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United States Research Report for 2016

by

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A. Status of the Fisheries (Subareas 3- 6 Inclusive)

Revised sampling and protocols were implemented in the Northeast Region in 1994, 2004, and 2010. Auditing and allocation procedures have been used to prorate total reported landings by species among areas. However, these procedures are subject to change and the landings, by area, are therefore still considered provisional.

Most spring and autumn Northeast Fisheries Science Center survey indices for 2009-2016 were converted from the FSV *Henry B. Bigelow* catches (weights) to RV *Albatross IV* catches (weights) using a either single conversion factor or length-specific conversion factors, which have been estimated for some species. Consequently, 2009-2016 survey data points should be interpreted cautiously, and these values may change in the future as new methodologies are adopted. The 2009-2016 data points have been plotted separately in the figures presenting spring and fall survey data. In 2014, the spring survey did not cover a large portion of the Mid-Atlantic region and this has impacted the survey indices for summer flounder, southern red hake, Atlantic mackerel, Atlantic herring, spiny dogfish and little skate. The impact differs for each species and is discussed in stock specific sections.

The United States has been allocated quota for Div. 3LNO yellowtail flounder (from Canada) and, from 2012-2016, a vessel fished in the NAFO regulatory area (NAFO Div. 3LNO). A second vessel fished in the area (but included NAFO Div. 3M) for Atlantic halibut from 2014-2016. The sections for cod, haddock, yellowtail flounder, white hake, halibut, other flounders, and small elasmobranchs contain the landings and the discards of these species. The landings and discards of species not included below are summarized in Table 1. The number of samples by species, catch disposition, gear type and NAFO Division are presented in Table 2.

1. Atlantic Cod

United States commercial landings of Atlantic cod (*Gadus morhua*) in 2016 were 1,432 mt, a 6% decrease from the 2015 landings of 1,527 mt. In addition, 3.4 mt were landed from Div. 3N and 33.6 mt were discarded. In Div. 3O, 1.4 mt were discarded. In Div. 3M 25.7 mt were landed and 1.5 mt were discarded.

Northeast Fisheries Science Center (NEFSC) research vessel survey biomass indices in the Gulf of Maine remain at time series lows (Figure 1) and the stock continues to exhibit a truncated age structure and exhibit low recruitment.

The NEFSC research vessel survey biomass indices for the Georges Bank stock remain low (Figure 2) and the stock continues to exhibit a truncated age structure and exhibit low recruitment.

2. <u>Haddock</u>

United States commercial landings of haddock (*Melanogrammus aeglefinus*) in 2016 were 5,023 mt, a 7% decrease from the 2015 landings of 5,413 mt. In addition, 0.1 mt of haddock were landed in Div. 3N and 0.1 mt were discarded.

Northeast Fisheries Science Center (NEFSC) research vessel survey biomass indices in the Gulf of Maine continue to increase (Figure 3) due to the presence of several strong year classes.

The NEFSC research vessel survey biomass indices for the Georges Bank stock are near the highest levels in the time series due to several recent exceptionally strong year classes (Figure 4).

3. <u>Redfish</u>

USA landings of Acadian redfish (*Sebastes fasciatus*) decreased by 21% from 4,930 mt in 2015 to 3,887 mt in 2016. Fall research vessel survey biomass indices generally increased from 1996 through 2012 (Figure 5), with the 2010 index value of 83.47 kg/tow being the highest on record, before declining in 2013. Most recently, the survey biomass indices decreased by 2% from 46.20 kg/tow in 2015 to 45.22 kg/tow in 2016.

4. <u>Pollock (USA Waters of Areas 5&6 stock)</u>

USA landings of pollock (*Pollachius virens*) decreased by 15% from 3,046 mt in 2015 to 2,582 mt in 2016. Fall research vessel survey indices reflected a general increase in pollock biomass from the mid-1990s through 2005, before declining in 2006 (Figure 6). The survey biomass index has been variable since 2006, reaching a record-low of 0.19 kg/tow in 2009. Most recently, the index decreased by 43% from 2.27 kg/tow in 2015 to 1.30 kg/tow in 2016.

5. <u>White Hake</u>

USA landings of white hake (*Urophycis tenuis*) from NAFO Subareas 5 and 6 decreased by 18.4% from 1,628 mt in 2015 to 1,329 mt in 2016. Landings from Div. 3N and 3O were 44 mt and 0.8 mt, respectively, while 107.8 mt were discarded in Div 3N, 7.5 mt were discarded in Div 3O and < 0.1 mt in Div. 3M. Research vessel survey indices declined during the 1990s and increased in 2000 and 2001 due to good recruitment of the 1998 year class. The indices have generally been variable since 2001. The indices have increased from a low value in 2013 (Figure 7).

6. Yellowtail Flounder

USA landings of yellowtail flounder (*Limanda ferruginea*) from NAFO subareas 5 and 6 were 616 mt in 2016, a 10.5% decrease from 2015 landings of 689 mt. In Div. 3N, landings increased 45% from 507 mt in 2015 to 735 mt in 2016. Additionally, 29 mt of yellowtail flounder were discarded in Div. 3N bringing the total catch of yellowtail flounder in Div. 3N to 764 mt in 2016. In Div. 3O 1 mt of yellowtail flounder was retained and < 1 mt discarded.

The NEFSC autumn research vessel survey biomass indices in the Gulf of Maine decreased slightly over the last three years (Figure 8). In 2016, the NEFSC autumn survey biomass increased from 1.89 kg/tow in 2015, to 2.47 kg/tow (Figure 8).

The NEFSC autumn research vessel survey biomass indices on Georges Bank have been decreasing over the last eight years. In 2016, the NEFSC autumn survey biomass is among the lowest of the time series. The 2016 autumn survey was 0.44 kg/tow compared to 0.47 kg/tow in 2015 (Figure 9).

The NEFSC autumn research vessel survey biomass indices in Southern New England-Mid Atlantic continued to decline. In 2015, the NEFSC autumn survey biomass was the lowest of the time series, estimated at 0.036 kg/tow (Figure 10), however, in 2016, it increased to 0.13kg/tow.

7. Other Flounders

USA commercial landings of flounders (other than yellowtail flounder and Atlantic halibut) from Subareas 3-6 in 2016 totaled 6,219 mt, 26% lower than in 2015. Summer flounder (*Paralichthys dentatus*; 57%), winter flounder (*Pseudopleuronectes americanus*; 19% comprising the Georges Bank, Southern New England, and Gulf of Maine stocks), American plaice (*Hippoglossoides platessoides*; 18%), witch flounder (*Glyptocephalus cynoglossus*; 6%), and windowpane flounder (*Scophthalmus aquosus*; <1% comprising the Northern and Southern stocks) accounted for virtually all of the 'other flounder' landings in 2016. Compared to 2015, commercial landings in 2016 were lower for windowpane flounder (-40%), winter flounder (-32%), summer flounder (-27%), witch flounder (-19%), and American plaice (-14%). The American plaice landings from Div. 3N were 53.3 mt. In addition, 36.5 mt of American plaice were discarded in Div. 3N bringing the total catch of American plaice in Div. 3N in 2015 to 89.8 mt. Landings of American plaice in Div. 3O were 0.8 mt white discards were 0.2. Discards of American plaice in Div. 3M were low (<1 mt). Discards of witch flounder were 1.2 mt in Div. 3N and 0.3 mt in Div. 3O. Landings of witch flounder were <0.1 mt in Div. 3N and 0.2 mt in Div. 3O.

Research vessel survey indices in 2016 remained similar to the previous year's indices for southern windowpane, northern windowpane flounder, American plaice and witch flounder, and decreased for Georges Bank winter flounder and summer flounder (Figures 11-16).

Atlantic halibut

USA landings of Atlantic halibut (*Hippoglossus hippoglossus*) in the Gulf of Maine - Georges Bank region were 63 (mt) in 2016 (Table 1) and 21 mt of halibut were discarded. Research vessel survey indices have little trend and high inter-annual variability due to the low capture rate of Atlantic halibut (Figure 17). In some years there are no Atlantic halibut caught, indicating that abundance is close to being below the detectability level of the survey. Indices for 2009 - 2016 were converted from H.B. Bigelow units to Albatross IV units using the mean calibration coefficient of other flounders (Table X2).

8. Silver hake

USA landings of silver hake (*Merluccius bilinearis*) from NAFO subareas 5 and 6 were 6,337 mt in 2016, a 1.8% decrease from 2015 landings of 6,454 mt.

The NEFSC autumn research vessel survey biomass indices for northern silver hake have been generally increasing over the last ten years, with a drop between 2012 and 2013. In 2016, the NEFSC autumn survey biomass was 21.51 kg/tow, an increase from the 2015 survey value of 19.49 kg/tow (Figure 18).

The NEFSC autumn research vessel survey biomass indices for southern silver hake increased from 2009 to 2010 and have steadily decreased since. In 2015, the NEFSC autumn survey biomass was 0.42 kg/tow, the lowest value in the time series (Figure 19), though it increased to 1.30 kg/tow in 2016.

9. Red Hake

USA landings of red hake (*Urophycis chuss*) increased 4% from 472 mt in 2015 to 493 mt in 2016. Research vessel survey biomass indices for the Gulf of Maine - Northern Georges Bank stock increased after the early 1970s, markedly declined in 2003, stable through 2014, and increased in 2015 to the second highest value in the time series but has since declined again (Figure 20). Indices for the Southern Georges Bank - Mid-Atlantic stock declined in the 1990s and remained low through 2016 (Figure 21).

10. Atlantic Herring

Preliminary USA landings of Atlantic herring (*Clupea harengus*) declined, equaling 80,766 mt in 2015 and 64,801 mt in 2016. Spring survey indices declined slightly during 2009-2016 and averaged 2.16 kg/tow (Figure 22). The 2016 spring survey index was 2.01 kg/tow. Based on a 2015 update to the 2012 assessment, spawning biomass generally increased from 1982 to 1997, declined from 1998 to 2009, and increased through 2014. The 2008 year class was estimated to be the largest on record and the 2011 cohort the second largest. A retrospective pattern reemerged in the 2015 update assessment that had been largely resolved using time varying natural mortality in the 2012 assessment. While time varying natural mortality was still applied in 2015, this feature no longer appears sufficient to remove the retrospective pattern. Age composition data show that the 2008 cohort has persisted and still significantly contributes to the fishery, but the 2011 cohort also comprises a large proportion of survey and fishery catches in recent years.

11. Atlantic Mackerel

USA commercial landings of Atlantic mackerel (*Scomber scombrus*) decreased 3.2% from 5,616 mt in 2015 to 5,437 mt in 2016. Recreational catches increased 22.5% from 1,157 mt in 2015 to 1,419 mt in 2016. Accordingly, 1968-2013 abundance indices were re-estimated using an abbreviated set of offshore strata and compared to estimates based on the full offshore strata set historically used to estimate mackerel spring survey indices. This comparison indicated that the use of an abbreviated set of strata did not impact temporal trends in relative abundance or biomass and only resulted in small changes in magnitude. Consequently, the full set of offshore strata was used here to derive relative abundance and biomass indices from 1968-2016, but it should be noted that the 2014 survey index is not based on all of the strata incorporated into the indices of other years. Spring survey indices increased during the 1990s and averaged 7.1 kg/tow during the last ten years (2007-2016). The spring survey index decreased from 9.29 kg/tow in 2015 to 4.34 kg/tow in 2016 (Figure 23). Estimated 2016 relative abundance was lower than the time series median of 23.26 mackerel-per-tow and 2016 relative biomass was equivalent to the time series median. A U.S. benchmark stock assessment is planned for the Fall of 2017.

12. Butterfish

USA landings of butterfish (*Peprilus triacanthus*) decreased 43.8% from 2104 mt in 2015 to 1,182 mt in 2016. Fall research vessel survey biomass indices have fluctuated substantially since the 1970s, but were generally highest in the late 1970s to early 1990s. Since 1995, annual values have typically been less than the long-term average (mean = 6.21 kg/tow). Biomass in 2016 was 6.21 kg/tow (Figure 24).

13. Squids

The USA small-mesh bottom trawl fishery for longfin inshore squid, *Doryteuthis (Amerigo) pealeii* began in 1987. During 1987-2015, landings averaged 15,362 mt, with a low of 6,913 in 2010 and a peak of 23,738 mt in 1989. In addition to other factors, landings have been affected by in-season quotas, since 2000, which have been trimester-based since 2007. During 2007-2015 landings were below the 1987-2015 mean and averaged 10,830 mt, but increased to 18,379 mt in 2016.

Fall survey relative abundance indices of longfin inshore squid (derived using only daytime tows) declined from the third highest point in the time series during 2006 (1,778 squid per tow) to 339 squid/tow in 2011 (Figure 25). During 2012-2014 relative abundance increased and was above the 1975-2015 median of 651 squid per tow, but then declined from 1,371 squid per tow in 2012 to 536 squid per tow in 2016.

The USA small-mesh bottom trawl fishery for Northern shortfin squid (*Illex illecebrosus*) began in 1987. During 1987-2015, landings averaged 12,095 mt, with a low of 1,958 mt in 1988 and a peak of 26,097 mt in 2004. In recent years, landings declined substantially from 18,797 mt in 2011 to 2,422 mt in 2015. Landings totaled 6,684 mt in 2016.

Fall survey relative abundance indices of Northern shortfin squid attained a record-high in 2006 (29.5 squid/tow) then steadily declined below the 1967-2015 median (8.0 squid per tow) to 4.7 squid/tow in 2013. Thereafter, relative abundance increased and was slightly above the median in 2015 (9.5 squid per tow) then declined to 7.6 squid per tow in 2016 (Figure 26).

14. Atlantic Sea Scallops

USA Atlantic sea scallop (*Placopecten magellanicus*) landings in 2016 were 18,526 mt (meats), an increase of about 2,300 mt over 2015. The ex-vessel value of the landings was

$486 million, about $48 million higher than 2015. Landings are expected to increase further during 2017-2018 as the very strong 2012 Georges Bank and 2013 Mid-Atlantic year classes enter the fishery.

The total biomass in 2016, based on dredge and optical surveys, was about 250,000 mt (meats), the highest on record, with about 156,000 mt on Georges Bank and 94,000 mt in the Mid-Atlantic.

15. Northern Shrimp

The USA fishery for northern shrimp has been closed since 2014 due to extremely low abundance of all life stages based on fishery independent surveys of northern shrimp in the Gulf of Maine. Recruitment indices have been at lowest observed values in three of the five years since 2012 (the time series began in 1984). Warming temperatures, increased predation pressure and overexploitation are factors thought to have been responsible for the collapse. Recruitment improved slightly in 2016, but the fishery remains closed.

16. Small Elasmobranchs

USA landings of spiny dogfish (*Squalus acanthias*) decreased 20% from 10,805 mt in 2014 to 8,656 mt in 2015. In addition, <0.1 mt were discarded in Div. 3N. Survey indices, which are highly variable, generally declined between the early 1990s and 2005, but increased sharply in 2006 and have since remained high (Figure 28). The 2014 data point is plotted, although the comparability with previous years has not been evaluated. The area not covered by the survey generally has a large proportion of the spiny dogfish biomass.

USA landings of skates (most species are still landed as unclassified) decreased 6% between 2014 and 2015 from 15,403 mt to 14,515 mt. The landings are sold as wings for human consumption and as bait for the lobster fishery. In addition, 55.1, 0.5, 0.2 and 1.3 mt of thorny skate were discarded in Div. 3N, 3L, 3M and 3O, respectively. Barndoor skate were also discarded in the same areas (0.5, 0.3, 0.3 and 0.1 mt). An additional 0.8 mt of spinytail, deepwater, spinytail and other skates were discarded in Subarea 3.

Survey biomass indices for winter skate (*Leucoraja ocellata*) peaked in the mid-1980s (Figure 29) but then declined, possibly due to an increase in the directed fishery in the late 1980s and early1990s. During the mid-1990s, the indices stabilized at an intermediate level, increased through 2009, declined through 2013, but increased in 2014. Although the index declined in 2015, it remained above the 2012-2013 values.

For little skate, the lack of coverage in the southern strata described above for spring 2014 was analyzed for the entire time series to show the difference between including and excluding these strata on the estimate of mean abundance. In general, little skate are more abundant in the northern strata. Thus relative abundance estimates (catch per tow) based on the northern strata only will be higher than estimates based on the entire strata set. Over the entire time series (1968-2013) the ratio of the time series without the southern strata to the full strata set is 1.091. Little skate (*Leucoraja erinacea*) survey indices have generally fluctuated without trend (Figure 30).

Survey indices for barndoor skate (*Dipturus laevis*) declined markedly in the mid-1960s, remained very low through the late-1980s, and subsequently increased to levels observed in the mid-1960s (Figure 31). Thorny skate (*Amblyraja radiata*) survey indices have declined over the entire time series, and are currently near record lows (Figure 32). Survey indices for smooth skate (*Malacoraja senta*) are highly variable, but have been generally stable for the last 20 years (Figure 33). Indices for both clearnose skate (*Raja eglanteria*) and rosette skate (*Leucoraja garmani*) generally increased over the time series (Figures 34 and 35).

B. Special Research Studies

1. Environmental Studies

a) Hydrographic Studies

A total of 1,356 CTD (conductivity, temperature, depth) profiles were collected and processed by the Northeast Fisheries Science Center (NEFSC) in 2016 during 7 research cruises. Of this total, 1,316 CTD profiles were obtained within NAFO Subareas 4, 5, and 6 Cruise reports, annual hydrographic summaries, and data are accessible at: http://www.nefsc.noaa.gov/epd/ocean/MainPage/index.html.

Hourly bottom temperature records obtained by participants of the Environmental Monitors on Lobster Trap Project (see emolt.org) at approximately 60 fixed locations/depths around the Gulf of Maine and Southern New England Shelf indicate that 2016 was almost as warm as 2012. These 16-year time series of hourly bottom temperatures at many locations are now being compared to multiple ocean models and, in some cases, being assimilated into hindcast runs.

Real time bottom temperature is now being reported from approximately a dozen Study Fleet Trawlers when the fishermen haul their gear. Beginning in May 2015, approximately 100 trawl-averaged bottom temperatures have been automatically transmitted each month via satellite from a variety of locations and depths. A pilot study is underway to send weather data as well.

Approximately 150 satellite-tracked surface drifters were deployed off the coast of New England in 2016, and dozens more are planned for 2017 (see http://www.nefsc.noaa.gov/drifter). The collective archive helps resolve the transport pathways of coastal currents in shelf waters. The drifter project is promoted as an educational tool where students are involved with both the construction of the instruments and the processing, plotting, and analysis of the data. Sensor packages are now being developed and housed on these drifters and a few dozen unmanned sailboats (see http://educationalpassages.org).

b) Plankton Studies

During 2016, zooplankton community distribution and abundance were monitored using 635 bongo net tow samples taken on six surveys. Each survey covered all or part of the continental shelf region from Cape Hatteras northeastward into the Gulf of Maine. 2016 was the third year where the Imaging FlowCytoBot unit from the Woods Hole Oceanographic Institute was used to collect images of phytoplankton from the scientific seawater flow-through system on all three ecosystem monitoring cruises. In addition, these three ecosystem monitoring cruises conducted a total of 424 nutrient casts done in collaboration with the University of Maine to monitor levels of nutrients in the euphotic zone. The three dedicated ecosystem monitoring surveys also collected 44 plankton samples for the Census of Marine Zooplankton Program, based at the University of Connecticut. These samples, collected with a set of smaller bongo nets, were for genetic analysis of the planktonic organisms to supplement identifications made by traditional visual taxonomic means. These same three surveys also collected 218 additional plankton samples with a smaller bongo net for larval fish and egg sample genetics studies. During an Atlantic Marine Assessment Program for Protected Species (AMAPPS) cruise conducted in August there were twenty four 1 x2meter net midwater trawls taken to capture Bluefin tuna larvae.

c) Benthic Studies

Wind Energy Benthic Habitat Investigation: Two new cruises were added this year to increase the amount of data available on habitat characterizations. Cruise time for wind energy-related benthic studies during 2016 was obtained aboard NOAA Ship *Pisces*: cruise PC16-06. Benthic sampling and multibeam mapping were performed in conjunction with a multi-year contract with the U.S. Department of Interior Bureau of Ocean Energy Management (BOEM) for a preliminary investigation of benthic/demersal habitats in designated wind energy lease areas (WEAs) off the coast of the northeast United States. Eight such areas have been designated by BOEM in association with adjacent states between Cape Cod, Massachusetts and Cape Hatteras, North Carolina (asterisks * indicate areas mapped and sampled during 2016):

- NAFO Subdivision 5Zw: Massachusetts (MA WEA), Rhode Island-Massachusetts (RIMA WEA),
- NAFO Division 6A: New York* (NY WEA), New Jersey (NJ WEA),
- NAFO Division 6B: Delaware (DE WEA), Maryland (MD WEA),
- NAFO Division 6C: Virginia (VA WEA), and North Carolina-Kitty Hawk (NC-KH WEA).

All WEA areas are located entirely on the continental shelf at depths ranging approximately 10-45 nautical miles (19-83 km) offshore in water depths of 15-60 m. The total area of these WEAs is about 2.6 million acres (≈10,500 km^2). The entire program involves high resolution acoustic mapping of the bottom in selected portions of WEAs as well as characterization of oceanographic conditions, topography, sediments, and benthic biota, including infauna, epifauna, and demersal fishes. Other acoustic mapping and underwater camera surveys of bottom have been performed before 2016, and a great deal of pre-existing data has been amassed for purposes of building benthic habitat profiles of the WEAs. Of particular interest are patches of hard substrate (gravel to boulders and rock outcrops) that may serve as shelter for shelter-seeking demersal fishes, e.g. black sea bass (*Centropristis striata*), scup (*Stenotomus chrysops*), and tautog (*Tautoga onitis*), and are potentially vulnerable to disturbance from construction or operational activities.

The 2016 Benthic Habitat cruise aboard *Pisces* was devoted to grab sampling for sediment grain size and benthic infaunal analysis and trawling with a 2 m beam trawl for epibenthic/demersal fauna in the NY WEA. The MD WEA was sampled in 2013, MA, RIMA, NY, NJ, and VA WEAs were sampled in 2014, and DE, VA, and NC-KH WEAs in 2015. During the 2016 *Pisces* cruise, 1) approximately 100 sq. km. of the NY WEA were mapped to a horizontal resolution of about 2 m, 2) 38 sites were sampled for benthic epifauna and sediments within the NY WEA. Sediment samples were taken with a Young-modified Van

Veen grab sampler and trawl samples were taken with a 2 m beam trawl with a 0.25" (6.35 mm) mesh net towed at 2 kt (1 m/sec) for 15-20 minutes. CTD profiles were collected at each station. Grab, trawl, and CTD operations were conducted on a 24-hour basis. Beam trawl catches were identified on board the cruise and benthic infauna were preserved for identification by a consultant on shore following the cruise.

Beam trawl catches were obtained from the same 38 benthic sampling stations. Catches in the NY WEA included 60 recognizable taxa (24 fishes, 35 invertebrates) in which the common sand dollar (*Echinarachnius parma*) was the overwhelming dominant in terms of both numbers and weight. Egg mops and early stage juveniles of longfin squid, little skates and skate eggs were also notable catches and widespread. Distribution patterns for sea scallops, little skates and sand dollars appeared to be related to hydrography, while black sea bass were more likely related to substrate. Samples for microplastic analysis were taken for the first time in the coastal ocean off the New York-New Jersey Harbor.

A number of taxa of interest were identified from among the epifaunal catches made with the 2 m beam trawls. Among these were little skates, flounder (summer, windowpane, and Gulf Stream), sea scallops, and black sea bass. Little skate catches comprised of mix of juveniles and adults, and were widely distributed within the NY WEA. However, they were encountered more frequently and in greater numbers in the southwest third of the WEA, corresponding approximately to depths beyond the 36 m contour. Summer and windowpane flounder catches were also widespread, but demonstrating no clear pattern on the scale of the WEA. Gulf Stream flounders were also widespread, but did demonstrate aggregation, with up to 74 individuals caught in one tow. Again, there was no clear pattern of distribution on the scale of the entire WEA. Sea scallops, like little skates, were widely distributed but more frequently encountered and in greater numbers in the southwest third of the WEA. The catch consisted of a wide range of sizes, spanning sub-legal to legal sizes. Black sea bass (*Centropristis striata*) are among the taxa of interest because, besides being a federally managed species, they are a species that seeks structured bottom habitats and shows substantial habitat fidelity seasonally during the warm season. This makes this stock potentially liable to impact from any human activities that may disturb hard bottom habitats, which are relatively rare in the region. Furthermore, nearshore habitat locations, particularly for young fish that appear to avoid adult habitats to avoid cannibalism, are poorly known. Fifteen black sea bass were caught in the NY WEA. Of these, ten (up to 5 per station) were caught in stations at the northwest end of the WEA, corresponding to the fishing area known as Cholera Bank. Only single individuals were caught at other stations, and none were caught at the southeast end of the WEA. All were juveniles, probably mostly young-of-the-year (YOY).

It is speculated that patterns of distribution of sand dollars, little skates and sea scallops, all of which are more abundant in the southeastern part of the WEA, may be related to this hydrographic pattern in which cooler water persists on the bottom through the summer in the southeastern area. The distribution of black sea bass in the shallower northwest, where the water column was isothermal by late summer, is more likely related to bottom substrate, but that remains to be demonstrated as the multibeam sonar data are analyzed.

Deep Sea Coral Investigations:
Since 2012, a major initiative has been underway in the northeast to locate, survey, and characterize deep-sea coral and sponge communities in this region. The fieldwork initiative

was guided by a Northeast Fieldwork Planning Team, implemented by Northeast NOAA scientists in collaboration with other NOAA line offices, other government agencies (including the Canadian Department of Fisheries and Oceans), and researchers from academic institutions, and funded in large part by NMFS's Deep-sea Coral Research and Technology Program. Because of the remoteness and inaccessibility of the Northeast's most significant structure forming deep-sea corals and sponge habitats, along with the scarcity of previously known deep-sea coral and sponge habitats in this region, as well as the lack of an already established deep-sea coral and sponge research infrastructure in the NEFSC, fieldwork on these organisms was a major logistical and financial undertaking. Much of what has been accomplished thus far required collaborative research partnerships and leveraging of funding. Also, because these projects were designed with the participation of the New England Fishery Management Council (NEFMC) and Mid-Atlantic Fishery Management Council (MAFMC), and their needs and goals were always kept at the forefront, the emphasis during the fieldwork initiative was on baseline exploration and reconnaissance, while trying to survey as many areas as possible, with data workup and analyses following. In addition, the projects would also be providing information and contributing to management decisions by other regional NOAA partners (e.g., Mid-Atlantic Regional Council on the Ocean, [MARCO]). Thus, the fieldwork initiative was designed to satisfy resource management needs as a major priority while significantly increasing our understanding of the region's deep-sea coral and sponge ecosystems.

The major objectives of the fieldwork initiative included:

- Assisting resource managers by characterizing the deep-sea coral and sponge ecosystems and determining the distribution, abundance, and diversity of deep-sea corals/sponges in select areas of the continental slope, including the submarine canyons, the seamounts within the EEZ, and select areas of the Gulf of Maine where major structure forming corals/sponges may or were known to exist. Establishing the spatial extent of corals/sponges in these areas, their scales of patchiness, and correlation with substrate features.
- Collecting specimens, where possible, for taxonomic analyses, age and growth studies, genetic analyses, and reproduction studies.
- Using the deep-sea coral/sponge survey and distribution data to refine the next iterations of the Northeast's deep-sea coral habitat suitability model; conversely, the model assisted in choosing survey sites and is thus continuously "field tested" and ground-truthed. These maps then assisted the regional Fishery Management Councils in drafting management alternatives to designate deep-sea coral zones in this region and also guide the planned field research.
- Continuing collaborative work with other NOAA line offices (NOS NCCOS, OER, OCS) to obtain high resolution multibeam maps and data of the Northeast shelf, slope, and seamounts where corals/sponges are known to or may occur.
- Assisting the NEFSC groundfish and shellfish surveys and the Observer Program in better identifying and quantifying their deep-sea coral and sponge bycatch.

By combining Program resources with other partners within and outside of NOAA, leveraging funding, and employing a wide range of research tools, the initiative advanced deep-sea coral science and management through three major fieldwork projects:

1. Surveys and exploration of coral/sponge habitats in submarine canyons, slope areas, and seamounts off New England and the Mid-Atlantic. These included at least 33 submarine canyons from the Hague Line to North Carolina (i.e., Heezen Canyon to Norfolk Canyon) and the four seamounts within the EEZ (Bear, Physalia, Retriever, and Mytilus).
2. Characterizations of seafloor communities in the U.S. and Canadian cross-boundary Gulf of Maine region (i.e., central Jordan Basin) and on the U.S. and Canadian continental margin (slope and canyons both north and south of the Hague Line).
3. Surveys of northern U.S. Gulf of Maine habitat areas for deep-sea corals and sponges at around 200 m, specifically in areas of Western and Central Jordan Basin, Outer Schoodic Ridges, Mount Desert Rock, and Georges Basin/Lindenkohl Knoll. Includes collecting specimens of the common sea pen (*Pennatula aculeata*) to determine if they are being used by fish larvae (perhaps redfish, *Sebastes* spp.) as nursery habitat, as has been observed in Canada (Baillon et al. 2012).

Detailed analyses of seafloor images to revise/refine the deep-sea coral predictive habitat model and to determine coral and sponge distributions in relation to geology, associated species (especially commercially important species), and coral size structure are ongoing. Specimens are being analyzed for taxonomy, reproduction, age/growth, genetics, and possible nursery habitat/essential fish habitat for redfish. Both the NEFMC and MAFMC have used and continue to use the information and results gathered from the recent surveys and the habitat suitability model to draft management alternatives to designate deep-sea coral zones in the Northeast and Mid-Atlantic and implement fishing restrictions necessary to protect the deep-sea corals within those zones. Peer-reviewed papers, reports, and data products are being produced and future exploratory research surveys and high resolution seafloor mapping efforts are being planned.

2. <u>Biological Studies</u>

a) <u>Fish Species</u>

<u>Flatfishes</u>: The team of researchers at the NOAA NMFS Howard Laboratory (Highlands, New Jersey), along with collaborators within the Northeast Fisheries Science Center and in academia, continue to implement experimental studies designed to evaluate the potential effects of future ocean conditions (elevated CO_2 and water temperature) on early life-stages of marine fishes. The key elements of this broad yet adaptive approach are that it uses i) multiple species that differ in their ecologies and resource values, ii) wide yet realistic ranges of environmental conditions (e.g., concurrent manipulation of CO_2 levels and water temperatures), and iii) diverse, ecologically relevant response variables. The research team has grown by bringing in colleagues and collaborators with different skills with respect to the set of biotic response variables to be included in the analyses. To date, we have completed seven experiments that evaluate the effects of high CO_2 seawater on the early life-stages of

finfish important to the NW Atlantic. Two experiments have been conducted on summer flounder, *Paralichthys dentatus*, four on winter flounder, *Pseudopleuronectes americanus*, and a new set of studies on Atlantic silverside, *Menidia menidia*. The first experiment on summer flounder, a one-way experimental design with CO_2 levels as the factor (at 3 levels) is complete and published (Chambers et al. 2014. *Biogeosciences*, 11, 1613-1626, doi:10.5194/bg-11-1613-2014, 2014.). The rates of growth and development of larvae in these two-way experiments are currently being analyzed. The responses scored are viability, survival, developmental rate, growth rate, histological changes, otolith allometry, biochemical measures of fish condition, and differential gene expression. Our results from the summer flounder one-way design showed a significant negative affect of increased CO_2 on embryo survival and on larval growth and development. Larvae were initially larger, develop more quickly but metamorphose at smaller sizes at high CO_2 levels. Results from the 2-way experiments on both flounder species show significant though opposite effects of CO_2 on fertilization rates with a negative impact of increasing CO_2 on fertilization in summer flounder but a positive one in winter flounder. Both species exhibited significant interactions in responses to CO_2, temperature, and parentage. In 2015 – 2016 we implemented OA work on two fronts: 1) the potential for transgenerational effects on the resilience of offspring to high CO_2, and 2) intraspecific, inter-population differences in resilience to high CO_2 between stocks that experience contrasting levels of environmental variance in CO_2 in situ. For the former study we are evaluating responses in three small-bodied forage species that can be housed and accommodated by our in-house CO_2 delivery system. Those taxa are Atlantic silverside (*Menidia menidia*), mummichog (*Fundulus heteroclitus*), and Atlantic tomcod (*Microgadus tomcod*). Juveniles are currently being maintained in the laboratory for spawning in 2017. Winter flounder is our experimental model for the inter-population contrasts. In early 2016 we collected and spawn adults, and compare responses of offspring derived from parents collected inshore at two latitudes (New Jersey, New Hampshire) with those from an offshore spawning population (Stellwagen Bank offshore from Massachusetts). The silverside work in 2016 focused on baseline informationon phenotypic variation and the environmental and genetic contributions to that variance. A new CO_2 delivery system was developed that allows us to expose test subjects to up to 12 constant or 6 fluctuating CO_2 regimes. Initial evaluations of the system look very promising and this high-frequency CO_2 system (HFCO2) will allow us to quantitatively characterize the shape of responses to elevated CO_2. During 2017 we anticipate using this system to explore CO_2 driven reaction norms, interactions between CO_2 and other environmental co-stressors, and the role of parentage in affecting the sensitivity / resilience of early life stages to elevated CO_2 levels.

<u>Sturgeons</u>: During 2014-15 we conducted multiple experiments on habitat constraints in shortnose and Atlantic sturgeons (*Acipenser brevirostrum* and *A. oxyrhynchus*, respectively) that built upon our earlier pilot eco-toxicological studies. Our earlier work evaluated the toxic responses of embryos and larvae after aqueous exposures to PCB 126 and TCDD (dioxin). Rates of uptake of radiolabelled PCB126 were also quantified. We measured viability, macro-phenotypic characters (e.g., days to hatch, morphometrics of recently hatched larvae, and starvation resistance), and molecular responses (CYP1A1). Uptake was a linear function of exposure doses, and lethal and sublethal toxicities to both contaminants were expressed in both species in responses including survival of early life-stages, the size and shape of larvae, and the development of key organs. These results are summarized in Chambers et al. 2012 (*Environmental Toxicology and Chemistry* 31:2324-2337). Our new work, funded for two years by the Hudson River Foundation, the NOAA National Ocean Service Office, and the Delaware River Basin Commission (DRBC) is evaluating the separate and combined effects of toxins and climate change on early life-stages of both sturgeon

species. The toxins to be used in 2014 were four congeners of PCBs (77, 81, 126, and 169), an Aroclor mixture, and dioxin. We challenged embryos to the entire thermal tolerance range of each species with up to 40 different constant temperatures which allowed us to clearly depict the functional form of phenotypic plasticity. In 2015 we conducted 2-way designs (toxin × temperature) in order to evaluate the interactive effects of these co-stressors. In addition, the DRBC-funded component evaluated the role of dissolved oxygen (hypoxia) with thermal warming as a co-stressor in Atlantic sturgeon. Sturgeon larvae were exposed to acute (2-hr) reductions in DO from 10 mg/L to 8, 6, 4, and 2 mg/L and scored for activity (based on video tracking) and prey consumption (maximum intake and attack rate inferred through functional response trials). Those data were presented at a USGS-NOAA workshop in May 2016 and at the Annual American Fisheries Society Meeting in August 2016.

Codfish: During 2016 we conducted multiple experiments on habitat constraints in Atlantic tomcod (*Microgadus tomcod*) that built upon our earlier eco-toxicological studies. Our earlier work evaluated the toxic responses of embryos and larvae after aqueous exposures to PCB 126 and TCDD (dioxin). Rates of uptake of radiolabelled PCB126 were also quantified. We measured viability, macro-phenotypic characters (e.g., days to hatch, morphometrics of recently hatched larvae, and starvation resistance), and molecular responses (CYP1A1). Uptake was a linear function of exposure doses, and lethal and sublethal toxicities to both contaminants were expressed in both species in responses including survival of early life-stages, the size and shape of larvae, and the development of key organs. Some of these results are summarized in Wirgin et al. 2014 (*Science* 331: 1322-1325). Our new work, funded for two years by the Hudson River Foundation evaluates the separate and combined effects of toxins and climate change on early life-stages of tomcod. The toxins used in 2016 were four congeners of PCBs (77, 81, 126, and 169), an Aroclor mixture, and dioxin. We challenged embryos to the entire thermal tolerance range of each species with up to 40 different constant temperatures which allowed us to clearly depict the functional form of phenotypic plasticity. In 2016 we also conducted 2-way designs (toxin × temperature) in order to evaluate the interactive effects of these co-stressors. In addition, the role of dissolved oxygen (hypoxia) with summer thermal regimes as a co-stressor after exposure of Atlantic tomcod to these contaminants..

A new program has been established:
Environmental Factors Controlling Ocean Finfish Abundances and landings.
A program has been underway since April, 2016 to investigate and describe the environmental factors that control abundances of commercially-important fish off the northeastern United States. This is an extension of a study that had been underway for several decades to describe the environmental factors that control abundances of bivalve mollusks in the region's coastal bays. Regarding the ocean finfish, the environmental factors under consideration relate to swings in the North Atlantic Oscillation. They include winds, temperature, and predation. The results so far show that the reason for declining landings is the declining recruitments of the juvenile fish to the adult stocks available to commercial fishermen. How these environmental factors interfere with the recruitments of the juvenile fish is being considered.

b) Resource Survey Cruises

During 2016, personnel from the Ecosystems Surveys Branch (ESB) staged, staffed, and supported the spring and fall multi-species bottom trawl survey and the northern shrimp trawl survey. Additional staff and gear support was provided for the sea scallop and surfclam/ocean quahog dredge surveys. In aggregate, the survey staff efforts totaled 174 research and charter vessel sea days. NOAA scientific and contract staff involvement in the various cruises totaled of 2,140 person sea days, and volunteers contributed another 408 person sea days. ESB cruises occupied 1,181 stations in an area extending from Cape Hatteras, North Carolina to Nova Scotia. A total of 506,189 length measurements were recorded, representing 2,416,500 individuals from 302 species during these cruises. Ecosystem survey data are used as fishery independent inputs for 48 single species stock assessments and for several ecosystem dynamics modeling efforts.

Significant effort was also expended in 2016 to fulfill special survey sampling requests from 74 NOAA and University investigators. This sampling included 14,636 feeding ecology observations, collection of 36,428 aging structures, and acquisition of 20,154 samples/specimens to support additional shore-based research.

c) Fishery Biology Program (http://www.nefsc.noaa.gov/fbp/)

Fish age determinations by the Fishery Biology Program are used in stock assessments and integrated ecosystem research plans for regions from the shared (US-Canada) boundary areas of the Gulf of Maine and Georges Bank, south through the middle US Atlantic seaboard. In 2016, the Program provided ages for nearly 56,500 otoliths and other hard structures from 20 species. The top species by number aged were haddock (7,978), yellowtail flounder (5,096), summer flounder (5,024), and Atlantic cod (4,451). Large numbers of black sea bass, scup, silver hake, pollock, American plaice, witch flounder were also aged (combined total 20,252). Most of this effort was production ages in support of age-structured stock assessments that serve as the basis for scientific advice to two federal fishery management councils (i.e., NEFMC, MAFMC). These data provide information on age compositions, recruitment strength and growth dynamics, which ultimately inform the scientific basis for determination of stock status, biological reference points and annual catch limits.

The Program implements a set of robust QA/QC protocols to monitor and maintain 1) accuracy and 2) precision in age determinations. Results of all these tests are posted publicly at http://www.nefsc.noaa.gov/fbp/QA-QC/.

1. Accuracy: Through the use of reference collections, personnel regularly test to measure whether there has been any deviation of their age estimates relative to a collection of consensus-aged samples.

2. Precision: A subsample of recently-aged samples is re-aged blindly by personnel to assess random error in the age estimates. In addition, inter-reader precision tests are conducted when there is a change in the person responsible for ageing a given species. A test of symmetry is used to detect any systematic differences between the original ages and the random test. If the coefficient of variation is under 5%, the ages are considered precise.

The Fishery Biology Program also partners with other agencies by exchanging age structures. In 2016, haddock age structures were exchanged with age readers from the St. Andrews Biological Station (Fisheries and Oceans Canada).

Related research for 2016:

1. Completed an estimate of American shad fecundity in the Connecticut River as a parameter used in a model to assess hydropower mitigation options. (http://journals.plos.org/plosone/article?id=10.1371/journal.pone.0164203)

2. Completed an age validation study of Atlantic surfclam, *Spisula solidissima*. (http://dx.doi.org/10.2983/035.035.0402)

3. Completed an estimate of individual fecundity for yellowtail flounder, *Limanda ferruginea*. (http://dx.doi.org/10.1016/j.seares.2015.06.015)

4. Initiated an age validation study for monkfish, *Lophius americanus*, with monthly collections of the strong 2015 strong year-class and sampling of numerous potential age structures.

5. Continued sampling of windowpane with the Study Fleet Biosampling Program to develop a marginal increment analysis to validate age estimates.

6. Continued analysis to decipher population structure for cod using growth pattern differences.

7. Continued partnership with Atlantic States Marine Fisheries Commission to create an aging manual that will standardize processing and aging for species of the Atlantic.

8. Continued a project on white hake life history, in partnership with the State of Maine.

9. Continued enhanced biological sampling of selected groundfishes to examine fecundity dynamics.

10. Continued calibration of macroscopic gonad staging performed during research vessel survey cruises as validated by an independent, gonad histology method.

11. Continued analysis of environmental effects on haddock growth and reproduction.

12. Continued to investigate the feasibility of measuring bioelectrical impedance (BIA) as a predictor of fish condition and reproductive potential.

13. Continued a reproductive study of maturation, sex change, and reproductive seasonality of the migratory black sea bass population from the mid-Atlantic states and southern New England.

d) Food Web Dynamics

The NEFSC continued studies of fish trophic dynamics based on an integrated program of long-term (since 1973) monitoring and process-oriented predation studies. Modeling and analytical efforts focused on species interactions among small pelagics, flatfish, elasmobranchs, and gadiformes.

Fish food habits samples were collected on the northeastern U.S. continental shelf (South-

Atlantic Bight to Scotian shelf) during NEFSC spring and autumn bottom trawl surveys. Estimates of prey volume and composition were made at sea for selected species. During 2016, stomachs from 8,443 individuals and 50 species were examined in the spring, and stomachs from 7,860 individuals and 50 species were examined in the autumn. Diet sampling emphasized gadiformes, elasmobranchs, small pelagics, flatfishes, and lesser known species.

The 44-year time series (1973-2016) of food habits data collected during NEFSC trawl surveys continued. The majority of the time series is now available for analysis, including data from over 640,000 stomach samples and over 160 predators. The processing of the 2016 bottom trawl survey food habits data is scheduled for completion in 2017.

Diet data undergo two rigorous data quality audits including initial checks at sea during sample collection and secondary checks in the lab to ensure data quality. These checks consider the various facets of prey taxonomy, predator/prey mass, predator/prey length, and prevent missing information. In 2016, stomachs from juveniles (<=12 cm) of predators routinely examined at sea were preserved for laboratory processing.

Since 2004, training workshops for identifying fish stomach contents and refreshing staff knowledge of marine invertebrate and fish taxonomy are now offered once per year in the winter prior to the spring trawl survey with lecture and laboratory components . These workshops continued in 2016 and provided class discussions and specimens as aids for prey identification in association with the spring and autumn trawl surveys.

Staff prepared several papers and reports for publication and presentations on a wide range of trophic ecology issues in the Northwest Atlantic ecosystem. Since trophic interactions are central to food web and ecosystem considerations, research continues with respect to functional feeding responses, dietary overlap, fish interactions with gelatinous zooplankton, incorporating fish consumption into stock assessments, and evaluating fisheries reference points.

e) Apex Predators Program

Apex Predators research focused on determining migration patterns, age and growth, feeding ecology, and reproductive biology of highly migratory species, particularly large Atlantic sharks. Members of the Cooperative Shark Tagging Program, involving over 6,000 volunteer recreational and commercial fishermen, scientists, and fisheries observers continued to tag large coastal and pelagic sharks and provide information to define essential fish habitat for shark species in US waters in 2016. Information was received on ~5,000 tagged and 400 recaptured fish bringing the total numbers tagged to 285,000 fish of more than 50 species and 17,400 recaptured of 33 species.

APP staff provided a working paper for an update to Southeast Data Assessment and Review (SEDAR) 21. The working paper detailed the length data and index of abundance for dusky sharks caught during the NEFSC Coastal Shark Bottom Longline Survey for use in an updated assessment of this species (McCandless and Natanson 2016).

Since 1961, recreational shark tournament sampling has been conducted annually during the summer from New Jersey to Maine. Tournaments are a primary source of biological samples used in NEFSC shark food habits, reproduction, and age/growth studies that provide biological reference points used during the ICCAT pelagic shark assessments and SEDAR process. In 2016 staff attended 8 tournaments and examined 121 sharks.

APP staff contributed to and participated on the Status Review and Extinction Risk Teams for the common and bigeye thresher sharks, the porbeagle, and the oceanic whitetip shark in response to positive 90-day findings indicating that petitions presented substantial information indicating that listing under the Endangered Species Act as threatened or endangered may be warranted for these species. APP staff provided data and conducted multiple analyses for use during the review process for these species. The Status Review Report for the common and bigeye thresher sharks (Young et al. 2016a) was made public following the publication of the negative 12-month finding indicating that listing under the Endangered Species Act was determined to be unwarranted for these species. The Status Review Report for the porbeagle (Curtis et al. 2016) was made public following the publication of the negative 12-month finding indicating that listing under the Endangered Species Act was determined to be unwarranted for this species. The Status Review Report for the oceanic whitetip shark (Young et al. 2016b) was made public following the publication of the positive 12-month finding indicating that this species warrants listing under the Endangered Species Act as threatened.

The NEFSC Cooperative Atlantic States Shark Pupping and Nursery (COASTSPAN) program continued to investigate known and putative shark nursery areas along the US east coast to describe their species composition, habitat preferences, and determine the relative abundance, distribution and migration of sharks through longline and gillnet sampling and mark-recapture data. In 2016, our COASTSPAN participants were the Massachusetts Division of Marine Fisheries (MDMF), Virginia Institute of Marine Science, South Carolina Department of Natural Resources (SCDNR), and the University of North Florida, which conducted the survey in both northern Florida and Georgia waters. MDMF staff conducts a survey in the U.S. Virgin Islands using COASTSPAN gear and methods. The NEFSC staff conducts the survey in Narragansett and Delaware Bays. In 2016, data from these COASTSPAN surveys were provided to NMFS Highly Migratory Species Management Division for use in updating the Essential Fish Habitat designations for all managed shark species.

APP staff also conducts fishery-dependent investigations of pelagic nursery grounds in conjunction with the high seas commercial longline fleet. This collaborative work involves sampling and tagging blue sharks and shortfin makos in a potential nursery area, and collecting length-frequency data and biological samples. Thus far over 3,700 sharks have been tagged and over 280 recaptured; the recaptures are primarily blue sharks recovered by commercial fishermen working in the mid-Atlantic. In 2016, 5 shortfin makos and 4 porbeagles were also tagged with satellite tags. To date, 500 blue sharks have been double tagged using two different tag types to help evaluate tag-shedding rates, which are used in sensitivity analyses of population estimates and to estimate blue shark fishing mortality and movement rates.

APP staff in cooperation with others from the NEFSC and staff from Florida State University, the Southeast Fisheries Science Center, the U.S. Geological Survey, the Greater Atlantic Regional Fisheries Office, and the Virginia Institute of Marine Science published a critical assessment of a purported trophic cascade in the northwest Atlantic Ocean where the depletion of large coastal sharks was thought to trigger predation release of cownose rays leading to the collapse of commercial bivalve stocks (Grubbs et al. 2016). Based on these claims a predator-control fishery for cownose rays was developed. A reexamination of data from this purported trophic cascade indicated that declines in large coastal sharks did not coincide with purported rapid increases in cownose ray abundance nor did the increase in cownose ray abundance coincide with declines in commercial bivalves. The lack of temporal correlations coupled with published diet data for large coastal sharks and cownose rays suggests the purported trophic cascade is lacking the empirical linkages required of a trophic cascade. Additionally, the life history parameters of cownose rays indicate that they are incapable of rapid increases due to low reproductive potential. This assessment emphasizes the need for hypothesized trophic cascades to be closely scrutinized as spurious conclusions may negatively influence conservation and management decisions.

APP staff contributed to the first multispecies assessment of climate vulnerability for fish and invertebrates that occur off the northeastern U.S. The Northeast Climate Vulnerability Assessment examined 82 species, including all commercially managed marine fish and invertebrate species in the northeast, a large number of recreational marine fish species, all marine fish species listed or under consideration for listing on the federal Endangered Species Act, and a range of ecologically important marine species (Hare 2016). APP staff contributed expertise on the 12 elasmobranch species assessed.

f) <u>Marine Mammals</u>

Cetacean surveys:

In 2016, NEFSC continued work on the Atlantic Marine Assessment Program for Protected Species (AMAPPS), which is a partnership with the Bureau of Ocean Energy Management (BOEM), the US Navy, and the US Fish and Wildlife Service. As part of this program, NMFS is conducting seasonal surveys of protected species along the Atlantic coast through the next several years. The goal of the program is to provide a better understanding of the distribution and abundance of sea turtle, marine mammal, and seabird populations, and to develop a decision-support tool for use in evaluating the likely impacts of various industrial, military, and development activities within U.S. Atlantic waters.

A summer aerial abundance survey was conducted on the NOAA Twin Otter during 14 August–28 September 2016. The southwestern extent was New Jersey and the northeastern extent was the southern tip of Nova Scotia, Canada. This survey covered waters from the coast line to about the 100 m depth contour with a higher coverage over the New York State Offshore Planning Area. This survey coordinated with other aerial surveys south of this study area in US waters and north of this area in Canadian waters, along with shipboard surveys which covered waters deeper than 100 m. Track lines were flown 183 m (600 ft) above the water surface, at about 200 kph (110 knots). The two-independent team methodology was used to collect data. In Beaufort sea states of six and less, about 11,872 km of on-effort track lines were surveyed, where 95% of this effort was in Beaufort 3 and below. The front team detected 5,415 individual cetaceans from 352 groups. The back team detected 1,919 individual cetaceans from 210 groups.

During 27 June – 25 August 2016, the Northeast Fisheries Science Center (NEFSC) conducted a shipboard abundance survey targeting marine mammals, sea turtles and seabirds on the NOAA ship *Henry B. Bigelow*. The survey area was between 36 and 42N and 65 and 74W, covering waters offshore of the 100 m depth contour. There were 2 independent teams targeting marine mammals and sea turtles using line transect sampling techniques, a team targeting targeting sea birds using strip transect sampling techniques, a team monitoring a towed hydrophone array, and a team collecting physical and biological oceanographic data.

Track lines were covered at about 10 knots. In Beaufort sea states of six and less, about 5354 km of on-effort track lines were surveyed. Over 1200 groups (16,000 individuals) of cetaceans, 26 groups (27 individuals) of sea turtles and 1977 groups (4677 individuals) of seabirds were recorded. Common dolphins (*Delphinus delphis*) were the most commonly detected species. The most common large whales were fin whales (*Balaenoptera physalus*) and humpback whales (*Megaptera novaeangliae*). Over 19 loggerhead turtles (*Caretta caretta*) were detected. In addition, 1 seal, over 23 basking sharks (*Cetorhinus maximus*) and 22 ocean sunfish (*Mola mola*) were also detected. Passive acoustic data were collected via towed hydrophone array during all daytime survey effort, and at night during Leg 3. Approximately 496 hours of array data were collected, with over 800 detections of vocally-active cetacean groups. In addition, 29 sonobuoy deployments were conducted to acoustically sample for large whales. During the day and night active acoustic sampling and 411 sampling events were completed. This included 189 casts of the 19+CTD, 119 bongo deployments, 26 VPR hauls, deployments, 42 neuston deployments, and 35 midwater trawls.

A shipboard North Atlantic right whale (*Eubalaena glacialis*) cruise was conducted during 29 April–17 May 2016 aboard the NOAA Ship *Gordon Gunter*. Principal objectives of the cruise were to obtain photo id and biopsy samples of North Atlantic right whales. Specific goals included: (1) Collecting biopsies and photographs of large whales from a RHIB (rigid hulled inflatable boat) on all good weather days that whales are present. (2) Apply dermal tags to North Atlantic right and sei (*Balaenoptera borealis)* whales from a RHIB on all good weather days that whales are present. (3) Deploy vertical profiling package from NOAA Ship *Gordon Gunter* in the trailing path of tagged whales for the duration of the tagging period (24-72 hr). (4) Conduct visual surveys in proximity to autonomous vehicles equipped with passive acoustic instrumentation. (5) Conduct zooplankton tows near whales from the ship. (6) Collect sei and North Atlantic right whale fecal, and respiratory vapor samples for hormone analysis. (7) Deploy sonobuoys to systematically monitor for North Atlantic right whales and sei whales. The primary survey areas included the Great South Channel and Cape Cod Bay. The secondary survey areas included waters from Cape Cod to the Northeast Channel and past the shelf break and the Block Island Sound Seasonal Management Area. Survey tracks were not designed to sample the area randomly, but were based upon past records of whale sightings, real time acoustic detections generated by the wave gliders, as well as assumptions concerning bathymetric characteristics of likely large whale habitats.

The North Atlantic Right Whale Sighting Survey (NARWSS) is a NOAA Fisheries program which locates and records the seasonal distribution of North Atlantic right whales off the northeastern coast of the United States. Images of individual whales are also collected for mark-recapture models to monitor the population. NARWSS flights conducted in 2016 followed systematic tracklines with randomized starting locations within 13 primary survey blocks: Cashes Ledge, Downeast Maine, Franklin Basin, Georges Basin, Great South Channel, Howell Swell, Jeffreys Ledge, Jordan Basin, Martha's Vineyard and Nantucket, Rhode Island Sound, Roseway Basin, Southern Georges Shelf Break, and Stellwagen Bank. During 2016, NARWSS flew 189.6 hours over 45 surveys, including 2 directed flights around acoustic detections and 2 directed flights near aggregations seen on a previous aerial survey. NARWSS detected 271 right whales (including possible duplicate sightings of the same individual), with 242 right whales sighted within survey blocks and 29 right whales sighted during transit to or from survey areas.

During January–March 2016, skin samples were collected from right whales on the calving grounds in the coastal region (<25 nmi from land) between Savannah, GA and St. Augustine, FL. Whales were located by aerial spotting teams, and skin and blubber samples were obtained using biopsy darts deployed by crew in an inflatable boat. DNA in right whale skin can be used to determine sex, and to create a genetic "fingerprint" for later re-identification. These samples will be added to the extensive collection of right whale DNA (obtained from approximately 300 individual right whales) maintained at Trent University in Ontario, Canada. DNA collected through the project will not only help researchers identify individual whales and their paternity, but also to: (1) assess genetic variation in the population; (2) determine how many females are reproductively active; (3) help determine paternity, and (4) better understand the right whale mating system.

During April 2016, a research crew working from NOAA research vessel Selkie (24' Safeboat) worked in Cape Cod Bay when right whales are there feeding. All right whales encountered were photographed for the NARW catalog. Six animals were biopsy sampled, including a mother and calf pair that had been determined to have swapped calves during the calving season. The sample confirmed the swap. Additionally, working in collaboration with colleagues at Woods Hole Oceanographic Institute, aerial photography using a small unmanned aerial system (hexacopter) was flown. Fifteen flights during three different days were flown to obtain images for a photogrammetry study. The images will be incorporated into a large multi-group project in order to determine parameters about health and growth rates.

Cetacean bycatch and other analyses:

Incidental bycatches of cetacean, turtle, and pinniped species were estimated based on observed takes in commercial fisheries from Maine to North Carolina. Fisheries observed during 2016 included gill nets, otter trawls, mid-water otter trawls, mid-water pair trawls, scallop trawls, scallop dredges, purse seines, and some pot and traps. Cetaceans observed taken included harbor porpoises, Risso's dolphins (*Grampus griseus*), short-beaked common dolphins, Atlantic white-sided dolphins (*Lagenorhynchus acutus*), and bottlenose dolphins. To support Atlantic Take Reduction Teams (e.g., harbor porpoise and Atlantic trawl teams), the observer data were analyzed to identify environmental factors, fishing practices, and gear characteristics associated with the bycatches.

Serious injury determinations were made on non-fatal large whale fishery interactions and vessel strikes, as well as bycaught small cetaceans and pinnipeds to determine causes and extents of injuries.

Work continued with the New England Aquarium and University of Rhode Island to update the North Atlantic Right Whale Individual ID catalogue and right whale sightings databases.

Cetacean acoustics:

NEFSC researchers in the Passive Acoustics Group have been working to: (1) elucidate the basic acoustic behavior of various marine mammal species; (2) monitor baleen whale presence using real time reporting from fixed and autonomous glider platforms; and (3) improve the application of passive acoustics as a tool for monitoring and mitigation.

In April 2016, 8 high-frequency recording packages (HARPs) were deployed along the U.S. east coast shelf break, from the waters off New England to Georgia. These units will record continuously for approximately one year. Three HARPs, deployed in 2015, were recovered from the New England sites. Additionally, a multi-year effort consisting of five lines (off Nantucket, Cape Hatteras, Cape Fear, Charleston and Brunswick) of Marine Autonomous Recording Units (MARUs) deployed across the continental shelf was continued. These units are turned around approximately every 6 months, and are aimed at monitoring changes in migratory movements of baleen whales. The mid-Atlantic region is covered by existing BOEM and NY State projects. A glider was deployed in the Great South Channel and 2 real-time monitoring buoys have been active since early 2015 to assess the efficacy of using these tools for assessing baleen whale presence. A glider and real-time buoy were also deployed off Mount Desert Rock, Maine, in conjunction with visual observations from a land station, to assess cetacean vocalization rates vs. visual detection rates, particularly for fin whales. Results from these can be found at http://dcs.whoi.edu/. Long term NOAA Noise Reference Station recorders continue to collect data in the Stellwagen Bank National Marine Sanctuary and by the seamounts off Georges Bank. Towed hydrophone array data were collected in conjunction with the summer AMAPPS shipboard survey. Nearly 500h of array data resulted in the real-time detection of over 500 groups of vocally-active delphinids and over 300 groups of sperm whales. Finally, the Caribbean Humpback Acoustic Monitoring Program (CHAMP), was initiated in the fall of 2016, with deployments of 10 acoustic recorders at six sites throughout the Caribbean. This international collaboration involved researchers from the Dominican Republic, Saint Martin, Guadeloupe, Martinique, Aruba and Bonaire. Recorders will be recovered in spring 2017.

Archival acoustic data from 2006 to present continue to be analyzed for right, fin, sei, blue and humpback whale presence. A manuscript on the patterns of distribution of North Atlantic right whales before and after 2010 is being finalized for submission. A manuscript from AMAPPS work on a new approach for 3D localization and depth calculation of beaked whales is in review at the Journal for the Acoustical Society of America; another manuscript on the effects of echosounders on detections rates of beaked whales is being submitted to Royal Society Open Science. A number of manuscripts involving colleagues from the Passive Acoustics Group were published in 2016, see our website for more details (https://www.nefsc.noaa.gov/psb/acoustics/psbAcousticPubs.html).

Pinnipeds:

In 2016, three NEFSC aerial seal surveys were conducted to monitor major gray seal (*Halichoerus grypus*) pupping colonies in Massachusetts and Maine coastal waters. Unmanned aerial systems were also employed to survey one of the pupping colonies. NEFSC also collaborated with the Center for Coastal Studies to perform 2 spring aerial surveys of gray seal and harbor seal (*Phoca vitulina*) haulouts in southeastern Massachusetts.
In January 2016, a diverse group of researchers collaborated on a gray seal pup capture project on Muskeget and South Monomoy Islands, Massachusetts. Partners included NEFSC's Protected Species Branch, Massachusetts Institute of Technology, Mystic Aquarium, Marine Mammals of Maine, the University of New England, the Woods Hole Oceanographic Institution, and the University of Connecticut. 110 gray seal pups were captured, sampled and flipper-tagged. Samples contributed to MIT's work on influenza in migratory wild populations among other projects.
Work continued in 2016 on stomach content analysis of bycaught harbor and gray seals.

Bycatch estimation of harbor, gray and harp (*Pagophilus groenlandicus*) seals was conducted based on observed takes in the Mid-Atlantic Gillnet, Northeast Sink Gillnet, and Northeast and mid-Atlantic bottom trawl fisheries.

g) Turtles

The NEFSC collaborated with academics, industry groups, and researchers from other NMFS science centers to (1) collect and assess data on sea turtles in U.S. Mid-Atlantic waters; and (2) assess and reduce sea turtle bycatch in U.S. commercial fisheries in the Northwest Atlantic Ocean.

In support of AMAPPS priorities, NEFSC contributed to regional collaborations to deploy satellite tags on wild-captured loggerhead sea turtles (*Caretta caretta*) to monitor movements and behavior and to collect information on diving and surfacing times to develop correction factors for the proportion of turtles underwater during aerial surveys (and therefore not observed during these surveys). In 2016 we placed satellite tags on loggerheads in the Mid-Atlantic region, and we did some pilot work on under-sampled waters in the northern portion of the range.

In 2016 the NEFSC conducted research related to turtle bycatch assessment. This included estimating turtle mortality rates in commercial gears using serious injury guidelines. The NEFSC also continues to develop quantitative methods for assessing anthropogenic threats to sea turtles.

In 2016, the NEFSC conducted two gear-related projects investigating methods to reduce sea turtle bycatch in fishing gear. The first was testing of a Cable Sorting Grid to reduce turtle bycatch in the summer Flounder fishery. Previous studies comparing catch rates of Turtle Excluder Device (TED)-equipped trawls and standard flatfish trawls found an average of 25-30% loss in targeted summer flounder (*Paralichthys dentatus*) catch in the TED equipped trawl. As such, additional bycatch reduction devices (e.g., topless trawls, cable grids) are being investigated. In 2016 the NESC was funded to run a comparative study of that catch comparison of a NETIII (a type of cable grid)-equipped trawl to that of a standard flatfish trawl in the summer flounder trawl fishery. The study documented operational issues and compared the catch data aboard two commercial fishing vessels. Aboard the FV Darana R, significant reductions (29-45%) in summer flounder catch were observed during leg 1 and 2 of the project. Aboard the FV Jersey Cape, a modified configuration was used and no significant reduction in summer flounder catch was observed. In total, four configurations were tested throughout the study in an attempt to improve target catch efficiency. From an operational and safety standpoint, the NETIII system was a substantial improvement from previous research using rigid grid TEDs. Because this study proved to be a proof of concept for this gear, with its many modifications, the NEFSC, with assistance from the SEFSC, is planning further research in 2017 on the NETIII system so that it may be used as an alternative to traditional fixed grid TEDs.

The second gear project involved investigating the ability of a large 12" (30.5 cm) mesh low profile gillnet to reduce sea turtle bycatch. We are comparing two different tie-down configurations: standard (12 meshes with 48 in (1.2 m) tie-downs) and low profile (eight meshes with 24 in (0.6 m) tie-downs) using the same experimental protocol. Previously this configuration proved successful at reducing the bycatch of Atlantic Sturgeon (*Acipenser oxyrinchus oxyrinchus*) with little effect on the targeted catch of monkfish (*Lophius americanus*) and winter skate (*Leucoraja ocellata*). Sixty paired sets are planned in waters off Cape Hatteras, NC, an area chosen because of the high densities of sea turtles in the winter months. Reports on both projects are located at: http://www.nefsc.noaa.gov/read/protspp/PR_gear_research/.

3. Studies of Fishing Operations

In 2016, NEFSC Observers were deployed on 4,013 trips aboard commercial fishing vessels. The kept and discarded catch was weighed or estimated for all observed hauls. Estimated kept weights were obtained for all unobserved hauls. Length frequencies were recorded and age structures were collected from a portion of observed hauls. NEFSC Observers recorded 138 marine mammal incidental takes, 20 sea turtle incidental takes, and 186 seabird incidental takes. For most of these animals, the information recorded included animal condition, length and other relevant body measurements, as well as species identification characteristics. Tissue samples were also collected from many of these animals, and entire animals were retained if possible.

In addition, the Northeast Fisheries Observer Program deployed At-Sea Monitors on 605 trips aboard commercial fishing vessels in 2016. On these trips there were 40 marine mammal and 78 seabird incidental takes documented.

a. New England and Mid-Atlantic Sink Anchored Gillnet Fisheries

In the sink anchored gillnet fishery, 1,104 trips were observed with a total of 4,662 gear retrievals by Observers. There were 94 observed marine mammal takes in this fishery (40 gray seals, 18 harbor seals, 11 harbor porpoises, nine common dolphins, five harp seals, five unidentified seals, one minke whale and one hooded seal). There were also two loggerhead turtles, one leatherback turtle and one green turtle and 152 seabird takes observed in this fishery.

At-Sea Monitors observed 156 trips in the sink anchored gillnet fishery with 694 gear retrievals. There were 27 marine mammal (20 harbor seals, four gray seals, two harbor porpoises and one unidentified seals) and 65 seabird (including 63 greater shearwaters) incidental takes recorded in this fishery by Monitors.

b. Float Drift Gillnet Fishery

There were 72 floating drift gillnet trips with 192 gear retrievals observed in 2016. There were not marine mammal or sea turtle takes but one brown pelican incidental take observed.

No Monitors deployed on float drift gillnet trips in 2016.

c. Otter Trawl Fisheries

In the bottom otter trawl fishery 1,435 trips were observed with a total of 7,711 gear retrievals recorded by Observers. In addition, there were 41 midwater trawl trips with 72 gear retrievals, 20 scallop trawl trips with 128 gear retrievals, ten shrimp bottom otter trawl trips with 1,025 gear retrievals, nine twin trawl trips with 117 gear retrievals, seven haddock separator trawl trips with 231 gear retrievals and one Ruhle trawl trip with 25 gear retrievals observed in 2016.

In the bottom otter trawl fishery, there were 37 observed marine mammal takes (22 common dolphins, six Risso's dolphins, five bottlenose dolphins, three gray seals and one unidentified toothed whale). There were also seven loggerhead turtles, one leatherback turtle and five seabird takes in this fishery. In the mid-water trawl fishery there were two unidentified pilot whale takes. In the scallop trawl fishery there were no takes observed. There were three sea turtle takes (one green, one Kemp's ridley and one loggerhead) observed in the shrimp bottom otter trawl fishery. On twin trawl trips there was one Kemp's ridley take and five seabird takes observed. There were no incidental takes observed on haddock separator trawl or Ruhle trawl trips in 2016.

At-Sea Monitors deployed on 425 bottom otter trawl trips with 4,381 gear retrievals, eight haddock separator trawl trips with 283 gear retrievals, three twin trawl trips with eight gear retrievals and no Ruhle trawl trips in 2016. There were 12 marine mammal (five whitesided dolphins, four unidentified pilot whale, two common dolphins and one gray seal) and ten seabird takes recorded by Monitors in the bottom otter trawl fishery. There was one whitesided dolphin take and one seabird take in the haddock separator trawl fishery in 2016. And, there were no incidental takes documented by Monitors on either Ruhle or twin trawl trips in 2016.

d. Sea Scallop Dredge Fishery

In the sea scallop dredge fishery, 661 trips were observed with a total of 43,168 gear retrievals. There were two loggerhead turtle, one Kemp's ridley turtle and 13 seabird takes observed in this fishery.

No Monitors deployed in the scallop dredge fishery in 2016.

e. Scottish Seine Fishery

No Scottish seine trips were covered by Observers or Monitors in 2016.

f. Drift Sink Gillnet Fishery

In the drift sink gillnet fishery in 2016, Observers were deployed on 325 trips with a total of 2,063 gear retrievals. There was one humpback whale, one hard-shell turtle and eight seabird takes in this fishery.

Monitors deployed on three trips with a total of 30 gear retrievals. There were two seabird takes documented by Monitors in this fishery.

g. Anchored Floating Gillnet Fishery

There were ten anchored floating gillnet trips with 25 gear retrievals observed in 2016. There were no marine mammal, sea turtle or seabird takes observed in this fishery.

No Monitors deployed on anchored floating gillnet trips in 2016.

h. Mid-water Pair Trawl Fishery

In 2016, there were 70 mid-water pair trawl trips observed with a total of 165 gear retrievals. There was one harbor seal and one unidentified pilot whale take observed in this fishery. No seabird takes were documented.

No Monitors deployed on mid-water pair trawl trips in 2016.

i. Bottom Longline Fishery

In the bottom longline fishery in 2016, there were 14 trips observed with a total of 174 gear retrievals. There were no marine mammal or sea turtle takes observed but one seabird take observed in the bottom longline fishery.

At-Sea Monitors covered a total of six bottom longline trip with 20 gear retrievals in 2016. There were no marine mammal, sea turtle or seabird takes observed by Monitors.

j. Beach Haul Seine Fishery

No beach haul seine trips were covered by Observers or Monitors in 2016.

k. Pound Net Fishery

No pound net trips were covered by Observers or Monitors in 2016.

l. Handline Fishery

In 2016, there were nine handline trips and 85 gear retrievals and four auto-jig handline trips and 28 gear retrievals observed. No marine mammals, sea turtles or seabirds were taken in these fisheries.

Monitors covered three handline trips and seven gear retrievals and one auto-jig handline trip and four gear retrievals observed in 2016. There were no documented takes in this fishery in 2016.

m. Herring Purse Seine Fishery

In 2016, there were 13 herring purse seine trips with 22 gear retrievals observed. There were five gray seal and one unidentified seal takes observed in this fishery. No sea turtles or seabirds were observed.

No herring purse seine trips were covered by Monitors in 2016.

n. Menhaden Purse Seine Fishery

No menhaden purse seine trips were covered by Observers or Monitors in 2016.

o. Tuna Purse Seine Fishery

No tuna purse seine trips were covered by Observers or Monitors in 2016.

p. Lobster Pot Fishery

In 2016, there were 79 lobster pot trips with 1,215 gear retrievals observed. There were no marine mammal, sea turtle or seabird takes in this fishery.

No lobster pot trips were covered by Monitors in 2016.

q. Fish Pot Fishery

In 2016, 22 fish pot trips with 125 gear retrievals were observed. No takes were documented.

No fish pot trips were covered by Monitors in 2016.

r. Conch Pot Fishery

In 2016, 51 conch pot trips and 500 gear retrievals were covered by Observers. No takes were documented.

No conch pot trips were covered by Monitors in 2016.

s. Hagfish Pot Fishery

One hagfish pot trip with 19 gear retrievals was observed in 2016. There were no takes observed in this fishery.

No hagfish pot trips were covered by Monitors in 2016.

t. Crab Pot Fishery

Crab pot trips with 143 gear retrievals were covered by Observers in 2016.

No crab pot trips were covered by Monitors in 2016.

u. Blue Crab Pot Fishery

No blue crab pot trips were covered by Observers or Monitors in 2016.

v. Clam Dredge Fishery

There were 45 clam dredge trips with 2,088 gear retrievals observed in 2016. There was one seabird take documented on clam dredge trips in 2016. No marine mammals or sea turtles were documented in 2016.

No clam dredge trips were covered by Monitors in 2016.

w. Scallop Beam Trawl Fishery

One scallop beam trawl trip with two gear retrievals were observed in 2016. There were no marine mammal, sea turtle or seabird takes documented in this fishery in 2016.

No scallop beam trawl trips were covered by Monitors in 2016.

x. Other Dredge Fisheries

No other dredge trips were covered by Observers or Monitors in 2016.

4. Observer estimation of catch on NAFO Div 3 trips

a. The checker pen is measured and total volume is calculated prior to the catch being dumped onboard (The F/V Titan uses varying size checker pens as they can change the size by adding or removing pen boards).

b. Once the catch is dumped the observer takes the depth of the checker pen (filled with catch) in 10 random locations within it using a measuring stick. The average depth of the fish in the checker pen is then calculated. The total volume of the catch is then calculated by multiplying the length times the width of the checker pen times the depth of the catch.

c. The observer then fills (depending on amount of catch) 1.47 cu. ft. baskets with the catch from random locations throughout the checker pen. The number of baskets varies from 8 to 15 (unless the catch is very low it could be less). The number of baskets used is then multiplied by the volume of one basket to obtain the Total Volume Subsampled. The fish are then separated by species and whether they are kept or discarded. The discard size is determined by the observer according to the legal U.S. fisheries regulations. The kept and discards of each species are weighed and recorded.

d. The kept and discarded catch weights are then calculated by the following formula:

1) A Sample Multiplier is calculated by (Total Volume (see # 2 above / total Subsample Volume (see # 3 above)

2) The weight of each species Subsampled is then multiplied by the Sample Multiplier to calculate the Estimated Total Weight for that species and catch disposition.

3) The percent Subsampled can be calculated by dividing the Total Subsample Volume by the Total Volume of the catch.

5. Population Dynamics Research

a) Stock Assessments

Population dynamics research conducted within the NEFSC supports a number of domestic and international fisheries management authorities. Within the United States Northeast Region, management plans are developed by the New England (states of Maine through Connecticut) and Mid-Atlantic (New York through North Carolina) Fishery Management Councils, and the Atlantic States Marine Fisheries Commission (ASMFC). There are about three dozen managed species; all require stock status updates as a basis for fishery management. Stock assessments are routinely reviewed in a peer review process termed the Stock Assessment Workshop (SAW). Stocks assessments conducted and reviewed through this process in 2016 included monkfish, black sea bass, witch flounder and surfclam.

Not all assessments conducted by the NEFSC are vetted at the SAW. Some are developed and reviewed in the US/Canada Transboundary Resources Assessment Committee (TRAC). In 2016, stock assessments conducted and reviewed through the TRAC process included Eastern Georges Bank cod, Eastern Georges Bank haddock, and Georges Bank yellowtail flounder. Other stock assessments in 2016 vetted in regional bodies included seven skate species, summer flounder, Atlantic mackerel, black sea bass, bluefish, ocean quahog, spiny dogfish, butterfish, tilefish and longfin and shortfin squid.

b) Atlantic Salmon Research

Atlantic salmon populations in eastern Maine are listed as endangered under the United States Endangered Species Act (ESA). Spawning populations have dwindled over the years, and both smolt escapement and ocean survival rates have declined. Research programs conducted by the NEFSC, in conjunction with various agencies, private partners and international collaborators, are designed to better understand the factors contributing to these declines. Research activities include a variety of projects in natal rivers, estuaries, and at sea. The data from these studies are used to provide information for local, national, and international stock assessment activities. These assessments support ESA and North Atlantic Salmon Conservation Organization (NASCO) management efforts.

Field research in 2016 focused on (1) a fish community survey within the Penobscot River estuary; (2) monitoring the importance of diadromous fishes as prey for nearshore Gulf of Maine groundfish species; (3) modeling the impacts of hydroelectric facilities on diadromous fish productivity; (4) identifying optimal stocking dates by relating thermal history of smolts to physiological readiness; (4) monitoring of fishery removals on the high seas; and (5) describing the ecosystem processes and connections that govern the productivity of Atlantic salmon in the marine environment. Through the application of active (pelagic trawling) and passive (multi-frequency split-beam hydroacoustics) techniques, estimates of biomass and habitat use for various commercially important fish species (e.g. Atlantic herring, alewife, blueback herring, American shad) are being developed for the Penobscot Estuary. Documentation of American shad spawning, the presence of multiple size classes of river herring utilizing the upper estuary and the detection of significant juvenile Atlantic herring biomass in the lower estuary highlights the importance of this estuarine nursery. Starting in 2012 a sampling program was initiated, in collaboration with the Maine Department of Marine Resources semi-annual nearshore groundfish surveys, to collect stomach samples from known diadromous fish predators. Analysis will be conducted to evaluate the contribution of diadromous fishes to the diets of captured nearshore predators. Life history modeling is being conducted on a number of different diadromous species and river systems to evaluate the impacts that hydroelectric facilities are having on the productivity of these species. Results are being used to support federal permitting efforts and to guide and evaluate restoration programs for these species. The initial year of a two year study was undertaken to describe the influence of thermal history (Accumulated Thermal Units) on physiological readiness, which has impacts on migration dynamics and migration success. Defining this relationship will help hatchery managers optimize thermal exposure and time of stocking to improve survival of restoration smolts. Monitoring the West Greenland fishery and collecting biological data and fishery statistics continued. These data are provided directly to ICES and are required for North American run-reconstruction modeling and for developing catch advice for the fishery. Finally, modeling efforts evaluating how ecosystem changes are affecting energy flow to Atlantic salmon and the impacts of those changes on salmon growth, survival, and productivity are underway. All of these studies will contribute to recommendations for additional measures to be considered to halt the decline of USA Atlantic salmon stocks and help restore these populations.

c) Cooperative Research

The Northeast Fisheries Science Center's Cooperative Research Branch (Cooperative Research) supports collaborations among fishermen and scientists to enhance marine fisheries data used in stock assessments, bycatch reduction, ecosystem modeling, and fisheries management. Additionally, Cooperative Research increases communication with fishing professionals in the region and seeks to leverage resources between diverse partners. Cooperative Research is supported by United States Federal Budget and fishery resource allocations that are 'set aside' and harvested to fund research programs (Research Set-Asides). Cooperative Research is conducted both within the Northeast Fisheries Science Center (NEFSC) and coordinated externally with academic institutions, states' marine resource agencies, private non-governmental research organizations (NGOs) and fishing industry partners. Cooperative Research supports fishery dependent, fishery independent, fishery biology, oceanography, bycatch reduction and education oriented programs.

1. Projects Coordinated by Northeast Fisheries Science Center

Enhanced Fishery Dependent Data**:**

- Study Fleet

The NEFSC Study Fleet program continues to facilitate the reporting of higher resolution fishery dependent data from Gulf of Maine, Georges Bank, Mid-Atlantic and Southern New England fleets. A study fleet is a subset of fishing vessels from which high quality, self-reported data on fishing effort, location, gear characteristics, catch, and biological observations are collected. Approximately 45 Study Fleet vessels use our laptop-based Fisheries Logbook and Data Recording System (FLDRS) to record and transfer more accurate and timely fishery data on a haul-by-haul basis. Haul-by haul catch and discard reporting is supplemented by temperature-depth data using specially designed sensors that are deployed on the fishing gear.

This combined catch and bottom temperature data is valuable to both scientists and the fishing industry, and is shared with oceanographic modelers, stock assessment scientists and other researchers to model ecosystem drivers of species distribution, co-occurrence, and aid in bycatch reduction. Cooperative Research has also continued to develop the scientific data collection capabilities of FLDRS with dynamic data elements which can be turned on or off to record information including but not limited to trip costs, gear modifications, damage to gear, designated access areas, and individual fish measurements. These capabilities can be used for targeted research studies with commercial vessels.

A more specialized Study-Fleet approach is focusing on collaborating with squid fishermen to better understand the combination of environmental, regulatory, and socioeconomic influences on fishing patterns. Fishermen have reported that storm systems and changes in the Asian stock market, set against rigid management regulations that don't allow for different annual fish movement patterns, create an almost insurmountable hurdle for these fisheries at times. Gaining a better understanding of the relationship between these important drivers are steps towards a more comprehensive, ecosystem-based management approach, and would be beneficial in all fisheries.

Through work with the Study Fleet, a groundfish conversion project is validating and/or updating the round-weight to processed-weight conversion factors used by fishery scientists and managers to calculate the total weight of a specific groundfish species removed from the population, based on the weight of processed fish that are landed and sold. Initial analyses indicate that conversion factors vary over time, and are being used as part of an Atlantic Coastal Cooperative Statistical Program effort to update conversion factors coast-wide.

- Comparing Self-Reported Study Fleet Data to Observer Data for Discards

Knowing the total amount of fish removed in a fishery is critical for estimating the total abundance, population growth rate, and fishing mortality of a species. This project is comparing discard estimates for selected species using both the Study Fleet and observer data to determine if they can complement one another in calculating the discard estimates used in stock assessments. These analyses also serve as a critical evaluation on the likely success of some electronic monitoring (cameras) approaches – specifically, the use of cameras to validate the self-reported discards estimates reported by vessel captains.

- River Herring Bycatch Reduction

Study Fleet vessels are providing data to help the small mesh bottom trawl herring fishery avoid river herring bycatch by examining small-scale variations in river herring distribution and abundance. Without mitigation, river herring bycatch caps could have serious financial impacts on this fishery. NEFSC staff work closely with the Massachusetts Division of Marine Fisheries on this project.

- Real-Time Data Transmission

Cooperative Research participants have been instrumental in testing low-cost methods to facilitate real-time transmission of the data they are collecting, which allows for its immediate use and provides opportunities for fishermen to receive quick feedback that may help the fish more selectively and avoid bycatch.

The telemetry technology being developed by Science Center oceanographers combines modifications to the ocean drifter transmitters used for the past decade, with the wireless temperature depth recorders recently developed for use on fishing gear with Cooperative Research support. As the fishermen haul their gear with the wireless temperature sensor attached, the data is automatically sent through an onboard computer system. The system detects new data and relays the average temperature and depth information for the tow through the transmitter to the GLOBALSTAR satellite system, along with its latitude/longitude position and time.

Catch data and any other numerical data can now be reported at a fraction of the cost of commercial ship-to-shore transmission systems. Within minutes of the haul, the data arrives on a computer server at the NEFSC laboratory in Woods Hole and is posted on an associated website for the participating fishermen and collaborating scientists. A summary of each haul includes time, approximate position, average temperature, standard deviation of temperature, average depth, range of depth, and time duration of the trawl.

Data from over 4,000 hauls has been reported so far, and all parties are excited about the possibilities. Fishermen can immediately view their data either in the wheelhouse or through the website to make connections between ocean bottom temperatures and catch composition, thus better targeting certain species and minimizing bycatch.

This new telemetry procedure will also allow dozens of boats to report actual bottom temperatures from a variety of locations along the entire Northeast continental shelf. The data will be assimilated into the ocean models to help tune and validate model simulations and forecasts. Additional sensors are being developed, including some that report directly to a smartphone instead of a shipboard computer, and participants are now testing a second-generation of cheaper, more easily accessible equipment.

- Electronic Vessel trip Reporting

A collaborative effort between Cooperative Research and the Cornell University Cooperative Extension program also continues to provide hardware, software, training, and field support for Electronic Vessel trip reporting (eVTR). Standard VTR data, aggregated at a statistical area level, can be entered into Cooperative Research's FLDRS electronic logbook, and uploaded electronically. This cuts down on delays in receiving paper VTRs, and errors due to illegible handwriting and transcription.

Cooperative Research has also developed and is providing support for a new eVTR software system for the clam industry (eCLAMS), now installed on most vessels in the clam fleet. Staff has also been testing equipment for wireless data transmission of eVTRs from selected Northeast dock sites to make data transmittal more convenient for the industry.

Fishery Independent Data:

- Western Gulf of Maine Bottom Longline Survey

In 2016, Cooperative Research and two commercial vessel partners successfully completed the third year of a pilot longline survey in the western and central Gulf of Maine. Forty-five base stations were sampled where catches of species of interest such as cusk, wolfish, cod, white hake, thorny, winter, and little skate, halibut, and dogfish were expected to be high.

This industry-based survey builds upon previous and ongoing cooperative longline sampling programs. Sampling stations include both hard and soft bottom, and efforts were made to be consistent with the coverage of the NEFSC bottom trawl survey in terms of stations per unit area. At each site, approximately one nautical mile of gear is set, covering a distance roughly equivalent to that of a bottom trawl survey tow. The industry-based survey timing is coordinated with the NEFSC research vessel Henry Bigelow's spring and fall survey schedules as much as possible to provide complementary sampling that can be compared to indices from the trawl survey.

The 34 species that have been caught to date include seven 'data-poor' species, of which four (Atlantic wolffish, Atlantic halibut, cusk, and thorny skate) are NOAA species of concern, with cusk and thorny skate being NOAA 'candidate' species under Endangered Species Act status review.

Seventeen of the species are considered 'data-rich' species, seven of which are being caught with sufficient abundance for the data to provide indices to help improve stock assessments, though additional years of the survey will be needed to establish a long-enough time series to incorporate into assessment models. These species include cod, haddock, little skate, pollock, red hake, spiny dogfish, and white hake. In 2016, the survey team also collaborated with the Greater Atlantic Regional Office of Protected Resources and the New England Aquarium to further work on the effects of barotrauma on bottom-dwelling species, and with the NEFSC Oceanography Branch to develop a novel type of current meter to better understand ocean bottom dynamics.

- Survey Gear Study for Witch Flounder Assessment

A joint industry-NEFSC team designed and completed an incredibly efficient August 2016 study onboard the F/V Karen Elizabeth to investigate the catchability of witch flounder in standard NEFSC bottom trawl survey gear. The experiment showed that the standard survey gear catches only approximately 29% of the witch flounder in its path. This value was then used to calculate a more accurate survey-based estimate of abundance across the entire stock area.

This analysis indicated that the field-based estimate of witch flounder abundance was about four times the value estimated from the traditional stock assessment model. This result allowed the assessment working group to better understand the uncertainty in the output of the model. The causes of the difference between the field-based and model-based estimates are not yet fully understood, but the cooperative field experiment will help guide the continued management advice for this species. These types of targeted studies can help address important questions that can result in improved assessments for many important commercial species.

- Fishery Biology, Oceanography, and Bycatch Avoidance

Vessels participating in the Cooperative Research Program have also contributed to enhanced biological sampling of commercially important species. By taking advantage of the year-round fishing operations of Study Fleet, the program has supplied more than 8,000 samples for reproductive studies. These studies have led to insights into the reproduction of yellowtail flounder, including annual variation, variation between stocks, reproductive regulation, and the effects of female condition on reproduction. Reproductive sampling of winter flounder has shown low levels of skipped spawning, annual variation in reproductive capacity, and spatial variation in maturity, spawning seasonality and reproductive capacity. For some of these flatfish species, the enhanced sampling has resulted in revised biological reference points for stock assessment modeling.

Ongoing work is attempting to understand the environmental and energetic drivers of reproductive potential in these flatfishes. Summer flounder samples have been used to validate the maturity classification scheme used on surveys, examine seasonality in spawning of the northern population segment, and size and seasonal variation in reproductive capacity. Herring samples are being obtained to evaluate skipped spawning, and the proportion of spring spawning herring. Reproductive samples are also being examined to understand the dynamics of reproductive investment in the Georges Bank haddock, which exhibits extreme recruitment fluctuation.

Several collaborative projects are recording bottom temperatures during commercial fishing activities in the Northeast and mid-Atlantic, and combining this information with fish capture data collected during surveys and study fleet trips to improve distribution maps of key commercial species, and determine the thermal niche availability of NEFSC trawl survey data for individual species.

Both the Environmental Monitors on Lobster Traps project (eMOLT) and the Cooperative Research Study Fleet are sharing this important data with IOOS, NERACOOS, and MARACOOS. Over several years, the Study Fleet has collected over 4.5 million bottom temperature and location records, and since 2001, the eMOLT program has recorded more than 5.5 million hourly records of bottom temperature. This additional information is helping oceanographic modelers better assess and improve models developed through earlier technology, and develop new models which forecast not only wave heights and current directions, but also ocean bottom temperatures. Integrating catch data with fishing gear's depth and temperature information will also facilitate and verify ecosystem modeling approaches which are greatly needed to better understand ocean dynamics and how they affect marine species.

Work on river herring bycatch is being conducted to help the small mesh bottom trawl herring fishery avoid river herring bycatch by examining small-scale variations in river herring distribution and abundance. Without mitigation, river herring bycatch caps could have serious financial impacts on the small mesh fishery. The Cooperative Research is working closely with staff from the Massachusetts Division of Marine Fisheries on this project, and also managing additional work funded by the Greater Atlantic Regional Office's Protected Resources Division with several of the vessels that are collecting more detailed environmental data and testing forecast models to help predict species mixing. The goal of this work is to test the accuracy of a predictive, survey-based model of river herring distribution using field-based observations aboard commercial fishing vessels. Fifty individual tows were made over ten days of sampling on commercial fishing vessels. Preliminary analysis indicates the model was able to predict the presence of river herring, which may help limit their bycatch.

- Collaborative Climate Data Collection

In January 2016, the Study Fleet began working on a collaborative project with the NEFSC's Oceanography Branch and NOAA's National Weather Service to gather important weather and climate-related data from mini-weather stations mounted on fishing vessels. The weather station includes a barometer to measure atmospheric pressure, anemometer to measure wind speed and direction, and an air temperature gauge. The station also has a built-in computer which factors out the ship's motion to derive a true wind speed and direction and can automatically report via satellite every hour as well as on a wheelhouse display.

2. External Projects

- Science Center for Marine Fisheries Science

The Science Center for Marine Fisheries (SCeMFiS) is a National Science Foundation Industry/University Cooperative Research Center (I/UCRC), partnering with the University of Southern Mississippi and Virginia Institute of Marine Science. The SCeMFiS science program is driven by industry partners and operates under partner oversight to direct funding to specific analytical or research tasks that are industry priorities for specific stock assessments or for the evaluation of specific management options. SCeMFiS allows industry partners to coordinate their responses to assessment and regulatory needs; collaborating with a wide range of scientific expertise, supporting stock sustainability, NSF sanctions for research products, and financial benefits, education, and training for industry partners.

This program also involves research in fishery-independent surveys, survey data processing and design, and improvement of survey methods. The primary use of the findings is to improve stock assessments by fully integrating ecosystem data and to develop improved survey designs and technologies. Current SCeMFiS projects involve surf clam and ocean quahog surveys, data processing, and studies of alternative survey designs. Preliminary results show promise in overall stock assessment improvements by use of enhanced fishery-independent survey methodologies and analytical modelling. Other species under consideration include black sea bass and New England groundfish. Funding has supported active analytical involvement of academic colleagues in several recent stock assessments and protected species consultations. More information on SCeMFis can be found at http://scemfis.org/.

- Marine Resource Education Program

The Marine Resource Education Program (MREP) is a highly successful and innovative program that has demonstrated marked success as a way to inform stakeholders about marine fisheries science and management processes. The program also enhances communication among Science and Management Offices of the National Marine Fisheries Service (NMFS) and the recreational and commercial fishing communities. Partnering with the Gulf of Maine Research Institute (GMRI), the MREP program provides opportunities for NMFS to engage in productive dialogue with marine stakeholders, further their understanding of marine fisheries science and management, and begin to build mutual understanding and respect for the role each organization plays in managing sustainable fisheries. In addition, MREP provides a more effective way to transfer science and policy information to stakeholders, raising the visibility of NMFS work among key constituents.

The MREP 100 course uses staff from the Northeast Fisheries Science Center (NEFSC), the Greater Atlantic Regional Fisheries Office (GARFO), both the Mid-Atlantic and New England Fishery Management Councils (MAFMC and NEFMC, respectively), and academic scholars to present Marine Fisheries Science and Management modules during two week-long sessions. GMRI also developed an advanced MREP 200 program for alumni of the introductory program that focuses on stock assessment science, fisheries monitoring, and survey technology. The participants visit Woods Hole laboratories and get a tour of the R/V Henry B. Bigelow. This module covers advanced stock assessments, age and growth, trawl systems monitoring, and onboard operations during trawl surveys. The participants view standard data capture systems, data quality assurance and control, and visit the Populations Dynamics Branch to see first hand stock assessment scientists modeling and analytical process.

In 2015 and 2016, MREP expanded its scope to hold the first Recreational Fisheries MREP module (October 2016 in Baltimore, MD and March 2017 in Warwick, RI). Participants are exposed to similar MREP 100 and 200 modules' information, but abbreviated. A review of the Marine Recreational Fisheries Information Program (MRIP) is presented and discussed. Council and state recreational fisheries management processes are presented and breakout groups formed to consider various ways to improve the process. A simulated Council meeting is convened after a presentation on Council process and the use of "Robert's Rules of Order."

The MREP also developed an Ecosystems Fisheries Science modules in 2016. Convened in Atlantic City, NJ in March 2016, this was the first ecosystems MREP module nationwide. Highly successful, the participants were exposed to the various ecosystem services that prey species contribute, the various environmental data used in ecosystem modeling, and ways that ecosystem models have contributed to enhancements of stock assessments. The participants had an opportunity to discuss their own observations of changes to the ecosystem and ideas on how to engage in future ecosystem fisheries science and management.

- Penobscot East/University of Maine Sentinel Survey

Penobscot East Resource Center's Sentinel Hook Survey Fishery is a collaborative project with the University of Maine and area fishermen that is attempting to shed light on the question of why Gulf of Maine cod stocks are in collapse and what can potentially be done to reverse the trend. Commercial fishermen use longline hook gear to catch and survey groundfish in eastern Maine. In 2013, the survey was augmented with jig stations in the shallower depths where longline and lobster gear conflicts limited sampling. This hook and line sampling was modeled after similar surveys on the west coast for Pacific rockfish and was felt to be a worthwhile addition to the program to inform future sampling design decisions. The issue of localized spatial depletion that the Sentinel Survey is documenting is an important aspect of the region-wide scientific and policy debate over groundfish science and management. The survey was initiated prior to the elimination of several dams in the Penobscot watershed of eastern Maine. The resulting restoration of river herring runs is hypothesized as one ecosystem component that may support a return of localized spawning aggregations of cod. While the existing time series is still very limited, the catch rate data from the survey is being used to evaluate indices of abundance, how they correspond to existing trawl indices of abundance in the hope that the expanded area coverage (especially hard bottom habitat) may improve stock assessments and future management plans.

3. Research Set-Aside (RSA) Programs

Research Set-Aside (RSA) programs are unique to Federal fisheries in the Greater Atlantic Region. No Federal funds are provided to support the research. Instead, the New England and Mid-Atlantic Fishery Management Councils (Councils) set aside allocations for quota or days-at-sea in the specified fisheries, and research funds are generated through the sale of these allocations.

The Cooperative Research Branch manages the Research Set-Aside programs, the priorities of which are established through RSA species oversight committees and the Councils. RSA projects are selected through a competitive grants process.

In 2016, programs for monkfish, Atlantic herring, and sea scallops were operational. The monkfish RSA program supported tagging projects to study movements between stock areas, age and growth, and influences on spawning by lunar cycles and water temperatures. The Atlantic herring RSA program support monitoring of herring harvest and bycatch of river herring through port sampling.

The sea scallop RSA program supported research on scallop dredge and sea turtle interactions, grey meat causation, ecology of Atlantic sea scallops with respect to population enhancements, rotational area surveys to estimate harvestable biomass, and spatiotemporal fleet management to reduce yellowtail flounder bycatch.

More detailed information on the RSA programs can be found at http://nefsc.noaa.gov/coopresearch/rsa_program.html

Table 1. Catches of species not included in the Status of the Fisheries Section by NAFO Div in Subarea 3.

Div.	Species	Retained	Discarded	Total
3L	Northern wolffish		0.235	0.235
3L	Spotted wolffish		0.053	0.053
3L	Greenland shark		0.227	0.227
3L	Greenland halibut		0.017	0.017
3L	Roughhead grenadier		0.079	0.079
3L	Cusk		0.008	0.008
3M	Northern wolffish		0.105	0.105
3M	Spotted wolffish		0.062	0.062
3N	Atlantic wolffish		0.694	0.694
3N	Blue shark		0.741	0.741
3N	American goosefish		0.037	0.037
3N	Northern wolffish		13.188	13.188
3N	Spotted wolffish		5.051	5.051
3N	Black dogfish		2.940	2.940
3N	Groundfishes, uncl		0.163	0.163
3N	Sea Raven		0.413	0.413
3N	Greenland halibut	3.206	1.300	4.506
3N	Marlin-spike		0.164	0.164
3N	Greenland shark		8.348	8.348
3N	Sculpins		0.733	0.733
3N	Mahi mahi		0.004	0.004
3N	Porbeagle		3.354	3.354
3N	Redfishes		0.689	0.689
3N	Roughhead grenadier		15.162	15.162
3N	Cusk	4.838	1.787	6.625
3O	Northern wolffish		0.024	0.024
3O	Spotted wolfish		0.627	0.627
3O	Atlantic wolffish		0.221	0.221
3O	Cusk	0.067	0.214	0.281
3O	Greenland halibut	0.070	0.058	0.128
3O	Greenland shark		4.156	4.156
3O	Roughhead grenadier		0.037	0.037
3O	Groundfishes		0.022	0.022

Table 2. NAFO Observer sampling of United States fishing trips from 2012-2016 by species, catch disposition (catch=discards+ retained), NAFO Division and gear. The otter trawl (OTB) uses 165 mm mesh.

Year	Code	Species	English_name	Catch/Disc./Ret.	Div	Gear	Samples	Individuals
2012	COD	*Gadus morhua*	Atlantic cod	Discard	3N	OTB	1	42
2012	PLA	*Hippoglossoides platessoides*	American plaice	Discard	3N	OTB	6	715
2012	PLA	*Hippoglossoides platessoides*	American plaice	Retained	3N	OTB	2	53
2012	YEL	*Limanda ferruginea*	Yellowtail flounder	Catch	3N	OTB	17	2046
2012	YEL	*Limanda ferruginea*	Yellowtail flounder	Discard	3N	OTB	17	3174
2012	YEL	*Limanda ferruginea*	Yellowtail flounder	Retained	3N	OTB	1	159
2013	PLA	*Hippoglossoides platessoides*	American plaice	Catch	3N	OTB	4	498
2013	PLA	*Hippoglossoides platessoides*	American plaice	Retained	3N	OTB	11	1399
2013	YEL	*Limanda ferruginea*	Yellowtail flounder	Catch	3N	OTB	9	1856
2013	YEL	*Limanda ferruginea*	Yellowtail flounder	Retained	3N	OTB	13	1769
2014	COD	*Gadus morhua*	Atlantic cod	Discard	3M	LL	4	110
2014	COD	*Gadus morhua*	Atlantic cod	Discard	3N	LL	4	91
2014	COD	*Gadus morhua*	Atlantic cod	Retained	3N	LL	1	30
2014	HAL	*Hippoglossus hippoglossus*	Atlantic halibut	Discard	3N	LL	1	1
2014	HAL	*Hippoglossus hippoglossus*	Atlantic halibut	Retained	3N	LL	7	12
2014	HKW	*Urophycis tenuis*	White hake	Discard	3N	LL	4	100
2014	HKW	*Urophycis tenuis*	White hake	Retained	3N	LL	2	21
2014	PLA	*Hippoglossoides platessoides*	American plaice	Catch	3N	OTB	13	1266
2014	PLA	*Hippoglossoides platessoides*	American plaice	Retained	3N	OTB	1	95
2014	RED	*Sebastes spp*	Redfish	Discard	3N	LL	1	23
2014	YEL	*Limanda ferruginea*	Yellowtail flounder	Catch	3N	OTB	17	2503
2014	YEL	*Limanda ferruginea*	Yellowtail flounder	Retained	3N	OTB	3	199
2015	COD	*Gadus morhua*	Atlantic cod	Discard	3M	LL	1	25
2015	COD	*Gadus morhua*	Atlantic cod	Discard	3N	LL	1	5
2015	COD	*Gadus morhua*	Atlantic cod	Retained	3N	LL	2	13
2015	COD	*Gadus morhua*	Atlantic cod	Discard	3N	OTB	2	2
2015	GHL	*Reinhardtius hippoglossoides*	Greenland halibut	Discard	3O	LL	1	1
2015	GHL	*Reinhardtius hippoglossoides*	Greenland halibut	Retained	3N	LL	1	4
2015	HAL	*Hippoglossus hippoglossus*	Atlantic halibut	Catch	3N	LL	5	24
2015	HAL	*Hippoglossus hippoglossus*	Atlantic halibut	Catch	3NO	LL	1	8
2015	HAL	*Hippoglossus hippoglossus*	Atlantic halibut	Catch	3O	LL	2	4
2015	HAL	*Hippoglossus hippoglossus*	Atlantic halibut	Discard	3N	LL	1	2
2015	HAL	*Hippoglossus hippoglossus*	Atlantic halibut	Discard	3O	LL	1	2

Table 2 cont. NAFO Observer sampling of United States fishing trips from 2012-2016 by species, catch disposition (catch=discards+ retained), NAFO Division and gear. The otter trawl (OTB) uses 165 mm mesh.

Year	Code	Species	English_name	Catch/Disc./Ret.	Div	Gear	Samples	Ind.
2015	HAL	*Hippoglossus hippoglossus*	Atlantic halibut	Retained	3N	LL	4	4
2015	HKW	*Urophycis tenuis*	White hake	Discard	3N	LL	1	22
2015	HKW	*Urophycis tenuis*	White hake	Retained	3N	LL	3	77
2015	OPT	*Zoarces americanus*	Ocean pout	Discard	3N	OTB	1	1
2015	PLA	*Hippoglossoides platessoides*	American plaice	Catch	3N	OTB	2	91
2015	REB	*Sebastes mentella*		Discard	3N	LL	1	35
2015	REG	*Sebastes norvegicus*	Golden redfish	Discard	3N	LL	1	1
2015	USK	*Brosme brosme*	Cusk	Retained	3N	LL	1	1
2015	YEL	*Limanda ferruginea*	Yellowtail flounder	Retained	3N	OTB	7	305
2016	COD	*Gadus morhua*	Atlantic cod	Catch	3N	LL	2	26
2016	COD	*Gadus morhua*	Atlantic cod	Discard	3N	LL	16	189
2016	COD	*Gadus morhua*	Atlantic cod	Retained	3M	LL	3	44
2016	COD	*Gadus morhua*	Atlantic cod	Retained	3N	LL	1	11
2016	GHL	*Reinhardtius hippoglossoides*	Greenland halibut	Discard	3M	LL	4	6
2016	GHL	*Reinhardtius hippoglossoides*	Greenland halibut	Discard	3N	LL	17	35
2016	GHL	*Reinhardtius hippoglossoides*	Greenland halibut	Retained	3N	LL	11	53
2016	HAL	*Hippoglossus hippoglossus*	Atlantic halibut	Discard	3N	LL	14	128
2016	HAL	*Hippoglossus hippoglossus*	Atlantic halibut	Retained	3N	LL	12	67
2016	HKW	*Urophycis tenuis*	White hake	Catch	3N	LL	8	124
2016	HKW	*Urophycis tenuis*	White hake	Discard	3N	LL	24	340
2016	HKW	*Urophycis tenuis*	White hake	Retained	3N	LL	1	21
2016	PLA	*Hippoglossoides platessoides*	American plaice	Discard	3N	LL	1	1
2016	PLA	*Hippoglossoides platessoides*	American plaice	Catch	3N	OTB	6	376
2016	PLA	*Hippoglossoides platessoides*	American plaice	Discard	3N	OTB	1	38
2016	PLA	*Hippoglossoides platessoides*	American plaice	Retained	3N	OTB	7	341
2016	RED	*Sebastes spp*	Redfish	Discard	3N	LL	11	39
2016	RED	*Sebastes spp*	Redfish	Retained	3N	LL	1	4
2016	YEL	*Limanda ferruginea*	Yellowtail flounder	Catch	3N	OTB	3	250
2016	YEL	*Limanda ferruginea*	Yellowtail flounder	Retained	3N	OTB	11	506

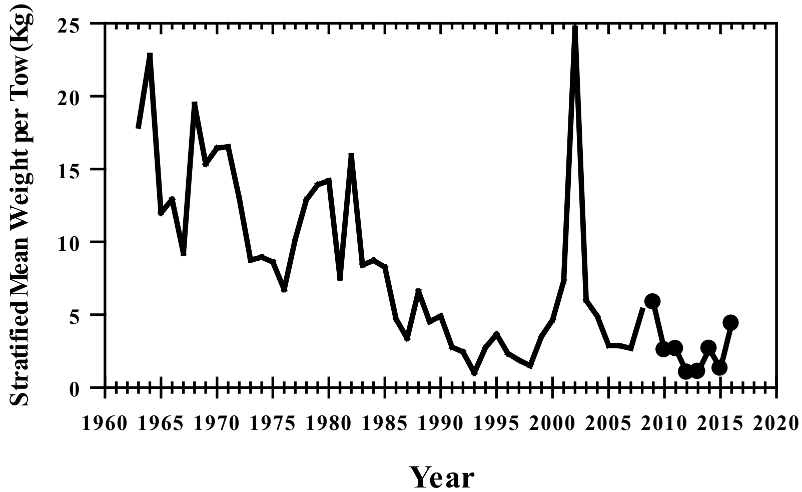

Fig. 1. NEFSC autumn bottom trawl survey biomass indices for Gulf of Maine cod.

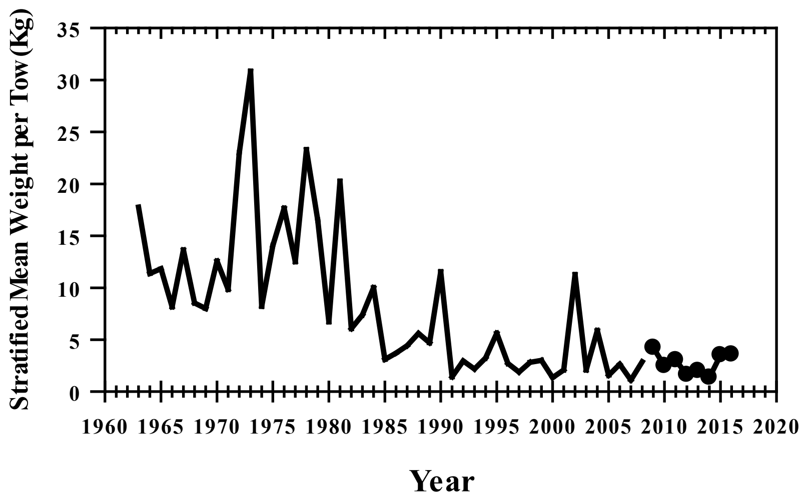

Fig. 2. NEFSC autumn bottom trawl survey biomass indices for Georges Bank cod.

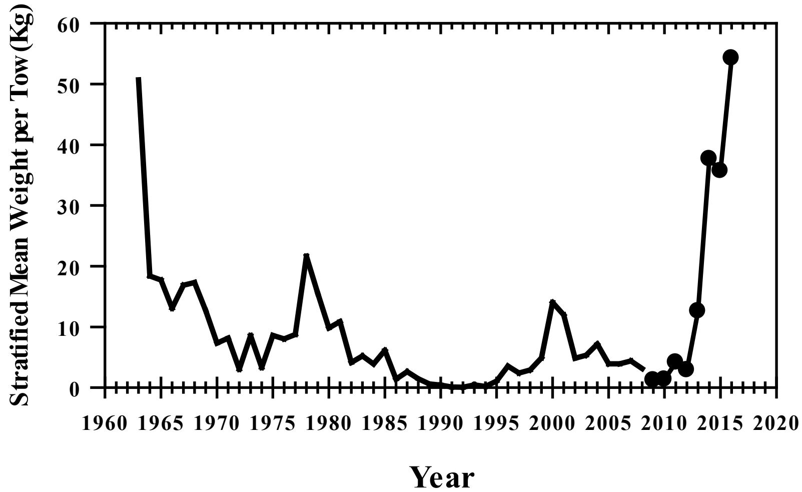

Fig. 3. NEFSC autumn bottom trawl survey biomass indices for Gulf of Maine haddock.

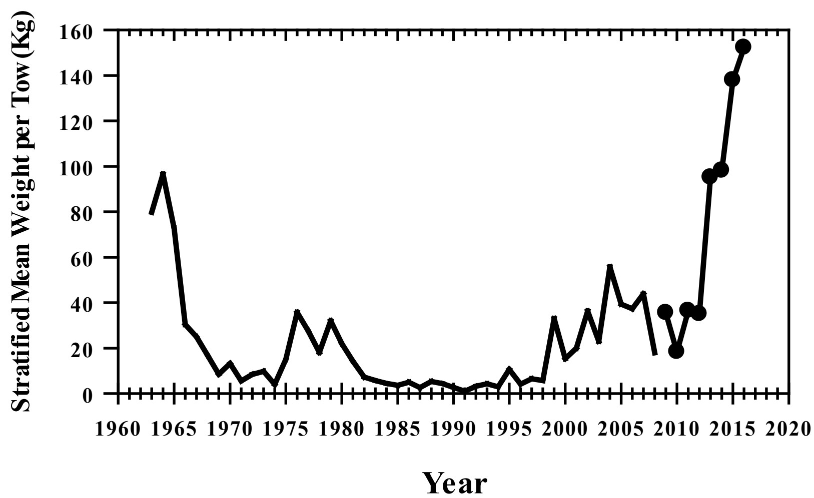

Fig. 4. NEFSC autumn bottom trawl survey biomass indices for Georges Bank haddock.

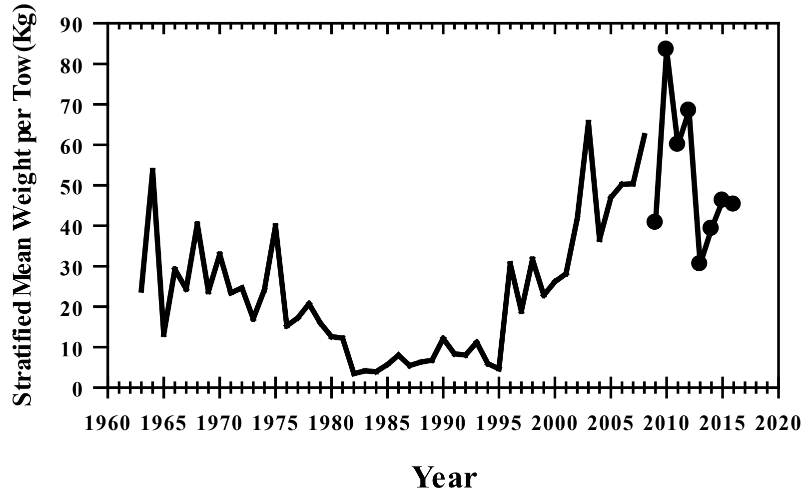

Fig. 5. NEFSC autumn bottom trawl survey biomass indices for Acadian redfish.

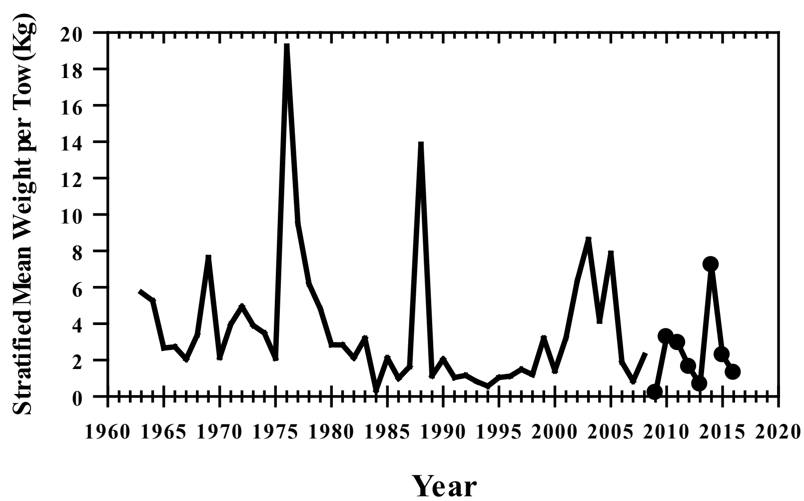

Fig. 6. NEFSC autumn bottom trawl survey biomass indices for pollock.

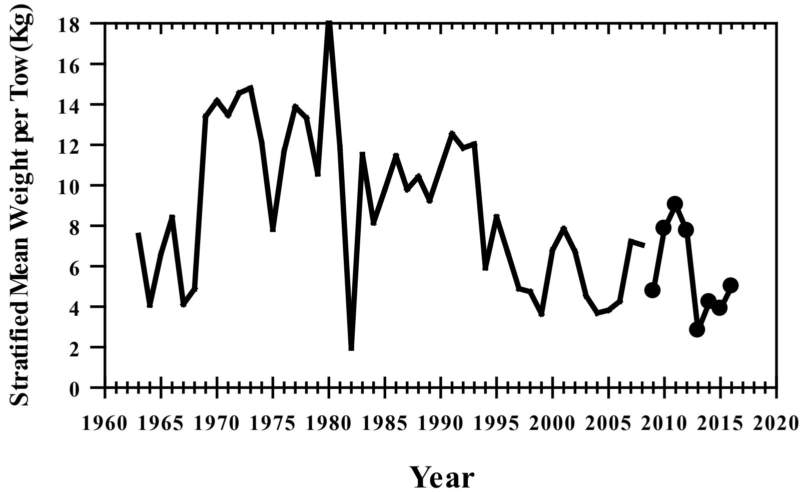

Fig. 7. NEFSC autumn bottom trawl survey biomass indices for white hake.

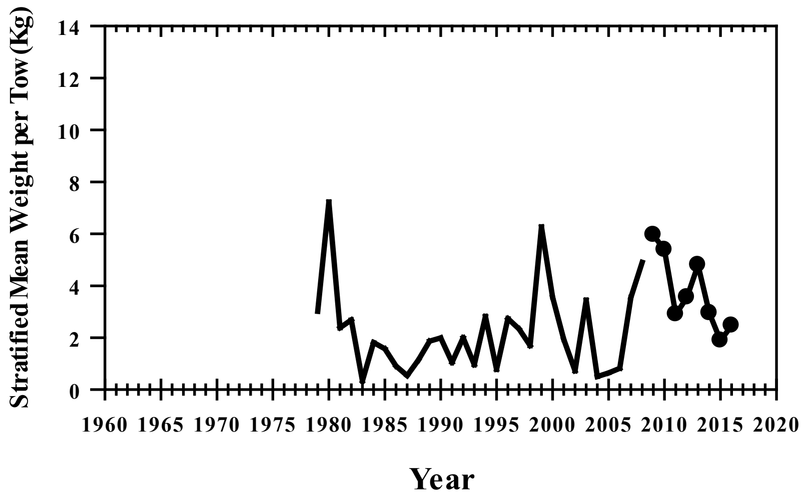

Fig. 8. NEFSC autumn bottom trawl survey biomass indices for Cape Cod-Gulf of Maine yellowtail flounder.

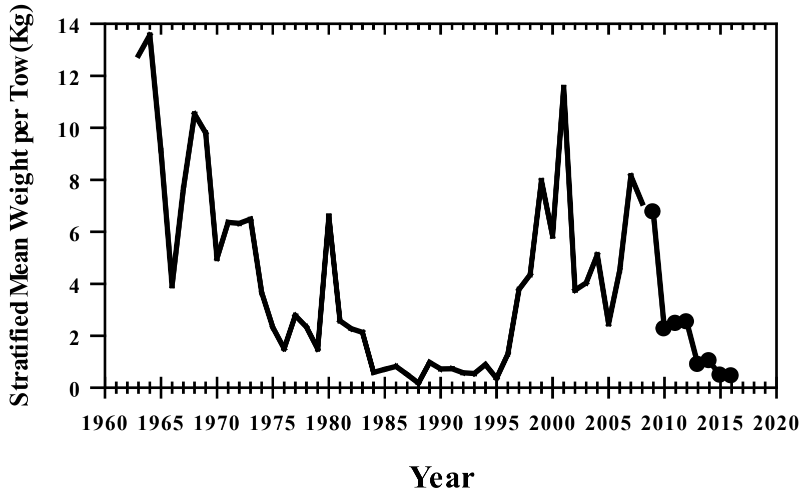

Fig. 9. NEFSC autumn bottom trawl survey biomass indices for Georges Bank yellowtail flounder.

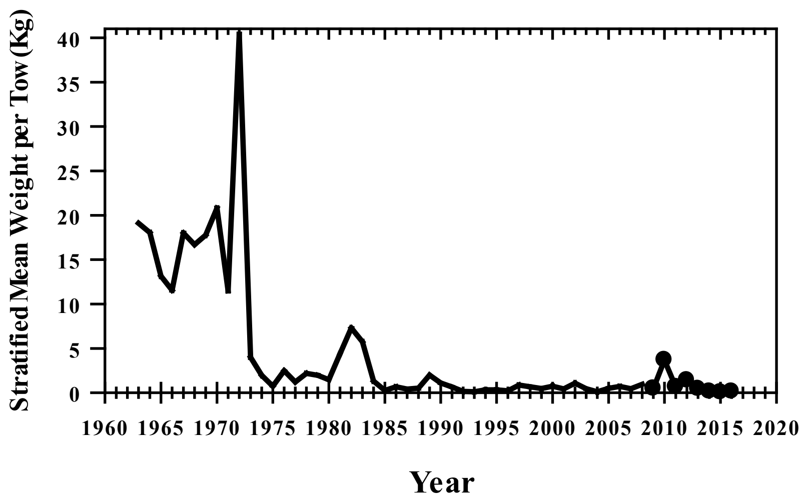

Fig. 10. NEFSC autumn bottom trawl survey biomass indices for Southern New England-Mid-Atlantic yellowtail flounder.

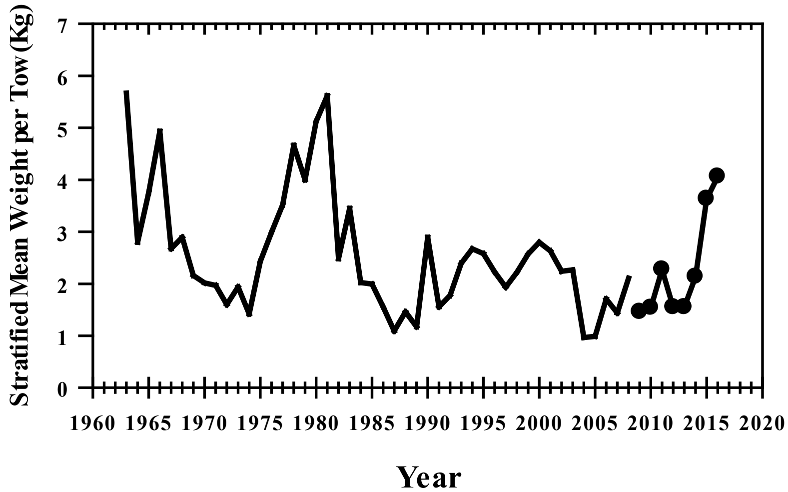

Fig. 11. NEFSC autumn bottom trawl survey biomass indices for American plaice.

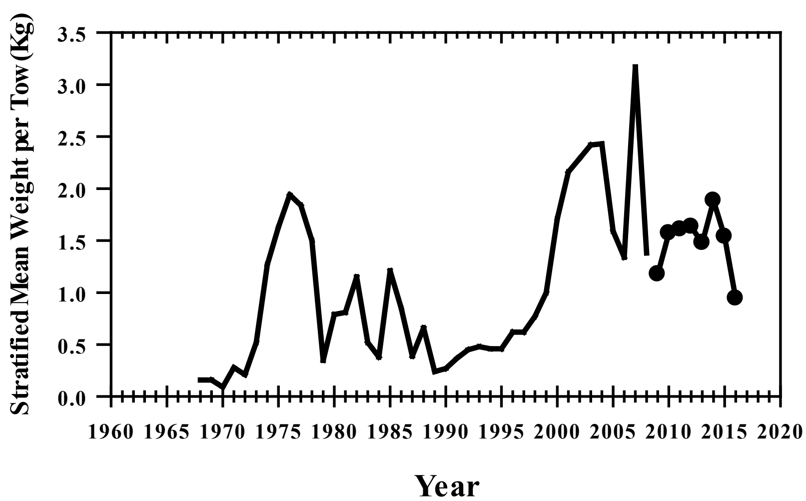

Fig. 12. NEFSC spring bottom trawl survey biomass indices for summer flounder.

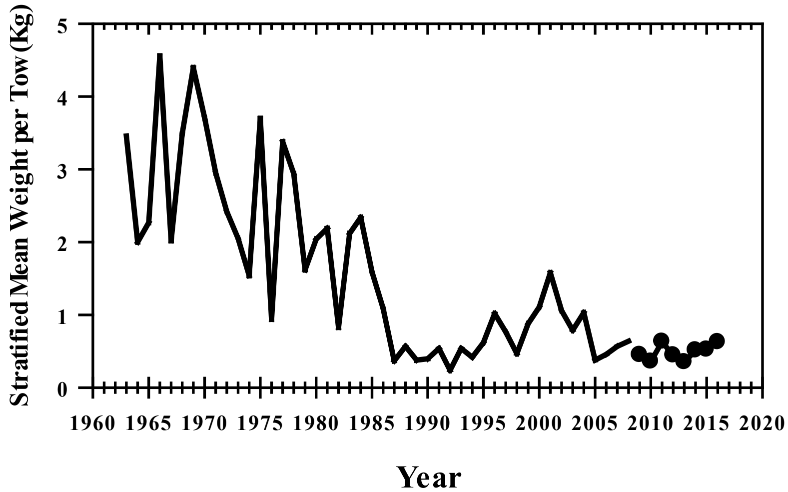

Fig. 13. NEFSC autumn bottom trawl survey biomass indices for witch flounder.

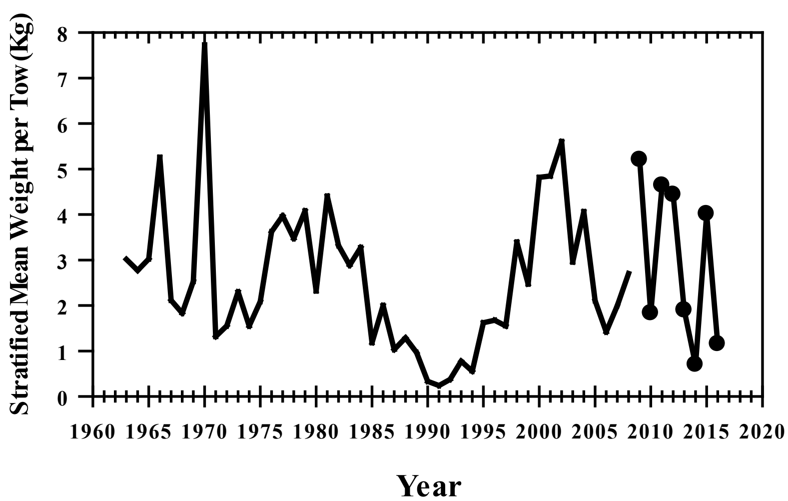

Fig. 14. NEFSC autumn bottom trawl survey biomass indices for Georges Bank winter flounder.

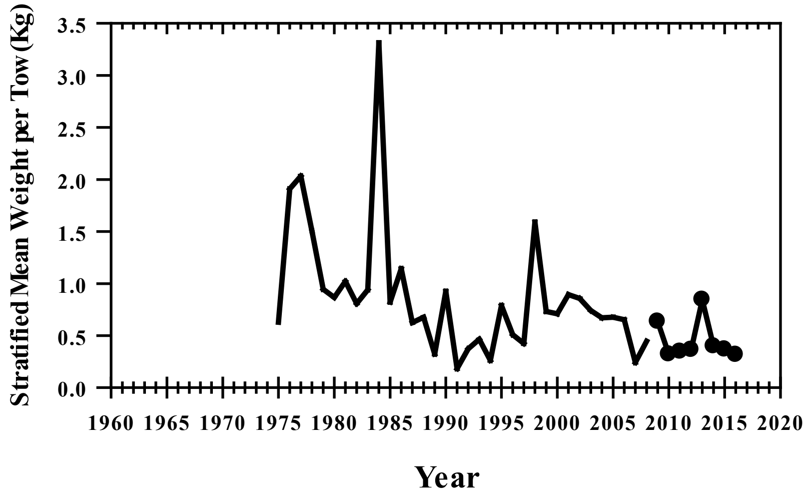

Fig.15. NEFSC autumn bottom trawl survey biomass indices for northern windowpane flounder.

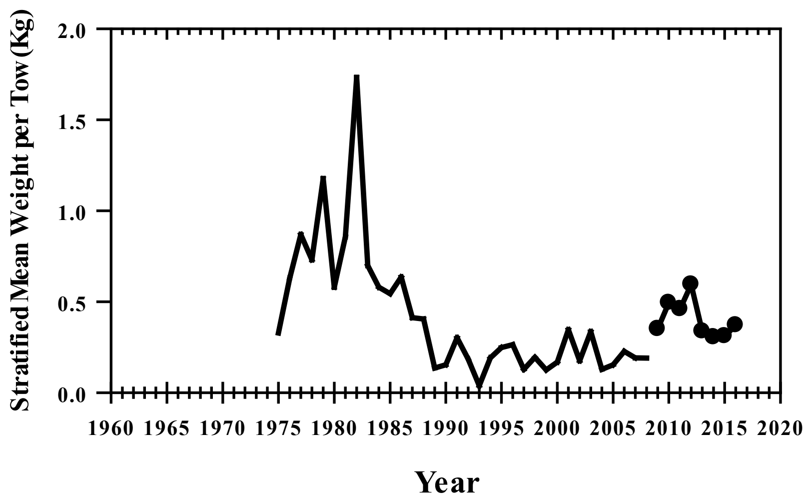

Fig. 16. NEFSC autumn bottom trawl survey biomass indices for southern windowpane flounder.

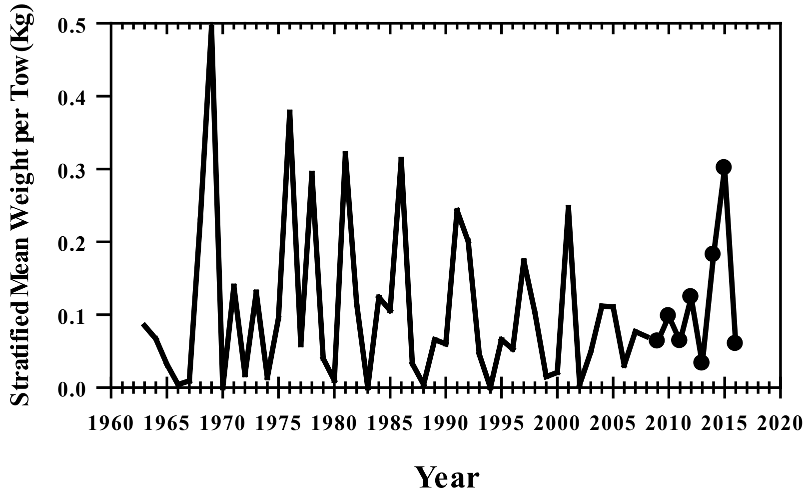

Fig. 17. NEFSC autumn bottom trawl survey biomass indices for Atlantic halibut.

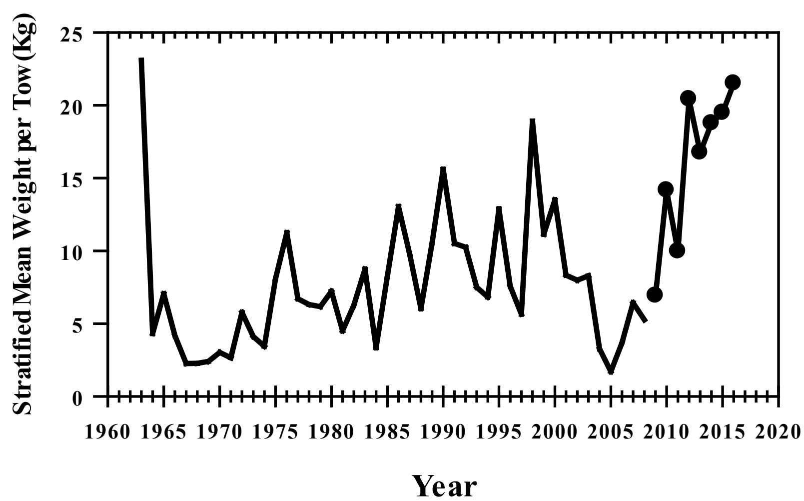

Fig.18. NEFSC autumn bottom trawl survey biomass indices for northern silver hake.

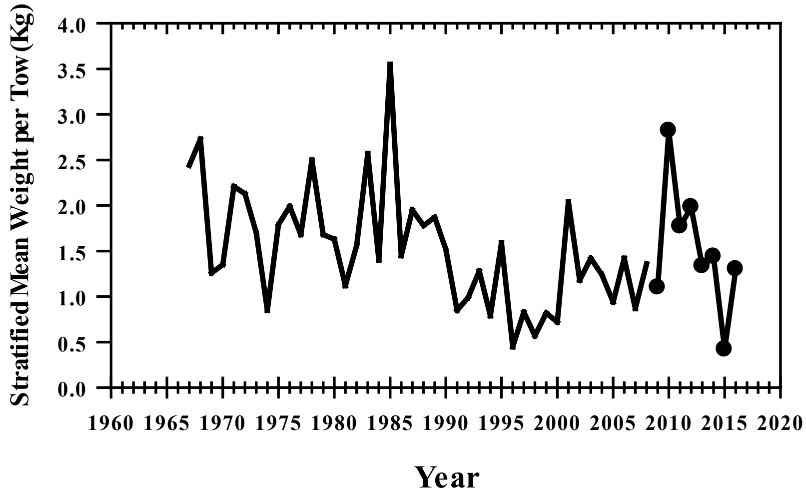

Fig. 19. NEFSC autumn bottom trawl survey biomass indices for southern silver hake.

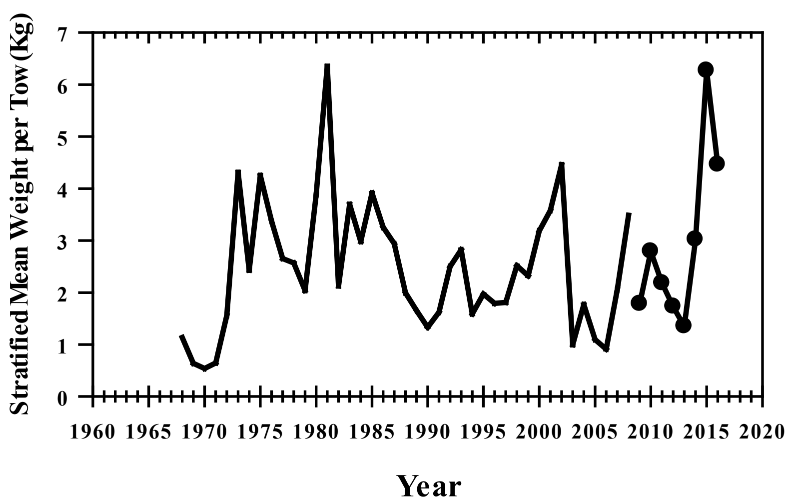

Fig. 20. NEFSC spring bottom trawl survey biomass indices for northern red hake.

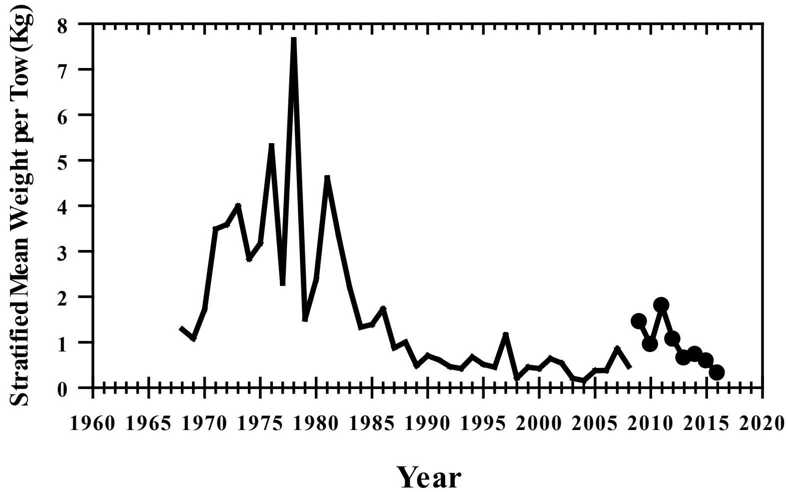

Fig. 21. NEFSC spring bottom trawl survey biomass indices for southern red hake.

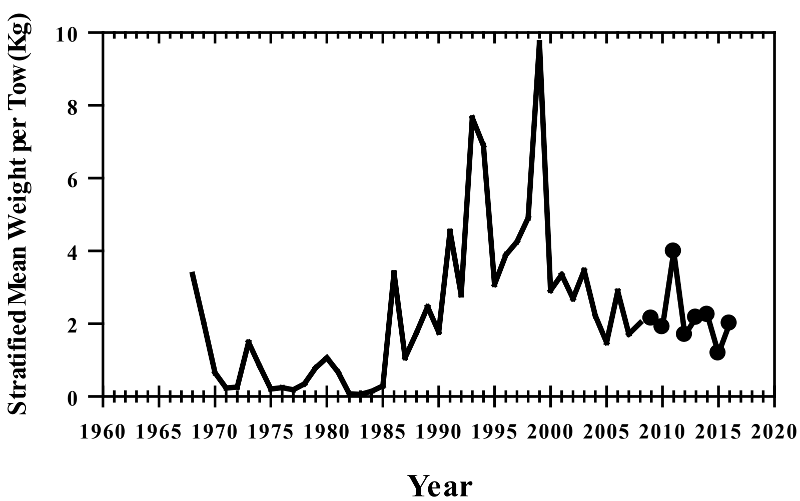

Fig. 22. NEFSC spring bottom trawl survey biomass indices for Atlantic herring.

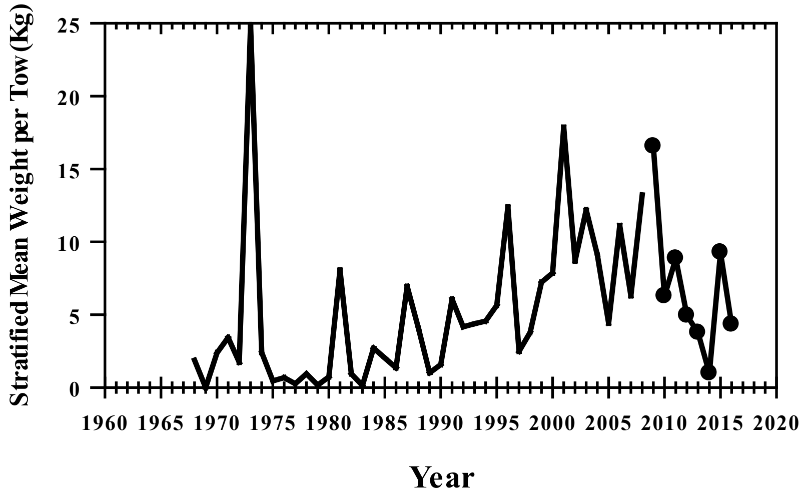

Fig. 23. NEFSC spring bottom trawl survey biomass indices for Atlantic mackerel.

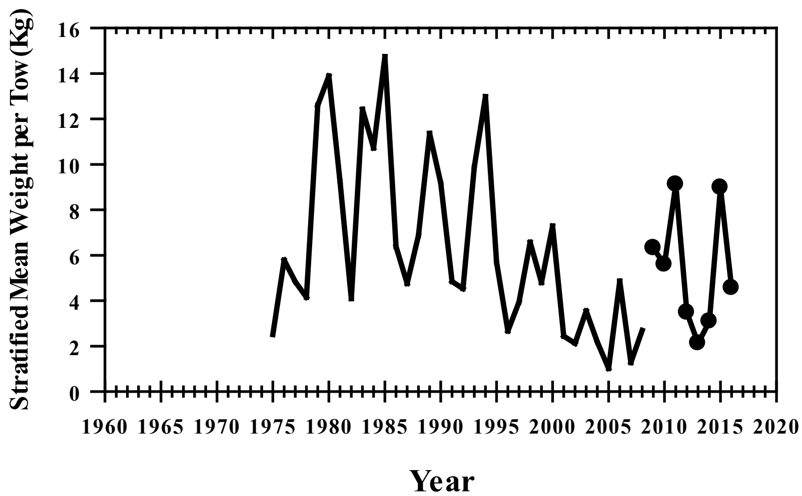

Fig. 24. NEFSC autumn bottom trawl survey biomass indices for butterfish.

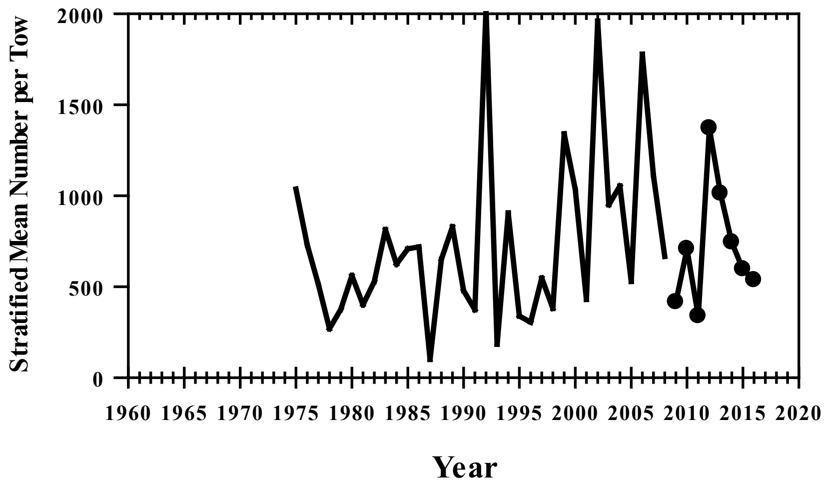

Fig. 25. NEFSC autumn bottom trawl survey abundance indices for longfin inshore squid.

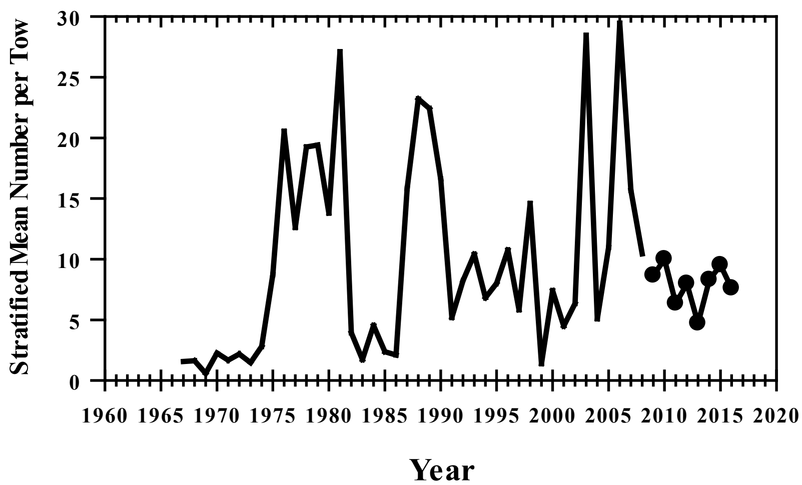

Fig. 26. NEFSC autumn bottom trawl survey abundance indices for northern shortfin squid.

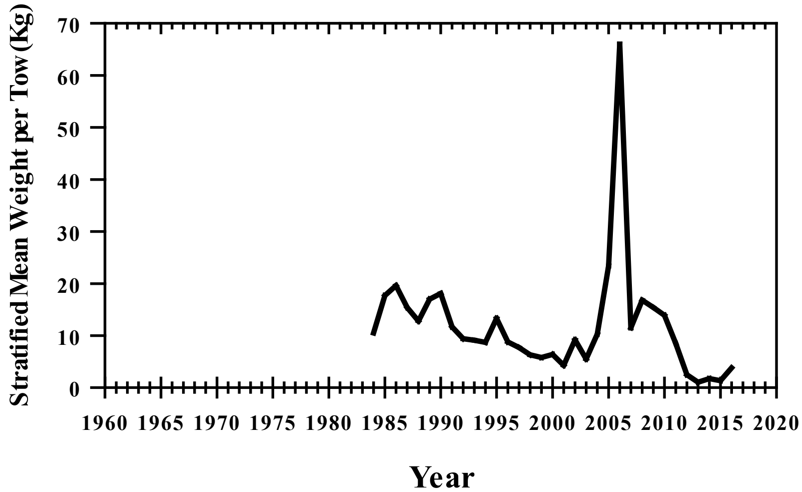

Fig. 27. ASMFC summer shrimp survey biomass indices for northern shrimp.

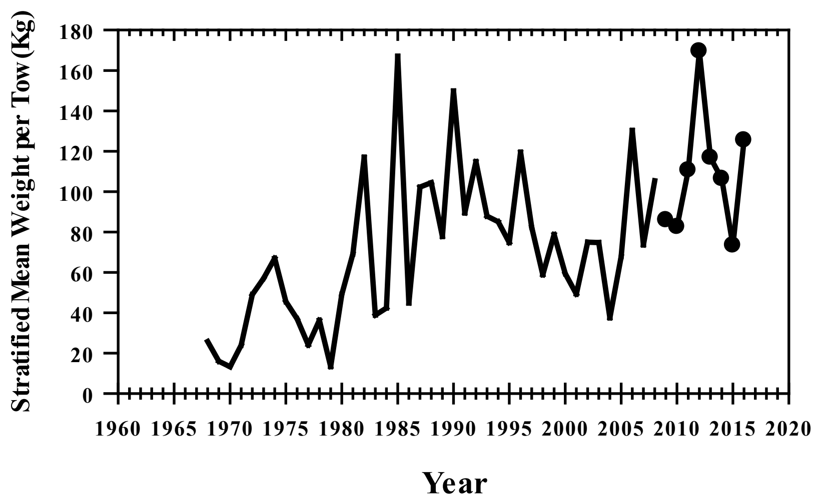

Fig. 28. NEFSC spring bottom trawl survey biomass indices for spiny dogfish.

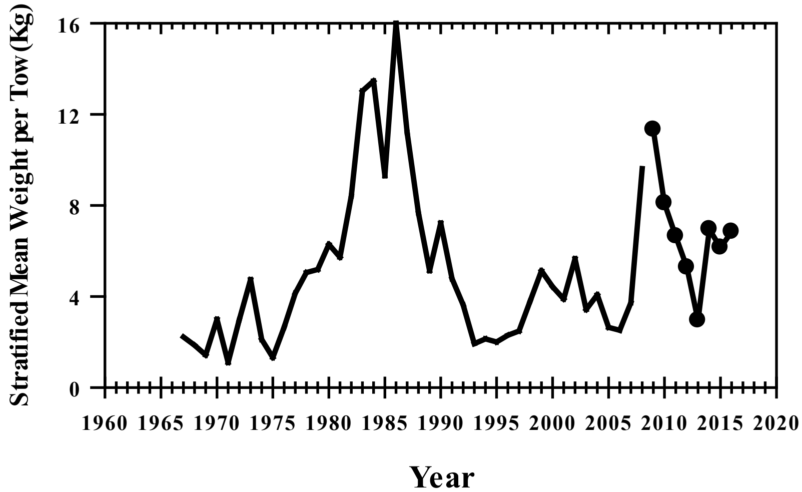

Fig. 29. NEFSC autumn bottom trawl survey biomass indices for winter skate.

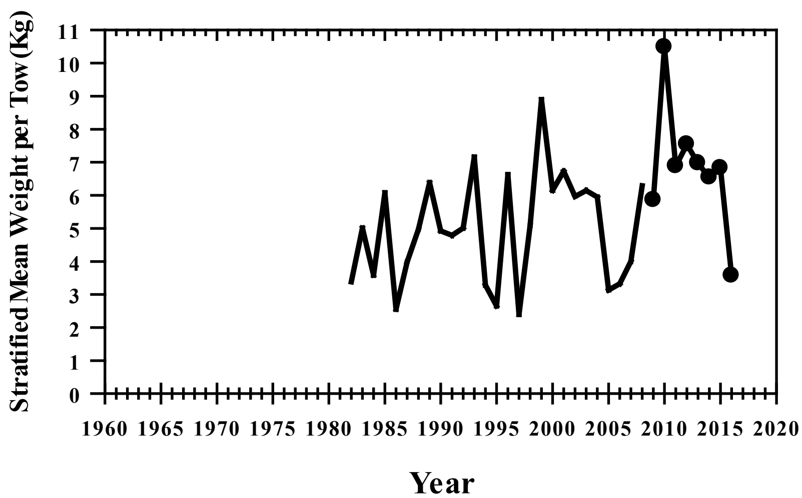

Fig. 30. NEFSC spring bottom trawl survey biomass indices for little skate.

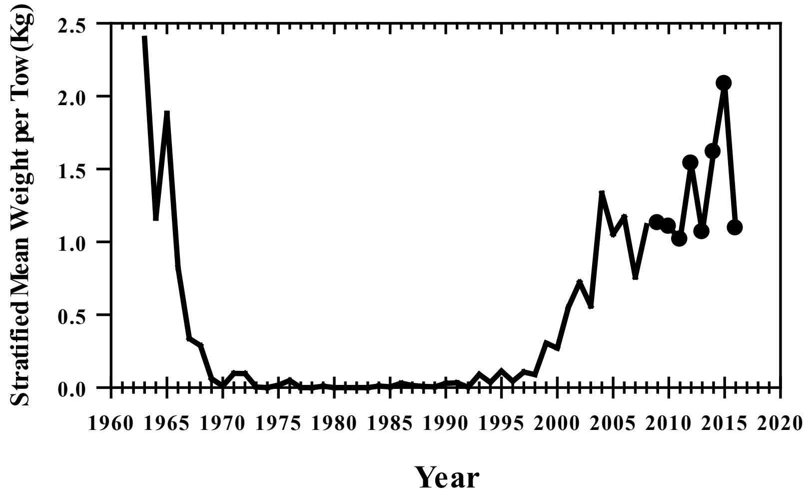

Fig. 31. NEFSC autumn bottom trawl survey biomass indices for barndoor skate.

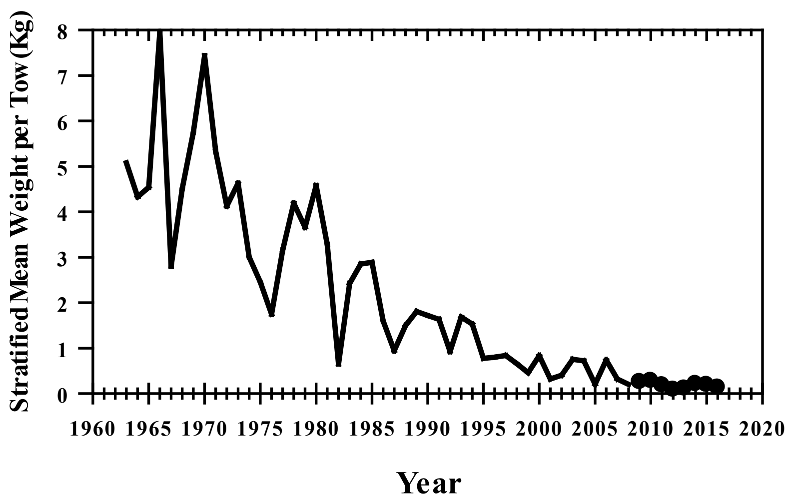

Fig. 32. NEFSC autumn bottom trawl survey biomass indices for thorny skate.

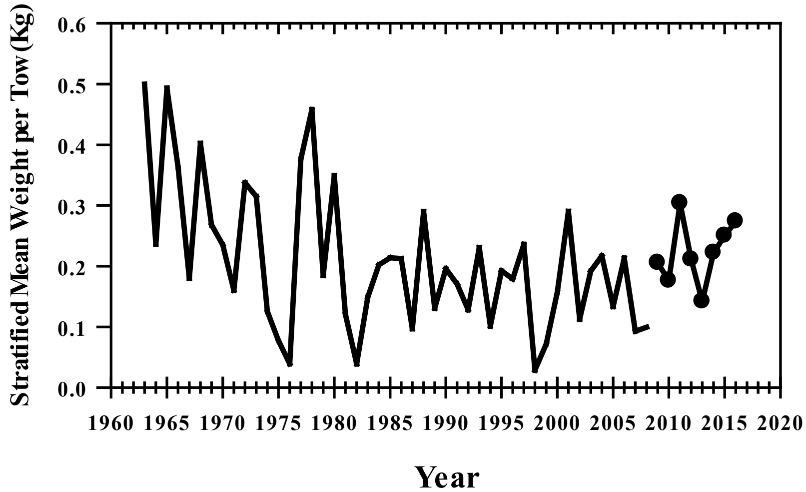

Fig. 33. NEFSC autumn bottom trawl survey biomass indices for smooth skate.

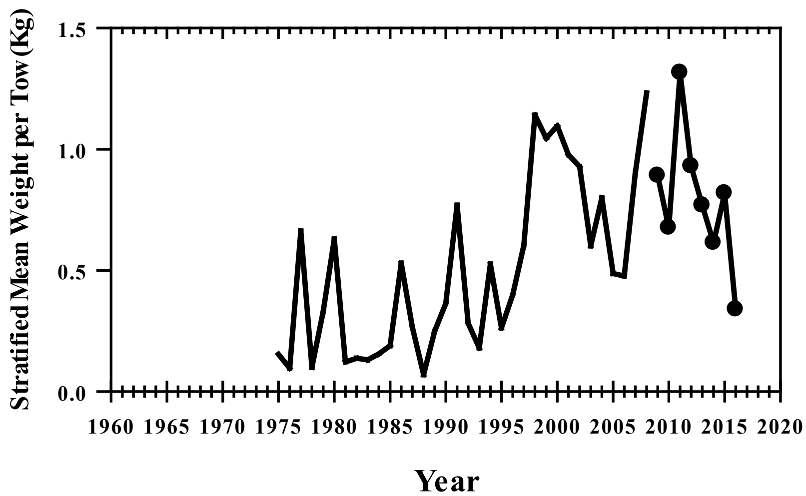

Fig. 34. NEFSC autumn bottom trawl survey biomass indices for clearnose skate.

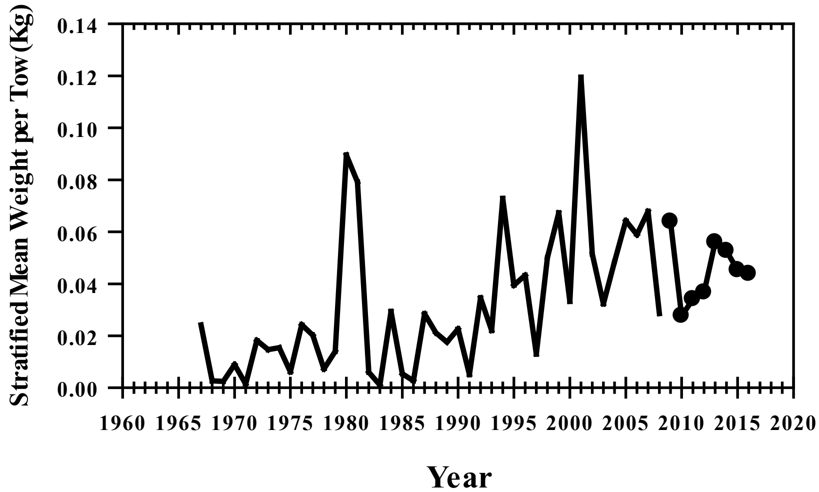

Fig. 35. NEFSC autumn bottom trawl survey biomass indices for rosette skate.