Serial No. N6957 **SCS Doc. 19/15**

SCIENTIFIC COUNCIL MEETING - JUNE 2019

United States Research Report for 2018

by

M.L. Traver and K.A. Sosebee
NOAA/NMFS, Northeast Fisheries Science Center
Woods Hole, MA 02543, USA
Michele.Traver@noaa.gov

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 2009-2018 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, 2009-2018 survey data points should be interpreted cautiously, and these values may change in the future as new methodologies are considered. The 2009-2018 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. In 2017, the fall survey did not cover the Southern New England to Mid-Atlantic region and this has impacted the survey indices for Southern New England yellowtail flounder, southern windowpane flounder, southern silver hake, butterfish, longfin inshore squid, shortfin squid, winter skate, barndoor skate, thorny skate, smooth skate, clearnose skate, and rosette skate. The impact differs for each species and is discussed in those sections. Additionally, the survey was conducted on a different vessel the FSV *Pisces*, which is considered ti be a sister ship the the FSV *Henry B. Bigelow*. The impact of this change is unknown but should be minimal.

For the last few years, the United States has been transferred quota for Div. 3LNO yellowtail flounder from Canada and, from 2012-2018 at least one vessel fished in the area. The sections for cod, haddock, yellowtail flounder, white hake, halibut, other flounders, and small elasmobranchs contain the landings and the discards of these species.

1. Atlantic Cod

United States commercial landings of Atlantic cod (*Gadus morhua*) in 2018 were 975 mt, a 16%
increase from the 2017 landings of 840 mt. In addition, 1.8 mt were landed from Div. 3N and 29.2 mt were discarded. In Div. 3M 0.3 mt were discarded while in Div. 3L 0.8 mt were discarded.

Northeast Fisheries Science Center (NEFSC) research vessel survey biomass indices in the Gulf of Maine remain below time series mean levels (Figure 1) and the stock continues to exhibit a truncated age structure and low recruitment. The NEFSC research vessel survey biomass indices for the Georges Bank stock remain low (Figure 2) and the stock continues to exhibit a truncated age structure and exhibit low recruitment.

2. Haddock

United States commercial landings of haddock (*Melanogrammus aeglefinus*) in 2017 were 6,557 mt, a 19% increase from the 2017 landings of 5,490 mt. In addition, <0.1 mt of haddock were landed in Div. 3N and <0.1 mt were discarded.

Northeast Fisheries Science Center (NEFSC) research vessel survey biomass indices in the Gulf of Maine are near time series highs (Figure 3) due to the presence of several strong year classes. The NEFSC research vessel survey biomass indices for the Georges Bank stock have decreased from the highest levels in the time series but are still above average (Figure 4).

3. Redfish

USA landings of Acadian redfish (*Sebastes fasciatus*) decreased by 13% from 5,159 mt in 2017 to 4,506 mt in 2018. Fall research vessel survey biomass indices generally increased from the mid-1990s through 2010, with the 2010 index value of 83.47 kg/tow being the highest on record, before generally decreasing through 2017 (Figure 5). Most recently, the survey biomass indices increased by 147% from 26.20 kg/tow in 2017 to 64.71 kg/tow in 2018.

4. Pollock (USA Waters of Areas 5&6 stock)

USA landings of pollock (*Pollachius virens*) decreased by 5% from 3,250 mt in 2017 to 3,078 mt in 2018. Fall research vessel survey indices reflected a general increase in pollock biomass from the mid-1990s through 2005, before declining in 2006 (Figure 6). The survey biomass indices have been variable since 2006, reaching a record-low of 0.19 kg/tow in 2009. Most recently, the index decreased by 23% from 0.94 kg/tow in 2017 to 0.72 kg/tow in 2018.

5. White Hake

Nominal USA landings of white hake (*Urophycis tenuis*) from NAFO Subareas 5 and 6 decreased by 1% from 1,978 mt in 2017 to 1,971 mt in 2018. Landings from Div. 3N were 48 mt while 3.8 mt were discarded. Research vessel survey indices declined during the 1990s and increased in 2000 and 2001 due to good recruitment of the 1998 year class. The indices have generally been variable since 2001. The indices have increased from a low value in 2013 (Figure 7).

6. Yellowtail Flounder

USA landings of yellowtail flounder (*Limanda ferruginea*) from NAFO subareas 5 and 6 were 274 mt in 2018, a 30% decrease from 2017 landings of 397 mt. In Div. 3N, landings decreased by approximately 78% from 782 mt in 2017 to 172 mt in 2018. Additionally, 7.6 mt of yellowtail flounder were discarded in Div. 3N bringing the total catch of yellowtail flounder in Div. 3N to 179 mt in 2018.

The NEFSC autumn research vessel survey biomass index in the Gulf of Maine has been steadily increasing in the recent three years (Figure 8). Incomplete survey coverage in the inshore habitat for the autumn survey in 2017 was analyzed to account examine the differences between including and excluding survey strata on the estimate of mean biomass. A linear relationship between survey estimates that excludes missing strata to survey estimates with the full strata values was applied to the observed 2017 autumn survey value of 4.41kg/tow, and resulted in an upward scaling of the fall survey estimate by approximately 14% (5.023 kg/tow). The 2018 index declined to 2016 values (Figure 8).

The NEFSC autumn research vessel survey biomass indices on Georges Bank have been declining over the last nine years. In 2017, the NEFSC autumn survey biomass is second lowest of the time series. The 2018 index increased from the low value in 2017 but is still low (Figure 9).

The 2017 biomass index for the NEFSC autumn survey was not computed for Southern New England-Mid Atlantic yellowtail because the primary habitat for this stock was not sampled due to mechanical problems with the survey vessel. The 2018 index was the lowest in the time series.

7. Other Flounders

USA commercial landings of flounders (other than yellowtail flounder and Atlantic halibut) from Subareas 3-6 in 2018 totaled 5,422 mt, <1% lower than in 2017. Summer flounder (*Paralichthys dentatus*; 51%), American plaice (*Hippoglossoides platessoides*; 21%), winter flounder (*Pseudopleuronectes americanus*; 17% comprising the Georges Bank, Southern New England, and Gulf of Maine stocks), witch flounder (*Glyptocephalus cynoglossus*; 11%), and windowpane flounder (*Scophthalmus aquosus*; <1% comprising the Northern and Southern stocks) accounted for virtually all of the 'other flounder' landings in 2018. Compared to 2017, commercial landings in 2018 were lower for winter flounder (-16%), American plaice (10%), and windowpane flounder (23%) , but higher for summer flounder (5%) witch flounder (36%),). The American plaice landings from Div. 3N were 15.2 mt. In addition, 21.4 mt of American plaice were discarded in Div. 3N bringing the total catch of American plaice in Div. 3N in 2018 to 36.6 mt. The witch flounder discards from Div. 3N were 2.3 mt.

Research vessel survey indices in 2018 increased for summer flounder, decreased for southern windowpane while Georges Bank winter flounder remained relatively unchanged (Figures 11-16). The 2018 research vessel survey index for American plaice, witch flounder, and northern windowpane are not available due to insufficient sampling of the standard strata set.

8. Atlantic halibut

USA landings of Atlantic halibut (*Hippoglossus hippoglossus*) in the Gulf of Maine-Georges Bank region decreased 10% from 59 mt in 2017 to 53 mt in 2018. In addition, 16.4 mt of halibut were landed in NAFO Div. 3N and 5.9 mt of halibut were discarded. In Div. 3M, 1.8 mt were landed and 0.2 mt 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 – 2017 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 5, 172 mt in 2018, a 3.5% decrease from 2017 landings of 5,357 mt.

The NEFSC autumn research vessel survey biomass indices for northern silver hake have generally been increasing over the last ten years. In 2018, the NEFSC autumn survey biomass was 13.3 kg/tow, a decrease from the 2017 survey value of 15.8 kg/tow (Figure 18).

The NEFSC autumn survey in the south has been relatively stable in the recent five years with the exception of the 2015 survey value estimated lowest in the time series (Figure 19). Due to mechanical issues of the vessel, survey coverage of primary habitat for this stock was incomplete. Stratum level average catches of unsampled strata in the autumn of 2017 were then recalculated using the recent three year averages (2014-2016) of mean stratum catches. The stratified mean biomass was then recalculated to account for the incomplete coverage in the south. The recalculated 2017 NEFSC autumn survey resulted in downward scaling of the observed survey value of 1.14 kg/tow by approximately 13% to 0.99 kg/tow. The 2018 index increased to 1.8 kg/tow.

10. Red Hake

USA landings of red hake (*Urophycis chuss*) increased 25% from 394 mt in 2017 to 492 mt in 2018. 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. The 2018, the NEFSC spring biomass index was 5.2 kg/tow, an increase from the 2017 value of 4.7 kg/tow (Figure 20). Indices for the Southern Georges Bank - Mid-Atlantic stock declined in the 1990s and remained low through 2018(Figure 21).

11. Atlantic Herring

Nominal USA landings of Atlantic herring (*Clupea harengus*) declined, equaling 67,574 mt in 2016 and 50,250 mt in 2017, which continues a decline that began in 2014. Spring survey indices generally declined during 2010-2018 and averaged 10.04 kg/tow (Figure 22). The 2018 spring survey index was 3.02 kg/tow, which was the lowest observation since 2010. Based on a 2017 benchmark stock assessment, spawning biomass generally increased from 1982 to 1997, declined from 1998 to 2009, increased through 2014, but has steadily declined since. Recruitment during 2012-2017 was below average, with two of the lowest recruitments ever observed occurring in the last five years. Recent assessments prior to 2017 included time-varying natural mortality, which was included at least in part to reduce a retrospective pattern. The 2017 benchmark assessment, however, did not exhibit a retrospective pattern and a constant natural mortality was used. The lack of a retrospective pattern may have been in part due to a modeled change in catchability to account for the change in survey vessel used for the spring and fall NMFS bottom trawl surveys. Age composition data show that the last above average recruitment that occurred in 2011 is still contributing to survey and fishery catches in recent years, but little or no evidence of strong cohorts since then. An update Atlantic herring assessment is scheduled for 2020, when examining the strength of recent cohorts is likely to be of great interest given the recent poor recruitments and subsequent reduced quotas.

12. Atlantic Mackerel

USA commercial landings of Atlantic mackerel (*Scomber scombrus*) increased 24.9% from 6,975 mt in 2017 to 8,712 mt in 2018. Recreational catches decreased 40.2% from 4,173 mt in 2017 to 2,496 mt in 2018. The 2017 recreational catch estimate differs notably from that reported in the previous U.S. research report because updated estimates are now calibrated to the new recreational effort survey.

For the 2017 U.S. assessment, a range-wide spawning stock biomass (SSB) index was developed that combined estimates from Canada's dedicated Atlantic mackerel egg survey and estimates from the U.S.'s ichthyoplankton surveys. The combined SSB index showed a general decline over the time series from a maximum of 1,846,983 mt in 1986 to 29,256 mt in 2010 (Figure 23). The proportion of the total spawning biomass represented by the southern contingent varied over time from a maximum of 43% in 1983 to a minimum of 1%

in 2005 and averaged 6.6% since 2010. Accordingly, trends in the combined SSB index closely followed those of the northern contingent.

Updates to the U.S. component of the spawning stock biomass index (representing the southern spawning contingent) were not available; however, Canada's Department of Fisheries and Oceans provided updated estimates through 2018 for the northern contingent. Given that trends in the combined index generally follow those of the northern contingent, updated trends in the spawning stock biomass index of the northern contingent are likely representative of the entire stock. Since reaching a time-series low in 2012, the spawning stock biomass of the northern contingent increased slightly to approximately 97,600 mt in 2017, but then decreased to 41,200 mt in 2018.

13. Butterfish

USA landings of butterfish (*Peprilus triacanthus*) decreased 54.9% from 3681 mt in 2017 to 1660 mt in 2018. Fall research vessel survey biomass indices have fluctuated since the 1970s, but were generally highest in the late 1970s to early 1990s. Since 1995, annual values have averaged 4.48 kg/tow. Biomass in 2017 was NA due to limited sampling of butterfish strata (Figure 24).

14. Squids

Longfin inshore squid

The USA small-mesh bottom trawl fishery for longfin inshore squid, *Doryteuthis (Amerigo) pealeii*, began in 1987. During 1987-2017, landings averaged 15,250 mt, with a low of 6,751 in 2010 and a peak of 23,733 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. With the exception of 2016 (18,182 mt), landings during 2007-2017 were below the 1987-2017 mean and averaged 11,254 mt. Landings during 2018 were slightly above the mean and totaled 11,612 mt.

Fall survey relative abundance 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). Between 2012 and 2016, relative abundance decreased from 1,371 squid per tow (above the 1975-2017 median of 638 squid per tow) to 536 squid per tow, respectively. Abundance indices were not computed for 2017 because there were mechanical problems with the survey vessel and the primary areas of longfin squid habitat were not sampled. During 2018, relative abundance was slightly below the median.

Northern shortfin squid

The USA small-mesh bottom trawl fishery for Northern shortfin squid (*Illex illecebrosus*) began in 1987. During 1987-2017, landings averaged 12,256 mt, with a low of 1,958 mt in 1988 and a peak of 26,097 mt in 2004. In recent years, landings declined from 18,797 mt in 2011 to 2,422 mt in 2015, but then increased through 2018. The fishery closed in 2017 (22,516 mt), when 98% of the quota (22,915 mt) was harvested, and in 2018 (24,117 mt) when the quota (22,915 mt) was exceeded by 5%.

Fall survey relative abundance of Northern shortfin squid attained a record-high in 2006 (29.5 squid/tow) then steadily declined to below the 1967-2017 median (8.0 squid per tow) to 4.7 squid/tow in 2013. Thereafter, relative abundance increased and was slightly above or near the median through 2016 (Figure 26). Abundance indices were not computed for 2017 because there were mechanical problems with the survey vessel and the primary areas of *Illex* habitat were not sampled. During 2018, relative abundance (15.8 squid per tow) was the highest since 2006 (29.5 squid per tow).

15. Atlantic Sea Scallops

USA Atlantic sea scallop (Placopecten magellanicus) landings in 2018 were 26,445 mt (meats), an increase of 2979 mt over 2017. The ex-vessel value of the 2018 landings was $533 million, about $24 million higher than 2017. Landings are expected to increase further in 2019, mainly from harvests of the very strong 2012 Georges Bank and 2013 Mid-Atlantic year classes.

Biomass in 2018, based on dredge and optical surveys, was about 141,032 mt (meats), on Georges Bank and 77,380 mt (meats) in the Mid-Atlantic, for a total of 218,412 mt. This is about a 20% decline from the record biomass in 2017, due to harvesting, natural mortality, and poor recruitment.

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. Recruitment indices have remained near time series lows since 2011 (the time series began in 1984). Warming temperatures, increased predation pressure and overexploitation are factors thought to have been responsible for the collapse. The fishery has been provisionally closed for 2019-2021 due to extremely low recruitment in 2016-2018.

17. Small Elasmobranchs

USA landings of spiny dogfish (*Squalus acanthias*) decreased 37% from 10,949 mt in 2017 to 6,878 mt in 2018. In addition, <0.1 mt were discarded in Div. 3N and Div. 3M. 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 27). The 2014 data point is plotted, although the comparability with previous years has not been evaluated. The area not covered by the survey generally had a large proportion of the spiny dogfish biomass. The survey index remained high in 2016, although the survey was a month later than normal and may have impacted the comparability of the estimate. The 2018 survey index increased from a low value in 2017.

USA nominal landings of skates (most species are still landed as unclassified) declined <1% between 2017 and 2018 from 14,591 mt to 14,497 mt. The landings are sold as wings for human consumption and as bait for the lobster fishery. One ton of spinytail skate was landed in Div. 3N. In addition, 0.2, 2.9 and 15.0 mt of thorny skate were discarded in Div. 3L, 3M and 3N, respectively. Barndoor skate were also discarded in 3N (<0.1 mt). An additional <0.1, 3.7 and 4.2 mt of spinytail skate were discarded in Div 3L, 3M and 3N, respectively. Discards of Arctic skate were 0.1 mt in 3M and 3N.

For winter skate, adjustment for the lack of coverage in the Southern New England and the Mid-Atlantic strata for fall 2017 was described in 2018. Survey biomass indices for winter skate (*Leucoraja ocellata*) peaked in the mid-1980s (Figure 28) 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 and remained above 2012-2013 values through 2017. For little skate, the adjustment for the lack of coverage in the southern strata described above for spring 2014 was described in 2015. Little skate (*Leucoraja erinacea*) survey indices have generally fluctuated without trend (Figure 29).

For barndoor skate, thorny skate and smooth skate, the adjustment for the lack of coverage in the Southern New England strata was described in 2018. Survey indices for barndoor skate (*Dipturus laevis*) declined markedly in the mid-1960s and remained very low through the late-1980s. Biomass indices subsequently increased to levels observed in the mid-1960s and in were the highest in the time series in 2018 (Figure 30). Thorny skate (*Amblyraja radiata*) survey indices have declined over the entire time series, and are currently near record lows (Figure 31). Survey indices for smooth skate (*Malacoraja senta*) are highly variable, but have been generally stable for the last 20 years (Figure 32) with an increase over the last several years. For clearnose and rosette skate, there were no indices available for 2017 since the entire strata set was not covered. Indices for both clearnose skate (*Raja eglanteria*) and rosette skate (*Leucoraja garmani*) generally increased over the time series (Figures 33 and 34) but have been stable the last couple of years.

B. Special Research Studies

1. Environmental Studies

a) Hydrographic Studies

A total of 986 CTD (conductivity, temperature, depth) profiles were collected and processed by the Northeast Fisheries Science Center (NEFSC) in 2018 over the course of 8 cruises. Of this total, 964 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 50 fixed locations/depths around the Gulf of Maine and Southern New England Shelf indicate that 2018 was in fairly warm except for a cooling period at many sites in mid-October.

Real-time bottom temperatures are now reported from more than two dozen commercial vessels each time they haul their gear. Beginning in May 2015, approximately 6200 haul-averaged bottom temperatures have been automatically transmitted via satellite from a variety of locations and depths. Sensors are now deployed on trawlers, scallop dredges, long lines, and traps. Observations are compared to three different local ocean models as well as the empirically-derived climatology.

Approximately 50 satellite-tracked surface drifters were deployed off the coast of New England in 2018 (see http://www.nefsc.noaa.gov/drifter). The collective archive helps resolve the transport pathways of coastal currents in shelf waters. The drifter project is promoted as an educational tool where students are involved with both the construction of the instruments and the processing, plotting, and analysis of the data. Sensor packages are now developed and can now be deployed on the few dozen unmanned sailboats (see http://educationalpassages.org) that are released each year.

b) Plankton Studies

During 2018, zooplankton community distribution and abundance were monitored using 382 bongo net tows taken on five surveys; two aboard the *FSV Henry Bigelow* during the spring and fall trawl surveys, and three dedicated ecosystem monitoring cruises using the NOAA FSV vessels *Henry Bigelow* and *Gordon Gunter,* and the UNOLS vessel *R/V Hugh R. Sharp*. Collectively the five surveys covered the entire continental shelf region encompassing the Middle Atlantic Bight, Southern New England, Georges Bank and the Gulf of Maine. However, the 2018 plankton sampling of the Gulf of Maine area was much more limited than in previous years due to weather, time and vessel constraints. During the Spring Ecosystem Monitoring Survey aboard the *Henry Bigelow*, 21 vertical net casts using a 70 cm diameter 200 micron mesh net were made in an effort to compare plankton catches made with this gear by the Canadians with standard double oblique bongo net tows done in the same area by U.S. NEFSC researchers. Initial results showed that much less water was filtered and smaller samples were obtained using the ring net gear and protocol combination.

2018 was the fifth year where the Imaging FlowCytoBot unit from the Woods Hole Oceanographic Institute was used to collect images of phytoplankton from the scientific seawater flow-through system on the three dedicated Ecosystem Monitoring Surveys. In addition, as in years past, these three ecosystem monitoring cruises conducted water casts, collecting 415 nutrient samples in collaboration with the University of Maine to monitor levels of nutrients in the euphotic zone. These same water casts also yielded 153 chlorophyll calibration samples for the Oceans and Climate Branch and 154 dissolved inorganic samples for the Atlantic Oceanographic and Meteorological Laboratory (AOML). Researchers from the URI Graduate School of Oceanography also used those vertical casts for analysis of seawater optical properties from different depths.

The three dedicated ecosystem monitoring surveys also collected 53 plankton samples for the Census of Marine Zooplankton Program, based at the University of Connecticut. These samples, collected with a set of smaller (20 cm diameter) bongo nets, having 165 micron mesh, were for genetic analysis of the planktonic organisms to supplement identifications made by traditional visual taxonomic means. These same three surveys also collected 144 plankton samples using the same smaller (20 cm diameter) bongo nets equipped with 335 micron mesh for larval fish and egg sample genetic studies. Ground-truthing of satellite sea-surface temperature observations was conducted during every dedicated ecosystem monitoring cruise by hand deploying a submersible radiometer during satellite overpasses to obtain simultaneous subsurface light readings for calibration of the algorithms used for the satellite observations.

c) Benthic Studies

No field work done for 2018

2. Biological Studies

a) Fish Species

Flatfishes: In 2015-18, we implemented work on the plasticity of responses to elevated CO_2, and the degree of 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 focus on phenotypic plasticity, we are evaluating responses in small-bodied forage species that can be housed and accommodated by our in-house CO_2 delivery system. The target species is Atlantic silverside (*Menidia menidia*) and results are discussed below. Winter flounder and summer flounder are our experimental models for the inter-population contrasts. In 2018, we began a study contrasting response to elevated CO_2 of summer flounder offspring drawn from parents collected near the northerly (New Jersey) and southerly reaches of its geographic range. The effort on summer flounder is also examining the early life-stage responses to thermal regimes. There, a large number of distinct constant thermal regimes (embryos, N=40 regimes; larvae and young juveniles, N=11) and seasonally varying regimes (larvae and young juveniles, N=2) are being evaluated for effects on viability, growth, and development.

Sturgeons: Macro-phenotypic data collected during 2014-2016are being further analyzed for publication.

Forage fish. A set of studies on Atlantic silverside, *Menidia menidia*, was continued into 2018. Those studies focus on effects of climate (thermal and CO2 variations), hypoxia, and parentage on key early life-stage traits (ELS). Results were presented at 2018 Ocean Sciences Meeting and the Effects of Climate Change on World's Oceans. Those data are being further analyzed.

An analogous HF system was developed in 2018 for dissolved oxygen and the first test used fertilization rate of Atlantic silverside as the response variable. A clear, negative trend in fertilization rate occurred with increasing degrees of hypoxia.

b) Resource Survey Cruises

During 2018, 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 dredge survey and the Atlantic surfclam dredge survey. In aggregate, the survey staff efforts totaled 164 research and charter vessel sea days. NOAA scientific and contract staff involvement in the various cruises totaled of 1,244 person sea days, and volunteers contributed another 270 person sea days. ESB cruises occupied 1,000 stations in an area extending from Cape Hatteras, North Carolina to Nova Scotia. A total of 400,496 length measurements were recorded, representing 1,595,366 individuals from 256 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 2018 to fulfill special survey sampling requests from 85 NOAA and university investigators. This sampling included 9,313 feeding ecology observations, collection of 39,884 aging structures, and acquisition of 30,028 samples/specimens to support additional shore-based research. Additionally, the HabCam cruise track from the scallop survey in the Georges Bank NAFO zone 5Ze completed 1,434 nm, while 358 nm were covered in the Mid-Atlantic Bight NAFO zone 6B.

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

Fish age determinations by the Fishery Biology Program are used in age-structured single- and multi-species stock assessments for regions from the international (US-Canada) border regions in the Gulf of Maine and Georges Bank, south through the middle US Atlantic seaboard. These stock assessments serve as the basis for scientific advice to two federal fishery management councils (i.e., NEFMC, MAFMC).

In 2018, FBP staff provided ages for over 53,700 otoliths and other hard structures from 20 species. The top species by number aged were haddock (8,687), silver hake (6,604), summer flounder (4,433), winter flounder (4,158), and Atlantic cod (3,813). Large numbers of yellowtail flounder, pollock, black sea bass, American plaice, and scup (combined total 13,882) were also aged. These data provide information on age composition, recruitment strength, and growth dynamics, which ultimately inform scientific determinations of stock status, biological reference points, and annual catch limits.

The FBP utilizes a robust set of QA/QC protocols to monitor and maintain 1) accuracy, 2) precision, and 3) inter-agency consistency in age determinations. Results of all these tests are posted publicly at http://www.nefsc.noaa.gov/fbp/QA-QC/. The coefficient of variation is used to measure precision levels, with values under 5% deemed acceptable. Samples re-aged as part of this testing are not counted in the above totals.

1. Accuracy: Through the use of reference collections, personnel are regularly tested to measure whether there has been any deviation of their age estimates relative to a collection of consensus-aged samples. The Program currently has reference collections for 4 species and is currently working to build reference collections for additional species.

2. Precision: A subsample of recently-aged samples is re-aged blindly by personnel to quantify the random error of the age estimates. In addition, inter-reader precision tests are conducted when there is a change in the person responsible for ageing of a given species. In

2018, 99 intra-reader precision tests were conducted across 18 species.

3. Inter-agency exchanges: For transboundary stocks, the FBP exchanges age structures with other laboratories. In 2018, two inter-agency exchanges were conducted with the St. Andrews Biological Station (Fisheries and Oceans Canada), for haddock and Atlantic herring.

d) Food Web Dynamics

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

Fish food habits samples were collected on the northeastern U.S. continental shelf (South-Atlantic Bight to Scotian shelf) during NEFSC spring and autumn bottom trawl surveys. Estimates of prey volume and composition were made at sea for selected species. During 2018, stomachs from 5,533 individuals and 50 species were examined in the spring, and stomachs from 5,663 individuals and 50 species were examined in the autumn. In the spring and autumn, diet sampling emphasized gadiformes, elasmobranchs, small pelagics, flatfishes, and lesser known species.

The collection of food habits data continued during NEFSC trawl surveys, creating a 46-year time series (1973-2018). The majority of the time series is now available for analysis, including data from over 655,000 stomach samples and over 160 predators. The processing of the 2018 bottom trawl survey food habits data is scheduled for completion in 2019.

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 2018, stomachs from juveniles (<=12 cm) of predators routinely examined at sea were preserved for laboratory processing.

Since 2004, training workshops for identifying fish stomach contents and refreshing staff knowledge of marine invertebrate and fish taxonomy are offered once per year in the winter prior to the spring trawl survey. These workshops continued in 2019 and provided class discussions and specimens as aids for prey identification in association with the spring and autumn trawl surveys.

Staff prepared several papers and reports for publication and presentations on a wide range of trophic ecology issues in the Northwest Atlantic ecosystem. Since trophic interactions are central to food web and ecosystem considerations, research continues with respect to general diet information, multispecies functional feeding responses, fish predation pressure on benthos, 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, reproductive biology and relative abundance trends of highly migratory species, particularly Atlantic sharks. Members of the Cooperative Shark Tagging Program (CSTP), involving over 6,000 volunteer recreational and commercial fishermen, scientists, and fisheries observers continued to tag coastal and pelagic sharks and provide information to define essential fish habitat for shark species in U.S waters in 2018. Information was received on over 5,000 fish that were tagged or recaptured in 2018; bringing the total to over 300,000 fish of more than 50 species. Additionally, mark-recapture data from the CSTP were analyzed in 2018 for use in a manuscript on bonnethead growth rates and in an update to the Southeast Data Assessment and Review (SEDAR) 29U for the blacktip shark in the Gulf of Mexico.

APP staff analyzed mark-recapture data from the CSTP and catch data from the NEFSC historical longline database for potential use in the assessment update for the blacktip shark in the Gulf of Mexico (SEDAR 29U) in 2018. CSTP data from blacktip sharks tagged or recaptured in the Gulf of Mexico and length and catch per unit effort data from historical longline surveys in the Gulf of Mexico were analyzed and reviewed.

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. APP staff provided tags for sharks released during the tournaments and examined 66 sharks at six tournaments in 2018.

The NEFSC Coastal Shark Bottom Longline Survey of Atlantic large and small coastal sharks began in 1986 and is conducted every two to three years. This survey is the longest running coast-wide (Florida to the Mid-Atlantic) 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. Results from the 2018 survey included 2,724 fish (2,713 sharks) representing 22 species, of which 2,052 (76%) were tagged and released. Sharks represented 99.6% of the total catch of which sandbar sharks were the most common, followed by, dusky, blacktip, and Atlantic sharpnose sharks.

The NEFSC Cooperative Atlantic States Shark Pupping and nursery (COASTSPAN) Program continued to survey and monitor shark nursery habitat in nearshore waters along the U.S. Atlantic coast using federal, state, university, and commercial platforms. COASTSPAN surveys help determine the relative abundance, distribution, and migrations of sharks using coastal nursery habitat through longline and gillnet sampling and mark-recapture data. In 2018, our COASTSPAN participants were the Virginia Institute of Marine Science, South Carolina Department of Natural Resources (SCDNR), the University of North Florida, which conducted the survey in both Georgia and northern Florida waters, and Florida Atlantic University. The NEFSC staff conducts the survey in Narragansett and Delaware Bays. In 2018, results from these COASTSPAN surveys were provided to NMFS Highly Migratory Species Management Division in 2018 for use in updating the EFH section of the annual Stock Assessment and Fisheries Evaluation (SAFE) Report. Additionally, mark-recapture data from the SCDNR COASTSPAN survey were analyzed for use in a manuscript on bonnethead growth rates.

In 2018, APP staff with co-authors from the NMFS Pacific Islands Fisheries Science Center, University of South Carolina, and KwaZulu-Natal Sharks Board contributed a book chapter on elasmobranch age and growth in *Shark Research: Emerging Technologies and Applications for the Field and Laboratory* published by CRC Press. This chapter discusses common methods used for elasmobranch age and growth, validation, and new frontiers in age and growth studies. It is noted that as age validation of elasmobranchs has progressed, it has become apparent that for some species vertebral band pairs either are not related to time or are only related to time for a specific period of life. In most cases, bomb carbon validation shows distinct underestimation of age for species studied. The basis for band pair formation needs to be determined due to the importance of age in determining stock status and management strategies. Equally important is the need for new methods of age determination that are not related to band pair counting.

APP staff in cooperation with staff from the Massachusetts Division of Marine Fisheries, Florida Atlantic University, Alaska Department of Fish and Game, and Wood River Animal

Hospital published a study investigating the relationship between vertebral band pairs (used to estimate shark age) and vertebral shape and growth in *Marine and Freshwater Research* in 2018. Intracolumn differences in centrum morphology (size and structure) and band pair counts were quantified in seven shark species: *Squatina dumeril, Carcharodon carcharias, Lamna nasus, Isurus oxyrinchus, Alopias vulpinus, Prionace glauca* and *Carcharhinus obscurus*. In all species examined, band pair deposition was closely related to body girth and the structural properties of the cartilaginous skeleton, relative to maximum size, and body type. These findings indicate the need to critically examine past studies on vertebral ageing. Future studies should assume that band pair deposition is not triggered by a time-related event, but rather to growth that may coincidentally correspond to time on some centra along the vertebral column for a portion of a species' lifespan. This study has far-reaching implications for the conservation and management of elasmobranch species and the data needed to calculate the productivity necessary for stock assessment modelling. The use of improper ages can seriously alter model output, thereby affecting management decisions.

A complimentary study to the one described above was published in 2018 by APP staff and co-authors from Florida Atlantic University in the *Journal of Experimental Biology* on the mechanical behavior of shark vertebra. This study used six of the same shark species (*Carcharodon carcharias, Lamna nasus, Isurus oxyrinchus, Alopias vulpinus, Prionace glauca* and *Carcharhinus obscurus*) to examine the biomechanics of the vertebral centra related to vertebral structure and function. Results showed that the mechanical properties of the shark vertebral centra vary among ontogeny, species and body type; further supporting the hypothesis that band pair structure is related to the function of the vertebral centra and not directly related to time.

f) <u>Marine Mammals</u>

During May, June, July, August, September and November 2018, visual detection data of primarily seabirds, but also marine mammals, turtles, and large pelagic fish were collected on 7 cruises including spring, summer and fall Ecosystem Monitoring (EcoMon) cruises and a deep diving cetacean ecology cruise. To further utilize the NOAA ships to survey additional habitats in a variety of seasons, observers also collected data while the ship was transiting between scientific cruises. These surveys covered waters from Maine in the Atlantic Ocean to Louisiana in the Gulf of Mexico. The 300 m strip transect methodology was used to collect the data by one or two on-effort observers when the ship was travelling during daylight hours. During these cruises over 10,700 sightings of birds and other marine megafauna were recorded in the survey zone and 18,021 in total.

During April 3-8, 2018, the National Science Foundation ship *R/V Endeavor* operated by the University of Rhode Island conducted a Rhode Island Endeavor Program research cruise intended to explore right whale distribution relative to prey layers and physical oceanography. NEFSC staff led key aspects of the marine mammal, zooplankton, physical oceanography, and active acoustic portions of the cruise. The study area was the continental shelf south of Rhode Island and Massachusetts. Two right whales (*Eubalaena glacialis*) were sighted in a region with previous sightings, after which the area was intensively investigated to determine the physical and biological oceanography defining their foraging habitat. Numerous types of sampling techniques were deployed, including a Video Plankton Recorder, bongo nets, CTD casts, XBTs, and 38, 120 and 200 kHz echosounders.

During 20 July – 19 August 2018, NEFSC and partners conducted a shipboard survey primarily on the region offshore of Georges Bank to test and integrate multiple new technologies to assess the ecology and distribution of deep diving cetacean species, such as beaked whales and sperm whales (*Physeter microcephalus*). This survey focused primarily on True's beaked whale (*Mesoplodon mirus*) habitat. The scientific crew included a visual observation team scanning for marine mammals and sea turtles, an additional observer collecting data on avian sightings, and a passive acoustic team monitoring a towed hydrophone array. New technologies that were tested on this survey included: a prototype tetrahedral passive acoustic array to conduct 3-D localization of vocalizing animals, drifting autonomous recording buoys with suspended hydrophone arrays, and a deep-water passive acoustic mooring deployed in water depths over 2000 m. Additionally, water samples were collected to conduct baseline testing of the efficacy of environmental DNA (eDNA) as a sampling tool within the vicinity of known cetacean groups. Approximately 3900 km were surveyed by the marine mammal visual team; passive acoustic data were collected over an additional 570 km. CTD data were collected at 8 stations, with bongo sampling conducted at 5 stations to assess the presence of larval bluefin tuna (*Thunnus thynnus*), and water samples collected at 3 stations to test for cetacean eDNA at depths up to 1500 m. Fifteen paired water samples were collected from the vicinity of 3 species of cetacean groups for eDNA testing. Seven biopsies were collected; four from True's beaked whales and 3 from other species. Focal follow data were collected for approximately 10 different True's beaked whale groups. One digital acoustic recording tag (DTAG) was deployed on a True's beaked whale for approximately 13 hrs, during which time data were recorded from 9 foraging dives.

The North Atlantic Right Whale Sighting Survey (NARWSS) is a NOAA Fisheries program which locates and records the seasonal distribution of North Atlantic right whales off the northeastern coast of the United States. Images of individual whales are also collected for mark-recapture models to monitor the population. NARWSS flights conducted in 2018 followed systematic tracklines within these survey areas: Atlantis Canyon, Backside of Cape Cod, Coastal Maine, Franklin Basin, Georges Basin, Great South Channel, Howell Swell, Jeffreys Ledge, Jordan Basin, Long Island, Martha's Vineyard and Nantucket, New Jersey, Race Point, Rhode Island Sound, Stellwagen Bank, and Wilkinson Basin. During 2018, NARWSS flew 220 hours over 43 surveys. NARWSS detected 680 right whales (including duplicate sightings of the same individual), with 617 right whales sighted within survey blocks and 63 right whales sighted during transit to or from survey areas.

Right whales were again persistent in southern New England waters during the late winter, mostly south of Martha's Vineyard and Nantucket. These waters are difficult to access and no vessel trips were attempted successfully. Record numbers of right whales populated Cape Cod Bay (CCB) early during the last weeks of February, when a NEFSC research vessel was able to work in the Bay. The weather during March was not conducive to small vessel work, and no attempts were made until late in the month. In April, whales persisted in record numbers with 145 individuals seen in one day by one aerial survey. NEFSC small boat crew were able to sail in CCB on 13 days from February 24th to May 1, 2019. All right whales encountered were photographed for the North Atlantic Right Whale catalog. Additionally, thirteen biopsy samples were collected from right whales that had never previously been sampled. The DNA in right whale skin can be used to determine sex, and to create a genetic "fingerprint" for future re-identification. This is very important for estimating calf survival rates. When calves are not photographed well at 8 or 9 months of age, when they are still with their mothers, matching young juveniles to these calves over the next few years is near impossible. The shift in summer habitat use by right whales has hindered the photographic capture of young during this vital stage (stable callosity pattern while still with their mother). Therefore, without genetic sampling to make the link between unknown juveniles with their mother, survival information is lost. During these spring trips, sei whale genetic samples were collected and photographs taken. We hope to investigate stocks of sei whales in our local waters.

The North Atlantic Right Whale Sighting Survey (NARWSS) is a NOAA Fisheries program which locates and records the seasonal distribution of North Atlantic right whales off the northeastern coast of the United States. Images of individual whales are also collected for mark-recapture models to monitor the population. NARWSS flights conducted in 2018 followed systematic tracklines within these survey areas: Atlantis Canyon, Backside of Cape Cod, Coastal Maine, Franklin Basin, Georges Basin, Great South Channel, Howell Swell,

Jeffreys Ledge, Jordan Basin, Long Island, Martha's Vineyard and Nantucket, New Jersey, Race Point, Rhode Island Sound, Stellwagen Bank, and Wilkinson Basin. During 2018, NARWSS flew 220 hours over 43 surveys. NARWSS detected 680 right whales (including duplicate sightings of the same individual), with 617 right whales sighted within survey blocks and 63 right whales sighted during transit to or from survey areas.

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 2018 included gill nets, otter trawls, mid-water otter trawls, mid-water pair trawls, scallop trawls, scallop dredges, purse seines, and some pot and traps. Cetaceans observed taken included harbor porpoises, short-beaked common dolphins, and bottlenose dolphins (*Tursiops truncatus*). To support Atlantic Take Reduction Teams (e.g., harbor porpoise and Atlantic trawl teams), the observer data were analyzed to identify environmental factors, fishing practices, and gear characteristics associated with the bycatches.

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

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

Cetacean acoustics:

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

In June/July 2018, 8 high-frequency recording packages (HARPs) were recovered and redeployed along the U.S. east coast shelf break, from the waters off New England to Georgia. These units will record continuously for approximately one year. Additionally, the final deployments of Marine Autonomous Recording Units (MARUs) along the continental shelf were conducted at three sites (off Massachusetts, North Carolina and Georgia). These deployments conclude a multi-year effort aimed at monitoring migratory movements of baleen whales along the U.S. eastern seaboard. Acoustic recorders were also deployed seasonally in four National Marine Sanctuaries (Stellwagen Bank, Gray's Reef, Florida Keys, and Flower Garden Banks), as part of a collaborative effort to evaluate sanctuary soundscapes. Long-term NOAA Noise Reference Station recorders continue to collect data in the Stellwagen Bank National Marine Sanctuary and offshore of Georges Bank. In collaboration with colleagues at the Woods Hole Oceanographic Institution, gliders were deployed in the Gulf of Maine, as was a real-time monitoring buoy; a real-time monitoring buoy is active in the New York Bight. These projects are aimed at evaluating the efficacy of using real-time information about baleen whale presence for management and mitigation; results from these projects can be found at http://dcs.whoi.edu/. Towed hydrophone array data were collected in conjunction with an AMAPPS cetacean ecology shipboard survey in July and August. Over 450h of array data resulted in the real-time detection and tracking of multiple species of beaked whales.

Archival acoustic data from 2006 to present continue to be analyzed for baleen whale presence, including right, fin, sei, blue, minke and humpback whales. Several manuscripts were published, including one on the effects of vessel noise on the communication space of baleen whales in Massachusetts Bay, and another describing the echolocation click characteristics of True's beaked whales. A manuscript on the Caribbean Humpback Acoustic Monitoring Program (CHAMP) was submitted for peer review. A number of additional manuscripts involving colleagues from the Passive Acoustics Group were published in 2018 see our website for more details (https://www.nefsc.noaa.gov/psb/acoustics/psbAcousticPubs.html).

Pinnipeds:

In 2018, the NEFSC conducted unmanned aerial flights of gray seal (*Halichoerus grypus*) pupping colonies on Muskeget Island, Massachusetts, in order to age pups and test infra-red camera technology. A full survey of the colony to count pups and adults was not accomplished due to weather conditions at the time of the survey. The NEFSC also conducted unmanned surveys over other haul-out sites on Cape Cod to monitor entanglement rates. 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, Atlantic Marine Conservation Society, Tufts University, Marine Mammals of Maine, the University of New England, the Woods Hole Oceanographic Institution, and the University of Connecticut. Close to 100 gray seal pups were captured, sampled, and flipper-tagged; a portion were also tagged with satellite and acoustic tags. This project contributed to Tuft's work on influenza in migratory wild populations, as well as movements of seals in relation to predatory white sharks (in collaboration with the Massachusetts Division of Marine Fisheries).

In June 2018, NOAA declared an Unusual Mortality Event (UME) in response to an elevated number of harbor and gray seal strandings throughout Maine, New Hampshire, and Massachusetts, which has since been associated with phocine distemper virus (PDV). The NEFSC contracted aerial surveys in late 2018 to survey the region to measure the geographic scope of the outbreak and possible impacts to the harbor and gray seal population.

Work continued in 2018 to study pinniped diet from fatty acids in blubber (predator) and various fish (prey) samples, in collaboration with researchers at University of Dalhousie, Canada, as well as from stomach content analysis of bycaught harbor and gray seals. In addition, a pilot study began in 2018 to investigate whether eDNA could be extracted from pinniped scat and stomachs to identify prey remains.

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

g) Turtles

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

From 06 July 6–19 July 2017, the NEFSC and partners conducted a Cetacean and Turtle cruise aboard the NOAA Ship R/V Henry B. Bigelow. This survey occurred in shelf and shelf break waters off of the Northeast United States and Canada. The southwestern extent was the shelf waters off of New Jersey and the northeastern extent was Canadian waters near the Northeast Channel. The cruise accomplished objectives related to loggerhead sea turtle ecology, maintenance (exchange) of fixed acoustic recording devices, and zooplankton, turtle, and cetacean distribution. We deployed 5 satellite related data loggers to collect information on loggerhead sea turtles. We retrieved and re-deployed acoustic devices at three locations. We collected temperature, depth, and salinity, and documented the distribution of zooplankton, turtles, and cetaceans. Throughout the cruise, we documented 2521 animals across 25 taxonomic groups.

In 2018 the NEFSC conducted research related to turtle bycatch assessment. This included estimating turtle mortality rates in commercial gears using serious injury guidelines. The NEFSC also continues to develop quantitative methods for assessing anthropogenic threats to sea turtles.

In 2018, the NEFSC in collaboration with the SEFSC (Nick Hopkins) conducted two gear-related projects investigating methods to reduce sea turtle bycatch in fishing gear. The first was a comparative study of a cable-sorting grid to reduce turtle bycatch in the summer flounder fishery. Previous studies comparing catch rates of Turtle Excluder Device (TED)-equipped trawls and standard flatfish trawls found an average of 25-30% loss in targeted summer flounder (*Paralichthys dentatus*) catch in the TED equipped trawl. In 2017, we did a full study of the NETIII (a type of cable grid) system in the most successful configuration from 2016 using a twin trawl out of Point Judith, RI. The vessel was able to complete 49-paired tows. The results, which were highly significant, showed that the NETIII Cable TED reduced that catch of the targeted summer flounder by almost 53% and reduced the targeted skate catch by almost 42%.. In 2018, we made changes to this design and retested using the same vessel and methodology as in 2017. We were able to accomplish 47-paired tows. The targeted fluke loss was approximately 49% and the skate loss was approximately 20%. These results further suggest that the TIII cable TED design in this configuration was unsuccessful at maintaining the targeted catch

The other study was another comparative cable TED study in the longfin inshore squid (*Loligo pealeii*) fishery. The cable TED [TI] tested is similar to a cable TED successfully tested in the croaker fishery. This work occurred in the southern New England waters in October of 2018 and matched work done in 2017 but tested a slight modification to the design used in 2017. The vessel was able to complete 30-paired tows. Results from this work, using a twin trawl configuration, showed that the cable equipped TED net did not effect the catch of the targeted longfin squid compared to an identical net without the cable TED attached. Additionally, the finfish bycatch, which was higher in the cable TED equipped trawl in 2017 was reduced so that it was also similar to the non- cable TED equipped trawl. Reports on PSB gear projects are located at: http://www.nefsc.noaa.gov/read/protspp/PR_gear_research/.

3. Studies of Fishing Operations

In 2018, NEFSC Observers were deployed on 3,958 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 226 marine mammal incidental takes, 20 sea turtle incidental takes, and 186 seabird incidental takes. For most of these animals, the information recorded included animal condition, length and other relevant body measurements, as well as species identification characteristics. Tissue samples were also collected from many of these animals, and entire animals were retained if possible.

In addition, the Northeast Fisheries Observer Program deployed At-Sea Monitors on 351 trips aboard commercial fishing vessels in 2018. On these trips there were eight marine mammal and eight seabird incidental takes documented.

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

In the sink anchored gillnet fishery, 897 trips were observed with a total of 3,629 gear retrievals by Observers. There were 167 observed marine mammal takes in this fishery (101 gray seals, 20 harbor seals, 17 unidentified seals, 11 common dolphins, nine harbor porpoises, four unidentified dolphins, two harp seals, one bottlenose dolphin, one unidentified porpoise/dolphin and one unidentified marine mammal). There were also four loggerhead turtles, one green turtle, one unidentified hard-shell turtle and 82 seabird takes observed in this fishery.

At-Sea Monitors observed 75 trips in the sink anchored gillnet fishery with 300 gear retrievals. There were seven marine mammal (five harbor seals and 2 gray seals) and six seabird incidental takes recorded in this fishery by Monitors.

b. Float Drift Gillnet Fishery

There were 48 floating drift gillnet trips with 173 gear retrievals observed in 2018. There were no marine mammal, sea turtle or seabird incidental takes observed.

No Monitors deployed on float drift gillnet trips in 2018.

c. Otter Trawl Fisheries

In the bottom otter trawl fishery 1,871 trips were observed with a total of 11,171 gear retrievals recorded by Observers. In addition, there were 12 midwater trawl trips with 11 gear retrievals, seven scallop trawl trips with 29 gear retrievals, one shrimp bottom otter trawl trip with three gear retrievals, 23 twin trawl trips with 279 gear retrievals, five haddock separator trawl trips with 131 gear retrievals and one Ruhle trawl trip with 11 gear retrievals observed in 2018.

In the bottom otter trawl fishery, there were 53 observed marine mammal takes (38 common dolphins, 12 gray seals, one bottlenose dolphin, one harbor seal and one unidentified seal). There were also seven loggerhead turtles, one Kemp's ridley turtle, one leatherback turtle and 25 seabird takes in this fishery. There were was one gray seal incidental take observed in the mid-water trawl fishery and three common dolphins in the twin trawl fishery. There were no incidental takes observed on scallop trawl, shrimp bottom otter trawl, haddock separator trawl, Ruhle trawl or large mesh belly panel trawl trips in 2018.

At-Sea Monitors deployed on 265 bottom otter trawl trips with 2,075 gear retrievals, two haddock separator trawl trips with 101 gear retrievals, two Ruhle trawl trips with seven gear retrievals and no twin trawl trips in 2018. There were one common dolphin and two seabird takes recorded by Monitors in the bottom otter trawl fishery. There were no incidental takes documented by Monitors on either the haddock separator trawl or twin trawl trips in 2018.

d. Sea Scallop Dredge Fishery

In the sea scallop dredge fishery, 603 trips were observed with a total of 29,879 gear retrievals. There were two loggerhead turtles and 64 seabird takes observed in this fishery.

No Monitors deployed in the scallop dredge fishery in 2018.

e. Scottish Seine Fishery

No Scottish seine trips were covered by Observers or Monitors in 2018.

f. Drift Sink Gillnet Fishery

In the drift sink gillnet fishery in 2018, Observers were deployed on 168 trips with a total of 1,075 gear retrievals. There were one bottlenose dolphin, three Kemp's ridley turtles and five seabird takes in this fishery.

Monitors did not deploy on any drift sink gillnet trips in 2018.

g. Anchored Floating Gillnet Fishery

There were 23 anchored floating gillnet trips with 66 gear retrievals observed in 2018. There were no marine mammal, sea turtle takes observed but there were three seabird takes observed in this fishery.

No Monitors deployed on anchored floating gillnet trips in 2018.

h. Mid-water Pair Trawl Fishery

In 2018, there were 12 mid-water pair trawl trips observed with a total of 30 gear retrievals. There were no marine mammal or sea turtle takes observed in this fishery. There were seven northern gannets documented.

No Monitors deployed on mid-water pair trawl trips in 2018.

i. Bottom Longline Fishery

In the bottom longline fishery in 2018 there were 66 trips observed with a total of 336 gear retrievals. There were no marine mammal, sea turtle or seabird takes observed in the bottom longline fishery.

At-Sea Monitors covered a total of six bottom longline trips with 22 gear retrievals in 2018. 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 2018.

k. Pound Net Fishery

No pound net trips were covered by Observers or Monitors in 2018.

l. Handline/Trolling Fisheries

In 2018, there were 56 handline trips and 501 gear retrievals, two auto-jig handline trips and 16 gear retrievals, and six troll line trips with 34 gear retrievals observed. No marine mammals, sea turtles or seabirds were taken in these fisheries.

Monitors covered one handline trip with 12 gear retrievals and no auto-jig handline or troll line trips in 2018. There were no documented takes in these fisheries in 2018.

m. Herring Purse Seine Fishery

In 2018, there were 16 herring purse seine trips with 22 gear retrievals observed. There was one gray seal take observed but no sea turtle or seabird takes observed.

No herring purse seine trips were covered by Monitors in 2018.

n. Menhaden Purse Seine Fishery

No menhaden purse seine trips were covered by Observers or Monitors in 2018.

o. Tuna Purse Seine Fishery

No tuna purse seine trips were covered by Observers or Monitors in 2018.

p. Pot / Trap Fisheries

In 2018, there were 27 lobster pot trips with 547 gear retrievals, 24 fish pot trips with 191 gear retrievals, 21 conch pot trips with 237 gear retrievals and 17 crab pot trips with 276 gear retrievals. There were no hagfish pot or blue crab trap or whelk pot trips observed. There were no marine mammal, sea turtle or seabird takes in these fisheries.

No lobster, fish, conch, hagfish, crab, blue crab or whelk pot trips were covered by Monitors in 2018.

q. Beam Trawl Fisheries

No beam trawl trips covered by Observers or Monitors in 2018.

r. Clam Dredge Fishery

There were 47 clam dredge trips with 2,661 gear retrievals observed in 2018. No marine mammals, sea turtles or seabirds were documented in 2018.

s. Other Dredge Fisheries

Four crab dredge trips with 45 gear retrievals were covered by Observers in 2018 with no incidental takes in this fishery. No horseshoe crab dredge trips were covered.

No other dredge trips were covered by Monitors in 2018.

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 2018 included Atlantic sea scallop, Atlantic herring, summer flounder and striped bass.

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 2018, stock assessments conducted and reviewed through the TRAC process included Eastern Georges Bank cod, Eastern Georges Bank haddock, and Georges Bank yellowtail flounder. Other stock assessments or data updates in 2018 vetted in regional bodies included summer flounder, bluefish, spiny dogfish, butterfish, Loligo and Illex squids, skates, scup, surf clam, and golden tilefish.

A benchmark sea scallop assessment was developed and reviewed in 2018. The most notable innovation was estimation of juvenile natural mortality in the Mid-Atlantic CASA stock assessment model, and estimation of natural mortality of all sizes in the Georges Bank Closed Area model. Results indicated that juvenile natural mortality in the Mid-Atlantic was variable, and that increased natural mortality was associated with large year classes, suggesting that it is density-dependent. In the Georges Bank Closed Areas, natural mortality was fairly steady at about M=0.2 except for a spike during 2010-2013, with a maximum of about 0.45 in 2011. As fishing mortality has declined, natural mortality has a stronger influence on population dynamics. The 2018 benchmark made significant progress to better understanding of this uncertain but important quantity.

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 2018 focused on (1) monitoring the importance of diadromous fishes as prey for nearshore Gulf of Maine groundfish species; (2) modeling the impacts of hydroelectric facilities on diadromous fish productivity; (3) optimizing stocking dates of age 1 hatchery smolts (4) monitoring of fishery removals on the high seas; and (5) describing the ecosystem processes through active techniques (multi-frequency split-beam hydroacoustics), 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.

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 restoration programs for these species. The second year of a two-year acoustic telemetry investigation was undertaken on the Narraguagus River to describe differences in survival between stock groups of age 1 hatchery smolts to evaluate performance through river, estuary and bay environments. Defining this relationship will help to inform hatchery managers to optimize time of stocking to improve survival into the GoM for these restoration smolts. Monitoring the West Greenland fishery and collecting biological data and fishery statistics continued. These data are provided directly to ICES and are required for North American run-reconstruction modeling and for developing catch advice for the fishery. Finally, estuary surveys have described seasonal (and annual) patters in fish distribution coincident with up-river restoration activities. 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

Fishery Independent Data Research and Development

Support for NEFSC Apex Predator COASTSPAN Shark Survey, Tagging, and Research

The NEFSC Apex Predator Program's Cooperative Atlantic States Shark Pupping and Nursery (COASTSPAN) Program surveys and monitors shark nursery habitat in nearshore waters along the U.S. Atlantic coast using federal, state, university, and commercial platforms. COASTSPAN surveys help determine the relative abundance, distribution, and migrations of sharks using coastal nursery habitat through longline and gillnet sampling and mark-recapture data. The Cooperative Research Program provided support for the Delaware Bay COASTSPAN survey in June, July, and August of 2018. The Delaware Bay survey uses two types of longline gear; one with small hooks that target juvenile sandbar sharks that are using the Bay as nursery habitat. This gear is set in a random stratified pattern by depth and geographic location throughout the Bay. The second gear uses larger hooks to target sand tigers at fixed locations such as wrecks and sharp changes in bathymetry where channels meet shoal areas. COASTSPAN data are also used to define and update Essential Fish Habitat (EFH) designations for multiple shark species. This data led to the designation of Delaware Bay as a Habitat Area of Particular Concern for juvenile sandbar sharks and all life stages of sand tigers. Additionally, the juvenile longline survey in Delaware Bay provides an important recruitment index for the Highly Migratory Species (HMS) stock assessment of the U.S. Atlantic sandbar shark population. Delaware Bay continues to provide important nursery habitat for sandbar sharks, smooth dogfish and sand tigers. The extensive use of the Bay by all life stages of sand tigers and smooth dogfish continues to highlight the seasonal importance of this essential shark habitat. Results from this survey were provided to the

NMFS HMS Management Division in 2018 for use in updating the EFH section of the annual Stock Assessment and Fisheries Evaluation (SAFE) Report.

Industry-Based Gulf of Maine Bottom Longline Survey

During 2018 staff from the NEFSC Cooperative Research Branch completed the Gulf of Maine bottom longline survey (LLS) started in 2014. This survey was started in an effort to provide additional sampling in rocky hard-bottom habitats and address concerns for some data poor species. The survey covers from the banks and ledges in the western Gulf of Maine across the Gulf to the US/Canada boundary. This includes all or portions of bottom trawl offshore survey strata 26-29, 36-37, and is further sub-stratified into smooth and rough bottom. The survey uses tub-trawl bottom longline gear similar to that used by commercial fishermen for groundfish. The biannual survey was conducted in 2017 completing 45 stations in both spring (April-May) and fall (Oct-Nov) with a total of 32 days at sea on two chartered commercial vessels. A total of 19,139 lengths were measured representing 20,230 individual organisms. Biological sampling of 2,354 organisms for samples such as age and maturity were collected, as well as tagging and other samples to support both NEFSC research studies and external investigators. The data collected on this survey will be used to support stock assessments, ecosystem and habitat studies, and management decisions for a range of fish, skates, and other species in the Gulf of Maine, and particularly beneficial for several data poor species.

Genomics-related research

A review of genomics-related research at the Northeast Fisheries Science Center (NEFSC) during 2018 compiled a diverse array of projects by investigators at all of the Center's location from New Jersey to Maine, including:

- Application of species-specific probes, Sanger and Next Generation sequencing for identifying stomach contents of marine invertebrates, fish, birds, and mammals
- Species identification from microorganisms, zooplankton, and ichthyoplankton.
- Population structure of marine fish and mammals
- Using eDNA for surveillance of aquatic pathogens and ichthyofaunal composition in estuaries
- Laboratory experiments to investigate eDNA shedding and decay rates
- Development of an eDNA toolkit for identifying diadromous fishes.

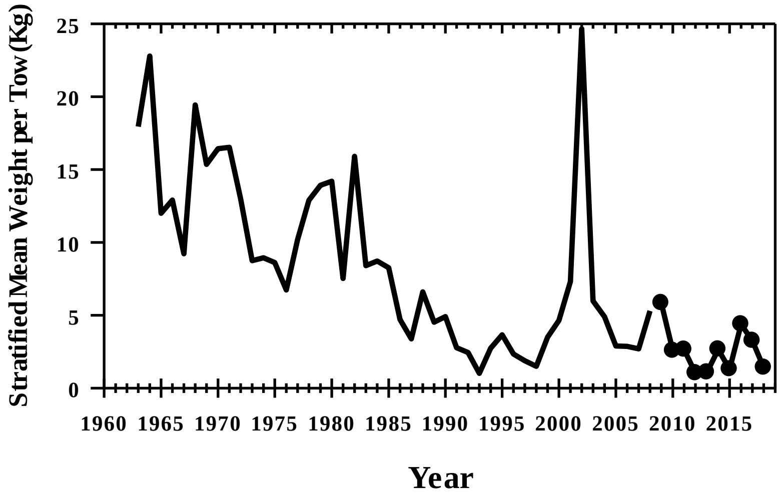

Figure 1. NEFSC autumn bottom trawl survey biomass indices for Gulf of Maine cod.

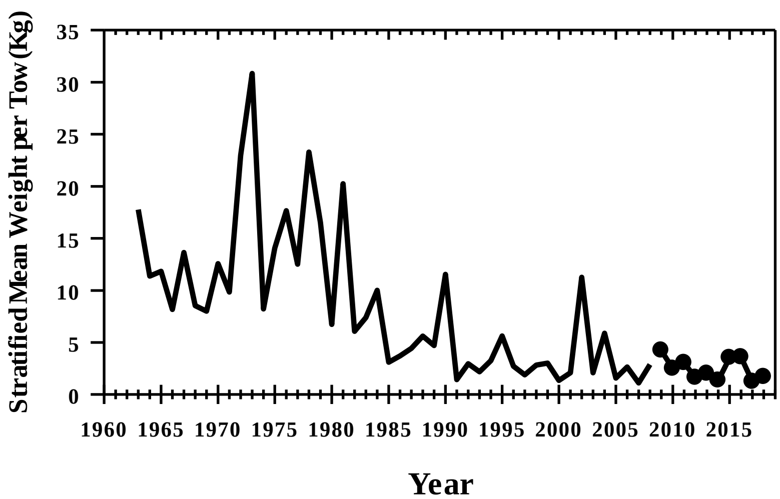

Figure 2. NEFSC autumn bottom trawl survey biomass indices for Georges Bank cod.

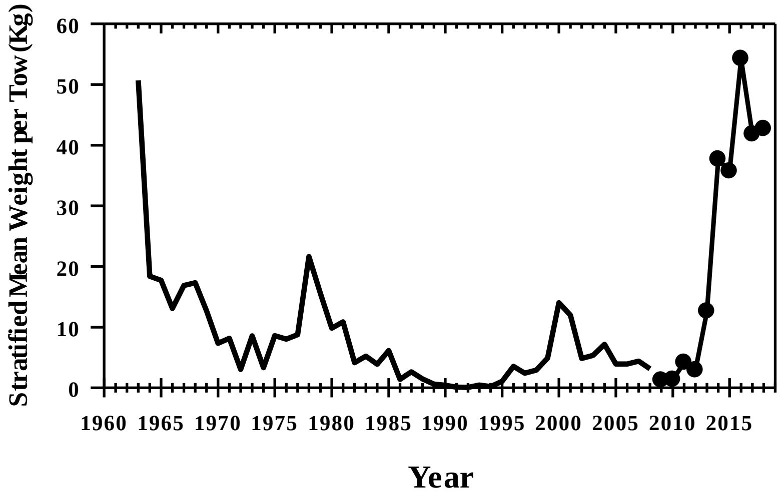

Figure 3. NEFSC autumn bottom trawl survey biomass indices for Gulf of Maine haddock.

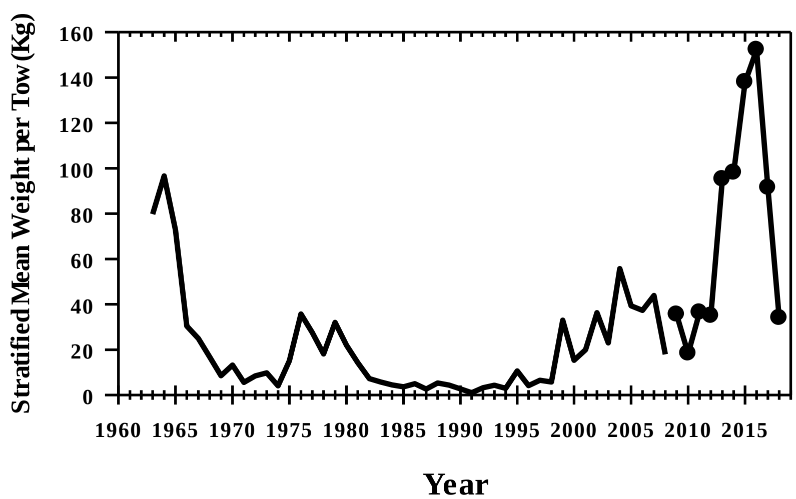

Figure 4. NEFSC autumn bottom trawl survey biomass indices for Georges Bank haddock.

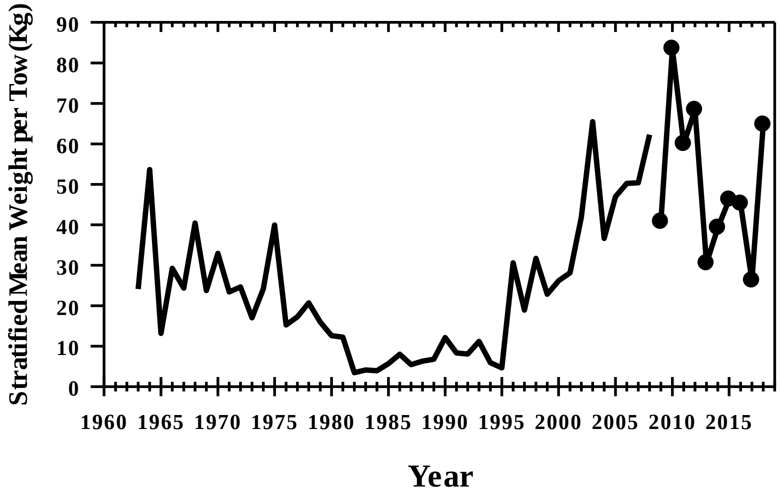

Figure 5. NEFSC autumn bottom trawl survey biomass indices for Acadian redfish.

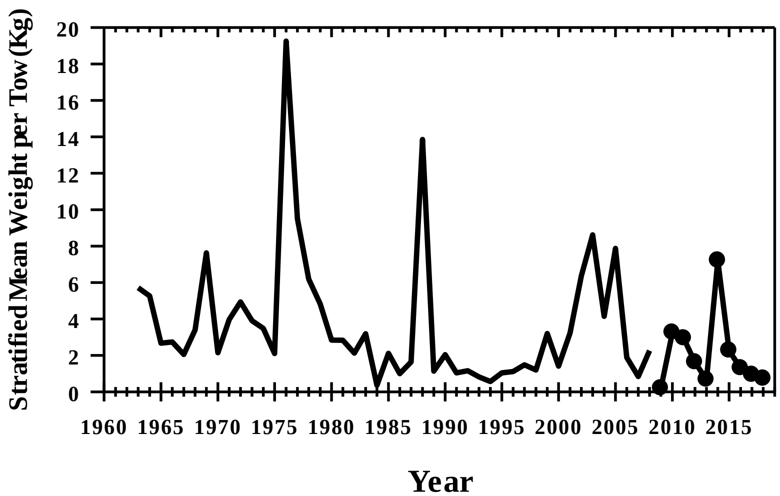

Figure 6. NEFSC autumn bottom trawl survey biomass indices for pollock.

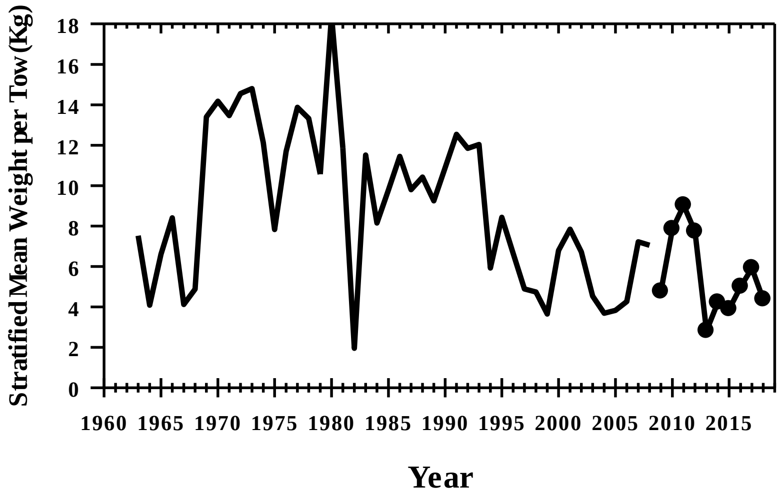

Figure 7. NEFSC autumn bottom trawl survey biomass indices for white hake.

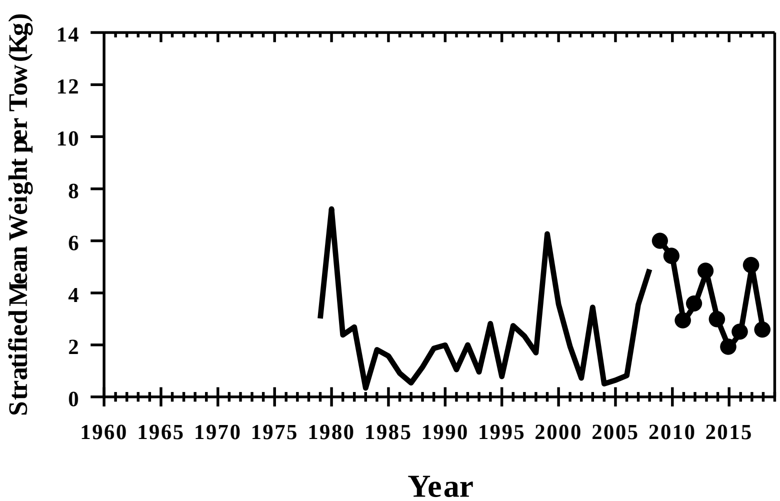

Figure 8. NEFSC autumn bottom trawl survey biomass indices for Cape Cod-Gulf of Maine yellowtail flounder.

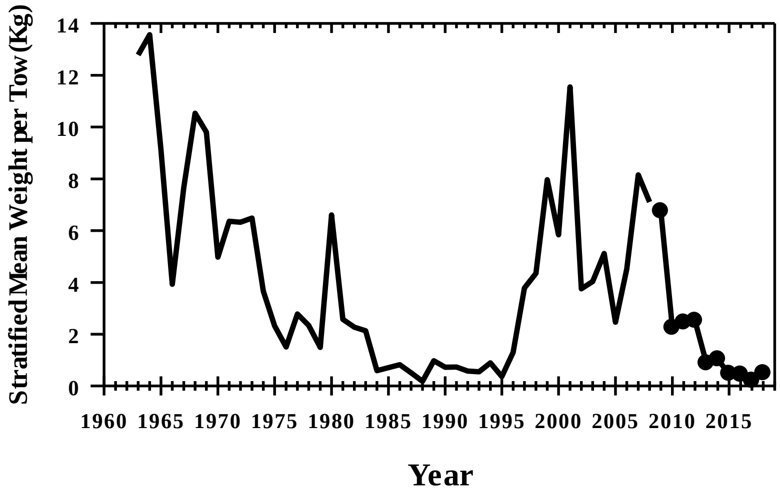

Figure 9. NEFSC autumn bottom trawl survey biomass indices for Georges Bank yellowtail flounder.

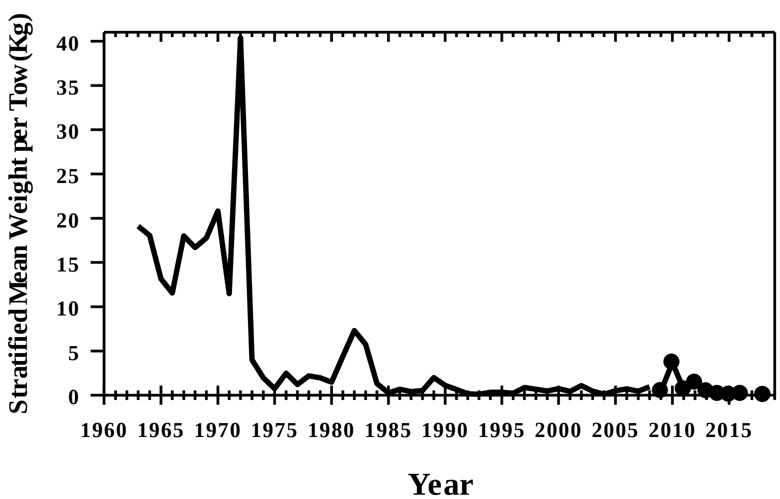

Figure 10. NEFSC autumn bottom trawl survey biomass indices for Southern New England-Mid-Atlantic yellowtail flounder.

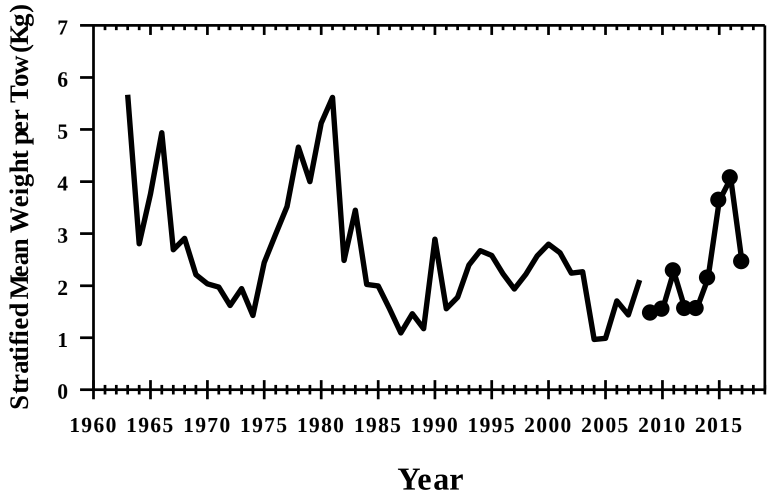

Figure 11. NEFSC autumn bottom trawl survey biomass indices for American plaice.

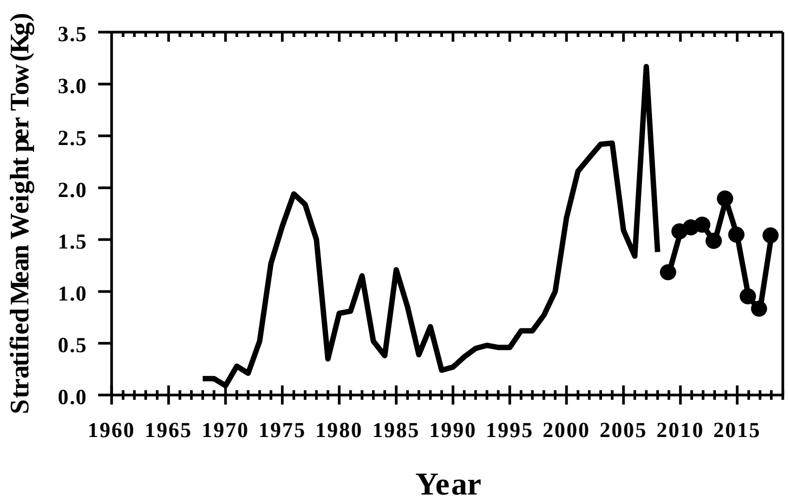

Figure 12. NEFSC spring bottom trawl survey biomass indices for summer flounder.

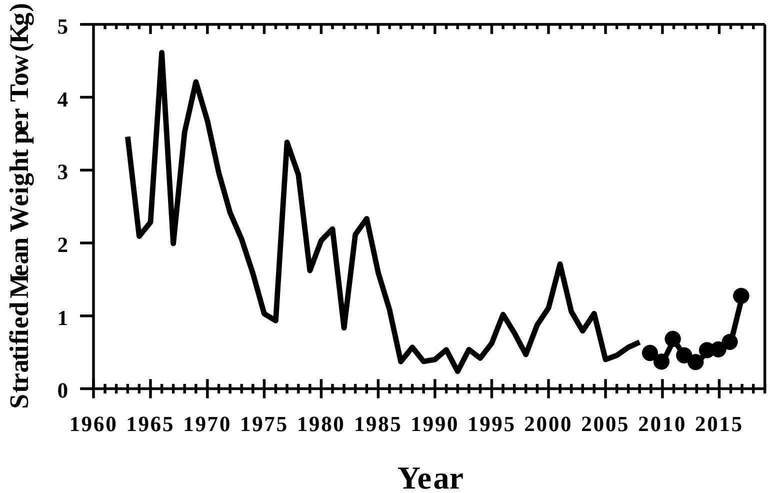

Figure 13. NEFSC autumn bottom trawl survey biomass indices for witch flounder.

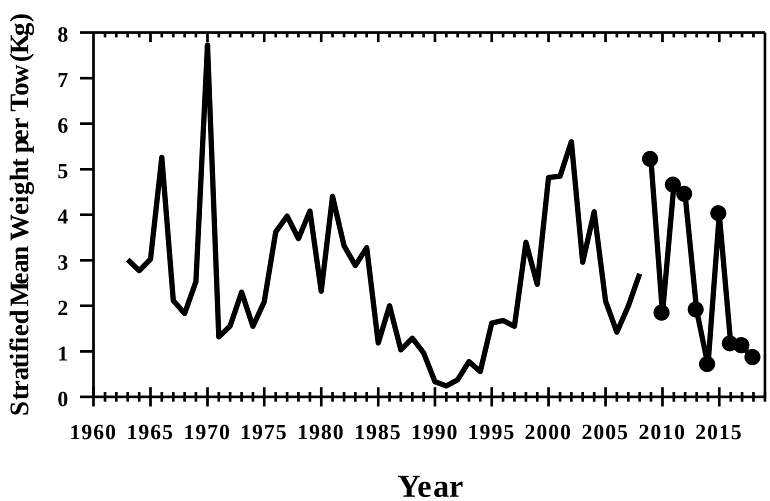

Figure 14. NEFSC autumn bottom trawl survey biomass indices for Georges Bank winter flounder.

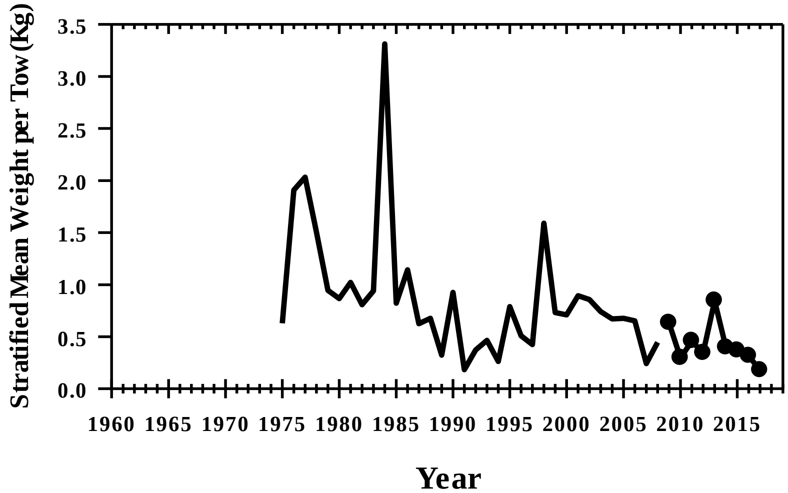

Figure 15. NEFSC autumn bottom trawl survey biomass indices for northern windowpane flounder.

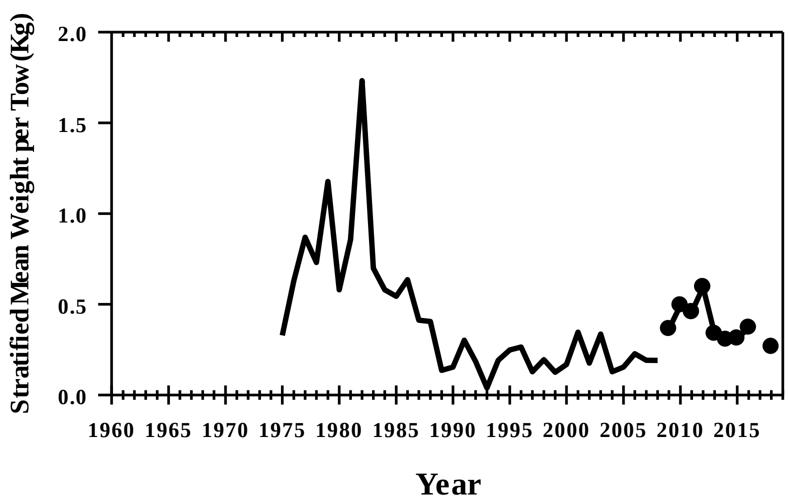

Figure 16. NEFSC autumn bottom trawl survey biomass indices for southern windowpane flounder.

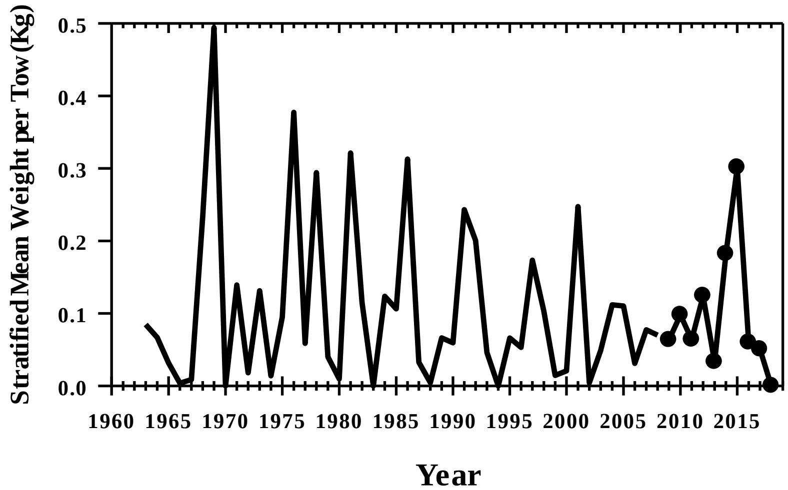

Figure 17. NEFSC autumn bottom trawl survey biomass indices for Atlantic halibut.

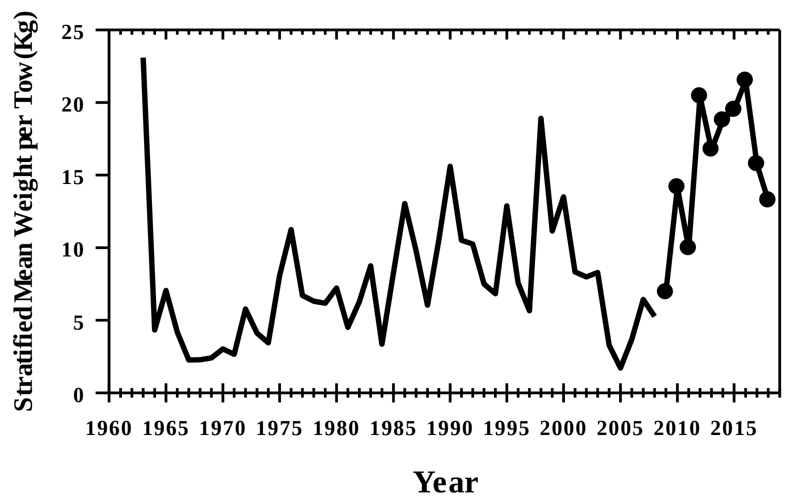

Figure 18. NEFSC autumn bottom trawl survey biomass indices for northern silver hake.

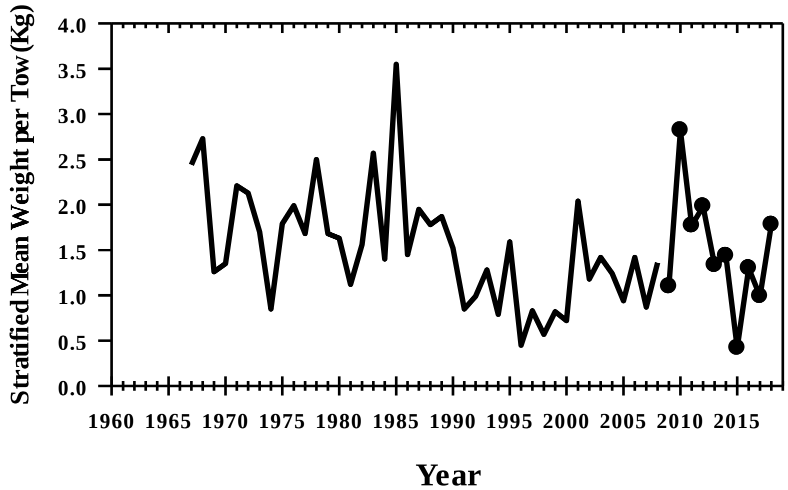

Figure 19. NEFSC autumn bottom trawl survey biomass indices for southern silver hake.

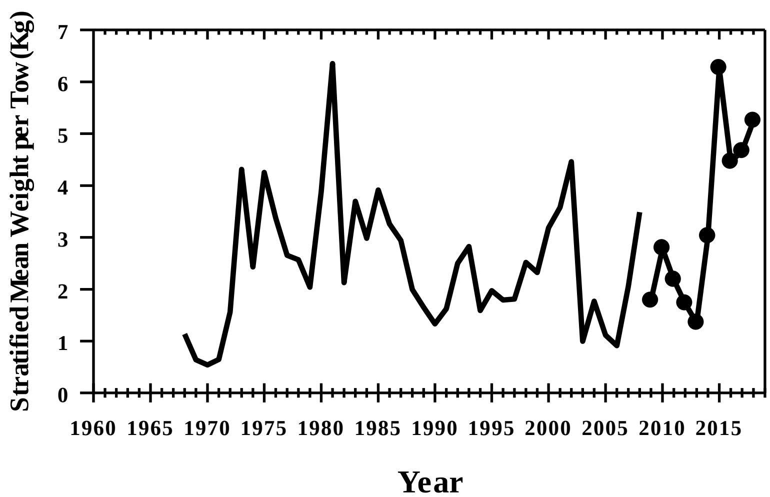

Figure 20. NEFSC spring bottom trawl survey biomass indices for northern red hake.

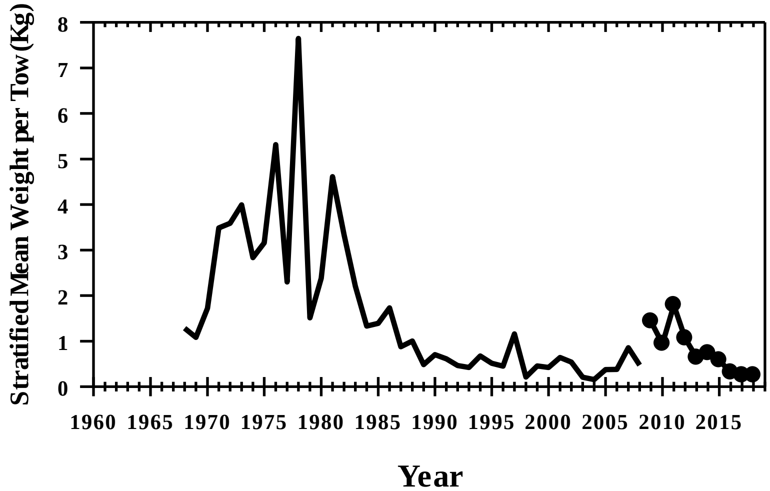

Figure 21. NEFSC spring bottom trawl survey biomass indices for southern red hake.

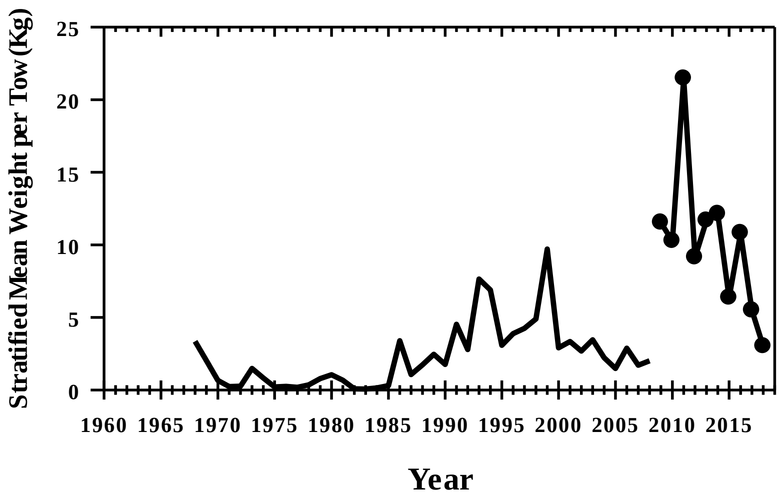

Figure 22. NEFSC spring bottom trawl survey biomass indices for Atlantic herring. Data from 2009-2018 have not been calibrated to the earlier time series.

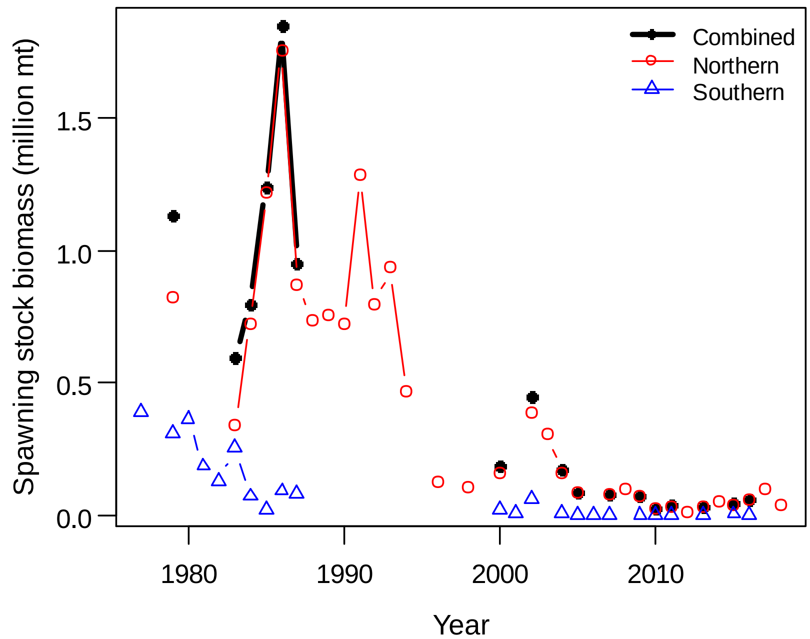

Figure 23. Atlantic mackerel spawning stock biomass index (millions metric tons) calculated using the total egg production method, based on egg densities observed in the southern Gulf of St. Lawrence (northern contingent) and the Northeast U.S. Continental Shelf (southern contingent). The combined SSB index represents the sum of northern and southern contingents and was only calculated in years where indices from both contingents were available. For the years since the last U.S. assessment (2017-2018), only index values from the northern contingent were available.

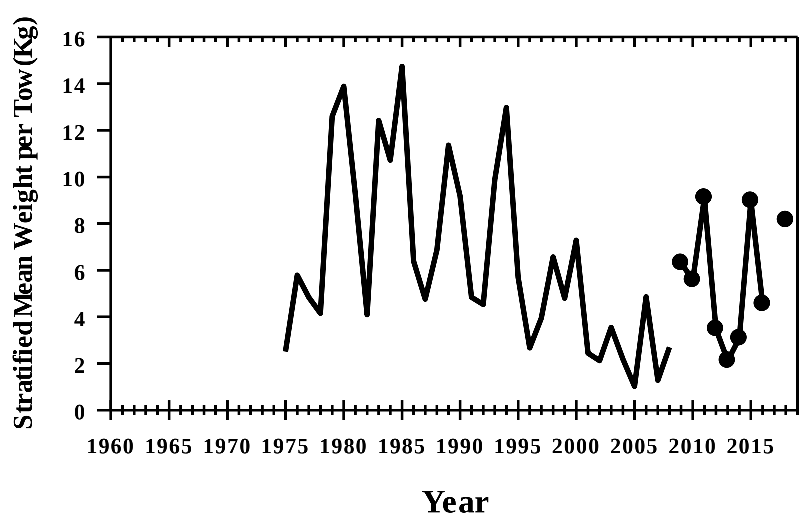

Figure 24. NEFSC autumn bottom trawl survey biomass indices for butterfish.

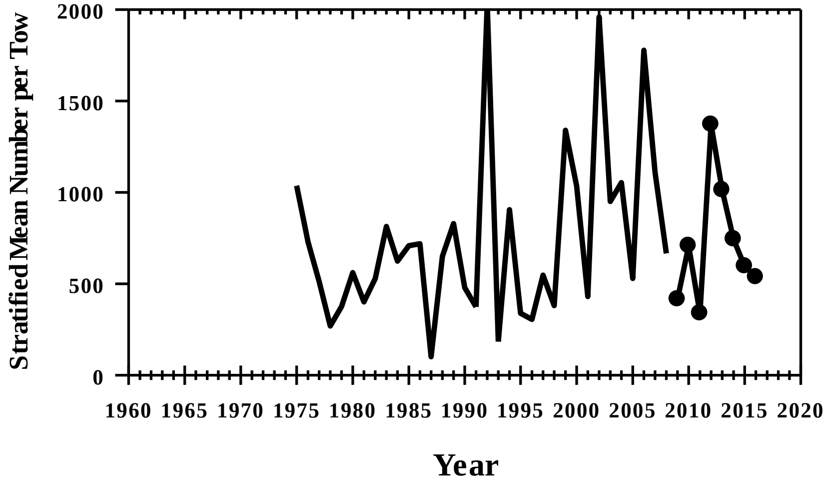

Figure 25. NEFSC autumn bottom trawl survey abundance indices for longfin inshore squid.

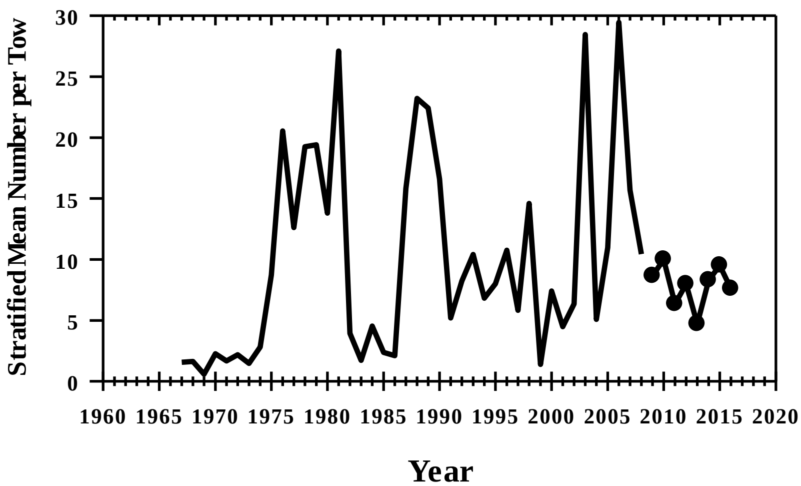

Figure 26. NEFSC autumn bottom trawl survey abundance indices for northern shortfin squid.

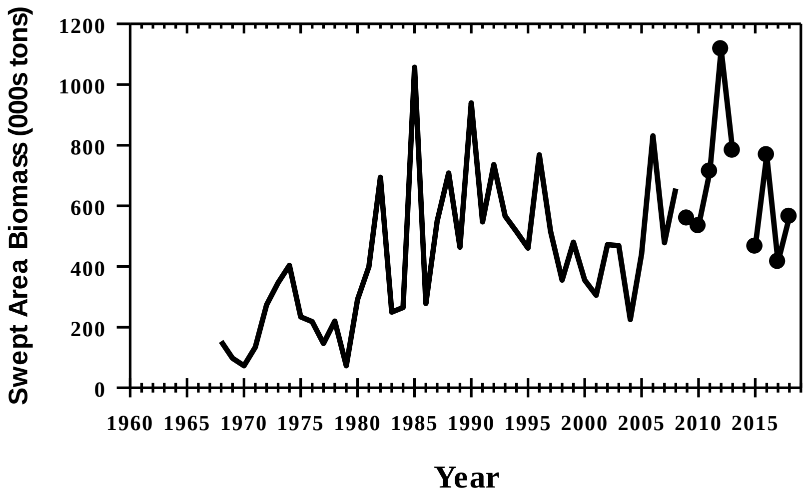

Figure 27. NEFSC spring bottom trawl survey biomass indices for spiny dogfish.

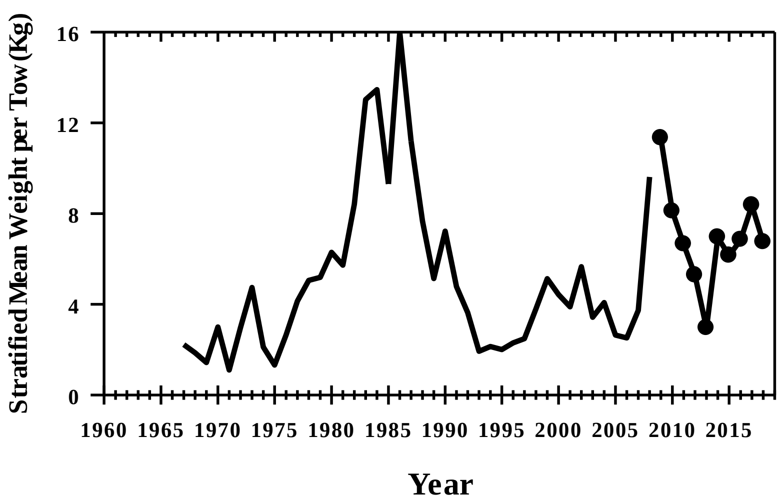

Figure 28. NEFSC autumn bottom trawl survey biomass indices for winter skate.

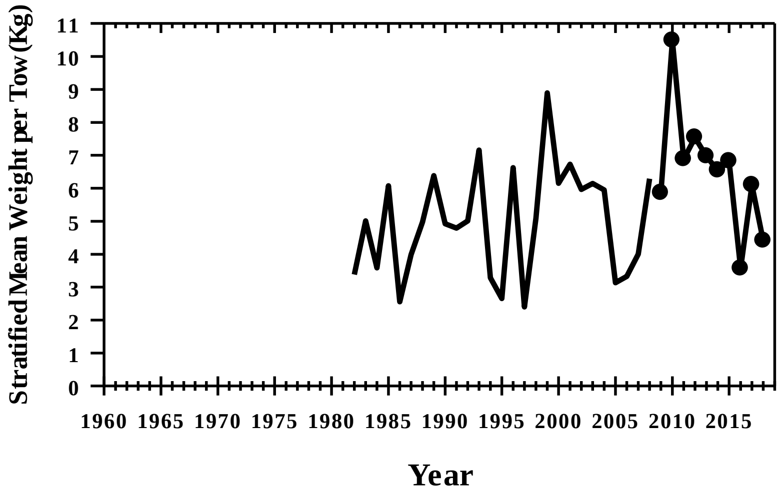

Figure 29. NEFSC spring bottom trawl survey biomass indices for little skate.

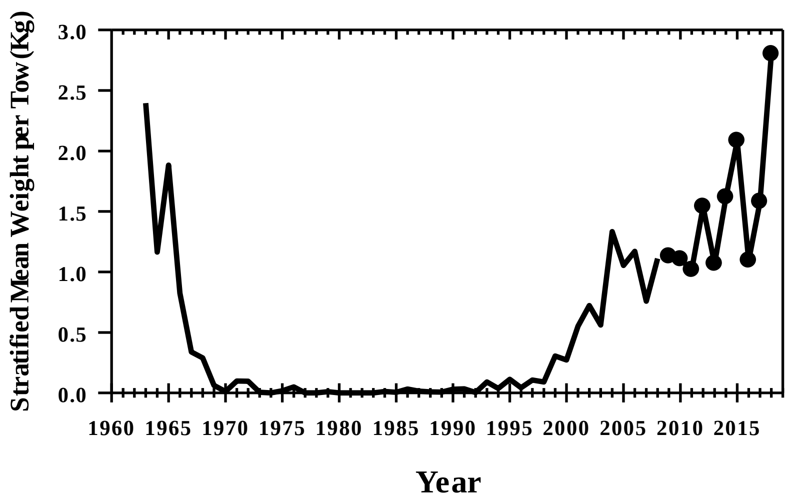

Figure 30. NEFSC autumn bottom trawl survey biomass indices for barndoor skate.

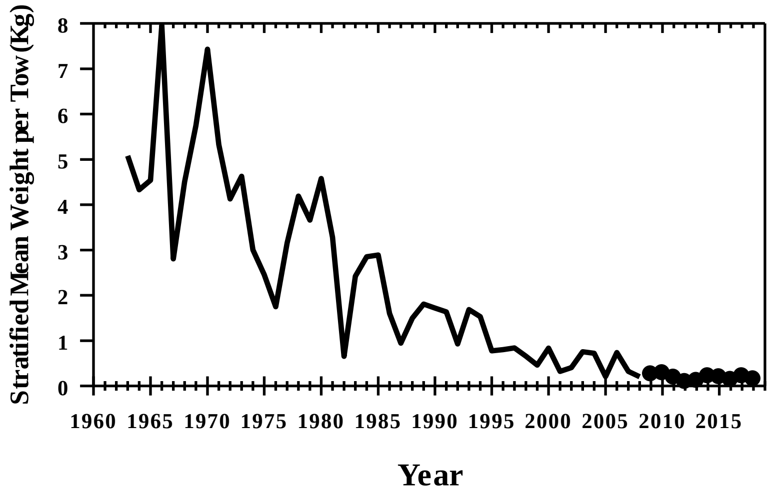

Figure 31. NEFSC autumn bottom trawl survey biomass indices for thorny skate.

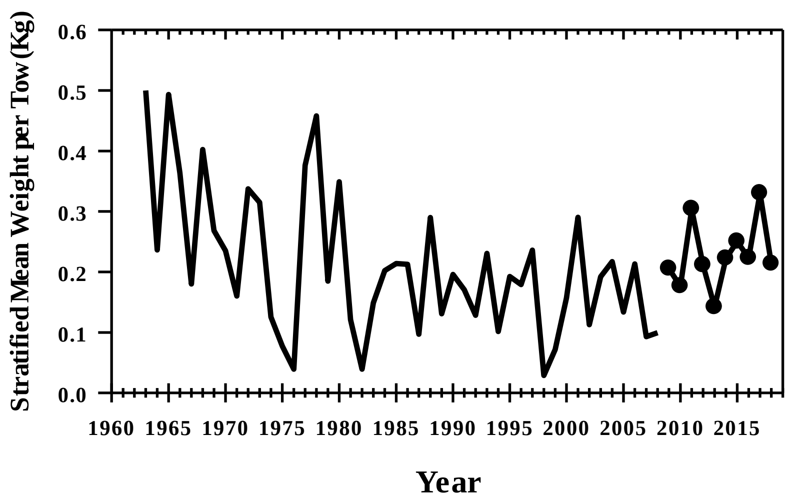

Figure 32. NEFSC autumn bottom trawl survey biomass indices for smooth skate.

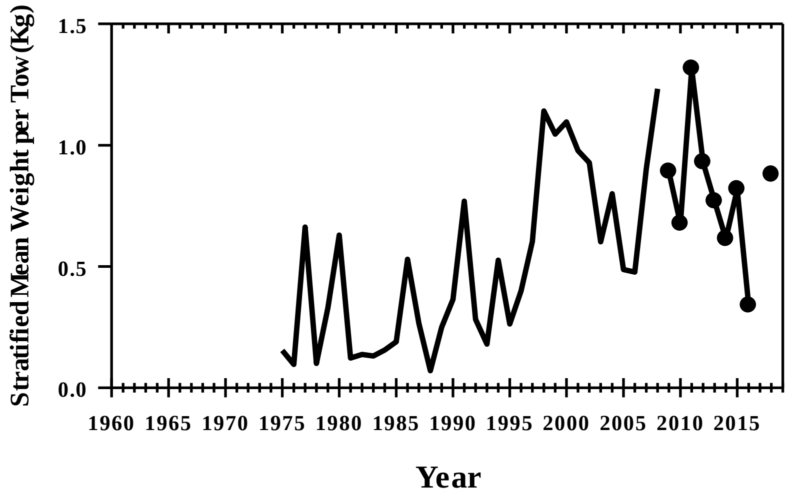

Figure 33. NEFSC autumn bottom trawl survey biomass indices for clearnose skate.

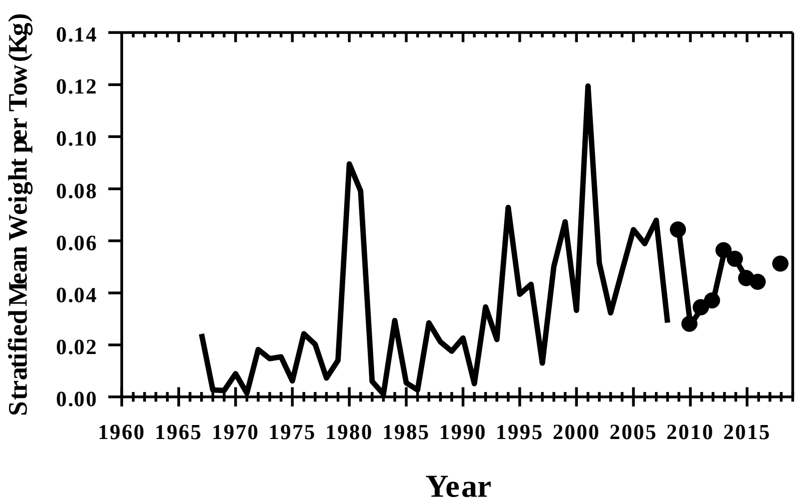

Figure 34. NEFSC autumn bottom trawl survey biomass indices for rosette skate.