Northwest Atlantic Fisheries Organization

Serial No. N7108 **NAFO SCS Doc. 20/18**

SCIENTIFIC COUNCIL MEETING – JUNE 2020

United States Research Report for 2019

by

K.A. Sosebee
NOAA/NMFS, Northeast Fisheries Science Center
Woods Hole, MA 02543, USA
Katherine.Sosebee@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 2009-2019 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, 2009-2019 survey data points should be interpreted cautiously, and these values may change in the future as new methodologies are considered. The 2009-2019 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 to be a sister ship of 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 2012-2019 at least one vessel fished in the area. The sections for cod, yellowtail flounder, other flounders, squids, and small elasmobranchs contain the landings and the discards of these species in 2019.

1. Atlantic Cod

United States commercial landings of Gulf of Maine Atlantic cod (*Gadus morhua*) in 2019 were 335 mt, a 16% decrease from the 2018 landings of 398 mt. United States commercial landings of Georges Bank Atlantic cod in 2019 were 682 mt, an 18% increase from the 2018 landings of 577 mt. In addition, <0.1 mt were landed from Div. 3N and < 0.1 mt were discarded.

Northeast Fisheries Science Center (NEFSC) research vessel survey biomass indices of Gulf of Maine cod 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 2019 were 5,252
mt on Georges Bank, a 31% increase from the 2018 landings of 4,017 mt. Haddock landings in the Gulf of Maine in 2019 were 3,464 mt, a 36% increase from the 2018 landings of 2,542 mt.

Northeast Fisheries Science Center (NEFSC) research vessel survey biomass indices in the Gulf of Maine are above the time series average but below recent historical highs (Figure 3). The NEFSC research vessel survey biomass indices for the Georges Bank stock have declined from recent historic high levels; the fall biomass index is now below the time series average (Figure 4).

3. Redfish

USA landings of Acadian redfish (*Sebastes fasciatus*) increased by 18% from 4,492 mt in 2018 to 5,320 mt in 2019. Fall research vessel survey biomass indices generally increased from the mid-1990s through 2012, with the 2010 index value of 83.47 kg/tow being the highest on record, before decreasing in 2013 (Figure 5). The survey biomass indices have varied without trend since 2013. Most recently, the survey biomass indices decreased by 69% from 64.71 kg/tow in 2018 to 20.24 kg/tow in 2019.

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

USA landings of pollock (*Pollachius virens*) increased by 3% from 3,078 mt in 2018 to 3,166 mt in 2019. Fall research vessel survey biomass indices generally increased from the mid-1990s through 2005, before decreasing in 2006 (Figure 6). The survey biomass indices have varied without trend since 2006, reaching a record-low of 0.19 kg/tow in 2009. Most recently, the index increased by 83% from 0.72 kg/tow in 2018 to 1.32 kg/tow in 2019.

5. White Hake

Nominal USA landings of white hake (*Urophycis tenuis*) from NAFO Subareas 5 and 6 increased by <1% from 1,969 mt in 2018 to 1,974 mt in 2019. Research vessel survey indices declined during the 1990s and increased in 2000 due to good recruitment of the 1998 year class. The indices have generally been variable since 2001. The indices have been stable since 2013 (Figure 7).

6. Yellowtail Flounder

USA landings of yellowtail flounder (*Limanda ferruginea*) from NAFO subareas 5 and 6 were 189 mt in 2019, a 30% decrease from 2018 landings of 269 mt. In Div. 3N, landings increased by approximately 25% from 177 mt in 2018 to 222 mt in 2019. Additionally, 1.0 mt of yellowtail flounder was discarded in Div. 3N bringing the total catch of yellowtail flounder in Div. 3N to 223 mt in 2019.

The NEFSC autumn survey biomass index in the Gulf of Maine has generally been variable since 2008. Most recently, the index increased by 50% from 2.5 kg/tow in 2018 to 3.8 kg/tow in 2019 (Figure 8). On Georges Bank, the NEFSC autumn survey has remained low since 2010 and currently the third lowest value in the time series. In 2019, the Georges Bank index increased from 0.30 kg in 2018 to 0.49 kg/tow. The Southern New England-Mid Atlantic yellowtail NEFSC autumn survey index is also at low levels and remained relatively unchanged in 2019 compared to 2018 (0.020 kg/tow in 2018 to 0.022 kg/tow in 2019 - Figure 9).

7. Other Flounders

USA commercial landings of flounders (other than yellowtail flounder and Atlantic halibut) from Subareas 3-6 in 2019 totaled 6,488 mt, 20% higher than in 2018. Summer flounder (*Paralichthys dentatus*; 63%), American plaice (*Hippoglossoides platessoides*; 15%), witch flounder (*Glyptocephalus cynoglossus*; 12%), winter flounder (*Pseudopleuronectes americanus*; 9% comprising the Georges Bank, Southern New England, and Gulf of Maine stocks), and windowpane flounder (*Scophthalmus aquosus*; <1% comprising the Northern and Southern stocks) accounted for virtually all of the 'other flounder' landings in 2019. Compared to 2018, commercial landings in 2019 were lower for windowpane flounder (-49%), winter flounder (-35%), and American plaice (-11%), but higher for summer flounder (47%) and witch flounder (34%). The American plaice landings from Div. 3N were 8.9 mt. In addition, 0.2 mt of American plaice were discarded in Div. 3N bringing the total catch of American plaice in Div. 3N in 2017 to 9.1 mt. The witch flounder landings from Div. 3N were < 1 mt while witch flounder discards were < 1 mt.

Research vessel survey indices in 2019 increased for Georges Bank winter flounder, decreased for American plaice while summer flounder, witch flounder, northern windowpane and southern windowpane remained relatively unchanged (Figures 11-16).

8. Atlantic halibut

USA landings of Atlantic halibut (*Hippoglossus hippoglossus*) in the Gulf of Maine-Georges Bank region decreased 8% from 54.2 mt in 2018 to 49.6 mt in 2019. No catches were reported from NAFO Subarea 3 in 2019. 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 – 2019 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 remain relatively stable compared to 2018. In 2019, US commercial landings of silver hake totaled 5,230 mt, only a 1% difference compared to 2018 of 5,168 mt.

The NEFSC autumn research vessel survey biomass indices for northern silver hake have generally been increasing over the last ten years. Most recently, the NEFSC autumn survey biomass index increased by 7% from 13.25 kg/tow in 2018 to 14.1 kg/tow in 2019 (Figure 18). In the south, the NEFSC autumn survey index has also been increasing albeit the incomplete coverage in 2017. Most recently, the autumn index increased by 37% from 1.8 kg/tow in 2018 to 2.4 kg/tow in 2019.

10. Red Hake

USA landings of red hake (*Urophycis chuss*) decreased from 484 mt in 2018 to 429 mt in 2019, slightly lower than the recent 5-year average. Research vessel survey biomass indices for the

Gulf of Maine - Northern Georges Bank stock increased after the early 1970s then markedly declined in 2003, but have been stable or increasing through 2019 and are now at the same level or higher than they were before 2003. In 2019, the NEFSC spring biomass index was 2.99 kg/tow, a decrease from 2018 but above the average post-2003 value of 2.86 kg/tow (Figure 20). Indices for the Southern Georges Bank - Mid-Atlantic stock declined in the 1990s and remained mostly below 1 kg/tow since then (Figure 21).

11. Atlantic Herring

Nominal USA landings of Atlantic herring (*Clupea harengus*) declined, equaling 45,527 mt in 2018 and 12,782 mt in 2019, which continues a decline that began in 2014. Spring survey indices generally declined during 2010-2019 and averaged 9.33 kg/tow (Figure 22). The 2019 spring survey index was 2.89 kg/tow, which was the lowest observation since 2010.

12. Atlantic Mackerel

U.S. commercial landings of Atlantic mackerel (*Scomber scombrus*) decreased 38.3% from 8,717 mt in 2018 to 5,379 mt in 2019. Recreational catches decreased 11.5% from 2,394 mt in 2018 to 2,119 mt in 2019.

Northwest Atlantic mackerel in NAFO subareas 3-6 was last assessed in the U.S. in 2017 through the Northeast Stock Assessment Workshop (SAW) process. This assessment recommended that Atlantic mackerel be considered overfished with overfishing occurring. A rebuilding plan has been developed by the U.S.'s Mid Atlantic Fishery Management Council (MAFMC).

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) for 2017-2019 and the 2019 index for the northern contingent (provided by Canada's Department of Fisheries and Oceans) were not available. However, 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 through 2018 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*) increased 102.8% from 1687 mt in 2018 to 3421 mt in 2019. 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 4.37 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 1987-2018, landings averaged 15,136 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. Landings during 2007-2018 averaged 11,284 mt and were slightly higher, totaling 12,458 mt in 2019.

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 1975-2018 median of 625 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 2019, relative abundance (717 squid per tow) was slightly above 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 when 98% of the quota was harvested in 2017 (22,516 mt) and again in 2018 and 2019 when the quotas were exceeded by 5% and 9%, respectively. The 2019 landings of 27,164 mt were the highest on record (since 1963) and surpassed the highest landings of the international and domestic fleets combined. There was < 1 mt discarded in NAFO Div. 3N.

Fall survey relative abundance of Northern shortfin squid attained a record-high in 2006 (29.5 squid/tow) then steadily declined to below the 1967-2018 median of 8.0 squid per tow in 2013. Relative abundance was 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, but then returned the median level.

15. Atlantic Sea Scallops

USA Atlantic sea scallop (*Placopecten magellanicus*) landings in 2019 were 27,650 mt (meats), the second highest of any year, and an increase of over 1,200 mt from 2018. Landings are expected to decline in 2020, mainly due to depletion of the strong 2012 year class in the western Nantucket Lightship area.

Biomass in 2018, based on dredge and optical surveys, was about 116,322 mt (meats) on Georges Bank and 68,452 mt (meats) in the Mid-Atlantic, for a total of 184,774 mt. This is about a 20% decline from the estimated 2018 biomass, again mainly due to declines in the Nantucket Lightship area. Recruitment was at about median levels on Georges Bank and below average in the Mid-Atlantic.

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 27). 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. Spiny Dogfish

USA landings of spiny dogfish (*Squalus acanthias*) increased 15% from 6,878 mt in 2018 to 7,910 mt in 2019. Survey indices, which are highly variable, generally declined between the early 1990s and 2005, but increased sharply in 2006 and have since generally remained high (Figure 28). The 2014 data point is plotted, although the comparability with previous years has not been evaluated. The area not covered by the survey generally 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 and 2019 survey indices increased from a low value in 2017.

18. Skates

USA nominal landings of skates declined 12% between 2018 and 2019 from 14,517 mt to 12,742 mt. The landings are sold as wings for human consumption and as bait for the lobster fishery. Landings have increasingly been reported by species resulting in only 375 mt reported as unclassified in 2019, a reduction from 5.8 % to 2.9% of the total.

Winter Skate

Winter skate (*Leucoraja ocellata*) reported landings decreased by 6% between 2018 and 2019 from 8,440 mt to 7,968 mt. For the survey, adjustment for the lack of coverage in the Southern New England and the Mid-Atlantic strata for fall 2017 was described in 2019 (SCS 19/15). A similar adjustment was made to account for missing strata in the north in 2018. Survey biomass indices for winter skate peaked in the mid-1980s (Figure 29) but then declined, possibly due to an increase in the directed fishery in the late 1980s and early 1990s. 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. In 2019, the index increased near the 2009 value.

Little Skate

Reported landings of little skate (*Leucoraja erinacea*) decreased 22% between 2018 and 2019 from 5,055 mt to 3,949 mt. For the survey, the adjustment for the lack of coverage in the southern strata described above for spring 2014 was described in 2015 (SCS 15/09). Little skate survey indices have generally fluctuated without trend (Figure 30).

Barndoor Skate

Landings of barndoor skate (*Dipturus laevis*) were allowed starting in 2018. Reported landings increased more than 2000% between 2018 and 2019 from 7 mt to 219 mt. The adjustment for the lack of coverage in the Southern New England strata was described in 2019 (SCS 19/15). In 2018, a similar adjustment was made to account for missing strata in the north. Survey indices 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 31).

Thorny Skate

There has been a possession prohibition on landings of thorny skate (*Amblyraja radiata*) in United States waters since 2003. Some landings still occur due to the high volume nature of the fishery. Reported landing decreased 94% from 2.3 mt in 2018 to 0.1 mt. in 2019. In addition, 3.1 mt of thorny skate were discarded in Div. 3N. The adjustment for the lack of coverage in the Southern New England strata was described in 2019 (SCS 19/15). In 2018, a similar adjustment was made to account for missing strata in the north. Thorny skate survey indices have declined over the entire time series, and are currently near record lows (Figure 32).

Smooth Skate

There has been a possession prohibition on landings of smooth skate (*Malacoraja senta*) in the Gulf of Maine (NAFO Div. 5Y) since 2003 although landings are permitted in other parts of the United States. The adjustment for the lack of coverage in the Southern New England strata was described in 2019 (SCS 19/15). In 2018, a similar adjustment was made to account for missing strata in the north. Survey indices for smooth skate are highly variable, but were been generally stable from the 1980s through 2005 (Figure 33) with a general increase over the last several years.

Clearnose Skate

Clearnose skate (*Raja eglanteria*) reported landings decreased by 58% between 2018 and 2019 from 31.5 mt to 13.1 mt. There were no indices available for 2017 since the entire strata set was not covered. Indices generally increased between 1995 and 2010 (Figure 34) but have been stable over the last decade.

Rosette Skate

Rosette skate (*Leucoraja garmani*) reported landings decreased by 90% between 2018 and 2019 from 0.2 mt to <0.1 mt. There were no indices available for 2017 since the entire strata set was not covered. Indices generally increased between 1995 and 2010 (Figure 35) but have been stable since.

B. Special Research Studies

1. Environmental Studies

a) Hydrographic Studies

A total of 1288 CTD (conductivity, temperature, depth) profiles were collected and processed by the Northeast Fisheries Science Center (NEFSC) in 2019 over the course of 8 cruises (Table X, provided). Of this total, 1267 CTD profiles were obtained within NAFO Subareas 4, 5, and 6. These data are archived in an oracle database. Cruise reports, and annual hydrographic summaries are accessible at: https://nefsc.noaa.gov/HydroAtlas/. Data are publicly available from the World Ocean Database maintained by NOAA's National Centers for Environmental Information at: http://www.nodc.noaa.gov/OC5/SELECT/dbsearch/dbsearch.html

Hourly bottom temperature records obtained by participants of the Environmental Monitors on Lobster Trap Project (see emolt.org) at approximately 40 fixed locations/depths around the Gulf of Maine and Southern New England Shelf indicate that 2019 was in fairly normal except for a warming that occurred at many sites in mid-October apparently due to an unusually strong Northeaster.

Real-time bottom temperatures are now reported from more than three dozen commercial vessels. Approximately 3000 haul-averaged bottom temperatures were automatically transmitted via satellite from a variety of locations and depths in 2019 bringing the project total to nearly 10K.. Observations from both fixed and mobile gear 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 2019 (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 2019, zooplankton community distribution and abundance were monitored using 423 bongo net tows taken on seven surveys. Three were aboard the FSV Henry Bigelow during the spring and fall trawl surveys, and the spring ecosystem monitoring survey, two were aboard the FSV Gordon Gunter during the summer and fall ecosystem monitoring surveys, and two additional surveys took place aboard the charter vessel Connecticut for a right whale survey and the UNOLS vessel Endeavor for an AMAPPS survey. Collectively the seven surveys covered the entire continental shelf region encompassing the Middle Atlantic Bight, Southern New England, Georges Bank and the Gulf of Maine. However, the 2019 plankton sampling of the Gulf of Maine area, although better than the 2018 coverage, was still more limited than in years prior to 2018, 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 and 2 additional vertical net casts were made on the Fall Ecosystem Monitoring Survey aboard the Gordon Gunter. These vertical casts were made for a comparison of Canadian plankton catches from this gear and protocol with the standard double oblique bongo net tows done in the same area by U.S. NEFSC researchers. The results obtained were similar to those from 2018, showing much less water was filtered and smaller samples were obtained with the ring net gear and vertical tow protocol combination. Nonetheless, these comparison tows will aid in correlating the US and Canadian datasets.

2019 was the sixth 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 76 CTD 911 /Niskin bottle rosette water casts, collecting nutrient samples in collaboration with the University of Maine to monitor levels of nutrients in the euphotic zone, chlorophyll calibration samples for the Oceans and Climate Branch and 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 62 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 279 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.

In 2019 a prototype new initiative was launched, the use of environmental DNA testing, conducted during the course of the Fall Ecosystem Survey aboard the Gordon Gunter. While no nets were used or plankton captured in the classic sense, 19 water casts were made to collect water samples from various depths that were filtered for later shore analysis of the DNA traces of organisms that had recently been in the water column. This was the first NEFSC attempt at using this technology to identify marine organisms in an offshore environment, and is a harbinger of an additional tool which will be used aboard future ecosystem monitoring surveys.

c) Benthic Studies

No field work done for 2019

2. Biological Studies

a) Fish Species

Flatfishes: During 2015-19, we have implemented work on the plasticity of responses to elevated CO2, and the degree of intraspecific, inter-population differences in resilience to high CO2 between stocks that experience contrasting levels of environmental variance in CO2 in situ. In 2019, we began a study contrasting response to elevated CO2 of summer flounder offspring drawn from parents collected near the northerly (New Jersey) and southerly reaches of its geographic range (Virginia). That study is continuing into 2020-21. The effort on summer flounder is also examining the early life-stage responses to thermal regimes. We are using a large number of distinct constant thermal regimes (embryos, N=20 regimes; larvae and young juveniles, N=11) and seasonally varying regimes (larvae and young juveniles, N=2) with fish evaluated for effects on viability, growth, and development.

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

Forage fish. A set of studies on Atlantic silverside, Menidia menidia, was continued into 2019. 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 2019, 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 174 research and charter vessel sea days. NOAA scientific and contract staff involvement in the various cruises totaled of 1,626 person sea days, and volunteers contributed another 578 person sea days. ESB cruises occupied 1,088 stations in an area extending from Cape Hatteras, North Carolina to Nova Scotia. A total of 380,772 length measurements were recorded, representing 1,651,443 individuals from 282 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 2019 to fulfill special survey sampling requests from 43 NOAA and university investigators. This sampling included 13,695 feeding ecology observations, collection of 25,442 aging structures, and acquisition of 32,412 samples/specimens to support additional shore-based research. Additionally, the HabCam cruise tracks from the scallop survey completed 3,210 nm, collecting a total of 2,585,168 image pairs.

¬c) Fishery Biology Program (https://www.fisheries.noaa.gov/new-england-mid-atlantic/science-data/age-and-growth-studies-northeast):

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 2019, FBP staff provided ages for over 48,400 otoliths and other hard structures from 22 species. The top species by number aged were haddock (5,448), summer flounder (4,386), silver hake (4,290), scup (4,110), and Atlantic cod (3,558). Large numbers of winter flounder, black sea bass, and American plaice (combined total 9,794) 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 https://fish.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, and inter-structure tests are conducted when there is a change in the method for ageing. In 2019, 87 intra-reader precision tests were conducted across 19 species, and two inter-structure tests were conducted for yellowtail flounder.

3. Inter-agency exchanges: For transboundary stocks, the FBP exchanges age structures with other laboratories. In 2019, one inter-agency exchange was conducted with the St. Andrews Biological Station (Fisheries and Oceans Canada), for haddock.

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 primarily at sea for selected species. During 2019, stomachs from 6,652 individuals and 51 species were examined in the spring, and stomachs from 7,043 individuals and 51 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 47-year time series (1973-2019). The majority of the time series is now available for analysis, including data from over 670,000 stomach samples and over 160 predators. The processing of the 2019 bottom trawl survey food habits data is scheduled for completion in 2020.

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 2019, 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 2020 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, comparing the footprints of fish predation pressure and bottom fishing effort 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 thousands of 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 2019. Over 300,000 fish including more than 50 shark species have been tagged since this program was initiated in 1962 and recaptures include more than 30 of the shark species tagged. A tagging atlas detailing the distribution and movements of 35 Atlantic shark species based on CSTP data from 1962 to 2013 was published in Marine Fisheries Review in 2019.

APP staff participated in the Southeast Data Assessment and Review (SEDAR) process in 2019 towards the assessment of the Atlantic blacktip shark population. A working paper summarizing blacktip shark mark/recapture data from the CSTP was presented during the SEDAR 65 Data Workshop. CSTP data supported the continued need for separate Atlantic and Gulf of Mexico assessments for the blacktip shark. Staff also presented working papers on blacktip shark reproductive parameters and discard estimates for the northeast sink gillnet fishery using data collected by the Northeast Fisheries Observer Program. Additionally, staff presented six working papers during the SEDAR 65 Data Workshop process detailing multiple indices of abundance and summarizing length data for Atlantic blacktip sharks using gillnet and longline survey data from the Cooperative Atlantic States Shark Pupping and Nursery (COASTSPAN) surveys and longline survey data from the NEFSC Coastal Shark Bottom Longline Survey and Southeast Area Monitoring and Assessment Program longline surveys by

the South Carolina Department of Natural Resources (SCDNR) and Georgia Department of Natural Resources.

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 41 sharks at six tournaments in 2019.

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. In 2019, blacktip shark reproductive data collected during this survey were analyzed with other data sources to determine reproductive parameters for use in the SEDAR 65 process. Additionally, blacktip shark catch-per-unit-effort data were analyzed with respect to environmental and spatiotemporal variables to develop a blacktip shark index of relative abundance for use in the SEDAR 65 process.

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 mi¬grations of sharks using coastal nursery habitat through longline and gillnet sampling and mark-recapture data. In 2019, our COASTSPAN participants were the Virginia Institute of Marine Science, SCDNR, the University of North Florida (UNF), 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 2019, results from these COASTSPAN surveys were provided to NMFS Highly Migratory Species Management Division for use in updating the EFH section of the annual Stock Assessment and Fisheries Evaluation (SAFE) Report. In addition, blacktip shark catch-per-unit-effort data from COASTSPAN gillnet and longline surveys conducted by the SCDNR and UNF were analyzed with respect to environmental and spatiotemporal variables to develop blacktip shark indices of relative abundance for use in the SEDAR 65 process.

In 2019, APP staff with coauthors from the Southeast Fisheries Science Center, Bedford Institute of Oceanography, and the University of New England published a study in Fishery Bulletin identifying a resting population of female porbeagles (Lamna nasus) in the general vicinity of Stellwagen Bank in the western North Atlantic Ocean. Previous porbeagle research based on specimens collected from the western North Atlantic Ocean has indicated that this lamnid shark has an annual reproductive cycle. However, the results of a recent evaluation of reproductive tracts from a geographically segregated group of porbeagles within the western North Atlantic Ocean indicate the presence of females in a resting stage of maturity, indicating a biennial reproductive cycle. The observation of a resting stage has implications not only in the reproductive cycle, biennial versus annual, of this species but also in the lifetime productivity. This finding indicates that this shark follows the typical lamnid resting period between pregnancies, a period that would decrease the lifetime output of young sharks and their resilience to direct and indirect fishing pressure.

APP staff, in cooperation with staff from the Southeast Fisheries Science Center, published a study in Fishery Bulletin in 2019 on using oxytetracycline (OTC) validation for confirmation of changes in vertebral band-pair deposition rates with ontogeny in sandbar sharks (Carcharhinus plumbeus) in the western North Atlantic Ocean. Age underestimation of many shark species, such as the sandbar shark, has been proven with age validation methods

including bomb radiocarbon dating, OTC injection, and tag recapture data. Validation studies indicate that band-pair deposition in vertebral centra may not be directly related to time, especially in older individuals of a species. In this study, vertebrae from tagged, OTC injected, and recaptured sandbar sharks were examined to determine if band-pair deposition past the OTC mark matched time at liberty. In 6 of 8 OTC-injected sharks at liberty for >1 year, band-pair count past the OTC mark underestimated time at liberty by 24–58%. Additionally, growth rates derived from tag-recapture data were slower than those described by previously published vertebral band-pair growth curves but were similar to those predicted by previous bomb radiocarbon dating and OTC results from this study. Together, the results from these studies indicate that modeling tag-recapture data may be more accurate for age determination in elasmobranchs given that band-pair counts on vertebral centra do not coincide with age throughout life. Analyses indicate that sandbar sharks may be less productive than previously understood.

APP staff contributed to a publication in the Journal of Zoology in 2019 with coauthors from the University of Oxford, Mount Holyoke College, and the University of Massachusetts Amherst on the variability and asymmetry in the shape of the spiny dogfish vagina revealed by 2D and 3D geometric morphometrics. The vast majority of research on genital morphology has been done on male genitalia and this is one of few studies on the female genital shape and the first using 3D geometric morphometrics. In a sample of 21 adult females, no correlations between body size and reproductive and non-reproductive trait size were found indicating no general allometric patterns. There was limited evidence for different 2D and 3D vaginal shapes in visibly pregnant and not visibly pregnant sharks. Results using 3D geometric morphometrics showed clearer trends than seen using 2D. High directional asymmetry (>48% of total variation) was found in visibly pregnant sharks, likely as a result of an asymmetric distribution of pups in the shark's paired oviducts. Since this asymmetry is functional rather than developmental, it presents an important consideration when studying vaginal shape. The lack of significant association of vaginal shape with pregnancy in a species with such a long gestation period suggests that differences in shape may be under selective forces such as sexual antagonism during copulation.

f) Marine Mammals

Cetacean surveys:
During spring (3 April–15 May 2019) and fall (13 October–24 November 2019), the NEFSC conducted aerial abundance surveys targeting marine mammals and sea turtles. The southwestern extent was New Jersey and the northeastern extent was off of Halifax, Nova Scotia, Canada on the Scotian Shelf. The surveys covered waters from the coastline to about the 2000 m depth contour. Track lines were flown 183 m (600 ft) above the water surface, at about 200 kph (110 knots). The two-independent team methodology was used to collect data. In the spring about 10,392 km of on-effort track lines were surveyed, where 89% of this effort was in Beaufort 3 and below. In the fall about 7,770 km of on-effort track lines were surveyed, where 85% of this effort was in Beaufort 3 and below. In the spring survey, the front team detected 1,406 individual cetaceans in 506 groups; the back team detected 834 individual cetaceans in 373 groups; this was from 15 cetacean species or species groups. In the fall survey, the front team detected 3,176 individual cetaceans in 361 groups; the back team detected 1,968 individual cetaceans in 361 groups; this was from 11 cetacean species or species groups. Common dolphins (*Delphinus delphis*) were the most frequently detected species. The most frequently detected large whales were humpback whales (*Megaptera novaeangliae*) in the spring and fin whales (*Balaenoptera physalus*) in the fall. In the spring only 1 loggerhead turtle (*Caretta caretta*) and 1 unidentified hardback turtle was detected. During the fall a few more turtles were detected: 4 leatherback turtles (*Dermochelys coriacea*), 7 loggerhead turtles and 1 green turtle (*Chelonia mydas*). Seals at-sea and ocean sunfish (*Mola mola*) were also commonly detected. In addition, seal haul-out sites were photographed, which will be used to define the distribution and abundance of gray seals (*Halichoerus grypus*)

and harbor seals (*Phoca vitulina*). More information on NEFSC aerial and shipboard surveys conducted under the auspices of the Atlantic Marine Assessment Program for Protected Species can be found online (https://www.fisheries.noaa.gov/new-england-mid-atlantic/population-assessments/atlantic-marine-assessment-program-protected#reports).

The North Atlantic Right Whale Sighting Survey (NARWSS) is a NOAA Fisheries program that locates and records the seasonal distribution of North Atlantic right whales off the northeastern coast of the United States and Canada. Images of individual whales are collected for mark-recapture models to monitor the population. NARWSS flights conducted in 2019 followed systematic tracklines within these survey areas: Atlantic Canyon, Block Canyon, Cashes Ledge, Coastal Maine, Downeast Maine, Franklin Basin, Georges Bank, Great South Channel, Hudson Canyon, Hydrographer Canyon, Jeffreys Ledge & Wildcat Knoll, Jordan Basin & Jeffrey's Bank, Long Island, Martha's Vineyard, Nantucket, New Jersey, New York Shipping lanes, Rhode Island Sound, Southern Gulf of St. Lawrence, and Stellwagen Bank Sanctuary. During 2019, NARWSS flew 450 hours over 93 surveys. NARWSS detected 1404 right whales (including duplicate sightings of the same individual), with 1402 right whales sighted within survey blocks and 2 right whales sighted during transit to or from survey areas.

During May, June, July, August, October and November 2019, visual detection data of primarily seabirds, but also marine mammals, turtles, and large pelagic fish were collected opportunistically on 5 cruises. These included the spring, summer and fall Ecosystem Monitoring (EcoMon) cruises and an additional two on Woods Hole Oceanographic Institution cruises that were part of an National Science Foundation sponsored project entitled "Shelfbreak frontal dynamics: mechanisms of upwelling, net community production, and ecological implications". The cruises sampled regions from the Gulf of Maine to North Carolina.

During 18–23 April 2019, 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. Oceanographic sampling included 4 deployments of the Video Plankton Recorder, 5 of the echosounder package, 2 CTDs (Conductivity Temperature Depth sensor), and continuous ADCP (Acoustic Doppler Current Profiler) current data were collected. Zooplankton samples were collected from 2 bongo net deployments, 1 Tucker trawl and 1 ring net. An innovative low-cost package with underwater cameras and hydrophones was developed and successfully field tested; this will be used in future studies and monitoring.

During 17–28 August 2019, NEFSC and partners conducted a shipboard survey primarily offshore of Georges Bank to assess the ecology and distribution of deep diving cetacean species, such as beaked whales (Ziphiidae), pygmy/dwarf sperm whales (*Kogia* spp.), and sperm whales (*Physeter macrocephalus*). The scientific crew included a visual observation team scanning for marine mammals and sea turtles, an additional observer or two collecting data on avian sightings, and a passive acoustic team monitoring a towed hydrophone array. Three High-Frequency Acoustic Recording Packages ("HARPs") were recovered during this cruise after a year of passive recording along the shelf break of the US eastern seaboard. Approximately 580 km were surveyed by the marine mammal visual team; passive acoustic data were collected over an additional 570 km. CTD data were collected at 3 stations in conjunction with recovery of the HARPs. Approximately 22 beaked whale groups were sighted. Three groups of pygmy/dwarf sperm whales were sighted, including at least one mother-calf pair. An estimated 60 groups of other cetaceans were sighted. Over 2,100 seabirds from at least 31 species were detected. The hydrophone arrays were monitored for 120 hours, yielding over 150 acoustic detections of cetacean groups, including 41 detections of beaked whales.

There were no efforts by the NEFSC in the North Atlantic right whale calving grounds in 2019, due to furlough. In March 2019, one vessel trip was made south of Martha's Vineyard in southern New England waters (SNE). This trip was a collaboration with Stellwagen Bank National Marine Sanctuary, where science crew from NEFSC worked aboard the sanctuary vessel, RV Auk. This trip yielded images of 16 unique North Atlantic right whales and 2 biopsy samples from right whales that had never previously been sampled. From late March through early May, research crews working from NOAA research vessel Selkie (24' Safeboat), and one trip aboard the sanctuary vessel, RV Auk, conducted seven research trips in Cape Cod Bay. All right whales encountered were photographed for the North Atlantic Right Whale catalog. Additionally, three biopsy samples were collected from right whales that had never previously been sampled. This included one calf of the year that had not been sampled on the calving grounds.

In May 2019, researchers from NEFSC completed a research cruise, focused on North Atlantic right whales, aboard the RV Connecticut (University of Connecticut research vessel). Both stable and dynamic aggregations of right whales were found in SNE waters. A total of 102 right whales were photographed over 11 different days.

The NEFSC is working with regional pot and trap fishermen to develop and test ropeless/buoyless systems primarily in the lobster fishery to mitigate large whale (mostly right whale) entanglement. Staff from the NEFSC have spent over 50 days at sea with local fishermen, engineers, and NGOs testing ropeless gear. This work is expected to increase in the future.

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 2019 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 (*Phocoena phocoena*), short-beaked common dolphins, white-sided dolphins (*Lagenorhynchus acutus*), Risso's dolphins (*Grampus griseus*), bottlenose dolphins (*Tursiops truncatus*), and pilot whales (*Globicephala* spp.). To support the 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 2019, 8 high-frequency recording packages (HARPs) were recovered from the shelf break waters of the U.S. east coast, from New England to Georgia. These deployments conclude a three-year effort aimed at monitoring the acoustic ecology of shelf break habitats 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. Acoustic recorders were deployed in waters south of Cape Cod and in the Gulf of Maine to monitor for North Atlantic right whales. In collaboration with colleagues at the Woods Hole Oceanographic Institution, gliders were deployed in the Gulf of Maine and Cox Ledge; two real-time monitoring buoys are also 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 August. Over 120 hours of array data resulted in the real-time detection of beaked whales, sperm whales, and other species.

Several manuscripts were published, on topics ranging from identifying the distribution of spawning cod acoustic technologies, to the results of the Caribbean Humpback Acoustic Monitoring Program (CHAMP), to a new description of sei whale vocalizations. A number of additional manuscripts involving colleagues from the Passive Acoustics Group were published in 2019 see our website for more details (https://www.fisheries.noaa.gov/resource/peer-reviewed-research/publications-northeast-passive-acoustic-research-staff).

Pinnipeds:

Much of NEFSC's 2019 winter field work on gray seal (*Halichoerus grypus*) pupping colonies was curtailed due to the government shutdown but several opportunistic Twin Otter aerial surveys of Muskeget Island, Massachusetts were conducted in coordination with right whale surveys. Haul out sites were also photographed during aerial surveys conducted as part of the Atlantic Marine Assessment Program for Protected Species (see cetacean surveys above).In collaboration with non-governmental organizations, thirteen satellite tags were deployed on weaned gray seal pups to study habitat usage and anthropogenic risk.

Work continued in 2019 to study pinniped diet from fatty acids in blubber (predator) and various fish (prey) samples, in collaboration with researchers at University of Dalhousie and Maritime Canada Department of Fisheries and Oceans, 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.
In 2019 the NEFSC participated in at-sea research on loggerhead and leatherback sea turtles. In June 5–8 2019, the NEFSC supplied tags for an externally led sea turtle ecology cruise. This cruise occurred on the Mid-Atlantic shelf. The team deployed 10 satellite relayed data loggers to collect information on loggerhead sea turtles. In May 13–23 and August 19–30 2019, the NEFSC participated in NMFS-led and externally-led leatherback research which deployed 13 satellite tags and numerous suction cup tags.

In 2019 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 2019, the NEFSC gear research program focused primarily on testing buoyless systems in the lobster fishery to reduce large whale and sea turtle entanglements. We worked with multiple pot/trap fishermen to test several systems designed to reduce the probability of whale and sea turtle entanglement by either releasing the vertical line or raising a trap by acoustic release systems. The technology works well but incorporating it on commercial vessels requires some individual operational challenges. Additionally, we have been testing the reliability of these systems in both the inshore and offshore fisheries.

Another project accomplished in 2019 in collaboration with the SEFSC (Nick Hopkins) 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 2019, we made changes to this design and retested using the same vessel and methodology as in previous years. Unfortunately, recent design changes did not improve the catch retention.

3. Studies of Fishing Operations

In 2019, NEFSC Observers were deployed on 4,157 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 240 marine mammal incidental takes, 15 sea turtle incidental takes, and 368 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 731 trips aboard commercial fishing vessels in 2019. On these trips there were 104 marine mammal and 73 seabird incidental takes documented.

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

In the sink anchored gillnet fishery, 1,007 trips were observed with a total of 3,831 gear retrievals by Observers. There were 328 observed marine mammal takes in this fishery (200 gray seals, 40 harbor seals, 34 harp seals, 29 harbor porpoises, 16 unidentified seals, three common dolphins, three unidentified dolphins, one bottlenose dolphin and one Risso's dolphins). There were also three loggerhead turtles, one green turtle, one leatherback turtle, one unidentified hard-shell turtle and 188 seabird takes (include 137 greater shearwater) observed in this fishery.

At-Sea Monitors observed 250 trips in the sink anchored gillnet fishery with 819 gear retrievals. There were 81 marine mammal (50 gray seals, 21 harbor seals, six harbor porpoises, three unidentified and one harp seal) and 61 seabird incidental takes (including 56 greater shearwater) recorded in this fishery by Monitors.

b. Float Drift Gillnet Fishery

There were 62 floating drift gillnet trips with 221 gear retrievals observed in 2019. There were no marine mammal, sea turtle or seabird incidental takes observed.

No Monitors deployed on float drift gillnet trips in 2019.

c. Otter Trawl Fisheries

In the bottom otter trawl fishery 1,984 trips were observed with a total of 12,308 gear retrievals recorded by Observers. In addition, there were 12 midwater trawl trips with 21 gear retrievals, 13 scallop trawl trips with 56 gear retrievals, 10 haddock separator trawl trips with 256 gear retrievals, nine twin trawl trips with 44 gear retrievals, and one Ruhle trawl trip with two gear retrievals observed in 2019.

In the bottom otter trawl fishery, there were 87 observed marine mammal takes (56 common dolphins, 11 whitesided dolphins, nine gray seals, four unidentified dolphins, two harbor porpoises, two harbor seals, one bottlenose dolphin, one unidentified pilot whale and one unidentified whale). There were also seven loggerhead turtles, one unidentified turtle and 39 seabird takes in this fishery. There were two seabirds in the mid-water trawl fishery and one whitesided dolphin and one gray seal in the haddock separator trawl fishery. There were no incidental takes observed on scallop trawl, shrimp bottom otter trawl, Ruhle trawl or large mesh belly panel trawl trips in 2019.

At-Sea Monitors deployed on 453 bottom otter trawl trips with 3,590 gear retrievals and seven haddock separator trawl trips with 189 gear retrievals, but no Ruhle trawl or twin trawl trips in 2019. There were 10 whitesided dolphins, three harbor porpoises, two harp seals, one common dolphin, one gray seal, one unidentified seal, one unidentified whale pilot and 11 seabird takes recorded by Monitors in the bottom otter trawl fishery. There were no incidental takes documented by Monitors on the haddock separator trawl trips in 2019.

d. Sea Scallop Dredge Fishery

In the sea scallop dredge fishery, 586 trips were observed with a total of 25,532 gear retrievals. There were one unidentified pilot whale, one loggerhead turtle and 10 seabird takes observed in this fishery.

No Monitors deployed in the scallop dredge fishery in 2019.

e. Scottish Seine Fishery

No Scottish seine trips were covered by Observers or Monitors in 2019.

f. Drift Sink Gillnet Fishery

In the drift sink gillnet fishery in 2019, Observers were deployed on 242 trips with a total of 1,596 gear retrievals. There were five gray seals, one harbor seal and one unidentified seal takes in this fishery.

Monitors deployed on two drift sink gillnet trips with 14 gear retrievals in 2019. There were two harbor seal, two unidentified seal and one great black-back gull takes on these trips.

g. Anchored Floating Gillnet Fishery

There were 23 anchored floating gillnet trips with 46 gear retrievals observed in 2019. There

were no marine mammal, sea turtle or seabird takes observed in this fishery.

No Monitors deployed on anchored floating gillnet trips in 2019.

h. Mid-water Pair Trawl Fishery

In 2019, there were six mid-water pair trawl trips observed with a total of 18 gear retrievals. There were no marine mammal, sea turtle or seabird takes observed in this fishery.

No Monitors deployed on mid-water pair trawl trips in 2019.

i. Bottom Longline Fishery

In the bottom longline fishery in 2019 there were 37 trips observed with a total of 238 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 16 bottom longline trips with 58 gear retrievals in 2019. 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 2019.

k. Pound Net Fishery

No pound net trips were covered by Observers or Monitors in 2019.

l. Handline/Trolling Fisheries

In 2019, there were 39 handline trips and 341 gear retrievals and one troll line trip with 10 gear retrievals observed. There were no auto-jig handline trips observed. One gray seal and one great black-back gull takes were observed in the handline fishery. No marine mammals or sea turtles were taken in these fisheries.

Monitors covered three handline trips with 23 gear retrievals in 2019. No auto-jig handline or troll line trips were covered in 2019. There were no documented takes in these fisheries in 2019.

m. Herring Purse Seine Fishery

In 2019, there were three herring purse seine trips with six gear retrievals observed. There were no takes observed.

No herring purse seine trips were covered by Monitors in 2019.

n. Menhaden Purse Seine Fishery

No menhaden purse seine trips were covered by Observers or Monitors in 2019.

o. Tuna Purse Seine Fishery

No tuna purse seine trips were covered by Observers or Monitors in 2019.

p. Pot / Trap Fisheries

In 2019, there were 31 lobster pot trips with 517 gear retrievals, 19 fish pot trips with 228 gear retrievals, 18 conch pot trips with 206 gear retrievals, 12 crab pot trips with 240 gear retrievals and six hagfish pot trips with 411 gear retrievals. There were no 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 2019.

q. Beam Trawl Fisheries

One scallop beam trawl trip with two gear retrievals was observed in 2019. There were no incidental takes on this trip.

No beam trawl trips covered by Monitors in 2019.

r. Clam Dredge Fishery

There were 35 clam dredge trips with 1,540 gear retrievals observed in 2019. No marine mammals, sea turtles or seabirds were documented in 2019.

s. Other Dredge Fisheries

No other dredge trips were covered by Observers or Monitors in 2019.

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 four dozen managed species; all require periodic 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). Operational stock assessments were completed and peer reviewed for 25 stocks including Monkfish, Black Sea Bass, Bluefish, Scup, Winter Skate, Little Skate, Barndoor Skate, Thorny Skate, Smooth Skate, Roseate Skate, Atlantic Sea Scallop, Georges Bank Cod, Gulf of Maine Cod, Georges Bank Haddock, Gulf of Maine Haddock, Gulf of Maine Yellowtail Flounder, Georges Bank Yellowtail Flounder, Southern New England Yellowtail Flounder, Georges Bank Winter Flounder, American Plaice, Witch Flounder, Northern and Southern Windowpane Flounder, White Hake and Pollock. Data updates were provided for 15 stocks including Golden Tilefish, Blueline Tilefish, Surfclam, Ocean Quahog, Logilo Squid, Illex Squid, Butterfish, Summer Flounder, Spiny Dogfish, Southern New England and Gulf of Maine Winter Flounder, Halibut, Redfish, Wolffish and Ocean Pout.

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 2019, stock assessments conducted and reviewed through the TRAC process included Eastern Georges Bank cod, Eastern Georges Bank haddock, and Georges Bank yellowtail flounder.

2019 was a transition year for the stock assessment process and as a result, no benchmark stock assessments were scheduled or completed. The region recently revamped its stock assessment scheduling and review process system to better serve our management partners. Beginning in 2020, the region will shift to a fixed schedule of management track assessments used for status determination and management purposes and research track assessments used to improve stock assessments and modeling approaches. Research track assessments will be conducted for Red Hake Stock Structure (Spring 2020) and Index Based Assessments and Reference Points (Autumn 2020). Management track assessments will be conducted for approximately 25 stocks in 2020.

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 2019 focused on (1) monitoring the importance of diadromous fishes as prey for nearshore Gulf of Maine groundfish species; (2) monitoring of fishery removals on the high seas; (3) describing the marine migration of salmon from Greenland to natal rivers

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. 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. Lastly, starting in 2018, salmon have been captured, tagged with popoff satellite tags and released at their feeding grounds at West Greenland. Data collected will allow researchers to describe migration pathways and the environmental conditions encountered en route to natal rivers to better understand the marine dynamics of the species.

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 mi¬grations of sharks using coastal nursery habitat through longline and gillnet sampling and mark-recapture data. The Cooperative Research Branch provided support for the Delaware Bay COASTSPAN survey in August of 2019. 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 2019 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 2019 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 and 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 2019 completing 45 stations in both spring (April-May) and fall (Oct-Nov) with a total of 42 days at sea on two chartered commercial vessels. A total of 23,481 lengths were measured representing 13,005 individual organisms. Biological sampling of 2,522 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.

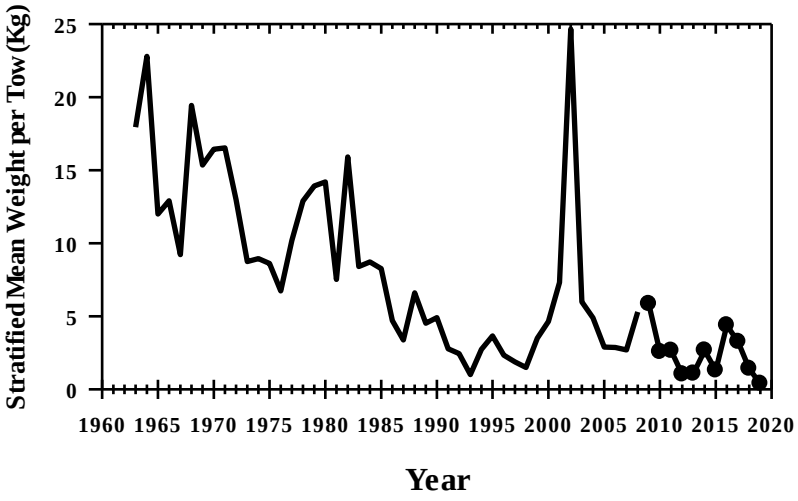

Figure 1. NEFSC autumn bottom trawl survey biomass indices for Gulf of Maine cod.

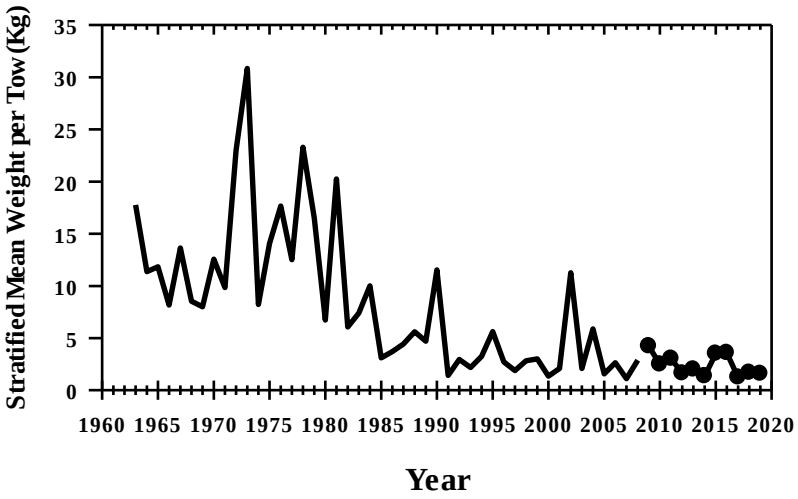

Figure 2. NEFSC autumn bottom trawl survey biomass indices for Georges Bank cod.

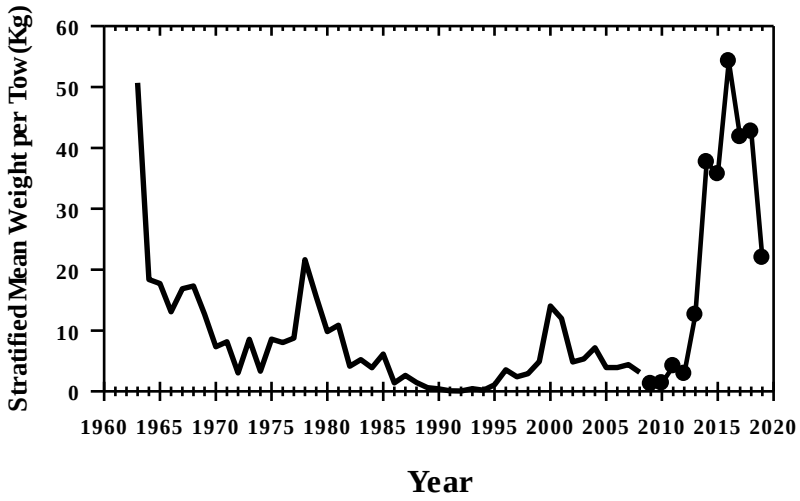

Figure 3. NEFSC autumn bottom trawl survey biomass indices for Gulf of Maine haddock.

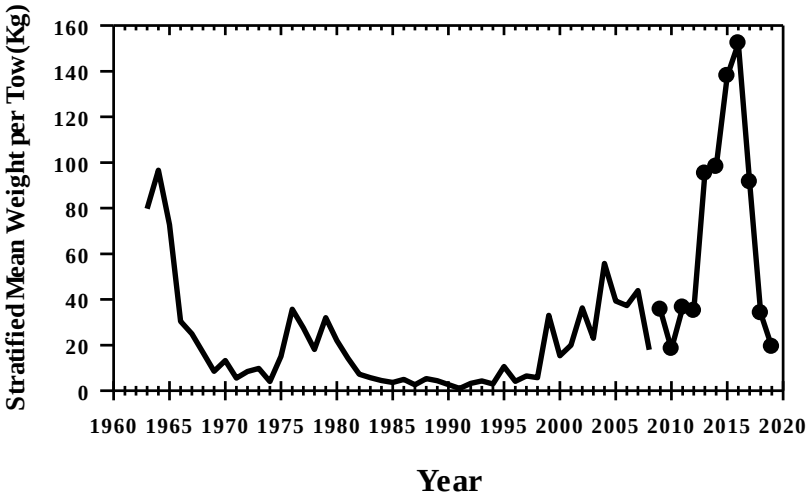

Figure 4. NEFSC autumn bottom trawl survey biomass indices for Georges Bank haddock.

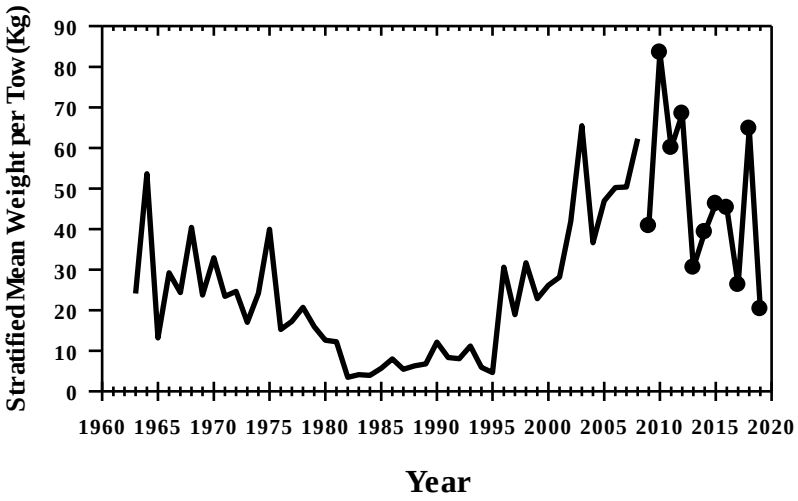

Figure 5. NEFSC autumn bottom trawl survey biomass indices for Acadian redfish.

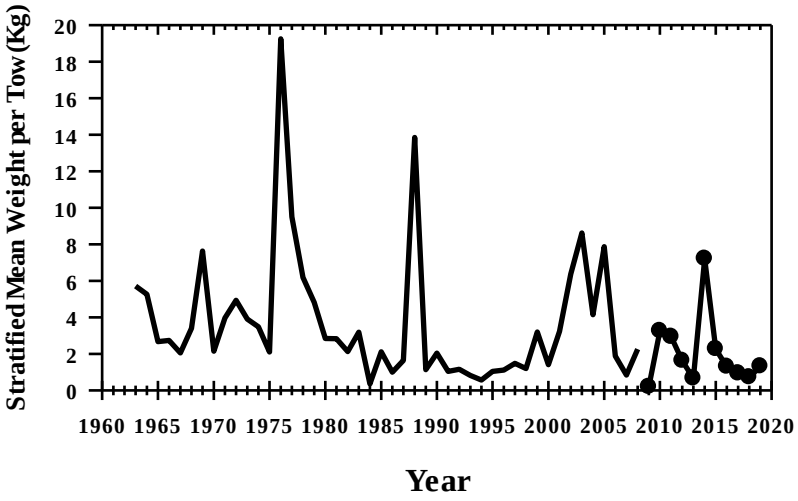

Figure 6. NEFSC autumn bottom trawl survey biomass indices for pollock.

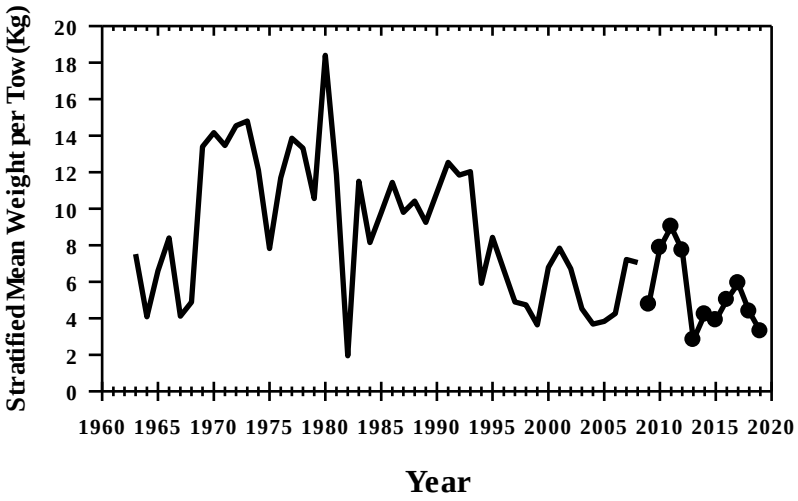

Figure 7. NEFSC autumn bottom trawl survey biomass indices for white hake.

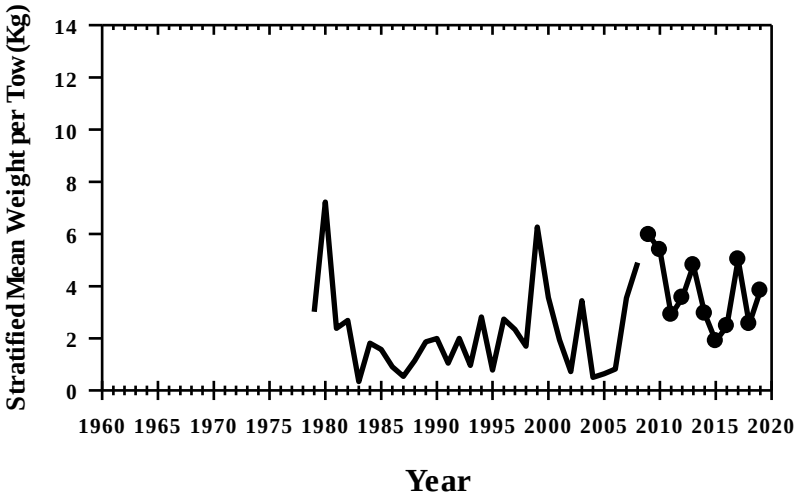

Figure 8. NEFSC autumn bottom trawl survey biomass indices for Cape Cod-Gulf of Maine yellowtail flounder.

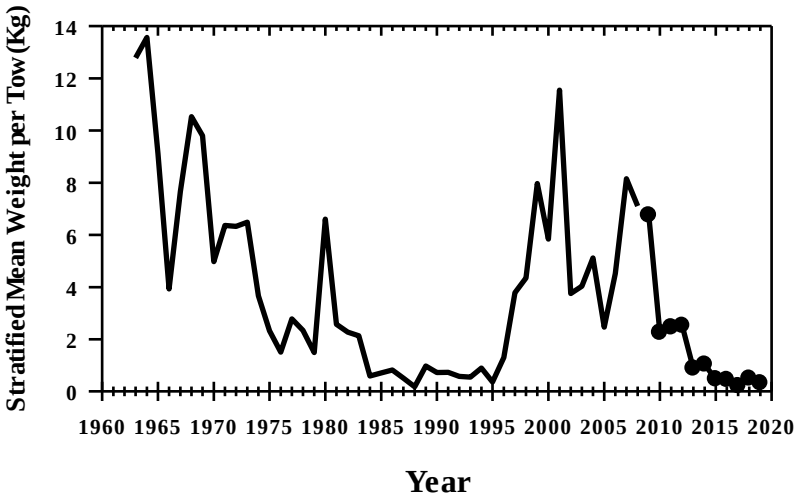

Figure 9. NEFSC autumn bottom trawl survey biomass indices for Georges Bank yellowtail flounder.

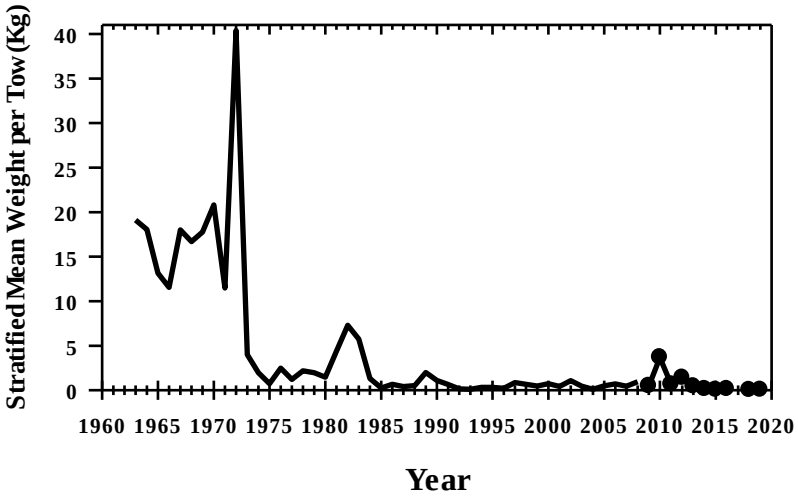

Figure 10. NEFSC autumn bottom trawl survey biomass indices for Southern New England-Mid-Atlantic yellowtail flounder.

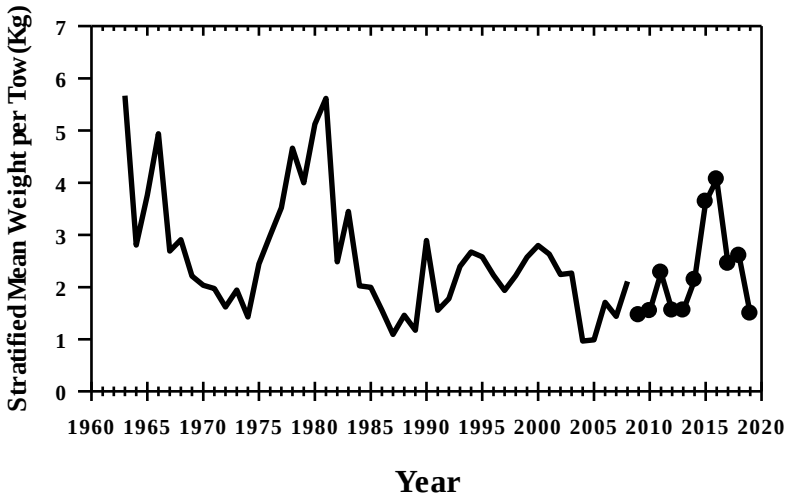

Figure 11. NEFSC autumn bottom trawl survey biomass indices for American plaice.

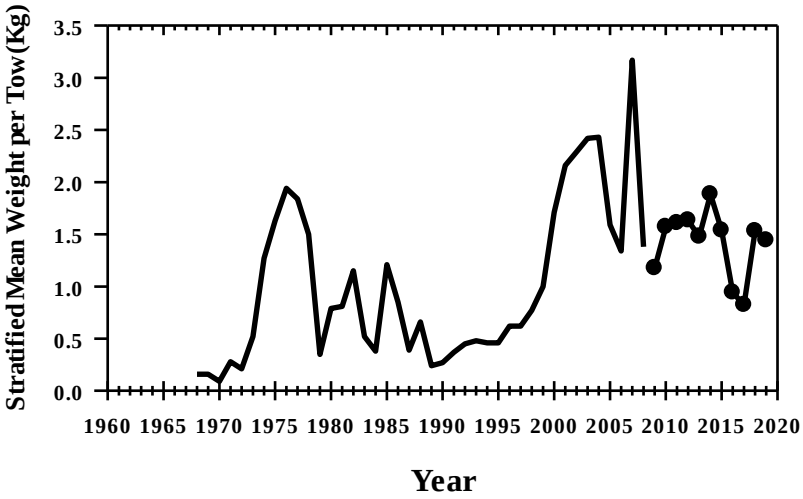

Figure 12. NEFSC spring bottom trawl survey biomass indices for summer flounder.

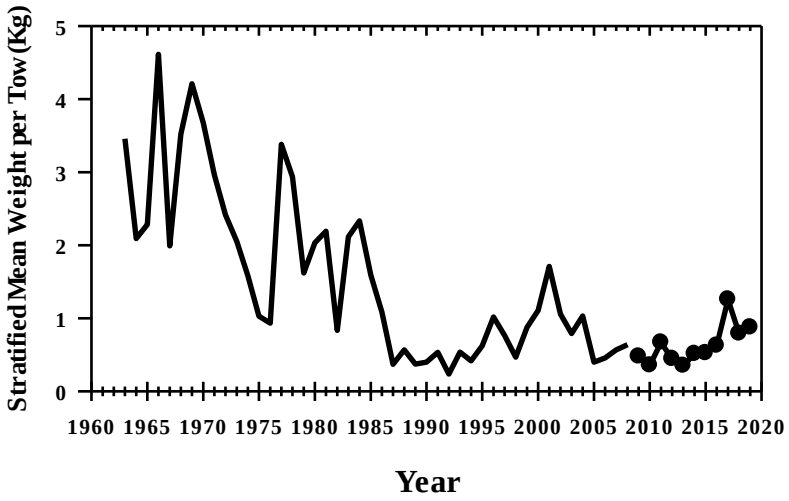

Figure 13. NEFSC autumn bottom trawl survey biomass indices for witch flounder.

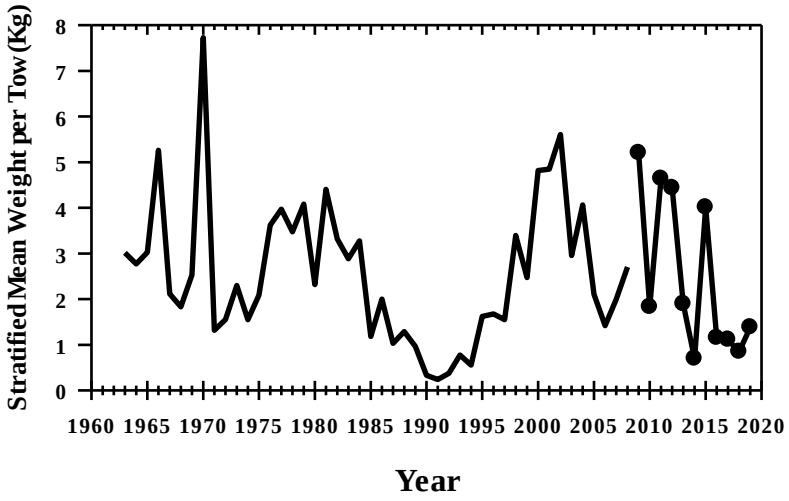

Figure 14. NEFSC autumn bottom trawl survey biomass indices for Georges Bank winter flounder.

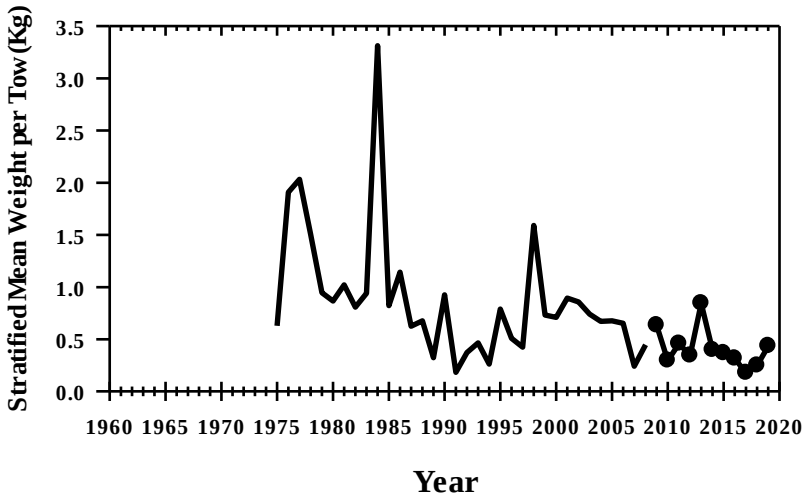

Figure 15. NEFSC autumn bottom trawl survey biomass indices for northern windowpane flounder.

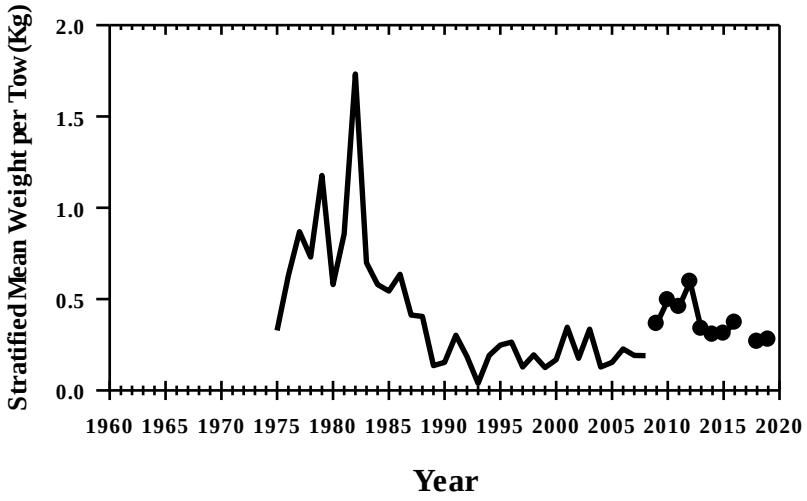

Figure 16. NEFSC autumn bottom trawl survey biomass indices for southern windowpane flounder.

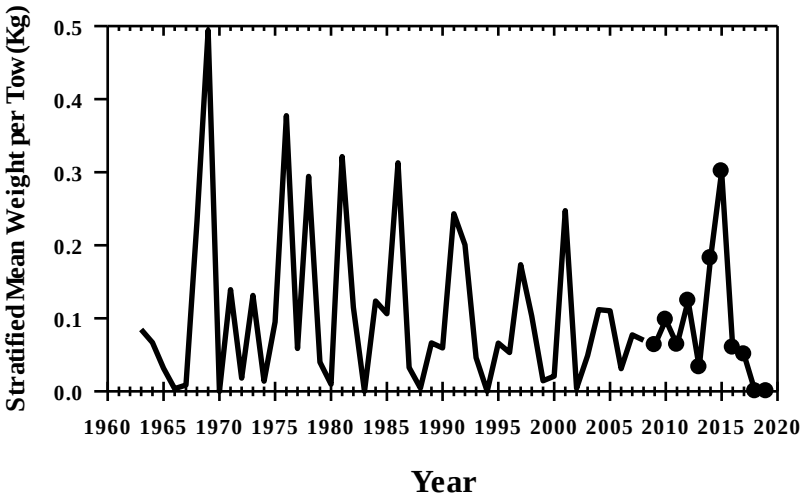

Figure 17. NEFSC autumn bottom trawl survey biomass indices for Atlantic halibut.

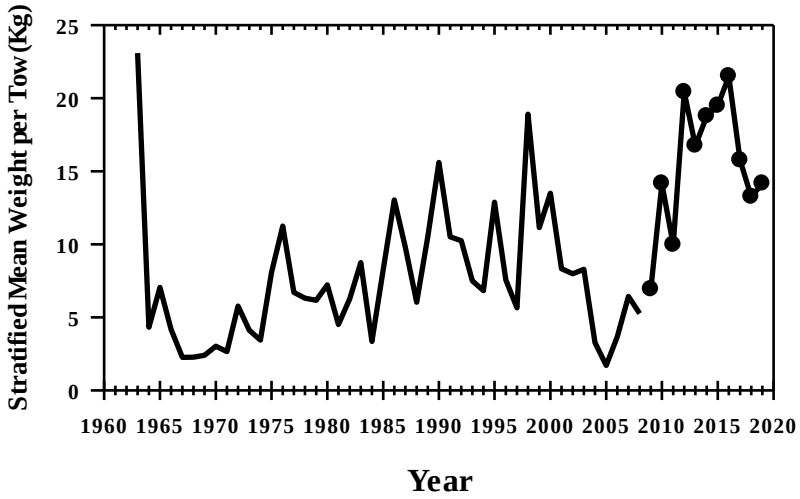

Figure 18. NEFSC autumn bottom trawl survey biomass indices for northern silver hake.

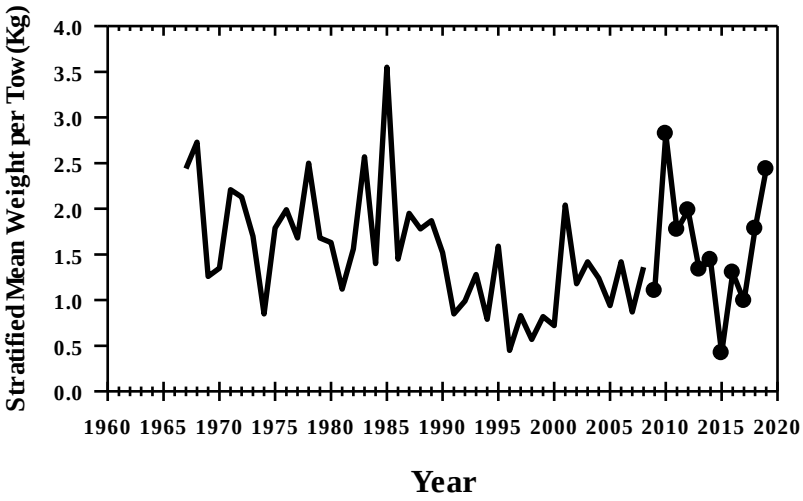

Figure 19. NEFSC autumn bottom trawl survey biomass indices for southern silver hake.

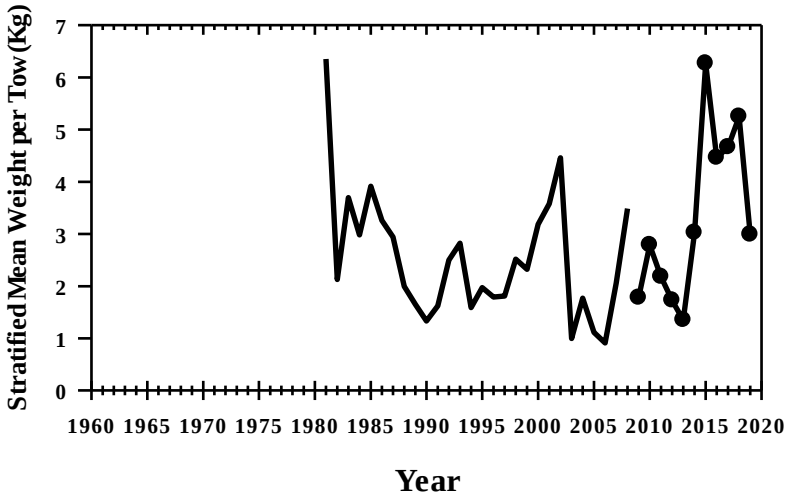

Figure 20. NEFSC spring bottom trawl survey biomass indices for northern red hake.

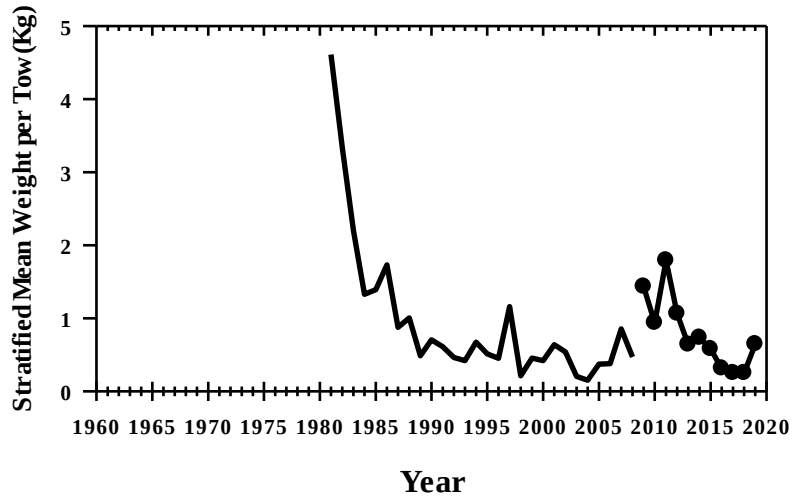

Figure 21. NEFSC spring bottom trawl survey biomass indices for southern red hake.

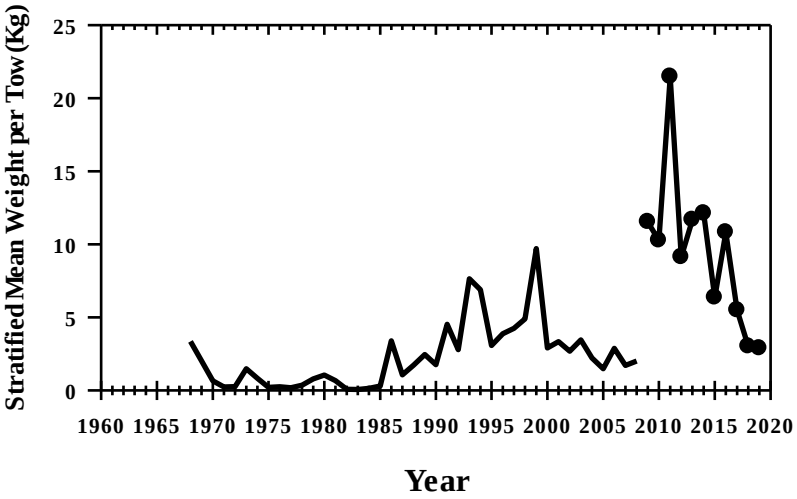

Figure 22. NEFSC spring bottom trawl survey biomass indices for Atlantic herring. Data from 2009-2019 have not been calibrated to the earlier time series.

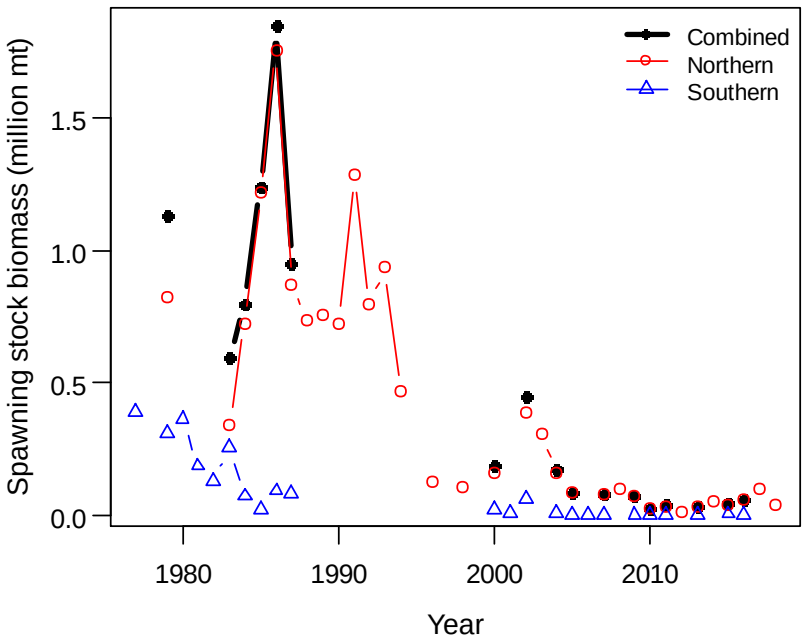

Figure 23. Atlantic mackerel spawning stock biomass index (millions metric tons) calculated using the total egg production method, based on egg densities observed in the southern Gulf of St. Lawrence (northern contingent) and the Northeast U.S. Continental Shelf (southern contingent). The combined SSB index represents the sum of northern and southern contingents and was only calculated in years where indices from both contingents were available. For 2017-2018, only index values from the northern contingent were available. For 2019, values were not available.

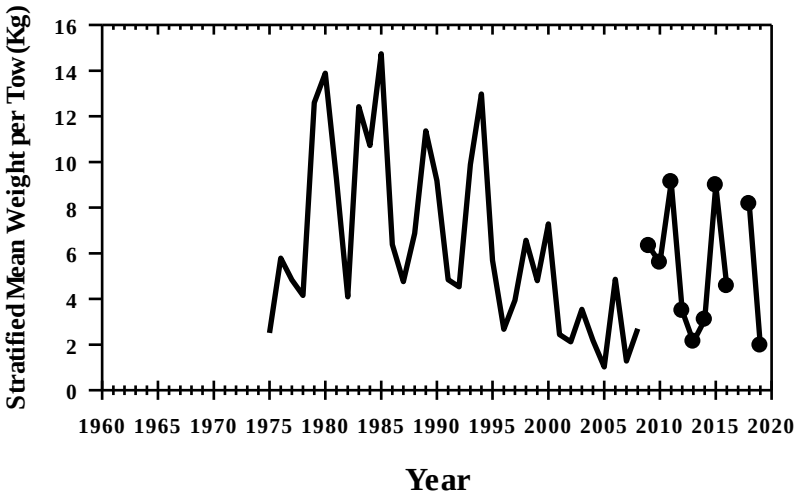

Figure 24. NEFSC autumn bottom trawl survey biomass indices for butterfish.

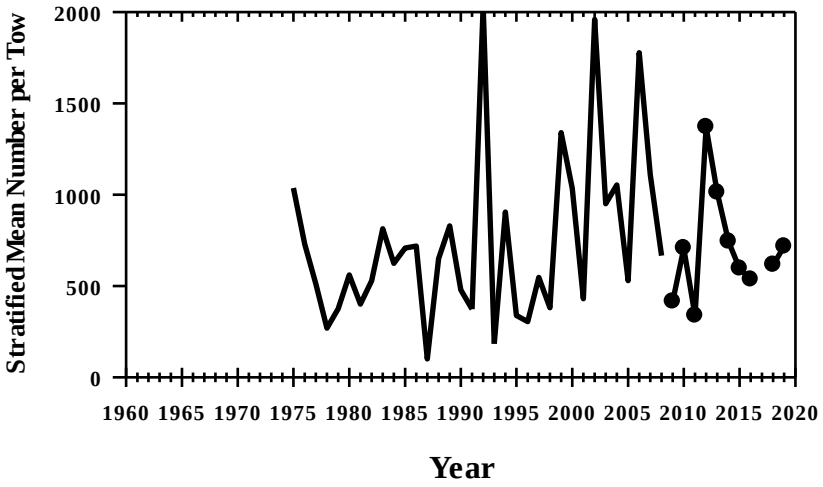

Figure 25. NEFSC autumn bottom trawl survey abundance indices for longfin inshore squid.

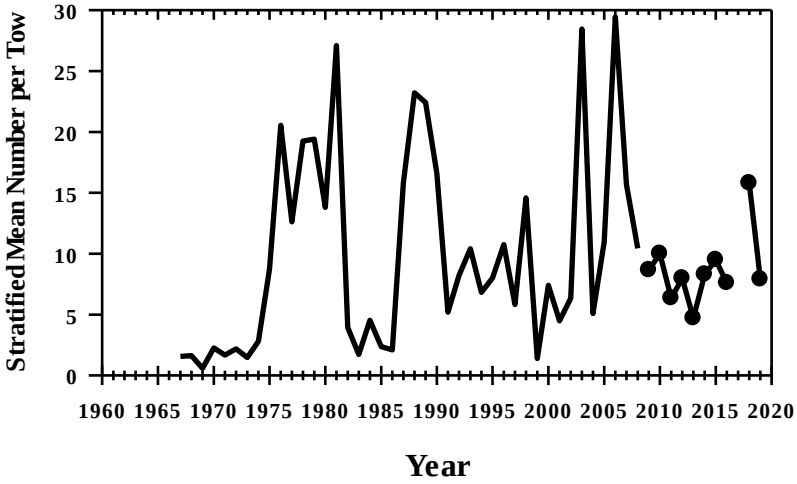

Figure 26. NEFSC autumn bottom trawl survey abundance indices for northern shortfin squid.

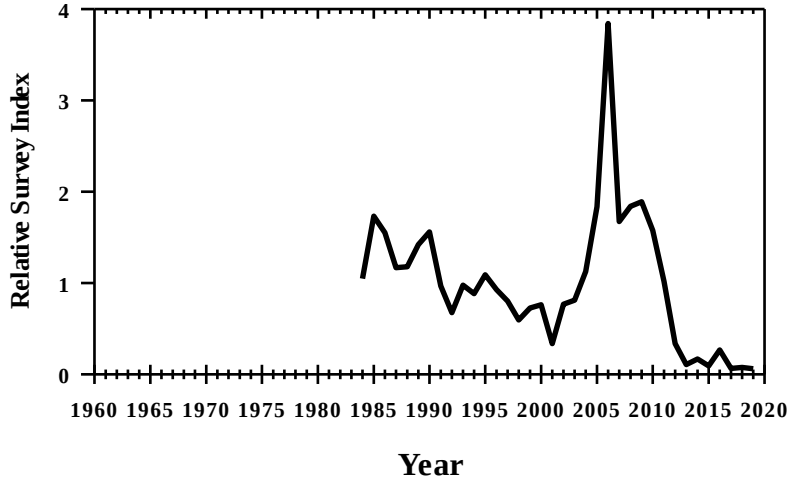

Figure 27. ASMFC summer shrimp survey biomass indices scaled to the mean for northern shrimp.

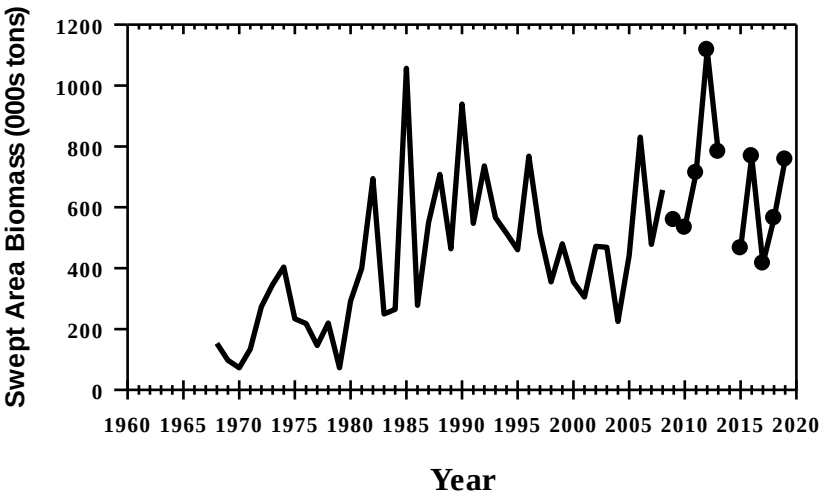

Figure 28. NEFSC spring bottom trawl survey biomass indices for spiny dogfish.

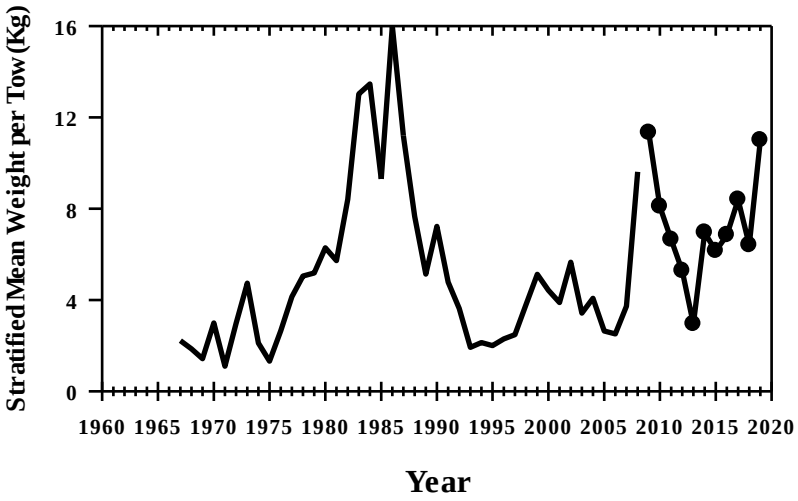

Figure 29. NEFSC autumn bottom trawl survey biomass indices for winter skate.

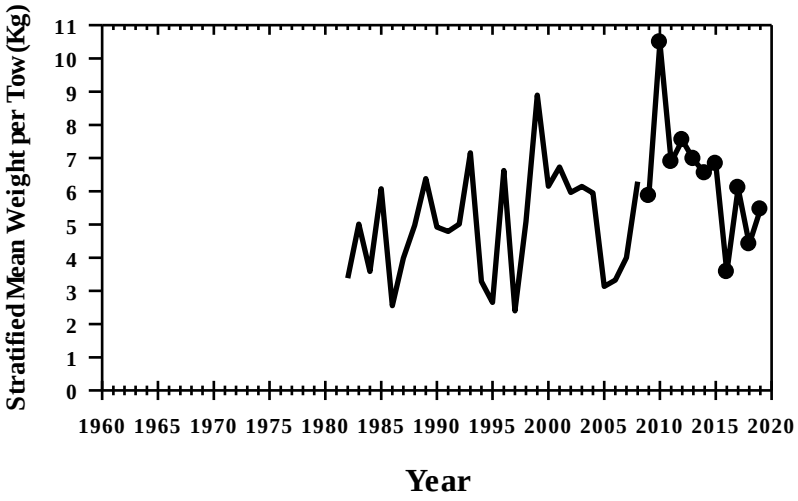

Figure 30. NEFSC spring bottom trawl survey biomass indices for little skate.

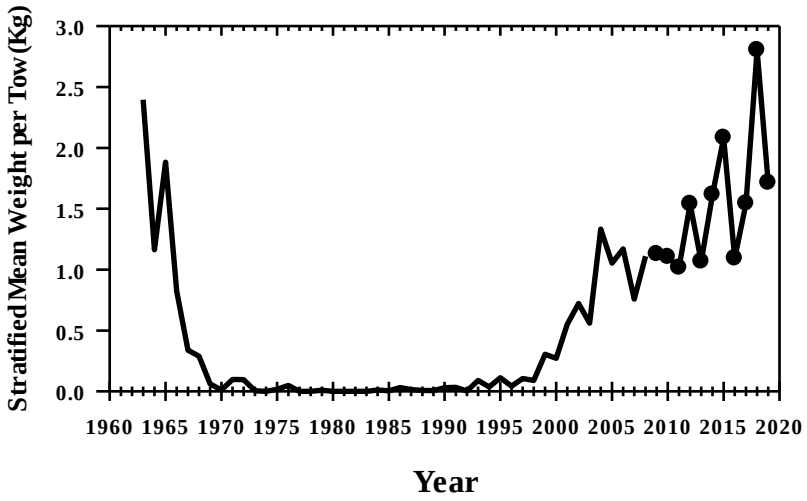

Figure 31. NEFSC autumn bottom trawl survey biomass indices for barndoor skate.

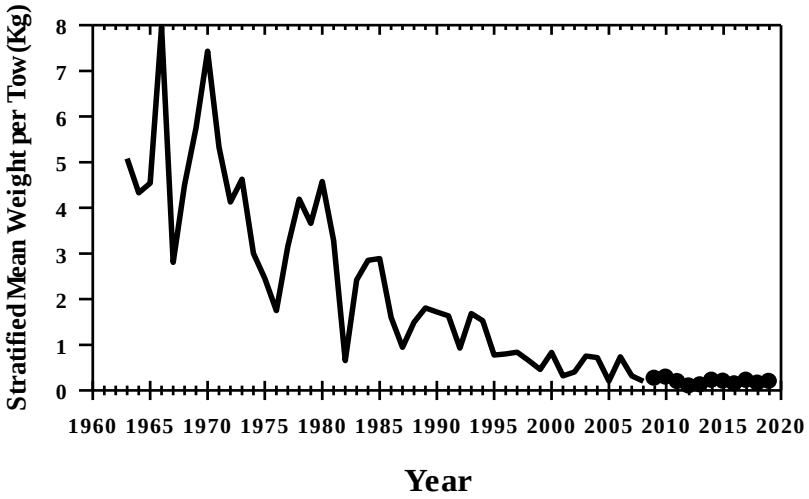

Figure 32. NEFSC autumn bottom trawl survey biomass indices for thorny skate.

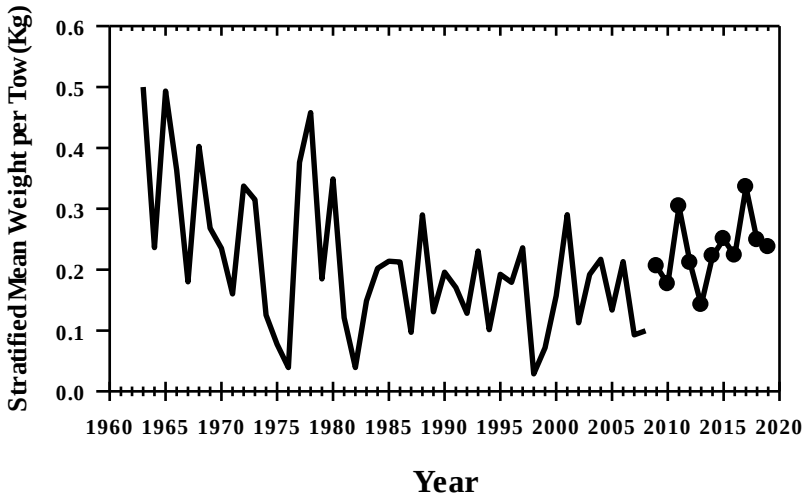

Figure 33. NEFSC autumn bottom trawl survey biomass indices for smooth skate.

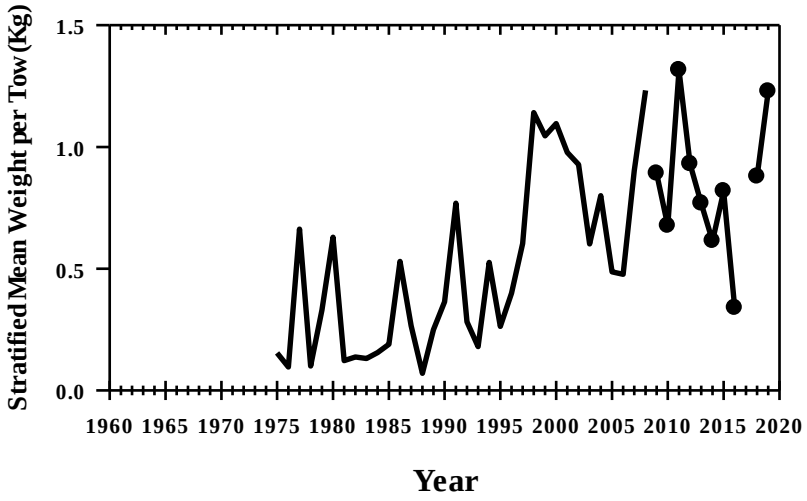

Figure 34. NEFSC autumn bottom trawl survey biomass indices for clearnose skate.

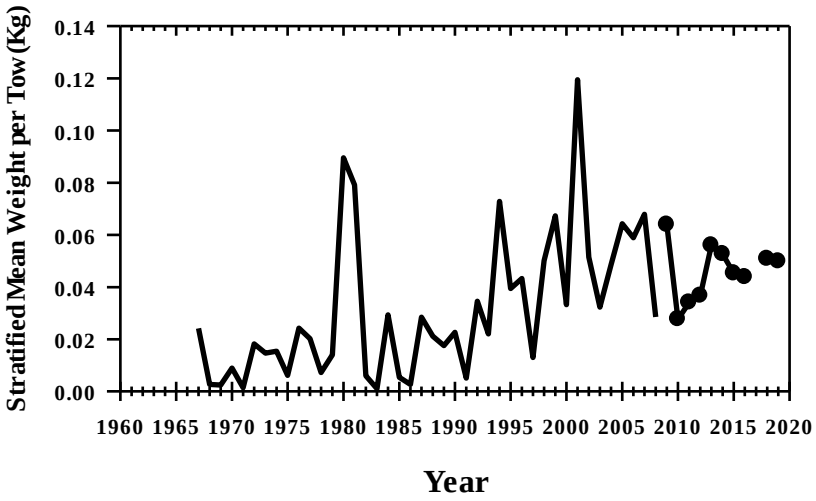

Figure 35. NEFSC autumn bottom trawl survey biomass indices for rosette skate.