Characterization of the Massachusetts Spring Longfin Squid Fishery

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EXECUTIVE SUMMARY

Since the exclusion of the international fleets from US waters, the longfin squid fishery in the Northeast US has provided a stable inshore and offshore fishery for vessels to prosecute year-round. Domestic fresh and frozen markets have been developed, and now create year-round demand. Shoreside infrastructure has been built and improved across multiple states in the Northeast US. Annual ex-vessel value exceeded $20 million in 13 of the last 15 years, and reached $50 million in 2016 (Figure 5). Annual ex-vessel prices continue to increase, exceeding $1.50/lb in the past 2 years.

The majority of recent (2018) coastwide longfin squid landings are attributable to Rhode Island (55%), New York (19%) and New Jersey (14%). Massachusetts is responsible for 6% of all landings with 5% of coastwide landings coming from those waters under the jurisdiction of the Commonwealth within federal statistical area 538 (Nantucket Sound, Vineyard Sound and Buzzards Bay). The state's commercial squid fishery is reliant on a seasonal inshore biomass of squid. This biomass provides a resilient, highly marketable fishery that can seasonally sustain a fleet of small and medium trawlers. This is particularly critical as groundfish stocks continue to rebuild, necessitating reduced fishing pressure. This inshore fishery provided over $15,000 in revenue to 25 different Massachusetts-based vessels in 2018 (MAFMC 2019a, Unpublished NMFS Dealer Data).

This characterization of the spring longfin squid fishery occurring in and adjacent to Massachusetts state waters is intended to: provide contextual data on the magnitude and value of landings of longfin squid; profile the fleet that participates in the Massachusetts longfin squid fishery; display the value of longfin squid landings to both the harvesters and dealers; and discuss the additional landings that the fishery provides to seafood consumers.

A thorough examination of at-sea sampling data allows this report to address the following:

- the catch composition (both the retained catch and discarded) and trends of species captured in the small-mesh directed trawl fishery. This includes over 50 commercially, recreationally and ecologically important species;
- seasonal and spatial description of effort and catch levels in the fishery; and
- catches and discards of species of interest or concern to multiple user groups.

Vital to these analyses are accurate harvester reporting, timely dealer reporting, and representative sea sampling. In instances where these data are insufficient, steps were taken to aggregate data to a higher level. Confidential data is withheld when necessary. Sea sampling data with low sample sizes are identified. Catch areas are combined or removed when locations could not be accurately obtained from existing reports. However, a comprehensive picture of a valuable inshore spring fishery that provides fresh, in-demand seafood to consumers is clear.

The longfin squid fishery is comprehensively managed at the federal level by the Mid-Atlantic Fishery Management Council, and more locally, by the Massachusetts Division of Marine Fisheries. A 2017 federal stock assessment update, conducted by the Northeast Fisheries Science Center, found that longfin squid was not overfished (and overfishing status could not be determined for this short-lived species) (Hendrickson 2017). Access to new participation is limited through moratorium permits, and the quota is managed in 4-month trimesters. Bycatch of butterfish, when deemed problematic, is restricted by a mortality cap. In 2018, federal fisheries managers considered the spatial needs of various near-shore user groups, including squid fishermen, recreational and for-hire fishermen, and declined to create seasonal buffer zones.

The Massachusetts fleet that prosecutes the longfin squid fishery primarily fishes out of small ports on southern Cape Cod, Martha's Vineyard or Nantucket. Primarily a day-boat fleet of small and medium-sized vessels, the opportunity to fish for a resource that doesn't require possessing, buying or trading individual quota is welcome. During the spring squid fishery businesses lining the wharves and ports of Nantucket Sound benefit from the commerce brought to the area by the fishery. When not prosecuting longfin squid, these Massachusetts vessels

pursue groundfish, scallops, summer flounder and monkfish. However, a successful month-and-a-half squid season can provide over a fifth of a vessel's annual income.

Relatively speaking for a small-mesh trawl fishery, the longfin squid fishery in and adjacent to Nantucket Sound is clean with bycatch rates near the median for all fisheries of the Greater Atlantic Region. Striped bass bycatch is low. Summer flounder and black sea bass discards are primarily due to regulations. Catch of endangered or threatened species are rare to nonexistent. Finally, sea sampling in this fishery is robust and allows for thorough in-season and historical analysis.

Improvements to management and science can be made:

- catch areas from harvester and dealer reporting prohibit analysis in further depth;
- bycatch and forage concerns can be discussed;
- impact on spawning habitat and eggs can be investigated; and
- discards of legal-sized fish suggest market and regulatory hurdles need to be addressed.

The Division of Marine Fisheries enjoys strong partnerships in the commercial, federal and academic sectors that promote novel research, accurate monitoring and creative problem solving. Squid fishermen continue to be proactive in accommodating sea samplers, displaying their desire to work with the Division. In-season monitoring, in collaboration with the Northeast Fisheries Observer Program, informs managers in near real-time during the spring squid fishery, allowing for responsible season extensions when warranted. The Division continues to be well-suited and staffed to move forward managing the interests of multiple user groups that rely on longfin squid and other resources of Nantucket Sound and adjacent waters.

LIST OF ACRONYMS AND ABBREVIATIONS

ACCSP	Atlantic Coastal Cooperative Statistics Program
ACFCMA	Atlantic Coastal Fisheries Cooperative Conservation and Management Act
ASMFC	Atlantic States Marine Fisheries Commission
Bmsy	Biomass at Maximum Sustainable Yield
℃	Celsius
CAP	Coastal Access Permit
CFDERS	Commercial Fisheries Database Biological Sample
CL	Confidence Limits
cm	Centimeters (0.3939 in)
CMR	Code of Massachusetts Regulations
CPUE	Catch per Unit Effort
CV	Coefficient of Variation
DMF	Massachusetts Division of Marine Fisheries
EEZ	Exclusive Economic Zone
°F	Fahrenheit
FDI	Fisheries Dependent Investigations
FMP	Fisheries Management Plan
FSB	Fisheries Sampling Branch
ft	Feet (0.3048 m)
GARFO	Greater Atlantic Regional Fisheries Office
hr	Hour
IAL	Individual Animal Log
in	Inches (2.54 in)
JVP	Joint Venture Processing
kg	Kilograms (2.2046 lb)
lb	Pounds (0.4536 kg)
m	Meters (3.2808 ft)
MAFMC	Mid-Atlantic Fishery Management Council
MAtl	Mid-Atlantic region
MFAC	Marine Fisheries Advisory Commission
M.G.L	Massachusetts General Law
mm	Millimeters
MSFCMA	Magnuson-Stevens Fishery Conservation and Management Act
mt	Metric Ton (2,204.6 lb)
NEAMAP	Northeast Area Monitoring and Assessment Program
NEFMC	New England Fishery Management Council
NEFOP	Northeast Fisheries Observer Program
NEFSC	Northeast Fisheries Science Center
NK	Not Known
nm	Nautical Miles (1,852 m or 6,076.1 ft)
NMFS	National Marine Fisheries Service
NOAA	National Oceanographic and Atmospheric Administration
OBDBS	Observer and At Sea Monitoring Database
RIDEM	Rhode Island Department of Environmental Management
SA	Statistical Area
SAFIS	Standard Atlantic Fisheries Information System

SBRM	Standardized Bycatch Reporting Methodology
SMB	Squid-Mackerel-Butterfish
SNE	Southern New England region
SQL	Structured Query Language
US	United States
U.S.C.	United States Code
VinNanSound	Area of Vineyard/Nantucket Sounds
VTR	Vessel Trip Report
0-3nmS	Area 0 to 3 nautical miles south of Martha's Vineyard and Nantucket Islands
3-6nmS	Area 3 to 6 nautical miles south of Martha's Vineyard and Nantucket Islands
6-12nmS	Area 6 to 12 nautical miles south of Martha's Vineyard and Nantucket Islands

1. INTRODUCTION

The Commonwealth of Massachusetts Division of Marine Fisheries (MADMF) is responsible for the management of the Commonwealth's living marine resources in balance with the environment resulting in sustainable fisheries and contributions to our economy, stable availability of diverse, health seafood and enriched opportunities that support coastal culture (MADMF Strategic Plan, 2010). Acting through powers described in Chapter 130 of Massachusetts General Law (M.G.L. c.130), the Atlantic Coastal Fisheries Cooperative Conservation and Management Act (ACFCMA), and the Magnuson-Stevens Fishery Conservation and Management Act (MSFCMA), the MADMF is involved in numerous state, interstate and federal fisheries management and conservation actions. Many of these efforts are overseen by the Massachusetts Marine Fisheries Advisory Commission (MFAC). This group of nine Governor's appointees advises the MADMF Director on the proper management and development of marine fisheries of the Commonwealth and approves all marine fisheries regulations related to the manner, size, times, quantities, and areas where fish may be taken within the waters under the jurisdiction of the Commonwealth (M.G.L. c.130, §§1B and 17A).

The MADMF and MFAC have devoted considerable time and effort to managing the harvest of commercially valuable species with the ecological need to maintain a robust forage base in local waters capable of sustaining other sought-after species. One such species is longfin squid (*Doryteuthis pealeii*), formerly *Loligo* squid. Balancing the springtime commercial harvest with the need to maintain a biomass of squid as forage for predators such as striped bass (*Morone saxatilis*), black sea bass (*Centropristis striata*) and summer flounder (*Paralichthys dentatus*), has become increasingly important. The waters of Nantucket Sound, Vineyard Sound and waters up to 3 nautical miles south of Martha's Vineyard and Nantucket islands, all under the jurisdiction of the Commonwealth, are home to an economically valuable fishery for longfin squid every year, from late April into June.

1.1 Purpose and Objectives

This report is intended to provide a characterization of the Massachusetts springtime longfin squid fishery. The relative value and impact of this fishery has recently gained increased scrutiny over bycatch and forage removal concerns. In 2019, with consideration to the ecological and economic importance of the longfin squid resource to the diverse user groups of waters of the Commonwealth, the Massachusetts state legislature requested a characterization of the commercial longfin squid fishery in the waters of Nantucket Sound, Vineyard Sound and state waters south of "the islands", hereafter known as "adjacent waters".

Similar to MADMF's 1995 report "Loligo Squid Fishery in Nantucket and Vineyard Sounds" (McKiernan and Pierce, 1995), this report describes the magnitude, value and composition of landings in the longfin squid fishery, primarily prosecuted with small-mesh bottom otter trawls and fish weirs, including allowable incidental catches and bycatch. Current management and significant historical management efforts, both state and federal, are detailed.

To provide a thorough and relevant depiction of landings and sampled catches in the longfin squid fishery of the Nantucket, Vineyard Sound and adjacent waters, a time period encompassing the five most recent years of complete fisheries data (calendar years 2013-2017) was selected.

2. BIOLOGY AND STOCK STATUS OF LONGFIN SQUID

Longfin squid is a schooling species of the molluscan family Loliginidae. It is distributed in the continental shelf and slope waters from Newfoundland to the Gulf of Venezuela (Jacobson 2005). The range of commercial exploitation occurs from Southern Georges Bank to Cape Hatteras, North Carolina. The Northwest Atlantic population is managed as a single stock based on the results of genetics studies conducted on squid samples collected between Cape Cod Bay and the Gulf of Mexico (Jacobson 2005).

2.1 Habitat and Growth

Longfin squid begin their lives as 1mm x 1.6mm (0.4 x 0.6") eggs, encased in a larger gelatinous capsule (Jacobson 2005). Each female can lay 20-30 capsules (Lange 1982), which are deposited on the ocean floor in clusters often referred to as "mops". Developmental time in Nantucket Sound varies from 12 to 34 days in water temps from 14-20°C (57-68°F) (Nichols *et al.* 2019). Juvenile squid shift from inhabiting surface waters to a demersal lifestyle at 45mm (1.8") (Vecchione 1981). Off Martha's Vineyard, the juvenile life stage lasts about 1 month. Subadults migrate by November to the outer shelf areas where they remain until March (Summers 1968a, b), and are thought to overwinter in deeper waters along the edge of the continental shelf (Black *et al.* 1987). Subadults are found with adults in mid-summer bottom trawl catches (Summers 1968a, b). Growth rates of juveniles and subadults are relatively fast with growth rates dependent on temperatures (Hatfield *et al.* 2001). The length at sexual maturity was found to be in the 8-12cm (3.2-4.7") mantle length range (Macy 1980; Brodziak and Hendrickson 1999), but also in the 16-20cm (6.3-7.9") range (Brodziak 1996; Macy and Brodziak 2001; Hatfield and Cadrin 2002), depending on season and location. Using statoliths for age, Brodziak and Macy (1996) were able to demonstrate that longfin squid experiences exponential growth and a life span that can be less than 9 months, reducing previous maximum age estimations. Longfin squid can reach sizes greater than 40-50cm (15.8-19.7") mantle length, although most are less than 30cm (11.8") (Vecchione *et al.* 1989). Growth is dependent on temperatures (Hatfield *et al.* 2001) and is highest for individuals hatched during winter (Macy and Brodziak 2001).

Longfin squid are generally found at water temperatures of at least 9°C (48°F) (Lange and Sissenwine 1980). In the waters off Massachusetts larger individuals migrate inshore first in April-May, while smaller individuals move inshore in the summer (Lange 1982). Catches of the offshore longfin squid fishery were found to be spawned during the previous inshore season and catches of the inshore fishery were spawned during the previous winter (Macy and Brodziak, 2001).

2.2 Predator and Prey

Longfin squid are important forage for many pelagic and demersal fish species of the Northeast US, as well as marine mammals and birds. Marine mammal predators include longfin pilot whales and common dolphins (Waring *et al.* 1990; Overholtz and Waring 1991; Gannon *et al.* 1997). Fish predators include striped bass, bluefish, black sea bass, mackerel, cod, haddock, pollock, silver hake, red hake, sea raven, spiny dogfish, goosefish, dogfish and flounders (Maurer 1975; Langton and Bowman 1977; Gosner 1978; Lange 1980).

Cannibalism is observed in individuals larger than 5cm (2.0") (Whitaker 1978). Juvenile longfin squid at 4-6cm (1.6-2.4") feed on euphausiids and arrow worms; whereas, at 6-10cm (2.4-3.9") juveniles will feed mostly on small crabs, but also polychaetes and shrimp. Adult longfin squid at 12-16cm (4.7-6.3") feed on fish (clupeids, myctophids) and larval and juvenile squid; whereas, adults greater than 16cm (6.3") feed on fish and squid (Vovk and Khvichiya 1980; Vovk 1985). Fish species that were preyed upon by longfin squid include silver hake, mackerel, herring, menhaden (Langton and Bowman 1977), sand lance, bay anchovy, menhaden, weakfish and silversides (Kier 1982).

2.3 Stock Status

During the most recent assessment the 2016 longfin squid stock was considered not to be overfished. This determination was made because the average of catchability-adjusted swept-area biomass estimates derived from the Northeast Fisheries Science Center (NEFSC) spring and Northeast Area Monitoring and Assessment Program (NEAMAP) fall surveys during 2015-2016 (73,762 mt;80% CL= 67,198-80,327) was much greater than the

threshold Bmsy proxy of 21,203 mt (Hendrickson 2017). Essentially, the estimated biomass was nearly 3.5 times greater than the pre-determined biomass of a sustainably harvested resource. The overfishing status could not be determined. No determination could be made because there are no fishing mortality reference points for the stock. Longfin squid are a short-lived species that mature in approximately 150 days and exhibit spawning cohorts throughout the year (Macy and Brodziak, 2001). These findings strongly support the hypothesis that the inshore fishery is entirely dependent upon squid which survive the winter offshore fishing season.

3. MANAGEMENT OF THE LONGFIN SQUID FISHERY

Longfin squid is targeted commercially with numerous gear types, including small-mesh otter trawls, mid-water otter trawls, fish weirs and rod and reel. Massachusetts commercial longfin squid fisheries primarily employ small-mesh bottom otter trawls and fish weirs.

3.1 Description of Massachusetts Longfin Squid Trawl Fishery

Fishing with small-mesh otter trawls (meshes <6.5" in codend) is highly regulated in the longfin squid trawl fishery and traditionally only occurs due to exemptions on mesh size restrictions. MADMF regulations [322 CMR §4.06(5)] contain an exemption, "to authorize commercial trawl fishermen to seasonally target valuable finfish species that cannot be caught in commercially viable quantities without the use of small-mesh trawls". Specifically, the regulation [322 CMR §4.06(5)(a)(2)] dictates that, during the period of April 23rd through June 9th, lawfully permitted vessels may fish small-mesh trawls within the small-mesh squid exempted area (Figure 1) and this seasonal allowance may be extended beyond June 9 by the MADMF Director. This allows small-mesh trawlers to pursue squid (and other catches) in certain state-waters for at least 48 calendar days each spring.

The small-mesh squid exempted area is inclusive of certain waters under the jurisdiction of the Commonwealth south of Cape Cod within Vineyard Sound, Nantucket Sound, and south of the islands. However, access to the small-mesh squid exempted area is further restricted in space and time by six seasonal and spatial closures [322 CMR §4.06(2)(e)-(j)]. Additionally, Buzzards Bay is closed year-round to all net fishing, including the use of small-mesh trawls [322 CMR §4.02(2)(e)] (Figure 1).

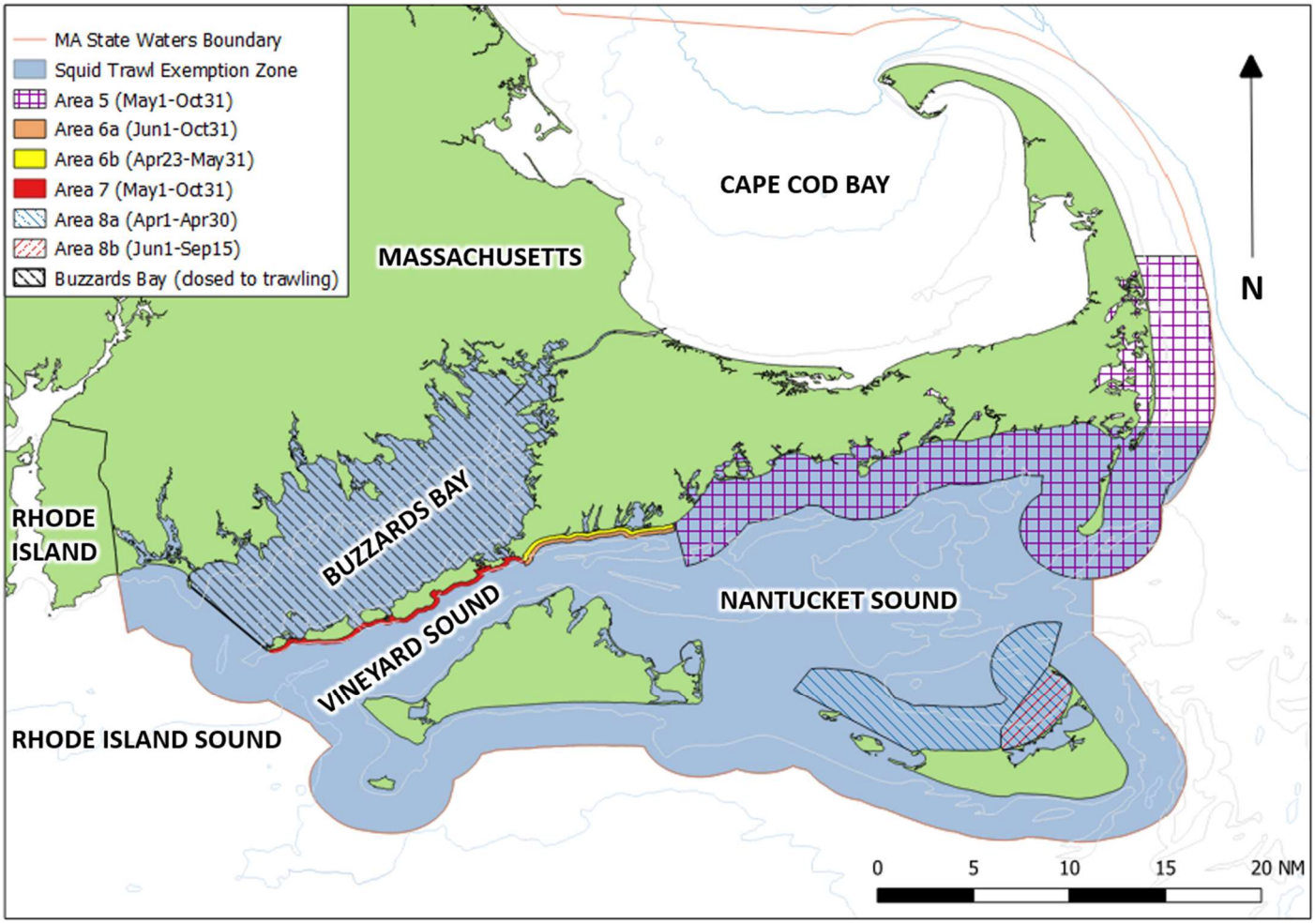

Figure 1 – Massachusetts small-mesh squid trawl exempted area
Source: MADMF

3.2 Reporting Areas

State-permitted commercial longfin squid harvesters report trip-level catches by state statistical reporting areas (Figure 2). State reporting areas 10 and 13 coincide with Nantucket and Vineyard Sound waters, while state reporting area 12 corresponds with state waters south of the islands. Federally permitted longfin squid harvesters submit trip-level Vessel Trip Reports (VTR), identifying catch locations using federal statistical areas (SA) (Figure 3). Federal statistical area 538 encompasses Nantucket and Vineyard Sounds, as well as Buzzards Bay. Federal sub-reporting areas 075 and 092 coincide with Nantucket and Vineyard Sounds. Federal statistical area 537, which covers state waters south of the islands south to the continental shelf break, is problematic in that catches from this area cannot be assigned to state or federal waters. This mismatch in reporting areas is addressed in detail in section 6.3.

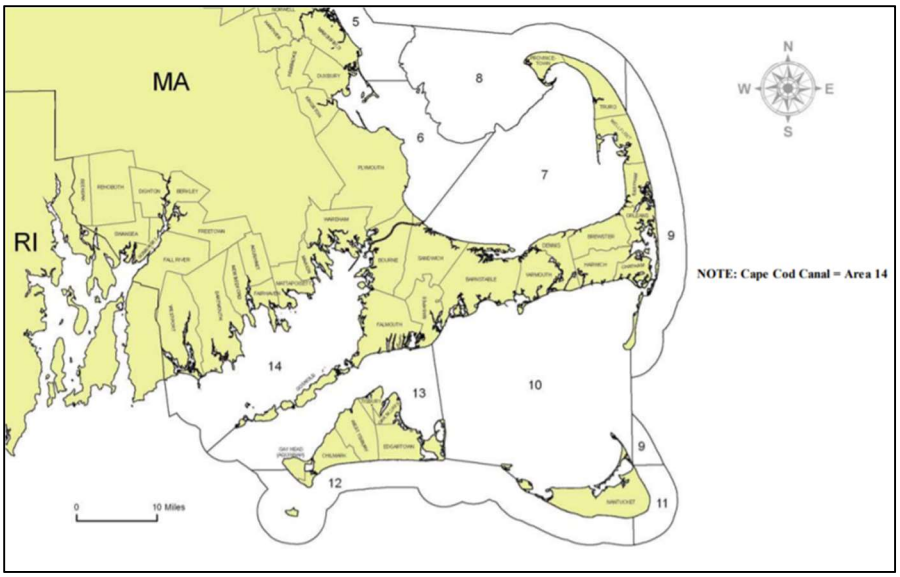

Figure 2 – Massachusetts State Reporting Areas
Source: MADMF

Figure 3 – NMFS Statistical Areas (bold) and State NEMFIS Reporting Areas
Source: Atlantic Coastal Cooperative Statistics Program

3.3 Vessels and Gear

Commercial fishing vessels must be no greater than 72 feet length overall [322 CMR 7.05(13)]. In general, vessels using otter bottom trawl gear may use net rollers (ground gear) with a maximum diameter of 12" [322 CMR 4.06(4)(b)]. For the small-mesh longfin squid trawl fishery the minimum codend mesh size is $1^{7/8}$" and net strengtheners and splitting straps are permitted for use to support the net [322 CMR 4.06(5)(a)]; these rules match federal regulations governing the springtime small-mesh trawl fishery for longfin squid in adjacent federal waters.

3.4 Permits and Endorsements

To participate in any mobile gear fishery in the waters under the jurisdiction of the Commonwealth, a Coastal Access Permit (CAP) must be held and may be further endorsed to participate in certain exempted mobile gear fisheries, including the small-mesh trawl fishery for squid (CAP-Squid) [M.G.L. c. 130, §80 and 322 CMR 7.01(4)(a)(2)(d)(ii) and 322 CMR 7.05(3) and (4)]. The Coastal Access Permit endorsement is "limited entry", meaning that permits may only be obtained through renewal and transfer (if allowed) and no new permit endorsements are issued; this serves to constrain opportunistic fishing effort within state waters, or waters under the jurisdiction of the state.

3.5 Catch Restrictions

Squid catches (daily and trip limits) are regulated by each vessel's longfin squid permit. Federally permitted vessels must possess a Squid-Mackerel-Butterfish (SMB) Moratorium Permit in order to retain over 250 lbs of longfin squid. Federal longfin squid moratorium Tier 1, 2 and 3 permits allow for unlimited, 5,000 lbs per trip and 2,500 lbs per trip respectively, during open seasons. State-permitted squid-endorsed vessels have no longfin squid landing limit during the spring season in Massachusetts state waters, while federal quota for the period remains available. If the federal quota for the period is taken, then a 2,500 pound trip limit is implemented and the MADMF Director may make in-season adjustments to the state's possession and landing limits for longfin squid in response to federal actions [322 CMR 6.39(2) and (3)].

Currently, state regulations [322 CMR 6.28(2)(c)(3)] allow vessels targeting longfin squid in the squid trawl exempted area to an incidental possession and landing limit of 100 lbs of black sea bass per day/trip (minimum size of 12"). This 100 lb limit was implemented in 2020; for the years of 2018-2019 the incidental catch was set at 50 lbs per day/trip. During the period (2013-17) that was analyzed for landings and sea sampling the retention of black sea bass was prohibited in the small-mesh trawl fishery for longfin squid. Scup retention limits for small-mesh trawl vessels are currently 2,000 lbs per trip from April 15-June 15 [322 CMR 6.27(2)(d)(2)]. However, during the analyzed period (2013-17) possession and landing limits for scup ranged from 800 lbs per day to 10,000 lbs per week (see Section 4.)

Vessels targeting longfin squid may also retain modest amounts of flounders: winter flounder (minimum size of 12"), yellowtail flounder (minimum size of 12"), and summer flounder (minimum size of 14"). However, in combination the possession of flounders may not exceed 100 lbs per day/trip [322 CMR 4.06(5)(a)(5)], and the retention of winter flounder is further constrained by a 50 pound commercial trip limit in those waters within the squid trawl exempted area [322 CMR 6.03(11)(a)(1)(b)].

There are also other notable catch restrictions on species of interest. The retention of striped bass by vessels using nets, such as small-mesh trawls is prohibited by state law [G.L. c 130, §100B. Additionally, since 2006, there has been a moratorium on river herring in Massachusetts [322 CMR 6.17(3)(a)]. While there is a state exemption allowing bait fisheries conducted in federal waters to land river herring in Massachusetts provided the river herring catch does not exceed 5% the weight of the overall catch [322 CMR 6.17(3)(c)], this does not apply to the small-mesh squid fishery.

3.6 Season

Vessels may use small-mesh trawls within the squid exempted area (**Error! Reference source not found.**) from April 23 to June 9 annually [322 CMR 4.06(5)(a)(2) and 6.39(1)]. Multiple mobile gear closures are effective during the spring season and must be avoided [322 CMR 4.02(2) and 4.06(2)(e)-(j)]. The season may be extended

at the discretion of the Director of MADMF. The fishery was extended in 2015, 2016, and 2019 as available sea sampling data showed the catch of quality squid continued in the area and did not raise heightened concerns regarding bycatch and discards (Table 1).

Year	Open Date	Close Date	Duration (days)
2013	April23	June10	48
2014	April23	June10	48
2015	April23	June19*	57
2016	April23	June17*	55
2017	April23	June10	48
2018	April23	June10	48
2019	April23	June17*	55

Table 1 - Dates and duration of recent Nantucket and Vineyard Sound longfin squid fishery
*Season extended by MADMF Director

3.7 Description of Longfin Squid Weir Fishery

Fish weirs, also known as pound nets, are passive fixed-gear traps that guide schooling fishes into a maze of nets and eventually into the "bowl", where escape is unlikely. One of the earliest methods of fishing in Massachusetts, the number of permits and active weirs has declined over the past century and even more so over recent decades. In 1990, 6 distinct fishing entities operated 17 weirs (McKiernan and Pierce, 1995). In 2000, 8 fish weir permits were active in Barnstable County, MA, landing over 300,000 lbs of squid. By 2010, only 4 active permits, belonging to fewer than 3 fishing entities were active. From 2013-2017, fewer than 3 commercial fishing entities have landed longfin squid from commercial fish weirs, and thus, landings data are confidential and cannot be displayed (Unpublished NMFS and MADMF data).

3.8 Description of Longfin Squid Handline/Rod and Reel Fishery

A relatively small amount of longfin squid is caught commercially using handline or rod and reel gear. From 2013-2017 state and federally permitted fishermen reported landing a total of 40,000 lbs of squid in MA ports during the spring squid season using these gears. Recreational squid harvest, often from shore (notably piers and docks) using rod and reel, has increased over recent years, but recreational harvest data is not collected for longfin squid. Without reliable records of recreational harvest, comparisons to commercial removals cannot be made.

4. HISTORY OF LONGFIN SQUID MANAGEMENT

In 1976 the Magnuson-Stevens Fishery Conservation and Management Act [Magnuson-Stevens Act, or MSFCMA, Public Law 94-265, 16 U.S.C. §1801 (1976)] was established in order to govern and manage the harvest of marine species from newly created 200 nautical mile federal waters jurisdiction, the Exclusive Economic Zone (EEZ). A group of regional fisheries management councils, comprised of state, federal and fishery resource stakeholders, was created to draft and modify fisheries management plans (FMPs) for important and valuable marine species.

4.1 Significant Federal Management Actions

The Mid-Atlantic Fishery Management Council (MAFMC), established a Squid FMP in 1978. This action created domestic and foreign quotas for longfin squid and shortfin squid (*Illex illecebrosus*) for the 1979-1980 fishing

year, as well as establishing catch reporting requirements and fishing gear restrictions (MAFMC 1978). In 1981 the squid FMP was merged with the FMP's for Atlantic mackerel (*Scomber scombrus*) and Atlantic butterfish (*Peprilus triacanthus*), creating the MAFMC Squid/Mackerel/Butterfish ("SMB") FMP (MAFMC 1981). Foreign nations were given allocations of longfin squid, however, these allocations were predominantly phased out in 1986 with the implementation of Amendment 2 to the SMB FMP. Over-the-side sales of longfin squid by domestic vessels to foreign processors were still permitted under the Joint Venture Processing (JVP) program, so long as they did not result in negative impacts on US processors. Amendment 2 also extended the FMP indefinitely, or until further amended. In 1996 Amendment 5 to the SMB FMP eliminated directed foreign fisheries for longfin and shortfin squid, required the acquisition of moratorium squid permits and described eligibility criteria for these permits. Weekly catch reporting and dealer permitting were also mandated. In 2009, after butterfish was found to be overfished, Amendment 10 created a butterfish mortality cap in the longfin squid fishery. This action, which also included minimum mesh size increases for the directed longfin squid fishery, was intended to reduce the bycatch and discards of butterfish by setting a mortality cap for each trimester of the squid fishery. This catch cap was converted to a discard cap in 2013, via Framework 7 to the FMP. Also, in 2013 NMFS set a control date (May 16, 2013) for the longfin squid fishery. Finally, in 2018, Amendment 20 enacted two major measures to modernize the management plan and limit effort in the longfin squid fishery. This amendment created the current tiered limited access moratorium permits for vessels that met activity requirements prior to 2013 and reduced the incidental possession limit for in-season closures to 250 pounds to avoid trimester quota overages. Seasonal closed areas in adjacent waters south of Martha's Vineyard and Nantucket were considered as part of Amendment 20 to alleviate perceived user conflicts, but were deferred for future consideration.

4.2 Significant State Management Actions

After the implementation of the Magnuson-Stevens Act in 1976, the waters of Nantucket Sound that extended greater than 3 nautical miles from the Massachusetts shoreline fell under the jurisdiction of the National Marine Fisheries Service. However, the Magnuson-Stevens Reauthorization Act (Public Law 97-483) of 1983 declared that, "the jurisdiction and authority of a State shall extend… (B) with respect to the body of water commonly known as Nantucket Sound, to the pocket of water west of the seventieth meridian west of Greenwich…" [16 U.S.C. §1856(2)(b)]. In response, Massachusetts General Law was updated to determine that, "the marine boundaries of the commonwealth in the area of Nantucket Sound shall be drawn to include the entire area of Nantucket Sound as territorial waters of the commonwealth" [M.G.L. c.1, §3]. These amendments provided MA DMF with the legal authority to regulate commercial and recreational fisheries existing within the entirety of Nantucket Sound. Thus, the MADMF, with guidance from the MFAC, is tasked with the development, implementation and oversight of policies and regulations pertaining to commercial and recreational harvested marine species in all of Nantucket Sound, including longfin squid.

4.3 Regulatory Limits

Changes to retention limits during the spring squid fishery for incidentally caught species have influenced the longfin squid fishery. These amendments are most often made in response to changing stock status and available quota. Through its regulations MADMF maintain the ability to adjust trip limits throughout the calendar year to maximize utilization of quotas and reduce unwanted mortality.

In 2014, MADMF established a weekly aggregate pilot program to allow squid trawl vessels to land scup with more flexibility. This program aggregated the existing daily retention limit (800 lbs) over seven open fishing days, thus allowing a vessel to land up to 5,600 lbs of scup in a calendar week, from May 1 to June 9. In 2017, regulations were adjusted to allow a 10,000 lb weekly aggregate limit, from May 1 to October 31, for all gear types. In 2018, small-mesh trawl vessels were restricted to just 200 lbs per trip from May 1 to September 30; this was implemented in response to the ASMFC notifying MADMF that its regulations were inconsistent with the interstate management plan for scup. In 2019, at the request of MADMF the interstate and federal plans were

amended to liberalize scup retention by commercial fishing vessels using trawl gear with cod end net mesh of less than 5". As a result, scup regulations allowed small-mesh trawl vessels to retain 2,000 lbs of scup per trip from April 15 to June 15. These increases were made in response to the underutilization of the coastwide scup quota, as well as expanding markets, vessel efficiency, discard rates and emerging year classes of scup.

MADMF's regulations concerning black sea bass retention have also evolved in recent years. Black sea bass retention limits from 2011 to 2012 permitted 100 lbs per trip prior to May 1, 80 lbs per trip from May 1 to May 31 during the 3 open fishing days per week, and 0 lbs thereafter. The spring black sea bass fishery was eliminated from 2013-2017, with commercial possession during the squid trawl season prohibited. In 2018 and 2019, regulations were liberalized for trawlers; allowing up to 50 lbs of black sea bass to be retained per trip taken during the spring squid fishery. Most recently, in 2020, the limit for trawlers fishing in the squid fishery was increased to 100 pounds.

While all vessels fishing in waters under the jurisdiction of the Commonwealth must abide by state regulations, it is worthwhile to take note of Rhode Island's retention regulations during this time period. Additionally, vessels fishing in federal waters south off the islands are bound by the retention rules in place in the state (port) of landing. Many vessels participating in the spring longfin squid fishery land in Rhode Island ports, and are subject to regulations set by the Rhode Island Department of Environmental Management (RI DEM). Scup retention limits for Rhode Island-landing vessels from 2013-2017 began the squid season at 50,000 lbs per day, but were sometimes reduced to 10,000 lbs per day in early May. Rhode Island had to make similar modifications to scup retention limits to regain compliance with ASMFC's interstate management plan. Black sea bass regulations varied annually as well, allowing 50 lbs per day in May of 2013 and 2015. Weekly retention limits were enacted for black sea bass during parts of the 2017 (700 lbs per week) and 2019 (850 lbs per week) seasons.

5. ANALYSIS METHODS OF THE LONGFIN SQUID FISHERY

5.1 Definition of a Squid Trip

In order to properly describe catch and landings of the longfin squid fishery operating within Nantucket and Vineyard Sounds, the definition of a directed squid trip needed to be established. During the Mid-Atlantic Fishery Management Council's development of Amendment 20 to their Squid-Mackerel-Butterfish management plan, Council staff investigated trips in the commercial fishing dealer weigh-out database (CFDERS) to determine if a specific trip definition could account for *most* longfin squid landed. This review found that, "all trips that had at least 40% longfin squid by weight for retained species… result[ed] in capturing 91% of all longfin squid landings in the dealer weigh-out database [from] 2014-2016" (MAFMC, 2018).

For purposes of this analysis, this '40% longfin squid threshold' was applied to all federal VTR and state harvester reported trips landing at least one pound of longfin squid in MA during the state's small-mesh trawl fishery for squid from 2013-2017. This resulted in the omission of 9.6% of trips but retained 99.3% of longfin squid landings by weight. Thus, the 40% rule established by MAFMC staff also accurately defines directed longfin squid effort in Massachusetts and adjacent waters.

For the purposes of describing the longfin squid directed fishery, it is necessary to remove trips with small amounts of squid caught while targeting other species from further analysis. This 'incidental catch' of squid can occur while targeting silver hake (whiting), scup and summer flounder (fluke), but also while groundfishing and fishing for other pelagic species such as illex squid, Atlantic herring and Atlantic mackerel. Since 1999, trips that landed 50 or fewer pounds of longfin squid in Massachusetts ports were most likely to be landing silver hake, scup or a mixture of groundfish species (Unpublished VTR data).

5.2 Landings Data

Federally reported landings from NMFS VTR and Commercial Fisheries Database Biological Sample (CFDBS) databases were queried to produce a comprehensive record of squid landings from federally permitted vessels. Generally, dealer data (located within CFDBS) are assumed to contain more accurate species weights and were used in place of VTR data (fishermen's best estimates) where possible. However, only VTR data contains useful gear-type and trip location information, therefore dealer and VTR data from unique trips were matched where possible. Landings from state-permitted harvesters were provided from the Standard Atlantic Fisheries Information System (SAFIS) database by the MADMF Statistics Project. All trips where longfin squid composed less than 40% of the overall trip hail were removed. All duplicate trip reports were removed.

5.3 At-Sea Catch, Bycatch and Biological Data

The NMFS Observer and At-Sea Monitoring Database (OBDBS) database was queried to produce full catch records of observed hauls where the captain identified longfin squid as one of the target species. These data were selected in order to build a dataset with catch estimations and accurate haul locations. Only hauls with begin latitude/longitudes within Nantucket Sound, Vineyard Sound and within 12nm south of Martha's Vineyard and Nantucket were retained. Observer-recorded lengths were also queried from OBDBS tables. Data from MADMF-sampled longfin squid trips were combined with the Northeast Fisheries Observer Program (NEFOP) dataset prior to analysis.

5.4 Analytical Programs

Oracle SQL Developer (18.4.0) was used to query NMFS databases and export data. R (3.3.2) and RStudio (1.0.136) were used to manipulate and filter data. Microsoft Office programs Excel, Powerpoint and Word were used to analyze data, create and format figures, and assemble the document. QGIS (2.8.2) was used to plot data and create figures for the document.

5.5 Data Confidentiality Standards

NOAA NMFS (50 CFR 600.405 – 600.425), the Commonwealth of Massachusetts (G.L. c. 130, §21) and Atlantic Coastal Cooperative Statistics Program (ACCSP) policies prohibit distribution of datasets that are considered confidential. Thus, data not satisfying the "rule of three" were withheld and note of omission made. The rule of three is defined as: Any fisheries data that would identify a single fisheries entity. For example, if 5 trips occur in a time and area, but only two unique fishing entities (companies) are responsible for those trips, that data must be omitted.

6. LANDINGS AND VALUE OF THE LONGFIN SQUID FISHERY

To provide context of the quantity of longfin squid that is landed by the fishery and its monetary value, federal landings data for the last 20 years (1999-2018) were analyzed. Presented first are data for coastwide landings for all gear types, then landings in Massachusetts ports from all areas during all months, then coastwide landings from all areas during the Massachusetts spring squid fishery (April 23 – early June), and finally landing data by state that were caught specifically from within Nantucket and Vineyard Sounds.

6.1 Coastwide Longfin Squid Landings and Value

The most recent 20 years of longfin squid landings data reveal coastwide catches between 35.8 and 13.5 million pounds annually (Figure 4). Rhode Island contributes the largest proportion of longfin squid landings in each of the last 20 years, while New York and New Jersey traditionally contributed the second and third most landings. Massachusetts and Connecticut landings generally ranked fourth or fifth annually, and the remaining states of

Virginia, North Carolina, Maryland, Maine and New Hampshire combined to comprise less than 1% of overall longfin squid landings, annually.

The annual longfin squid quota was managed in trimesters beginning in 2000. From 2001-2006 quarterly quotas were in effect, however trimester quotas were reinstated for 2007 and have been utilized since. From 2000 to 2014, longfin squid quarterly quotas were reached in 58.3% of quarters, and trimester quotas were reached in 31.0% of trimesters (MAFMC 2015).

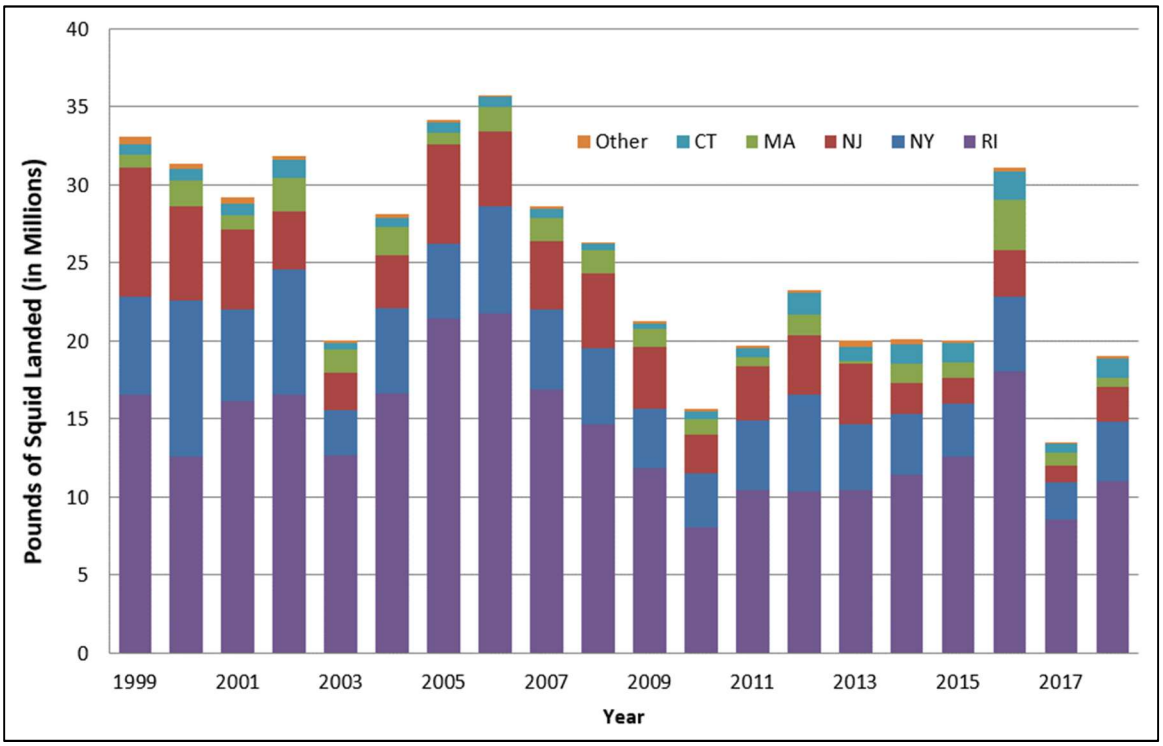

Figure 4 – Coastwide landings of longfin squid, all gear types, 1999-2018
Source: Unpublished NMFS VTR Data

The longfin squid fishery generates a significant amount of revenue for many vessels in the northeast U.S., especially those that cannot target groundfish species throughout the calendar year. Since 1999, coastwide annual revenues from the commercial sale of longfin squid averaged $26.8 million dollars, and ranged from $15.8 million (2010) to $50.1 million (2016) (Figure 5).

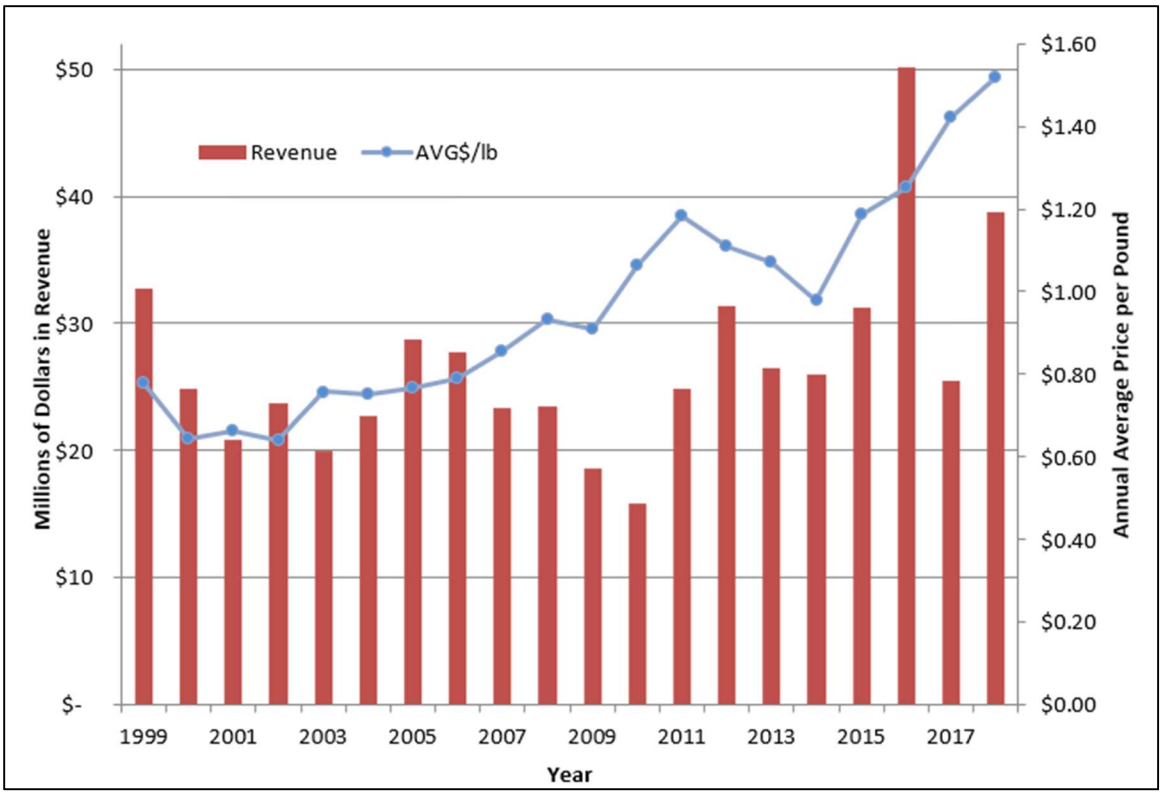

Figure 5 – Annual revenue generated by longfin squid sales and average annual price per pound, 1999-2018
Source: Unpublished NMFS Dealer Data

According to NMFS dealer data, average annual prices have steadily increased from $0.64/lb in 2002 to $1.52/lb in 2018 (not corrected for inflation). Except for 2014, when prices averaged $0.98/lb, average annual prices have exceeded one dollar per pound each year since 2010. Massachusetts revenues and average annual prices have followed coastwide trends closely.

6.2 Massachusetts Longfin Squid Landings

Over the past 20 years, landings in Massachusetts ports averaged 1.26 million pounds of longfin squid annually (Figure 6). Recent years have seen greater variability in landings, with 2013 returning the worst year in the time series, and 2016 the best year. The 2013 fishery represented an atypical year for fishermen operating out of most states, not solely Massachusetts. Federal VTR data from 1999-2018 show that roughly 50.2% of annual longfin squid is landed in the first half of the calendar year (January 1-June 30). However, in 2013 only 9.3% of the annual longfin squid landings (~1.85 mil lbs) occurred in the first half of the year (Appendix, Figure 49). This suggests that the seasonal distribution of longfin squid can drastically affect landings for different fishery participants. High availability of squid in the second half of 2013 allowed the fishery to land nearly as much as the previous year (2012), and more than two years prior (2011).

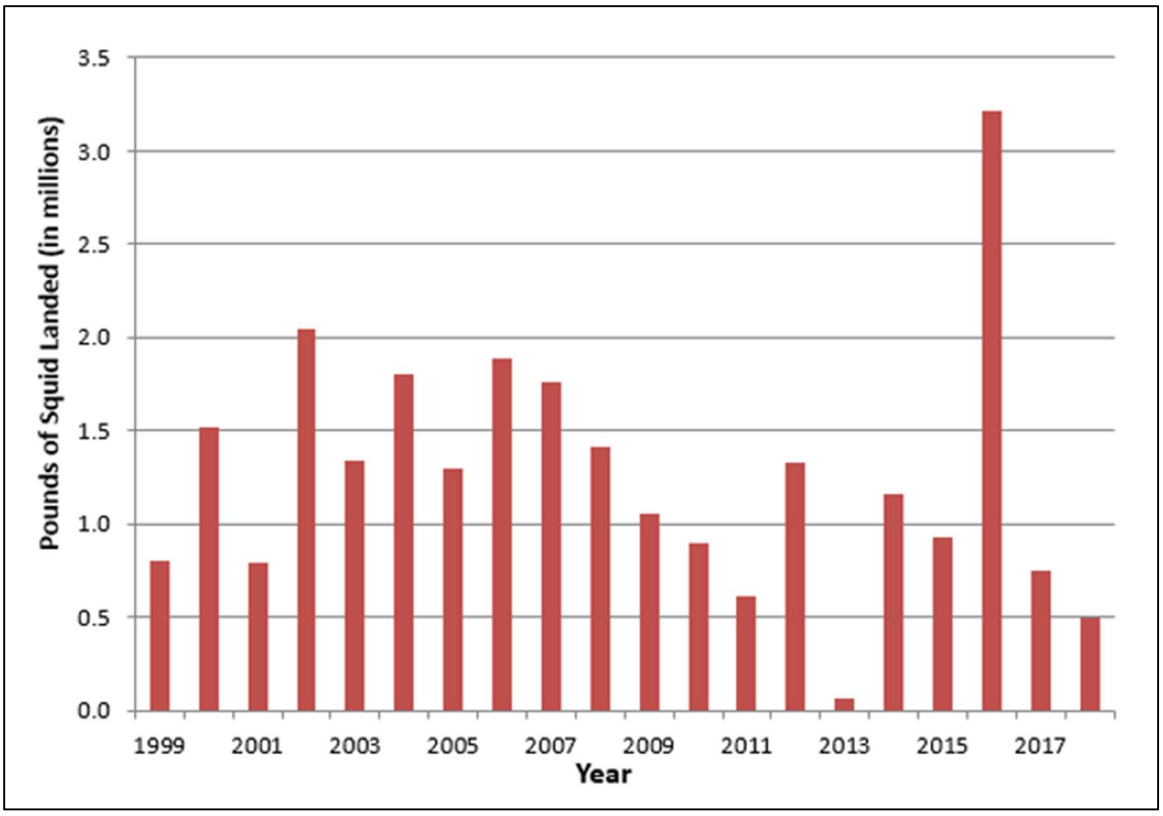

Figure 6 – Historical landings of longfin squid in Massachusetts ports (from all areas in all months)
Source: Unpublished NMFS VTR Data

6.3 Coastwide Landings During Massachusetts Spring Longfin Squid Spring Fishery

More recent landings data (2013-2017) during the period of the Massachusetts spring fishery (April 23 through early June) show that the majority of squid are landed in Rhode Island (55.0%), Massachusetts (28.7%) and New York (11.7%) ports (Table 2). Spring fishing effort is spread across much of southern New England, with the most longfin squid landed from statistical areas 537 (40.5%), 538 (30.5%) and 539 (9.6%) (unpublished NMFS VTR data). Due to confidentiality rules, states with limited landings were aggregated under "Other". The data show that spring squid landings from all areas exhibit a similar 2013 "bust" and 2016 "boom" that vessels landing in Massachusetts witnessed in those years (Figure 6).

Thousands of pounds	RI	MA	NY	CT	NJ	Other	Total
2013	183.1	93.7	86.9	31.5	1.2	1.1	397.6
2014	1,469.3	1,255.7	250.1	118.8	73.2	48.6	3,215.6
2015	1,536.8	633.7	157.6	16.4	8.5	6.3	2,359.4
2016	4,532.6	1,799.2	1,071.0	280.3	31.5	23.9	7,738.6
2017	1,117.4	825.6	323.0	17.3	78.9	1.2	2,363.3

Table 2 – Thousands of pounds of longfin squid landed during the Massachusetts spring fishery, coastwide from all areas
Source: Unpublished NMFS and MADMF Dealer Data

In order to more accurately characterize the spring longfin squid fishery in Nantucket Sound and adjacent waters, landings during the spring squid season (April 23 through early June), from the last 5 years for which finalized data are available (2013-2017), need to be explored. Springtime longfin squid landings from dealer reports, which

seldom produce reliable catch location information, show that during the April 23 – early June state waters fishery, the largest proportion of longfin squid is landed by vessels fishing out of Rhode Island and Massachusetts ports. While vessels from Rhode Island and New York do participate in the Nantucket Sound squid fishery, exploitable biomass of squid often exist closer to homeports of those states, which diverts effort away from Nantucket and Vineyard Sound waters.

Using catch locations from federal VTRs and state landings reports, we can look at the specific harvest of federally reported longfin squid from the waters of Nantucket and Vineyard Sound during the annual spring squid season. This fishery occurs in NMFS SA 538 (including sub-areas 092 and 075) (Figure 3), which encompasses Massachusetts State Reporting Areas 10 and 13 (Figure 2). Due to statistical area granularity and lack of reliable catch locations from dealer data, landings information from state waters south of Martha's Vineyard and Nantucket cannot be accurately reported. For example, trips from NMFS SA 537 often cannot be attributed to state or federal waters, and thus cannot be included in this analysis.

6.4 Landings by State from Nantucket and Vineyard Sounds

Longfin squid landings, number of trips conducted per year and state of landing are shown in Table 3. Trips landed in Connecticut did not satisfy confidentiality rules (fewer than 3 trips or fishing entities) and were removed from the remainder of this analysis. There were no landings from the Nantucket and Vineyard Sound fishery in states outside of Massachusetts, Rhode Island or Connecticut. From 2013-2017, roughly 76% of squid landings during the spring squid season came from SA 538.

YEAR	Massachusetts		Rhode Island		Total Pounds of Longfin Squid Landed
	Pounds	Trips	Pounds	Trips	
2013	63,906	131	5,648	6	69,554
2014	1,140,684	395	507,888	39	1,648,572
2015	423,733	240	279,989	29	703,722
2016	1,241,765	426	538,427	33	1,780,192
2017	667,970	379	396,542	46	1,064,512

Table 3 – Pounds of longfin squid landed and trips conducted, by state, from SA 538

Source: Unpublished NMFS and MADMF Dealer and VTR Data

Annually, landings in Massachusetts ports make up 60-70% of the total catch from the trips conducted in SA 538. Vessels landing in Rhode Island exhibit a larger amount of catch per trip, suggesting that far more multi-day trips are being conducted. In fact, Massachusetts and Rhode Island vessels display very different fishing characteristics when broken into fleets.

6.5 Landings of Longfin Squid by Bottom-Trawl Vessel Size

Analyzing landings by vessel size helps characterize the longfin squid fishery and illustrates how fishing activities, that occur in the same areas, differ by state. Vessels that landed at least 3 longfin squid trips in any one year were binned by Length: 45 feet or less (small), 46 – 59 feet (medium), and 60 feet or larger (large). During the years of 2013-2017, 'small' vessels constituted the largest portion of the fleet (Figure 7).

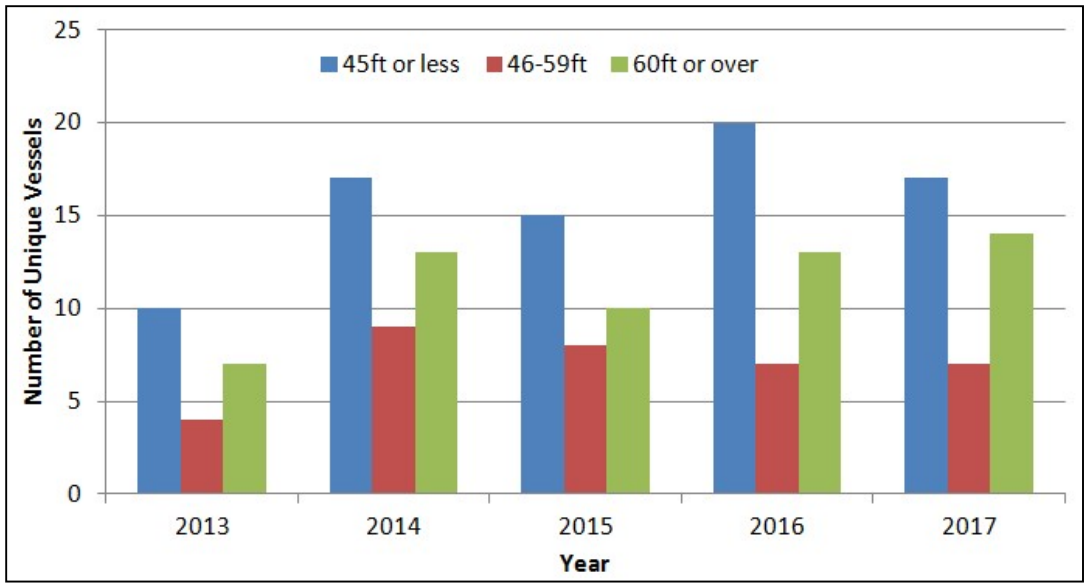

Figure 7 – Number of unique participating vessels that landed trips from SA 538, by vessel length class
Source: Unpublished NMFS and MADMF Dealer and VTR Data

The number of trips conducted annually by vessels in these length classes (Figure 8) show that more than twice as many trips are conducted by 'small' vessels than 'large' vessels. This suggests a day-boat (fishing for a single day then returning to port) versus trip-boat (multi-day fishing trip) difference in fishing practices.

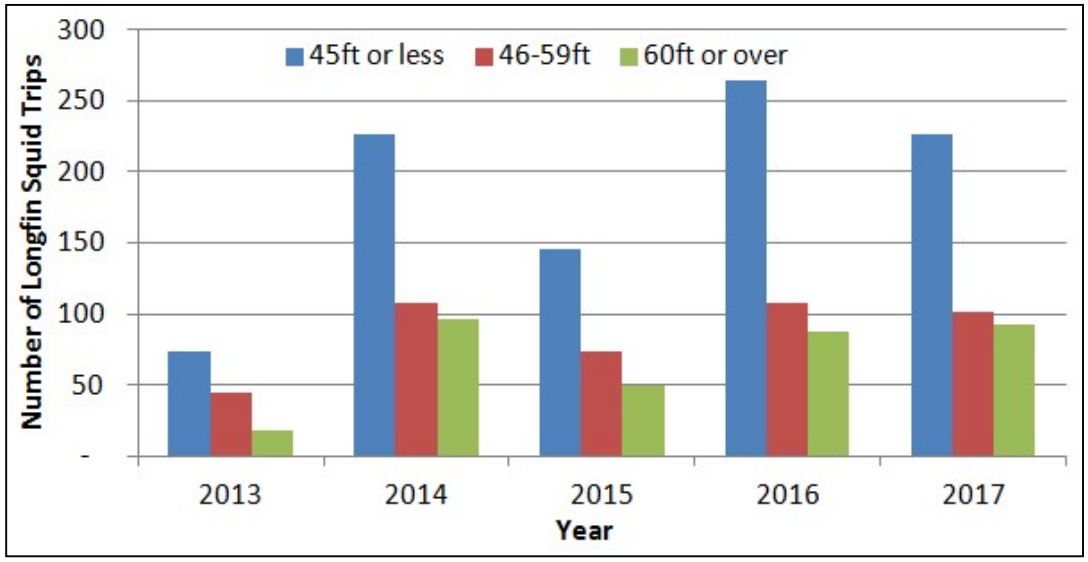

Figure 8 – Number of longfin squid trips conducted in SA 538, by vessel length class
Source: Unpublished NMFS and MADMF Dealer and VTR Data

However, when landings were applied to the vessel's practices by size, the large 'trip-boats' land more than twice as much longfin squid as the small 'day-boats' (Figure 9).

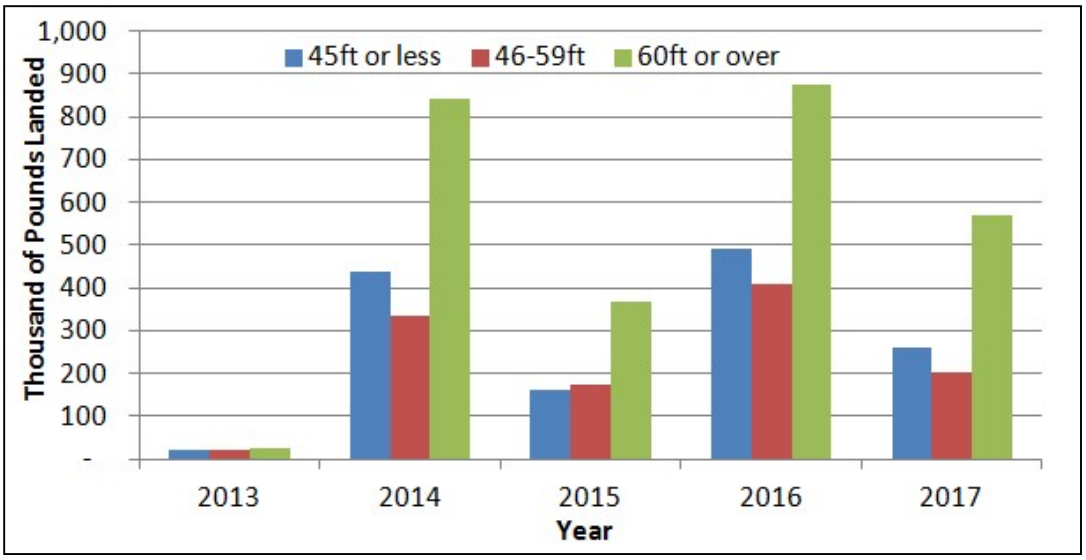

Figure 9 – Pounds of longfin squid landed from SA 538, by vessel length class
Source: Unpublished NMFS and MADMF Dealer and VTR Data

By analyzing fishing practices and landings by vessel length class and state of landing it is apparent that Rhode Island-landing vessels are predominantly of the large (60ft or larger) length class, while Massachusetts-landing vessels are represented in all 3 length classes (unpublished NMFS and MADMF Dealer data, and VTR data). In Rhode Island, over 90% of longfin squid trips and over 95% of landings can be attributed to large vessels, whereas in Massachusetts only 13% of trips and 31% of landings are attributable to large vessels. Small vessels (45ft or less) make up the most trips conducted (60%) and the largest portion of landings (39%). The average trip hail weight of longfin squid also differed by state; Massachusetts trips landed roughly 2,200 lbs per trip while Rhode Island vessels landed just over 11,400 lbs per trip.

This difference in average trip landings can likely be attributed to vessel size, but more likely to trip duration. By looking at trip duration (days) from Nantucket and Vineyard Sound effort in 2013-2017 (Figure 10), it is apparent that trips landing in Rhode Island are significantly longer (average 1.7 days in MA vs 4.8 days in RI). Both Vessel Trip Report and NEFOP data were used to describe trip length. As expected, the larger Rhode Island vessels that are fishing further from their homeports, and landing more squid, conduct longer trips. A comparison of trip duration (days) by state and year, using both Vessel Trip Reports and NOAA Fisheries Observer data (from a subset of trips), shows that Rhode Island vessels conduct trips averaging 4-5 days length, while Massachusetts boats average 1-2 day trips (Figure 10).

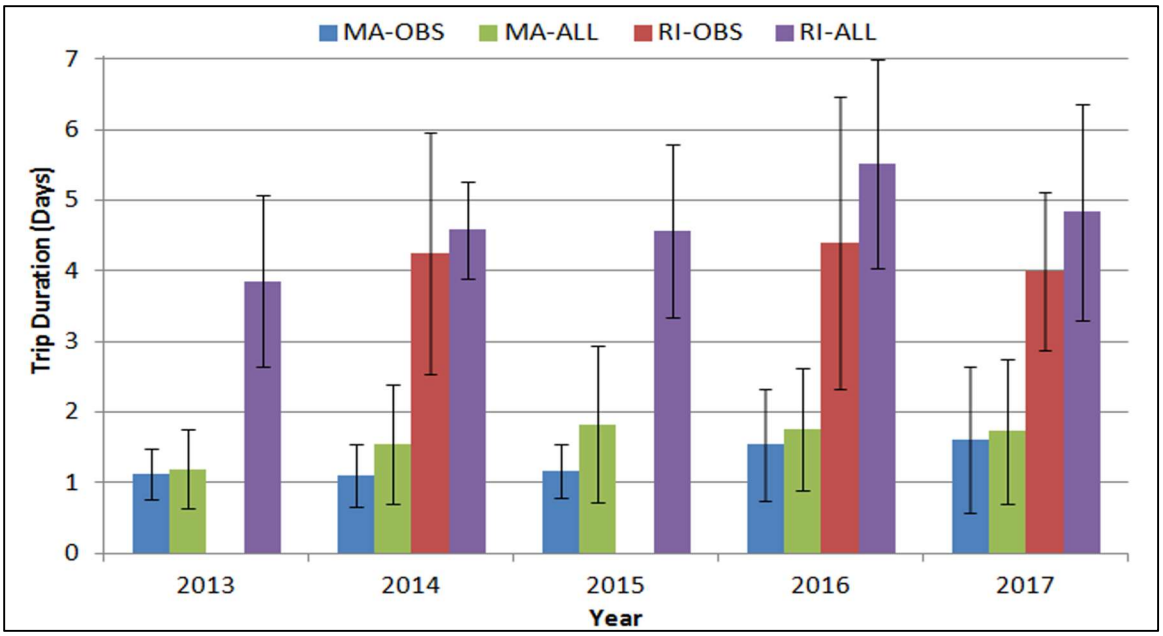

Figure 10 – Duration of observed (OBS) trips and all trips conducted in Nantucket and Vineyard Sound

Source: Unpublished NEFOP and NMFS VTR data

Note: Confidential data is omitted for 2013 and 2015

6.6 Value of Spring Longfin Squid Landings from All Areas

Value of longfin squid landings from all areas, as recorded in NMFS dealer data, is displayed for 2013-2017 during the period where the Nantucket and Vineyard Sound fishery is open. Since dealer data does not contain reliable catch location records, value of landings from the Nantucket and Vineyard Sound fishery itself could not be presented.

Year	RI	MA	NY	CT	NJ	Other	Coastwide
2013	$ 1.66	$ 2.32	$ 1.92	$ 1.73	$ 1.46	$ 1.73	$ 1.88
2014	$ 1.03	$ 0.97	$ 1.30	$ 1.11	$ 1.20	$ 0.87	$ 1.03
2015	$ 1.33	$ 1.47	$ 1.53	$ 1.66	$ 1.88	$ 1.01	$ 1.39
2016	$ 1.37	$ 1.34	$ 1.30	$ 1.28	$ 1.49	$ 1.12	$ 1.35
2017	$ 1.63	$ 1.69	$ 1.43	$ 1.64	$ 1.40	$ 1.48	$ 1.61

Table 4 – Average annual price (dollars per pound) of longfin squid, by state of landing, during the spring squid fishery

Source: Unpublished NMFS and MADMF Dealer Data

Average annual prices paid by dealers to fishermen (Table 4), per pound of longfin squid, shows that Massachusetts-landing vessels often receive higher than coastwide average prices. Once again, 2013 was an outlier year, and prices were potentially inflated due to lack of supply. Prices paid to fishermen often reflect squid quality and size, market demand, market glut and dealer infrastructure within a given port (Personal communications).

By viewing average dealer price paid by month within a year (Table 5), it is apparent that prices decrease over the course of a season in almost every state and every year with April offering the best average monthly price in each year. One factor in this price decrease may be the reduction in squid size over the course of the spring season. When displayed by month, sea sampling lengths confirm that Nantucket Sound squid catches indeed decrease in size from April to June (Appendix, Figure 25).

Year	Month	RI	MA	NY	CT	NJ	Other
2013	Apr	$ 2.04	$ 2.55	$ 2.39	$ 2.36	*	$ 1.13
	May	$ 1.79	$ 2.22	$ 2.05	$ 1.58	$ 1.49	$ 1.36
	Jun	$ 1.42	$ 2.31	$ 1.62	$ 1.86	*	*
2014	Apr	$ 1.09	$ 1.92	$ 1.40	$ 1.16	$ 1.57	$ 0.68
	May	$ 1.02	$ 0.99	$ 1.42	$ 1.07	$ 1.19	$ 0.88
	Jun	$ 1.01	$ 0.89	$ 1.08	$ 1.08	$ 1.05	*
2015	Apr	$ 1.51	$ 1.87	$ 1.73	$ 1.48	$ 1.97	$ 0.94
	May	$ 1.43	$ 1.55	$ 1.59	$ 2.10	$ 1.72	$ 1.06
	Jun	$ 1.30	$ 1.31	$ 1.37	$ 1.48	$ 1.28	*NA*
2016	Apr	$ 1.37	$ 1.79	$ 1.78	$ 1.52	$ 1.75	$ 1.22
	May	$ 1.52	$ 1.39	$ 1.39	$ 1.42	$ 1.70	$ 0.99
	Jun	$ 1.33	$ 1.20	$ 1.27	$ 1.27	$ 1.36	*
2017	Apr	$ 1.46	$ 2.16	$ 2.27	$ 2.23	$ 1.72	$ 0.90
	May	$ 1.69	$ 1.62	$ 1.52	$ 1.69	$ 1.49	$ 1.58
	Jun	$ 1.53	$ 1.50	$ 1.28	$ 1.27	$ 1.37	*

Table 5 – Average price (dollars per pound) of longfin squid, by state of landing and month, during the spring squid fishery
Source: Unpublished NMFS and MADMF Dealer Data
(* denotes confidential data, could not be displayed)

6.7 Value of Landings by Port

Price per pound of longfin squid, as reported by dealers, during the spring squid fishery was fairly consistent across major landing ports and counties. For 2013-2017 spring catches, dealers in the top 5 landing counties (Washington County, RI, Barnstable County, MA, Suffolk County, NY, Bristol County, MA and New London County, CT) paid between $1.29 and $1.37 per pound (average of $1.35). Counties of landing were used in place of actual port landed due to port naming inconsistencies.

6.8 Incidentally Kept Species Landings and Value

In addition to longfin squid, vessels fishing under the small-mesh squid exemption may retain incidentally caught scup, black sea bass, summer flounder (fluke), butterfish and other permitted species in accordance with the regulations in the landing state. The top ten species landed (by weight) in all ports and states from 2013-2017 squid trips occurring in Nantucket and Vineyard Sound are displayed in Table 6. Scup, which has had increased quotas and liberalized landing limits in recent years, struggles with low demand and low dock prices. Summer flounder and black sea bass have stricter trip limits, but carry higher prices on the dock. As detailed in Section 4, states may enact different retention and landing limits. Thus, while no landings of black sea bass from the longfin squid fishery were permitted in Massachusetts ports from 2013-2017, vessels landing in Rhode Island had daily and weekly limits in some of these years. Additionally, retention limits for species such as scup changed significantly from year to year during the time period displayed.

Species	Pounds Landed	#Trips Landing 1+ lb	Average $/Pound *
SQUID, ATL LONG-FIN	5,266,552	1,726	$ 1.45
SCUP	386,580	1,150	$ 0.42
BUTTERFISH	53,211	664	$ 1.70
FLOUNDER, SUMMER (FLUKE)	23,425	778	$ 4.13
BLUEFISH	12,457	337	$ 0.72
MACKEREL, ATLANTIC	8,110	367	$ 0.48
CRAB, HORSESHOE	4,058	151	$ 1.35
SEA BASS, BLACK	3,799	96	$ 4.09
FLOUNDER, WINTER	1,402	96	$ 2.14
TAUTOG	797	69	$ 3.21
HAKE, RED	682	11	$ 0.38

Table 6 – Top ten species landed from Nantucket and Vineyard Sound longfin squid trips, 2013-2017

Source: Unpublished NMFS VTR and Dealer Data, and MADMF Harvester Data

*Value generated from regional dealer prices, April-June, on trips using bottom trawl gear only.

Massachusetts, while not as reliant on longfin squid as other states, generates substantial revenues from longfin squid sales annually. Vessels landing in Massachusetts ports during the spring squid season receive competitive prices from dealers. Composed mainly of small and medium-sized vessels conducting mostly day trips, the fleet that prosecutes the longfin squid fishery during the spring season can access a high-quality local seafood resource.

6.9 Economic Significance of Spring Longfin Squid Fishery to Participating Vessels

The spring longfin squid fishery represents an important fishing opportunity and source of income for vessels landing in MA and RI ports. During the spring squid fisheries of 2013-2017 there were 23 vessels that averaged over 10,000 lbs of longfin squid landings (in MA) and were active in 3 of the 5 years. In Rhode Island there were 34 individual vessels that met these criteria.

A complete record of year-round landings for these 57 spring squid vessels was queried to explore their reliance on various fisheries and species. Longfin squid sales accounted for 22.7% of the total annual revenue ($30,011,000 over 5 years) for the “Massachusetts squid boats” and 49.7% of the “Rhode Island squid boats” total annual revenue ($111,534,000 over 5 years). For the MA squid boats, summer flounder (11.5%), sea scallops (9.9%) and monkfish (7.0%) revenue made up over 5% each (Figure 11). Multispecies groundfish (combination of 14 regulated species) sales made up 33.8% of revenue, with American plaice flounder (7.7%) the most valuable species. Atlantic cod, winter flounder, haddock, white hake and witch flounder contributed 3-5% each.

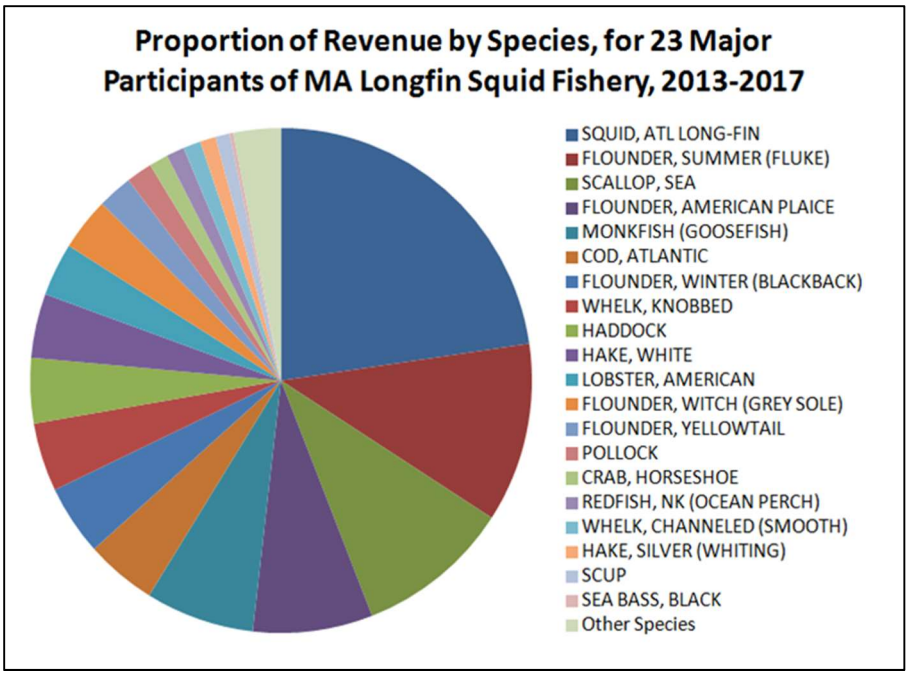

Figure 11 – Proportion of overall revenue by species sold, 2013-2017
Source: Unpublished NMFS Dealer Data

Rhode Island vessels were understandably more dependent on mid-Atlantic species, with longfin squid, summer flounder (15.5%) and scup (10.1%) making up over 75% of overall revenue (Appendix, Figure 24). Silver hake, Atlantic herring, shortfin squid and yellowtail flounder contribute 2-4% each to annual revenue.

This information demonstrates the importance of the springtime longfin squid fishery in supplementing the groundfish fishery, which continues to deal with rebuilding stocks. Many of the Massachusetts-based vessels that participate in the springtime squid fishery are mobile and can fish out of multiple ports, depending on where fishing opportunity and markets exist. The importance of sea scallop landings suggests that these vessels can re-rig (change gear types and work-deck configurations) in order to participate in other fisheries. Ultimately, squid may not constitute most of the revenue for MA squid boats, as it does in RI, but it provides an important seasonal fishing opportunity that contributes to a vessel's annual business plan.

The spring longfin squid fishery creates additional benefit beyond that of the fishermen. Piers in small Cape and Islands ports have vessels docked two and three-wide during the spring season. Dealers picking up fish daily, fuel trucks making frequent deliveries, net-makers delivering new and mended gear, and local stores, hotels and restaurants all benefit economically from the activity during the near two-month season.

7. AT-SEA CATCH SAMPLING (2013-2017)

7.1 Sampling Programs and Agencies

Federal sea sampling in the Northeast U.S. is conducted by the NOAA Northeast Fisheries Science Center's Fisheries Sampling Branch (FSB), which operates the Northeast Fisheries Observer Program (NEFOP). The program trains, deploys, debriefs, and oversees more than 120 observers each year (NEFSC 2020). These observers are professionally trained biological scientists who collect catch data dockside and onboard fishing vessels in all federal fisheries from North Carolina to Maine. Similarly, the MADMF also possesses a sampling program called the Fisheries Dependent Investigations (FDI). The FDI program is a lot smaller in scale, but has a wider array of responsibilities and duties. Their at-sea sampling focuses on fisheries that are conducted in and adjacent to Massachusetts state waters. MA DMF possesses greater flexibility in trip selection and can allocate

resources to under-sampled areas of a fishery. Both programs sample the longfin squid fishery and collect, process and manage data and biological samples obtained during commercial fishing trips.

7.2 Fisheries Observer Duties

Fisheries observers are federal contractors who are trained over the course of three or more weeks and must complete at least three training trips before becoming a fully certified fisheries observer. Observers are tasked with recording data about the trip, vessel, fishing gear, catch (discarded and kept) and biological characteristics of the catches. Data is submitted to NEFOP within days of landing. NEFOP staff edits and audits the data and debriefs the observer in order to enforce protocols and maintain high data quality. Further training and certifications are provided to refresh observers on updated sampling protocols or additional gear types and fisheries. Observers utilize digital, motion-compensated scales to attain accurate weights, and use ruggedized tablets to record and upload data to NEFOP in an expedited manner. Fisheries observers collect biological data, including lengths and age structures (scales, otoliths, bones, etc.) for priority species, and retain biological samples when a legitimate data request has been authorized. Monitoring and sampling of marine mammals, sea birds and turtles is also a primary duty of a NEFOP fisheries observer.

For the observers, processing catches in the longfin squid small-mesh bottom trawl fishery is relatively straightforward when catches are clean, and discards are low. For any given haul, the observer would likely be able to collect all discards, sort and weigh them by species and disposition code (reason for discarding). Larger volume hauls, or hauls with more mixed catches, may require subsampling. In this case the observer will select a random unbiased portion of the catch, representing at least 20% of the haul by volume, sort it and obtain species weights. These weights are then extrapolated to represent the entire haul's catch. All subsampling calculations are shown on the observer's logs and data editors later confirm the methods and calculations are correct. The protocols for sampling small-mesh catches have been refined over the past decades in order to provide high quality data that allows for analysis by end-users.

7.3 Catch Sampling Effort

The number of NEFOP sea days allocated annually to the small-mesh bottom trawl fleet (which includes the longfin squid fishery) is determined by the NOAA Standardized Bycatch Reporting Methodology (SBRM) (Wigley *et al.* 2011). This annual analysis establishes the number of sea sampling days needed in each fleet to achieve a 30% coefficient of variation (CV) on discards. In general, a fleet with higher levels of bycatch, or highly variable catches, would require more sea days to accurately estimate bycatch and discards. A fleet is defined as vessels having the same geographic region, gear type, net mesh size category, access to restricted areas, and trip category. Therefore, vessels fishing out of New England ports with small-mesh bottom trawls in open areas would all be covered under the same sea day allocation, regardless of what species they were targeting or whether they were fishing in state or federal waters. For example, in May 2016, NEFOP scheduled 16 Massachusetts-based sea days and 58 Rhode Island-based sea days to be completed with the small-medium mesh (<5.49") otter trawl fleet (personal communications, NOAA). The service provider (a federal contractor that employs trained fisheries observers) tasked with accomplishing these sea days is responsible for ensuring these criteria are met, but specific fishing locations are not sought out. However, NEFOP maintain a goal of assigning fisheries observers to vessels within a fleet in order to produce data that can be viewed as representative of a given fishery (personal communication, S.Weeks).

MADMF's FDI project conducts sea sampling when time and resources allow. FDI samplers follow NEFOP protocols on commercial squid trips and maintain open lines of communication with fishery participants. This allows MADMF to gain insight into the fishery through open discussions, as well as, relay important regulatory information back to fishermen.

Sea sampling data are used to inform management, quota monitoring and stock assessments. In recent years, in anticipation of the closure of the spring longfin squid fishery in Massachusetts waters, MADMF has aggregated and summarized available information for managers. In early June of 2015-2019, significant resources were allocated by NEFOP personnel (to edit and scan raw data logs) and FDI staff (to enter, analyze and summarize data) to provide managers with an accurate understanding of the catches (kept and discarded) occurring on recent trips of the spring longfin squid fishery. These efforts justified fishery extensions in 2015, 2016 and 2019. This notable partnership allows for sampling data to be used in near real-time to inform important management decisions.

7.4 Sea Sampling Data Selection Methods

In order to capture all sea sampling data from 2013-2017, commercial small-mesh squid trawl fishing hauls (or "tows") that began within SAs 537 or 538, where a captain identified longfin squid as a target species, were queried from NOAA OBDBS data tables. All unobserved hauls (where all catch could not be sampled) were removed. These data were then filtered for hauls occurring only on dates where the MA state waters longfin squid fishery was open (Table 1), and for trips occurring either in Massachusetts state waters, or within 12 nautical miles of Martha's Vineyard or Nantucket's southern shorelines. These hauls were then assigned to each of 4 distinct spatial areas (Figure 12); Vineyard Sound/Nantucket Sound ("**VinNanSound**"), state waters south of Martha's Vineyard and Nantucket ("**0-3nmS**"), federal waters 3-6 nautical miles south of Martha's Vineyard and Nantucket ("**3-6nmS**"), and federal waters 6-12 nautical miles south of Martha's Vineyard and Nantucket ("**6-12nmS**"). Twenty-three trips conducted hauls in multiple areas, and some trips targeted multiple species with multiple nets on the same trip.

The following data represent 199 distinct sea sampling trips (195 NEFOP and 4 MADMF) and 1,405 hauls where longfin squid was targeted with small-mesh bottom trawl gear in and adjacent to Massachusetts state waters during the squid seasons of 2013-2017.

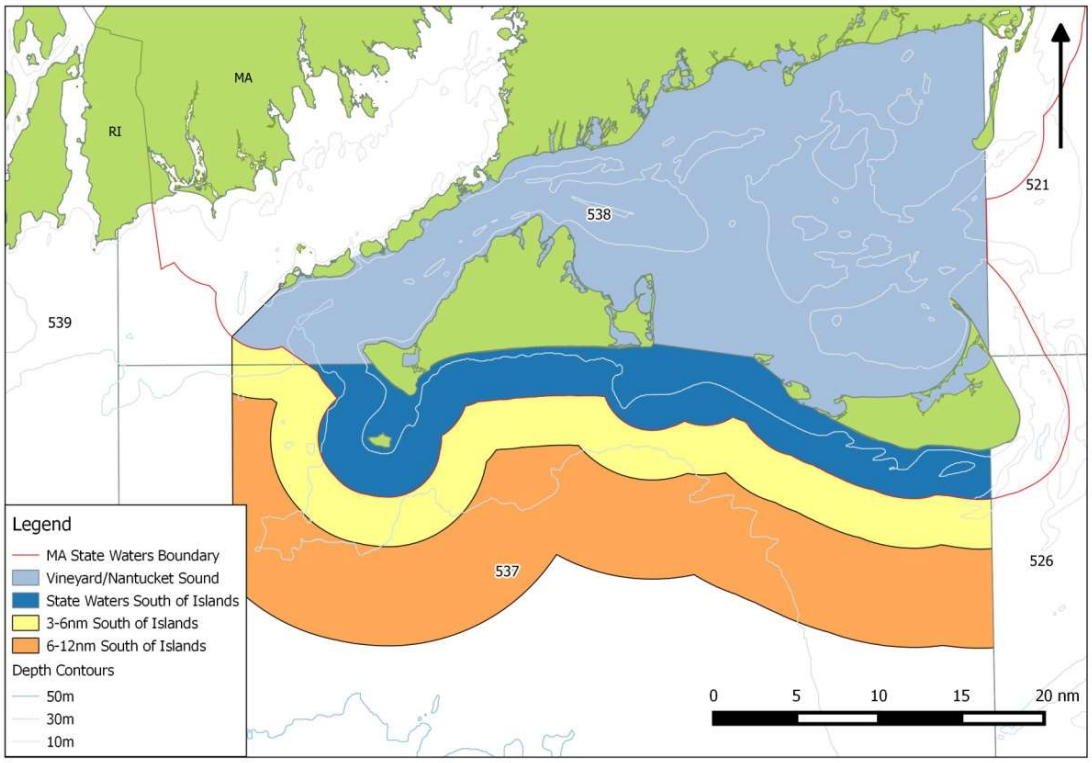

Figure 12 –Longfin squid fishing areas for sea sampling analysis
Source: MADMF

7.5 Annual Sampling Effort

During the spring longfin squid fishery in Nantucket Sound, Vineyard Sound and state waters south of the islands from 2013-2017, NEFOP and MADMF sampled 178 trips. In federal waters 3-12 nm south of the islands, 21 trips were observed by NEFOP. Multiple trips conducted hauls in more than one area, in which case Table 7 and Table 9 display partial trips, attributing them equally to each area containing effort. Due to fewer than 3 trips or individual vessels being sampled within an area each year, catch data from specific years may be deemed confidential and cannot be displayed.

Observed Trips	All Areas	State Waters		Federal Waters	
		VinNanSound	0-3nmS	3-6nmS	6-12nmS
2013	12	10	0	1.5	0.5
2014	63	61	1	0.5	0.5
2015	21	19	1.5	0.5	0
2016	44	31.17	4.17	7.67	1
2017	59	47.83	2.33	7	1.83
Total	199	169	9	17.17	3.83

Table 7 – Sampled trips by year and area, during the spring longfin squid fishery

Source: Unpublished NEFOP data

Note: Trips conducted in multiple areas account for partial trips

During the spring longfin squid fisheries of 2013-2017, NEFOP and MADMF observed 1,239 hauls targeting longfin squid in state waters (Table 8), and 166 hauls in federal waters 3-12nm south of Martha's Vineyard and Nantucket.

Observed Hauls	All Areas	State Waters		Federal Waters	
		VinNanSound	0-3nmS	3-6nmS	6-12nmS
2013	95	82	0	10	3
2014	392	375	2	14	1
2015	144	127	15	2	0
2016	385	240	29	109	7
2017	389	355	14	17	3
Total	1,405	1,179	60	152	14

Table 8 – Observed hauls targeting longfin squid by year and area, during the spring longfin squid fishery

Source: Unpublished NEFOP data

7.6 Coverage Rates

These sampled trips, which are selected at random by NEFOP, are assumed to be representative of the longfin squid fleet's effort. Fishery sampling is conducted out of all Massachusetts and Rhode Island ports where squid are landed. According to the NOAA SBRM analysis for 2017, to achieve a 30% CV on discards in the small-mesh bottom otter trawl fleet (which includes the spring longfin squid fishery), 3,327 observer sea days would need to be completed coastwide. This value is allocated by quarter, state and observer service provider, and trips using small-mesh otter trawls are then selected for coverage. The coverage achieved in 2013-2017 is a result of these analyses and resource allocations.

Due to the inability to display overall effort and landings of longfin squid with spatial accuracy from the waters south of Martha's Vineyard and Nantucket (see Section 3.2), fishery sampling coverage rates can only be derived for trips occurring in the "VinNanSound" area. Annually, combined NEFOP and MADMF coverage rates averaged 9.8% and ranged from 6.8% to 14.1% (Table 9).

VinNanSound Trips	Sampled	Landed	% Sampled
2013	10	139	7.2%
2014	61	434	14.1%
2015	19	269	7.1%
2016	31.17*	459	6.8%
2017	47.83*	425	11.3%
Total	169	1,726	9.8%

Table 9 – Annual sea sampling coverage rates for spring longfin squid trips occurring in the VinNanSound area
Source: Unpublished NMFS NEFOP, VTR and MADMF dealer data
* Trips conducted in multiple areas account for partial trips

Over 5 years, 1,405 hauls on 199 separate trips were observed, including recording precise locations where fishing gear was set and hauled, actual or estimated weights on kept and discarded species, reasons for discarding, lengths of priority discarded and kept species, and observations of interactions with species of interest/concern. This amount of data allows for detailed analysis on many specific data elements. Unfortunately, only 14 hauls were observed in the **6-12nmS** strata, and specific conclusions may be withheld for that area due to small sample size.

7.7 Spring Fishery Bottom Trawl Fishing Grounds

Participants in Massachusetts' springtime commercial small-mesh trawl squid fishery described the names and locations of the primary squid fishing grounds. Fishermen referred to these areas by the common names that they typically use when talking to other fishermen and on the water.

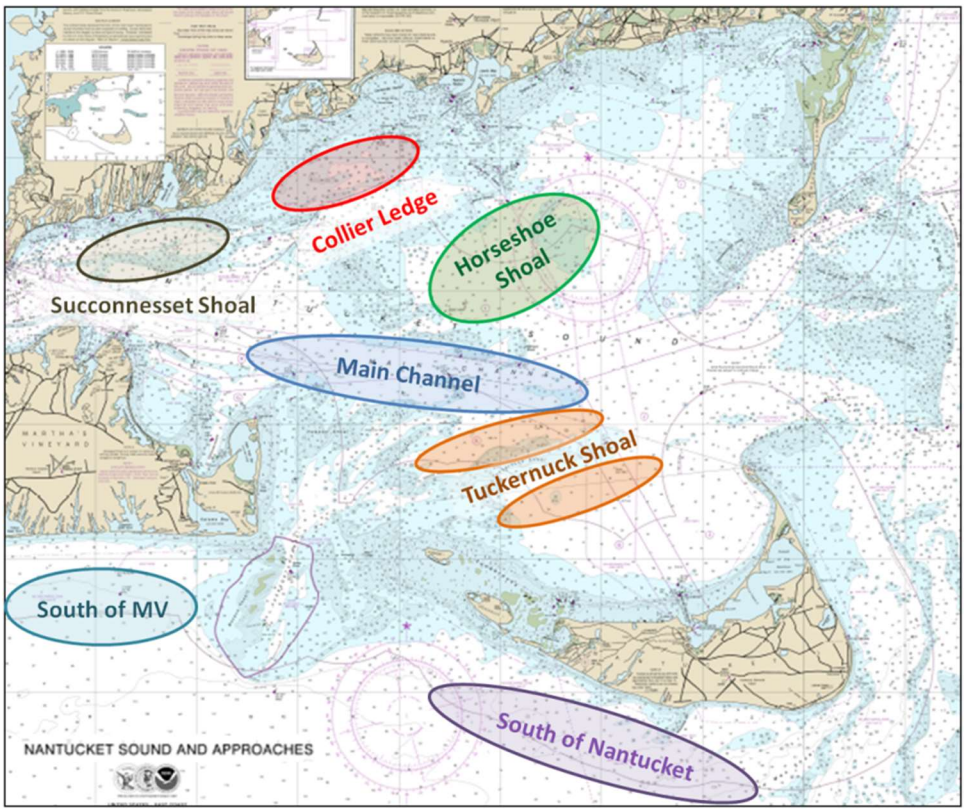

Figure 13 – Commonly referred to fishing grounds in Nantucket Sound, south of Martha's Vineyard and Nantucket islands
Source: Personal Communications

7.8 Location of Sampled Hauls

For all 1,405 hauls, the fisheries observer's recorded "haul begin" location was assigned to one of the 4 spatial strata (Figure 12). Observed hauls from these strata were used to generate a "Heatmap", which was then assigned within the boundaries of the strata. The resulting maps (Figure 14, enlarged in Appendix Figures 26-29) show specific areas of longfin squid fishery effort, and higher effort areas validate multiple fishermen-identified fishing grounds (Figure 13). In Nantucket Sound, most effort is displayed in the Main Channel area, with Horseshoe Shoal, Tuckernuck Shoal and Collier Ledge showing lower levels of effort. South of Martha's Vineyard and Nantucket, one clear east-west tow appears south of Nantucket, and another south of Martha's Vineyard (hauls may begin at either end of the area).

7.8.1 *Effort by Area*

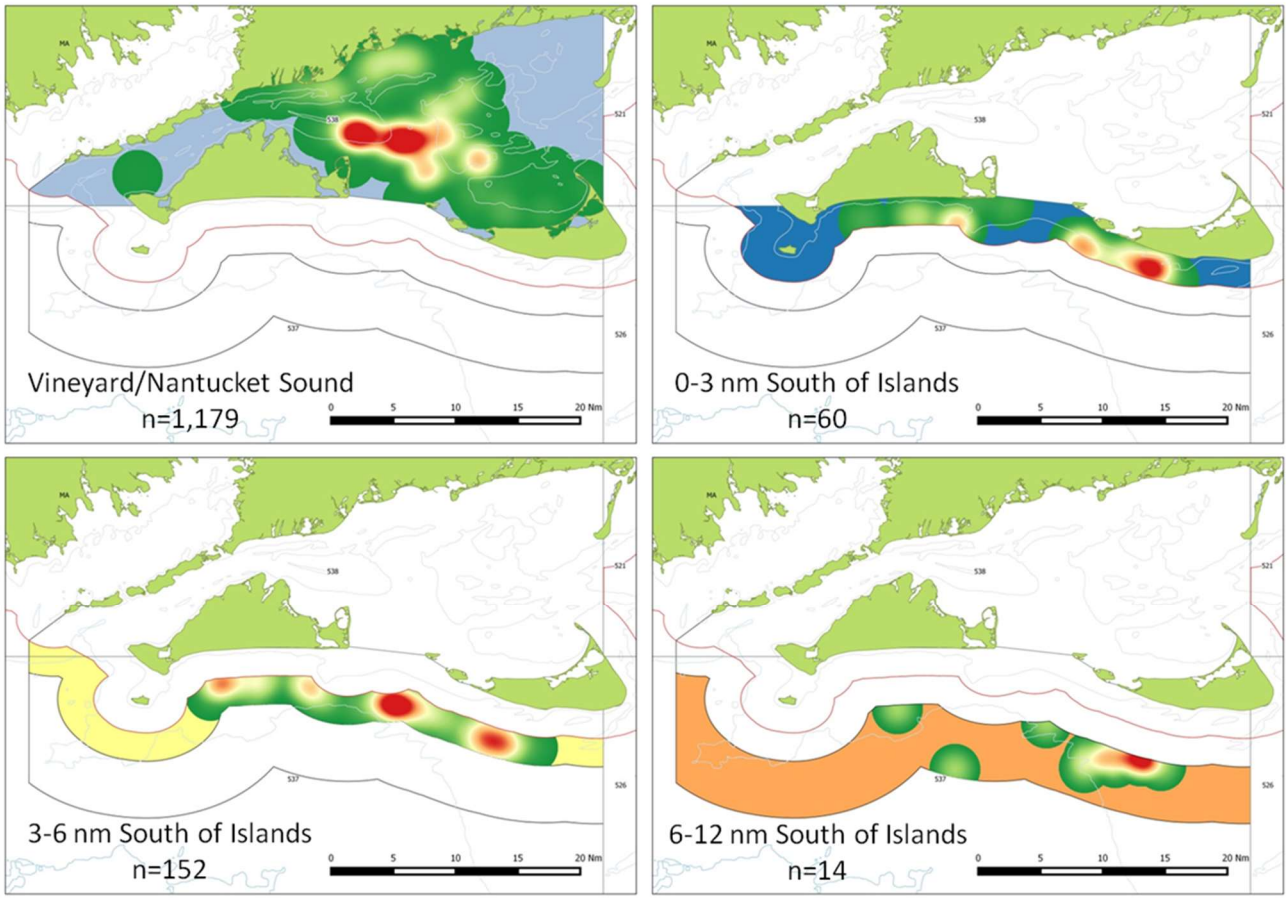

Figure 14 – Heatmaps displaying starting location of observed hauls in four selected spatial strata
Source: Unpublished NEFOP data

Many vessels that were sampled were not permitted to fish in Massachusetts state waters in the **0-3nmS** strata (CMR 7.05, vessels no greater than 72'), and their efforts are clear in federal waters just south of the Massachusetts state water boundary (Figure 14). The same mapping exercise was conducted for all areas, showing effort by month (Figure 15, enlarged in Appendix Figures 30-32).

7.8.2 *Effort by Month*

Monthly effort heatmaps corroborate fishermen's description of where large, marketable squid initially show up in the last week of April when the fishery opens, or early May when waters warm. Initial effort is focused on Collier Ledge, which under longstanding regulation closes to mobile gear fishing on May 1 (Figure 1). Effort in May is primarily in the Main Channel, Tuckernuck Shoal and Horseshoe Shoal areas, with a broad range of lesser effort spreading south of the islands as well. Effort in June, which lasts at least 9 days and may be extended by MADMF, is exhibited in the Horseshoe Shoal and Tuckernuck Shoal areas, and south of Nantucket and Martha's Vineyard. Effort in federal waters is not limited to a specific time period, but can be restricted by the Trimester II squid quota or butterfish cap. However only observer data collected during the time period of the Massachusetts spring longfin squid fishery is displayed. This progression of effort suggests that fishermen are following a biomass of squid as it moves within Nantucket Sound, or as it migrates out of Nantucket Sound and out of state waters.

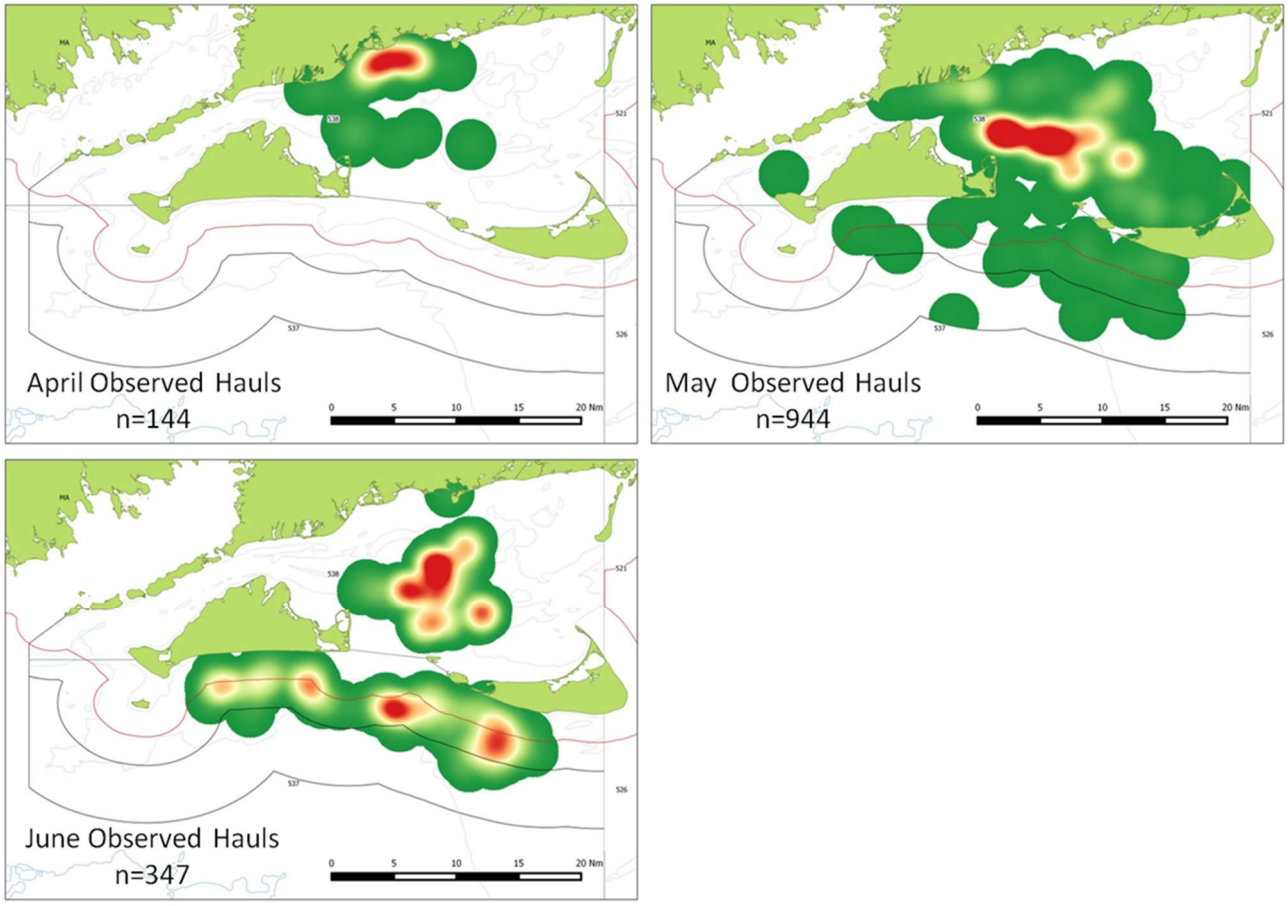

Figure 15 – Heatmaps displaying starting location of observed hauls by month
Source: Unpublished NEFOP data

7.9 Summary of Sampled Catches

Catch weights from 1,405 observed hauls on 199 trips targeting longfin squid in the Massachusetts spring fishery were aggregated by species groups (Table 10), and then further broken down into finfishes (Table 11), shellfishes (Table 12) and other catches. Sampled catches totaled 1.23 million pounds, 34.6% of which was discarded. Longfin squid and scup make up nearly three quarters of the catch. Butterfish, black sea bass and summer flounder (species that can also be retained) make up 4.7% of the remaining catch. Seaweed NK ("Not Known") accounts for 8.4% of the catch. The catch of seaweed is a common occurrence when filamentous algae that exists in the water column is caught by the trawl; this catch plugs the meshes of the nets, reduces catch efficiency and makes sorting the catch exponentially more difficult. Species "NK" designations are used when a fisheries observer was not able to fully confirm species identification. This can occur due to sampling time constraints, poor condition of catch and other extenuating circumstances. Notable 'Other Species/Debris' include debris (fishing gear, rocks, wood, plastic, metal, etc.), jellyfish NK, sponge NK, eggs NK, starfish/seastar NK, sand dollar, scallop shell and sea urchin NK. Seaweed, NK accounts for 97.5% of catch weight within the 'Other Species/Debris' group, at 103,198 lbs overall catch. To better describe overall catch of finfishes and shellfishes, Seaweed, NK is removed from further calculations.

Species Group	Kept lbs	Discard lbs	Total lbs	% Discard	% Total Catch
Finfishes	41,357	283,516	324,873	87.3%	26.4%
Shellfishes (including squids)	763,046	36,538	799,585	4.6%	65.0%
Other Species/Debris	0	105,848	105,848	100.0%	8.6%
Grand Total	**804,403**	**425,902**	**1,230,305**	**34.6%**	**100%**

Table 10 – Aggregated catch weights and proportions, by species group

Source: Unpublished NEFOP data

7.9.1 Finfishes

Species	Kept lbs	Discard lbs	Total lbs	% Discard	% Finfish Catch	% Total Catch
SCUP	23,881	136,933	160,814	85.1%	49.5%	14.3%
SEA BASS, BLACK	1,354	22,091	23,445	94.2%	7.2%	2.1%
BUTTERFISH	6,330	15,376	21,706	70.8%	6.7%	1.9%
SKATE, LITTLE	0	20,679	20,679	100.0%	6.4%	1.8%
SEA ROBIN, NORTHERN	24	19,129	19,152	99.9%	5.9%	1.7%
SKATE, WINTER	1,162	17,705	18,867	93.8%	5.8%	1.7%
FLOUNDER, SUMMER (FLUKE)	3,007	9,325	12,331	75.6%	3.8%	1.1%
MACKEREL, ATLANTIC	1,988	7,811	9,798	79.7%	3.0%	0.9%
DOGFISH, SMOOTH	189	6,483	6,672	97.2%	2.1%	0.6%
FLOUNDER, WINTER	105	4,457	4,561	97.7%	1.4%	0.4%
FLOUNDER, WINDOWPANE	250	3,354	3,604	93.1%	1.1%	0.3%
ALEWIFE	100	3,249	3,349	97.0%	1.0%	0.3%
SKATE, LITTLE/WINTER, NK	0	2,250	2,250	100.0%	0.7%	0.2%
BLUEFISH	2,053	131	2,184	6.0%	0.7%	0.2%
HERRING, NK	0	2,145	2,145	100.0%	0.7%	0.2%
HAKE, SILVER (WHITING)	145	1,636	1,781	91.9%	0.5%	0.2%
TAUTOG (BLACKFISH)	195	1,496	1,690	88.5%	0.5%	0.1%
BASS, STRIPED	0	1,479	1,479	100.0%	0.5%	0.1%
FLOUNDER, FOURSPOT	0	1,399	1,399	100.0%	0.4%	0.1%
SKATE, NK	0	1,050	1,050	100.0%	0.3%	0.1%
SEA ROBIN, STRIPED	64	872	936	93.2%	0.3%	0.1%
SEA ROBIN, NK	122	700	822	85.2%	0.3%	0.1%
HERRING, ATLANTIC	135	652	787	82.9%	0.2%	0.1%
HERRING, BLUEBACK	0	468	468	100.0%	0.1%	0.0%
SHAD, AMERICAN	0	444	444	100.0%	0.1%	0.0%
MENHADEN, ATLANTIC	4	244	248	98.6%	0.1%	0.0%
MONKFISH	99	97	196	49.4%	0.1%	0.0%
WEAKFISH	0	34	34	100.0%	0.0%	0.0%
COD, ATLANTIC	4	13	17	79.3%	0.0%	0.0%
Other Finfish Species	149	1,814	1,963	92.43%	0.60%	0.17%
Finfish Total	**41,357**	**283,516**	**324,873**	**87.3%**	**100.0%**	**28.8%**

Table 11 – Aggregated catch weights and proportions for top 20 finfish and other species of interest

Source: Unpublished NEFOP data

7.9.2 *Shellfishes*

Species	Kept lbs	Discard lbs	Total lbs	% Discard	% Shellfish Catch	% Total Catch
SQUID, ATL LONG-FIN	755,848	1,786	757,634	0.2%	94.8%	67.2%
CRAB, LADY	0	15,335	15,335	100.0%	1.9%	1.4%
SQUID, NK	5,950	15	5,965	0.3%	0.7%	0.5%
CRAB, SPIDER, NK	0	5,866	5,866	100.0%	0.7%	0.5%
SQUID EGGS, ATL LONG-FIN	0	5,069	5,069	100.0%	0.6%	0.4%
CRAB, HORSESHOE	1,076	2,140	3,216	66.5%	0.4%	0.3%
CRAB, ROCK	0	2,008	2,008	100.0%	0.3%	0.2%
SHELL, NK	0	1,224	1,224	100.0%	0.2%	0.1%
CRAB, JONAH	0	1,014	1,014	100.0%	0.1%	0.1%
SQUID, SHORT-FIN	67	797	864	92.3%	0.1%	0.1%
LOBSTER, AMERICAN	23	319	342	93.3%	0.0%	0.0%
WHELK, KNOBBED	7	6	13	48.0%	0.0%	0.0%
CRAB, BLUE	0	13	13	100.0%	0.0%	0.0%
SCALLOP, BAY	0	1	1	100.0%	0.0%	0.0%
SCALLOP, SEA	0	1	1	100.0%	0.0%	0.0%
Other Shellfish Species	76	945	1,021	92.6%	0.1%	0.1%
Shellfish Total	**763,046**	**36,538**	**799,584**	**4.6%**	**100.0%**	**70.9%**

Table 12 – Aggregated catch weights and proportions for top 10 shellfish and other species of interest
Source: Unpublished NEFOP data

7.10 Target Species Catch

7.10.1 *Longfin Squid*

Longfin squid catches, both kept and discarded, were aggregated by each of the four spatial sub-areas (Figure 12). Average haul weights reveal that the amount of squid caught increases as effort moves south from state waters into federal waters, but discarding of squid occurs more frequently during hauls in federal waters as well. Over 98% of all hauls kept longfin squid and only 14.9% of hauls had squid discards. Of note, the low sample size in the 6-12nmS area makes drawing strong conclusions from that data difficult. Additionally, since vessels over 72 feet in length cannot fish in the Massachusetts state waters (VinNanSound and 0-3nmS areas), data from federal waters may be skewed by larger vessels conducting hauls and trips of longer duration.

Longfin Squid	**AREA**	**VinNanSound**	**0-3nmS**	**3-6nmS**	**6-12nmS**	**Total**
	# hauls observed	1,177	60	152	13	1402
KEPT	Avg. haul (lbs)	350	814	1,811	1,536	539
	% hauls w/ kept catch	99.2%	93.3%	97.4%	92.3%	98.7%
DISCARDED	Avg. haul (lbs)	1	0.01	7	12	1
	% hauls w/ discarded catch	13.2%	1.7%	30.3%	53.8%	14.9%

Table 13 – Catch statistics of kept and discarded longfin squid by area
Source: Unpublished NEFOP data

7.11 Vessel Size and Haul Duration Effects

Vessel lengths of observed trips were plotted by area (Figure 16). This confirmed that small and medium-sized vessels (under 60 ft) make up most observed trips in the VinNanSound area. Most trips that were observed in the 0-3nmS area were conducted by vessels 50-65ft in length. Many vessels fishing in federal waters were 64-75 ft in length, and the largest vessel(s) exceeded 90 ft in length. Summarizing vessel lengths by area from 199 observed trips may not be entirely representative of vessel sizes in the entire inshore longfin squid fishery, but the theory that smaller vessels fish inshore and larger vessels in federal waters is confirmed by the existing data. This vessel size trend could also explain the increase in average squid catch per haul as the fishery moves south.

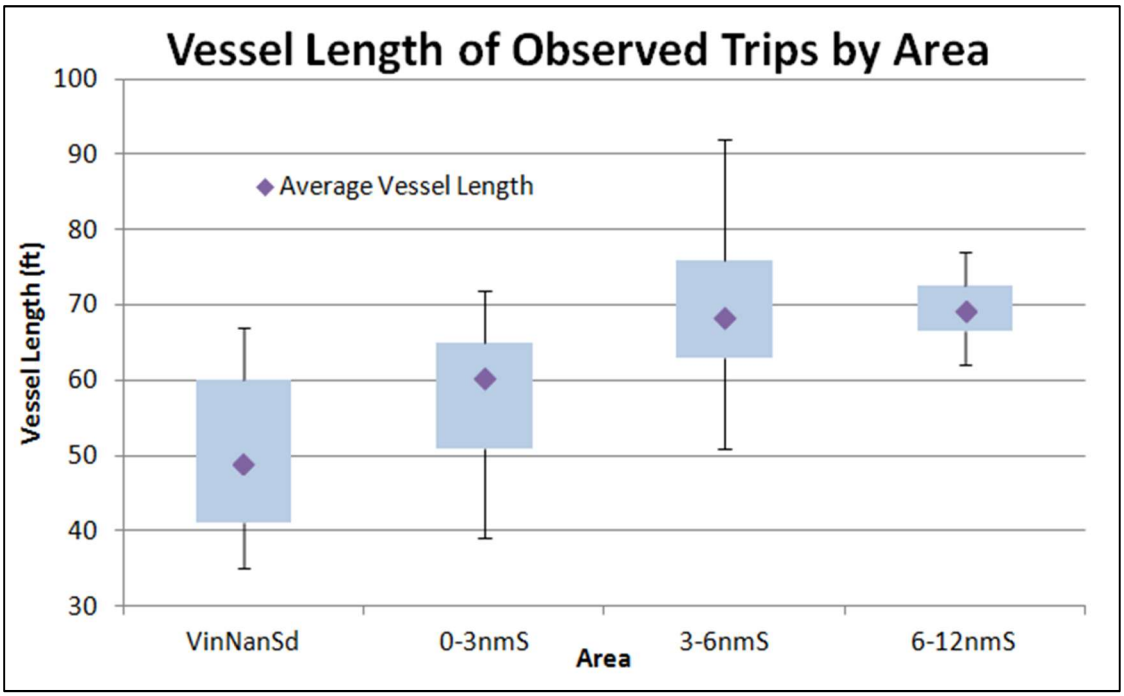

Figure 16 – Boxplot of vessel lengths of observed trips by area
Source: Unpublished NEFOP data

Further, larger vessels that conduct longer trips tend to make longer hauls since they have more horsepower, deck space, larger holds and more crew. Average haul durations for VinNanSound and 0-3nmS were 1.23 hours and 1.97 hours, respectively. In contrast, average hauls in federal waters exceeded 2 hours; 2.77 hours and 2.03 hours for 3-6nmS and 6-12nmS, respectively.

7.12 Standardized Catch Rates

To account for differences in squid catches caused by hauls of varying duration a Catch per Unit Effort (CPUE) is generated to standardize catch rates. By calculating CPUEs (in pounds of catch per hour towing) of kept and discarded squid, catch rates can be compared across areas, years and vessel size classes (Figure 17). As is suggested in Table 13, longfin squid catch rates increase as hauls move south, and discards are minimal to nonexistent, especially in state waters. Annually, observer data corroborates overall catch trends seen in landings data, with very low CPUEs in 2013 and higher catch rates in 2016.

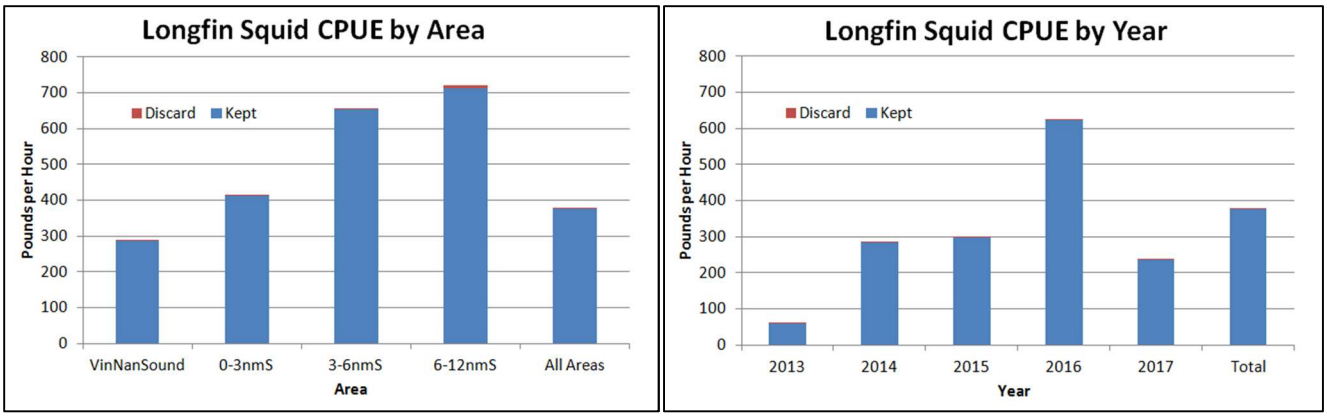

Figure 17 – Catch per Unit Effort of longfin squid by area and year

Source: Unpublished NEFOP data

In order to describe the effect of vessel size on catch rates, CPUEs are calculated by the vessel size groups used in Figures 7-9, with an additional group of 73ft+ vessels that are prohibited from fishing in Massachusetts state waters. This analysis shows that vessels in the 45 ft or less, 46-59 ft and 60-72 ft length classes have relatively similar CPUEs (250-300 lbs/hr) (Appendix, Figure 33). However, 73 ft+ vessels have a longfin squid CPUE of 587 lbs/hr. This increased efficiency most likely boosts the catch rate data for the 3-6nmS area most.

7.13 Catch Rate Seasonality

Plotted by week, observer data shows that CPUEs increase over the course of the season for all areas. The final week of the season (June 3-9, roughly corresponding with Week 24 in (Figure 18) shows catch rates of longfin squid continuing to increase in the 0-3nmS and 3-6nmS areas. Lack of observer data from VinNanSound suggests reduced effort in the area during the final week of the season. Catch rates during the fisheries extensions (Week 25) of 2015 and 2016 show further increases.

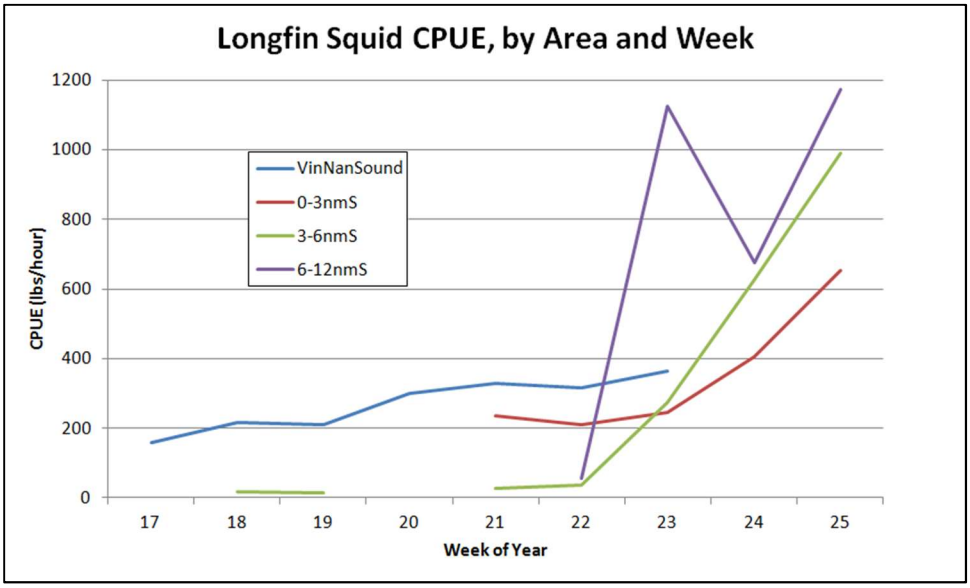

Figure 18 – Catch per unit effort of longfin squid, by week of season and area

Source: Unpublished NEFOP data

Looking more closely at weekly catch rates by vessel size reveals that 46-59 ft, 60-72 ft and 73 ft+ vessels have CPUEs exceeding the overall season average (321 lbs/hr) during the fishery in Week 25 (roughly the third week of June). These high catch rates of longfin squid during the season extension (2015 and 2016 only) also hold true for vessels fishing exclusively in state waters (532 lbs/hr). These data cannot be displayed visually, however, due to confidentiality rules. This finding may suggest that a robust biomass of squid remain in the area of investigation at the end of the scheduled season, and that profitable trips are being foregone.

7.14 Squid Lengths

Longfin squid, as a target species, are a top priority for observers to collect lengths on while fishing with bottom trawl gear in SAs 538 and 537. Mantle lengths of 2,943 squid were collected by observers, showing a length cutoff for what fishermen preferred to keep and discard (Appendix, Figure 34). However, with a small number of lengths collected on discarded squid (n=28), and fishermen selling to dealers with different markets and size preferences, it is difficult to find consistency across captains regarding which squid are considered too small to keep. Only 0.24% (1,786 lbs) of longfin squid caught on 1,405 observed hauls were discarded.

7.14.1 Reason for Discarding Longfin Squid

Reasons for discarding of longfin squid were predominantly due to small size. When a species is discarded, an observer asks the captain for a reason and records a corresponding "disposition code". While different captains may have different explanations for discarding the same species, these codes allow for insight into fishing practices and why certain fish might be kept or discarded. Over 80% of squid discards were explained as "no market, too small" or "poor quality, reason not specified" (Appendix, Figure 35).

7.15 Non-Target Species Catch

While targeting longfin squid, vessels encounter various species that they are permitted to retain, and those species are retained when there is sufficient market demand. These incidentally caught species can supplement trip revenue, and when squid catches are low, act as a source of ancillary income. Fishermen may have different reasons for retaining or discarding these species such as appropriate permitting, dealer preferences, fishing practices, or regulations in the state of landing.

Catch of four major finfish species (scup, butterfish, summer flounder and black sea bass) comprise over two-thirds of the total incidental catch by weight of finfish. Information detailing the catch and encounter rates, size of catches and reasons for discard are provided in the following section. Effects of regulatory, stock status and market-based changes are presented where applicable.

7.15.1 Scup

Scup were the second most encountered and retained species (14.3% of total catch by weight) and the primary incidentally caught and retained finfish. However, most scup (85.1% by weight) were discarded (Table 11). They were kept on half of hauls and discarded on over three-quarters of hauls (Table 14). Scup have a 9" (22.9 cm) minimum total length requirement, but due to low prices and insufficient market demand, scup over 9" are sometimes discarded.

Scup	AREA	VinNanSound	0-3nmS	3-6nmS	6-12nmS	Total
	# hauls observed	1,177	60	152	13	1,402
KEPT	Avg. haul (lbs)	18	2	10	38	17
	% hauls w/ kept catch	51.8%	15.0%	57.2%	61.5%	50.9%
DISCARDED	Avg. haul (lbs)	90	57	170	114	98
	% hauls w/ discarded catch	73.7%	85.0%	93.4%	100.0%	76.6%

Table 14 – Catch statistics of kept and discarded scup by area
Source: Unpublished NEFOP data

Kept scup CPUEs exceeded 10 lbs/hr in VinNanSound and 6-12nmS, while discarded Scup CPUEs exceeded 25 lbs/hr in each area (Figure 19). Discard CPUEs for scup increased greatly in 2016 and 2017. Over 88% of the measured discards from 2016 were sub-legal (<9") and were likely attributable to the presence of fish from the 2015 year class, which was the largest in history of the scup stock assessment (326 million fish) (MAFMC 2019b). The 2015 year class of scup would have also been sub-legal sized during the spring of 2017 and would have required discarding.

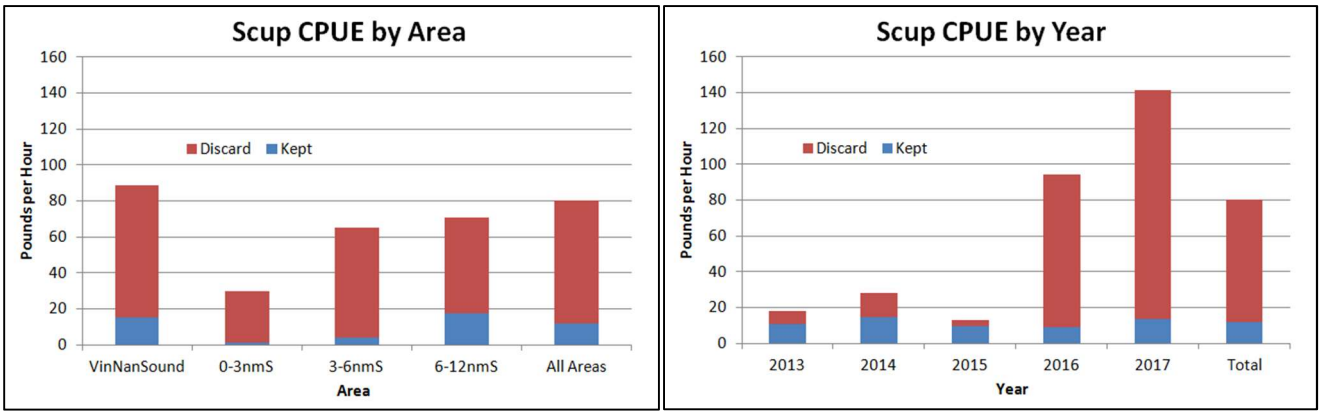

Figure 19 – Catch per Unit Effort of scup by area and year
Source: Unpublished NEFOP data

Over 3,500 scup lengths (priority 1 in SA537, priority 2 in SA538) were collected by observers. The majority of kept scup were 23-33cm (9-13") fork length, while most discarded scup were 22 cm (8.7") and smaller (Appendix, Figure 36). This corresponds with the 9" (total length) minimum requirement. However, over 10% of scup discards were fish greater than the 9" minimum length, suggesting market-related discarding reasons.

According to observer records, the primary reasons for scup discards were size-related. "Regulations prohibit retention, too small" and "no market, too small" accounted for roughly 80% of discards (Appendix, Figure 37). Trip quotas also drove some discarding, with "regulations prohibit any retention, quota filled" and "vessel retaining only certain size for best price due to trip quota" accounting for over 10% of discards. In response to large year classes and high availability of scup MADMF increased retention limits, however the commercial market demand for scup remains limited.

7.15.2 Butterfish

Butterfish were an important supplementary species for longfin squid vessels, but not all fishermen had markets with a demand for butterfish. Making up 1.9% of overall catch (6.7% of finfish catch), 70.8% of butterfish catch were discarded (Table 11). Small amounts of butterfish are kept on roughly one-third of hauls; more in federal waters south of the islands. Over 90% of hauls in federal waters have butterfish discards (Table 15). Butterfish do

not possess a minimum length requirement, nor is there a state retention limit, and most discards are a result of market-related factors.

Butterfish	AREA	VinNanSound	0-3nmS	3-6nmS	6-12nmS	Total
	# hauls observed	1,177	60	152	13	1,402
KEPT	Avg. haul (lbs)	5	0.3	6	5	5
	% hauls w/ kept catch	32.9%	8.3%	46.1%	46.2%	33.4%
DISCARDED	Avg. haul (lbs)	6	6	47	44	11
	% hauls w/ discarded catch	46.3%	61.7%	90.1%	92.3%	52.1%

Table 15 – Catch statistics of kept and discarded butterfish by area
Source: Unpublished NEFOP data

Kept and discarded butterfish CPUEs show that a higher ratio of butterfish were kept on the VinNanSound observed trips. However, interactions with butterfish were much higher in federal waters. Trips observed more recently (2016-2017) showed an increase in discarded butterfish catch rates (Figure 20).

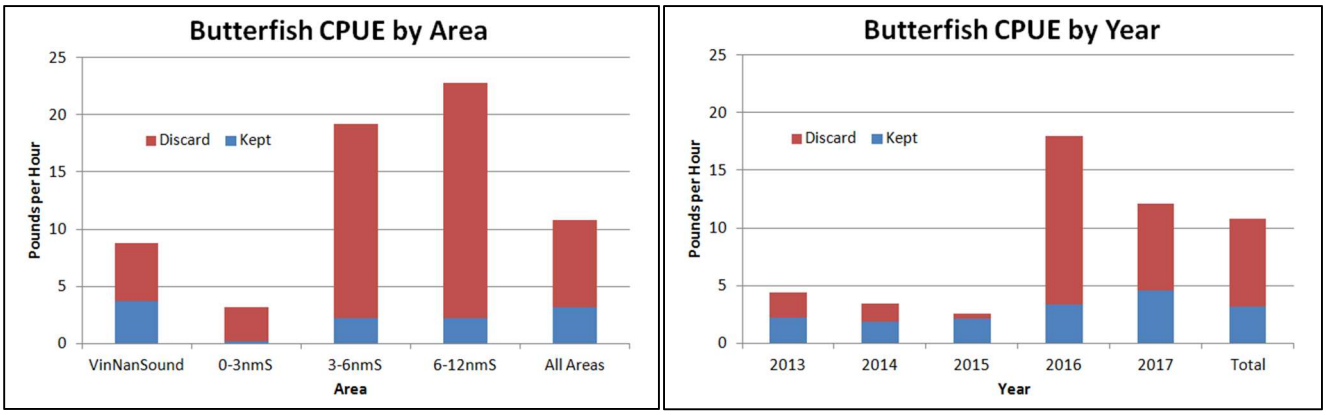

Figure 20 - Catch per Unit Effort of butterfish by area and year
Source: Unpublished NEFOP data

Butterfish were a priority 1 species for collecting lengths in SA 537 (south of Martha's Vineyard and Nantucket) but a priority 2 species in SA 538 (Nantucket Sound). In total, 568 butterfish lengths were collected, showing that the majority of kept butterfish were 14-20 cm (5.5"-7.9") fork length, and discarded butterfish were 10-18 cm (3.9"-7.1") (Appendix, Figure 38). This suggests that some fishermen weren't keeping butterfish that others might have kept.

Over 80% of butterfish discards were explained by "no market, too small", and the remainder were explained by "no market, reason not specified", and "regulations prohibit retention, too small" (Appendix, Figure 39).

In 2009, due to low butterfish stock levels, the MAFMC created a butterfish mortality cap for the directed longfin squid fishery (MAFMC, 2010). Observer data is used to track butterfish discards and the longfin squid fishery is closed when the 95% of the cap is projected caught. Thus, NMFS is actively monitoring the interactions and discards of butterfish in this fishery.

7.15.3 Summer Flounder

Summer flounder (fluke) only accounted for 1.1% of overall longfin squid fishery catch (3.8% of finfish catch) and 75.6% of summer flounder catch by weight was discarded (Table 11). However, high prices made this a

valuable incidental catch for some vessels, especially in waters south of the islands. Average kept and discarded catches increased as effort moved south, as did encounter rates (Table 16).

Summer Flounder	AREA	VinNanSound	0-3nmS	3-6nmS	6-12nmS	Total
	# hauls observed	1,177	60	152	13	1,402
KEPT	Avg. haul (lbs)	1	4	7	9	2
	% hauls w/ kept catch	22.0%	28.3%	28.3%	38.5%	23.1%
DISCARDED	Avg. haul (lbs)	1	11	44	55	7
	% hauls w/ discarded catch	22.2%	36.7%	82.9%	92.3%	30.0%

Table 16 – Catch statistics of kept and discarded summer flounder by area
Source: Unpublished NEFOP data

Kept summer flounder CPUEs increased slightly as effort moved south, whereas discard CPUEs increased far more as effort moved south of Martha's Vineyard and Nantucket islands and into federal waters (Figure 21). Higher discard rates in 2016 (and 2013 to a lesser degree) may drive some of this increase.

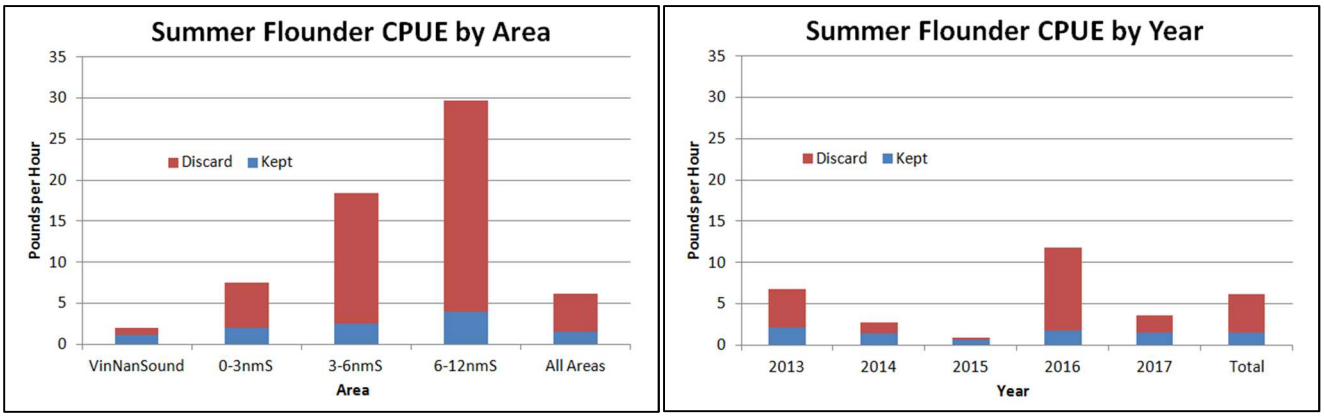

Figure 21 – Catch per Unit Effort of summer flounder by area and year
Source: Unpublished NEFOP data

Summer flounder are a priority species for observers to record lengths on, and 233 individual lengths were collected by observers. A minimum length (35.6 cm) is required to retain summer flounder, and the majority of kept fish were 38-49cm (14.9-19.3"). Discarded summer flounder ranged from 24-44 cm (9.5-17.3") (Appendix, Figure 40). Retention limits for trips landing in Massachusetts (100 lbs of any flounder species) and Rhode Island ports (100 lbs in 2013-2015, 50 lbs in 2016, 200 lbs in 2017) likely resulted in some discards once vessels had reached their limit.

Reasons given to observers for discarding of summer flounder were varied; "regulations prohibit any retention, quota filled", "regulations prohibit any retention (including no permit)" and "vessel retaining only certain size for best price due to trip quota" constituted roughly 70% of discards (Appendix, Figure 41). "No market, won't keep until trip end" made up about 15% of discards, as did the combination of fish too small due to "no market" and "regulations". High prices for summer flounder (exceeding $4.00/lb coastwide in 2017) suggest that very few legal-sized fish would be discarded (MAFMC 2019c). Just over 38% of summer flounder discards were due to trip quota being filled, so trip limits implemented by states may impact the ability of captains to land marketable fish.

7.15.4 Black Sea Bass

Black sea bass made up 2.1% of overall catch in the fishery (7.2% of finfish catch) and 94.2% of black sea bass by weight were discarded. Permit conditions and state retention limits appear to be a factor in discarding. Massachusetts did not allow commercial landings of black sea bass by squid trawl vessels from 2013-2017, while Rhode Island allowed 50 lbs/trip in multiple years, and up to 700 lbs/week in others. Only 9% of hauls kept black sea bass, while over 60% had discards (Table 17).

Black Sea Bass	AREA	VinNanSound	0-3nmS	3-6nmS	6-12nmS	Total
	# hauls observed	1,177	60	152	13	1,402
KEPT	Avg. haul (lbs)	1	2	2	6	1
	% hauls w/ kept catch	8.2%	3.3%	14.5%	53.8%	9.1%
DISCARDED	Avg. haul (lbs)	12	30	42	9	16
	% hauls w/ discarded catch	60.2%	66.7%	69.7%	69.2%	61.6%

Table 17 – Catch statistics of kept and discarded black sea bass by area

Source: Unpublished NEFOP data

While based on a small number of observed hauls, black sea bass catch in the 6-12nmS area had the highest kept to discard CPUE ratio (Figure 22). Increases in discard CPUE rates in 2014 and 2016 are clear when looking at annual kept and discard rates. These increases in discarding likely coincide with the two largest recruitment events in the stock assessment time series; an estimated 144.7 million fish in 2011 and 79.4 million fish in 2015 (NEFSC 2019).

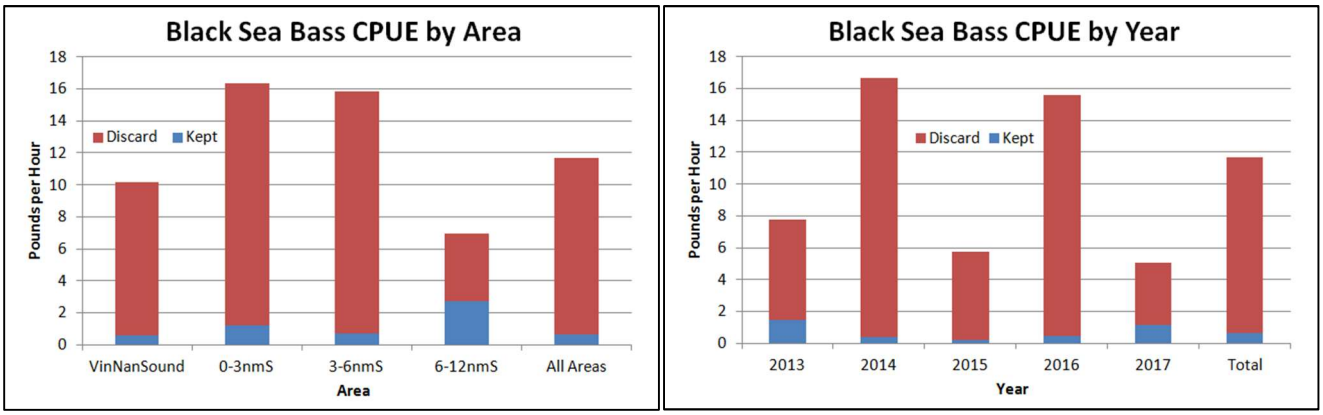

Figure 22 – Catch per Unit Effort of black sea bass by area and year

Source: Unpublished NEFOP data

Black sea bass are a priority 1 species for lengths in both SAs 537 and 538, and 1,356 individuals were measured. Most kept fish were between 35-46 cm (13.7”-18.1”), while discarded black sea bass were 24-44cm (9.4”-17.3”) (Appendix, Figure 42). Minimum size requirements of 12” (30.5 cm) and Rhode Island state trip limits may affect how fishermen decide to keep black sea bass. Massachusetts did not allow black sea bass landings from the longfin squid trawl fishery from 2013-2017.

The most common reason for discarding black sea bass (over 50%) was “regulations prohibit any retention (including no permit)”, followed by “regulations prohibit any retention, no quota in area” at roughly 30%. Remaining reasons for discarding included, “vessel retaining only certain size for best price due to trip quota”, “regulations prohibit any retention, quota filled” and “regulations prohibit any retention, too small” (~5%) (Appendix, Figure 43). In response to unwanted discarding and a robust black sea bass stock, Massachusetts enacted a 50 lb/trip retention limit in 2018 and increased this limit to 100 lb/trip for 2020. These actions intended to reduce regulatory discards, but occurred in years following the study period.

7.15.5 Additional Kept Catches

Vessels may retain and sell additional species if they possess the necessary permits or endorsements and are landing in states that have sufficient retention limits. Available markets and adequate prices also play a role in whether a vessel will retain these catches. While longfin squid, butterfish, scup, summer flounder and black sea bass make up the most kept catches (98.3%), retention and sale of additional species can help supplement trip income. Details of these additional kept catches, and average price paid to fishermen landing in Massachusetts and Rhode Island ports during the spring longfin squid seasons of 2013-2017, are presented in Table 18.

Species Name	Total Catch lbs	Kept Catch lbs	Average $/lb	% of hauls with kept lbs			
				VinNanSound	0-3nmS	3-6nmS	6-12nmS
SEA ROBINS**	20,702	208	$ 0.10	0.7%	1.7%	1.3%	0.0%
SKATE, WINTER	18,867	1,162	$ 0.47*	0.1%	1.7%	16.4%	21.4%
MACKEREL, ATLANTIC	9,798	1,988	$ 0.35	8.1%	5.0%	9.2%	28.6%
DOGFISH, SMOOTH	6,672	189	$ 0.34	0.0%	0.0%	2.0%	0.0%
FLOUNDER, WINTER	4,561	105	$ 1.73	2.9%	0.0%	3.3%	0.0%
FLOUNDER, WINDOWPANE	3,604	250	$ 0.61	0.1%	0.0%	0.0%	0.0%
CRAB, HORSESHOE	3,216	1,076	$ 1.16	7.4%	0.0%	0.0%	0.0%
BLUEFISH	2,184	2,053	$ 0.83	6.6%	20.0%	31.6%	14.3%
HAKE, SILVER	1,781	145	$ 0.51	0.2%	1.7%	11.8%	21.4%
TAUTOG	1,690	195	$ 3.52	2.0%	0.0%	0.7%	0.0%
SQUID, SHORT-FIN	864	67	$ 0.50	0.2%	0.0%	0.7%	0.0%
HERRING, ATLANTIC	787	135	$ 0.14	0.1%	0.0%	0.0%	0.0%
LOBSTER, AMERICAN	342	23	$ 5.38	0.0%	0.0%	4.6%	0.0%
HAKE, RED	330	77	$ 0.29	0.0%	3.3%	5.3%	14.3%
MONKFISH	196	99	$ 1.53	0.1%	0.0%	6.6%	21.4%
WHELK, ASSORTED***	115	83	$ 5.87*	2.2%	0.0%	0.0%	0.0%

Table 18 – Pounds of total and kept catch, average price and encounter rate (for kept catches) by area for additional species

Source: Unpublished NMFS Dealer and NEFOP data

* Some prices are for processed fish/shellfish and cannot be applied to round weights (total and kept catch lbs)

** Sea Robins species group includes northern sea robin, striped sea robin and sea robin, NK.

*** Whelk, Assorted species group includes channeled whelk, knobbed whelk, true whelk and whelk, NK

Over 1,000 lbs each of bluefish, Atlantic mackerel, winter skate and horseshoe crab were kept and landed from the 1,405 observed hauls. Between 100 and 250 lbs each of windowpane flounder, tautog, smooth dogfish, silver hake, Atl. herring, sea robins (northern and striped) and winter flounder were kept on these observed hauls. Other notable species kept, at weights less than 100 lbs included; monkfish, red hake, shortfin squid, American lobster and various whelk species. Details of these kept species, and frequency of encounter can be found in Table 18.

7.15.6 Additional Discarded Catches

Discards on observed hauls in the longfin squid fishery from 2013-2017 totaled 425,904 of the 1,230,305 pounds caught. However Seaweed, NK comprised 103,198 lbs (24.23%) of these discards and has been removed from further statistics, resulting in an **overall discard rate of 28.6%**. Discard rates (discarded lbs/all catch lbs, excluding seaweed) were consistent across fishing areas, ranging from 23.1-36.0%. Annually, discard rates varied more; highest in 2013 (54.2%) and 2017 (46.2%), and lowest in 2015 (8.0%) (Figure 23).

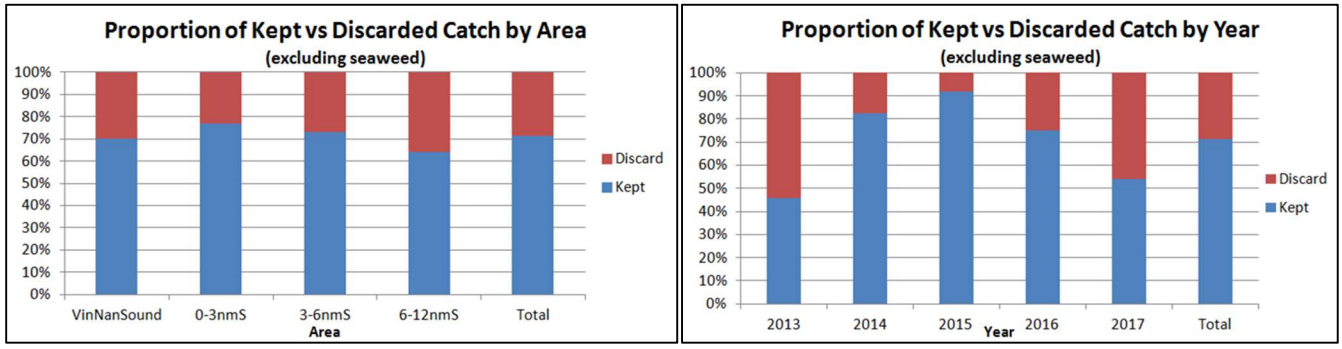

Figure 23 – Proportion of catch kept and discarded, by year and area

Source: Unpublished NEFOP data

The large 2015 year class of scup was a significant source of discards in 2016 and 2017, making up 39.1% and 56.5% of total discards in those years, respectively. The elevated discard rate in 2013 was primarily composed of winter skate and little skate (34% combined), spider crab, scup, black sea bass and winter flounder (all exceeding 5% of 2013 discards). By month, discard rates were 22.1%, 35.1% and 22.3% for April, May and June, respectively. In April, discards consisted mostly of spider crab, scup and horseshoe crab. May discards were primarily scup and sea robins, whereas June discards were scup, little and winter skate and black sea bass.

Excluding longfin squid, scup, butterfish, summer flounder and black sea bass, the top 10 discarded species by weight, and 6 additional species of recreational, ecological or forage importance, which are also subject to interstate management plans, are displayed in Table 19. These 16 species account for 83.9% of remaining discards.

Species Name	Total Catch lbs	% Discard	% of hauls with discard lbs			
			VinNanSound	0-3nmS	3-6nmS	6-12nmS
SKATE, LITTLE	20,679	100%	18.2%	45.0%	83.6%	92.9%
SEA ROBIN, NORTHERN	19,152	99.9%	55.0%	36.7%	62.5%	92.9%
SKATE, WINTER	18,867	93.8%	2.1%	56.7%	69.1%	71.4%
CRAB, LADY	15,335	100%	67.8%	91.7%	78.3%	85.7%
MACKEREL, ATLANTIC	9,798	79.7%	14.5%	18.3%	25.7%	28.6%
DOGFISH, SMOOTH	6,672	97.2%	13.4%	15.0%	52.6%	57.1%
CRAB, SPIDER	5,866	100%	52.2%	1.7%	1.3%	7.1%
SQUID EGGS, ATL LONG-FIN	5,069	100%	14.2%	20.0%	19.1%	14.3%
FLOUNDER, WINTER	4,561	97.7%	38.1%	35.0%	80.9%	85.7%
FLOUNDER, WINDOWPANE	3,604	93.1%	33.8%	56.7%	88.8%	92.9%
ALEWIFE	3,349	97.0%	26.5%	8.3%	26.3%	28.6%
CRAB, HORSESHOE	3,216	66.5%	22.8%	0.0%	0.7%	0.0%
TAUTOG (BLACKFISH)	1,690	88.5%	20.4%	0.0%	0.7%	0.0%
BASS, STRIPED	1,479	100%	5.5%	16.7%	19.7%	14.3%
HERRING, BLUEBACK	468	100%	7.0%	15.0%	10.5%	21.4%
SHAD, AMERICAN	444	100%	4.7%	0.0%	28.3%	35.7%

Table 19 – Total weights of top 10 discard species, and 6 species subject to interstate management plans, and encounter rate (for discard) by area

Source: Unpublished NEFOP data

Note: Longfin squid, scup, butterfish, summer flounder, black sea bass and seaweed removed

This breakdown of lesser caught species shows that skates, both little skate and winter skate, are encountered primarily in the waters south of Martha's Vineyard/Nantucket, and in federal waters, and are usually discarded. Lady crabs commonly appear in catches from all areas, whereas spider crabs occur primarily in Nantucket/Vineyard Sound. Anadromous river herring (alewife and blueback herring) and American shad, species that have been the subject of conservation measures for over a decade, were encountered more often in federal waters. However, alewife are discarded on roughly one quarter of hauls in Nantucket/Vineyard Sound. Striped bass, totaling 1,479 lbs (0.13% of overall catch) were encountered primarily outside of Nantucket/Vineyard Sound.

7.16 Summary of Discards by Category

As mentioned above, the reasons for discarding catch varied widely, but can be divided into three broad categories: Market-related, regulatory, and all other discards which includes debris and atypical catches.

7.16.1 Market-Related Discards

Market driven discards accounted for 186,187.2 lbs (57.7%) of the 322,704.3 lbs of discards (excluding seaweed). Reasons recorded for these discards can include "too small", "won't keep until trip end", "vessel only retaining certain size for best price", "reason not specified", etc (Appendix, Figure 44). The top 5 species accounting for market-related discards were scup, little skate, Northern sea robin, winter skate and lady crab.

7.16.2 Regulatory Discards

Regulatory discards accounted for 132,887.8 lbs (41.2%) of overall discards (excluding seaweed). Reasons given to observers for these discards included "too small", "quota filled", "no permit", "v-notched (lobster)", etc (Appendix, Figure 45). The top 5 species accounting for regulatory discards were scup, black sea bass, summer flounder, winter flounder and windowpane flounder.

7.16.3 Other Discards

Discards of other than regulatory and market-related reasons accounted for 3,629.3 lbs (1.1%) of overall discards (excluding seaweed). Forty-three percent of these discards were listed as debris (consisting of fishing gear, rocks, wood, metal), empty shells (34%), or catch of "poor quality, reason not specified" (12%) (Appendix, Figure 46).

7.16.4 Notable Catches

Species not commonly encountered, or of specific interest, are sampled and recorded by fisheries observers in the Individual Animal Log (IAL). IAL species include pelagics (billfish, tunas, sharks, etc.), rays, sturgeons, mola mola and any tagged animals. Catches or interactions with marine mammals, birds or turtles are considered Incidental Takes. Four out of 199 observed trips (5 out of 1,405 observed hauls) had Incidental Takes. These takes consisted of gray seals, a Risso's dolphin and a dolphin, NK.

From the 199 observed trips, 6 trips had catches of IAL species. These catches included torpedo rays, basking and sand tiger sharks, and mola mola. These animals were sampled and released alive over 85% of the time.

8. DISCUSSION

8.1 Factors Contributing to Sustainability

Longfin squid is a sustainably managed and responsibly harvested resource. The most recent stock assessment for longfin squid found that biomass estimates were nearly 3.5 times the pre-determined biomass target. Species resiliency and sound management on both federal and state levels are reasons for this healthy stock.

8.1.1 Species Resiliency

Longfin squid are a fast-growing and fecund species that is biologically resilient due to their life history. Unlike many other marine species, spawning and recruitment occurs throughout the calendar year, with seasonal 'micro-cohorts' that overlap temporally. Each micro-cohort has an average life span of roughly six months, but many individuals over nine months old (but less than one year old) have been sampled. Adult females (mature at roughly 150 days) can lay multiple clutches of eggs during a period of up to three weeks (Macy and Brodziak, 2001). These eggs are attached to fixed objects on the seabed and hatch in 2 to 5 weeks, depending on water temperature (Nichols *et al.* 2019).

There are two major spawning and fishing areas: inshore waters (<60m deep from Cape Hatteras to Cape Cod) and offshore waters (submarine canyons, >100m deep, at the edge of the continental shelf). Macy and Brodziak found that, "the inshore fishery harvested squid hatched during winter, while the offshore fishery harvested squid hatched during summer and early autumn." Thus, squid that enter Nantucket Sound in April and May each year are the result of October-January hatching events on the squid wintering grounds. Stock assessment biologists and managers acknowledge that the success of a spring (inshore) or winter (offshore) squid fishery is partially dependent on adequate spawner escapement from the previous season. Setting annual quotas and allocating them by trimesters ensures some level of foregone yield (uncaught quota) in most years, increasing the chances for escapement (Hendrickson 2017). Overall, this dynamic helps buffer the impact of longfin squid fishery removals on subsequent seasons' recruitment.

Due to their strong swimming ability, and the dynamic oceanographic environment of Nantucket Sound, schools of squid can move significant distances within one or two tidal cycles. Further, squid perform diel vertical migrations (rising to the surface from dusk until before dawn), making towing for them at night ineffective. In fact, of the 1,405 hauls in the 2013-2017 observer dataset, zero observed hauls began between 2000hrs and 0400hrs, with over three-quarters of the observed hauls starting between 0500hrs and 1300hrs. While MADMF prohibits nighttime trawling [322 CMR 4.06(3)], it is notable that no hauls from federal waters where nighttime trawling prohibitions do not exist were observed. As a result, fishermen are faced with finding and following the squid biomass daily, and avoiding masses of seaweed, resulting in challenges that result in inefficient harvest and further escapement for longfin squid.

8.2 Catch and Bycatch Data

8.2.1 Stock Status Concerns

Multiple finfish species of conservation concern appear in Table 11. NOAA Fisheries, as of December 2019, identifies witch flounder, yellowtail flounder (SNE/MAtl stock), winter flounder (SNE stock), red hake, bluefish and Atlantic mackerel as "overfished" (biomass assessed to be below target levels). Of these species, Atlantic mackerel (0.87%), winter flounder (0.41%) and bluefish (0.19%) make up more than one-tenth of one percent of the incidental catch of finfish in this small-mesh trawl squid fishery. The most recent ASMFC stock assessment for striped bass (which constitute 0.1% of total catch) found that the species was overfished (ASMFC 2019).

Each of these species is managed with strict quotas, and generally, if quota overages occur future quota reductions ("accountability measures") are enforced. For bluefish, only 17% of the annual quota is allocated to the commercial fishery (recreational sector gets 83% of quota) and the commercial allocation has not been fully

utilized since prior to 2012. Managers of Atlantic mackerel implemented a rebuilding plan in 2019, and stocks have already rebounded to acceptable levels, resulting in increased commercial quota. The southern New England/mid-Atlantic winter flounder stock was assessed to be overfished in 2017, and a stock rebuilding plan remains in place. Quota utilization of the SNE/MAtl winter flounder stock has not exceeded 78% in any year since 2013 (GARFO Quota Monitoring). The striped bass stock assessment found that during 2013-2017 commercial discards, which includes discards of directed fisheries as well as bycatch, constitute only 1.5% of all striped bass removals.

Simultaneously, "overfishing is occurring" on four species that appear in the catches of the longfin squid fishery; Atlantic mackerel (0.87% of total catch), striped bass (0.1%) red hake (0.03%) and Atlantic cod (0.001%). This designation is applied to species where the annual fishing mortality rate exceeds the target rate previously set by scientists and managers. As previously stated, mackerel are currently managed under a rebuilding plan, and the stock has rebounded to the point where quotas nearly doubled in recent years. Commercial discards of striped bass make up a very small portion of overall mortality. The extremely low levels of red hake and Atlantic cod catch suggest that the longfin squid fishery is not in any way impacting the rebuilding of these species.

River herring (alewife and blueback herring) and American shad are species of particular ecological importance that are encountered at low levels (0.38% of total catch, combined) in the spring longfin squid fishery. Since river herring and shad return to spawn in their natal rivers, stock assessments for these species are completed on a river-by-river basis. The 2017 stock assessment showed that river herring remain depleted on a coastwide basis, but some river systems began recording positive trends. The 2007 American shad stock assessment found stocks to be near an all-time low, coastwide. An updated stock assessment is expected in late 2020, but data collection remains an impediment to creating more robust stock assessments. Bycatch of river herring and shad in marine fisheries has been discussed by managers of some fisheries, and addressed by others. River herring/shad catch caps exist for the midwater trawl and bottom trawl fisheries for Atlantic herring and mackerel. The MAFMC has an 18-member River Herring and Shad Committee, and the ASMFC a 16-state Shad/River herring Management Board tasked with managing the species.

These levels of scientific assessment, management oversight and quota accountability suggest that if the spring longfin squid fishery were to increase its catches of these species to the point where a detrimental impact was clear, regulatory backstops are in place to effectively mitigate these issues.

8.2.2 Conservation and Forage Concerns

Catch and discards of species of particular concern to various user groups exist within the longfin squid fishery. Important recreational fisheries exist for striped bass, scup, black sea bass, summer flounder, bluefish, tautog, cod and haddock. Of these species, scup (14.3% of total catch), black sea bass (2.1%) and summer flounder (1.1%) are notable in that they comprise over 1% of total catch, and over three-quarters of these species (by weight) are discarded. However, these species have rigid annual quotas with allocation splits between recreational and commercial sectors. Traditionally, the commercial allocation of scup is under-utilized and the biomass of spawning-age scup, assessed in 2017, was 396 million pounds and roughly twice the target set by the management plan. Black sea bass commercial quota utilization reaches 90-100% each year. However, in each year since 2008 the recreational harvest of black sea bass is at least twice as much as the commercial harvest (NEFSC 2019). Finally, summer flounder quota, with 60% allocated annually to the commercial sector, is 90-100% utilized annually. After a recent recalibration of recreational fisheries catch data which tripled recent recreational catch estimates, it is apparent that recreational catch and discards exceed commercial catch and discards each year since 2012 (MAFMC 2019c). The July 2019 summer flounder stock assessment found that the spawning stock biomass is 78% of the target, and that fishing mortality rates are 25% lower than target levels. These species of commercial and recreational importance, managed by both the MAFMC and ASMFC, continue to produce enough data for stock assessments, and enough fish to sustain existing recreational and commercial fisheries.

Catches of the most sought after recreational fish in Massachusetts, striped bass (1,479.1 lbs, 0.13% of total catch), do not appear to be a concern. In Massachusetts striped bass may only be harvested using rod and reel, and must be discarded if caught in the squid fishery. If the 1,405 observed hauls on 199 trips are representative of the entire fishery, bycatch and discards of striped bass for every 1 million lbs of longfin squid caught in each spring fishery would be on the scale of 1,000-3,000 lbs. It should be noted that this extrapolation is based on limited data and would have extremely high variability. However, applying this rate to the average catch of longfin squid in Nantucket Sound during the 2014-2017 fisheries (1.3 million lbs of squid landed) results in an annual removal of 2,542 lbs of striped bass. This value assumes 100% discard mortality, which is not likely the case. McKiernan and Pierce suggested that an 18% mortality rate was likely an overestimate and found most trawl-caught striped bass to be lively and in good condition. FDI samplers can confirm that short tows in shallow water usually result in lively striped bass that swim freely upon return to water.

In the context of the Massachusetts commercial rod and reel fishery landings (823,409 lbs in 2017) and recreational harvest (5.67 million lbs in 2017) (Nelson 2018), the striped bass bycatch of the longfin squid fishery is not a concern. Understanding the importance of striped bass to Massachusetts recreational and commercial anglers, and the recently depressed stock status, MADMF will continue to monitor bycatch of striped bass in state waters.

River herring (alewife and blueback herring) and shads (American, hickory and gizzard shad) are anadromous species that return to spawn in freshwater ecosystems each year. These species serve as forage for larger predators and have been the subject of countless restoration projects (dam removals, fish ladder installations, culvert replacements, etc.) coastwide over recent decades. Unfortunately, most river systems continue to see low numbers and troubling biological metrics. In addition to the anthropomorphic threats river herring and shad face when attempting to find suitable spawning habitat, they are also subject to fishing mortality while in their marine phase. At-sea bycatch in small-mesh fisheries is a contributing factor to delayed rebuilding of river herring populations. Recent monitoring and genetic research in the small-mesh Atlantic herring and mackerel fisheries has revealed that bycatch of marine phase river herring can have disproportionate impacts on river herring from different geographical population segments (Hasselman *et al.* 2016). It can be hypothesized that river herring and shad caught during the spring in and around Nantucket Sound would have originated in the adjacent estuarine systems of southern New England. Whether bycatch of river herring (0.34% of total catch) and shads (0.04%) in the longfin squid fishery impacts local or regional runs is difficult to conclude. Genetic tools are being developed that aim to link at-sea bycatch to a region or river system of natal origin. Until this can be done, and representative sampling of river herring bycatch from the longfin squid fishery can be conducted, uncertainty around the impact of this bycatch will remain. It should be noted that while this small-mesh fishery has the ability to interact with river herring and shad, the bycatch rates observed appear to be an order of magnitude lower than other small-mesh fisheries in the region (Atlantic herring, Atlantic mackerel and whiting fisheries). This could be attributed to the sequential timing of the spring squid fishery and the up-river spawning migrations of river herring.

Additionally, the removal of a portion of the forage base for recreationally important species, such as striped bass, registers concern with fishery stakeholders. Fears that the squid trawl fishery could deplete the forage base, thus forcing predators to relocate for food, are unsupported at this point. In fact, striped bass inhabiting Nantucket Sound have been shown to have a diverse diet. Nelson *et al.* (2003) found that the diets of 220 striped bass caught in Nantucket Sound from 1997-2000 was composed of over 50% crustaceans (by weight). These crustaceans were primarily lady crabs, rock crabs and crangon shrimp. Bony fishes made up 40% of striped bass diet by weight, with sand lance, northern sea robin, menhaden making up over 5% of stomach contents. Scup (3.4%) and butterfish (<0.1%) were less common. Unidentified cephalopods (likely squid) made up 3.3% of diets by weight. Thus, striped bass appear able to adapt to a variety of prey items within Nantucket Sound.

Disruption of longfin squid egg clusters, or “mops”, by bottom trawling has been raised as a conservation concern. Currently no directed studies have been conducted that reveal the degree to which the viability of longfin squid eggs are impacted by bottom trawl disruption. Although squid mops often remain intact when caught in a

small-mesh net, evidence exists that disruption or displacement of egg mops could cause squid to hatch early and be unable to fully absorb the yolk sac (Boletzky and Hanlon 1983). Acknowledging that any squid eggs being impacted in and adjacent to Nantucket Sound constitute the potential recruits for the offshore winter fishery (and vice versa), a direct impact on in-season abundance would not be expected. Also, a large portion of Nantucket Sound waters remain inaccessible to the bottom trawl fishery due to spatial closures, presence of fixed gear and untowable bottom, giving squid egg clusters a degree of refuge. However, the unknown impact of squid egg cluster disruption remains a topic worth investigating.

8.2.3 Discard Rates Relative to Other Fisheries

The available data for the spring longfin squid fishery in and adjacent to Nantucket Sound (199 trips/1,405 observed hauls) reveals a fishery bycatch ratio (estimated fishery bycatch/(estimated fishery bycatch + fishery landings)) of 28.63%. Annually, NOAA Fisheries completes a National Bycatch Report that calculates bycatch rates for fisheries and fleets from each region of the country. The most recent National Bycatch Report (February 2019) calculates bycatch rates for 34 fisheries in 2014 and 35 fisheries in 2015. The small-mesh spring squid fishery is accounted for in these analyses, calculated as part of the New England Small-Mesh Otter Trawl group. This group also includes other fisheries; Atlantic herring and mackerel, whiting and squid (outside of the spring longfin squid fishery). The Mid-Atlantic Small-Mesh Otter Trawl group accounts for small-mesh fisheries that land in ports from Connecticut to North Carolina, including some squid effort.

In 2014, the New England Small-Mesh Otter Trawl fishery group ranked 18th out of 34 fishery groups, with a bycatch ratio of roughly 24% (Appendix, Figure 47) (Benaka *et al.* 2019). In 2015, the New England Small-Mesh Otter Trawl fishery group ranked 18th out of 35 fishery groups, with a bycatch ratio of approximately 23% (Appendix, Figure 48). These numbers show that the bycatch in the overall small-mesh otter trawl fishery is near the median when measured against other fisheries and gear types. This is not surprising, nor concerning, considering the use of small-mesh nets.

8.2.4 Addressing Regulatory Discards

Regulatory discards, when fish or shellfish must be discarded due to being too small, having insufficient permits or no available quota, can often be alleviated. For example, black sea bass retention limits in Massachusetts from 2013-2017 were set at zero pounds. From catches on the 199 at-sea sampled trips, 14,431 lbs of black sea bass were discarded by vessels landing in Massachusetts, while vessels landing in Rhode Island retained 1,183 lbs. Each state receives a proportion of the annual black sea quota and allows landings as they see fit. The 2016 black sea bass stock assessment revealed that the biomass of spawning fish was 2.3 times the target, and catches could be increased. As a result, MADMF relaxed retention limits for the longfin squid trawl fishery, allowing 50 lbs per trip, and beginning in 2020, 100 lbs per trip. This is one example of unequal state regulations promoting a potentially unnecessary discard of a valuable commercial species. These scenarios are often difficult to identify and remedy in-season, but maintaining open communications between fishermen and managers can help avoid similar scenarios.

The small-mesh bottom trawl fishery for longfin squid provides a valuable opportunity for fishermen to target a sustainable stock for which a thriving domestic market exists. While groundfish stocks continue rebuilding, the ability to fish freely, without having to use, trade or purchase individual quota, is welcomed by harvesters. The realities of fishing with small-mesh nets do not escape the longfin squid fishery, but notable bycatch of endangered or threatened species are absent, and bycatch species of concern are few. With recent stock assessments detailing recruitment booms of forage species like scup, concerns regarding lack of forage are somewhat abated. Many species' annual quotas, including longfin squid, remain underharvested on an annual basis. In 2018 the northeast U.S. inshore longfin squid fishery became the first squid fishery in the world to

receive a Marine Stewardship Council certification after a detailed 11-month assessment. Ultimately, the resilient longfin squid resource receives quality oversight and management from the Mid-Atlantic Fishery Management Council, and its landings are thoughtfully managed by the Massachusetts Division of Marine Fisheries.

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10. LITERATURE CITED

ASMFC 2019. Summary of the 2019 Benchmark Stock Assessment for Atlantic Striped Bass. April 2019. Available: http://www.asmfc.org/uploads/file/5d28f18dAtlanticStripedBassAssessmentSummaryReport_April2019.pdf

Benaka, L.R., D. Bullock, A.L. Hoover, and N.A. Olsen (editors). U.S. National Bycatch Report First Edition Update 3. 2019. U.S. Dept. of Commerce, NOAA. NOAA Technical Memorandum NMFS-F/SPO-190, 95 p.

Black, G.A.P, T.W. Rowell, and E.G. Dawe. 1987. Atlas of the biology and distribution of the squids *Illex illecebrosus* and *Loligo pealei* in the northwest Atlantic. Canadian Special Publication of Fisheries and Aquatic Sciences. 100. 62p.

Boletzky S. von, Hanlon R. T. 1983. A review of the laboratory maintenance, rearing and culture of cephalopod molluscs. Memoirs of the national Museum, Melbourne, Australia. 44:147–187.

Brodziak, J.K.T., and W.K. Macy, III. 1996. Growth of long-finned squid, *Loligo pealeii*, in the northwest Atlantic. Fishery Bulletin., 94:212-236.

Brodziak, J.K.T. and L.C. Hendrickson. 1999. An analysis of environmental effects on survey catches of squids *Loligo pealei* and *Illex illecebrosus* in the northwest Atlantic. Fishery Bulletin. 97:9-24.

GARFO. Quota Monitoring in the Greater Atlantic Region (2020). Available: https://www.fisheries.noaa.gov/new-england-mid-atlantic/commercial-fishing/quota-monitoring-greater-atlantic-region

Gannon, D.P., A.J. Read, J.E. Craddock, K.M. Fristrup, and J.R. Nicolas. 1997. Feeding ecology of long-finned pilot whales, *Globicephala melas*, in the western North Atlantic. Marine Ecology Progress Series. 148:1-10.

Gosner, K.L. 1978. A field guide to the Atlantic seashore: Invertebrates and seaweeds of the Atlantic coast from the Bay of Fundy to Cape Hatteras. Houghton Mifflin Company, Boston. 329 p.

Hasselman, D. J., E. C. Anderson, E. E. Argo, D. Bethoney, S. R. Gephard, D. M. Post, B. P. Schondelmeier, T. F. Schultz, T. V. Willis, and E. P. Palkovacs. 2016. Genetic stock composition of marine bycatch reveals disproportional impacts on depleted river herring genetic stocks. Canadian Journal of Fisheries and Aquatic Sciences 73:951–963.

Hatfield, M.C., R.T. Hanlon, J.W. Forsythe, and E.P.M. Grist. 2001. Laboratory testing of a growth hypothesis for juvenile squid *Loligo pealeii*. Canadian Journal of Fisheries and Aquatic Sciences. 58:845-857.

Hatfield, E.M.C., and S.X. Cadrin. 2002. Geographic and temporal patterns in size and maturity of the longfin squid (*Loligo pealeii*) off the northeastern United States. Fishery Bulletin., 100: 200-213.

Hendrickson, L. Longfin inshore squid (*Doryteuthis (Amerigo) pealeii*) stock assessment update for 2017, April 25, 2017. Available: https://static1.squarespace.com/static/511cdc7fe4b00307a2628ac6/t/59073cc9be65945087783a84/1493646537724/Doryteuthis_update_April_2017.pdf

Jacobson, L. 2005. Essential fish habitat source document: longfin inshore squid, *Loligo pealeii*, life history and habitat characteristics, Second Edition. NOAA Tech. Memo. NMFS-NE-193.

Kier, W.M. 1982. The functional morphology of the musculature of squid (Longinidae). Arms and tentacles. Journal of Morphology. 172: 179-192.

Lange, A.M.T. 1980. The biology and population dynamics of the squids, *Loligo pealei* and *Illex illecebrosus*, from the northwest Atlantic. M.S. thesis, University of Washington, Seattle, WA. 178 p.

Lange, A.M.T, and M.P. Sissenwine. 1980. Biological considerations relevant to the management of squid (*Loligo pealei* and *Illex illecebrosus*) of the northwest Atlantic. Marine Fisheries Review. 42(7-8): 23-38.

Lange, A.M.T. 1982. Long-finned squid, *Loligo peale*i. In: Grosslein, M.D., Azarovitz T.R., editors. Fish Distribution. MESA New York Bight Atlas Monograph 15. Albany, NY: N.Y. Sea Grant Institute. P.133-135.

Langton, R.W. and R.E. Bowman. 1977. An abridged account of predator-prey interactions for some northwest Atlantic species of fish and squid. NMFS-NEFSC Reference Document. 77-17.

Macy, W.K., III. 1980. The ecology of the common squid, *Loligo pealei*, in Rhode Island waters. Ph.D. dissertation, Dalhousie Univ. Halifax, Nova Scotia.

Macy, W.K., III and J.K.T. Brodziak. 2001. Seasonal maturity and size at age of *Loligo pealeii* in waters of southern New England. ICES Journal of Marine Science. 58(4): 852-864.

MADMF 2010. Massachusetts Division of Marine Fisheries Strategic Plan 2010-2014.

MAFMC 1978. Federal Environmental Impact Statement/Fishery Management Plan for the Squid Fishery of the Northwest Atlantic Ocean. November 1978. Available: https://static1.squarespace.com/static/511cdc7fe4b00307a2628ac6/t/53e3cd73e4b006554847fa90/1407438195981/SMB__Squid__Original_Plan.pdf

MAFMC 1981. Amendment 3 (Merged FMP) to the Atlantic Mackerel, Squid and Butterfish Fishery Management Plan. October 1981. Available: https://static1.squarespace.com/static/511cdc7fe4b00307a2628ac6/t/53e3d689e4b0d4852873a7b2/1407440521947/SMB_Merged_FMP.pdf

MAFMC 2010. Amendment 10 to the Atlantic Mackerel, Squid and Butterfish Fishery Management Plan. January 2010. Available: https://static1.squarespace.com/static/511cdc7fe4b00307a2628ac6/t/51719927e4b0532e10d31e6a/1366399271266/SMB_Amend10_FSEIS.pdf

MAFMC 2015. Longfin AP Informational Document. April 2015. Available: https://static1.squarespace.com/static/511cdc7fe4b00307a2628ac6/t/553a4946e4b0d3a13ade874e/1429883206975/Longfin+APInfo-2015.pdf

MAFMC 2018. Amendment 20 to the Atlantic Mackerel, Squid and Butterfish Fishery Management Plan. December 2018. Available: http://www.mafmc.org/s/20181018_Squid-Amendment-Final-EA.pdf

MAFMC 2019a. Longfin Squid Fishery Information Document. April 2019. Available: https://static1.squarespace.com/static/511cdc7fe4b00307a2628ac6/t/5cc1c0ba8165f53f1f86c362/1556201659086/4_2019+Longfin+AP+Info+Doc.pdf

MAFMC 2019b. Scup Fishery Information Document. August 2019. Available: https://static1.squarespace.com/static/511cdc7fe4b00307a2628ac6/t/5d55bde28d11b30001127169/1565900259295/Scup_info_doc_2019_FINAL.pdf

MAFMC 2019c. Summer Flounder Fishery Information Document. August 2019. Available: https://static1.squarespace.com/static/511cdc7fe4b00307a2628ac6/t/5d55721e64a93e00014deeb4/1565880863628/Fluke+AP+FPR+Info+Doc_Final2019.pdf

Magnuson-Stevens Fishery Conservation and Management Act of 1976. U.S. Code, volume 16, sections 1801 et seq.

Maurer, R. 1975. A preliminary description of some important feeding relationships. ICNAF Research Document 75/IX/130.

McKiernan, D.J., and D.E. Pierce, 1995. Loligo squid fishery in Nantucket and Vineyard Sounds. Massachusetts Division of Marine Fisheries Technical Report (TR-1):78p.

NEFSC 2019. Black sea bass operational assessment for 2019. August 2019 Pre-publication Document. Available: https://static1.squarespace.com/static/511cdc7fe4b00307a2628ac6/t/5d602faa7947a70001db590c/1566584756933/3_OpAssessments_Aug2019-Prepublication-8-23-2019-f.pdf

NEFSC 2020. Northeast Fisheries Observer Program. https://www.fisheries.noaa.gov/new-england-mid-atlantic/fisheries-observers/northeast-fisheries-observer-program

Nelson, Gary A., Chase, B.C., Stockwell, J. 2003. Food Habits of Striped Bass (Morone saxatilis) in Coastal Water of Massachusetts. Journal of Northwest Atlantic Fisheries Science, Volume 32.

Nelson, Gary A., 2018. Massachusetts Striped Bass Monitoring Report for 2017. Massachusetts Division of Marine Fisheries Technical Report TR-68.

Nichols, Owen C., Groglio, K. and Eldridge, E. 2019. In Situ Monitoring of Longfin Inshore Squid Egg Deposition and Embryonic Development. Journal of Shellfish Research. Vol.38(2): 371-374.

Overholtz, W.J. and G.T. Waring. 1991. Diet composition of pilot whales, *Globicephala* sp. And common dolphins, *Delphinus delphis* in the Mid-Atlantic Bight during spring 1989. Fishery Bulletin. 89: 723-728.

Summers, W.C. 1968a. Winter distribution of *Loligo pealei* determined by exploratory trawling. Biological Bulletin. Woods Hole, MA. 133:489.

Summers, W.C. 1968b. The growth and size distribution of current year class *Loligo pealei*. Biological Bulletin. Woods Hole, MA. 135:366-377.

U.S. Office of the Federal Register. 2015. Fisheries of the Northeastern United States; Standardized Bycatch Reporting Methodology Omnibus Amendment. Code of Federal Regulations, Title 50, Part 648. U.S. Government Printing Office, Washington, D.C.

Vecchione, M. 1981. Aspects of the early life history of *Loligo pealei*. Journal of Shellfish Research 1:171-180.

Vecchione, M., C.F.E Roper, M.J. and Sweeney. 1989. Marine flora and fauna of the eastern United States. Mollusca: Cephalopoda. NOAA Technical Report. NMFS 73. 23p.

Vovk, A.N. 1985. Feeding spectrum of longfin squid (*Loligo pealei*) in the northwest Atlantic and its position in the ecosystem. Northwest Atlantic Fisheries Organization (NAFO) Science Council Study. 8: 33-38.

Vovk, A.N. and L.A. Khvichiya. 1980. On feeding of long-finned squid (Loligo pealei) juveniles in Subareas 5 and 6. Northwest Atlantic Fisheries Organization (NAFO) Science Council Research Document. 80/VI/50. 9 p.

Waring, G.T., P. Gerrior, P.M. Payne, B.L. Parry, and J.R. Nicolas. 1990. Incidental take of marine mammals in foreign fishery activities off the northeast United States, 1977-1988. Fishery Bulletin. 88: 347-360.

Whitaker, J.D. 1978. A contribution to the biology of *Loligo pealei* and *Loligo plei* off the southeastern coast of the United States. M.S. thesis, College of Charleston, Charleston, SC. 164 p.

Wigley SE, Blaylock J, Rago PJ, Tang J, Haas HL, and Shield G. 2011. Standardized Bycatch Reporting Methodology 3-year Review Report 2011- Part 1. US Department of Commerce, Northeast Fisheries Science Center Reference Document 11-09; 285 p.

Appendix 1
Supplemental Figures and Tables

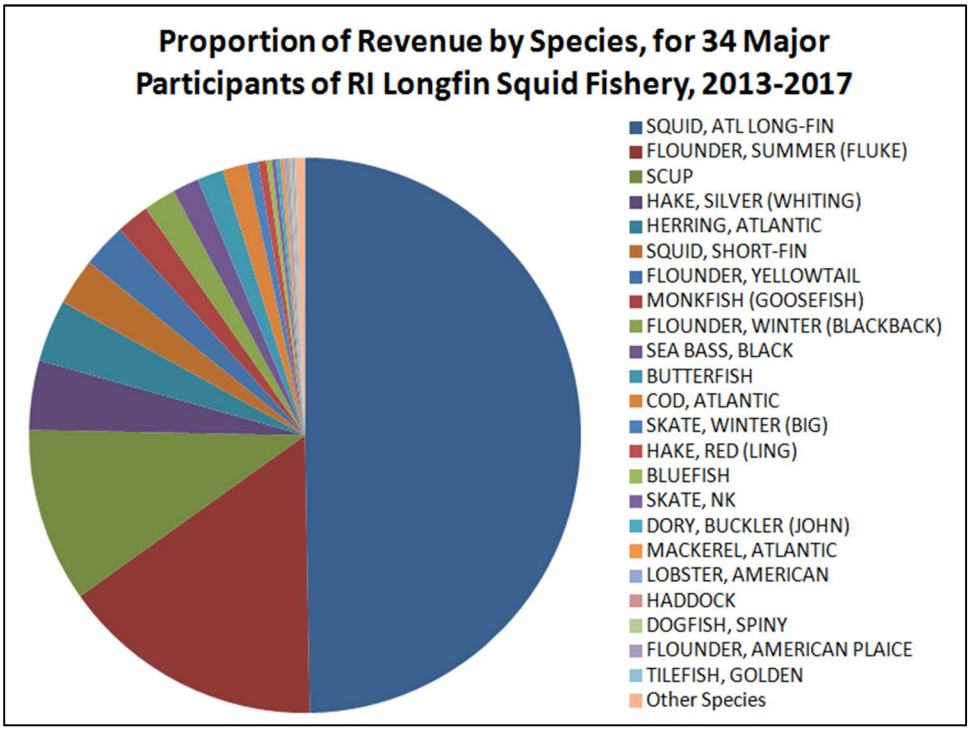

Figure 24 - Proportion of overall revenue by species sold, for major Rhode Island participants in the spring longfin squid fishery, 2013-2017

Source: Unpublished NMFS Dealer Data

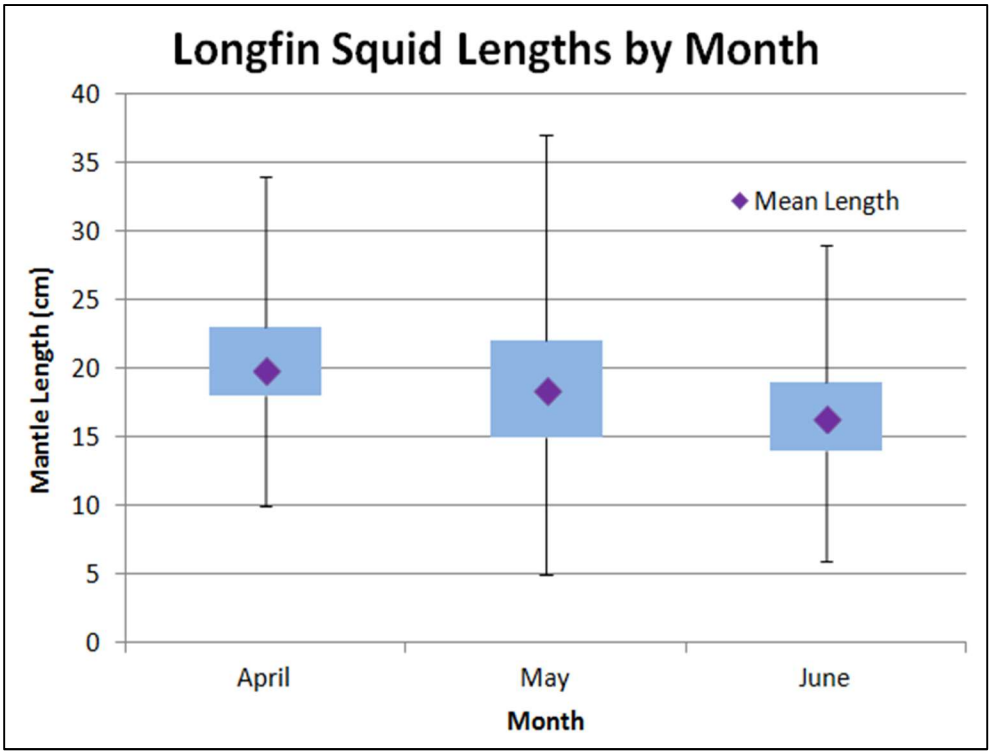

Figure 25 – Boxplot of squid lengths by month

Source: Unpublished NEFOP data

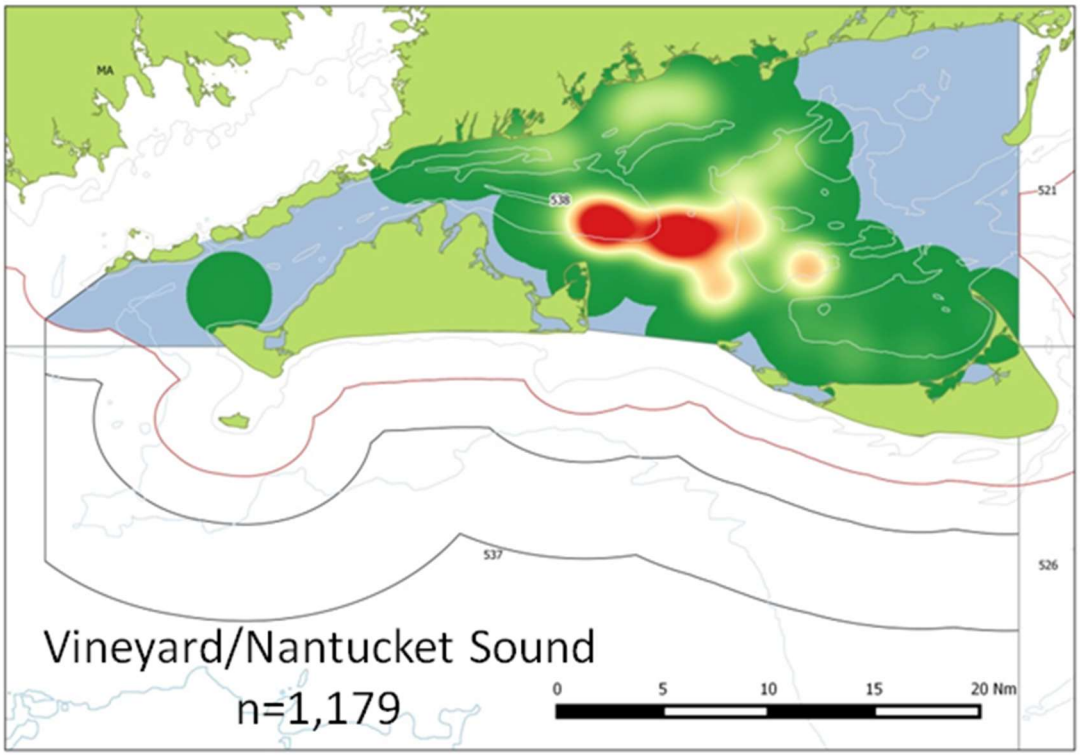

Figure 26 – Heatmap displaying starting location of observed hauls in Vineyard/Nantucket Sound
Source: Unpublished NEFOP data

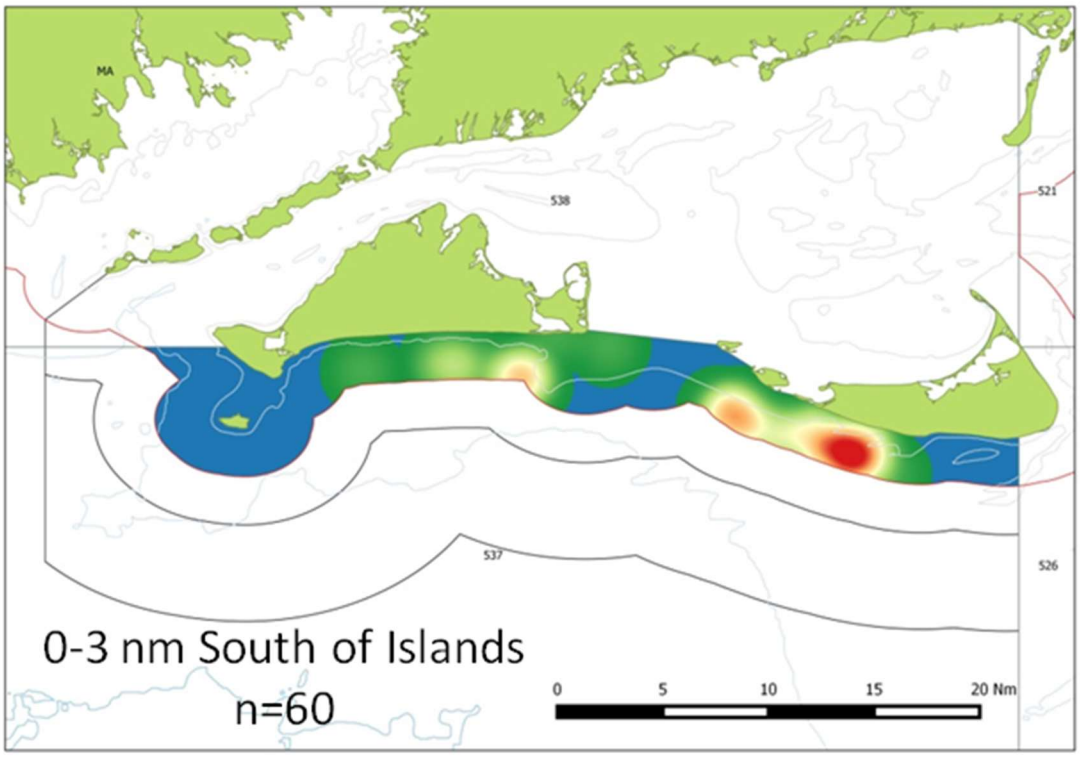

Figure 27 – Heatmap displaying starting location of observed hauls in state waters 0-3 nautical miles south of islands
Source: Unpublished NEFOP data

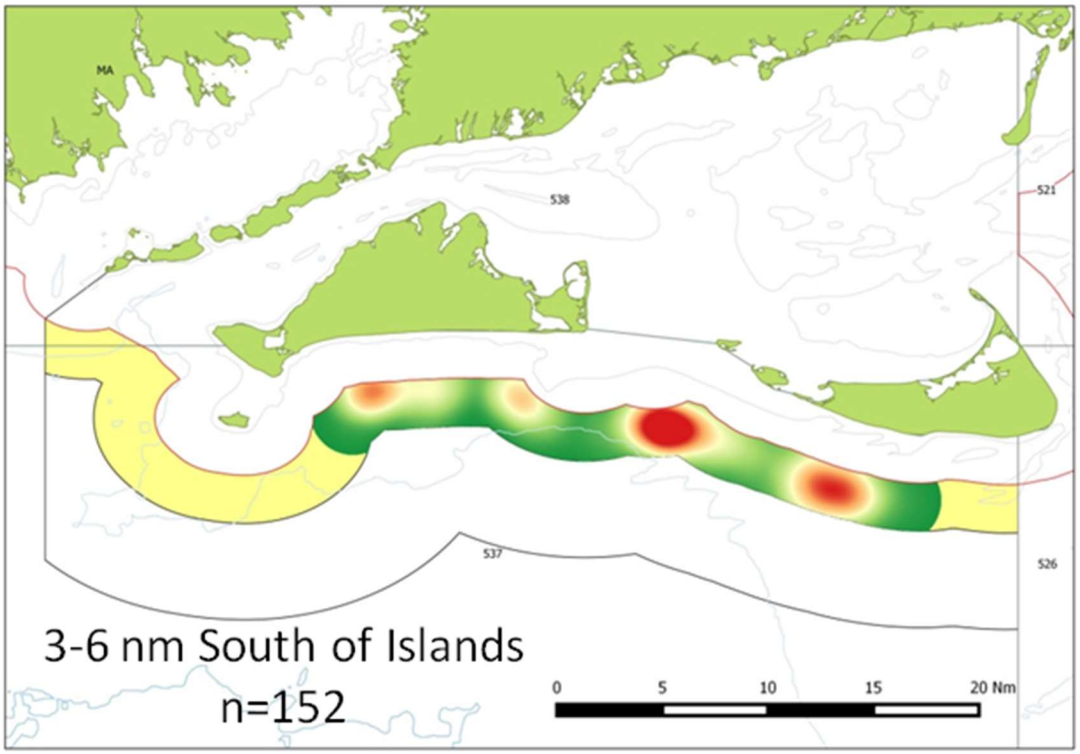

Figure 28 – Heatmap displaying starting location of observed hauls in federal waters 3-6 nautical miles south of islands
Source: Unpublished NEFOP data

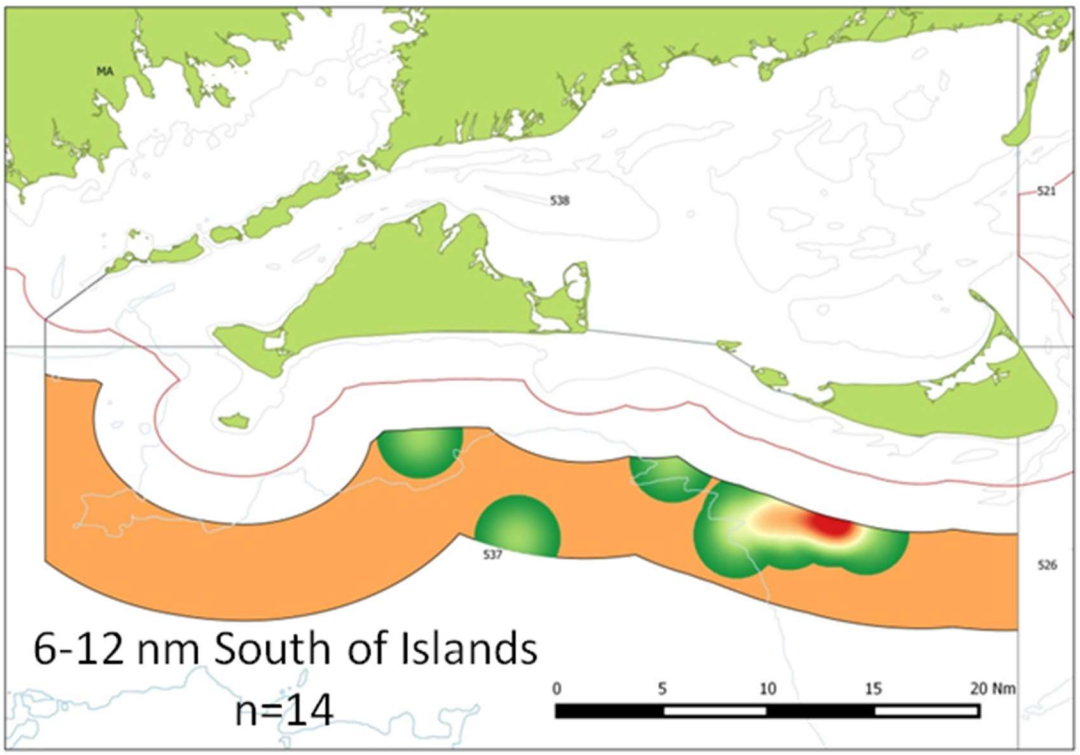

Figure 29 – Heatmap displaying starting location of observed hauls in federal waters 6-12 nautical miles south of islands
Source: Unpublished NEFOP data

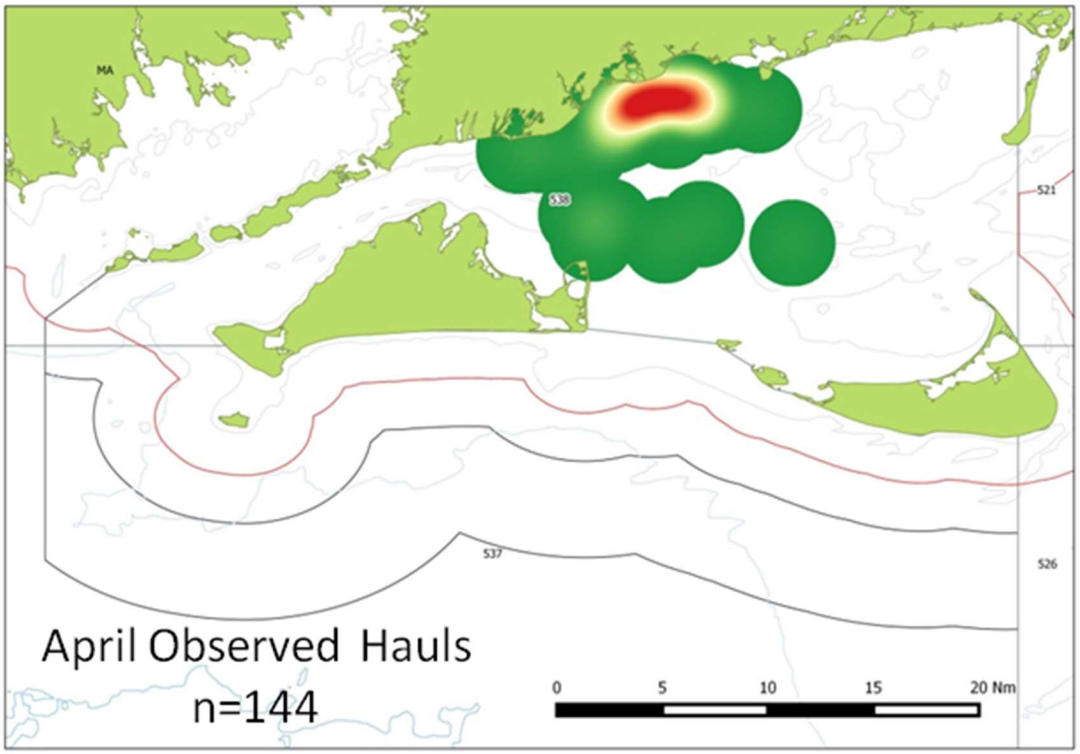

Figure 30 – Heatmap displaying starting location of observed hauls conducted in April
Source: Unpublished NEFOP data

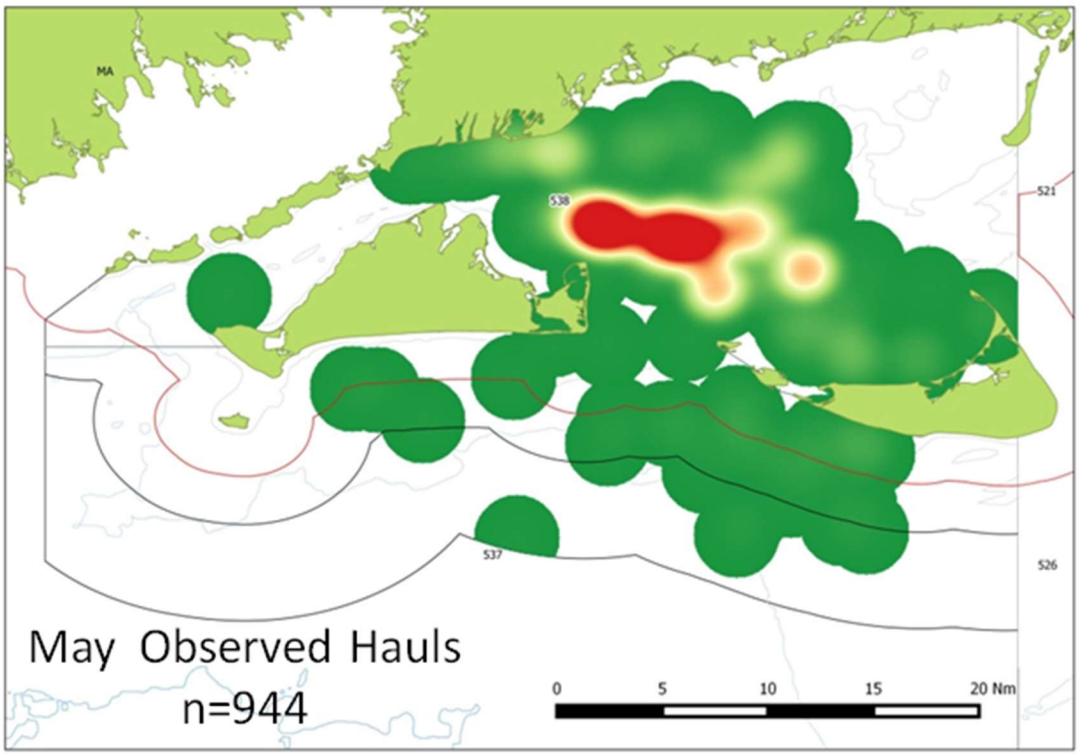

Figure 31 – Heatmap displaying starting location of observed hauls conducted in May
Source: Unpublished NEFOP data

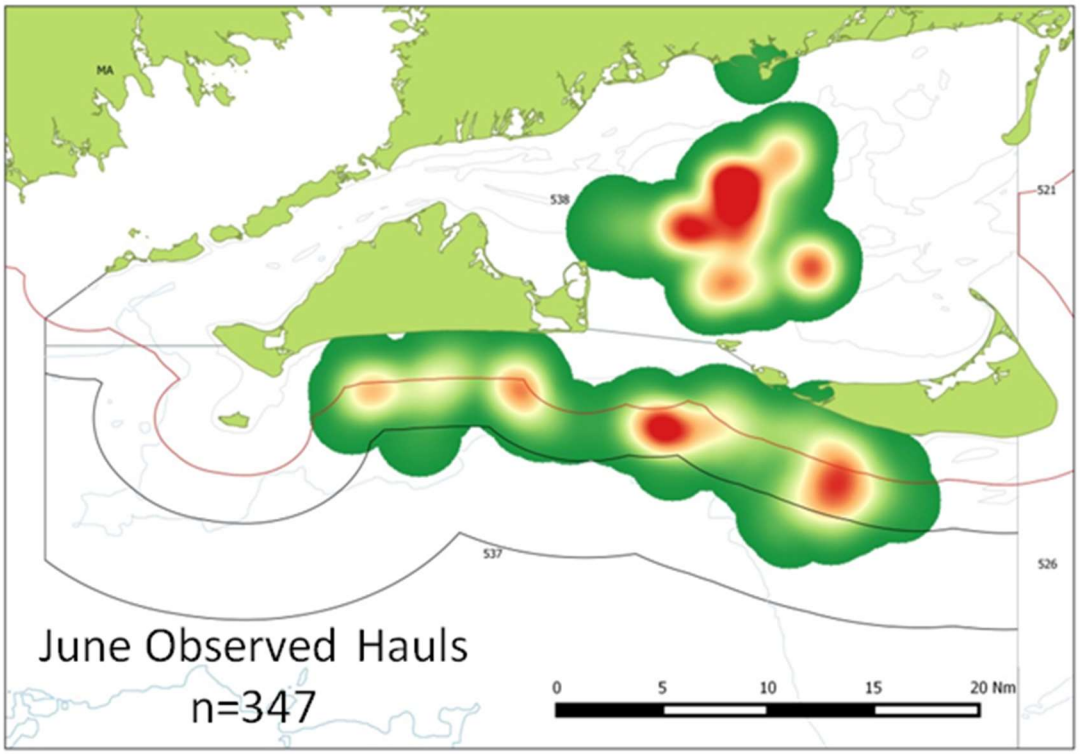

Figure 32 – Heatmap displaying starting location of observed hauls conducted in June
Source: Unpublished NEFOP data

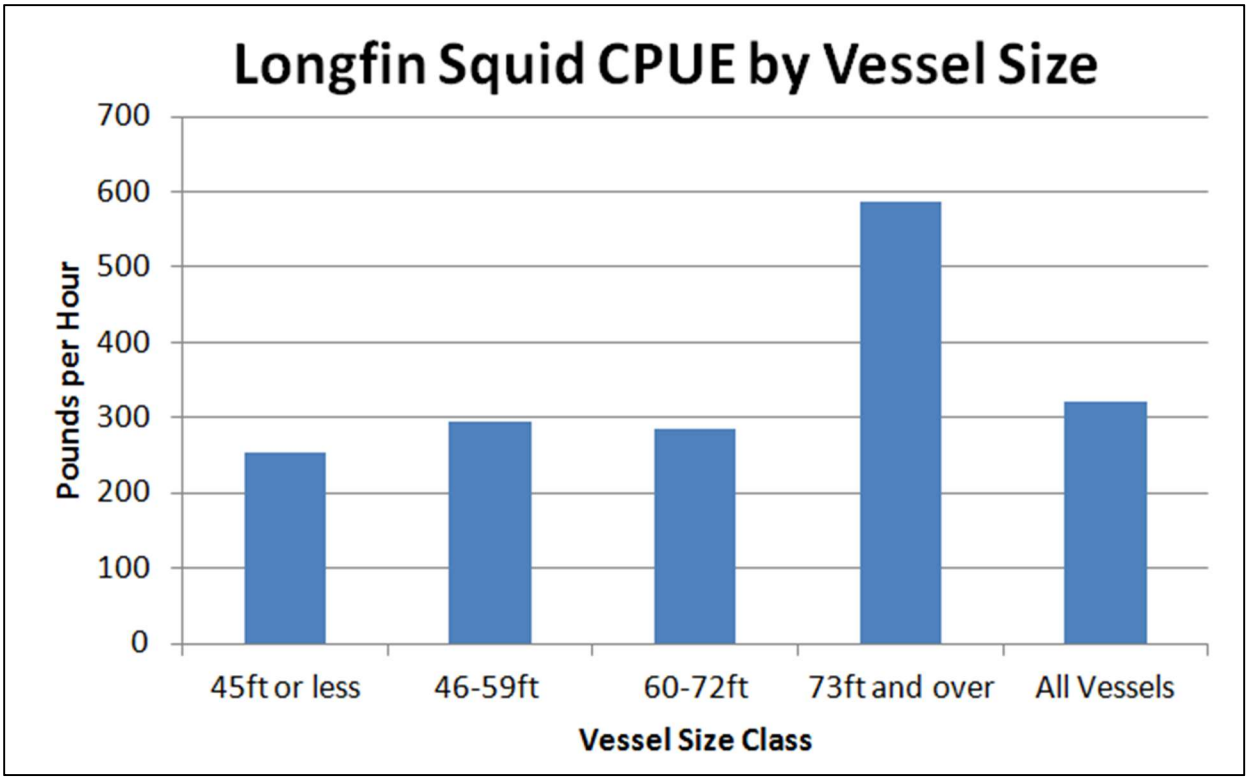

Figure 33 – Catch per unit effort of longfin squid by vessel size class
Source: Unpublished NEFOP data

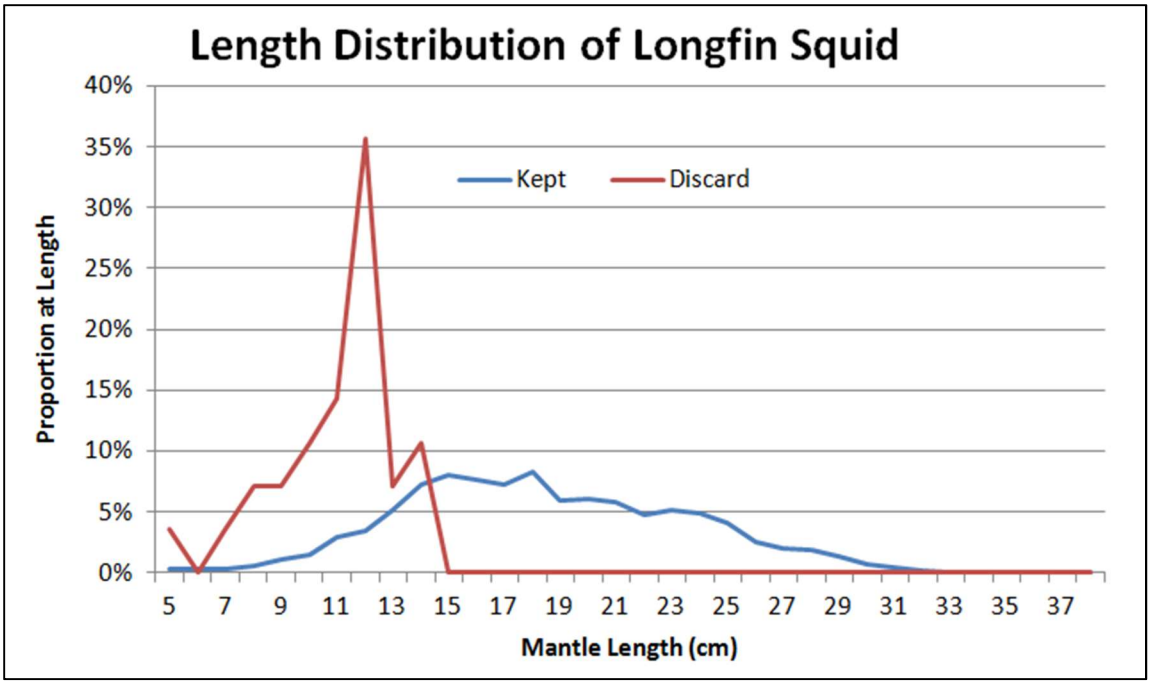

Figure 34 – Length distribution of kept (n=2915) and discarded (n=28) longfin squid

Source: Unpublished NEFOP data

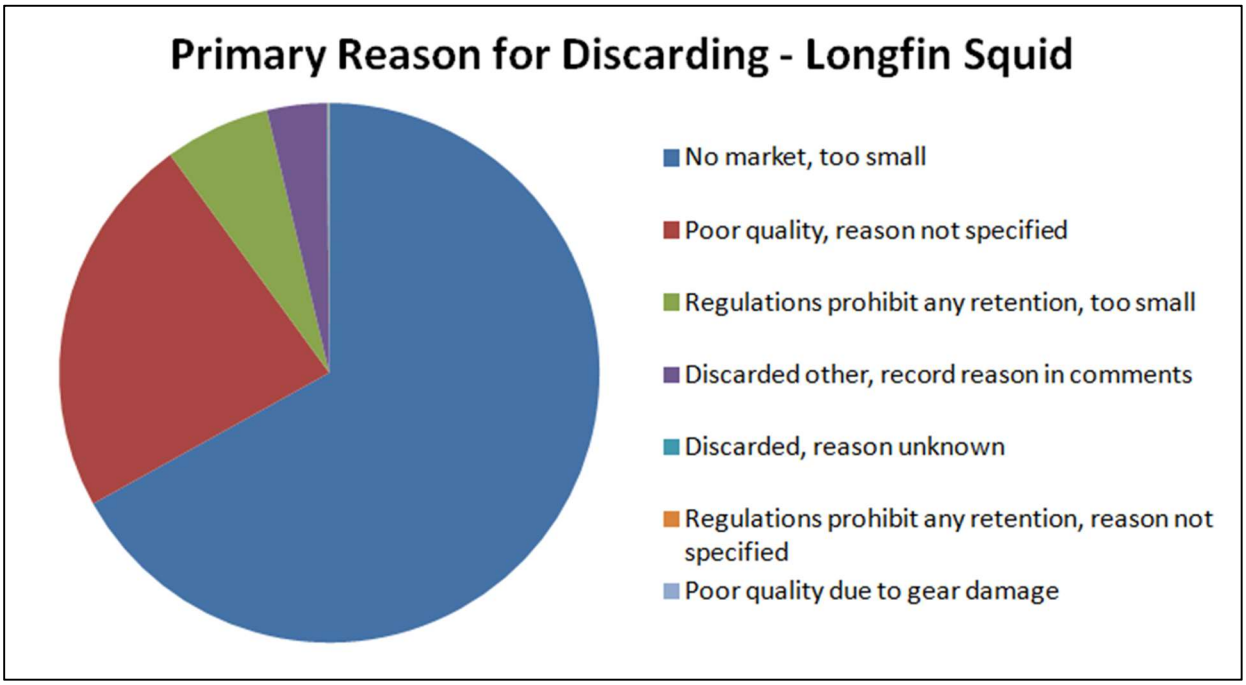

Figure 35 – Recorded reason for discarding of longfin squid

Source: Unpublished NEFOP data

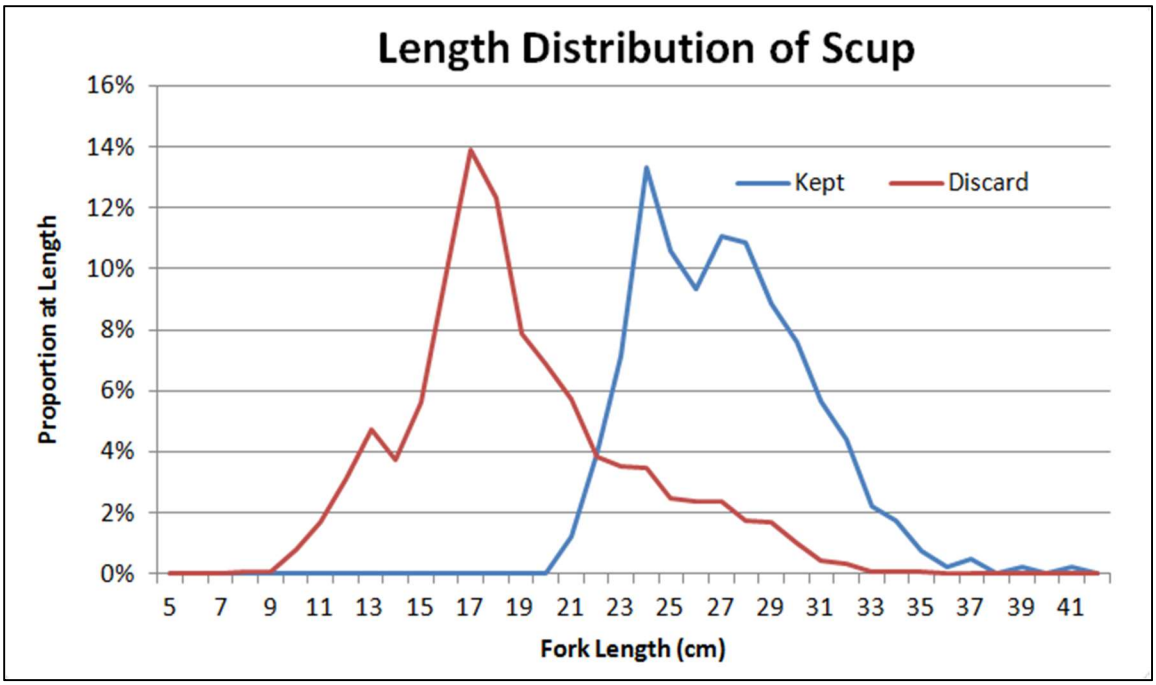

Figure 36 - Length distribution of kept (n=406) and discarded (n=3177) scup

Source: Unpublished NEFOP data

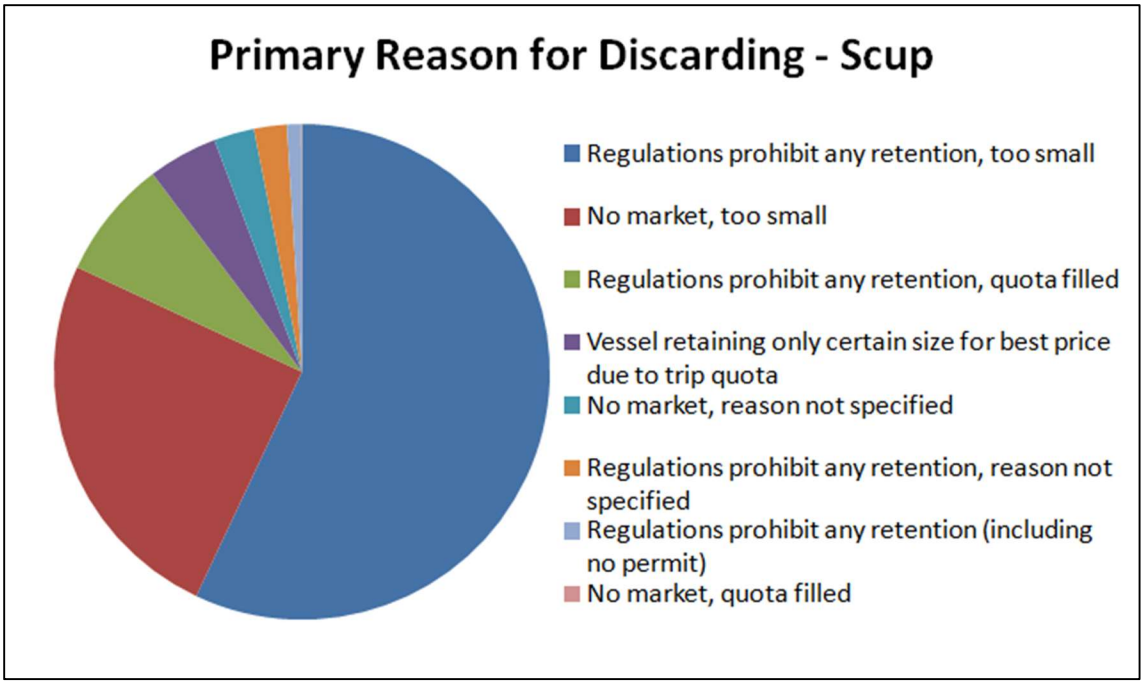

Figure 37 – Recorded reason for discarding of scup

Source: Unpublished NEFOP data

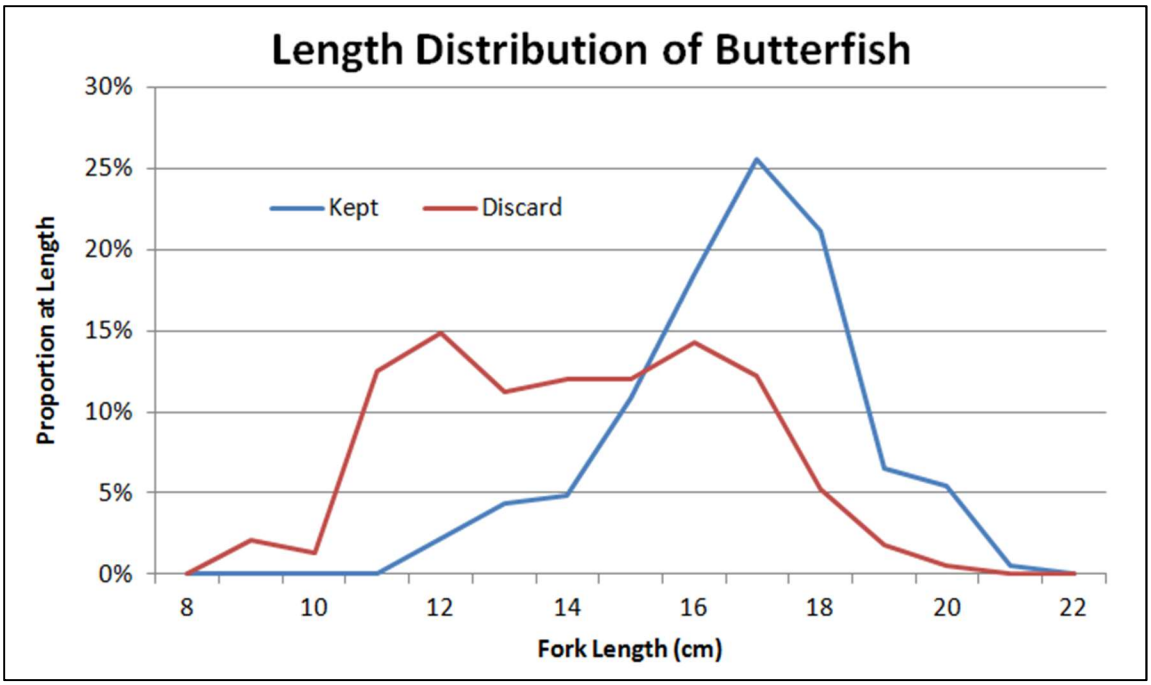

Figure 38 - Length distribution of kept (n=184) and discarded (n=384) butterfish

Source: Unpublished NEFOP data

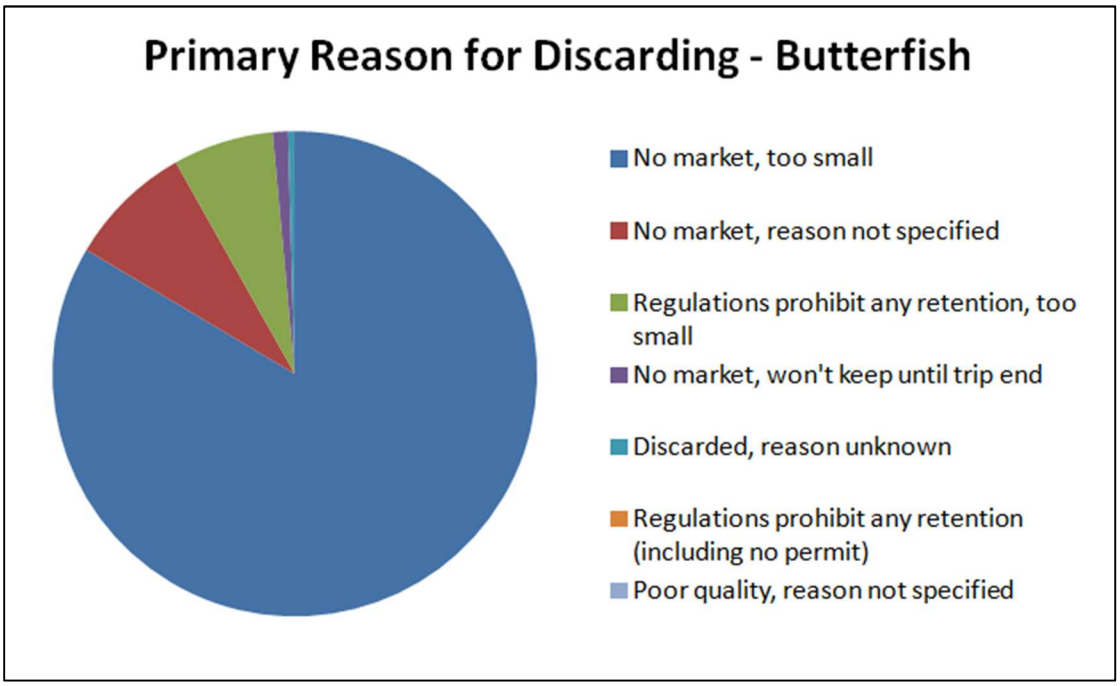

Figure 39 – Recorded reason for discarding of butterfish

Source: Unpublished NEFOP data

Species Name	Kept lbs	Discard lbs	Total lbs	Discard Ratio	Catch Ratio
SQUID, ATL LONG-FIN	755,848	1,786	757,634	0.0024	0.6158
SCUP	23,881	136,933	160,814	0.8515	0.1307
SEAWEED, NK	-	103,198	103,198	1.0000	0.0839
SEA BASS, BLACK	1,354	22,091	23,445	0.9422	0.0191
BUTTERFISH	6,330	15,376	21,706	0.7084	0.0176
SEA ROBIN, NORTHERN	24	19,129	19,153	0.9988	0.0156
SKATE, WINTER	1,162	17,705	18,867	0.9384	0.0153
FLOUNDER, SUMMER (FLUKE)	3,007	9,325	12,332	0.7562	0.0100
MACKEREL, ATLANTIC	1,988	7,811	9,799	0.7971	0.0080
DOGFISH, SMOOTH	189	6,483	6,672	0.9716	0.0054
SQUID, NK	5,950	15	5,965	0.0025	0.0048
SQUID EGGS, ATL LONG-FIN	-	5,069	5,069	1.0000	0.0041
FLOUNDER, WINTER	105	4,457	4,562	0.9771	0.0037
FLOUNDER, WINDOWPANE	250	3,354	3,604	0.9306	0.0029
ALEWIFE	100	3,249	3,349	0.9701	0.0027
CRAB, HORSESHOE	1,076	2,140	3,216	0.6654	0.0026
BLUEFISH	2,053	131	2,184	0.0602	0.0018
HERRING, NK	-	2,145	2,145	1.0000	0.0017
HAKE, SILVER (WHITING)	145	1,636	1,781	0.9188	0.0014
TAUTOG (BLACKFISH)	195	1,496	1,691	0.8849	0.0014
BASS, STRIPED	-	1,479	1,479	1.0000	0.0012
SEA ROBIN, STRIPED	64	872	936	0.9316	0.0008
SQUID, SHORT-FIN	67	797	864	0.9227	0.0007
SEA ROBIN, NK	122	700	822	0.8516	0.0007
HERRING, ATLANTIC	135	652	787	0.8287	0.0006
HERRING, BLUEBACK	-	468	468	1.0000	0.0004
SHAD, AMERICAN	-	444	444	1.0000	0.0004
LOBSTER, AMERICAN	23	319	342	0.9328	0.0003
HAKE, RED (LING)	77	253	330	0.7658	0.0003
HAKE, SPOTTED	8	308	316	0.9734	0.0003
MENHADEN, ATLANTIC	4	244	248	0.9859	0.0002
MONKFISH (GOOSEFISH)	99	97	196	0.4944	0.0002
HAKE, NK	55	97	152	0.6386	0.0001
DOGFISH, SPINY	-	118	118	1.0000	0.0001
WHELK, NK, CONCH	72	15	87	0.1686	0.0001
WEAKFISH (SQUETEAGUE)	-	34	34	1.0000	0.0000
COD, ATLANTIC	4	13	17	0.7929	0.0000
KINGFISH, NORTHERN	3	11	14	0.7887	0.0000
WHELK, TRUE UNC	3	10	13	0.7727	0.0000
WHELK, KNOBBED	7	6	13	0.4803	0.0000
Other species	6	55,438	55,444	0.9999	0.0451
Grand Total	**804,403**	**425,902**	**1,230,305**	**0.3462**	

Table 20 – Kept and discarded weights of top 40 species and species of interest, from 1,405 observed hauls

Source: Unpublished NEFOP data

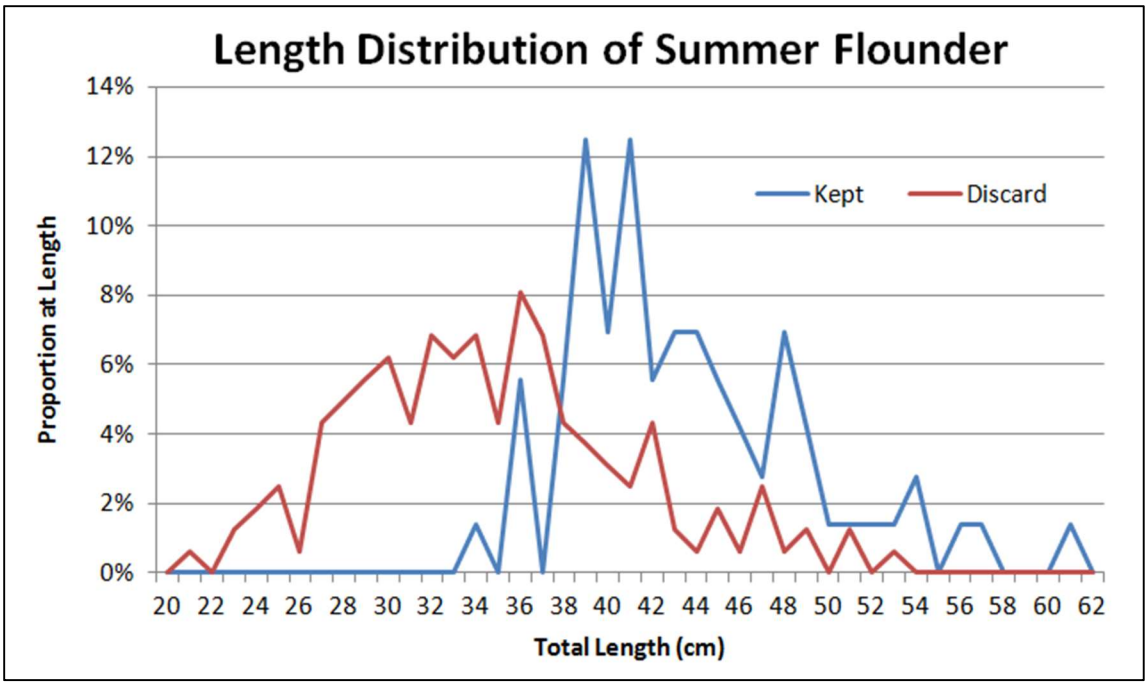

Figure 40 – Length distribution of kept (n=72) and discarded (n=161) summer flounder

Source: Unpublished NEFOP data

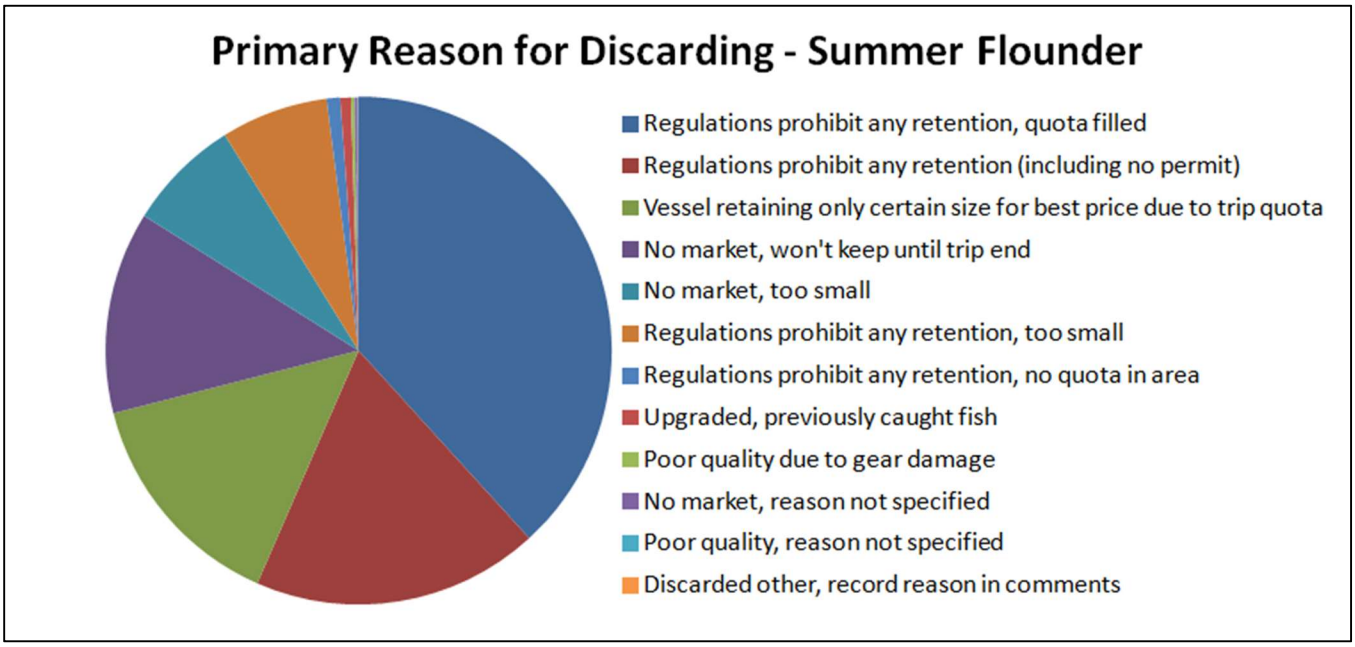

Figure 41 – Recorded reason for discarding of summer flounder

Source: Unpublished NEFOP data

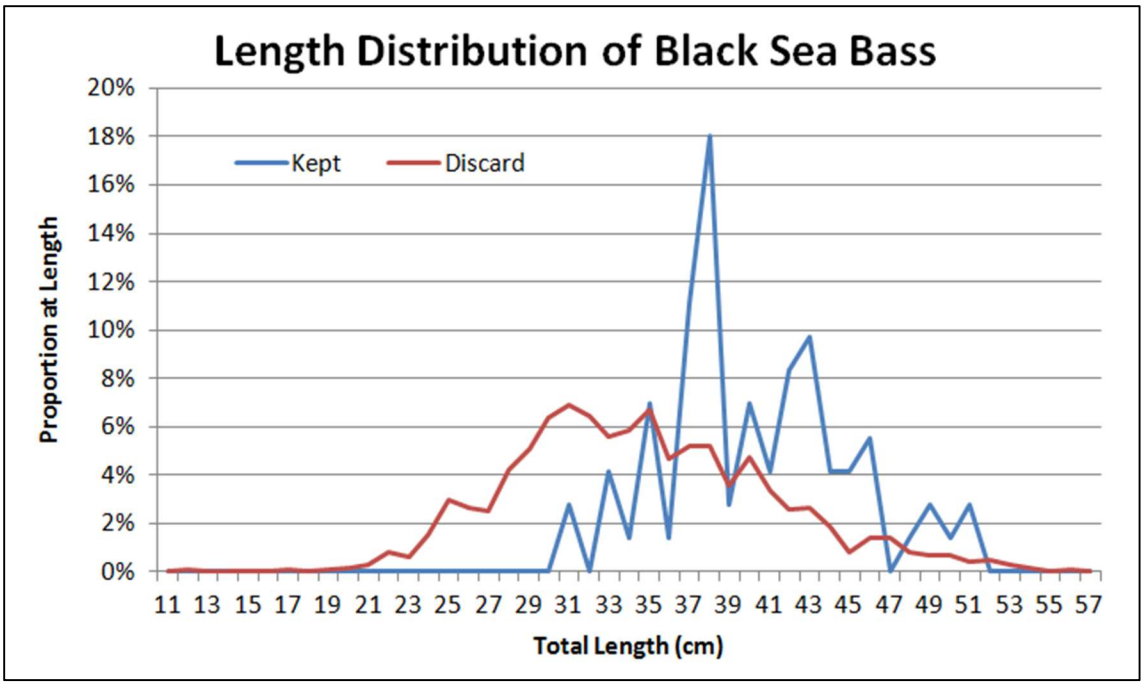

Figure 42 – Length distribution of kept (n=72) and discarded (n=1284) black sea bass

Source: Unpublished NEFOP data

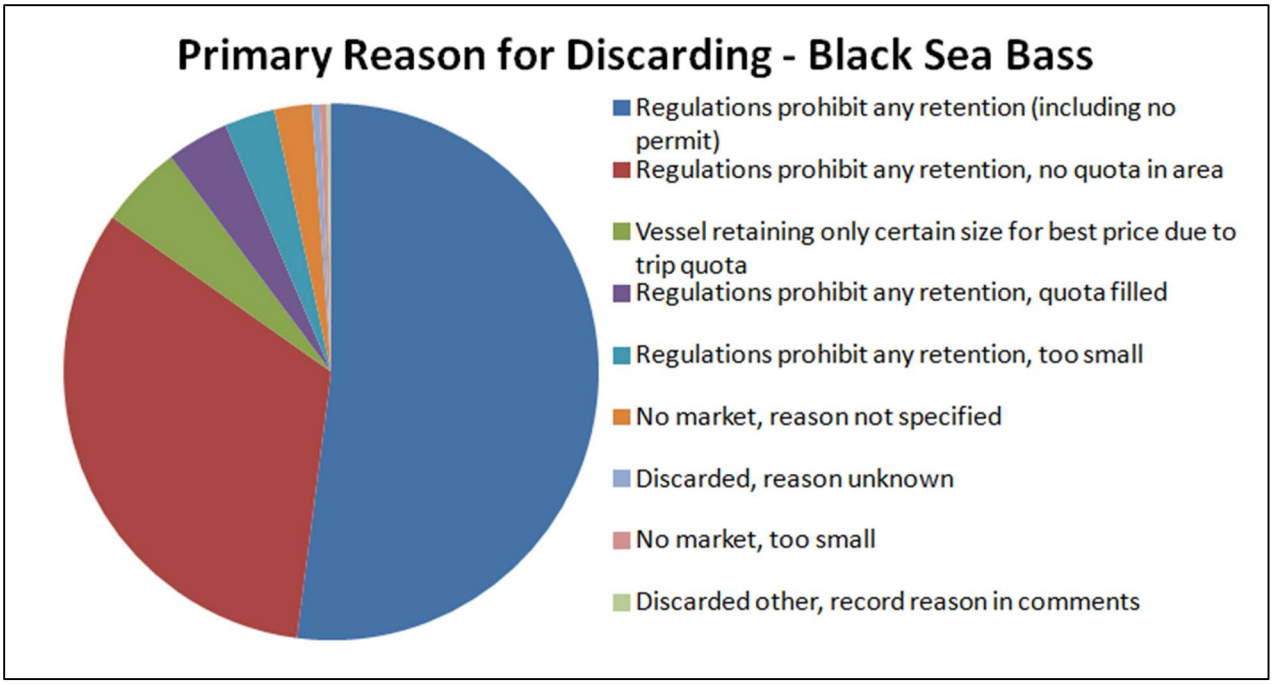

Figure 43 – Recorded reason for discarding of black sea bass

Source: Unpublished NEFOP data

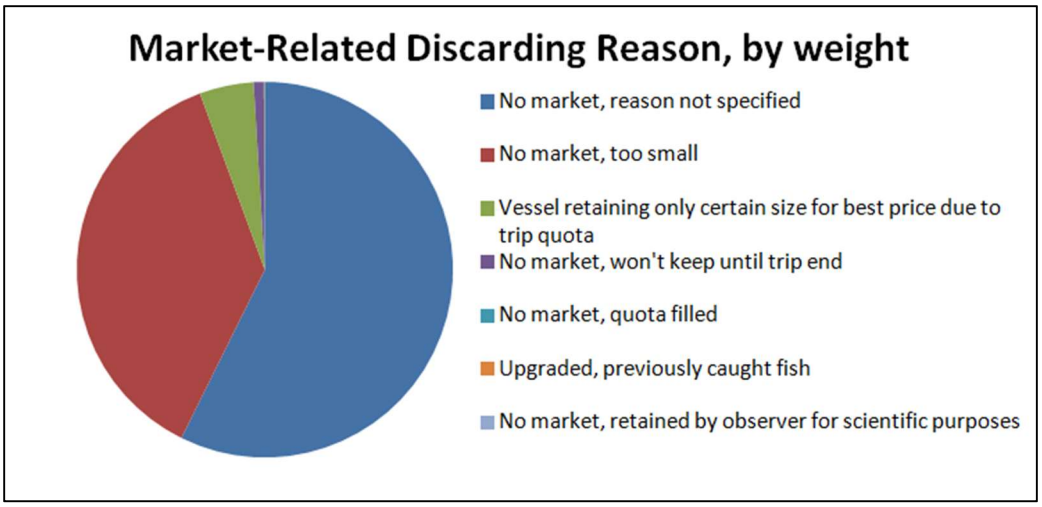

Figure 44 – Proportion of market-related discards, by recorded reason

Source: Unpublished NEFOP data

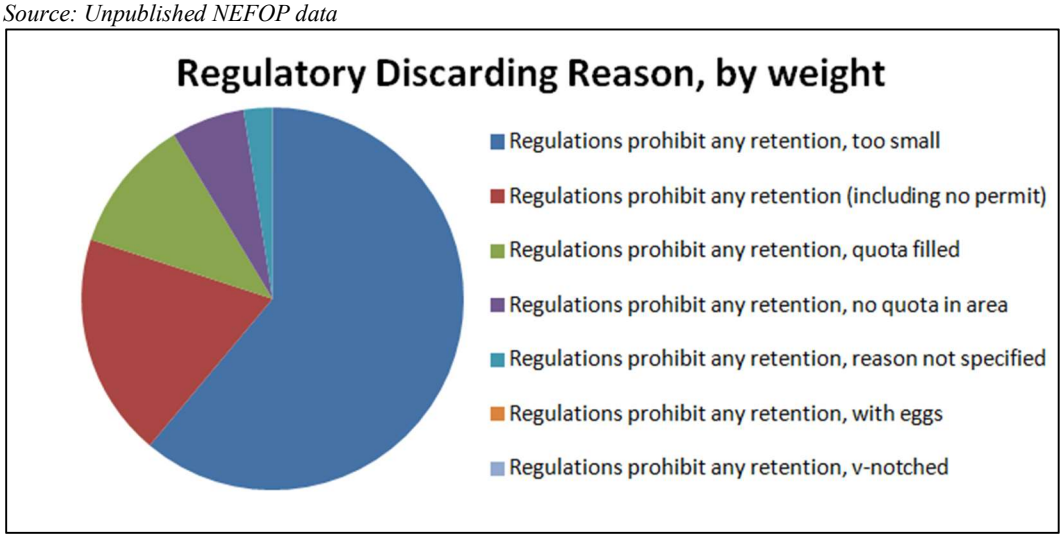

Figure 45 – Proportion of regulatory discards, by recorded reason

Source: Unpublished NEFOP data

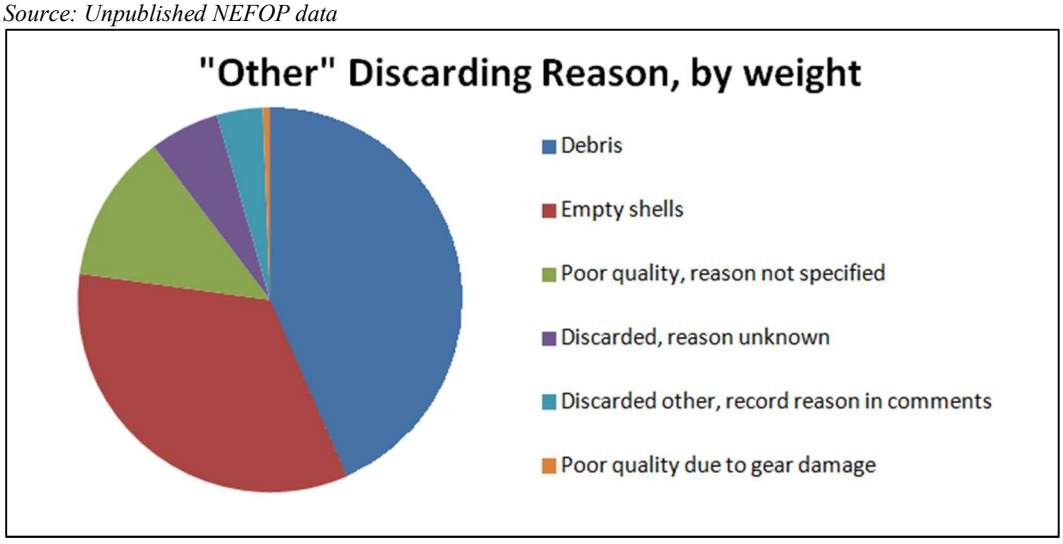

Figure 46 – Proportion of "other" discards, by recorded reason

Source: Unpublished NEFOP data

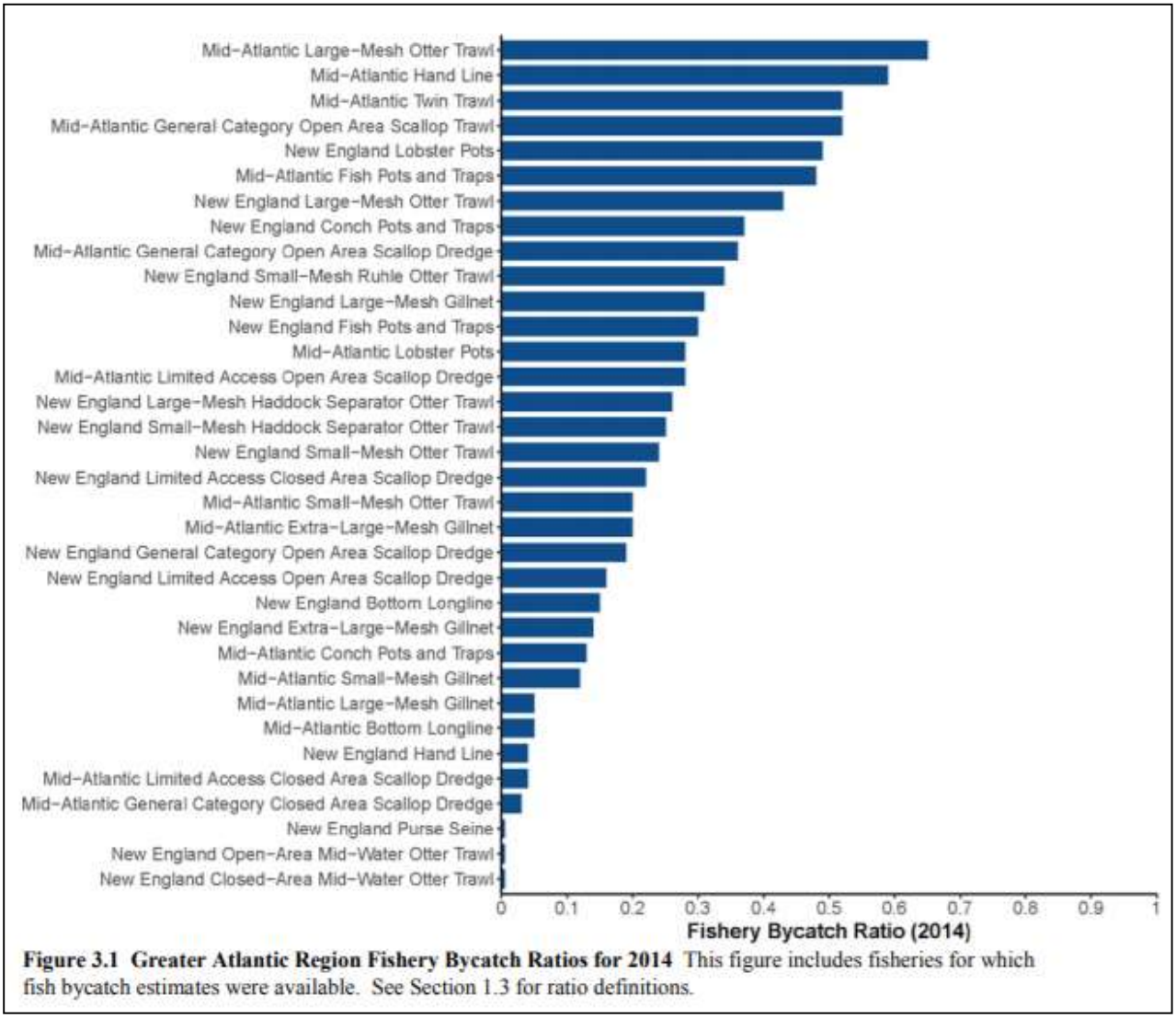

Figure 3.1 Greater Atlantic Region Fishery Bycatch Ratios for 2014 This figure includes fisheries for which fish bycatch estimates were available. See Section 1.3 for ratio definitions.

Figure 47 – Greater Atlantic region fishery bycatch ratios for 2014

Source: NOAA GARFO National Bycatch Report, 2019

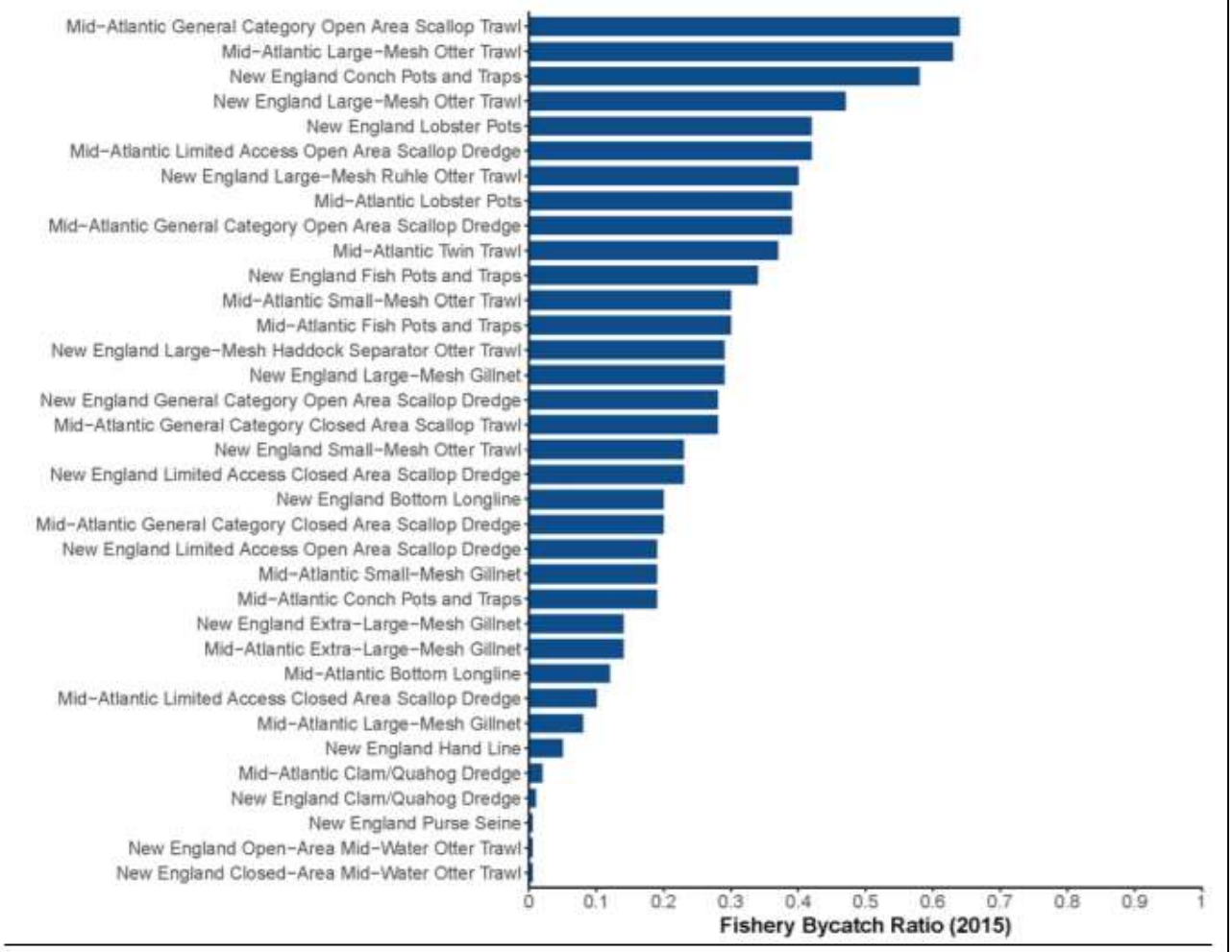

Figure 3.3 Greater Atlantic Region Fishery Bycatch Ratios for 2015 This figure includes fisheries for which fish bycatch estimates were available. See Section 1.3 for ratio definitions.

Figure 48 – Greater Atlantic region fishery bycatch ratios for 2015

Source: NOAA GARFO National Bycatch Report, 2019

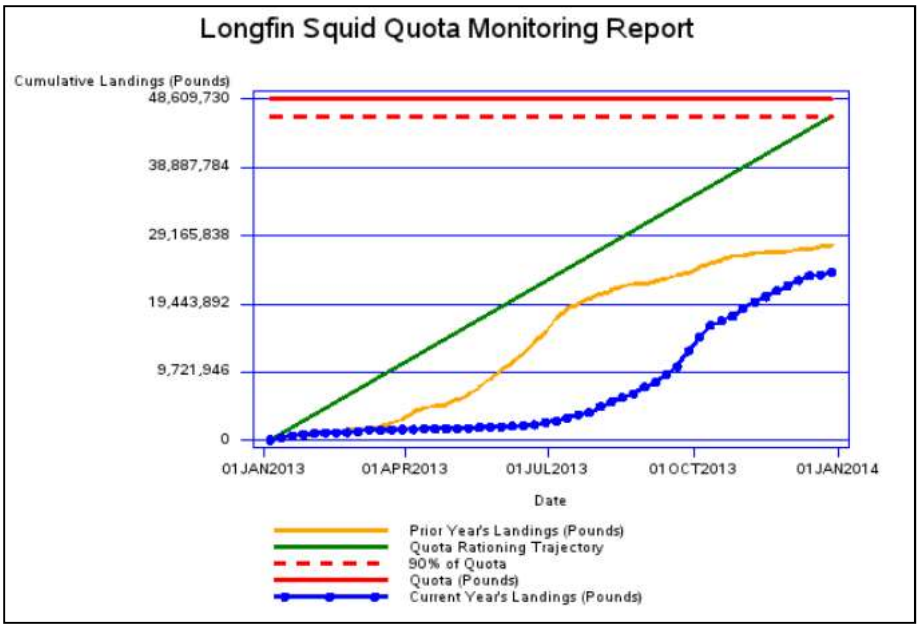

Figure 49 – NMFS Longfin Squid Quota Monitoring Report, 2013

Source: GARFO, Quota Monitoring in the Greater Atlantic Region