the mid-Atlantic region.

b. The Fishery and Gear

The pound-net is a fixed gear whose design dates back to the weirs fished by Native Americans. Almost all pound-net fisheries target multiple species, though in many the vast majority of fish landed consist of a single species. The gear operates like a large trap catching and retaining a wide size distribution of fishes and variety of animals due to its funneling design and small mesh construction. Individual net design varies with location and fisher, but all nets essentially consist of a leader of relatively large mesh that intercepts mobile fishes and directs them through a series of entrapping bays and funnels into a holding net which resembles a box lined with small webbing (4.8 cm, 1.9 in).

Figure II-5.1.1. A pound net with leader directing fish into a single heart and connected funnel (From DeAlteris, 1998).



Bycatch

The small mesh in the pound net box or head is necessary to maintain the efficiency of the gear (Meyers 1976, Hager 2000) and unavoidably retains large numbers of sub-legal and/or non-marketable commercially and recreationally important fishes. Pound-nets retain numerous undersized fish (Houston 1929, McHugh 1960, Meyers 1976, Austin *et al.* 1998), including the catch and retention of a large number of undersized weakfish and summer flounder (Hildebrand and Schroeder 1928, Reid 1955, Massman 1963, Austin *et al.* 1998, Hager 2000).

Harvest methods play a key role in pound net discard mortality. Physiological stresses induced when fish are brailed into large dip nets and then allowed to remain on deck while remaining catch is landed and then sorted can result in substantial mortality (Beamish 1966, Howell and Langan 1992). When catches are large, landing and sorting time is augmented, and stress and crushing result in very close to 100% mortality (Hager 2000). Landing methods can be modified, such as the use of culling boards that are used on each bailed net, to increase discard survivability. However, these methods decrease catch-per-unit-effort because they are time consuming and are thus not commonly applied (Hager 2000). If this method is used and weakfish sorted immediately after bailing, release survival was determined to be approximately 18% (Swihart *et al.* 1995). Some species are naturally more resilient to handling and biological and environmental conditions significantly effect survival (Ross and Hokenson 1997). In general, survival under similar handling conditions of tougher fishes like Moronidae would likely be improved when immediate sorting is applied, while survival of delicate fishes like Clupeidae are unlikely to be significantly reduced.

Numerous investigators have tried to engineer a solution to promote the passive release of undersized fishes. Increased head mesh size promotes gilling and spoilage to the point that the gear becomes dysfunctional (Higgins and Pearson 1928, Houston 1929, Meyers 1976). Placing sorting panels in the head has met with greater success. Soft panels consisting of larger webbing were tried by Gearhart (1998) and Boyd (1996) with a variety of panel and webbing sizes and locations tested. Greatest success was achieved by Gearhart (1998) using a relatively large panel (3.05 x 3.05 meters in a head that measured 6.1 x 6.1 x 6.1 meters) consisting of 7.6 cm (3 in) mesh. Initially, this soft panel also resulted in excessive gilling. This attribute was effectively addressed by increasing twine size to #84. With this alteration 25% of the undersized and 20% of the legal sized weakfish were released.

Release efficiency was vastly improved with respect to numerous species through gear engineering solutions designed by the Potomac River Fisheries Commission in cooperation with their pound-net industry in 1998-2001. Initial research concentrated on engineering and testing ring and slot dimensions for desired culling performance. Once adequate size selectivity of openings was determined, small rigid panels were engineered and location and total number of openings tested to determine which specific design and locations resulted in optimal release efficiencies. The best design consisted of eight rigid panels with two panels placed in all four corners of the head at right angles so that the panel's bottoms intersect the head's (Figure II-5.2.1, Hager, 2008). Placement in all four corners at right angles provided maximum release, presumably promoting both passive and active release during tidal variations and harvest (Hager 2000).

Panel design was subsequently incorporated into a light inexpensive plastic panel that could stand the stresses of fishing at low temperatures and could be easily sewn into the head's corners without weakening the gear's construction. When tested these panels reduced retention of sublegal weakfish (<12 inch, *Cynosion regalis*) by 83% and sublegal flounder (<14 inch, *Paralichthys dentatus*) by 77%. This percentage in catch alteration is based on an assumption of an equal sublegal/legal fish ratio between paired trial days. Percent sublegal retained decreased by 42% and 19% respectively, if no such assumption is presumed. In addition, at least 66% of bluefish (*Pomatomus saltatrix*) <10 inch, 28% of spot (*Leiostomus xanthurus*) <6 inch and 100% of croaker (*Micropogonius undulatus*) <9 inch were released. Fish below these marketable sizes were legal to harvest at the time, however, they are of less value due to their reduced size and if landed are done so as bait (Hager 2008). Because the stationary pound net trap design has an inherently low mortality until harvest, BRPs can result in significant catch alterations and make pound-netting an ecologically sound method of sustainable harvest.

c. Interactions with protected species

The primary protected and endangered interactions recorded as occurring in pound-nets are with protected marine mammals and turtles. Some migratory birds are trapped but most use the nets as a resource of captured and easily attainable fishes. This use can be so intense that reprisal by fishers does occur. Reprisal for theft of fishes is generally taken on birds that are so swollen from consumption that they cannot get out of the net when the gear is approached for harvest. In the Chesapeake, bird species that suffer mortality are cormorants and brown pelicans. In addition, some Atlantic and shortnosed sturgeon are taken. Due to the trap and hold nature of the gear those that enter the head show good survival. Some have been observed entangled and killed in the gear's leaders in both northern and southern waters (e.g., Maine v. Virginia) but data on this aspect of gear interactions remains poor.

In 2004 and 2005, NMFS implemented a coordinated research program with pound-net industry participants and other interested parties to develop and test a modified pound-net leader design with the goal of eliminating or reducing sea turtle interactions while retaining an acceptable level of fish catch. The modified pound-net leader design used in the experiment consisted of a combination of mesh and stiff vertical lines.

The mesh size was equal to or less than 8 inches (20.3 cm) and positioned at a depth that was no more than one-third the depth of the water. The vertical lines were 5/16 inch (0.8 cm) in diameter strung vertically at a minimum of every 2 feet (61 cm) and attached to a top line. The vertical lines rose from the top of the mesh up to a top line to which they were attached. The stiffness of the vertical lines in the modified leader was achieved by coating them with paint in 2004 and using painted, twisted, hard lay lines in 2005. The hard lay lines used in 2005 were made of 5/16 inch (0.8 cm) twisted sinking line. The line was made of a blend of polypropylene and polyethylene (polysteel® was the manufacturer's name), and it was coated with copper paint.

During the 2-year study, the modified leader was found to be effective in reducing sea turtle interactions as compared to the unmodified leader. The final results of the 2004 study found that out of eight turtles impinged on or entangled in pound-net leaders, seven were in an unmodified leader. One leatherback turtle was found entangled in the vertical lines of a modified leader. In response to the leatherback entanglement, the gear was further modified by increasing the stiffness of the vertical lines for the 2005 experiment. Results from the 2005 experiment indicated that no sea turtles were found in the modified gear. In 2005, 15 turtles entangled in or impinged on the leaders of unmodified leaders, and no turtles were found entangled in or impinged on modified leaders. Furthermore, results of the finfish catch comparison suggest that the modified leader caught similar quantities and size compositions as the unmodified leader. Although the unmodified leaders had to be pulled out of the water partway through the experiment in 2005, NMFS believes that the results of the modified leader experiment provide sufficient new information and justification to propose allowing the use of the modified leader.

In some specific locations, marine mammals become entangled in pound-net leaders. One area where interactions with bottlenose dolphin (*Tursiops truncates*) occur with some regularity is in a series of pound-nets located outside the Chesapeake Bay off of Cape Henry, Virginia. A pound net leader consists of large mesh [4-12 inch (10.2-30.6 cm) stretched mesh] and functions as a barrier directing fish toward the net's entrapping funnels and eventually into the head where they are retained until harvest. It is argued that bottlenose dolphin use the leader's blocking characteristic to trap schools of fish and then become entangled when they attempt to feed on these corralled fish (Mark Swingle, Virginia Aquarium Stranding Response Program, personal communication). From 1997 to 2006, 17 dead and 4 live dolphins were observed in Cape Henry pound net leaders. As of October of 2007, five more were recorded (VAQS unpublished stranding data presented at BDTRT 2007). In addition, two were found on near by beaches with marks from twisted twine on their beaks and rostrums (Susan Barco, VAQS, personal communication).

In an effort to reduce these interactions, the leader alterations successfully tested by NOAA in 2004 and 2005 along Cape Charles, Virginia to reduce turtle interactions are now being applied to the Cape Henry nets to reduce dolphin entanglements. Research is being funded by the Bottlenose Dolphin Take Reduction Team (BDTRT). Such leader alterations are presumed to be of mutual benefit to dolphins based on the fact that all previous entanglements have been recorded to occur in the top third of the leader (Mark Swingle, VAQS, personal communication). Since the turtle leaders consist of only vertical lines in the top two thirds, it is hoped that this alteration will greatly reduce entanglements of dolphin as well.

II.5.2 Ghost Gear and Habitat Impacts

Pound net gear is very seldom lost. If it does come away from the poles, generally netting becomes wrapped on other poles or lies down on the bottom to be retrieved by the fisher when weather settles. Fishers are required to remove poles in some regions yearly and are required to remove poles from old stands due to Coast Guard navigation regulations in all navigable waters when a stand is no longer to be used. Despite this requirement, occasionally poles are left that may become a navigational hazard. Habitat impacts of this stationary gear are thought to be minimal.

II.5.3 Summary and Recommendations:

Though the selectivity of pound-nets in the Chesapeake Bay and elsewhere in the mid-Atlantic can be vastly improved by using BRPs in the gear's head, only the Potomac River Commission actively encourages such use. Unfortunately, these techniques have not been widely employed in pound-nets coastally or even within the neighboring waters of Maryland and Virginia where many undersized fish which escape capture in the Potomac may be recaptured. Bycatch reduction panels have not been tested elsewhere in pound-nets, but many of the species taken in these nets are also taken in the Chesapeake, suggesting culling characteristics are likely similar with regard to these overlapping targets. Further investigations might be warranted to determine effect on dissimilar species. Since marine turtles are protected by the Endangered Species Act federal regulations forced alterations to Virginia's pound-net leaders to reduce such interactions in the lower Chesapeake Bay. It remains to be seen if this leader design will have any mutually beneficial effect on bottlenose dolphin takes or sturgeon. The stationary trap design of pound-nets has an inherently low mortality of entrapped fish until harvest, therefore, if regionally appropriate BRP panels are used and the gear modified to reduce protected and endangered species interactions, pound-nets can be an ecologically sound method of selective and thus sustainable harvest well into the future.

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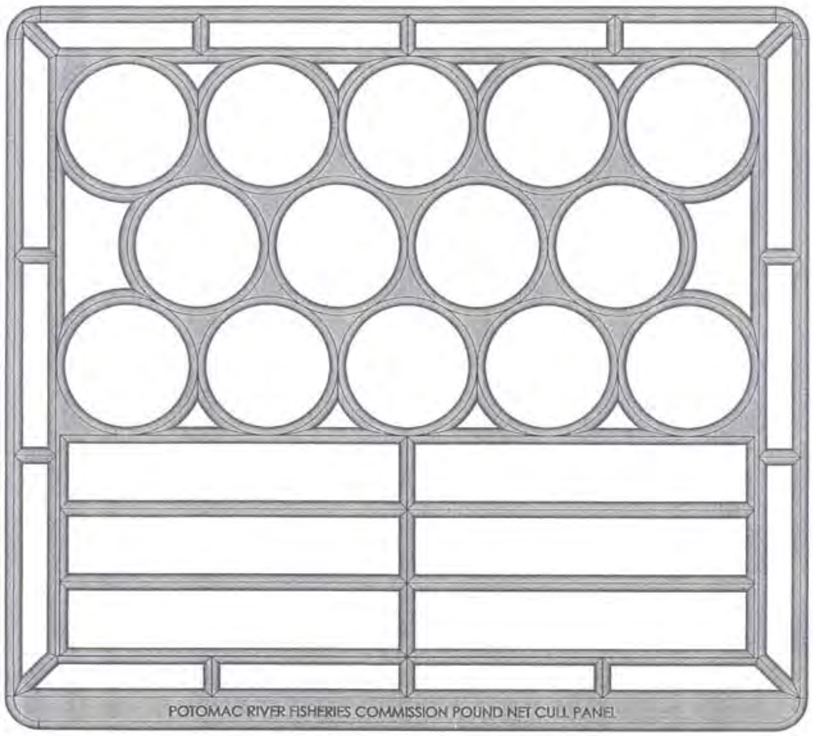
Figure II-5.2.1. The bycatch reduction panel, made from an inexpensive polyester resin, found in Potomac River pound nets.



II.6 Gillnet Fisheries for Coastal Sharks, Spiny Dogfish, and Striped Bass

II.6.1 Introduction

Gillnet fisheries for coastal sharks (Atlantic sharpnose, *Rhizopriondon terraenovae*, blacknose, *Carcharhinus acronotus*, finetooth, *Carcharhinus isodon*, and bonnethead, *Sphyrna tiburo*), spiny dogfish *Squalus acanthias*, and striped bass *Morone saxatilis* were identified as fisheries of concern and were grouped together because of similar gear characteristics. In general, these fisheries were identified as having moderate levels of catch of non-target finfish, moderate to major levels of interaction with protected, endangered and threatened species, and minor to moderate levels of bycatch of sublegals. Separate sections were developed for each target for non-target species, sub-legal fish, and protected, endangered and threatened species interactions.

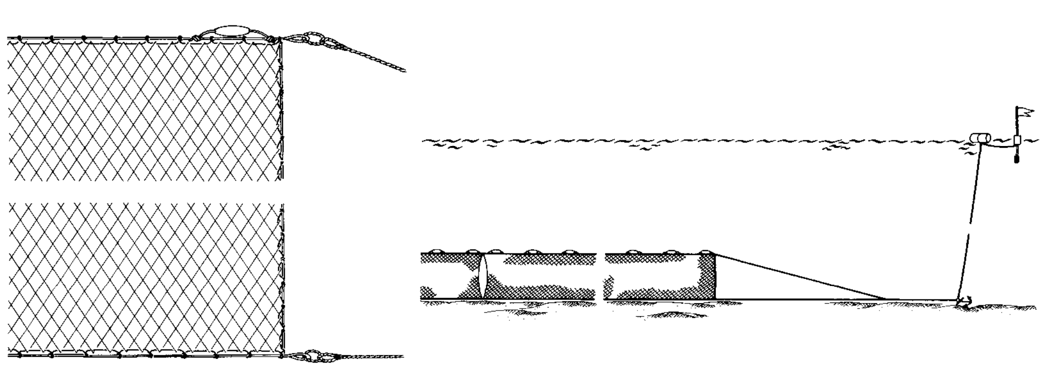
II.6.1.1 Coastal sharks

a. Background and Description of Fishery

The coastal shark gillnet fishery is prosecuted in the waters off the southeast United States. The gillnet fishery includes strike net, a drift gillnet, and sink gillnet components. The strike net fishery primarily captures blacktip shark (>90%), and also captures finetooth, spinner, blacknose and dusky sharks. The drift gillnet fishery captures primarily Atlantic sharpnose shark, and also captures blacknose, scalloped hammerhead, bonnethead, and spinner sharks. The sink gillnet fishery primarily captures bonnethead shark, and also captures finetooth, Atlantic sharpnose, blacknose, and spinner sharks.

Vessels in the fishery are home ported primarily in northern Florida. Nets have stretched mesh sizes ranging from 12.7-30.4 cm. Strike netters use the largest meshes (22.9-30.4 cm), and soak durations average 3.2 hours. Sink gillnets used to capture shark have mesh sizes ranging from 7.3-20.3 cm and soak durations of 6.1 hours. Drift nets used to capture sharks have stretched mesh lengths of 12.7-22.9 cm and soak durations of 10.7 hours.

Figure II-6.1.1. Sink gill net (From DeAlteris, 1998).



II.6.1.2 Spiny dogfish

a. Background and Description of Fishery

Spiny dogfish is the most abundant shark in the western North Atlantic Ocean, ranging all along the US Atlantic Coast, and is managed as a single stock (Colette and MacPhee 2002, Sosebee and Rago 2006). Massachusetts and North Carolina land the majority of dogfish (Rulifson 2007).

The target fishery consists primarily of sink gillnets (Rulfison 2007); high levels of spiny dogfish are captured in gillnet fisheries targeting other species. Mesh sizes used to target spiny dogfish are typically 14.0-16.5 cm; in non-dogfish gillnet fisheries, mesh sizes from 14.0-30.5 cm are used. Soak durations are generally 24-48 hours although in certain areas, day sets for dogfish are common. Because the New England and Mid-Atlantic spiny dogfish sink gillnet fisheries have estimated annual mortalities and serious injury of a marine mammal stock is greater than or equal to 50 percent of the PBR (Potential Biological Removal) level, they have been classified as Category I fisheries in the List of Fisheries (72 Fed. Reg 66048 (November 27, 2007)).

II.6.1.3 Striped bass

a. Background and Description of Fishery

Striped bass are commercially targeted coastally using pound nets, haul seines, traps, gillnets of various configurations and hook and line. Gill nets are used commercially in Rhode Island, New York, Delaware, Maryland, PRFC, Virginia, and North Carolina. Only Massachusetts commercially targets striped bass using solely hook and line gear. Striped bass of various sizes suffer mortality due to bycatch in every coastal state. In some, it is the target and thus a high percentage of these fish are retained for sale.

Commercial striped bass landings have remained relatively stable since 1997 with the Chesapeake Bay region (Virginia, Maryland, and PRFC) accounting for 77% of the landings by number and 58% by weight (based on 2003 data, 2005 Biennial report to Congress). The fishery is not over fished (Report to Congress 2005) though the recreational fishery, which harvests the vast majority of fish and has by far the largest discard mortality by number and weight, continues to grow (Report to Congress 2005).

The Atlantic's coastal fisheries depend primarily on three spawning stocks the Hudson, the Delaware, and the Chesapeake, which includes all tributaries of the Chesapeake in Maryland, Virginia and Pennsylvania. Since these estuaries provide most of the fish for the coastal fisheries, bycatch mortality of sub-harvestable (<50 cm) and regulatory discards within these nurseries is likely of greater magnitude and thus importance to the coastally dependent states.

The intent of this section is to discuss bycatch and striped bass discards occurring in gillnet fisheries that target striped bass, not to identify the fisheries in which striped bass are killed as bycatch. This potentially significant source of mortalities should be the topic of further examination since every state that conducts commercial fisheries within state waters (within three miles) along the coast during the fish's migration periods has some degree of striped bass bycatch. Amendment six to the Atlantic Striped Bass Management Plan and a subsequent addendum identify the need for a better understanding of this bycatch and suggest the implementation of state specific monitoring and research programs to fill this gap in species management.

II.6.2 Bycatch

II.6.2.1 Coastal sharks

a. *Bycatch of sublegal target and non-target species*

Bycatch in the directed coastal shark gillnet fishery is monitored with 100% observer coverage from November to March, and 33% for all trips from April to October (NMFS 2007), and is very low. In 2005 the bycatch rate by weight varied from 11% in the drift gillnet fishery, to 17% in the directed sink gillnet fishery, to less than 1% on the directed strike gillnet fishery. The coastal shark fishery has no gear regulations with regard to mesh size, but anticipating the potential for minimum and/or maximum mesh size regulations to improve the biological condition of the stock, Carlson and Cortes (2003) investigated the selectivity of gillnets used off the southeastern United States. They used gillnets ranging in size from 8.9 to 20.3 cm, and the selectivity of these mesh sizes was estimated using a maximum likelihood model that fit a gamma distribution to length data for each mesh size using the log-likelihood function. While the authors report fork lengths at estimated peak selectivity for each mesh size and shark species studied, it is perhaps more instructive to estimate the mean selection factor (L_{opt}/ml) for each species: Atlantic sharpnose is 8.3, finetooth is 6.0, and bonnethead and blacknose are 5.4. The selection factor is a non-dimensional number that related the optimal fish length for capture from a normal distribution selection curve for a particular mesh size to the stretch mesh length for that mesh size. The selection factor is used to predict the size selection characteristics of other mesh sizes for which there is no size selection data. These values are substantially higher that typically estimated for teleost fish where the gill net selection factors range from 3.5 to 4.5. The results of another investigation of the selectivity on gillnets for sharks were reported by Fonseca *et al.* (2005), where the authors conducted experiments with gillnets ranging in mesh size from 4 to 8 cm, and caught a wide variety of teleost fish and the small-spotted dogfish, *Scyliorhinus canicula*, in coastal Europe. The selection factors estimated for these mesh sizes for this species of shark ranged from 6.6 to 6.9.

b. Interactions with protected species

Loggerhead and leatherback sea turtles are rarely caught in the shark gillnet fishery (NMFS, 2007). From 2000 to 2007 15 loggerheads and one leatherback were observed interacting with shark gillnets in the southeast United States. One smalltooth sawfish was also captured in this period and was released alive. Observed takes of marine mammals from 1999 to 2007 in this fishery included 12 bottlenose dolphins and four spotted dolphins. In January 2006 a dead right whale calf was spotted offshore of Jacksonville, FL, and after investigation NMFS determined that an entanglement with shark gillnet gear had ultimately lead to the death of the whale.

II.6.2.2 Spiny dogfish

a. *Bycatch of sublegal target and non-target species*

No evidence was found that catch of small-sized spiny dogfish in targeted fisheries is a concern. Spiny dogfish do not have a minimum landing size, and analysis of observer data conducted for this assessment indicates that, in 2007, NMFS NEFSC observers recorded a discard rate of approximately 9% (3.1 MT discard from 35.3 MT total caught) from gillnet gear targeting spiny dogfish (number of hauls = 113).

These discards were regulatory in nature, due to closed fisheries or quotas. Fifty-six percent of observed discards were recorded as due to quotas being filled; another 38% did not have a discard reason (NMFS NEFSC, unpubl. data). Gillnet selectivity of spiny dogfish appears not to have been studied; reported mesh sizes of 14.5-16.5 inches (37-42 cm) in the targeted fishery appeared to be adequately selective.

Spiny dogfish are a common non-target catch in other directed fisheries using gillnets. Discarding in these fisheries is also regulatory in nature. Additionally, the low value of dogfish and special handling procedures encourages economic discarding when more valuable species are present, or if insufficient quantities of dogfish are caught (Vonderweidt *et al.* 2006). There has been no prior quantitative analysis of spiny dogfish discarding.

Observer data from 2007 reported 78% discard of dogfish from gillnet hauls targeting 15 different species or species groups (108.1 MT discarded to 151.4 MT caught). High spiny dogfish catches (>0.05 MT/haul) where dogfish were retained were reported for gillnets targeting (in descending order): Atl. croaker (0.50 MT/haul), mixed groundfish, mixed flounders, Atl. cod, summer flounder, white hake/pollock/haddock, kingfish, winter flounder, and striped bass (0.05 MT/haul). High levels of discard of spiny dogfish were reported for hauls targeting, in descending levels, white hake/pollock/haddock (0.51 MT/haul), groundfish, summer flounder, Atl. cod, winter flounder, mixed flounders, grey sole, and mixed skates (0.05 MT /haul).

Catches of finfish in spiny dogfish targeted gillnet fisheries were investigated using observer data. Desirable bycatch of smooth dogfish, Atlantic croaker, striped bass, and skates were found to exceed 0.05 MT/haul in 2007 observer data. Discard of finfish were found to be low – below 0.02 MT/haul.

He (2006) found some evidence that lowering the height of a gillnet could reduce catch of spiny dogfish compared to standard cod gillnets. However, little other gear research has been conducted to reduce spiny dogfish catches when targeting other species with gillnets, although recent increases in abundance have spurred additional investigation. The broad diet, voracity and ubiquity of dogfish may make it difficult to avoid unwanted catches. As spiny dogfish are well-known to swim in large schools or packs (Colette and MacPhee 2002), and are seasonal, avoidance of dogfish by setting gillnets when dogfish are absent, as is common in industry practice, is currently recommended.

Estimated discard numbers for otter trawl and gillnets (using using estimated discard mortalities (trawl: 50%; gillnet: 30%)) have exceeded the yearly quota in some years (Sosebee and Rago 2006). The gillnet discard mortality rate (in the absence of predation) was based on gillnet capture of 2,284 spiny dogfish (Rulifson 2007). He reported an overall gillnet mortality rate of 55%, comprising an initial mortality of 17.5% with an additional 33% mortality after 48 hours. This work appears to be the only research on spiny dogfish survival following gillnet capture.

b. Interactions with protected species

Takes of several species each of turtles, birds, dolphins, seals, and whales have been associated with the types of gillnets used to target spiny dogfish. In 2006 the NMFS NEFSC estimated that the northeast sink gillnet fishery take of marine mammals was 20 common dolphins, 514 harbor porpoise, 41 Atlantic white sided dolphins, 248 gray seals, 87 harbor seals, and 65 harp seals (Belden and Orphanides, 2007). For the Mid-Atlantic gillnet fishery the estimated 2006 takes were 512 harbor porpoises, 11 common dolphins, and 26 harbor seals (Belden and Orphanides, 2007).

Currently, all coastal sink gillnets must be modified to comply with the Atlantic Large Whale, Harbor Porpoise, and Bottlenose Dolphin Take Reduction Plans. Gear modifications include the elimination of floating ground lines between gillnets and anchors and at surface buoys, inclusion of weak links in end lines and float lines, and the use of acoustic signaling devices (pingers). Time-area restrictions have also been imposed, along with gear tending requirements. The Take Reduction Teams actively develop and assess gear modifications.

Harbor porpoise takes were effectively reduced after implementation of the Take Reduction Plan. However, in 2007, takes exceeded the potential biological removal (PBR) for the first time since implementation (Palka, 2007; Waring *et al.* 2007). Palka (2007) identified increased takes associated with absence of pingers or inadequate numbers of pingers (<80% of required number). Further, no adequate method of testing individual pingers has been developed; consequently, neither fishermen nor enforcement personnel can quickly determine if an individual pinger is functioning. Inadequate use of pingers or use of non-functioning pingers is proposed to be addressed through education of fishermen and enforcement officials, use of pinger testing devices, and reconfiguring areas where pingers are required to decrease takes (HPTRT 2007). Bordino *et al.* (2002) suggested that pingers may attract pinnipeds; however, raising the emitted frequency of the pingers above seal hearing has been suggested as a solution (Kraus *et al.*, 1997). Further, Palka (2007) found no evidence of seal habituation.

Byrd *et al.* (2007) suggested that effort reduction in the winter gillnet fishery for spiny dogfish off North Carolina led to decreases in observed mortalities and in stranding rates of bottlenose dolphins.

The effectiveness of implementation of the Atlantic Large Whale Take Reduction Plan has not been assessed.

All sea turtles that occur in U.S. waters are listed as either endangered or threatened under the Endangered Species Act of 1973 (ESA) and gillnets are a known threat to sea turtles in waters south of Cape Cod (Anonymous 2007). Gillnet mesh size restrictions are currently in place in Federal waters off the coast of North Carolina to limit turtle takes (67 FR 71895, December 3, 2002.) The final rule imposes time and area restrictions on gillnets with mesh sizes larger than 8.0 inches. Attempts to reduce sea turtle takes in southern flounder gillnets by reducing headline height and not using tie downs resulted in a significant loss of target catch (the reduced headline net captured only 60% of the catch as the standard tie-down gillnet), however the authors conclude that this loss was acceptable to commercial fishermen in order to be able to continue to participate in the fishery (Blake and Price, 2007).

Approximately 400 bird takes per year have been observed in sink gillnet gear from 2005-2007. In gear where spiny dogfish were also caught, approximately 40 bird takes were observed per year. In 2007, 9 birds were observed in sink gillnet gear targeting spiny dogfish: 2 common loons and 7 red-throated loons (NMFS NEFSC, unpubl. data). Reduction of bird bycatch is not a current priority. Strategies for avoidance of bird bycatch in gillnets were synthesized by Melvin *et al.* (1999).

II.6.2.3 Striped bass

a. *Bycatch of sublegal target and non-target species*

Since recovery, discard mortality has increased in importance. Data on the magnitude and mortality associated with discards is limited. Since the striped bass fisheries occur within state waters NMFS observer data is generally inadequate to describe bycatch and discards in these fisheries. Discard mortality varies due to gear and application factors associated with gear. Discard mortality for anchored gill nets has been estimated at 43%, drift gill nets at 8%, hook and line at 8%, otter trawls at 35%, traps and pounds at 5%, and haul seines at 5% (Report to Congress 2005). Many of these estimates, however, are based on a single study and in general do not take into account essential metabolic variables such as water temperature (Hartman 1993), gear configuration, or application factors such as soak time that are known to significantly affect discard survival with respect to gill nets (ASMFC 2007).

Like all fishes, striped bass metabolism is integrally linked to water temperature and at a given temperature normal metabolism is negatively affected. Hartman (1993) suggests that this temperature is approximately 15° C, based on research that determined that maximum growth based on C max occurs for adult fish (≥1000 gm) at this temperature. Beyond 15° C growth is limited by metabolism alone regardless of external stress. Stresses associated with gear interaction are magnified when these metabolic tolerance levels are exceeded. This implies that additional stress, as endured by fish that encounter gear at temperatures equal to or beyond this, would suffer metabolic losses that would bring mortality on more quickly and make recovery less likely as well.

The bycatch of other species and discards of striped bass that occur in anchored gillnets set for striped bass varies coastally. Since the striped bass is anadromous, temporal and spatial characteristics of each fishery and associated life history aspects of the fish alter the size distribution of captured fish in unique ways. Mature striped bass migrate into distinct spawning grounds each spring and then a large portion of this adult population migrates north each summer, therefore, the coastal gill net and to some degree the estuarine fisheries in each state affect the coastal biomass' reproductive potential.

Mesh size selection often reflects fisher preference rather than specific management decisions to reduce bycatch. Mesh size regulations drastically affect the size of striped bass retained as well as bycatch composition, as illustrated by the results of an analysis of gillnet catch data in Virginia waters (C. Hager, VA Sea Grant, unpublished data, Figure II-6.2.1). The results of the Virginia selectivity study indicate 5, 6, 7, and 8 inch (127, 152, 179, 203 mm) mesh sizes had optimum lengths of capture (L_{opt}) of 22.8, 27.8, 32.3, and 35.6 inches (580, 705, 820, and 904 mm) respectively, with a mean selection factor of 4.6 for all the meshes (Table II-6.2.1). These data demonstrate the highly size selective nature of gillnet in general, and potential effect of improper selection with regard to the minimum, mean/mode, and maximum sizes observed retained in various meshes. Mesh size selection studies for the striped bass gillnet fishery have also been conducted by the Maryland Department of Natural Resources for Maryland's portion of the Chesapeake Bay (Spier 2001, Spier and Early 2001).

Observer based sampling of Virginia's anchored striped bass gillnet fishery in the Chesapeake and nearshore waters (147 million foot net hours) during the early spring and fall indicates that numerous finfish species are taken as bycatch. Bycatch composition was affected by temporal and spatial alterations in deployment. In the Chesapeake and its tributaries, bycatch of menhaden in large mesh nets (7-8 in) can be as high as 42% by number. In specific locations near tributary mouths in the spring, American shad catches were as high as 10% in medium mesh sizes (4.75-5 in). It should be noted these mesh sizes were historically fished in these very locations for American shad and thus shad retention by this gear in this location is really no surprise. Offshore, larger mesh nets (7-8.5 in) were observed to retain from 3-21% dogfish by number, with retention of dogfish inversely correlated with mesh size. In side by side panel test with equal lengths and heights, 8.5 inch mesh retained no dogfish, 8 inch retained 40% dogfish by number and 7 inch retained 80% dogfish.

b. Interactions with protected species

The striped bass gillnet fishery is prosecuted primarily in mid-Atlantic waters. In 2006 the NMFS NEFSC estimated that the mid-Atlantic gillnet fishery take of marine mammals was 512 harbor porpoises, 11 common dolphins, and 26 harbor seals (Belden and Orphanides, 2007). Atlantic sturgeon was the only protected species observed taken as bycatch in Virginia's observer program and they occurred in both large and medium mesh sizes. Catch-per-unit-effort was low, two orders magnitude below what Collins *et al.* (1996) had observed in southern shad gillnet fisheries. Landed mortality (7%) was also very low in comparisons to what had been recorded as the mean landed mortality (22%) through NMFS Northeast Observer Program (Stein *et al.*, 2004). Shorter set times averaging approximately 24 hours and cooler water temperatures during the spring and fall striped bass season likely where highly influential. Gear variations may also have played a role in increasing survival rates.

II.6.3 Ghost Gear

Ghost fishing by lost or discarded gillnets is a problem in all gillnet fisheries. Gillnet fisheries characterized by unattended, long sets are more prone to experience gear losses due to interactions with mobile fishing gear or storms that drag the gear away for the set location, thus preventing the fisherman from retrieving the gear. There were no studies found documenting the number of lost gillnets in these specific fisheries, or that estimate the number of fish lost due to ghost fishing. However, multiple studies have examined continuing mortality in ghost gillnets worldwide. In southern New England, Carr *et al.* (1992) found typical commercial gillnets continued to fish effectively for over two years, with changes over time in the species captured.

II.6.4 Habitat Impacts

Gillnet fisheries may have habitat impacts, as they can be dragged across the bottom during hauling and can shift laterally with currents and during turbulence. They are often anchored at each end of a string which may have impacts on habitat. Gillnets can entangle corals, pipe clay, and other bottom features (Williamson 1998).

II.6.5 Summary and Recommendations

Capture of sub-legal individuals of target species can generally be avoided using gillnets where the relationship between fish size and mesh size is known. There are considerable size selectivity data available for coastal sharks and striped bass. Where this information is absent (dogfish), gillnet selectivity studies should be conducted to determine appropriate mesh sizes. However, size selectivity characteristics of dogfish gillnets could be estimated based on available data for similar species. Appropriate matching of minimum landing sizes or desired market sized target fish to mesh sizes can then be implemented in regulations or adopted as good practices by fishermen.

Improving the species selectivity of gillnets in these fisheries is a more complex issue potentially requiring a combination of time and area closures and modifications to the gear so as to reduce bycatch. Some research suggests modification of the height of gillnets, either through the use of tie-downs, reduced meshes, or floatline modifications, can reduce catches of similar sized, undesired non-target species. Where net modifications are not practical or possible, information on the separation of target and bycatch species by season, area, or depth should be employed. If this information is unknown, further investigation of spatial and temporal distributions of target and non-target species should be conducted. Knowledge obtained on the avoidance of non-targets should be widely distributed.

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Figure II-6.2.1. Probability of capture for striped bass as function of fish length in mm.

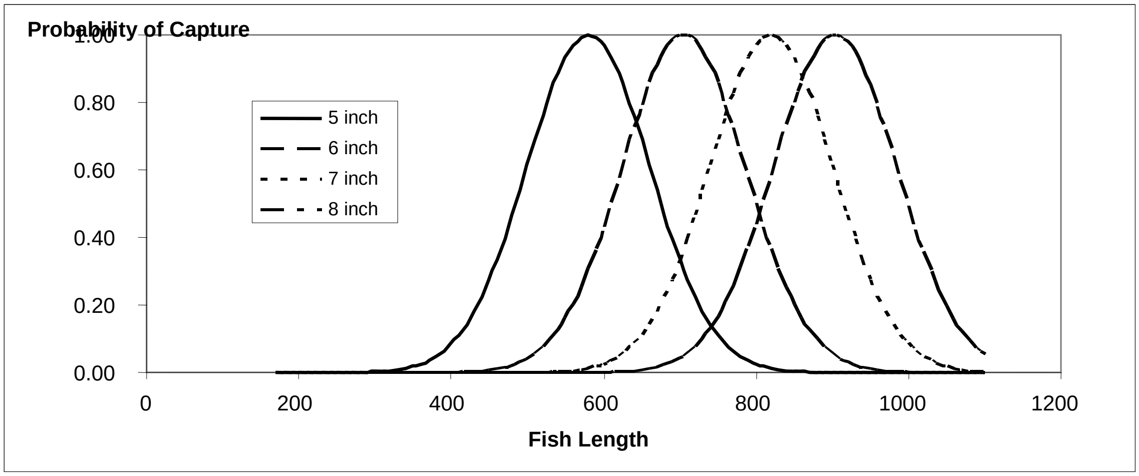


Table II-6.2.1. Selectivity characteristics of 5, 6, 7, and 8 inch gillnet for striped bass.

mesh size (in)	mesh size (mm)	L50 (mm)	L50 (in)	SF
5	127	580	22.8	4.6
6	152	705	27.8	4.6
7	179	820	32.3	4.6
8	203	904	35.6	4.5

II.7 Atlantic Herring Mid-water Trawl Fishery

II.7.1 Introduction

a. Background

The midwater trawl fisheries for herring, mackerel, squid, and scup were identified as possibly problematic because of the bycatch of protected species, sublegal pelagic species and sublegal haddock. The goal of this report is to describe the midwater trawl fishery that primarily targets herring and outline the bycatch issues surrounding this fishery to assist in ascertaining the relative importance of the bycatch concerns.

b. Life History and Status of the Resource

Atlantic herring (*Clupea harengus*) are a schooling species that inhabit northern temperate waters in both the eastern and western Atlantic. In North America, Atlantic herring are found from Labrador to Cape Hatteras (Figure II-7.1.1). Previously herring along the East Coast of the United States were divided into the Gulf of Maine and Georges Bank stocks. Currently there is no evidence to suggest that these two components are separate stocks genetically. However, phenotypic differences have been observed among herring from the Gulf of Maine, Georges Bank, and the Scotian shelf (Overholtz, 2006).

Herring exhibit diurnal depth preferences, residing near the seafloor during the day and rising to the surface waters at night. Adult herring schools migrate extensively along the coast from areas where they feed, spawn, and overwinter.

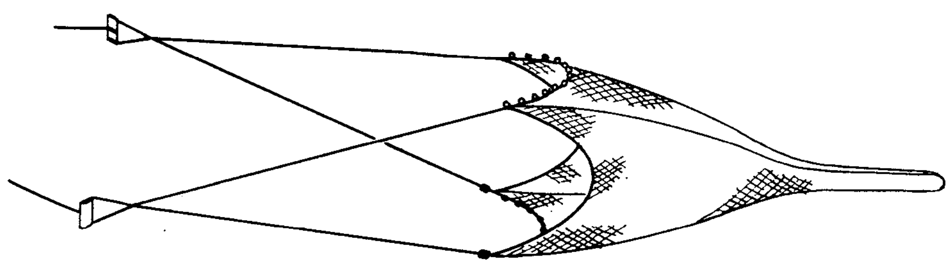
The Gulf of Maine-Georges Bank herring complex began to recover during the late 1980s and current total biomass (age 2+) is now comparable to the 1960s. Biomass increased from a low of about 105,000 MT in 1982 to near 1.3 million MT in 2001, and declined slightly to about 1.0 million MT in 2005, but is still substantially above the B_{MSY} (629,000 MT). Fishing mortality has remained low since the early 1990s and has averaged 0.1 since 2002 far below F_{MSY} (0.31) (Overholtz, 2006).

c. The Fishery and Gear

Between 1996 and 2004, nearly 83% of midwater trawl trips were considered Atlantic herring trips because herring compromised the majority of the catch. Atlantic mackerel was the main species on approximately 10% of the trips. The other species that occasionally comprised the dominant catch include Atlantic croaker, bluefish, Illex squid, Loligo squid, and scup (Orphanides and Magnusson 2007).

Between 1996 and 2004, landings from midwater trawls have grown, and herring has accounted for the majority of landings for the entire period. However, since 2002 the dominance of herring has been waning and by 2004 herring accounted for only 71,446 MT of the 124,493 MT (live weight) landed by the fleet, or 58% of the total. Mackerel landings accounted for an increasing share of the increased landings for the midwater trawl fishery (Table II-7.1.1) (Orphanides and Magnusson 2007).

Figure II-7.1.2. Midwater trawl (From DeAlteris, 1998).



In terms of fishing regions, the proportion of effort on Georges Bank (GB) and in the Mid-Atlantic (MA) has grown (Table II-7.1.2). However, the Gulf of Maine (GOM) and Northern-Southern New England (NSNE) continue to be the major source of landings. Despite having similar landings in the last few years of the time series, the NSNE region provided a slightly higher share of calculated value than the GOM (Orphanides and Magnusson 2007). In nominal and real terms, the combined value of landings from GB and the MA have accounted for approximately one-third of value throughout the time series, with the GOM and NSNE accounting for approximately one-third each (Orphanides and Magnusson 2007).

During the 2005 fishing year, there were 115 vessels that held federal Category 1 permits for the Atlantic herring fishery, but less than 40 of those vessels averaged more than 2,000 pounds of herring per trip that documented herring landings. Preliminary information suggests those vessels accounted for more than 95% of the total herring landings during the 2005 fishing year (NEFMC 2006a).

The midwater trawl nets typically have mesh size of 1.5 inches (3.8 cm). Prior to 2001, the mesh size was approximately ½ inch larger (Orphanides and Magnusson 2007). The average footrope size increased in 2000 but has since been consistent at about 200 ft (61 m) (Orphanides and Magnusson 2007).

Midwater trawl nets use high-aspect otter boards to open the pelagic trawl mouth horizontally, while floats along the headrope and weights along the footrope open the trawl vertically. After the trawl's position in the water column has stabilized, the water flow acts on the tapered panels of the net to open it. The net is usually constructed of four panels, with a gentle taper, and is generally much longer than a bottom trawl net. Midwater trawls generally employ multiple mesh sizes with the largest in the jibs and forward bellies, reducing in the aft bellies, and the smallest mesh in the codend. The wings are relatively small or nonexistent. Fishermen choose the mesh suitable to the target species. When fishing close to the bottom, an extension may be fitted on the top of the net to bring the headrope forward of the headrope, preventing upward flight (MAFMC and ASMFC 2002) (Sainsbury 1996).

Most midwater trawling operations use acoustic instruments to both locate the fish, and to deploy and monitor the fishing gear. To optimally position the trawl net, fishermen usually use sonar to locate fish ahead of the vessel, and an echo sounder to determine the depth and size of the school, then adjust the length of the warps and speed of the tow. Because many pelagic fish have high visual acuity and are fast swimmers, pelagic trawls are generally large and towed fast (MAFMC and ASMFC 2002) (Sainsbury 1996).

d. Management and Regulations

An international fishery for Atlantic herring in the Gulf of Maine began in 1967. Its principle participants were the United States and Canada with minor catches by Germany from 1969 to 1975. The stock was heavily fished using otter trawls and purse seines between 1969 and 1972, with annual catch averaging 38,000 MT (nearly 84 million lbs.). During the 1970s, the majority of the catch was taken in state waters, reflecting the predominance of the fixed gear fishery. In recent years, the increased use of mobile gear to target herring has resulted in an effort shift into federal waters (Overholtz 2006). Midwater trawling for herring by the USA and Canada began in earnest around 1994, with landings peaking at about 102,000 MT in 2001 and averaging about 69,000 MT during 1994-2004 (Orphanides and Magnusson 2007).

The U.S. herring fishery is managed as one stock complex along the East Coast from Maine to Cape Hatteras, NC, although evidence suggests that separate spawning components exist within the stock complex. The Council and the Atlantic States Marine Fisheries Commission (ASMFC) adopted management measures for the herring fishery in state and Federal waters in 1999, and National Marine Fisheries Service (NMFS) approved most of the management measures in the Herring Fishery including the establishment of an allowable biological catch (ABC) of 194,000 MT and an optimum yield (OY) of 145,000 MT. Estimates of total stock biomass for the coastal stock complex exceeded 1 million MT before the collapse of the Georges Bank fishery. After the collapse in the early 1980s, stock size estimates declined to about 100,000 MT. Stock biomass has since increased substantiality primarily due to improved recruits. The offshore spawning component, which was the largest historic component of the stock complex, is now fully recovered. The stock complex is not overfished and overfishing is not occurring (Overholtz, 2006).

Herring is managed by the New England Fishery Management Council by a quota system (“hard” Total Allowable Catches). When 95% of the annual quota is caught within one of the herring management areas, that area is closed to fishing until the start of the next fishing year (NEFMC 1999).

II.7.2 Bycatch

a. Bycatch of sublegal target species

There is no information on the size selectivity of midwater trawls targeting Atlantic herring or Atlantic mackerel. It is recommended that length-frequency data from observed trips be used to estimate sizes of fish vulnerable to midwater trawls.

There is no information on discard rates and discard mortality from midwater trawls targeting Atlantic herring or Atlantic mackerel. Suuronen *et al.* (1996) described high mortality (77-100%) of Atlantic herring encountering and escaping midwater trawl gear.

b. Bycatch of non-target species

Finfish bycatch in paired and single midwater trawls is comprised predominantly of Atlantic herring and spiny dogfish (Table II-7.2.1). Discarding when the vessel exceeds its capacity is a common reason for discard of Atlantic herring, along with capture of undersized individuals and spawning adults (NEFMC 1999). The other predominant bycatch species include haddock, silver hake, scup, redfish, and mackerel (Table II-7.2.1).

Haddock bycatch has been considered a substantial problem. However, haddock bycatch levels from NMFS Observer data from January 2001 through November 2004 are not substantial, with a few exceptional hauls. The majority of haddock bycatch was observed on hauls in 2004, primarily along the northern edge of Georges Bank and the northwest corner of statistical area 522 (NEFMC, 2005). It is believed that groundfish bycatch occurred only on occasions when midwater trawls were fishing on or near the bottom.

River herring bycatch in the sea herring fishery may be substantial as well. A new Amendment was initiated with the goal of reducing river herring bycatch in the Atlantic herring fishery (ASMFC 2007b). Preliminary estimates from recent years of at-sea observer and portside sampling of the Atlantic herring midwater trawl fishery indicate bycatch of river herring is approximately 0.1-2.0% of Atlantic herring landings. However, with respect to the river herring commercial fishery, bycatch of river herring is 8-89% of total coast wide river herring landings, or on average, approximately 750,000 pounds (341 MT) annually (M. Cieri, Maine DMR, personal communication; Table II-7.2.2).

c. Protected species interactions

The herring midwater trawl fishery (including paired trawl) is listed in Category II which is defined as a fishery which has an "annual mortality and serious injury of a stock in a given fishery is greater than 1 percent and less than 50 percent of the PBR level" (Federal Register 2007a).

The NMFS has documented the bycatch of marine mammals in the herring midwater trawl fishery in the summer and fall around Northern Georges Bank in both paired and single midwater trawls (ASMFC 2006, NEFMC 2006). This marine mammal bycatch is predominantly pilot whales and the Atlantic white-sided dolphin, though there is also documented bycatch of harbor porpoise (ASMFC 2006). Between 2003 and 2005 there was an average of 103 takes of white sided dolphins and an average of 8 pilot whale takes per year in the northeast and mid-Atlantic regions combined.

Although no sea turtles have been observed caught in this fishery by the NEFSC observer program, the NMFS has provided an incidental take permit that authorizes the limited take of 6 loggerhead (no more than 3 lethal), 1 Kemp, 1 green, and 1 leatherback (either lethal or non-lethal) in this fishery.

II.7.3 Ghost Gear

Ghost fishing by lost or discarded nets is a minor problem in the Atlantic herring midwater trawl fishery. There are no studies documenting the number of lost trawls or the number of fish encountering ghost gear.

II.7.4 Habitat Impacts

Midwater trawls are generally considered minimally damaging to habitats because they fish above the substrate. There has been concern that some of the midwater trawl fishing results in the gear being towed on the substrate but at this time, it is unknown what percentage of time this occurs and if it is frequent enough that habitat impacts need to be considered. A Final Environmental Impact Statement was issue by NMFS (70 FR 4119) which concluded that for the herring fishery "No Action is required at this time to minimize potential adverse effects of fishing on EFH."

II.7.5 Summary and Recommendations

Although there is a concern about bycatch of regulated and protected species in this fishery, midwater trawl fisheries are generally considered relatively "clean," meaning that the bycatch rates are low in comparison to many other fisheries. This is due to the schooling nature of the targeted catch and the relative efficiency of the fishing operation, allowing the vessels to effectively target schools of fish. Because the fishing occurs mainly off the bottom, the habitat effects from this fishery are considered minimal. Although there is a documented bycatch of marine mammals, mainly pilot whales and the Atlantic white-sided dolphins, neither of these species are considered strategic (i.e., endangered). At this time sea turtle bycatch has not been observed by NMFS in this fishery in the northwest Atlantic.

From the information contained in this report, we recommend the ASMFC does not give this fishery a high priority relative to other more problematic fisheries in regards to the examination of new mitigation strategies to reduce bycatch. If the fishery changes or the bycatch increases, the further assessment of this fishery and bycatch mitigation strategies might be warranted. Although we do not suggest this fishery is a high priority relative to other more problematic fisheries, our understanding of the bycatch issues in this fishery would be improved with a higher level of observer coverage.

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Table II-7.1.1. Total live weight (metric tons) kept by species for the U.S. Northeast and Mid-Atlantic mid-water trawl fishery, 1996–2004. (From Orphanides and Magnusson 2007).

	1996	1997	1998	1999	2000	2001	2002	2003	2004	Avg
Atlantic Herring	53,894	50,380	55,615	57,365	76,157	101,844	72,215	84,968	71,466	69,320
Atlantic Mackerel	2,854	6,167	7,524	5,438	3,723	7,213	23,633	32,368	52,834	15,750
Illex squid	2,051	359	2,288	497	40	22	0	589	0	649
Atlantic Croaker	202	328	144	344	419	313	153	192	92	243
Loligo squid	663	192	622	76	90	99	94	3	24	207
Scup	610	260	230	217	980	141	40	290	56	314
All others	38	108	50	23	14	5	10	0	41	32
TOTAL	**60,312**	**57,794**	**66,473**	**63,960**	**81,422**	**109,636**	**96,144**	**118,411**	**124,493**	**86,516**

Table II-7.1.2. Days fished by fishing region for the U.S. Northeast and Mid-Atlantic midwater trawl fishery, 1996-2004 (From Orphanides and Magnusson 2007).

	Gulf of Maine	**Georges Bank**	**North Southern New England**	**South Southern New England**	**Mid-Atlantic**	**Unknown**	**Total**
1996	150	27	210	0	94	3	484
1997	141	17	186	0	29	1	374
1998	158	65	150	0	64	8	445
1999	128	21	147	0	38	2	336
2000	131	41	151	1	21	0	345
2001	159	119	71	0	22	0	371
2002	163	72	86	0	7	0	328
2003	156	78	100	0	15	0	349
2004	137	40	104	0	21	0	302

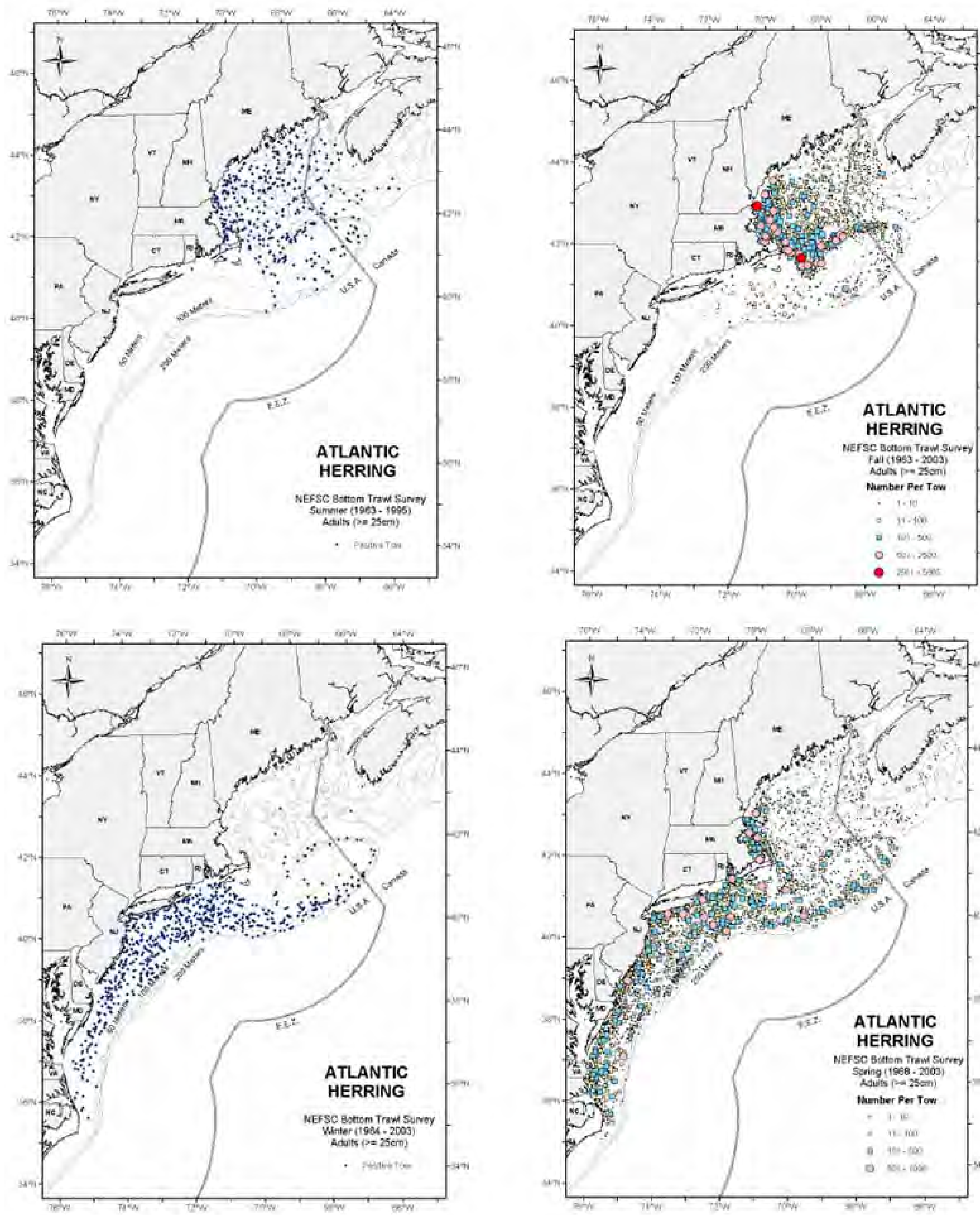
Table II-7.2.1: Catch and discards (pounds) on 44 observed midwater trawl trips in 2005 (From NEFMC 2006b).

Species	Discard	Kept	Total
Spiny dogfish	21,050	72	21,122
Haddock	18,650	1,108	19,758
Atlantic Herring	15,603	7,127,206	7,142,809
Silver Hake	7,645	955	8,600
Atlantic Mackerel	7,428	1,089,541	1,096,969
Redfish	2,467	400	2,867
Scup	2,201	18,000	20,201
Alewife	801	2,660	3,461
Striped Bass	476	31	507
Shrimp	201	8	209
American shad	62	56	118
Winter flounder	13		13
Bluefish	12		12
Hickory shad	1	10	11
Weakfish	1	20	21
Summer flounder		100	100
Blueback herring		155	155
Atlantic menhaden		20	20

Table II-7.2.2. Estimated annual bycatch of river herring from 2005-2007 in the midwater trawl fishery (from M. Cieri, Maine Division of Marine Resources, unpublished data) and comparisons to annual commercial river herring landings (from ASMFC State Compliance Reports).

	2005	2006	2007	Total
Bycatch (pounds) (CV)	129.5 (31%)	52.5 (36%)	438.1 (30%)	620.2 (31%)
Landings (pounds)	411.3	671.0	490.1	1572.5
% bycatch / landings	32%	8%	89%	39%

Figure II-7.1.1. Distribution of adult Atlantic herring in NW Atlantic from the NMFS bottom trawl survey (From Stevenson and Scott 2005).



II.8 Croaker Flynet Trawl Fishery

II.8.1 Introduction

a. Background

For the purposes of this report, this fishery is defined as the oceanic high rise trawl fishery operating primarily off of Virginia and North Carolina and targeting Sciaenids (chiefly Atlantic croaker and weakfish). The most important issues with this fishery are: catch and discard of non-marketable or sublegal finfish species, several of which are managed by ASMFC, and the catch of threatened sea turtles.

b. Life History & Status of the Resource

Sciaenids have been one of the most important families of fish species harvested for food along the Atlantic seaboard south of New England, at least since the 1800s (Hildebrand and Schroeder 1927). The previous reference reviews the life history of the major species. Spot, *Leiostomus xanthurus*, and Atlantic croaker, *Micropogonias undulatus*, spawn on the continental shelf in fall and winter, with young recruiting to estuaries beginning in fall. Weakfish, *Cynoscion regalis*, and kingfish, *Menticirrhus* spp., spawn in a protracted season nearshore from spring through fall, with subsequent recruitment of young fish to estuaries. These species can become vulnerable to fishing gear by one year or less in age (Nye and Targett 2008). Other species landed in this fishery, such as Atlantic menhaden, spiny dogfish, and striped bass are reviewed in sections of the larger report (NMFS unpub. observer data). The status of sciaenid stocks other than weakfish, which is currently at low abundance levels, and Atlantic croaker from North Carolina north, which is in good stock condition, is unknown (http://www.asmfc.org/).

c. The Fishery and Gear

A flynet is a high opening, two seam, bottom otter trawl typically used to catch sciaenids or other schooling species in the mid-Atlantic region. Flynets have a slow 3:1 taper and large mesh wings, from 16-64 inches (41-163 cm) stretched mesh with mesh size in subsequent sections of the trawl decreasing in half size graduations. These trawls tend the bottom and open approximately 30 feet off the seafloor with trawl sizes ranging from 80-120 ft (24-36 m) headrope length. Water pressure against the wings and body sections causes the nets to ‘fly’, maximizing the headrope height. The fishery operates inside of 30 fathoms (55 m) from North Carolina to New Jersey. The number of flynet and flounder trawl vessels ranged from 30-72 annually from 2000-2006 (NC DMF database). The fishery lands several million pounds of finfish per year (Table II-8.1.1) in North Carolina and Virginia (pers. comm. NMFS, Fisheries Statistics Division, Silver Spring, MD).

d. Management & Regulations

The principal management tools used to regulate this fishery are codend minimum mesh sizes and area closures. Fishers targeting weakfish in North Carolina waters, for example, must use flynets having a minimum codend mesh size of at least 3.75 inch (9.5 cm) diamond mesh, or 3.5 inch (8.9 cm) square mesh. In Virginia it is managed through weakfish regulations, which include trawl net cod end mesh regulations of 3 inch minimum, and a closed season from Sept. 26-March 31 during which no more than 150 lb. of weakfish can be possessed, which cannot exceed possession total weight of other species. (http://www.mrc.state.va.us/regulations/COMMERCIALFISH.pdf). Weakfish must be 12 inches in total length, consistent with ASMFC regulations. Area closures include the 1994 prohibition of flynet gear south of Cape Hatteras, implemented by North Carolina to comply with ASMFC mandates and minimize juvenile weakfish bycatch.

II.8.2 Bycatch

a. Bycatch of sublegal target species

One of the main problems with trying to minimize bycatch in this fishery is the large amount of biomass encountered. In North Carolina waters, a 30-minute tow can yield up to 45.5 MT of fish. Weakfish and Atlantic croaker are the species most commonly targeted by the nearshore (<45 m), winter fishery off North Carolina and Virginia with size limits only applying to weakfish (>12-inch TL). Bycatch of sublegal weakfish were high in this fishery prior to the 1994 closure of the fishing grounds south of Cape Hatteras, NC. Since then the primary target species for this fishery has shifted to Atlantic croaker, which has no size limit.

b. Bycatch of non-target species

NMFS observer data indicates that roughly half of the discards of this fishery include a wide variety of species, including finfish, sharks, and rays. In past decades, finfish were landed and sorted to marketable and unmarketable sizes, with the small fish being sold in the "scrap" fishery as food for mink farms or crab bait (Wolff 1972; C. Wenner, SCDNR, 2008, pers. comm.).

Codend research in this fishery consists of McKenna and Monaghan's (1993) examination of the retention capabilities of various mesh sizes (2 ½, 2 ¾, and 3 inch) and shapes (square vs. diamond) of codends in the North Carolina flynet fishery. Generally, square mesh codends contained larger fish than the same size diamond bag, and fish size increased as mesh size increased.

c. Protected species interactions

There are no data on interactions between the flynet fishery and marine mammals. However, by analogy, there is potential for small cetacean interactions in this trawl fishery. Recently, the

National Marine Fisheries Service (NMFS) published an Advanced Notice of Proposed Rule Making (ANPR) that considers requiring the use of turtle excluder devices (TEDs) in flynets (Federal Register, 2007). Observer data from flynet trips showed that 35% of the loggerhead sea turtle (*Caretta caretta*) interactions were from flynets targeting Atlantic croaker and weakfish (Murray 2006). The highest loggerhead sea turtle bycatch rates calculated by Murray (2006) occurred in water depths less than 50 m, with many interactions off the Outer Banks in the winter—an area and time when the inshore flynet fishery is active.

TED development in the nearshore Atlantic croaker fishery began in 1999. Since then, several prototypes have been developed and evaluated aboard commercial vessels operating off North Carolina. Since research was initiated in this fishery, TED designs have advanced significantly with the current generation incorporating a center cable section that allows the TED to bend when stored on a net reel and return to a normal flat configuration when towed (Figure II-8.2.1). This flexible feature is crucial to the functionality of this gear since all vessels participating in this fishery utilize net reels of various sizes to store their gear. The 'Semi-Rigid' design has successfully passed tests for turtle exclusion capabilities utilizing both the small turtle and wild turtle testing protocols (55 FR 41982, October 9, 1990). Second and third generations of this design have incorporated additional changes aimed at improving turtle exclusion rates, catch retention, and durability.

In addition to the Semi-Rigid TED prototypes, several other grid designs constructed of alternative synthetic non-metallic materials have been evaluated for use in this fishery. These grids provide flexibility for storage on net reels and are lightweight alternatives to traditional grids constructed of metal. However, diver and commercial fishing evaluations have revealed that none of the non-metallic prototypes examined to date are applicable in this fishery as functional TEDs. Two common problems that have been observed are lack of structural integrity and inability to maintain a rigid shape when towed.

Currently, there is no implementation schedule for TEDs in this fishery. Nevertheless, research will continue in an effort to perfect designs and conduct technology transfer in anticipation of future TED requirements.

II.8.3 Ghost gear

All trawling activity loses trawl gear to "hangs" at some time. Because this fishery operates primarily over soft bottom (J. DeAlteris, Univ. R.I., 2008, pers. comm.) the number of lost trawls that continue to catch is probably less than for trawl fisheries that operate near or over rocky bottoms.

II.8.4 Habitat Impacts

There are no specific studies of the effects of flynet trawls on benthic habitat. However, for the most part these fisheries are prosecuted on relatively smooth, sand to mud bottoms with nets using chain and cookie sweeps. These gears minimally disturb the seabed, despite rather intense levels of fishing in some areas. The habitat impact is believed to be minimal.

II.8.5 Summary and Recommendations

This fishery should continue to be monitored under ACCSP protocols to determine the magnitude of catch of ASMFC managed species and account for their removals in stock assessments. NEAMAP and SEAMAP fishery-independent trawl surveys are useful in examining the take of flynet fisheries from a sustainability perspective. Progress on flexible TED testing and implementation should continue. Field testing and quantitative analyses of codend mesh size retention should continue, specifically on mesh sizes ranging from 3-5 inch hung in square and diamond shape.

II.8.6 Literature cited

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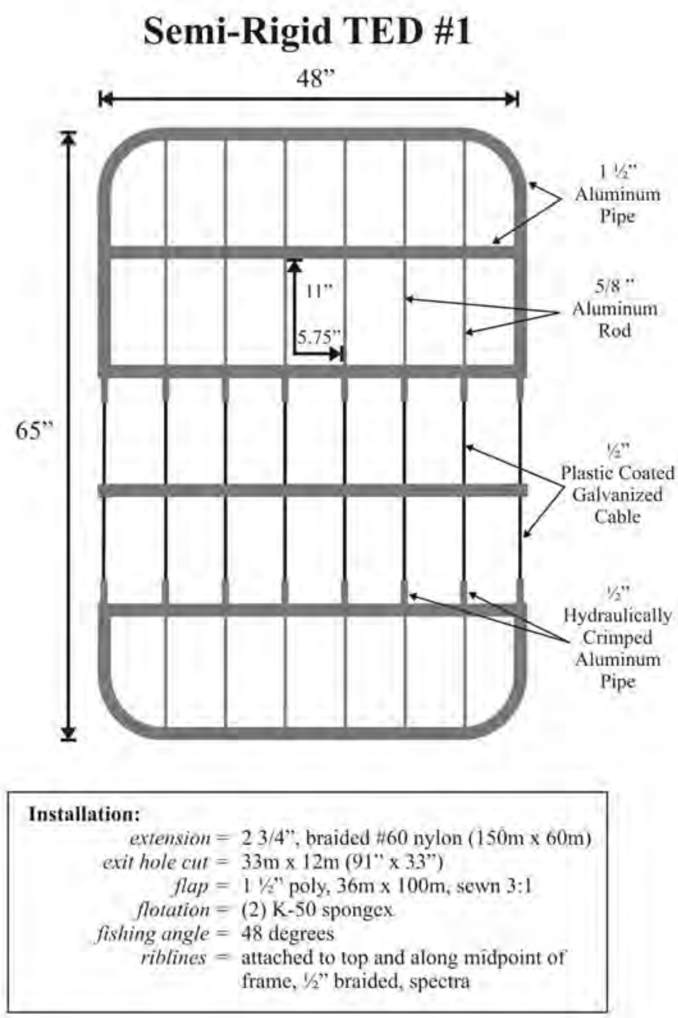
ble II-8.1.1. Number of flynet vessels and trips, and combined landings of flynet and flounder trawl fisheries in North Carolina 2000-2006 (NCDMF).

Year	Number of Vessels	Trips	Landings (MT)
2000	35	181	4,866
2001	60	281	4,759
2002	50	230	5,031
2003	59	292	6,754
2004	72	363	6,520
2005	40	265	5,762
2006	30	221	5,609

Figure II-8.2.1. Diagram of a Semi-Rigid TED designed for use in flynet trawls (NMFS).



II.9 Atlantic Menhaden Purse Seine Fishery

II.9.1 Introduction

a. Background

The Atlantic menhaden purse seine fishery was identified as a fishery of interest based on its volume of landings (177,105 MT in 2006) and a recent resurgence in interest in the fishery's bycatch. By far the largest effort by fleet is based out of Virginia, however, small scale fisheries exists coastally, primarily to provide for bait, from North Carolina to Massachusetts. Only two of the five categories identified in the matrix were assessed as being of even minor importance. The only potential bycatch problems identified for the fishery were catches of non-target finfish and interactions with protected, endangered and threatened species.

b. Life History and Status of the Resource

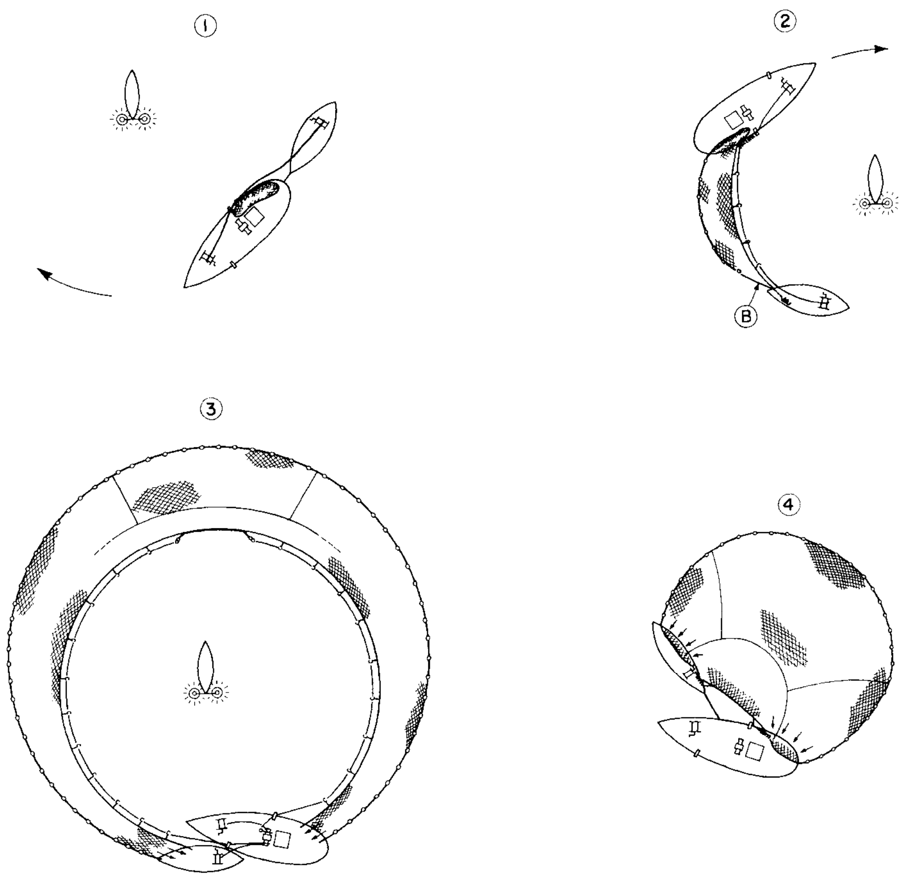
Atlantic menhaden, *Brevoortia tyrannus,* are found in estuarine and coastal waters from northern Florida to Nova Scotia and serve as prey (food) for many fish, sea birds and marine mammals. Adult and juvenile menhaden form large, near-surface schools, primarily in estuaries and nearshore ocean waters from early spring through early winter. By summer, menhaden schools stratify by size and age along the coast, with older and larger menhaden found farther north. During fall-early winter, menhaden of all sizes and ages migrate south around the North Carolina capes to spawn.

The 2006 stock assessment update found on a coast wide basis Atlantic menhaden are not overfished and overfishing is not occurring. The current coast wide estimate of fishing mortality is near the lowest of the time series (1955-2005). However, a recent decline in juveniles seen in Chesapeake Bay seine surveys is a cause for concern.

c. The Fishery and Gear

A purse seine consists of a wall of seine net that is deployed from a small vessel to encircle a spotted school of menhaden. Often spotter planes are used but historically a crow's nest was employed. Once the school is surrounded, the net is pursed by deployment of a large counterweight. This pursing draws the net's bottom together preventing escape. As the purse's netting is brailed into an ever smaller area, fish are herded into a mass that allows them to be bailed into the mother vessel's hold.

Figure II-9.1.1. Purse seining (From DeAlteris, 1998).



d. Management and Regulations

Management authority is vested in the states because the vast majority of landings come from state waters. Recently, new overfishing/overfished definitions were established based on fishing mortality and spawning stock biomass. In 2004, biological reference points were revised and the frequency of stock assessments changed to every three years instead of annually. The new biomass target and threshold are based on fecundity (or the number of mature or ripe eggs/ova) instead of spawning stock biomass. A new fishing mortality target and threshold have also been adopted.

In 2006, a five-year annual cap was established on reduction fishery harvests in Chesapeake Bay of 109,020 metric tons, a number derived from the average of harvests from 2001–2005. The cap was implemented in 2006 and will extend through 2010. Harvest for reduction purposes will be prohibited in the Chesapeake Bay when 100% of the cap is landed. Overharvest in any given year is deducted from the next year's quota, and there is a provision allowing under-harvest in one year to be credited only to the following year's harvest, not to exceed 122,740 metric tons.

II.9.2 Bycatch

a. Bycatch of sublegal target species

Currently the bycatch of small menhaden is not believed to be a problem associated with this fishery.

b. Bycatch of non-target species

Concerns over finfish bycatch in the Atlantic menhaden purse seine fishery have resulted in several studies in the Atlantic bight. Concerns are based in part due to the large volume of menhaden harvested and in part due to the fact that these harvests occur primarily within the Chesapeake Bay where large numbers of the general public and recreational anglers witness the fishery (Austin *et al.* 1994). In order to investigate the extent of bycatch in the fishery, a regulatory-enforcement type sampling scheme was used by Austin *et al.* (1994). All inspections/sampling efforts were unannounced and conducted during off loading and on-board during harvesting from June to November 1992. Relative to the total menhaden catch by number, bycatch of finfish and shellfish averaged 0.04% and ranged from 0.14% in August to 0.002% in November. Of the eight major recreational species taken, bluefish, weakfish, spot, Atlantic croaker, Spanish mackerel, striped bass, false albacore and summer flounder, bluefish accounted for the largest portion, approximately 0.008% of the catch (Austin *et al.* 1994). Significant differences in bycatch percentages were observed between dockside and at-sea sampling regimes with at-sea always exceeding dockside. This finding suggests that dockside sampling alone is not sufficient to assess bycatch of the fishery.

In 1995, the data from Austin *et al.* (1994) was reexamined to attain a better estimate of bycatch by weight. Bycatch of all species by weight across all months was estimated at 0.585% which exceeded the 0.04% estimate by number but remained well below the one percent legal limit (Kirkley 1995). During August, the month of largest bycatch by weight and number, Spanish mackerel was the prominent finfish by far in weight and number, followed by bluefish in number and cownose ray in weight (Table II-9.2.1).

c. Protected Species Interactions

No protected, endangered and threatened species were killed, entangled, captured, or observed during Austin *et al.*'s 1992 sampling (Austin *et al.* 1994). Menhaden studies in the Gulf of Mexico predate those of the Atlantic bight and are more numerous. In the Gulf, retained bycatch rates ranged from 0.05 (Dunham, 1972) to 3.9% (Christmas *et al.* 1960) by number and 1% (de

Silva and Condrey 1998) to 2.8% by weight (Christmas *et al.* 1960). More importantly, none of these works have recorded interactions with current protected, endangered, or threatened species.

II.9.3 Ghost Gear

Purse seines rarely encounter the bottom and are not susceptible to loss. It is believed that there is minimal to no purse seine ghost gear with respect to the menhaden fishery.

II.9.4 Habitat Impact

A purse seine may sweep the bottom when occasionally fished in shallow water. There is potential for some habitat impact, although bottom types are typically sand and are less susceptible to gear effects than more delicate substrate types.

II.9.5 Summary and Recommendations

The Atlantic menhaden fishery continues to come under fire and its legality in Virginia's waters is currently being debated by the Virginia legislature. However, its importance with regard to non-targeted species bycatch is minor even when considering the magnitude of the fishery. In addition, negative impacts on protected, endangered and threatened species are not documented in the published literature. Due to the size of the fishery, bycatch does not have to be a very large portion of the catch in order to potentially be biologically significant for management. If further bycatch research is warranted in the future, a regulatory-enforcement type sampling scheme that incorporates unannounced inspections/sampling efforts conducted during off loading and on-board during harvesting is suggested. Significant differences in bycatch percentages have been observed between dockside and at-sea sampling regimes with at-sea often exceeding dockside (Austin *et al.* 1994).

II.9.6 Literature Cited

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Dunham. F.O. 1972. A study of commercially important estuary dependent fishes. Louisiana Wildlife and Fisheries Comm. Tech Bull. 4: 63.

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Table II-9.2.1. Bycatch in the menhaden purse seine fishery (n_{sets} =15) during August 1992 (From Kirkley, 1995).

Species	Number of Observations	Total Weight (lbs)	Percent Bycatch by Weight
Spanish mackerel	1,144	3,622.70	0.372%
Bluefish	801	945.56	0.097%
Croaker	507	130.30	0.013%
Hogchoker	472	68.19	0.007%
Sea trout	220	43.00	0.004%
Cownose ray	148	1,810.72	0.186%
Butterfish	141	25.79	0.003%
Squid	126	4.93	0.001%
Harvest fish	124	124.00	0.013%
Blue crab	119	15.83	0.002%
Thread herring	95	95.00	0.010%
Summer flounder	72	9.37	0.001%
Sandbar shark	51	341.70	0.035%
Spider crab	49	24.50	0.003%
Spot	46	8.42	0.001%
Total bycatch	4,114	7,270	0.746%
Menhaden	1,433,000	960,110	
Total catch	1,441,229	974,650	

II.10 Striped Bass Recreational Fishery

II.10.1 Introduction

The striped bass recreational fishery was identified as a priority because of the majority of effort and landings attributed to the recreational sector, and the wide variety of regulations and fishing practices coast wide that may lead to substantial mortality due to high-grading, discarding of sub-legal fish, and catch and release. See ASMFC 2003b for specifics on individual state size and daily bag limits, seasonal quotas, and open seasons.

II.10.2 Bycatch

Recreational releases of striped bass reached nearly 26.0 million fish in 2006, which is estimated to result in 2.1 million dead discards (8% mortality). In 2004, recreational discards accounted for approximately 27% of removals, while commercial discards accounted for approximately 10% (ASMFC 2007a).

Large recreational catches of sub-legal fish are not unique to the striped bass fishery. In a study of the red snapper recreational fishery in coastal Texas, 64% of fish caught were below the minimum length. An estimated 40% of these discarded fish suffered mortality. Discard:landing ratios and mean fish length varied spatially, with lower mean lengths and higher discard frequencies occurring in shallower areas (Dorf, 2003).

Implementation of alternative management strategies may reduce mortality due to discarding of sub-legal fish or high-grading. An analysis of red drum recreational catch data and alternative size and bag limits indicated a reduction in maximum size (as is currently in place in Maine for striped bass), concurrent with a higher bag limit, could result in the same biomass of removals. This reduction would discourage high-grading by prohibiting the retention of the largest fish and permitting more small fish to be retained (Vaughan and Carmichael, 2002).

Raising minimum size limits is suspected of producing higher discard rates and associated mortality. However, in the case of tautog, recreationally caught fish at various sizes (sub-legal and legal) experienced low release mortality rates, indicating an increase in minimum size limit is an effective management tool for reducing fishing mortality (Lucy and Arendt, 2002).

The mandatory conversion from J-hooks to circle hooks (Figure II-10.2.1) in the Pacific halibut fishery led to substantial reductions in the mortality of discarded fish (Trumble *et al.*, 2002). In studies of striped bass hooking mortality, fish caught with circle hooks experienced higher survival rates than those caught on J-hooks (Table II-10.1.1; Caruso, 2000; Lucakovic, 2000; Lucakovic and Uphoff, 2002). Hook comparison studies for several other species have also shown lower mortality associated with circle hook-caught fish (Aguilar *et al.*, 2002; Grover *et al.*, 2002; Skomal *et al.*, 2002; Cooke and Suski, 2004; Vecchio and Wenner, 2007). Increasing the use of circle hooks in the recreational striped bass fishery is recommended as a more realistic approach to reducing unwanted mortality.

Amendment 6 to the Interstate Fishery Management Plan for Striped Bass (ASMFC 2003a) recommends the use of circle hooks to reduce hooking mortality in the recreational fishery. Amendment 6 also required the development of a bycatch data collection program, leading to the development of Addendum I. This addendum will implement a bycatch data collection program to evaluate current estimates and better quantify bycatch mortality by gear, time, area, etc., and implement an angler education program (ASMFC 2007b).

ASMFC recommendations for reducing striped bass recreational bycatch/discard mortality:

- use circle hooks in the recreational fishery
- evaluate the percentage of fishermen currently using circle hooks
- implement an angler education program
- use circle hooks only when chumming
- use heavier lines
- minimize play and landing times
- no targeting during warm water conditions due to reduced survival of released fish

II.10.3 Summary and Recommendations

Discarding and the resulting mortality is an important problem in both the commercial and recreational fisheries for striped bass. In the recreational striped bass fishery increasing the use of circle hooks is recommended. An additional recommendation is to continue and expand angler education efforts to encourage the use of circle hooks and the careful play and handling of fish, and explain the implications of high-grading (*see* Lockwood 2008). The Mid-Atlantic Fishery Management Council (MAFMC) is developing an ethical angling brochure. It is recommended the ASMFC collaborate with the MAFMC on this brochure and its distribution to the recreational fishing community and general public. Although angler education is not a direct gear technology solution, it is related to the use of gear by recreational fishermen and how they can contribute to promoting the survival of fish returned to the water. The issues and potential solutions related to the striped bass recreational fishery apply to other species caught recreationally. Although striped bass is evaluated here, results should be explored for possible implementation in other recreational fisheries.

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Table II-10.1.1. Striped bass mortality rates by hook type and location (From ASMFC, 2003b).

Study	Species	Hook Type	Total Caught (n)	Hook Location Jaw/mwth	Deep	Foul/Gills	Unknown	% Mortality
Caruso, 2000	Striped	*Circle*	60	58 (97%)	1 (1.6%)	1 (1.6%)	0	3%
	Bass	*"J"*	58	35 (60%)	14 (24.1%)	9 (15.5%)	0	15.50%

Summary - Release mortality appears to be significantly lower with the use of circle hooks than that estimated for J-hooks (12.5% lower). Incidence of potentially lethal wounding was extremely low among fish captured with circle hooks versus J-hooks. Use of circle hooks could significantly reduce the likelihood of wounding at sites that can result in trauma to major organs and subsequent death. Fisheries managers should seriously consider promoting the use of circle hooks in the Massachusetts striped bass fisheries.

Study	Species		Total Caught (n)	Hook Location Jaw/mwth	Deep	Foul/Gills	Unknown	% Mortality
Lukacovic and	Striped	*October*	90	73 (81.0%)	17 (18.9%)			12% (11/90)
Uphoff, 2002	Bass	*June*	131	61 (46.6%)	70 (53.4%)			36% (47/131)

Summary - High mortality of large, shallow hooked striped bass in June suggests a broader catch and release problem not confined to chumming. Deep hooking percentage decreased approximately four fold in June when circle hooks were used instead of standard chumming (J) hooks. Circle hooks provide anglers with an option that lowers deep hooking and their use should be promoted.

Study	Species	Hook Type	Total Caught (n)	Jaw/mwth	Hook Location Deep	Deep	Unknown	% Mortality (includes sublegal fish)
Lukacovic, 2000	Striped	*Circle*	640	96.6%	3.4%			0.8%
	Bass	*"J"*	476	82.8%	17.2%			9.1%

* - Only 287 circle hook caught and 384 J-hook caught fish were used in the mortality portion of the study.

Summary - Average size and % legal size (>18") did not differ appreciably between the two hook types. Sub-legal striped bass were gut hooked 15.2% of the time by J-hooks and 2.0% of the time by non-offset circle hooks, figures consistent with the author's 2001 study. Projected mortality of sub-legal striped bass caught in this study was 93.8% lower with non-offset circle hooks than with J-hooks.

Study	Species	Hook Type	Total Caught (n)	Jaw/mwth	Hook Location Deep	Deep	Unknown	% Mortality (includes sublegal fish)
Lukacovic, 2001	Striped	*Circle*	392*	94.4%	5.6%	3.3%		1.9%
	Bass	*"J"*	467*	85.0%	15.0%	10.9%		8.7%
				(all sizes)	(all sizes)	(sub-legal)		

* - Only 241 circle hook caught and 264 J-hook caught fish were used in the mortality portion of the study.

Summary - Overall deep hooking frequency was nearly three times lower when non-offset circle hooks were used (5.6% vs. 15.0%).

Study	Species	Hook Type	Total Caught (n)	Jaw/mwth	Hook Location Deep	Foul/Gills	Unkn	% Mortality (estimated) (sub legal fish)
Lukacovic, 2002	Striped	*Circle*	173	93.4%	6.6%			0.80%
	Bass	*"J"*	260	83.2%	17.1%			7.40%

Summary - Anglers using "J" hooks landed a fish 42% of the time they detected a strike. When using a non-offset circle hook they landed a fish 27% of the time. "J" hooks were 52% more efficient than non-offset circle hooks in landing a fish once a strike was detected.

Figure II-10.2.1. Two types of circle hooks (a, b) and a J-hook (c) (From Cooke and Suski 2004).

(a) (b) (c)

III. SUMMARY AND CONCLUSIONS

III.1 Summary

For trawl fisheries the FGTWG found that considerable body of research has been conducted and used to develop management regulations on the size selection characteristics of trawl codends for summer flounder, winter flounder, and scup. Bycatch of non-target finfish species in the scup fishery remains a problem in need of better documenting through at-sea sampling. Additional research is needed to minimize effects on catch rates of target species that may occur with the introduction of TEDs into trawl nets (as NMFS is considering on a seasonal basis in trawls operating south of Cape Cod), as well as developing new technologies to reduce small cetacean interactions with trawls.

For lobster pot fisheries the FGTWG noted that solutions to catches of sublegal lobster, finfish, and ghost gear have been partially resolved by the addition of escape vents and biodegradable panels. Evaluations of escape vent selectivity should be revisited so that results can lead to more accurate field implementation. Thorough investigation of capture, discard, and predation mortality of sublegal and other lobsters should be prioritized if capture cannot be avoided. Some of the modifications summarized in the Atlantic Large Whale Take Reduction Team (ALWTRT) matrix have been implemented, and they may be effective: it has been informally reported that entanglement rates are declining.

The implementation of the Nordmøre grate in the northern shrimp trawl fishery in 1992 greatly reduced finfish bycatch in the fishery, ranging from 90 to 95% in one report to about 60% in another. There are still bycatch issues in the fishery, but recent development on the modification to the Nordmøre grate and new designs of trawls (e.g., rope grate, topless trawl) may provide further reductions in finfish bycatch. One concern is small shrimps caught in the fishery. Further research is needed to devise systems to reduce the catch of small shrimps. There are no reports on serious interactions of shrimp trawls with protected species.

In the southern shrimp trawl fishery the FGTWG found that despite concerted efforts by government agencies and fishermen, some intractable problems remain with achieving levels of bycatch reduction in the shrimp trawl fishery that may improve stock levels of species such as weakfish. For the southeast Atlantic, we recommend additional testing of newer devices that reduce finfish bycatch, such as the Composite Panel BRD.

The selectivity of pound-nets in the Chesapeake Bay and elsewhere in the mid-Atlantic can be vastly improved by using BRPs in the gear's head, but currently only the Potomac River Commission actively encourages such use. Large mesh escape panels in the heads of pound nets have been used in North Carolina for some time. Although not tested in Northeast pound nets, BRPs may be useful there, as many species taken in these nets are also taken in the Chesapeake and culling characteristics are likely similar. The design of Virginia's pound net leaders was altered to reduce sea turtle interactions in the lower Chesapeake Bay.

Testing is underway to determine if this modified design will also reduce interactions with bottlenose dolphin or sturgeon.

In the gillnet fisheries for coastal sharks, spiny dogfish, and striped bass, sublegal target individuals can be avoided where the relationship between fish size and mesh size is known. Where this information is absent (i.e., dogfish), gillnet selectivity studies should be conducted to determine appropriate mesh sizes, but selectivity characteristics could be estimated based on available data for similar species in the mean time. Some research suggests modification of the height of gillnets, either through the use of tie-downs, reduced meshes, or floatline modifications, can reduce catches of similar sized, undesired non-target species. Where net modifications are not practical or possible, information on the separation of target and bycatch species by season, area, or depth could be employed to implement time-area closures.

In the Atlantic herring mid-water trawl fishery is generally considered to be relatively 'clean,' as bycatch rates are low in comparison to many other fisheries, although there is concern about bycatch of regulated and protected species.

BRD and flexible TED testing and implementation should continue in the croaker fly net trawl fishery. Field testing and quantitative analyses of codend mesh size retention should continue, specifically on mesh sizes ranging from 3-5 inch hung in square and diamond shapes.

The importance of the Atlantic menhaden purse seine fishery with regard to non-targeted species bycatch is minor even when considering the magnitude of the fishery. In addition, negative impacts on protected, endangered and threatened species are not documented in the published literature.

The FGWTG recommends increasing the use of circle hooks in the recreational striped bass fishery to reduce release mortality, along with the expansion of angler education efforts to encourage the use of circle hooks and the careful play and handling of fish, and explain the implications of high-grading.

III.2 Conclusions

Of the ten fisheries identified during the prioritization process, nine are commercial and one is recreational. In all of the fisheries investigated, the committee identified issues related to ecosystem impacts from the capture process, and evaluated previous research that addressed issues related to selectivity, bycatch reduction, and habitat impact. In most of the fisheries investigated, previous research was directed at providing an understanding of size selection characteristics of a particular gear type for a particular species; attempts to reduce the bycatch of unwanted, unmarketable, or protected species by making technological changes to the gear; or the results of studies addressing an increase in the survival of captured animals that are released or discarded after capture.

The northern shrimp trawl fishery provides an example of the introduction of Bycatch Reduction Technology (BRT), in this case the Nordmøre Grate, which successfully reduced finfish bycatch and improved the quality of target species catch. The technology was introduced based on the results of cooperative research conducted by fishermen and scientists, and subsequently integrated into the regulatory process based on this research. On the other hand, Bycatch Reduction Panels (BRPs) have also been shown to improve the selectivity of pound nets, but are currently implemented only on a voluntary basis in a limited geographic range (the Potomac River). The primary issue associated with the recreational striped bass fishery is the survival of released fish, and the results of previous research suggest the greater use of circle hooks will reduce hooking mortality. Angler outreach and education are an important component in achieving increased circle hook use and reduced release mortality.

The primary gear research needs at present are related to reducing finfish bycatch and protected species interactions in the trawl fisheries, the lobster pot fishery, the southern shrimp trawl fishery, the pound net fishery, the gillnet fisheries, the herring mid-water trawl fishery, and croaker fly-net fishery. The results of the FGTWG review are summarized in Table III-3.1 in terms of recent advances in capture gear technology that have been researched, tested, and implemented into management. The FGTWG found that for the fisheries considered, there are many gear modifications that research has been shown to be promising, but have not been adequately tested under a variety of conditions, and therefore have not been implemented into management. The extent of management implementation varies for thoroughly researched and tested gear. The FGTWG advises the ASMFC to support further research and testing of gear modifications so as to reduce finfish bycatch and protected species interactions.

In general improved communication between fishery managers, fishing gear scientists, and fishermen, is needed to address ecosystem impacts associated with the capture process. The NMFS, NEFSC, Protected Species Branch has established a process for developing, testing, and evaluating modifications to fishing gear that will reduce both interactions with protected species while attempting to minimize effects on commercial fishing operations and efficiency (Figure III.-1.1). The FGTWG recommends that ASMFC support a similar process. As existing technological modifications to fishing gear that have proven successful in testing and evaluation are integrated into management, ASMFC and other fishery management organizations should anticipate the continuing development and modification of fishing gear and develop policies for their development, evaluation, and implementation. The goal of any technological modification to fishing gear should be to reduce the ecosystem impacts of fishing, while minimally affecting the efficiency of the gear for the target species. This goal can only be accomplished after adequate testing and evaluation of the gear modification in the fishery. The best approach facilitates and conducts cooperative research between fishermen and scientists.

Table III-3.1. Recent Fishing Gear Modifications and Evaluation Status. 'Research' - gear modification has not been rigorously evaluated in a controlled setting and is recommended for research; 'Industry Testing' - gear modification is ready for evaluation in the fishery; and 'Management Implementation' - gear modification has been industry tested and recommended for implementation throughout the fishery.

Gear Adaptation	Research	Industry Testing	Management Implementation
Otter Trawl Time/Area Management	X		
Otter Trawl Codend Mesh Size			X
Otter Trawl Discard Mortality	X		
Otter Trawl TEDs	X	X	
Lobster Pot Vents	X (Escapement from baited pots)	X (Placement)	X
Lobster Discard Mortality	X		
Lobster Pot Vertical Lines, Ground/Floating Lines	See ALWTRP matrix	See ALWTRP matrix	See ALWTRP matrix
Lobster Pot, Escape Panels	X	X (Placement)	
Lobster Pot, Sublegal Release at Depth	X (Hydrostatic release)		
Northern Shrimp Trawl, Nordmøre Grate			X
Northern Shrimp Trawl, Rope Grate	X		
Northern Shrimp Topless Trawl	X	X	
Southern Shrimp Trawl, Square Mesh Codend		X	
Southern Shrimp Trawl, Composite BRD	X	X	
Pound Net Vertical Lines		X (Testing for bottlenose)	X (Implemented for turtles)
Pound Net Corner Panels		X	X (Implementation restricted to Potomac & is voluntary)
Gillnet Mesh Size Selectivity	X	X	X
Gillnet Heights	X (Dogfish)	X (Dogfish)	
Fly Net BRDs	X		
Fly Net Flexible TED		X	
Fly Net Codend Mesh Sizes	X	X	
Striped Bass Recreational Fishery, Circle Hooks	X		X (For selected fisheries)

Figure III-1.1. The NEFSC/PSB process for evaluating and implementing new fishing gear.