Northwest Atlantic Fisheries Organization

Serial No. N6552 **NAFO SCS Doc. 16/06**

SCIENTIFIC COUNCIL MEETING – JUNE 2016

United States Research Report for 2015

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, in 2004, and in 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 survey indices for 2009-2015 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 only been estimated for some species. Consequently, 2009-2015 survey data points should be interpreted cautiously, and these values may change in the future as new methodologies are considered. The 2009-2015 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 those sections.

For the last few years, the United States has been allocated quota for Div. 3LNO yellowtail flounder and, from 2012-2015, a vessel fished in the area. An additional vessel fished in area for Atlantic halibut in 2014 and 2015. 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.

1. Atlantic Cod

USA commercial landings of Atlantic cod (*Gadus morhua*) from Subareas 5&6 in 2015 were 1,527 mt, a 35% decrease from the 2014 landings of 2,346 mt. In addition, 2.5 mt were landed from Div. 3N and 14.8 mt were discarded. In Div. 3O, <0.1 mt were kept and <0.1 mt were discarded. In Div. 3M and 3L there were 3.7 and 5.2 mt discarded, respectively.

Northeast Fisheries Science Center (NEFSC) research vessel survey biomass indices in the Gulf of Maine have been generally declining over the past five years (Figure 1). The 2015 biomass indices are some of the lowest of the time series. The stock continues to experience low recruitment.

The NEFSC research vessel survey biomass indices for the Georges Bank stock have been variable and among the lowest in the time series in recent years (Figure 2). Stock productivity remains poor with recent age-1 recruitment well below the long term average.

2. <u>Haddock</u>

United States commercial landings of haddock (*Melanogrammus aeglefinus*) increased by 19% from 4,554 mt in 2014 to 5,413 mt in 2015. In addition, 0.1 mt of haddock were landed in Div. 3N and <0.1 mt were discarded.

The autumn research vessel survey biomass indices for the Gulf of Maine stock increased substantially in 2014 to 37.7 kg/tow relative to the 2013 estimate of 12.6 kg/tow and remained high in 2015 (Figure 3). The recent increase in biomass is due to strong recruitment observed over the past three years. Since 2004 large fluctuations have occurred in the Georges Bank survey index as year classes increased in weight. Mean biomass per tow was about 35 kg/tow in 2011 and 2012, and increased to above 95 kg/tow in 2013 and 2014, as the very large 2010 year class grew in length and weight. The biomass index in 2015 increased to 138 kg/tow, the highest value in the time series (Figure 4).

3. <u>Redfish</u>

USA landings of Acadian redfish (*Sebastes fasciatus*) increased by 8% from 4,574 mt in 2014 to 4,930 mt in 2015. 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 increased by 18% from 39.24 kg/tow in 2014 to 46.20 kg/tow in 2015.

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

USA landings of pollock (*Pollachius virens*) decreased by 33% from 4,546 mt in 2014 to 3,046 mt in 2015. Fall research vessel survey indices reflected a general increase in pollock biomass from the mid-1990s through 2005 (Figure 6). The survey biomass index has been variable since 2006, reaching a record-low of 0.22 kg/tow in 2009. Most recently, the index decreased by 68% from 7.21 kg/tow in 2014 to 2.27 kg/tow in 2015.

5. <u>White Hake</u>

Nominal USA landings of white hake (*Urophycis tenuis*) from NAFO Subareas 5 and 6 decreased by 19.1% from 1,857 mt in 2014 to 1,503 mt in 2015. Landings from Div. 3N were 12.6 mt, while 58.6 mt were discarded in Div 3N and 2.7 mt were discarded in Div 3O. 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, however, the indices for the last three years are among the lowest in the time series (Figure 7).

6. <u>Yellowtail Flounder</u>

USA landings of yellowtail flounder (*Limanda ferruginea*) from NAFO subareas 5 and 6 were 689 mt in 2015, a 31.7% decrease from 2014 landings of 1,008 mt. In Div. 3N, landings decreased 34% from 769 mt in 2014 to 507 mt in 2015. Additionally, 27.9 mt of yellowtail flounder were discarded in Div. 3N bringing the total catch of yellowtail flounder in Div. 3N to 535 mt in 2015. Less than 1 mt of yellowtail flounder was discarded in Div. 3O.

The NEFSC autumn research vessel survey biomass indices in the Gulf of Maine decreased slightly over the last three years (Figure 8). In 2015, the NEFSC autumn survey biomass was 1.89 kg/tow, a decrease from the 2014 survey value of 2.95kg/tow (Figure 8).

The NEFSC autumn research vessel survey biomass indices on Georges Bank have been decreasing over the last eight years (Figure 1). In 2015, the NEFSC autumn survey biomass is among the lowest of the time series. The 2015 autumn survey was 0.47 kg/tow compared to 1.02 kg/tow in 2014 (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 is the lowest of the time series, estimated at 0.036 kg/tow (Figure 10).

7. Other Flounders

USA commercial landings of flounders (other than yellowtail flounder and Atlantic halibut) from Subareas 3-6 in 2015 totaled 8,363 mt, 6% lower than in 2014. Summer flounder (*Paralichthys dentatus*; 58%), winter flounder (*Pseudopleuronectes americanus*; 20% comprising the Georges Bank, Southern New England, and Gulf of Maine stocks), American plaice (*Hippoglossoides platessoides*; 16%), 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 2015. Compared to 2014, commercial landings in 2015 were higher for windowpane flounder (46%) and lower for winter flounder (-14%), witch flounder (-14%), summer flounder (-3%), and American plaice (-4%). The American plaice landings from Div. 3N were 31 mt. In addition, 25 mt of American plaice were discarded in Div. 3N bringing the total catch of American plaice in Div. 3N in 2015 to 56 mt. Discards of American plaice in Div. 3O were low (<1 mt). Discards of witch flounder were 1.9 mt in Div. 3N and 0.2 mt in Div. 3O.

Research vessel survey indices in 2015 remained similar to the previous year's indices for southern windowpane and northern windowpane flounder, increased for American plaice, Georges Bank winter flounder and witch flounder and decreased for summer flounder (Figures 11-16).

8. Atlantic halibut

USA landings of Atlantic halibut (*Hippoglossus hippoglossus*) in the Gulf of Maine-Georges Bank region decreased 16% from 46 mt in 2014 to 39 mt in 2015. In addition, 72 mt of halibut were landed in NAFO Subarea3 and 12 mt of halibut were discarded. Research vessel survey indices have little trend and high interannual 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 – 2015 were converted from FSV *Henry .B. Bigelow* units to RV *Albatross IV* units using the mean calibration coefficient of other flounders.

9. Silver hake

USA landings of silver hake (*Merluccius bilinearis*) from NAFO subareas 5 and 6 were 6,454 mt in 2015, a 12% decrease from 2014 landings of 7,357 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

2015, the NEFSC autumn survey biomass was 19.49 kg/tow, an increase from the 2014 survey value of 18.77 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).

10. Red Hake

USA landings of red hake (*Urophycis chuss*) decreased 26% from 634 mt in 2014 to 472 mt in 2015. 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 (Figure 20). Indices for the Southern Georges Bank - Mid-Atlantic stock declined in the 1990s and remained low through 2015 (Figure 21).

11. Atlantic Herring

Nominal preliminary USA landings of Atlantic herring (*Clupea harengus*) declined slightly, equaling 93,168 mt in 2014 and 80,766 mt in 2015. Spring survey indices were relatively stable during 2008-2015 and averaged 2.17 kg/tow (Figure 22). The 2015 spring survey index was 1.18 kg/tow.

12. Atlantic Mackerel

USA commercial landings of Atlantic mackerel (*Scomber scombrus*) decreased 4.9% from 5,905 mt in 2014 to 5,616 mt in 2015. Recreational catches increased 46.8% from 788 mt in 2014 to 1,157 mt in 2015. In the 2014 spring survey, the southernmost strata were not sampled due to delays in the survey. 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. Consequently, the abbreviated set of offshore strata was used to derive relative abundance and biomass indices from 1968-2015 so that the 2015 estimate could be directly compared to that of 2014. Spring survey indices increased during the 1990s and averaged 7.7 kg/tow during the last ten years (2005-2014). The spring survey index increased from 0.99 kg/tow in 2014 to 10.56 kg/tow in 2015. Estimated 2015 relative abundance and biomass indices were both greater than the time series medians of 22.13 mackerel-per-tow and 4.13 kg-per-tow.

13. Butterfish

USA landings of butterfish (*Peprilus triacanthus*) decreased 33.7% from 3,141 mt in 2014 to 2,081 mt in 2015. 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 = 6.25 kg/tow), although biomass in 2015 was 8.98 kg/tow (Figure 24).

14. Squids

The USA small-mesh bottom trawl fishery for longfin inshore squid, *Doryteuthis (Amerigo) pealeii* began in 1987. During 1987-2014, landings averaged 15,484 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 2007-2014 landings were below the 1987-2014 mean and averaged 10,689 mt. Landings declined from 12,354 mt in 2007 to 6,913 mt in 2010, and then increased to 12,820 mt in 2012. Since then, landings have been stable and totaled 11,928 mt in 2015.

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 median of 659 squid per tow, but declined from 1,371 squid per tow in 2012 to 744 squid per tow in 2014. Relative abundance dropped below the median in 2015 to 596 squid per tow.

The USA small-mesh bottom trawl fishery for Northern shortfin squid (*Illex illecebrosus*) began in 1987. During 1987-2014, landings averaged 12,440 mt, with a low of 1,958 mt in 1988 and a time series peak (USA and foreign landings, 1963-2015) of 26,097 mt in 2004. In recent years, landings declined substantially from 18,797 mt in 2011 to 2,423 mt in 2015. The decline in landings was attributable to reduced fishing effort due to low value of the species on the international squid market.

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

15. Atlantic Sea Scallops

USA Atlantic sea scallop (*Placopecten magellanicus*) landings in 2015 were 16,187 mt (meats), slightly greater than 2014. The 2015 landings were below the recent (2001-2015) mean, but still well more than the long-term (1957-2015) mean. The ex-vessel value of the landings was $438 million, modestly higher than 2014. The relatively low landings reflect weak 2007-2009 year classes in the Mid-Atlantic Bight and weak 2009-2010 year classes on Georges Bank. Landings are expected to increase during 2016-2018 as the very strong 2012 Georges Bank and 2013 Mid-Atlantic year classes enter the fishery.

Stratified mean scallop dredge survey biomass indices increased substantially in the Mid-Atlantic and more modestly on Georges Bank in 2015 (Figures 27 and 28). Recruitment in the Mid-Atlantic was very high. This 2013 year class is second only to 2001 in the 1979-2015 Mid-Atlantic time series. It is centered in the Elephant Trunk region off of New Jersey and Delaware. Recruitment on Georges Bank was moderate.

16. 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 (Figure 29). Recruitment indices have been at lowest observed values in three of the four years since 2012 (the time series began in 1984). The stock is considered to be in a collapsed state. Warming temperatures, increased predation pressure and overexploitation are factors thought to be involved in the depressed condition of the stock.

17. 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 30). 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 (15, 0.3, 0.3 and 0.1 mt). An additional 0.8 mt of spinytail, deepwater, shorttail and other skates were discarded in Subarea 3.

Survey biomass indices for winter skate (*Leucoraja ocellata*) peaked in the mid-1980s (Figure 31) 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. To adjust the observed 2014 value for this average ratio, the 2014 value of 7.14 was divided by 1.091 yielding a value of 6.54Little skate (*Leucoraja erinacea*) survey indices have generally fluctuated without trend (Figure 32).

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 33). Thorny skate (*Amblyraja radiata*) survey indices have declined over the entire time series, and are currently near record lows (Figure 34). Survey indices for smooth skate (*Malacoraja senta*) are highly variable, but have been generally stable for the last 20 years (Figure 35). Indices for both clearnose skate (*Raja eglanteria*) and rosette skate (*Leucoraja garmani*) generally increased over the time series (Figures 36 and 37).

B. Special Research Studies

1. Environmental Studies

a) Hydrographic Studies

A total of 1240 CTD (conductivity, temperature, depth) profiles were collected and processed by the Northeast Fisheries Science Center (NEFSC) in 2015 over the course of 8 cruises. Of this total, 1167 CTD profiles were obtained within NAFO Subareas 4, 5, and 6. These data are archived in an oracle database. 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 70 fixed locations/depths around the Gulf of Maine and Southern New England Shelf indicate that 2015 was the year of extremes. It started out with a very warm January, quickly cooled to one of the coldest in eMOLT springs but, by the end of the year, was very warm again. It is looking like 2016 may be similar to the 2012 warm year if the trend continues. These 15-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.

Realtime 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.

More than 200 satellite-tracked surface drifters were deployed off the coast of New England in 2015, and dozens more are planned for 2016 (see http://www.nefsc.noaa.gov/drifter). The collective archive helps resolve the transport pathways of coastal current 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.

b) Plankton Studies

During 2015, zooplankton community distribution and abundance were monitored using 454 bongo net tow samples taken on five surveys. Each survey covered all or part of the continental shelf region from Cape Hatteras northeastward into the Gulf of Maine. 2015 was the second year where the spring and autumn ecosystem monitoring surveys were equipped with an imaging flow-cytobot unit from the Woods Hole Oceanographic Institute connected to the scientific seawater flow-through system. This unit collected images of phytoplankton and marine ciliates from near-surface water pumped in from the bow of the vessel. In addition, these same two cruises conducted a total of 60 nutrient casts done in collaboration with the University of Maine to monitor levels of nutrients in the euphotic zone. The two dedicated ecosystem monitoring surveys also collected 42 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 plankton samples, to supplement identifications made by traditional visual taxonomic means. These same two surveys also collected 149 additional plankton samples with a smaller bongo net for larval fish and egg sample genetics studies.

c) Benthic Studies

Wind Energy Benthic Habitat Investigation: Cruise time for wind energy-related benthic studies during 2015 was obtained aboard NOAA Ship *Henry B. Bigelow*: cruise HB15-05 and multibeam mapping aboard NOAA Ships *Henry B. Bigelow* and *Thomas Jefferson*. Benthic sampling and multibeam mapping was 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 sampled during 2015, crosses $^{+}$ indicate areas mapped during 2015):

- 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 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 will involve high resolution acoustic mapping of the bottom in selected portions of all eight 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 2015, or will be performed subsequently, 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 2015 Benthic Habitat cruise aboard *Henry B. Bigelow* 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 DE, VA, and KH-NC WEAs. The MD WEA was sampled in 2013 and MA, RIMA, NY, NJ, and VA WEAs were sampled in 2014. A total of 156 grab samples was made in 2015 using a Young-modified Van Veen grab sampler and 56 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.

Catches in the DE WEA included 61 recognizable taxa in which blue mussels (*Mytilus edulis*) were the overwhelming dominant in terms of both numbers and weight. However, this distribution is strongly skewed by a single station at which a dense mussel bed was encountered and over 30,000 mussels collected. Removing the data from that station from the totals results in a biota that includes 59 taxa and is more representative of the WEA as a whole. Northern sea robins were clearly the dominant fish catch, with Gulf Stream flounder and spotted hake playing secondary roles in terms of numbers and weights, respectively. The invertebrate catch consisted of a mix of hard bottom (e.g. sea grapes, bryozoans, sulfur sponges) and sandy bottom (e.g. sand dollars, threeline mud snails) faunas. Species assemblages in the other two WEAs overlapped those of the DE WEA, with northern sea robins, gulf stream flounders, and spotted hake again playing prominent roles, but with juvenile scallops (2 species) playing strong roles and hard bottom taxa largely absent. Some specimens of sea whip corals (*Leptogorgia virgulata*) and star corals (*Astrangia poculata*) were also taken in the DE WEA.

Regarding scallops, juvenile (<20 mm) sea scallops (*Placopecten magellanicus*) were the overwhelming dominant in the KH-NC WEA as a whole in terms of both abundance (numbers) and weight, with calico scallop juveniles (*Argopecten gibbus*: <15 mm) playing a secondary role. Calico scallop juveniles were also prominent in the VA WEA, but sea scallops were entirely absent. Scallops of both species represented juvenile (probably young-of-the-year) sets. Of 10,681 calico scallops caught in the KH_NC WEA, only were 3 adults. Among 91,098 sea scallops, no adults were caught.

<u>Deep Sea Coral Investigations</u>: Following up on the extensive mapping and visual surveys conducted on the continental margin and in the Gulf of Maine from 2012-2014, further visual surveys were conducted on the continental slope and canyons off southern New England: the southern margin of Georges Bank between Hydrographer and Lydonia Canyons in NAFO subdivision 5Ze. This cruise was conducted using a towed camera system (Woods Hole Oceanographic Institution *TowCam*) in search of deep sea coral habitats and their association with fishes primarily at depths exceeding ~500 m. Habitat suitability models for major coral taxa were successfully employed as a guide to finding these habitats. Another cruise was conducted in the western Gulf of Maine (NAFO division 5Y) that discovered additional areas of deep sea coral habitat at around 200 m in the vicinities of Outer Schoodic Ridge, Mount Desert Rock, Georges Basin, and Lindenkohl Knoll, with implications for their function as fish habitats.

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 five 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*, and three on winter flounder, *Pseudopleuronectes americanus*. 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 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 2016. Winter flounder is our experimental model for the inter-population contrasts. In early 2016 we will collect 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 (Banks offshore from Massachusetts).

<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 are being presented at a USGS-NOAA workshop in May 2016 and at the Annual American Fisheries Society Meeting in August 2016.

b) Resource Survey Cruises

During 2015, 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 189 research and charter vessel sea days. NOAA scientific and contract staff involvement in the various cruises totaled of 1,889 person sea days, and volunteers contributed another 606 person sea days. ESB cruises occupied 1,235 stations in an area extending from Cape Hatteras, North Carolina to Nova Scotia. A total of 124,652 length measurements were recorded, representing 1,798,599 individuals from 319 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 2015 to fulfill special survey sampling requests from 72 NOAA and University investigators. This sampling included 15,931 feeding ecology observations, collection of 30,936 aging structures, and acquisition of 30,296 samples/specimens to support additional shore-based research.

c) Age and Growth (http://www.nefsc.noaa.gov/fbp/)

Fish ages produced 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 area, and throughout the middle US Atlantic seaboard. In 2015, the Program provided ages on nearly 68,000 otoliths and other hard structures from 19 species. The top species by numbers aged were: haddock (10,062), American plaice (8,033), summer flounder (6,755), Atlantic cod (6,422), winter flounder (5,533), yellowtail flounder (4,411), witch flounder (3,652) and 3,565 scup. Other species worth mentioning are black seabass, pollock, silver and red hake, Atlantic herring, butterfish and bluefish for which 13,333 specimens were aged. Most otoliths and other hard part structures are read for production ages that support age-structured stock assessments that serve as the basis for scientific advice to two federal fishery management councils (i.e., the 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.

1) Accuracy: Through the use of reference collections, personnel each year determine if any bias or deviation of their age estimates occurs compared to the previous years. The Fishery Biology Program also partners with other agencies by exchanging age structures. In 2015, haddock, cod, and Atlantic herring age structures were exchanged with age readers from the St. Andrews Biological Station (Fisheries and Oceans Canada). A conference was held in Woods Hole that included twelve age and growth laboratories from Florida to Maine to create an Age and Growth Manual for both Atlantic and Gulf of Mexico species.

2) Precision: A subsample of specimens is re-aged blindly by personnel to assess deviation from 1:1 equivalence. 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.

Related research - Research projects in 2015 included:

1. initiated a life history project on the spawning run of American shad in the Connecticut River,

2. continued sampling of windowpane with the Study Fleet Biosampling Program to develop a marginal increment analysis to validate age estimates;

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

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

5. continued a project on white hake life history, in partnership with the State of Maine;

6. continued enhanced biological sampling selected groundfishes to examine fecundity dynamics;

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

8. continued analysis of environmental effects on haddock growth and reproduction;

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

10. 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) <u>Food Web Dynamics</u>

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. and Mid-Atlantic continental shelf during NEFSC spring and autumn bottom trawl surveys. Estimates of prey volume and composition were made at sea for selected species. During 2015, stomachs from 8,138 individuals and 51 species were examined in the spring, and stomachs from 7,807 individuals and 51 species were examined in the autumn. Diet sampling emphasized gadiformes, elasmobranchs, small pelagics, flatfishes, and lesser known species.

The 43-year time series (1973-2015) 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 615,000 stomach samples and over 160 predators. The processing of the 2015 bottom trawl survey food habits data is scheduled for completion in 2016.

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 2015, 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 have been offered regularly throughout the year (approximately 2-4 times). These workshops continued in 2015 and provided class discussions and freshly caught 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 climate, dietary niche width, 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 2015. Information was received on 5,418 tagged and 413 recaptured fish bringing the total numbers tagged to 280,000 fish of more than 50 species and 17,000 recaptured of 33 species.

The NEFSC Coastal Shark Bottom Longline Survey of Atlantic large and small coastal sharks, started in 1986 and conducted every two to three years, is the longest fishery-independent shark survey in the U.S. Atlantic Ocean. Its primary objective is to conduct a standardized, systematic survey of the shark populations off the U.S. Atlantic coast to provide unbiased indices of relative abundance for species inhabiting the waters from Florida to the Mid-Atlantic. Results from the 2015 survey included 2,841 fish (2,835 sharks) representing 16 species, of which 2,179 (77%) were tagged and released. These totals were higher than in any previous survey. Sharks represented 99.8% of the total catch of which sandbar sharks were the most common, followed by Atlantic sharpnose, dusky and tiger sharks.

Staff participated in the Southeast Data Assessment and Review (SEDAR) Procedural Workshop 7, Data Best Practices as part of the Indices Technical Group. The Workshop Summary Report contains the recommendations from the Indices Technical Group on the following topics: the use of index report cards, converting index to weight when using surplus production models, common criteria for inclusion and ranking of indices, fishery-dependent index development, timing of events, working papers, data workshop report, and procedural expectations.

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 2015, our COASTSPAN participants were the Massachusetts Division of Marine Fisheries (MDMF), Stony Brook University, Virginia Institute of Marine Science, University of North Carolina, South Carolina Department of Natural Resources (SCDNR), Georgia Department of Natural Resources, and the University of North Florida. MDMF staff also 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 2015, 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. Additionally, mark-recapture data on bonnetheads from the SCDNR COASTSPAN survey were used in combination with data from Mote Marine Laboratory and the NMFS Southeast Fisheries Science Center (Panama City and Pascagoula Labs) in a cooperative study comparing growth rates between bonnetheads from the Gulf of Mexico and South Carolina waters. Preliminary results were presented at the 2015 American Elasmobranch Society Meeting in Reno, Nevada and indicate that these regional life histories are more similar than current literature suggest.

Age and growth estimates for the white shark (*Carcharodon carcharias*) in the western North Atlantic Ocean were derived using band pair counts on the vertebral centra of 81 specimens collected between 1963 and 2010. These band pairs were interpreted and assessed using D14C levels from a recent bomb radiocarbon validation study in the WNA. Age estimates, validated up to 44 years, were used to develop a growth curve for the species and indicate that white sharks grow more slowly and live longer than previously thought.

Another white shark study used the mitochondrial control region and 14 nuclear-encoded microsatellite loci to assess genetic diversity in 2 regions: the Northwest Atlantic (NWA, N = 35) and southern Africa (SA, N = 131). These 2 regions were found to harbor genetically distinct white shark populations. Overall, the findings indicated that white population dynamics within NWA and SA are determined more by intrinsic reproduction than immigration and there is genetic evidence of a population decline in the NWA, further justifying the strong domestic protective measures that have been taken for this species in this region.

Bomb radiocarbon dating was used to determine the periodicity of band pair formation in the vertebral centra of three common thresher sharks (*Alopias vulpinus)*. Updated estimates of age at maturity remained the same for males (8 years) and increased by one year to 13 years for females. The primary finding was the increase in longevity for this species from a band pair count estimate of 24 years to a bomb radiocarbon validated estimate of 38 years, indicating this species lives much longer than previously thought.

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 2015 staff attended 8 tournaments and examined 157 sharks.

More than 150 spiny dogfish, that were OTC injected during the 2011-2012 tagging study, have been returned to the APP for age validation, with 90 of these fish in good condition to obtain measurements for reproductive studies. In addition, samples of mature females were collected monthly (a total of 24 months) for analysis of the reproductive stage of the female and the embryos for a study on the seasonal cycle of female spiny dogfish reproduction. Data were analyzed and a draft was revised in December.

f) <u>Marine Mammals</u>

Cetacean surveys:

In 2015, 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. During 2015, much of the work dedicated to this project was spent on the development of spatially-explicit density models.

A winter aerial abundance survey was conducted on the NOAA Twin Otter during 5 December 2014–14 January 2015. This survey covered waters from the coast line to about the 2000 m depth contour with a higher coverage over the New York State Offshore Planning Area. 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 the data. In Beaufort sea states of six and less, about 5670 km of on-effort track lines were surveyed. About 1900 individuals within 84 groups of 17 species (or species groups) of live cetaceans, seals and large fish were detected by one or both teams.
During 10–19 Jun 2015, a shipboard survey was conducted on the NOAA ship *Henry B. Bigelow* around Georges Bank to collect distribution, ecosystem, and acoustic data on cetaceans, in particular sei whales (*Balaenoptera borealis*). To achieve this, two visual teams of data searched for marine mammals, a seabird team searched for birds, a team collected acoustic recordings using a towed array and sonobouys, and another team collected physical and biological data using the ship's sensor system, bongo nets, conductivity, temperature and depth (CTDs) probes, midwater trawls, and backscatter data via a Simrad EK60. In addition, a pilot study was conducted to test the efficacy of a video system, consisting of a high definition video camera and a long wave infrared camera, as compared to corresponding visual and acoustic observations. In total, over 2000 cetaceans and over 2500 birds were detected. Twelve sonobuoys were successfully deployed and over 28 hrs of acoustic data were recorded. CTD data were collected from 20 sites, 22 midwater trawls were conducted and backscatter data were collected during the times of the visual surveys and during some nights.

To estimate the amount of time sea turtles are available to line-transect abundance surveys, the NOAA ship *Henry B. Bigelow* was used to capture and tag 3 loggerhead sea turtles (*Caretta caretta*) and 1 Kemp's ridley turtle (*Lepidochelys kempii*) that were located on the southern flank of Georges Bank during 23 Jun – 2 Jul 2015. These captures also allowed an opportunity to collect associated biological information from these tagged animals. A Puma fixed wing unmanned aerial system was deployed for the first time from a large ship and was used to expand the ability to detect turtles over the standard searching with high powered binoculars and naked eye. A high-frequency acoustic recording package (HARP) was deployed near Corsair Canyon and will be recording passive acoustic data for one year. In addition to searching for turtles to tag, marine mammals and large fish species sightings were recorded, passive acoustic recordings were made, and samples of potential turtle prey were taken using a visual plankton recorder, a Sound Metrics Didson 300 imaging sonar, and a paired Go-Pro video system.

A shipboard North Atlantic right whale (*Eubalaena glacialis*) cruise was conducted during 15 May–05 June 2015 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) Photographing and biopsy sampling of large cetaceans (mostly North Atlantic right whales) for individual identification; (2) Applying dermal tags to right and sei whales; (3) Conducting oceanographic sampling in proximity to tagged whales (4) Conducting zooplankton sampling to examine prey sources; (5) Collecting right whale fecal samples for hormone analysis; (6) Testing Slocum and wave gliders real-time acoustic detection to aid in finding right and sei whales during the cruise; and (7) Deplying sonobouys near feeding aggregations of 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. NARWSS flights conducted in 2015 followed systematic tracklines with randomized starting locations within 13 primary survey blocks: Cashes Ledge, Gulf of Maine, Franklin Basin, Georges Basin, Georges Shoal, Great South Channel, Howell Swell, Jeffreys Ledge, Jordan Basin, Lindenkohl Basin, Rhode Island Sound, Martha's Vineyard and Nantucket and Stellwagen Bank. During 2015, NARWSS flew 344.9 hours over 81 surveys, including a directed flight for a whale carcass, and sawtooth flights in both Atlantis Canyon and Mount Desert Rock and Grand Manan. NARWSS detected 127 right whales (including possible duplicate sightings of the same individual), with 114 right whales sighted within survey blocks and 13 right whales sighted during transit to or from survey areas. During the summer of 2015 directed flights were conducted in Canadian waters, with 56.6 hours over 13 surveys locating 83 right whales.

During January–March 2015, 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 and archived 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) monitor the health of individual animals, and (4) better understand the right whale mating system.

In 2015, the fifth year of a five year study of the ontogeny of right whale calves was conducted in two different habitats. During this final season, researchers from NEFSC and Syracuse University were focused on attaching suction cup tags equipped with hydrophones (Acousonde tags) in order to record vocalizations between right whale mothers and calves. Focal follows of the tagged whales and associated mother or calf were also recorded. The study looked at the ontogeny of right whale calves both acoustically and behaviorally through the first eight to ten months of age. During the winter season, which is the right whale calving season in the waters off the southeastern United States, the NOAA Research Vessel *Selkie* (24' Safeboat) crew deployed two tags on two different animals during two days at sea. During the spring feeding season in Cape Cod Bay, the NOAA R/V *Selkie* crew deployed 11 tags on 8 different individual right whales during 8 days at sea. Additionally, all right whales encountered were photographed for the NARW catalog and select individuals were biopsy sampled.

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 2015 included gill nets, otter trawls, mid-water otter trawls, mid-water pair trawls, scallop trawls, shrimp trawls, scallop dredges, clam dredges, purse seines, beach anchored gillnets, bottom longline, pound nets, 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, coastal bottlenose dolphin, 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 data bases.

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 2015, 3 high frequency recording packages (HARPs) were deployed off the Northeast US shelf break. In October 2015, a 3 year long effort consisting of 5 lines (Nantucket, Cape Hatteras, Cape Fear, Savannah and Georgia) of Cornell marine autonomous recording units (32 units total) were deployed along the US coast. The aim is to monitor changes in migratory movements in baleen whales. The mid Atlantic 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. Results from these can be found at http://dcs.whoi.edu/. A glider has also been used to monitor and locate cod spawning grounds in Massachusetts Bay. 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.

Archival acoustic data from 2006 to present continues to be worked up for right, fin, sei, blue and humpback whale presence. Right whale analyses will be finished by the summer. A manuscript on how communication space differs between species and call types is being finalized for an Endangered Species Research special issue. A manuscript was accepted on acoustic ecology policy for the NOAA Ocean Noise Framework in same issue. Manuscripts from AMAPPS work on how beaked whales show responses to echosounders and new approach for 3D localization and depth calculation of beaked whales are being written up.

Pinnipeds:

In 2015, two NEFSC aerial seal surveys were conducted to monitor major gray seal (*Halichoerus grypus*) pupping colonies in Massachusetts and Maine coastal waters. NEFSC also collaborated with the Center for Coastal Studies to conduct monthly year-round aerial surveys of gray seal and harbor seal (*Phoca vitulina*) haulouts in southeastern Massachusetts.

In January 2015, 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. 128 gray seal pups were captured, sampled and flipper-tagged. One fully-molted female pup was satellite-tagged. Samples contributed to MIT's work on influenza in migratory wild populations among other projects.

Work continued in 2015 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) reduce sea turtle bycatch in U.S. commercial fisheries in the Northwest Atlantic Ocean.

In 2015, the NEFSC continued two gear and gear-related projects investigating methods to reduce sea turtle bycatch in fishing gear. These included: (1) an operational feasibility and comparative study of the performance of two rigid turtle excluder devices (TEDs) on the targeted catch in the scallop trawl fishery; and (2) continued refinement and investigation of the usefulness and capability of a tow time data logger to accurately record tow time in the bottom trawl fishery. Reports on both projects are located at: http://www.nefsc.noaa.gov/read/protspp/PR_gear_research/.

In 2015 the NEFSC conducted research related to turtle bycatch assessment. These included: (1) estimating turtle mortality rates in commercial gears using serious injury guidelines; (2) estimating bycatch of turtles in Mid-Atlantic bottom otter trawl and scallop trawl fisheries from 2010-2014. The NEFSC also continues to develop quantitative methods for assessing anthropogenic threats to sea turtles.

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 2015 we undertook pilot work on the under-sampled waters in the northern portion of the range for hard shelled sea turtles (northeast of Long Island, NY).

3. Studies of Fishing Operations

In 2015, NEFSC Observers were deployed on 3,198 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 189 marine mammal incidental takes, 32 sea turtle incidental takes, and 267 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 984 trips aboard commercial fishing vessels in 2015. On these trips there were 153 marine mammal and 209 seabird incidental takes documented.

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

In the sink anchored gillnet fishery, 738 trips were observed with a total of 3,224 gear retrievals by Observers. There were 134 observed marine mammal takes in this fishery (67 gray seals, 26 harbor seals, 15 harbor porpoises, nine harp seals, seven unidentified seals, six common dolphins, two unidentified dolphins, one bottlenose dolphin and one unidentified porpoise/dolphin). There were also five loggerhead turtles, four Kemp's ridley, one unidentified hard-shell turtle, one unidentified turtle and 201 seabird takes observed in this fishery.

At-Sea Monitors observed 418 trips in the sink anchored gillnet fishery with 1,685 gear retrievals. There were 145 marine mammal (64 gray seals, 64 harbor seals, 11 harbor porpoises, three harp seals and three unidentified seals) and 205 seabird (189 of which were greater shearwaters) incidental takes recorded in this fishery by Monitors.

b. Float Drift Gillnet Fishery

There were 45 floating drift gillnet trips with 106 gear retrievals observed in 2015. There were no marine mammal, sea turtle, or seabird takes observed.

No Monitors deployed on float drift gillnet trips in 2015.

c. Otter Trawl Fisheries

In the bottom otter trawl fishery 1,150 trips were observed with a total of 9,565 gear retrievals recorded by Observers. In addition, there were 13 midwater trawl trips with 25 gear retrievals, ten scallop trawl trips with 67 gear retrievals, one shrimp bottom otter trawl trip with eight gear retrievals, ten twin trawl trips with 150 gear retrievals, 19 haddock separator trawl trips with 506 gear retrievals and three Ruhle trawl trips with 21 gear retrievals observed in 2015.

In the bottom otter trawl fishery, there were 44 observed marine mammal takes (28 common dolphins, four gray seals, three Risso's dolphins, three bottlenose dolphins, three whitesided dolphins, one harbor seal, one unidentified dolphins and one unidentified baleen whale). There were also eight loggerhead turtles, three Kemp's ridley, one green turtle and five seabird takes in this fishery. In the mid-water trawl fishery there were two harbor seal takes. In the scallop trawl fishery there was one loggerhead turtle and one unidentified hard-shell turtle take observed. No marine mammal, sea turtle or seabird takes were observed in the shrimp bottom otter trawl fishery. On twin trawl trips there were two common dolphins takes observed. There were no incidental takes observed on haddock separator trawl or Ruhle trawl trips in 2015.

At-Sea Monitors deployed on 536 bottom otter trawl trips with 5,624 gear retrievals, 12 haddock separator trawl trips with 295 gear retrievals, six twin trawl trips with 27 gear retrievals and no Ruhle trawl trips in 2015. There were seven marine mammal (three whitesided dolphins, two common dolphins, one harbor porpoise and one gray seal) and three seabird takes recorded by Monitors in the bottom otter trawl fishery. There was one whitesided dolphin take in the haddock separator trawl fishery in 2015. And, there were no incidental takes documented by Monitors on either Ruhle or twin trawl trips in 2015.

d. Sea Scallop Dredge Fishery

In the sea scallop dredge fishery, 533 trips were observed with a total of 32,620 gear retrievals. There were one unidentified seal, one Kemp's ridley turtle and one loggerhead turtle and 14 seabird takes observed in this fishery.

No Monitors deployed in the scallop dredge fishery in 2015.

e. Scottish Seine Fishery

No Scottish seine trips were covered by Observers or Monitors in 2015.

f. Drift Sink Gillnet Fishery

In the drift sink gillnet fishery in 2015, Observers were deployed on 237 trips with a total of 1,598 gear retrievals. There were three harbor seal, one gray seal, one bottlenose dolphin, two Kemp's ridley turtle, one loggerhead turtle, one unidentified hard-shell turtle and 37 seabird takes in this fishery.

Monitors deployed on three trips with a total of 44 gear retrievals. There was one seabird take documented by Monitors in this fishery.

g. Anchored Floating Gillnet Fishery

There were 15 anchored floating gillnet trips with 51 gear retrievals observed in 2015. There were no marine mammal or sea turtle takes observed in this fishery. There were five seabird takes observed in this fishery.

No Monitors deployed on anchored floating gillnet trips in 2015.

h. Mid-water Pair Trawl Fishery

In 2015, there were 20 mid-water pair trawl trips observed with a total of 58 gear retrievals. Five seabird takes were observed in this fishery. No marine mammals or sea turtles were documented.

No Monitors deployed on mid-water pair trawl trips in 2015.

i. Bottom Longline Fishery

In the bottom longline fishery in 2015, there were eight trips observed with a total of 141 gear retrievals. There were no marine mammal, sea turtle or seabird takes observed.

At-Sea Monitors covered a total of one bottom longline trip with five gear retrievals in 2015. 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 2015.

k. Pound Net Fishery

No pound net trips were covered by Observers or Monitors in 2015.

l. Handline Fishery

In 2015, there were ten handline trips and 81 gear retrievals, one auto-jig handline trip and 50 gear retrievals observed. No marine mammals, sea turtles or seabirds were taken in these fisheries.

Monitors covered eight handline trips and 55 gear retrievals in 2015. There were no documented takes in this fishery in 2015.

m. Herring Purse Seine Fishery

In 2015, there were 15 herring purse seine trips with 20 gear retrievals observed. There were two unidentified seals observed in this fishery. No sea turtles or seabirds were observed.

No herring purse seine trips were covered by Monitors in 2015.

n. Menhaden Purse Seine Fishery

No menhaden purse seine trips were covered by Observers or Monitors in 2015.

o. Tuna Purse Seine Fishery

Six tuna purse seine trips with three gear retrievals were observed in 2015. There were no marine mammal, sea turtle or seabird takes observed.

No tuna purse seine trips were covered by Monitors in 2015.

p. Lobster Pot Fishery

In 2015, there were 283 lobster pot trips with 6,818 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 2015.

q. Fish Pot Fishery

In 2015, 17 fish pot trips with 128 gear retrievals were observed. No takes were documented.

No fish pot trips were covered by Monitors in 2015.

r. Conch Pot Fishery

In 2015, 39 conch pot trips and 478 gear retrievals were covered by Observers. No takes were documented.

No conch pot trips were covered by Monitors in 2015.

s. Red Crab Pot Fishery

No red crab pot trips were covered by Observers or Monitors in 2015.

t. Blue Crab Pot Fishery

No blue crab pot trips were covered by Observers or Monitors in 2015.

u. Clam Dredge Fishery

There were 23 clam dredge trips with 1,012 gear retrievals observed in 2015. There were no documented takes of marine mammals, sea turtles or seabirds in 2015.

No clam dredge trips were covered by Monitors in 2015.

v. Scallop Beam Trawl Fishery

Two scallop beam trawl trips with six gear retrievals were observed in 2015. There were no marine mammal, sea turtle or seabird takes documented in this fishery in 2015.

No scallop beam trawl trips were covered by Monitors in 2015.

w. Other Dredge Fisheries

No other dredge trips were covered by Observers or Monitors in 2015.

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 2015 included scup and bluefish.

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 2015, stock assessments conducted and reviewed through the TRAC process included Eastern Georges Bank cod, Eastern Georges Bank haddock, and Georges Bank yellowtail flounder. Twenty-one stocks were updated through a separate process (operational assessments) and included Atlantic herring, Gulf of Maine cod, Georges Bank cod, Gulf of Maine haddock, Georges Bank haddock, white hake, pollock, Cape Cod/Gulf of Maine yellowtail flounder, Georges Bank yellowtail flounder, Southern New England/ Mid-Atlantic yellowtail flounder, American plaice, witch flounder, Gulf of Maine winter flounder, Georges Bank winter flounder, Southern New England winter flounder, Gulf of Maine/ Georges Bank windowpane flounder, Southern New England/Mid-Atlantic windowpane flounder, Acadian redfish, Atlantic halibut, Atlantic wolfish, and ocean pout. Other stock assessments in 2015 vetted in regional bodies included summer flounder, black sea bass, spiny dogfish, and striped bass.

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 2015 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) marine telemetry; (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. Telemetry studies have identified significant mortality during the transition to the marine environment for both wild and hatchery-reared Atlantic salmon smolts. Zones of increased mortality have been identified, and potential causal mechanisms (poor physiological condition, predation, etc.) and evaluation of different hatchery products are being investigated through follow-up studies. 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 Cooperative Research Program (NCRP) began in 1999. NCRP supports collaborations among fishermen and scientists to enhance marine fisheries science used in stock assessments, bycatch reduction, and for use by marine fisheries managers. Additionally, NCRP increases communication and learning among fishing professionals in the region while leveraging competencies among diverse partners. NCRP 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). NCRP research is conducted both internally to 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. Only internal projects are described here. Cooperative research addresses fishery dependent, fishery independent, fishery biology and oceanography, and bycatch reduction/education oriented studies.

Fishery Dependent Data**:**

The NEFSC Study Fleet continues to support 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 37 Study Fleet captains use our Electronic Logbook System (FLDRS) to record and transfer more accurate and timely fishery-based data on a tow-by-tow basis. Study Fleet tow-by-tow reporting is supplemented by temperature-depth data using specially designed sensor probes that are deployed on mobile 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 studies with commercial vessels.

In 2015, a more specialized Study-Fleet approach began working 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 fish movement patterns, create an almost insurmountable hurdle in 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.

An on-going collaborative effort between the Pacific States Marine Fisheries Commission (PSMFC), NCRP and NEFSC Data Management Services (DMS) also continued 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. Approximately 80 vessels are currently equipped to report their eVTR data in near-real-time.

The NCRP also collaborated with the NEFSC DMS Division and the clam industry to develop and test a new eVTR software system for the clam industry (eCLAMS), now installed on most fleet vessels. NCRP 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.

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 of 3,656 individual fish (1,896 Atlantic cod, 646 monkfish, 686 haddock, 264 Atlantic pollock, 66 winter skate, and 98 white hake) indicate that conversion factors vary over time. The information being collected is also being used as part of an Atlantic Coastal Cooperative Statistical Program effort to update conversion factors coast-wide.

<u>Fishery Independent Data</u>: In 2015, the NCRP and two commercial vessels successfully completed the second 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, and used methods and sampling gear consistent with that of the Eastern Gulf of Maine Sentinel Survey Fishery conducted by the Penobscot East Resource Center and the University of Maine's School of Marine Sciences to collect catch and biological data. Sampling stations included 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 was set, covering a distance roughly equivalent to that of a bottom trawl survey tow. The industry-based survey timing was coordinated with the NEFSC research vessel Henry Bigelow's survey schedule as much as possible to provide complementary sampling that can be compared to indices from the trawl survey.

This survey is also intended to increase the understanding of age, growth, and maturity for some of the target data-poor species. Samples obtained through this work for species of concern, such as cusk, may be particularly helpful in developing proactive conservation measures and informing protected species decisions.

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 7,500 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 NCRP 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.

In 2015, NEFSC habitat ecologists and oceanographers began expanding Study Fleet efforts with herring and mackerel fishermen to refine real-time ocean temperature models and forecasts. This information will help researchers better understand factors that drive fish movement, and define the thermal habitat of these species to determine they were available to be caught during standard surveys. Refining survey data in this way can improve stock assessments as was recently done for butterfish, dogfish, and scup.

Another collaborative project between NOAA's National Weather Service and NCRP participants is beginning to explore the potential to mount mini-weather stations on fishing vessels to help record important weather and climate-related data.

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 NCRP 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.

<u>Real-Time Data Transmission:</u> 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 NCRP 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 1,000 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.

d) Stock Assessment Methods Development

Many national and international studies have concluded that stock assessments should evaluate resource status using a number of different analytical approaches. By doing so, some indication of the robustness of conclusions regarding stock status is achieved. To this end, NEFSC researchers have been collaborating with other NOAA fisheries scientists to develop a standardized suite of methods collected into a software toolbox. The NOAA Fisheries Toolbox (NFT) incorporates a wide range of methods (such as virtual population analysis, reference point estimation, surplus production and forward-projection methods) into a stable environment with tested software products. The NFT is used for many routine assessment tasks. No new methods were added to the toolbox in 2015. The complete package may be accessed at http://nft.nefsc.noaa.gov/ (note that a password is no longer required).

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

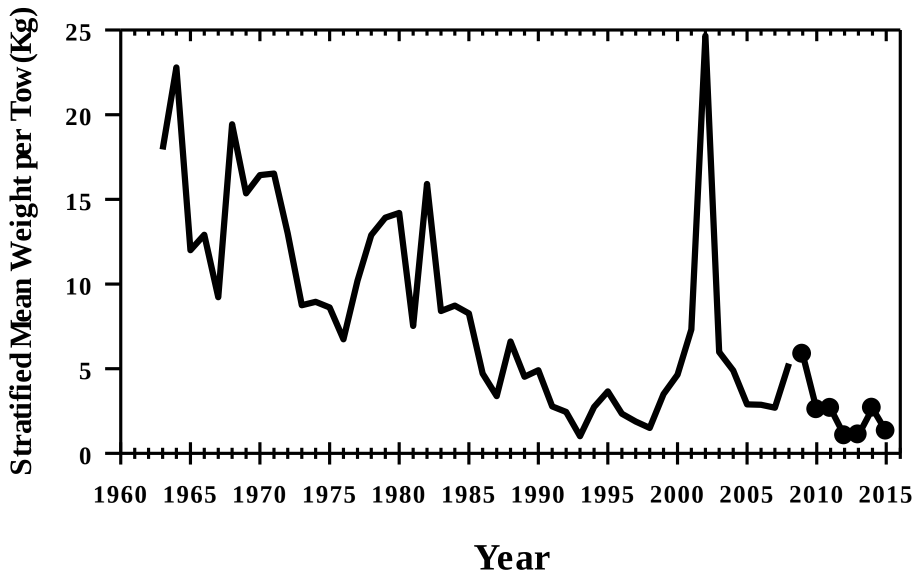

Fig. 1. NEFSC autumn bottom trawl survey biomass indices for Gulf of Maine cod.

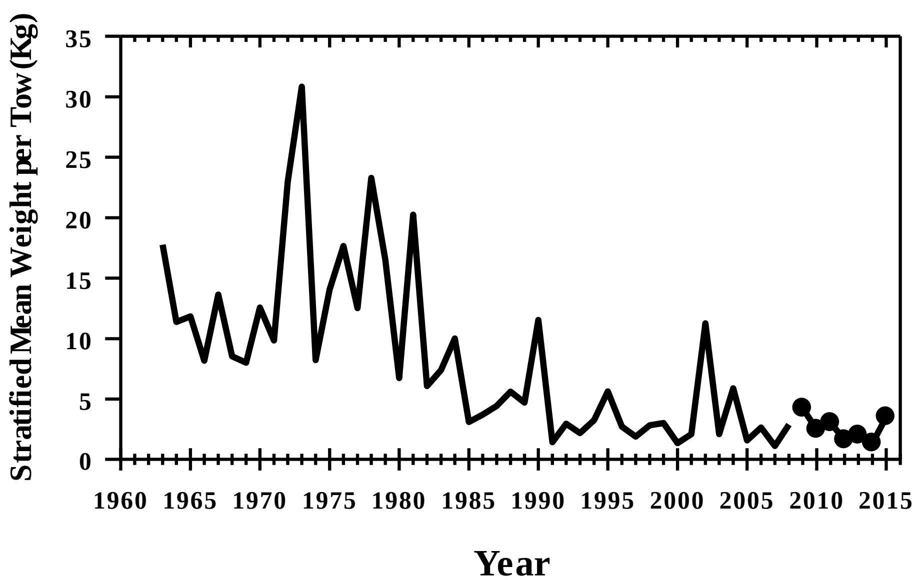

Fig. 2. NEFSC autumn bottom trawl survey biomass indices for Georges Bank cod.

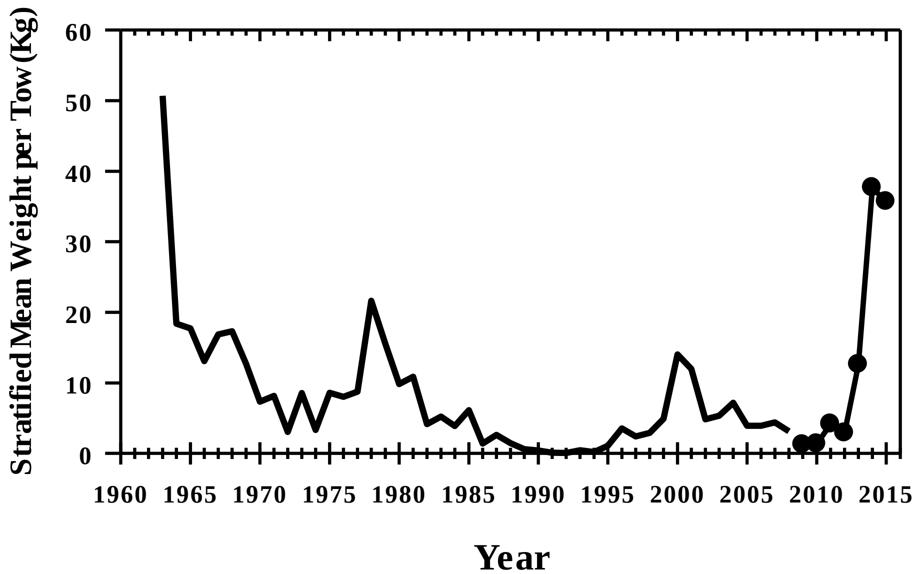

Fig. 3. NEFSC autumn bottom trawl survey biomass indices for Gulf of Maine haddock.

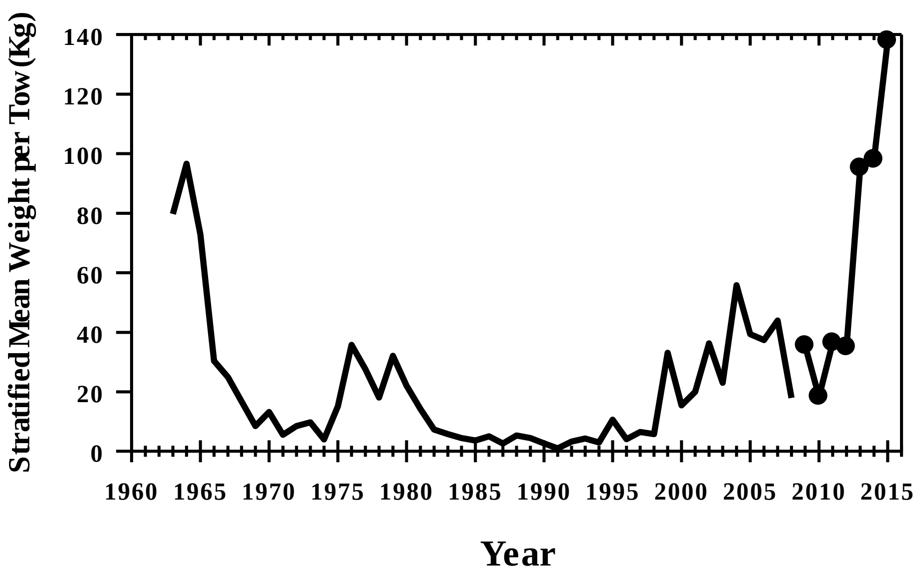

Fig. 4. NEFSC autumn bottom trawl survey biomass indices for Georges Bank haddock.

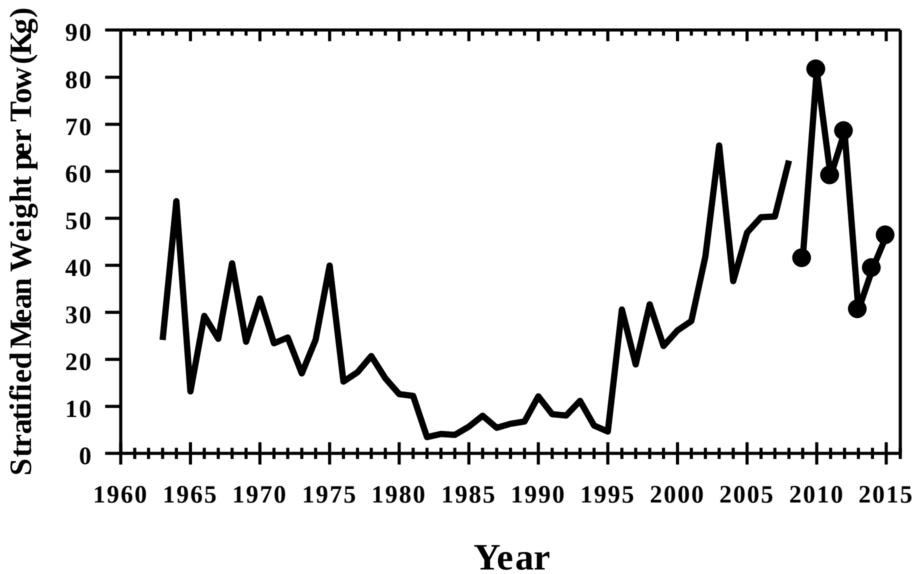

Fig. 5. NEFSC autumn bottom trawl survey biomass indices for Acadian redfish.

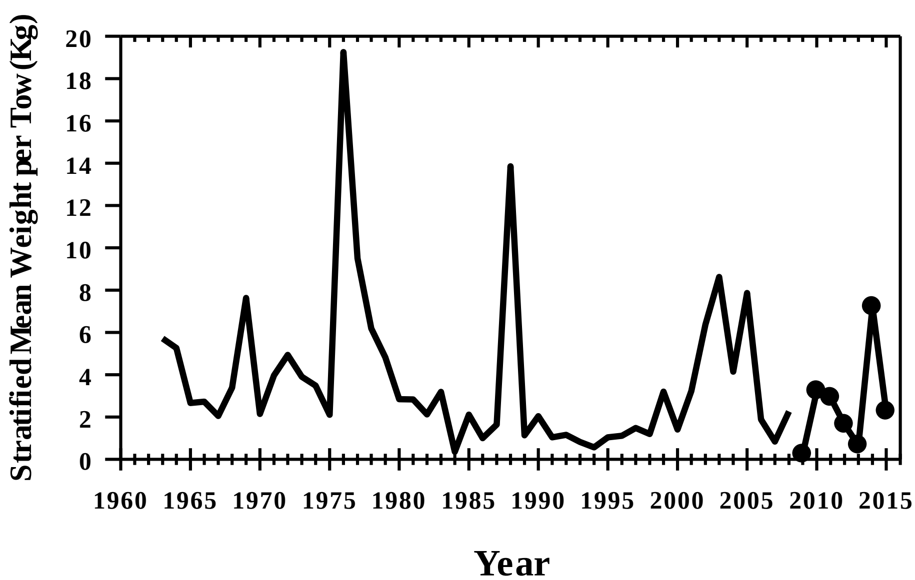

Fig. 6. NEFSC autumn bottom trawl survey biomass indices for pollock.

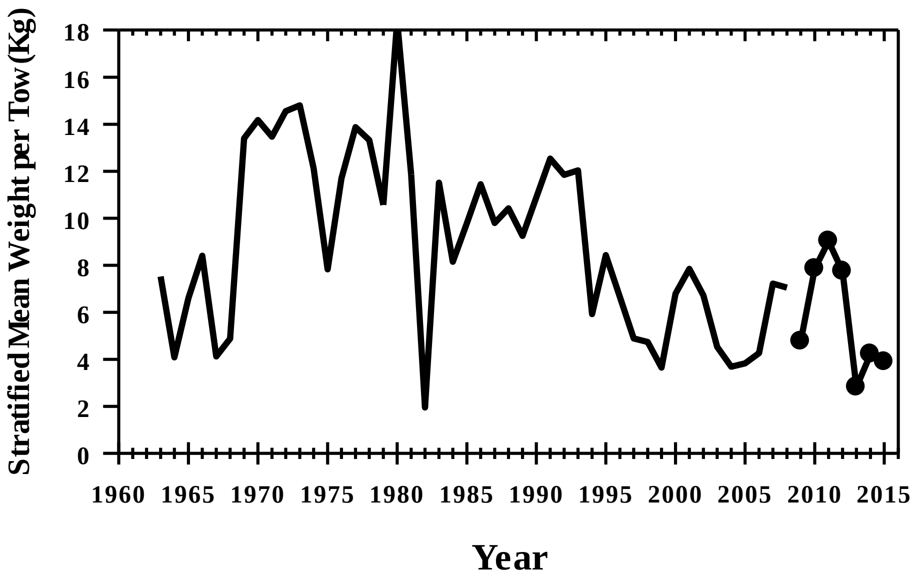

Fig. 7. NEFSC autumn bottom trawl survey biomass indices for white hake.

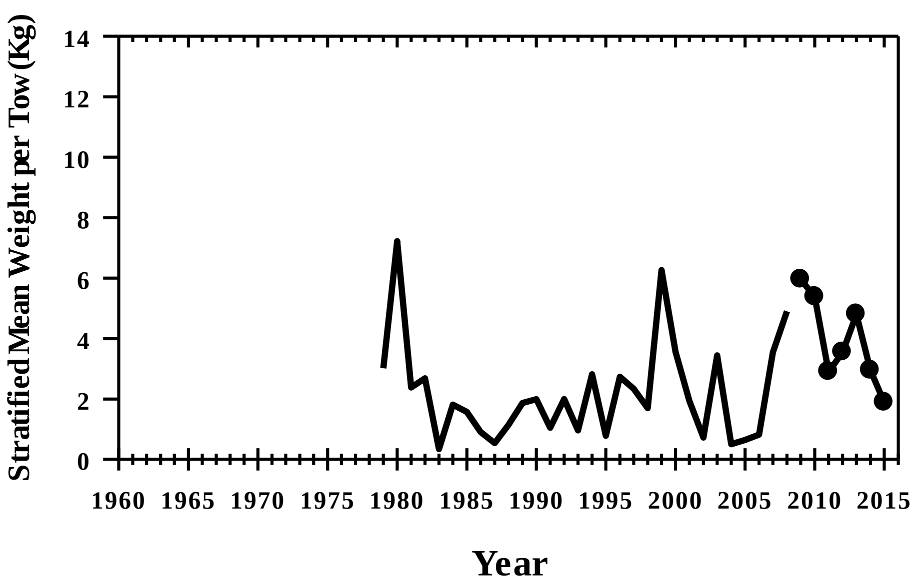

Fig. 8. NEFSC autumn bottom trawl survey biomass indices for Cape Cod-Gulf of Maine yellowtail flounder.

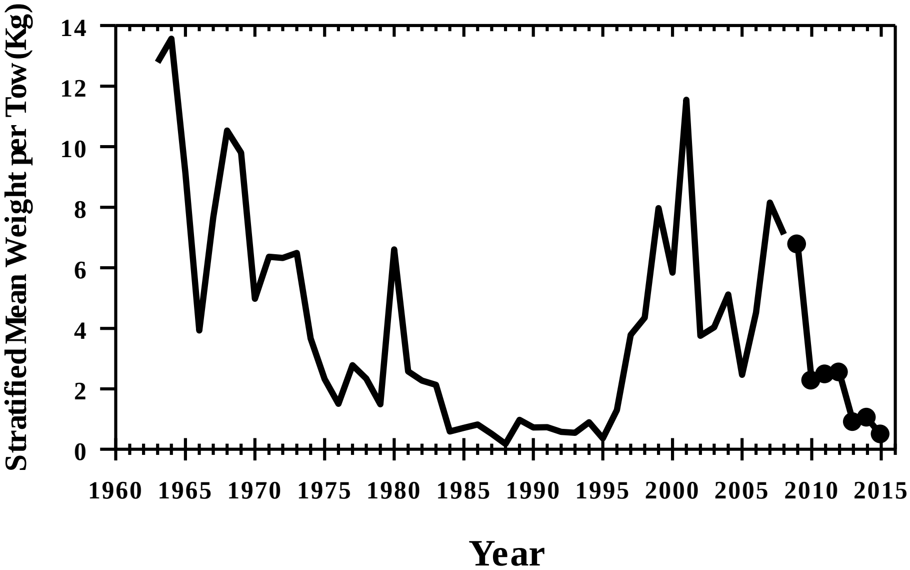

Fig. 9. NEFSC autumn bottom trawl survey biomass indices for Georges Bank yellowtail flounder.

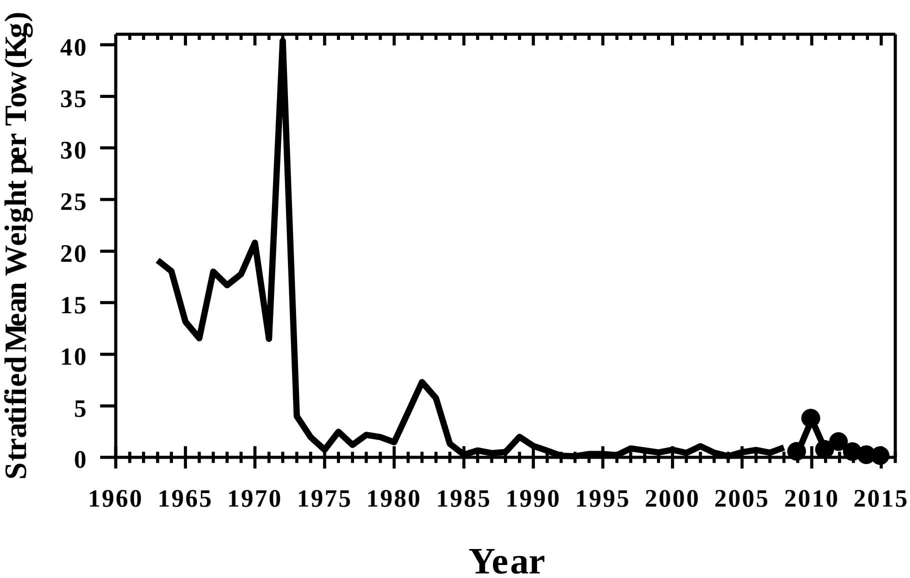

Fig. 10. NEFSC autumn bottom trawl survey biomass indices for Southern New England-Mid-Atlantic yellowtail flounder.

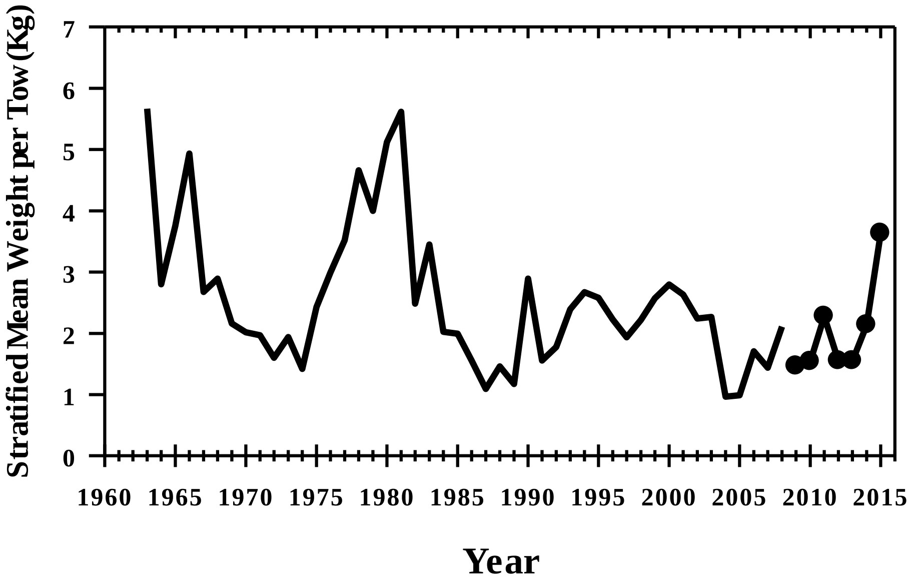

Fig. 11. NEFSC autumn bottom trawl survey biomass indices for American plaice.

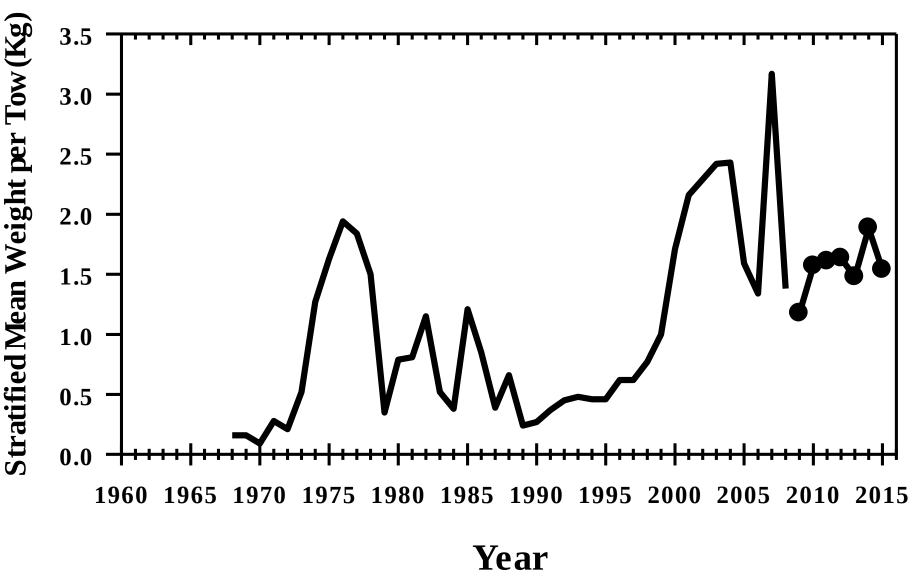

Fig. 12. NEFSC spring bottom trawl survey biomass indices for summer flounder.

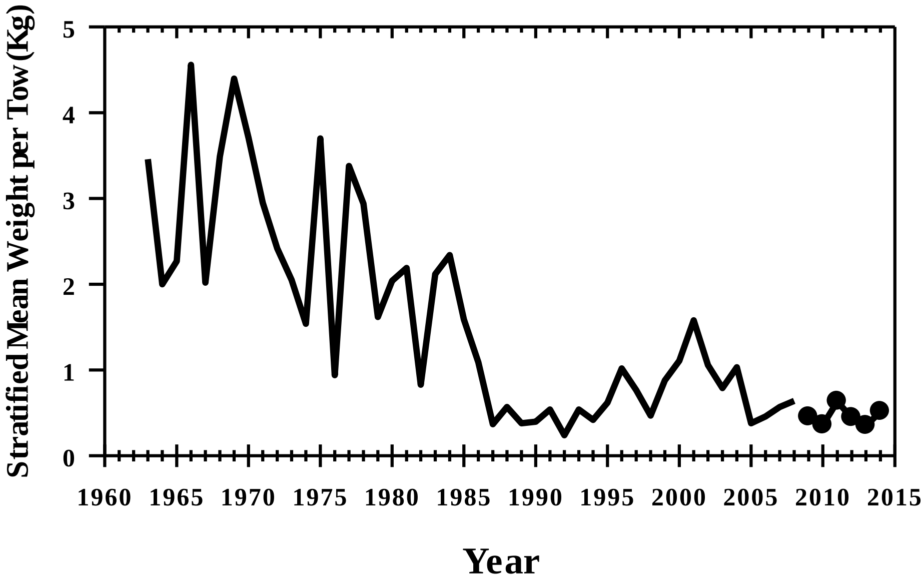

Fig.13. NEFSC autumn bottom trawl survey biomass indices for witch flounder.

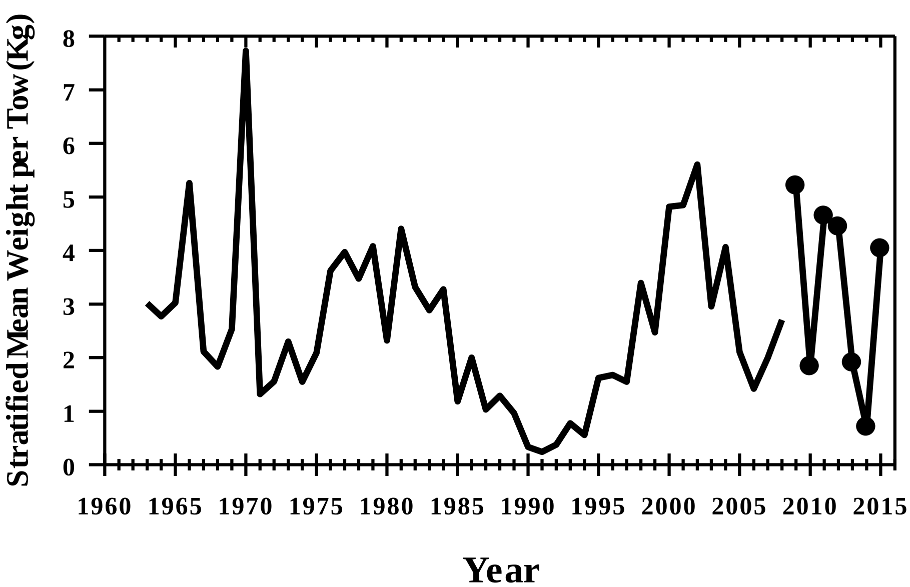

Fig. 14. NEFSC autumn bottom trawl survey biomass indices for Georges Bank winter flounder.

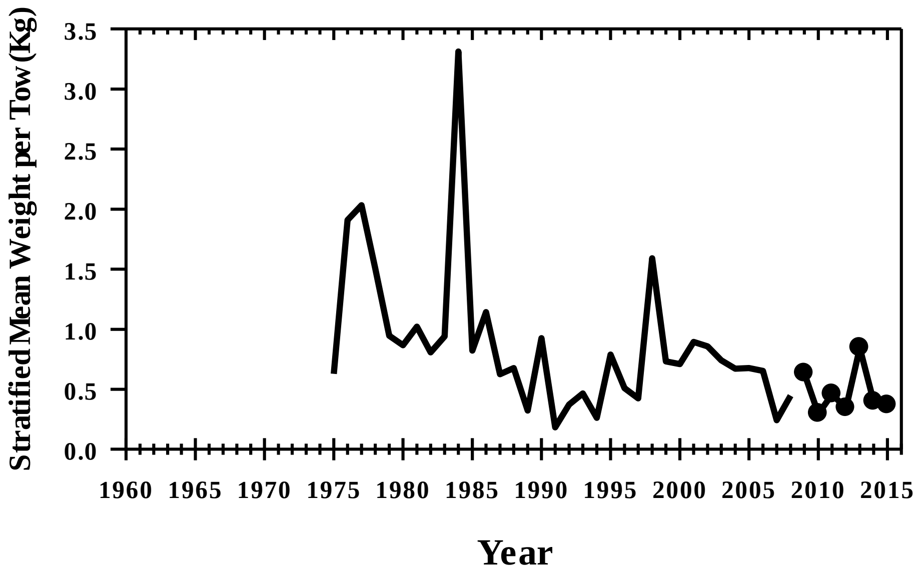

Fig.15. NEFSC autumn bottom trawl survey biomass indices for northern windowpane flounder.

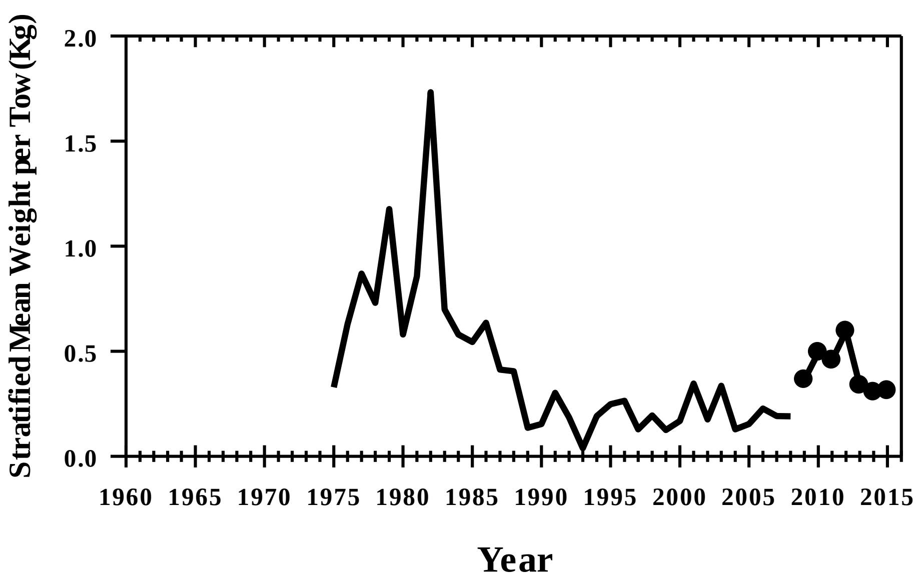

Fig. 16. NEFSC autumn bottom trawl survey biomass indices for southern windowpane flounder.

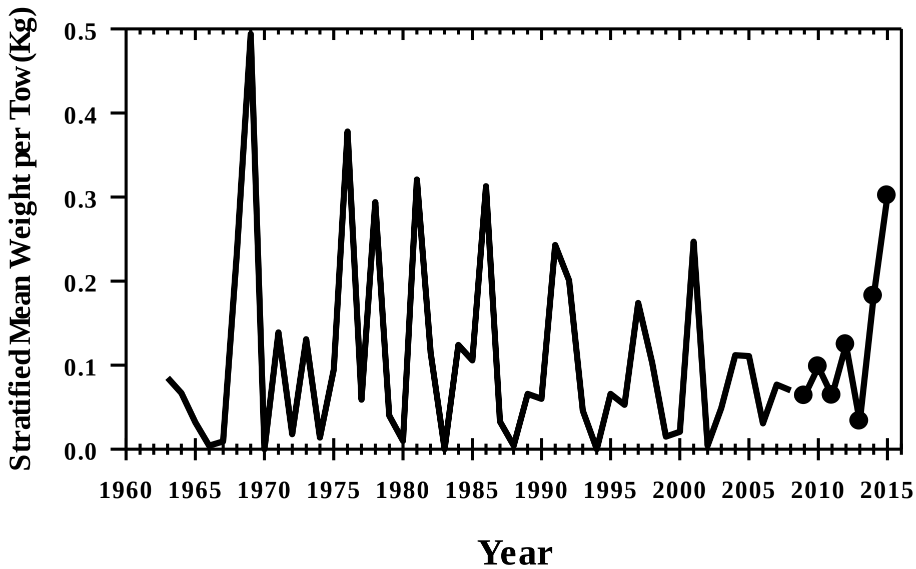

Fig. 17. NEFSC autumn bottom trawl survey biomass indices for Atlantic halibut.

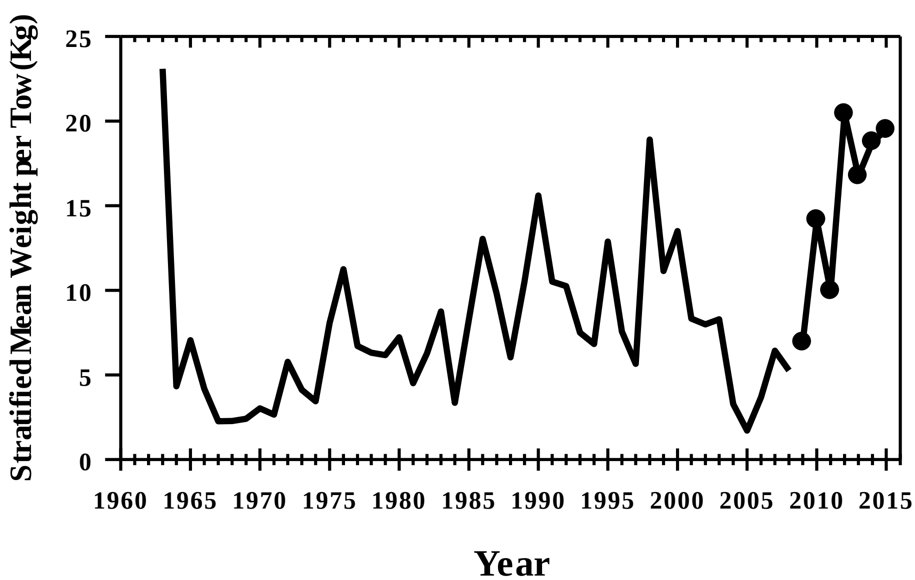

Fig. 18. NEFSC autumn bottom trawl survey biomass indices for northern silver hake.

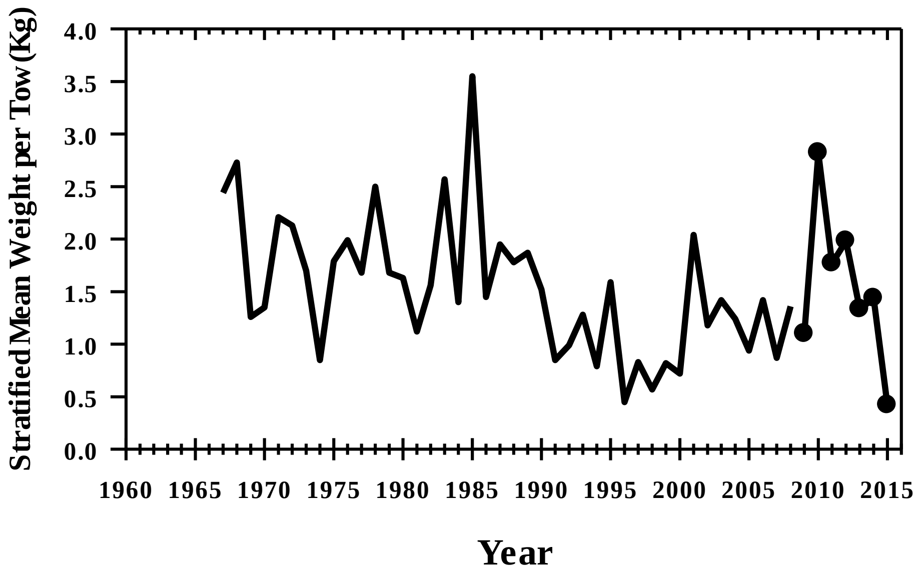

Fig. 19. NEFSC autumn bottom trawl survey biomass indices for southern silver hake.

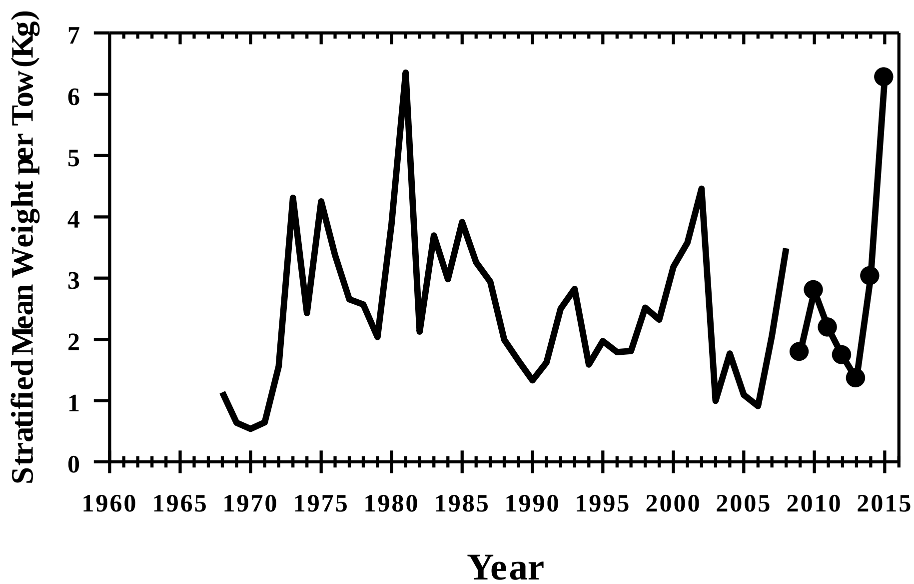

Fig. 20. NEFSC spring bottom trawl survey biomass indices for northern red hake.

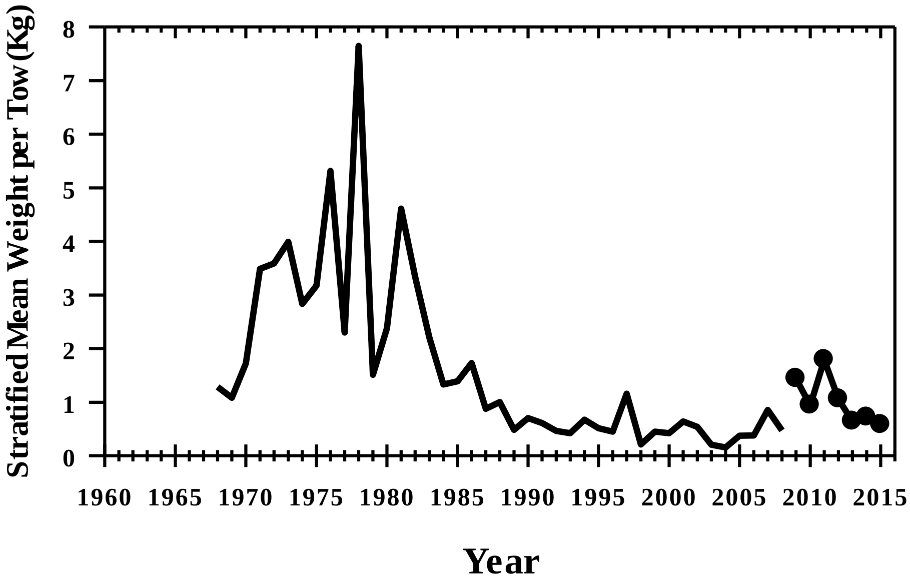

Fig. 21. NEFSC spring bottom trawl survey biomass indices for southern red hake.

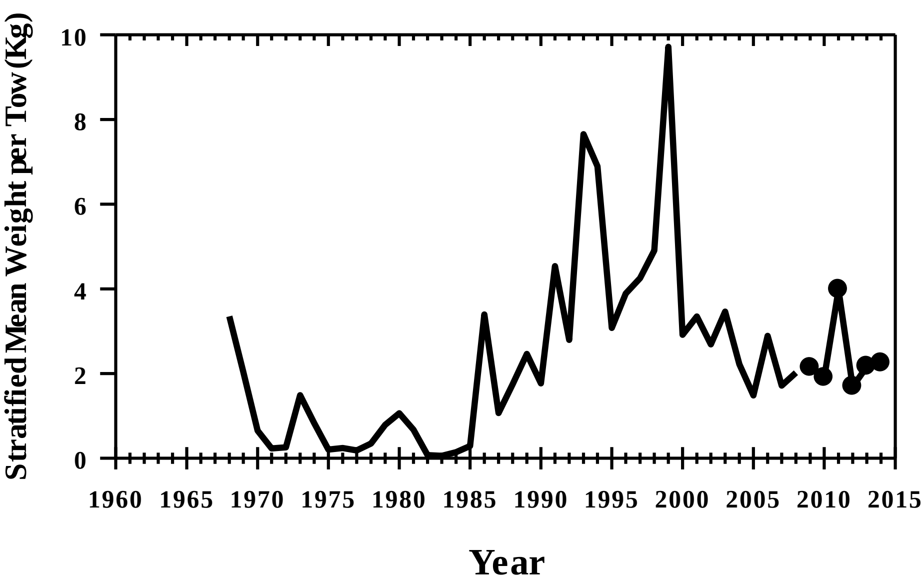

Fig. 22. NEFSC spring bottom trawl survey biomass indices for Atlantic herring.

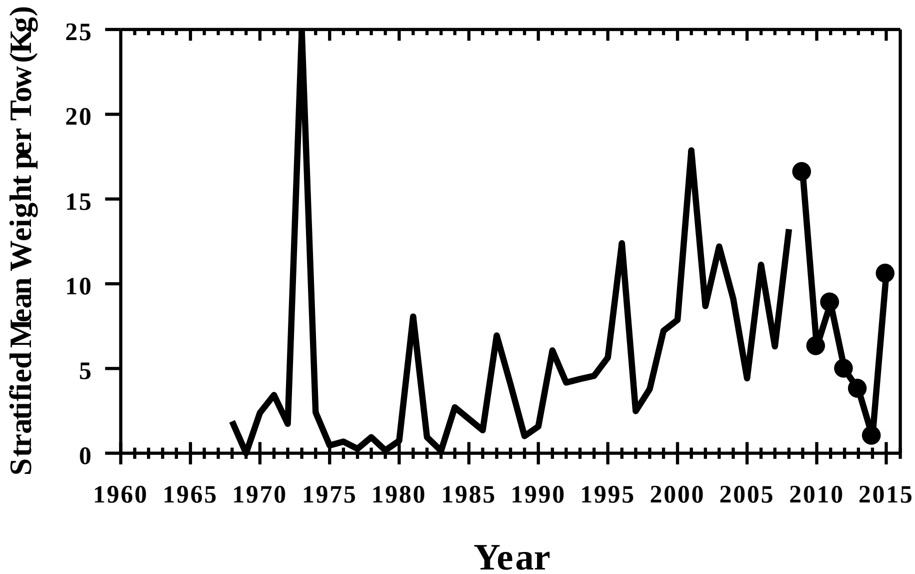

Fig. 23. NEFSC spring bottom trawl survey biomass indices for Atlantic mackerel.

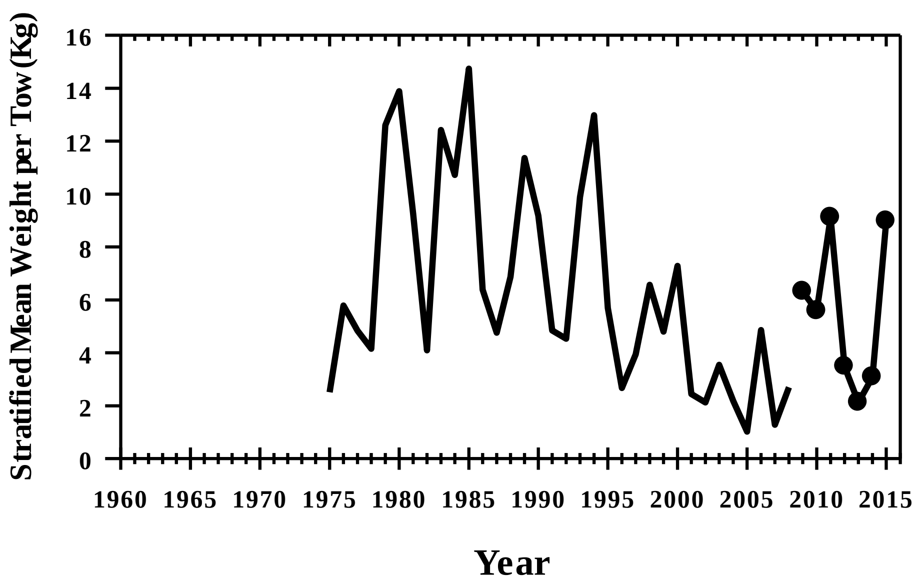

Fig. 24. NEFSC autumn bottom trawl survey biomass indices for butterfish.

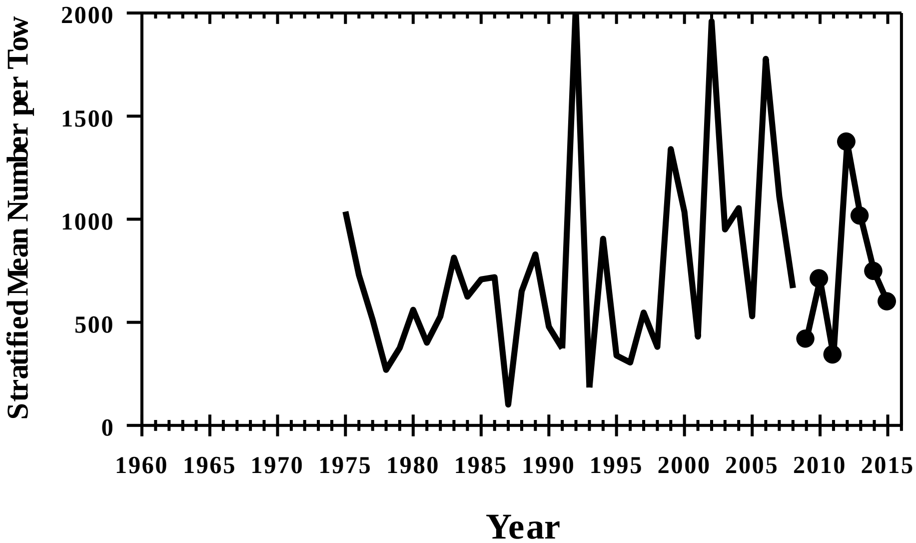

Fig. 25. NEFSC autumn bottom trawl survey abundance indices for longfin inshore squid.

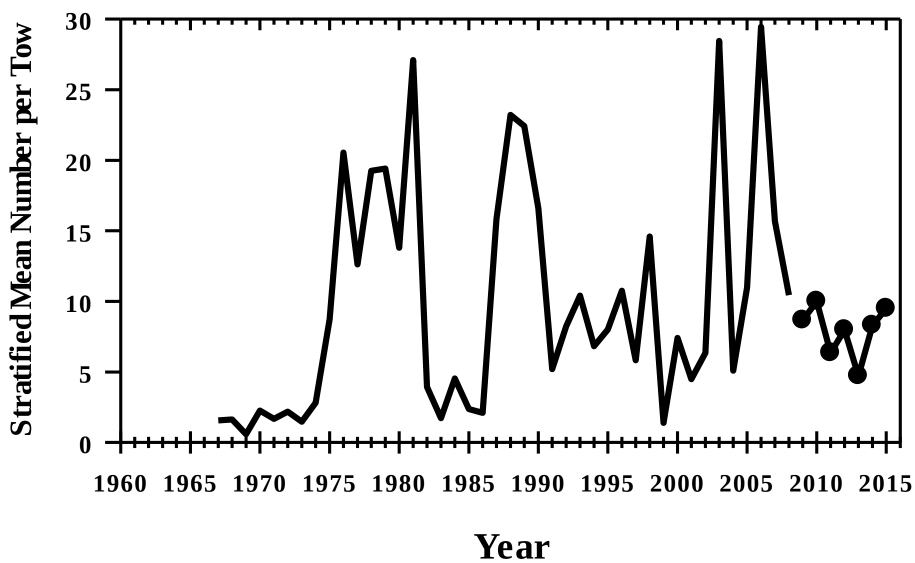

Fig. 26. NEFSC autumn bottom trawl survey abundance indices for northern shortfin squid.

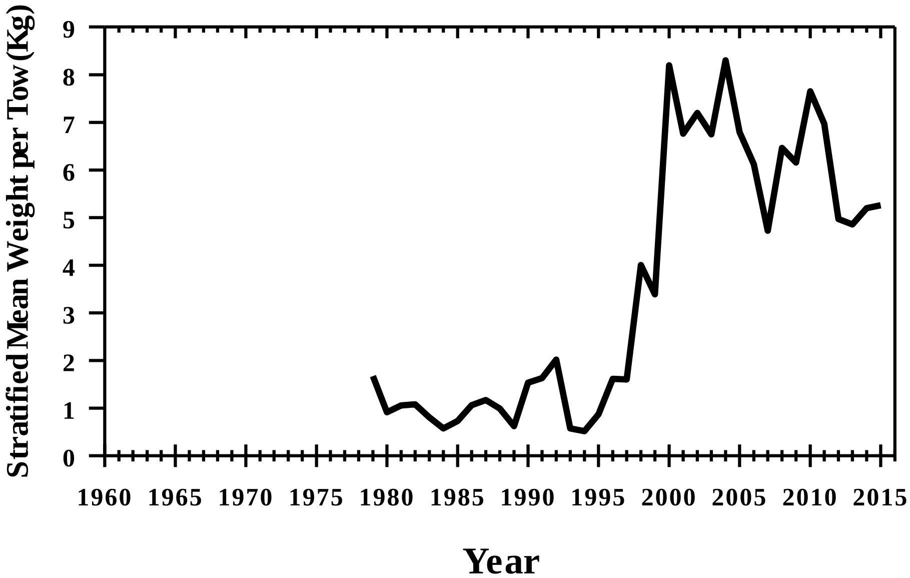

Fig. 27. NEFSC scallop survey biomass indices for Georges Bank sea scallops.

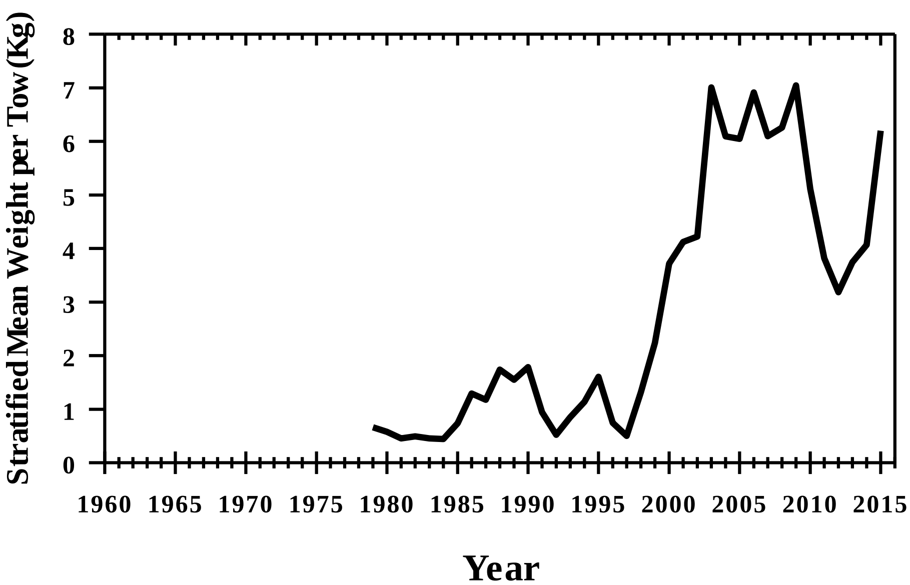

Fig.28. NEFSC scallop survey biomass indices for Mid-Atlantic Bight sea scallops.

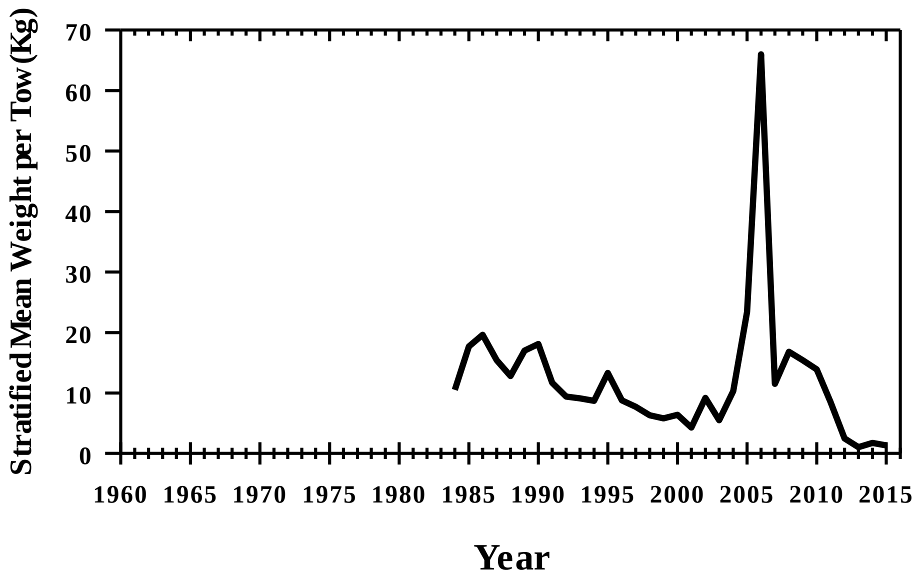

Fig. 29. ASMFC summer shrimp survey biomass indices for northern shrimp.

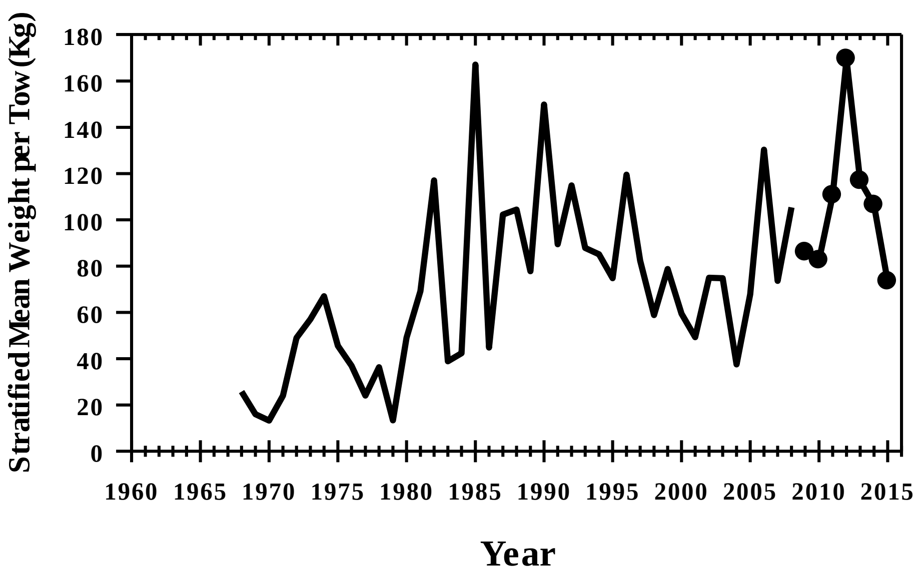

Fig. 30. NEFSC spring bottom trawl survey biomass indices for spiny dogfish.

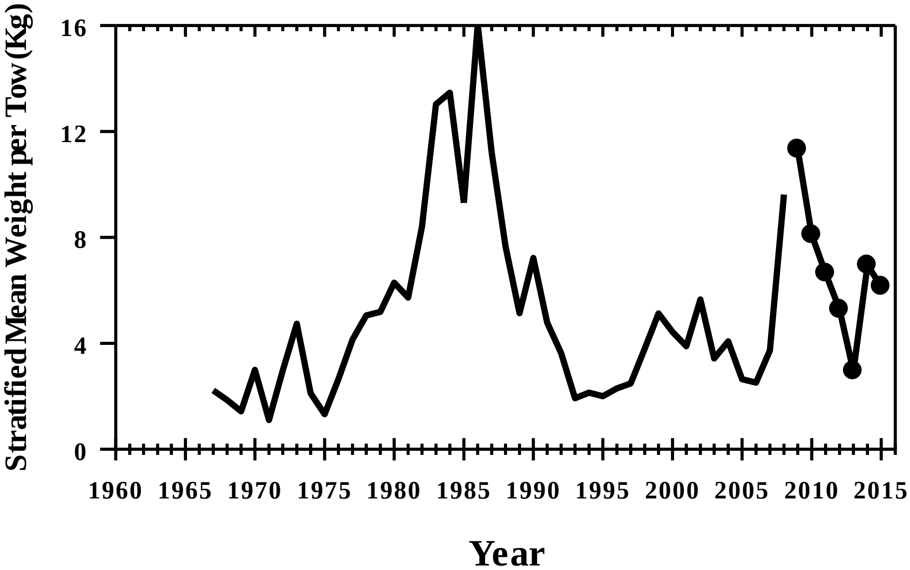

Fig. 31. NEFSC autumn bottom trawl survey biomass indices for winter skate.

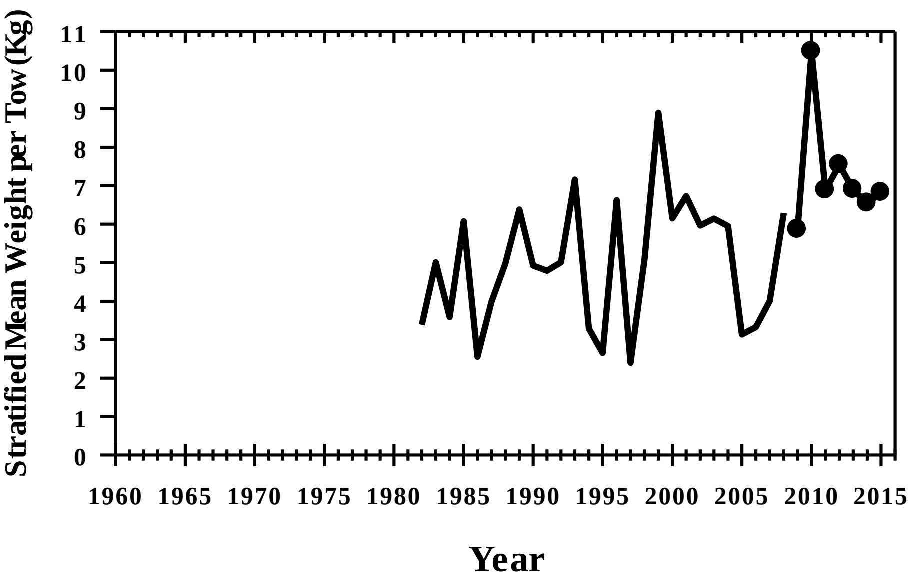

Fig. 32. NEFSC spring bottom trawl survey biomass indices for little skate.

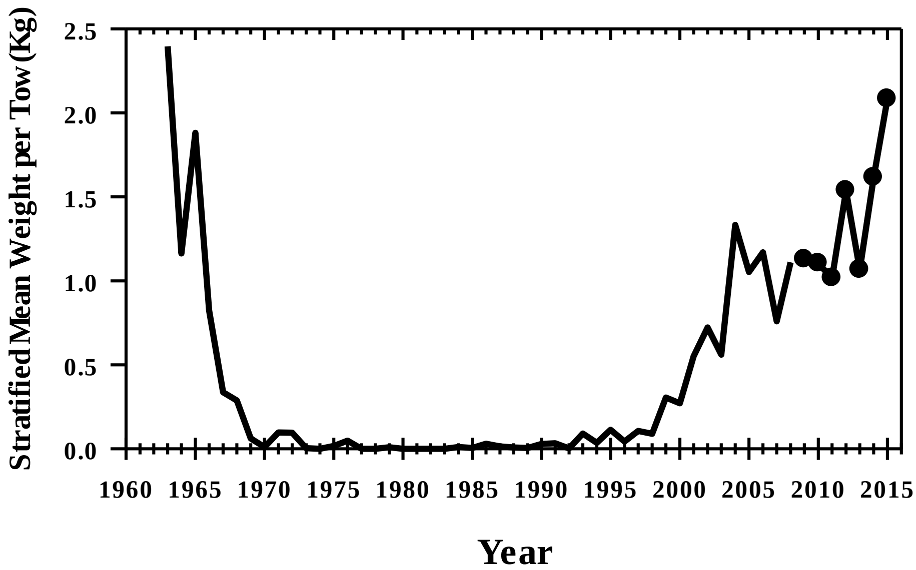

Fig. 33. NEFSC autumn bottom trawl survey biomass indices for barndoor skate.

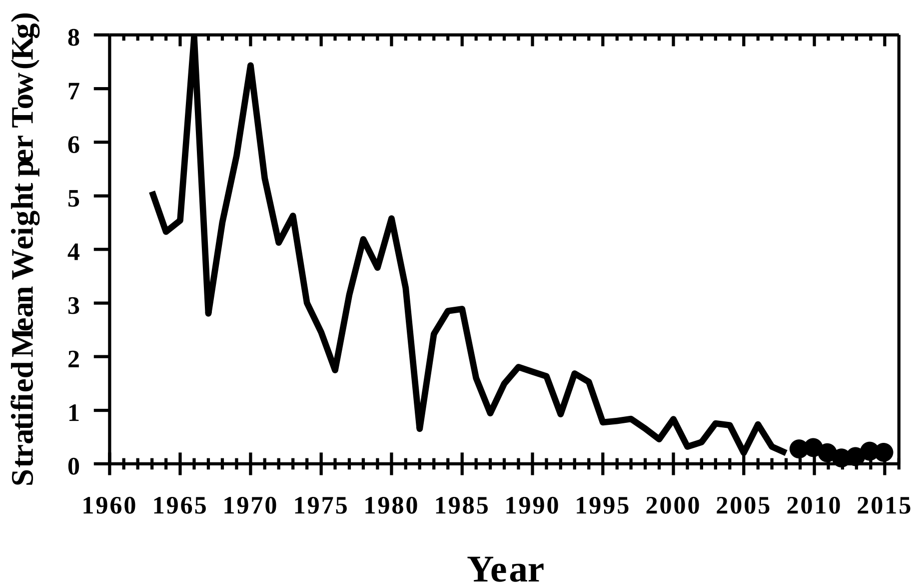

Fig. 34. NEFSC autumn bottom trawl survey biomass indices for thorny skate.

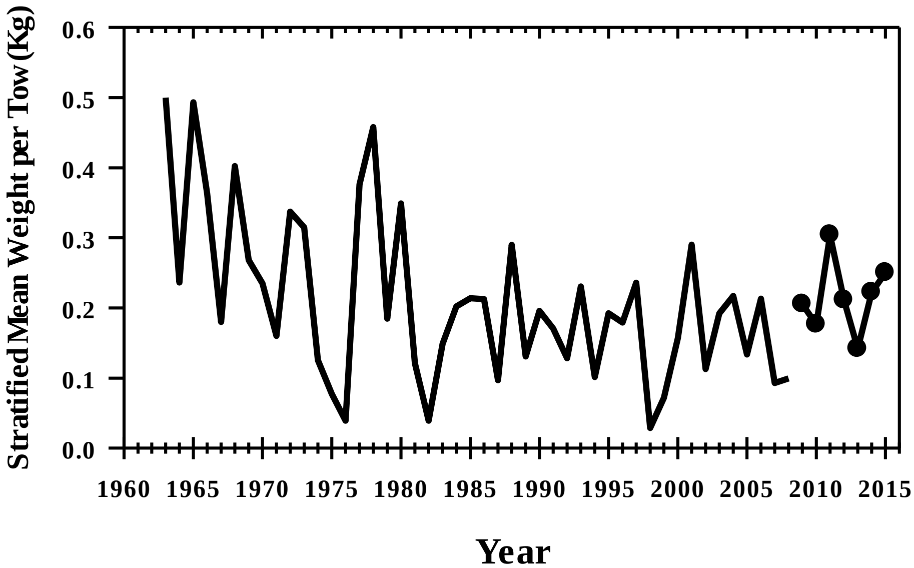

Fig. 35. NEFSC autumn bottom trawl survey biomass indices for smooth skate.

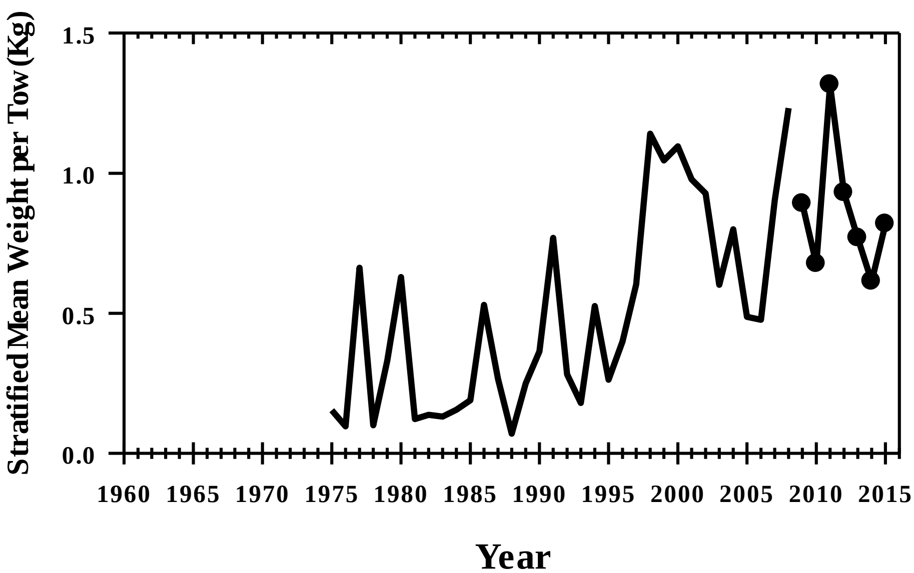

Fig. 36. NEFSC autumn bottom trawl survey biomass indices for clearnose skate.

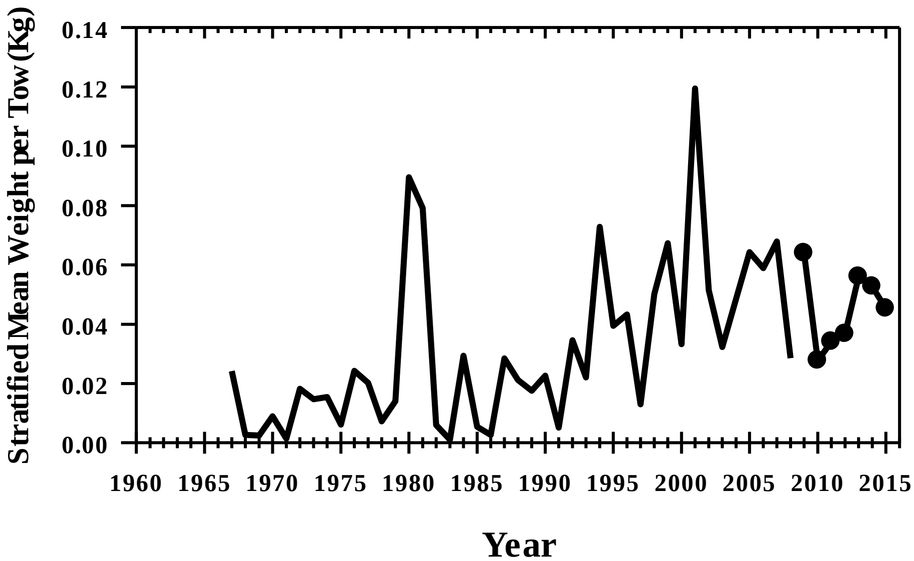

Fig. 37. NEFSC autumn bottom trawl survey biomass indices for rosette skate.