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United States Research Report for 2020

by

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

Revised sampling and protocols were implemented in the Northeast Region in 1994, in 2004, and in 2010. Auditing and allocation procedures have been used to prorate total reported landings by species among areas. However, these procedures are subject to change and the landings, by area, are 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 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 this 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 this is discussed in those sections. Additionally, the survey was conducted on a different vessel the FSV *Pisces*, which is considered a sister ship of the FSV *Henry B. Bigelow*. The impact of this change is unknown but should be minimal. The spring survey in 2020 was only partially conducted covering NAFO Subarea 6 aboard the FSV *Henry B. Bigelow*. Due to COVID-19 only 133 stations out of the normal 350-380 were successfully completed. No fall survey was conducted. Therefore, the survey data for all species sections have not been updated.

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, Atlantic halibut, squids, and small elasmobranchs contain the landings and the discards of these species in 2020.

1. Atlantic Cod

United States commercial landings of Atlantic cod (*Gadus morhua*) in 2020 were 732 mt, a 27% decrease from the 2019 landings of 1009 mt. In addition, <0.1 mt were landed from Div. 3N and 0.5 mt were discarded in 2020.

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 2020 were 10,128 mt, a 17% increase from the 2019 landings of 8,692 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 10% from 5,320 mt in 2019 to 5,870 mt in 2020. 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 11% from 3,167 mt in 2019 to 3,525 mt in 2020. 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 2% from 1,828 mt in 2019 to 1,872 mt in 2020. 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 405 mt in 2020, a 51% increase from 2019 landings of 269 mt. In Div. 3N, landings increased by 79% from 222 mt in 2019 to 398 mt in 2020. Additionally, 4.5 mt of yellowtail flounder was discarded in Div. 3N bringing the total catch of yellowtail flounder in Div. 3N to 402.8 mt in 2020.

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 2020 totaled 6,181 mt, 5% lower than in 2019. Summer flounder (*Paralichthys dentatus*; 67%), witch flounder (*Glyptocephalus cynoglossus*; 14%), American plaice (*Hippoglossoides platessoides*; 11%), winter flounder (*Pseudopleuronectes americanus*; 8% 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 2020. Compared to 2019, commercial landings in 2020 were lower for American plaice (-30%), winter flounder (-16%), windowpane flounder (-7%) but higher for witch flounder (8%) and summer flounder (1%). The American plaice landings from Div. 3N were 41.5 mt. In addition, 10.1 mt of American plaice were discarded in Div. 3N bringing the total catch of American plaice in Div. 3N in 2017 to 51.6 mt. Witch flounder discards were 0,6 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 13% from 49.6 mt in 2019 to 43.2 mt in 2020. The discards in NAFO Subarea 3 were < 0.1 mt in 2020 and no landings were reported. 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 2019. In 2020, US commercial landings of silver hake totaled 5,072 mt, only a 3% difference compared to 2019 of 5,230 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 448 mt in 2019 to 328 mt in 2020, a 27% decline. 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 9,533 mt in 2020 and 12,999 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*) increased 49.4% from 5,379 mt in 2019 to 8,038 mt in 2020.

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*) decreased 30.9% from 3432 mt in 2019 to 2370 mt in 2020. 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 2007-2019 averaged 11,365 mt and declined by 25% in 2020 to 9,405 mt, which was 41% of the annual quota.

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 1987-2019, landings averaged 13,068 mt, with a low of 1,958 mt in 1988 and a high of 27,163 mt in 2019. In recent years, landings declined from 18,797 mt in 2011 to 2,422 mt in 2015, but then increased to a very high level in 2017 (22,516 mt). The US fishery experienced four consecutive years of very high landings during 2017-2020, resulting in fishery closures during each of these years. This type of trend has never occurred before in the domestic fishery. The 2004 time series high was exceeded in 2019 (27,163 mt) and again in 2020 (28,135) due to increases in fishing effort associated with quota increases of 1,900 mt (plus a quota overage of 9%) and 3,800 mt, respectively. 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 2020 were 22,179 mt (meats), a decline of about 5,500 mt from 2019. Landings are expected to decline further in the next several years due to the depletion of the large 2012 and 2013 year classes and the below average recruitment in subsequent years.

Biomass in 2020, based on dredge and optical surveys, was about 101,184 mt (meats) on Georges Bank and 38,061 mt (meats) in the Mid-Atlantic Bight, for a total of 139,244 mt (meats). This is about a 25% decline from the estimated 2019 biomass, although the stock remains above B_{MSY}. Recruitment was about average on Georges Bank and below average in the Mid-Atlantic Bight.

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*) remained stable from 7,910 mt in 2019 to 7,915 mt in 2020. 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 5.6% between 2019 and 2020 from 12,743 mt in 2019 to 13,453 mt in 2020. In addition, <1 mt of skate were landed and 13.7 mt were discarded in Div. 3N. 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 300 mt reported as unclassified in 2020, a reduction from 2.9% to 2.2% of the total.

Winter Skate

Winter skate (*Leucoraja ocellata*) reported landings increased by 25% between 2019 and 2020 from 7,968 mt to 9,970 mt. In addition, <1 mt of winter skate were landed and 6.1 mt were discarded in Div. 3N. 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 29.3% between 2019 and 2020 from 3,949 mt to 2,791 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 decreased 18% between 2019 and 2020 from 219 mt to 179 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 97% from 0.136 mt in 2019 to 0.004 mt. in 2020. In addition, 2.5 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. Smooth skate reported landings decreased by 25% between 2019 and 2020 from 218.5 mt to 164.5 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 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 increased by 263% between 2019 and 2020 from 13.1 mt to 47.7 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 to zero between 2019 and 2020 from <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 total of 139 CTD (conductivity, temperature, depth) profiles were collected and processed by the Northeast Fisheries Science Center (NEFSC) in 2020 over the course of 2 cruises. Most sea-going activities were canceled in response the global COVID-19 pandemic, resulting in drastically reduced sampling across the region. Of this total, 130 CTD profiles were obtained within NAFO Subareas 5 and 6, with no profiles collected in NAFO Subarea 4. These data are archived in an oracle database. Cruise reports, and annual hydrographic summaries are accessible at: https://www.fisheries.noaa.gov/resource/data/2010-2019-hydrographic-conditions-northeast-us-continental-shelf-conductivity. 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 were obtained by participants of the **Environmental Monitors on Lobster Trap Project** (see emolt.org) at approximately 30 fixed locations/depths around the Gulf of Maine and Southern New England Shelf. The results indicate that 2020 was, in general, a fairly normal year relative to the 20 years the project has been underway. Collaboration with similar projects like, for example, the **Fishermen Scientist Research Society** based in Nova Scotia and the **Commercial Fisheries Research Foundation** based in Rhode Island, has resulted in nearly doubling the master database.

Real-time bottom temperatures have now been reported from more than 50 commercial vessels. Approximately 4500 haul-averaged bottom temperatures were automatically transmitted via satellite from a variety of locations and depths in 2020 bringing the project total to nearly 14,000 hauls. Observations from both fixed and mobile gear are compared to three different local ocean models as well as the empirically-derived climatology. The results are displayed in both tabulated and mapped form.

Approximately 40 **satellite-tracked surface drifters** were deployed off the coast of New England in 2020 (see http://apps-nefsc.fisheries.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 can now be deployed on the few dozen unmanned sailboats (see http://educationalpassages.org) that are released each year.

b) Plankton Studies

During 2020, field operations to monitor zooplankton community distribution and abundance were severely curtailed due to the coronavirus pandemic, which halted surveys in the spring. As a result there were only two surveys taken, with a total of 45 bongo net tows made. One was aboard the FSV

Henry Bigelow during the spring trawl survey, which ended early after completing only 36 bongo net tows. The vessel returned to port to avoid the spread of Covid-19 among the crew and science staff. The other survey was aboard the FSV Gloria Michelle, which completed a short cruise with 9 bongo tows.

Since no dedicated ecosystem monitoring surveys were conducted in 2020, Imaging FlowCytoBotvideos of phytoplankton from the scientific seawater flow-through system were not collected. The absence of ecosystem monitoring surveys also meant that no Census of Marine Zooplankton samples were collected for the University of Connecticut, and no nutrient samples for the University of Maine. No ground-truthing of sea-surface water temperatures using a submersible radiometer during satellite overpasses was conducted, and there was also no continuation of the environmental DNA Program that was initiated in 2019.

c) Benthic Studies

No field work done for 2020

2. Biological Studies

a) Fish Species

Flatfishes: During 2015-2020, we have 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*. In 2019, we began a study contrasting response to elevated CO_2 of summer flounder (*Paralichthys dentatus*) offspring drawn from parents collected near the northerly (New Jersey) and southerly reaches of its geographic range (Virginia). Due to restrictions placed on our work by Hurricane Dorian (autumn, 2019) and COVID (March through December 2020), the study was restricted to New Jersey population only. This effort continued into 2020. 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. A similar evaluation of effects of thermal regimes on winter flounder (*Psuedopleuronectes americanus*) was conducted in the winter 2019-2020 where nine constant temperatures (7 to 15 °C) and one seasonally increasing one were implemented.

Sturgeons: Macro-phenotypic data on effects of thermal regimes and of contaminants that were collected during 2014-2017 are being further analyzed for publication.

Forage fish. A set of studies on Atlantic silverside, *Menidia menidia*, continued through 2019. Those studies focus on effects of climate (thermal and CO_2 variations), hypoxia, and parentage on key early life-stage traits (ELS). Those data are being further analyzed. An analogous system with a large number of treatment levels 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.

Indicator species. A study on the potential effects of contaminated sediments on finfish was initiated in 2020. Using white perch, *Morone americana*, as an indicator species but also an ecologically important one in estuaries and source river water in the Mid-Atlantic States, studies began on evidence of reproductive impairment in fish inhabiting waterways of New Jersey known to have been subjected to contaminants. Adults are being assayed for evidence of impairment at the genetic to organismal levels. Sediments are being used for exposure experiment on the embryos and young larvae. The study includes fish populations and sediments from target (contaminated) and reference locations.

Acoustic Studies: In order to better understand the sounds produced by fish species in our passive acoustic datasets, we have been working on linking passive acoustic data with underwater video footage collected from GoPros deployed near bottom-mounted recorders (SoundTraps) from areas off North Carolina to Florida. By doing this we can go through our passive acoustic datasets collected without concurrent visual data and attribute previously unknown sounds to particular fish species, thereby using passive acoustics as a method in improving our knowledge of temporal and spatial fish distributions. So far, 5 unique signals could be attributed to 5 different fish species. This work is ongoing, with more unique signals to be compared to video footage to determine the source.

b) Resource Survey Cruises

During 2020, personnel from the Ecosystems Surveys Branch (ESB) staged, staffed, and supported the spring multi-species bottom trawl survey for the one leg that took place prior to the remaining cruise legs being canceled as a result of the COVID-19 pandemic. The northern shrimp trawl survey, sea scallop dredge survey and the Atlantic surfclam dredge survey were canceled due to the COVID-19 pandemic. The survey staff efforts totaled 17 research sea days. NOAA scientific and contract staff involvement in the various cruises totaled 170 person sea days, and volunteers contributed another 85 person sea days. ESB cruises occupied 132 stations in an area extending from Cape Hatteras, North Carolina to Nova Scotia. A total of 57,794 length measurements were recorded, representing 229,111 individuals from 231 species during this cruise. 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 2020 to fulfill special survey sampling requests from 26 NOAA and university investigators. This sampling included 1,762 feeding ecology observations, collection of 2,157 aging structures, and acquisition of 36 samples/specimens to support additional shore-based research.

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 2020, FBP staff provided ages for over 28,200 otoliths and other hard structures from 21 species. The top species by number aged were scup (3,426), silver hake (3,331), haddock (3,324), and black sea bass (2,902). Large numbers of summer flounder, cod, and American plaice (combined total 5,980) 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 2020, 63 intra-reader precision tests were conducted across 19 species.

3. Inter-agency exchanges: For transboundary stocks, the FBP exchanges age structures with other laboratories. In 2020, there were no inter-agency exchanges conducted.

d) Food Web Dynamics

The NEFSC collections of fish diet data as part of a long-term (since 1973) monitoring program were heavily reduced in 2020 due to the COVID-19 pandemic. Despite the pandemic, data were collected and modeling and analytical efforts continued to focus on species interactions among small pelagics, flatfish, elasmobranchs, and gadiformes.

Fish diet samples were collected on the northeastern U.S. continental shelf and were limited primarily to the Mid-Atlantic Bight during the NEFSC spring bottom trawl survey. Estimates of prey volume and composition were made primarily at sea for selected species. During 2020, stomachs from 1,762 individuals and 38 species were examined in the spring. Data were not collected in the autumn. Diet sampling emphasized gadiformes, elasmobranchs, small pelagics, flatfishes, and lesser known species.

The time series of fish trophic interactions now spans 48 years (1973-2020). The majority of the time series is available for analysis, including data from over 685,000 stomach samples and over 160 predators. The processing of the 2020 bottom trawl survey diet data is scheduled for completion in 2021.

These 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 2020, 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, generating fish diet metadata and making them publically accessible, comparing footprints of fish predation pressure and bottom fishing effort on benthos relative to fish stock rebuilding, incorporating fish consumption into stock assessments, and evaluating fisheries reference points.

e) Apex Predators Program

Apex Predators Program (APP) 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 2020. 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. In 2020, CSTP summer tag distribution to commercial and recreational fishers was up 7% from last year and our recapture reporting rate thru October was up 25% from last year based on online and email reporting.

APP staff participated in the Southeast Data Assessment and Review (SEDAR) process in 2020 towards the assessment of the Atlantic blacktip shark population. A working paper was presented during the SEDAR 65 Assessment Workshop exploring multiple methods (three-year moving average of discard estimates, multi-year block averaging of discard estimates, and multi-year block averaging of discard ratios) for improving available discard time series (northeast sink gillnet fishery, the southeast coastal gillnet fishery, and the shark bottom longline fishery) to use in sensitivity analyses in the assessment of Atlantic blacktip sharks. Additionally, staff presented a working paper detailing the development of a recruitment index of abundance using standardized, young-of-the-year, catch-per-unit-effort data from the Cooperative Atlantic States Shark Pupping and Nursery (COASTSPAN) gillnet and longline surveys in a hierarchical analysis during the SEDAR 65 Assessment Workshop.

The NEFSC Coastal Shark Bottom Longline Survey and the majority of recreational shark tournaments were cancelled in 2020 limiting biological sampling to stranding events and opportunistic sampling of commercial incidental mortalities.

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 2020, our COASTSPAN participants were the Virginia Institute of Marine Science, South Carolina Department of Natural Resources (SCDNR), the University of North Florida (UNF), which conducted the survey in both Georgia and northern Florida waters, and Florida Atlantic University. NEFSC staff did not conduct COASTSPAN surveys in Narragansett and Delaware Bays in 2020. Results from 2020 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, standardized, young-of-the-year, catch-per-unit-effort data from COASTSPAN gillnet and longline surveys conducted by the SCDNR and UNF were used to create a recruitment index of abundance for Atlantic blacktip sharks during the SEDAR 65 assessment process.

In 2020, NEFSC staff from the Northeast Fisheries Observer Program and the APP worked in cooperation with staff from the Anderson Cabot Center for Ocean Life, Bedford Institute of Oceanography, Massachusetts Division of Marine Fisheries, and the University of Massachusetts Dartmouth to publish a study in *Fishery Bulletin*. This publication was on the seasonal distribution and habitat use of the common thresher shark, *Alopias vulpinus*, in the western North Atlantic Ocean (WNA) inferred from fishery-dependent data, a study topic needed to improve our understanding of these interactions for future management. Data on 3478 fishery-dependent capture records in the WNA between 1964 and 2019 were compiled and analyzed by sex and life stage (i.e., young of the year, juvenile, and adult). Capture locations occurred over a broad geographic range from the Gulf of Mexico to the Grand Banks, primarily in continental shelf waters shallower than 200 m. Seasonal north–south movements along the east coasts of the United States and Canada were observed for all life stages and both sexes, with occurrences at more northerly latitudes in the summer and more southerly latitudes in the winter. Distinct areas of frequent capture were identified for all life stages throughout their range. Common thresher sharks were most commonly observed in waters with sea-surface temperatures of 12–18°C (range: 4–31°C). These results will help to identify essential fish habitat for each life stage of common thresher sharks along the U.S east coast and to develop management measures for the WNA population.

APP staff contributed to a publication in *Marine and Freshwater Research* in 2020 of dissertation work by a University of Rhode Island graduate on the positional and ontogenetic variation in vertebral centra morphology in five batoid species. Elasmobranchs studies increasingly show that band-pair counts in vertebral centra do not accurately reflect age. Recent shark research indicates that the number of band pairs vary with body size and that centrum morphology is related to structural needs. This study examined the relationship between band-pair deposition and morphology of centra along the vertebral column, and ontogenetically, for five batoid species (little skate, *Leucoraja erinacea*, winter skate, *Leucoraja ocellata*, barndoor skate, *Dipturus laevis*, Atlantic stingray, *Dasyatis sabina*, and round ray, *Urobatis halleri*). Centrum morphology and band-pair count varied along the vertebral column in all individuals of all species, except in young of the year. Variation in band-pair counts among centra within individuals supports the hypothesis that band-pair formation is related to somatic growth and body shape rather than to an annual cycle.

In 2020, APP staff with coauthors from the South Carolina Department of Natural Resources, Mote Marine Laboratory's Center for Shark Research, and NOAA Fisheries Southeast Regional Office and Southeast Fisheries Science Center published a study in *Fishery Bulletin* on growth rates of bonnetheads, *Sphyrna tiburo*, estimated from tag-recapture data. Results from published age and growth models for bonnetheads indicate significant differences in life history between populations in the eastern Gulf of Mexico (GOM) and those in estuarine waters of the Atlantic coast of the southeastern United States. An age-independent model, GROTAG, was used with region-specific tag-recapture data to generate estimates of von Bertalanffy growth parameters and growth rates for sharks in each of these regions. Results from the GROTAG model indicate that female bonnetheads in the GOM initially grew faster and attained a smaller maximum size than females in the Atlantic region. The final GROTAG model for females in the Atlantic region produced estimates of von Bertalanffy parameters and growth rates similar to those produced by the age-based growth model. For the population in the GOM, GROTAG model results indicate that growth rates were slower and average maximum size and longevity were greater than those from age-based models. Although models for males were generated with tag-recapture data, large 95% confidence intervals hindered comparisons. For both sexes and regions, calculated maximum longevity and age at 50% maturity are larger than published estimates, indicating that age underestimation may have occurred in both age and growth studies, with significant differences in life history estimates for bonnetheads in the GOM.

APP staff contributed to a study on inferring life history characteristics of the oceanic whitetip shark, *Carcharhinus longimanus*, from vertebral bomb radiocarbon that was published in *Frontiers in Marine Science* with coauthors from the University of South Carolina and the University of Hawai'i in 2020. This work revealed that high-precision vertebral bomb radiocarbon measurements likely track philopatric movements in oceanic whitetip sharks. The use of a novel replicate sampling design revealed remarkably precise $\Delta\ ^{14}C$ patterns across vertebral centra within the same shark, giving the ability to infer migratory patterns based on dietary ^{14}C shifts over the lifespans of individual sharks. Further work using vertebral d ^{13}C patterns is needed to verify these findings. Age estimates were validated up to 13 years, but older specimens from sharks alive in the 1950s-60s are needed to validate longevity. The $\Delta\ ^{14}C$ of pre-birth material formed in utero is also reported, which may provide future insights into maternal movements and diet during gestation.

In 2020, APP staff worked in cooperation with staff from Macquarie University, the University of New Castle, and the Sydney Institute of Marine Sciences to publish a study in *Fisheries Research* on the inability to age common sawsharks, *Pristiophorus cirratus*, using traditional ageing methods. The vertebral morphology of common sawsharks was first assessed to determine the best method for band pair elucidation. Vertebrae located in the post-brachial region were identified as the largest and least variable for band pair analysis. A total of eight different age-determination methods were then applied to the shark vertebrae to test the viability of traditional and nontraditional techniques in elucidating band pairs. Band pairs were indeterminable across all treatments. This research adds to the growing body of evidence that vertebral band pairs may not be appropriate for age determination in some groups of sharks and that novel techniques need to be developed to accurately age sawsharks.

f) Marine Mammals

Cetacean surveys:

Fieldwork was limited in 2020 due to COVID-19 restrictions. One right whale cruise was conducted on the Gloria Michelle to collected photo id, biological and physical oceanographic data in the area of sighted right whales. This is part of an effort to better understand right whale prey resources in southern New England. Zooplankton samples were collected with bongo nets and were processed at the Poland Sorting Center, returning species ID and abundance for zooplankton species, and as well as life stage information for *Calanus finmarchicus*. We also collected VPR data to quantify zooplankton at particular depths in the water column. Lastly, we collected echosounding data multiple frequencies to be paired with VPR and bongo net data to examine the preyscape over a larger time and area. Analysis of these data is ongoing and will be compared with similar data collected in 2021.

Analysis and reporting of data collected as part of the Atlantic Marine Assessment Program for Protected Species (AMAPPS) continued in 2020. More information of this program as well as links to reports can be found at https://www.fisheries.noaa.gov/new-england-mid-atlantic/population-assessments/atlantic-marine-assessment-program-protected.

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 abundance. No flights were conducted in Canada in 2020 due to the COVID-19 pandemic. In the US, NARWSS flights conducted in 2020 followed systematic tracklines within these survey areas: Coastal Maine, Franklin Basin, Georges Basin, Great South Channel, Jeffreys Ledge & Wildcat Knoll, Jordan Basin & Jeffreys Bank, Martha's Vineyard & Nantucket, New York shipping lanes, Rhode Island Sound, and South East of Nantucket. During 2020, NARWSS flew 171 hours over 34 surveys. NARWSS detected 335 right whales (including duplicate sightings of the same individual), with 333 right whales sighted within survey blocks and 2 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 2020 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.

In 2020, the NEFSC gear research program continued to focus on testing buoyless systems in the lobster fishery to reduce large whale and sea turtle entanglements. We procured ropeless systems from seven different manufacturers. These systems were added to a "gear library" that we are maintaining to provide fishermen and researchers ropeless systems to trial and develop. We have leveraged systems from multiple NGOs and presently have over 50 systems available for testing. Additionally, we have worked with multiple offshore and inshore fishermen to trial ropeless systems. The goals of these trails are to: (1) facilitate discussion and communication between fishermen, engineers, NGOs and managers, (2) brainstorm solutions to operational issues, (3) collect data to inform the development of ropeless technologies. Another effort was a NASA technology search to provide market research of companies capable of assisting in the development of geolocation strategies. We were able to identify multiple groups who have the capacity to assist in this effort.

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; (3) improve the application of passive acoustics as a tool for monitoring and mitigation; and (4) set up a long term database for acoustic data collection and detection information.

In March/June 2020, 8 SoundTraps were deployed along the coast of Maine. These deployments include a continuous monitoring effort, primarily focused for monitoring for North Atlantic right whale presence. Additionally, acoustic recorders were deployed in waters south of Cape Cod to monitor for North Atlantic right whales, Atlantic Cod, and Harbor Porpoises. Acoustic recorders were also deployed seasonally in three National Marine Sanctuaries (Stellwagen Bank, Gray's Reef, and Florida Keys), as part of a collaborative effort to evaluate sanctuary soundscapes throughout National Marine Sanctuaries. 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, Stellwagen Bank National Marine Sanctuary, and Cox Ledge; real-time monitoring buoys are also active off Martha's Vineyard, the New York Bight, the New Jersey Coast, and Cape Hatteras, North Carolina. 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/. Additionally, detections from these real-time platforms are being used to trigger North Atlantic right whale Slow Zones.

SanctSound is a national level acoustic monitoring program of marine sanctuaries within US waters. Its goal is to understand contributors to the soundscape of the various marine sanctuaries. During 2020, analyses continued calculating sound metrics, and running detectors for daily, hourly, or encounter level presence of anthropogenic (vessels) and biological sound sources (baleen whales, dolphins, fish, snapping shrimp). More information on this project and the various data products available can be found on their website: https://sanctuaries.noaa.gov/science/monitoring/sound/.

Outside of US waters, the Passive Acoustic Research Group is also monitoring the soundscapes at Australian Marine Parks, with the goal being to detect and classify illegal vessel activities within the parks. Additionally, we are also characterizing the biological sound sources and calculating sound metrics to provide a complete view of the soundscape. Of the parks analyzed in 2020, the soundscape was mainly comprised of biological sound sources, with one park (Murat) only having 4 instances of vessel presence over approximately a two month period.

As part of the AMAPPS program, analyses of the distributions of sperm whales, beaked whales, members of the Kogiidae family, and baleen whales continued for data collected both on the towed array and bottom mounted recorders deployed in previous years. Finer scale studies of improving classification methods of passive acoustic data using machine learning continued, as well as looking at the effects of naval sonar on beaked whale acoustic detections and assessing the diving behavior of True's beaked whales (*Mesoplodon mirus*) combining both dTag and focal follow datasets. Using bottom mounted recorders deployed along the shelf break from 2016, seismic airgun pulses were examined and time delays between recorders were calculated in an effort to localize where seismic activity was being conducted.

The Passive Acoustic Group is working on creating a database to store information for recordings and cetacean detections. Additionally, they have created a web application to display all detection information from various times, analyses, and across recording platforms, as a tool to be able to view all available data that have been analyzed since 2004. We are building this tool to allow for inclusion from any colleague or stakeholder collecting and analyzing for acoustic detections and will be integral with the Wind Energy companies who will be collecting and monitoring for baleen whale species, specifically North Atlantic right whales, during operations.

Several manuscripts were published, on topics ranging from the distribution, and changes thereof, of baleen whale species in the North Atlantic, to the monitoring of vessel activity in marine parks, to monitoring for Atlantic Cod and studying the acoustic communication in Black Sea Bass. A number of additional manuscripts involving colleagues from the Passive Acoustics Group were published in 2020. See our website for more details (https://www.fisheries.noaa.gov/resource/peer-reviewed-research/publications-northeast-passive-acoustic-research-staff).

Pinnipeds:

In 2020 the NEFSC, in collaboration with non-governmental organizations, captured 56 weaned gray seal pups to study health and habitat usage. Twenty satellite tags and 10 acoustic tags were deployed during these captures. A manuscript is currently in review which uses telemetry data collected in 2019 and 2020 to evaluate gray seal susceptibility to fisheries bycatch and other anthropogenic risks. Other fieldwork was curtailed due to COVID-19. In 2020 the NEFSC also completed a population trend analysis of Atlantic harbor seals and updated estimates of abundance based on a 2018 survey. A manuscript documenting the results is currently in review.

The NEFSC mentored 2 NOAA Hollings students in 2020 working on seal related projects. One student developed algorithms to automatically count seals from aerial surveys using Video and Image Analytics for Marine Environments (VIAME) software. The other student analyzed harbor and gray seal aerial survey counts collected just after the 2018 Unusual Mortality Event (UME).

Work continued in 2020 to collect data on 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 hard part remains obtained from bycaught harbor and gray seals. Analysis of hard part remains, and prey fatty acid signature data will begin in 2021. In addition, a pilot study that began in 2018 continues to investigate the feasibility of seal diet analysis via DNA analysis of pinniped scat and stomachs. Initial results processed at the University of Guelph were not sufficient to confidently identify seal prey so alternate methods are being explored including DNA extraction using a Qiagen Stool kit designed to maximize DNA yield for fecal samples. Samples are currently at a next generation sequencing facility, and data should be available for interpretation later this year.

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 the Greater Atlantic; and (2) assess and reduce sea turtle bycatch in U.S. commercial fisheries in the Northwest Atlantic Ocean.

During 2020, the NEFSC Turtle Ecology Team attempted as much fieldwork as possible. In May, we had 2 weeks of small boat leatherback turtle (*Dermochelys coriacea*) research planned in coastal North Carolina. The primary objective was to deploy satellite tags on migrating leatherbacks. In June, we had a loggerhead turtle (*Caretta caretta*) research cruise scheduled on the NOAA ship Gordon Gunter. Primary cruise objectives were to deploy satellite tags on loggerheads and to perform laparoscopies on as many loggerheads as possible to validate hormone-based sex ratio estimates. Pandemic restrictions resulted in the cancellation of the above activities. In late summer and early fall of 2020, we planned small boat work in coastal Massachusetts to deploy satellite tags and suction cup tags on leatherbacks. Covid restrictions prevented us from deploying the satellite tags (because close contact between researchers would have been required to capture the leatherbacks in preparation for satellite tag attachment). With mitigation measures in place, we were able to undertake the higher resolution suction cup tagging of leatherback sea turtles in coastal Massachusetts in the early fall. From 24

September to 23 October 2020, we successfully conducted several day trips for leatherback tagging within Massachusetts state waters and deployed 11 camera tags. Gathering this second year of foraging and diving data will allow us to begin to examine year-to-year variation. The team continued database development, ecological analysis, and manuscript preparation.

Finally, this winter we successfully navigated the hurdles of COVID-19 and completed a comparative study of a low-profile gillnet to reduce sea turtle bycatch. Preliminary results show that the large mesh bottom set gillnet with the tie-down height reduced by half, reduced the bycatch of sea turtles in the study by ~60%. As this work was recently completed, robust data analysis and reports have not yet been completed. This is the same design that was previously tested in the sturgeon fishery with similar positive results. It has also been shown to only minimally reduce the catch of the target species, primarily monkfish.

h) Environmental DNA

1) Processed metabarcoding samples for a continental shelf faunal survey. Two hundred eDNA samples collected from the 2019 ecosystem monitoring survey aboard NOAA Ship Gordon Gunter were processed with DNA extraction and polymerase chain reaction. These samples are at a next generation sequencing facility and raw data should be available later this year.

2) Processed metabarcoding samples for an investigation of seal trophic dynamics. One hundred eDNA samples from grey seal and harbor seal fecal samples were processed with DNA extraction and polymerase chain reaction to study the vertebrate species that these marine mammals consume. These samples are at a next generation sequencing facility and raw data should be available later this year.

3) Expanding reference materials in GenBank. NEFSC collaborated with Rockefeller University, Smithsonian National Museum of Natural History, Florida Fish and Wildlife Conservation Commission and South Carolina Department of Natural Resources Marine Resources Institute to enrich the existing reference library of barcode regions of fishes common in the Western Atlantic.

4) Analyzed samples of sugar kelp to provide guidance on siting aquaculture operations. eDNA metabarcoding data analysis is being conducted on microbial communities associated with aquacultured sugar kelp. The goal is to identify potential microbial pathogens and to provide advice on site selection of sugar kelp farms and monitoring efforts.

3. Studies of Fishing Operations

In 2020, NEFSC Observers were deployed on 870 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 documented 95 marine mammal incidental takes and 210 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 390 trips aboard commercial fishing vessels in 2020. On these trips there were 20 marine mammal, and 73 seabird incidental takes documented.

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

In the sink anchored gillnet fishery, 234 trips were observed with a total of 956 gear retrievals by Observers. There were 29 observed marine mammal takes in this fishery (13 gray seals, seven harbor porpoises, six harbor seals, two common dolphins, and one unidentified seal). There were also 201 seabird takes (including 128 greater shearwater) observed in this fishery.

At-Sea Monitors observed 55 trips in the sink anchored gillnet fishery with 244 gear retrievals. There were five marine mammal (four harbor porpoises and one gray seal) and 68 seabird incidental takes recorded in this fishery by Monitors.

b. Float Drift Gillnet Fishery

There were six floating drift gillnet trips with 18 gear retrievals observed in 2020. There were no marine mammal, sea turtle or seabird incidental takes observed.

No Monitors deployed on float drift gillnet trips in 2020.

c. Otter Trawl Fisheries

In the bottom otter trawl fishery 326 trips were observed with a total of 2,933 gear retrievals recorded by Observers. In addition, there were seven midwater trawl trips with 15 gear retrievals, two haddock separator trawl trips with 48 gear retrievals, nine twin trawl trips with 116 gear retrievals, and one Ruhle trawl trip with ten gear retrievals observed in 2020.

In the bottom otter trawl fishery, there were 60 observed marine mammal takes (51 common dolphins, two Risso's dolphins, two gray seals, one bottlenose dolphin, one whitesided dolphin, one harbor seal, one unidentified pilot whale and one unidentified dolphin). There were also seven seabird takes in this fishery. There was one common dolphin take documented in the Ruhle trawl fishery. There were four common dolphin takes documented on twin trawl trips. There were no incidental takes observed on midwater trawl, haddock separator trawl, scallop trawl, shrimp bottom otter trawl or large mesh belly panel trawl trips in 2020.

At-Sea Monitors deployed on 322 bottom otter trawl trips with 3,680 gear retrievals and ten haddock separator trawl trips with 282 gear retrievals, but no Ruhle trawl or twin trawl trips in 2020. There were four whitesided dolphins, four gray seals, two common dolphins, one harbor seal, one unidentified pilot whale and one unidentified whale and five seabird takes recorded by Monitors in the bottom otter trawl fishery. There were two gray seal takes documented by Monitors on the haddock separator trawl trips in 2020.

d. Sea Scallop Dredge Fishery

In the sea scallop dredge fishery, 168 trips were observed with a total of 10,714 gear retrievals. There was one gray seal take observed in this fishery.

No Monitors deployed in the scallop dredge fishery in 2020.

e. Scottish Seine Fishery

No Scottish seine trips were covered by Observers or Monitors in 2020.

f. Drift Sink Gillnet Fishery

In the drift sink gillnet fishery in 2020, Observers deployed on 54 trips with a total of 344 gear retrievals. There were two seabird takes in this fishery.

One drift sink gillnet trip with five gear retrievals was covered in 2020. There were no takes documented on this trip.

g. Anchored Floating Gillnet Fishery

No Observers deployed on anchored floating gillnet trips in 2020.

No Monitors deployed on anchored floating gillnet trips in 2020.

h. Mid-water Pair Trawl Fishery

In 2020, there were eight mid-water pair trawl trips observed with a total of six 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 2020.

i. Bottom Longline Fishery

In the bottom longline fishery in 2020, there were four trips observed with a total of 48 gear retrievals. There were no marine mammal, sea turtle or seabird takes observed in the bottom longline fishery.

At-Sea Monitors covered two bottom longline trips with seven gear retrievals in 2020. 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 2020.

k. Pound Net Fishery

No pound net trips were covered by Observers or Monitors in 2020.

l. Handline/Trolling Fisheries

In 2020, there were four handline trips and ten gear retrievals observed. There were no marine mammal, sea turtle or seabird takes in the handline fishery. There were no troll line or auto-jig handline trips observed.

Monitors did not deploy on handline, troll line or auto-jig trips in 2020.

m. Herring Purse Seine Fishery

In 2020, there were two herring purse seine trips with two gear retrievals observed. There were no takes observed.

No herring purse seine trips were covered by Monitors in 2020.

n. Menhaden Purse Seine Fishery

No menhaden purse seine trips were covered by Observers or Monitors in 2020.

o. Tuna Purse Seine Fishery

No tuna purse seine trips were covered by Observers or Monitors in 2020.

p. Pot / Trap Fisheries

In 2020, there were 11 lobster pot trips with 248 gear retrievals, five fish pot trips with 80 gear retrievals, five conch pot trips with 87 gear retrievals and eight crab pot trips with 120 gear retrievals. There were no marine mammal, sea turtle or seabird takes in these fisheries. There were no hagfish pot, blue crab trap or whelk pot trips observed.

No lobster, fish, conch, hagfish, crab, blue crab or whelk pot trips were covered by Monitors in 2020.

q. Beam Trawl Fisheries

No beam trawl trips covered by Observers or Monitors in 2020.

r. Clam Dredge Fishery

There were 16 clam dredge trips with 485 gear retrievals in 2020. There were no observed takes of marine mammals, sea turtles or seabirds on these trips.

No clam dredge trips were covered by Monitors in 2020.

s. Other Dredge Fisheries

No other dredge trips were covered by Observers or Monitors in 2020.

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.

The Northeast Region recently revamped its stock assessment scheduling and review process system to better serve our management partners. The region has transitioned to a new stock assessment process that separates stock assessment development from operational stock assessments used to inform management. The Research Track Assessment Process is designed to develop, review and implement new stock assessment approaches for individual or groups of species. Results of the Research Track are not used directly in management, rather they establish the stock assessment approaches and methods that will be used in the Management Track process. The Management Track process is designed to develop, review and approve updated stock assessments for use in management (e.g. specification setting).

In 2020, the Northeast Region conducted two Research Track Assessments, one on Red Hake stock structure and another on Index Based Methods for informing management. In 2021-2022, Research Track Assessments are planned for haddock (Gulf of Maine and Georges Bank), shortfin inshore squid (Georges Bank/Cape Hatteras), butterfish (Gulf of Maine/Cape Hatteras), American plaice (Gulf of Maine/Georges Bank), bluefish (Atlantic Coast), black sea Bass (Gulf of Maine/Cape Hatteras) and spiny dogfish (Atlantic Coast).

In addition, the Management Track produced updated stock assessments in 2020 for Atlantic herring (Northwestern Atlantic Coast), Atlantic surfclam (Mid-Atlantic Coast), butterfish (Gulf of Maine/Cape Hatteras), longfin inshore squid (Georges Bank/Cape Hatteras), ocean quahog (Atlantic Coast), Acadian redfish (Gulf of Maine / Georges Bank), American lobster (Gulf of Maine/Georges Bank & Southern New England), Atlantic halibut (Northwestern Atlantic Coast), Atlantic wolffish (Gulf of Maine/Georges Bank), ocean pout (Northwestern Atlantic Coast), red hake (Gulf of Maine/Northern Georges Bank), red hake (Southern Georges Bank/Mid-Atlantic), sea scallop (Northwestern Atlantic Coast), silver & offshore hake (Southern Georges Bank/Mid-Atlantic), silver hake (Gulf of Maine / Northern Georges Bank), windowpane flounder (Gulf of Maine/Georges Bank & Southern New England/Mid-Atlantic), and winter flounder (Georges Bank, Gulf of Maine, Southern New England/Mid-Atlantic).

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 2020, stock assessments conducted and reviewed through the TRAC process included Eastern Georges Bank cod, Eastern Georges Bank haddock, and Georges Bank yellowtail flounder.

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.

Research has recently 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. However, in 2020 these research efforts were not conducted due the COVID-19 pandemic. Our expectations are that these activities will continue once the go-ahead is given to resume in a safe capacity.

c) Cooperative Research

Industry-Based Gulf of Maine Bottom Longline Survey

During 2020 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 normally biannual survey was conducted in 2020 completing 45 stations in the fall only (Oct-Nov) with a total of 24 days at sea on two chartered commercial vessels. The spring survey (April-May) did not occur in 2020. A total of 7,411 lengths were measured representing 7,768 individual organisms. Biological sampling of 750 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.

Development of CPUE indices from fishery data

In 2020 we worked to leverage existing fishery data sets to create standardized catch per unit effort (CPUE) time series to inform a number of stock assessments. In the northeast US the development of electronic logbook technology and a sustained investment in the Northeast Fisheries Science Center's Cooperative Study Fleet Research Program has greatly facilitated the collection of high-resolution catch, effort, and environmental data by fishing captains. Fine-scale data from a number of the region's fisheries has accumulated over the past fifteen years, as the hardware and software associated with the logbooks has evolved. Today this data set is an extensive time series that is utilized by regional scientists and managers. This fine-scale catch and effort information is similar to the data collected by the NEFSC's observer program, and can be used to answer a variety of research questions about catch rates, environmental drivers, and fishery dynamics. For example, Study Fleet catch and effort data has been utilized in the stock assessments for summer flounder (*Paralichthys dentatus*) and scup (*Stenotomus chrysops*). In 2020, we worked to develop standardized CPUE time series to inform the stock assessment for haddock (*Melanogrammus aeglefinus*) and provide scientific advice on northern shortfin squid (*Illex illecebrosus)* for the Mid-Atlantic Fisheries Management Council. In addition to these concrete applications of fishery data, a larger collaborative project aimed at developing standardized CPUE indices for species regulated in the large mesh groundfish fishery was initiated in collaboration with scientists from University of Massachusetts Dartmouth's School for Marine Science & Technology and the New England Fisheries Management Council.

Application of fishery data to evaluate operational conflicts with wind developments

The fine-scale fishery data collected from the Northeast Fisheries Science Center's Cooperative Study Fleet Research Program was also used in 2020 to enhance our understanding of fishery footprints and the potential spatial conflict with planned offshore wind energy developments. For this work, the time series of fine scale effort information was explored for the longfin squid fishery (*Doryteuthis pealeii*).

Preliminary results suggest that the fine-scale effort information collected by the Northeast Fisheries Science Center's Cooperative Study Fleet Research Program improves our understanding of the impact of offshore wind energy development on fishing operations by better characterizing the true footprint of individual fishing trips and effort events, and by providing higher coverage in fisheries that are likely to be impacted (e.g., the longfin squid (*Doryteuthis pealeii*) fishery).

Exploration of empirical conversion factors

The Northeast Fisheries Science Center's Cooperative Research Branch has collected paired weight estimates (whole/round, head/gutted) from a number of groundfish species over the last ten years. In 2020, we analyzed the results from this research to help inform the haddock stock assessment. This involved comparing the conversion factor (the ratio of whole:gutted weights) recorded by our scientific staff in recent years to those that have historically been used in the haddock stock assessment. Results from this pilot suggested that the current value used in the US haddock stock assessment (1.14) may be slightly lower (~5%) than the true conversion factor, but further work is needed to evaluate seasonal variation in the conversion factor ratio as well as potential differences caused by different processing methods (gutting by hand vs. via machine).

Estimates of the previously unaccounted for releases of butterfish

As part of the butterfish research track assessment, we developed a method to estimate the weight of butterfish that were likely released and not accounted for in the current discard estimates. This involved curating the observer records of releases of butterfish from 2014-2019 (the period when releases have been systematically recorded), consulting members of the fishing industry who participate in the butterfish fishery and developing a method to expand observer-recorded butterfish releases to the larger set of trips. These expanded estimates were then included in a recent management update of the butterfish stock assessment. Results from these explorations indicated that these releases do not impact the assessment in a significant way.

In 2020, Cooperative Research Branch staff conducted analyses in support of the Mid-Atlantic Fishery Management Council's Illex Working Group. Fishery independent survey data from the NEFSC and several state-run bottom trawl surveys were incorporated into a species distribution model for the southern component of the northern shortfin squid (*Illex illecebrosus*) stock. The modeled occupied area was compared to the approximate area accessed by the fishery to derive an estimate of *I. illecebrosus* availability to the U.S. shortfin squid fishery. The availability estimate was considered in quota adjustments for this data-limited stock. In late 2020, CRB staff began developing additional analyses and support tools as well as gathering qualitative information from *Illex* harvesters to inform model-building and provide context for consideration in 2021 research track stock assessment.

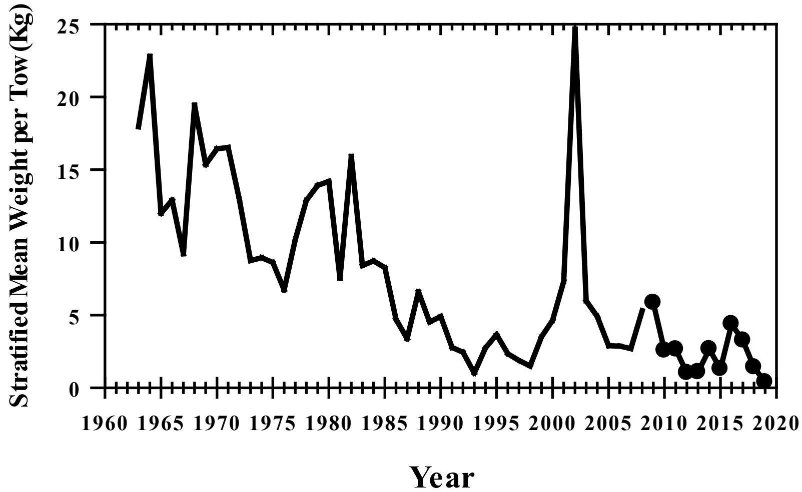

Figure 1. NEFSC autumn bottom trawl survey biomass indices for Gulf of Maine cod.

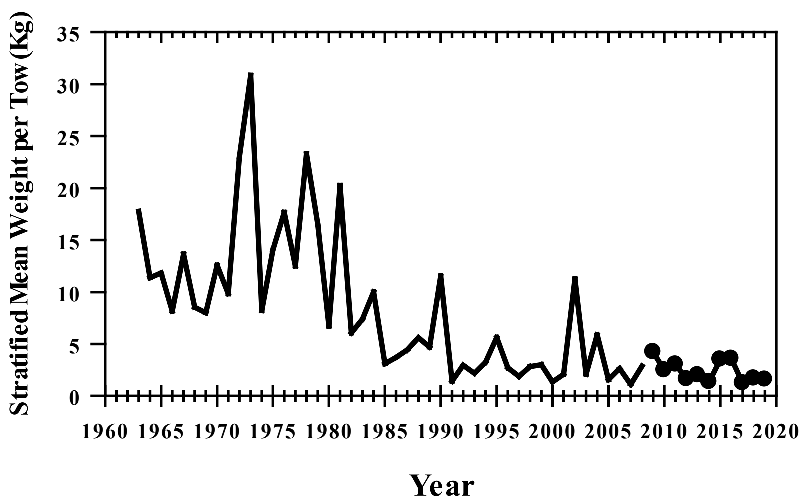

Figure 2. NEFSC autumn bottom trawl survey biomass indices for Georges Bank cod.

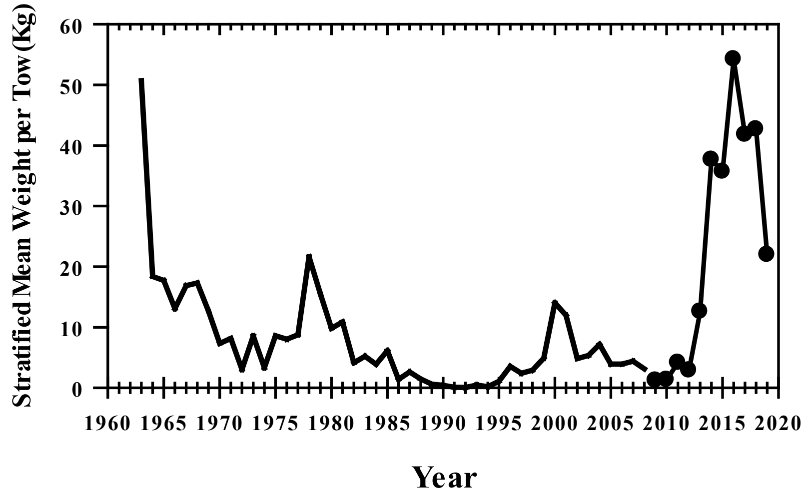

Figure 3. NEFSC autumn bottom trawl survey biomass indices for Gulf of Maine haddock.

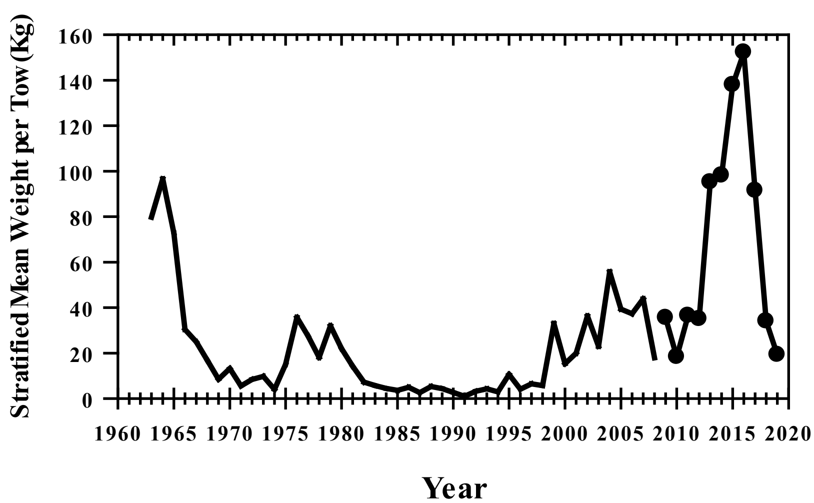

Figure 4. NEFSC autumn bottom trawl survey biomass indices for Georges Bank haddock.

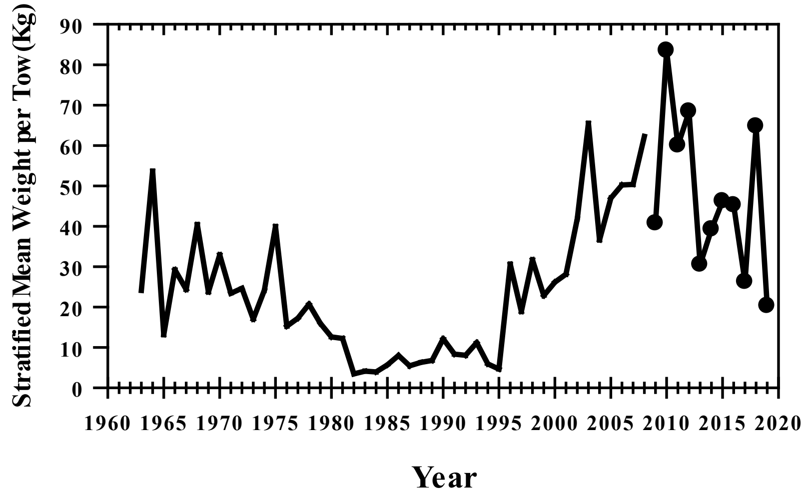

Figure 5. NEFSC autumn bottom trawl survey biomass indices for Acadian redfish.

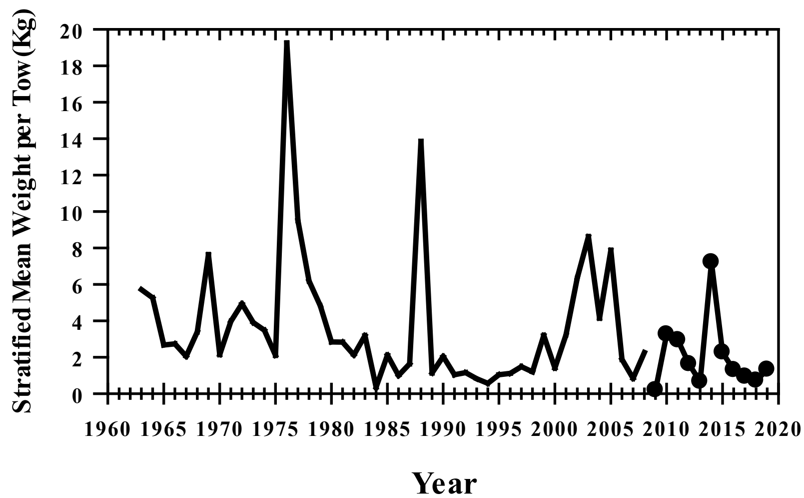

Figure 6. NEFSC autumn bottom trawl survey biomass indices for pollock.

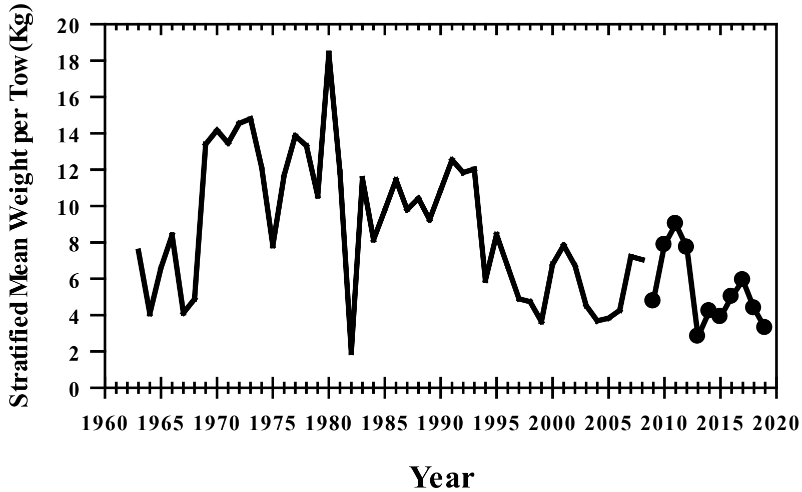

Figure 7. NEFSC autumn bottom trawl survey biomass indices for white hake.

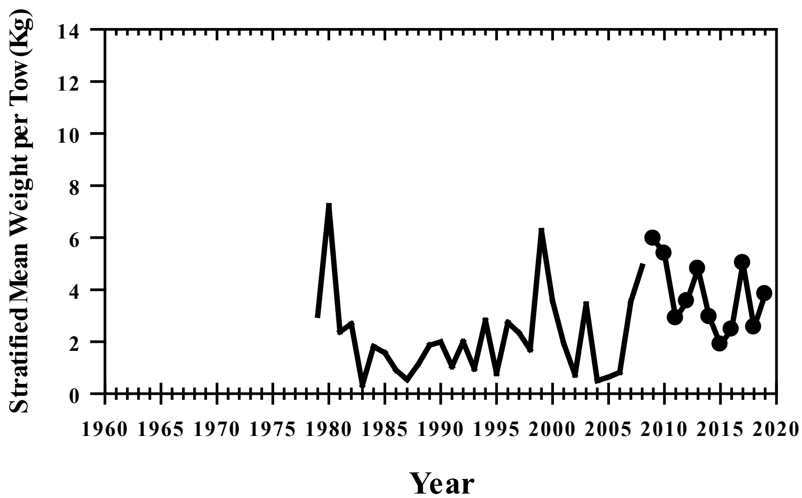

Figure 8. NEFSC autumn bottom trawl survey biomass indices for Cape Cod-Gulf of Maine yellowtail flounder.

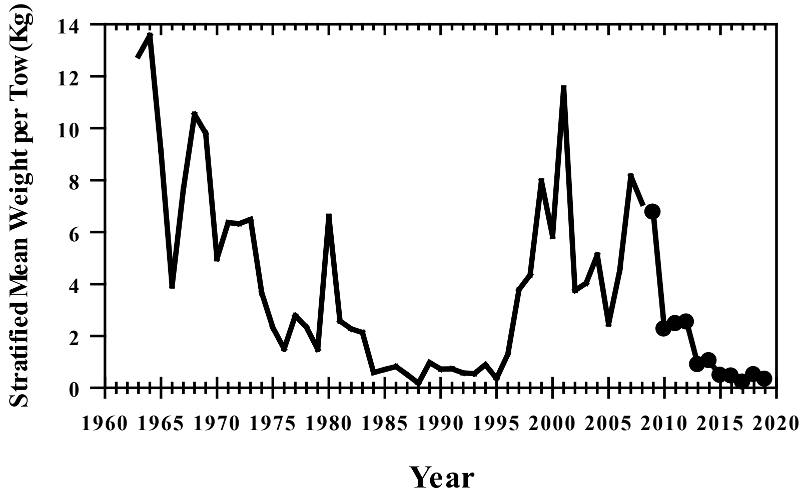

Figure 9. NEFSC autumn bottom trawl survey biomass indices for Georges Bank yellowtail flounder.

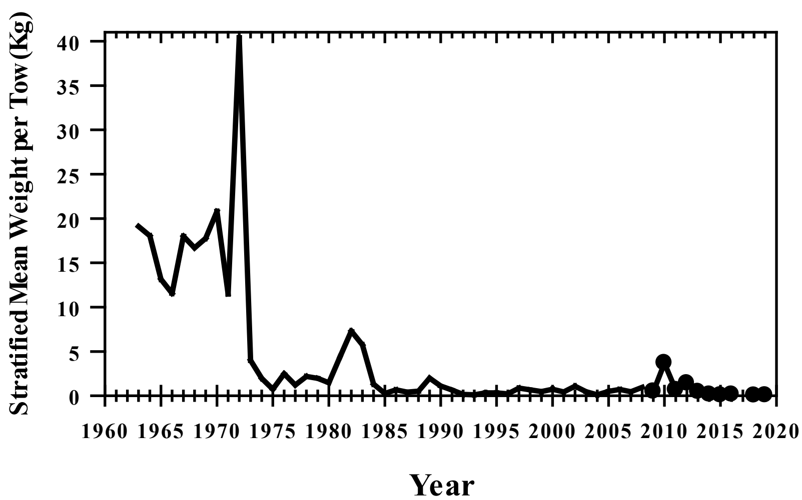

Figure 10. NEFSC autumn bottom trawl survey biomass indices for Southern New England-Mid-Atlantic yellowtail flounder.

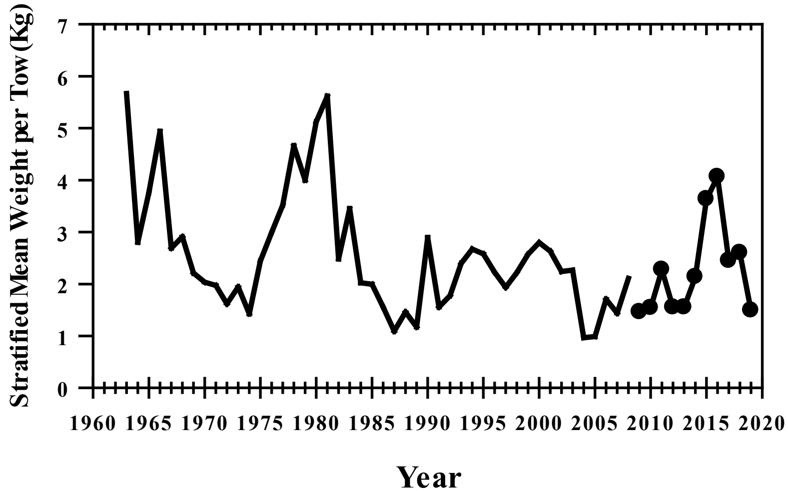

Figure 11. NEFSC autumn bottom trawl survey biomass indices for American plaice.

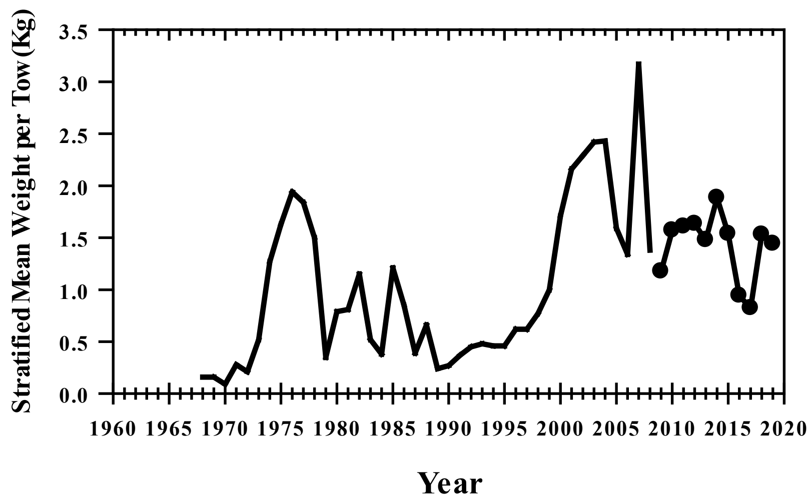

Figure 12. NEFSC spring bottom trawl survey biomass indices for summer flounder.

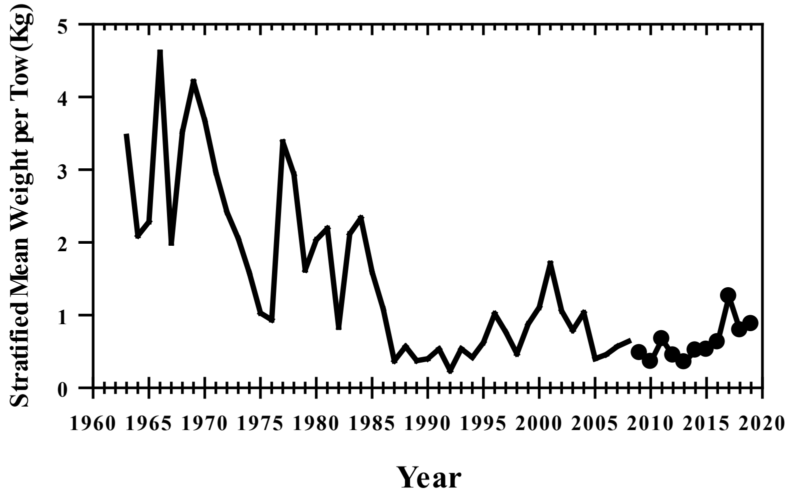

Figure 13. NEFSC autumn bottom trawl survey biomass indices for witch flounder.

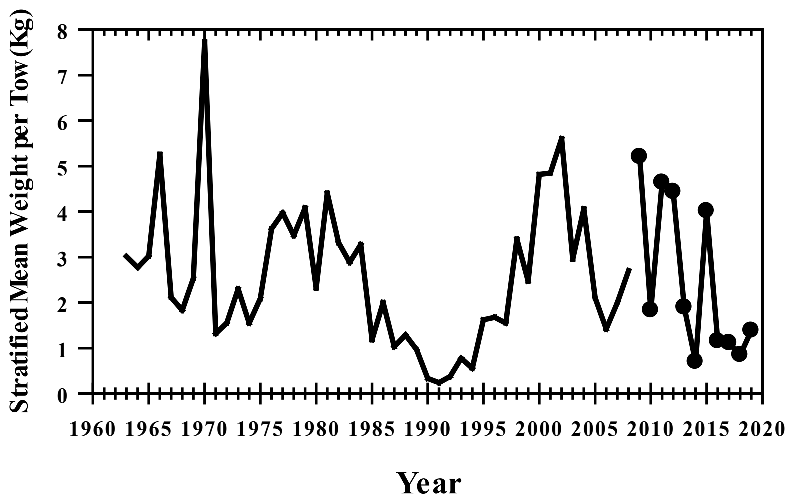

Figure 14. NEFSC autumn bottom trawl survey biomass indices for Georges Bank winter flounder.

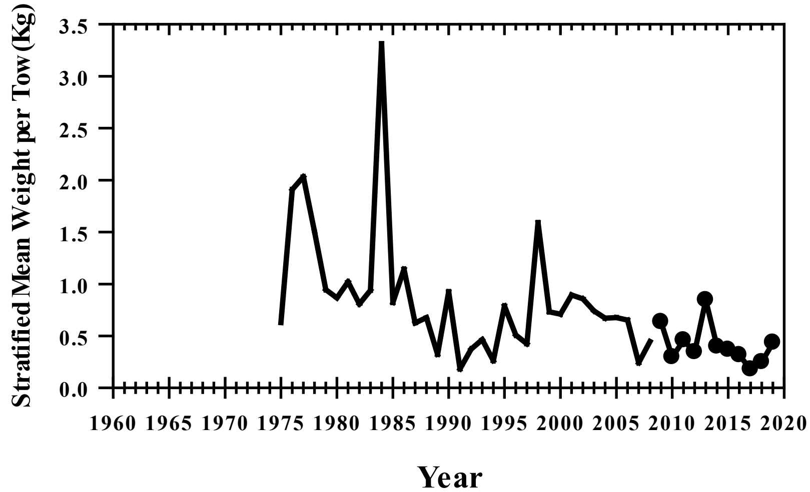

Figure 15. NEFSC autumn bottom trawl survey biomass indices for northern windowpane flounder.

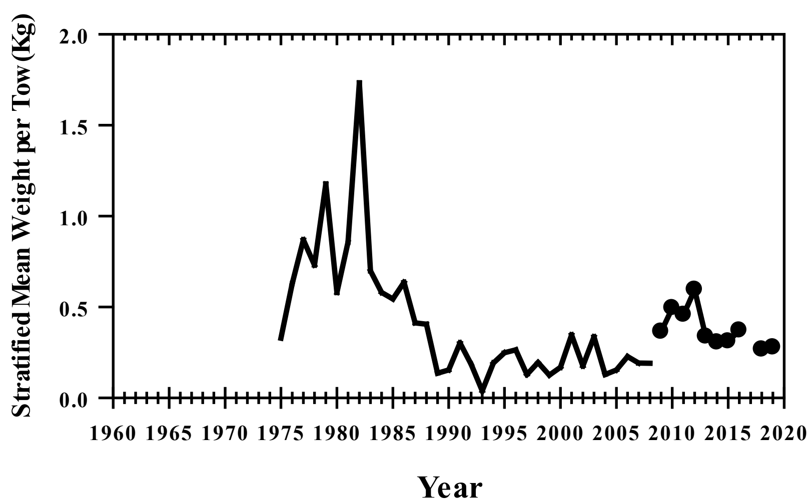

Figure 16. NEFSC autumn bottom trawl survey biomass indices for southern windowpane flounder.

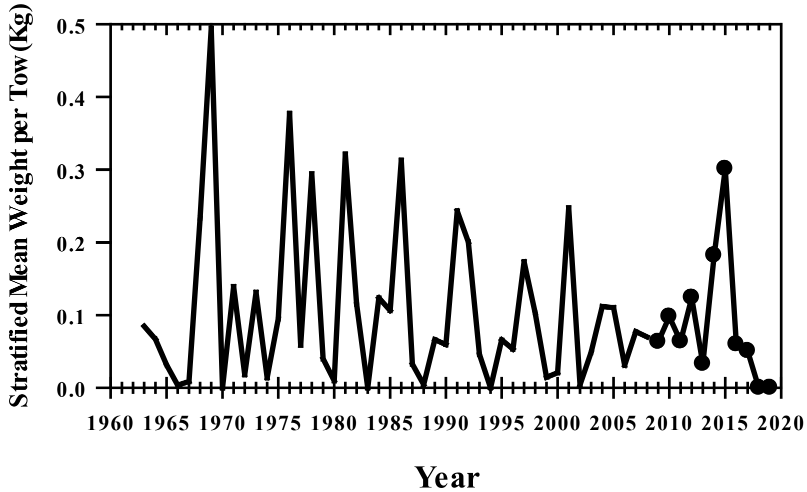

Figure 17. NEFSC autumn bottom trawl survey biomass indices for Atlantic halibut.

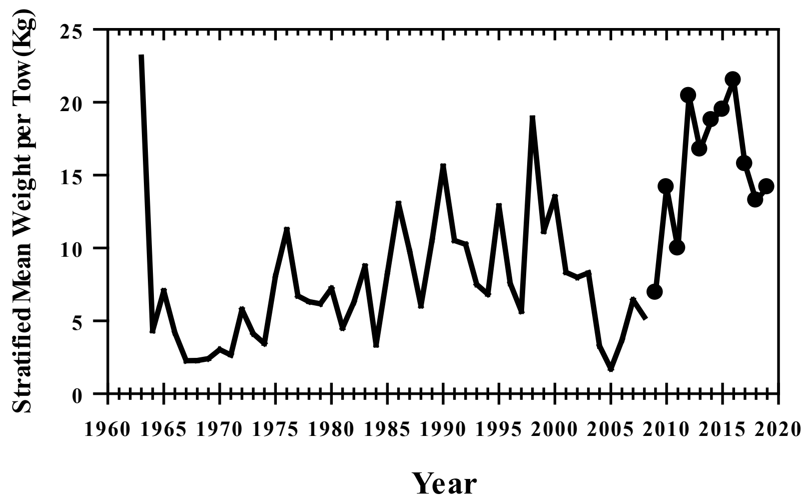

Figure 18. NEFSC autumn bottom trawl survey biomass indices for northern silver hake.

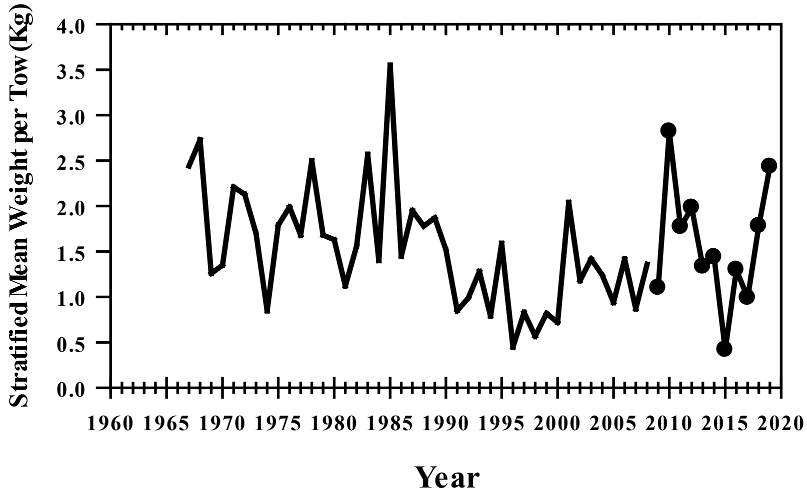

Figure 19. NEFSC autumn bottom trawl survey biomass indices for southern silver hake.

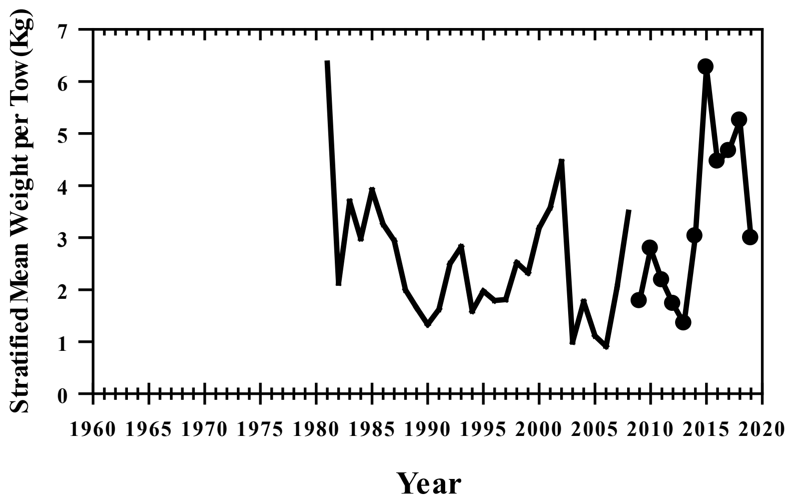

Figure 20. NEFSC spring bottom trawl survey biomass indices for northern red hake.

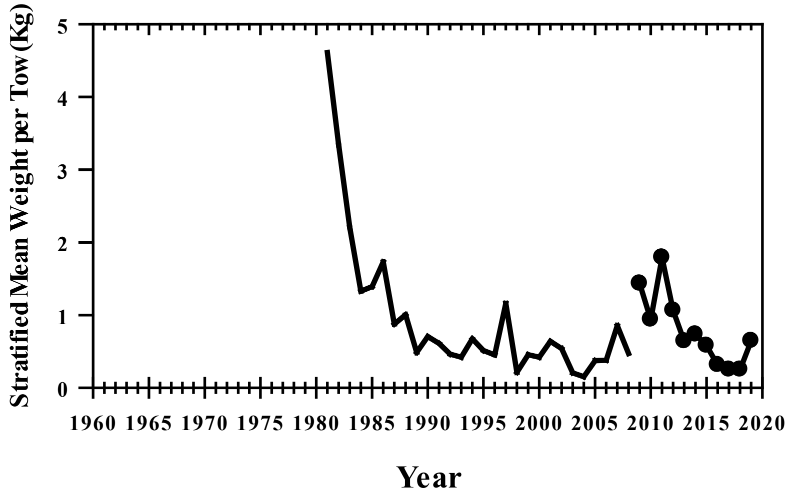

Figure 21. NEFSC spring bottom trawl survey biomass indices for southern red hake.

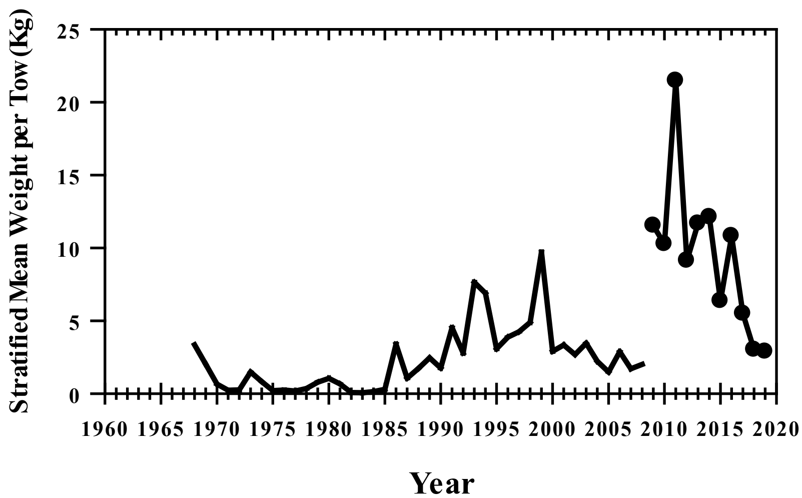

Figure 22. NEFSC spring bottom trawl survey biomass indices for Atlantic herring. Data from 2009-2019 have not been calibrated to the earlier time series.

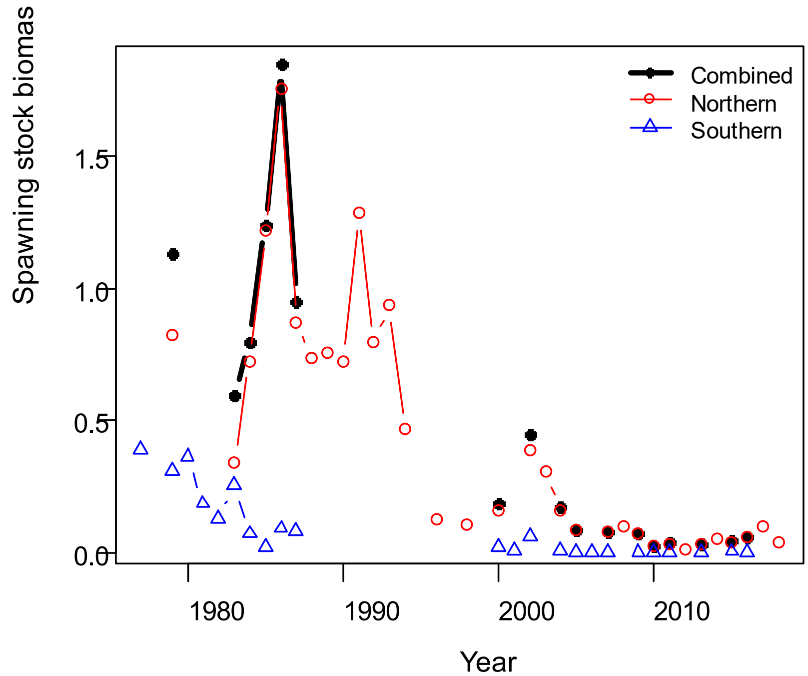

Figure 23. Atlantic mackerel spawning stock biomass index (millions metric tons) calculated using the total egg production method, based on egg densities observed in the southern Gulf of St. Lawrence (northern contingent) and the Northeast U.S. Continental Shelf (southern contingent). The combined SSB 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.

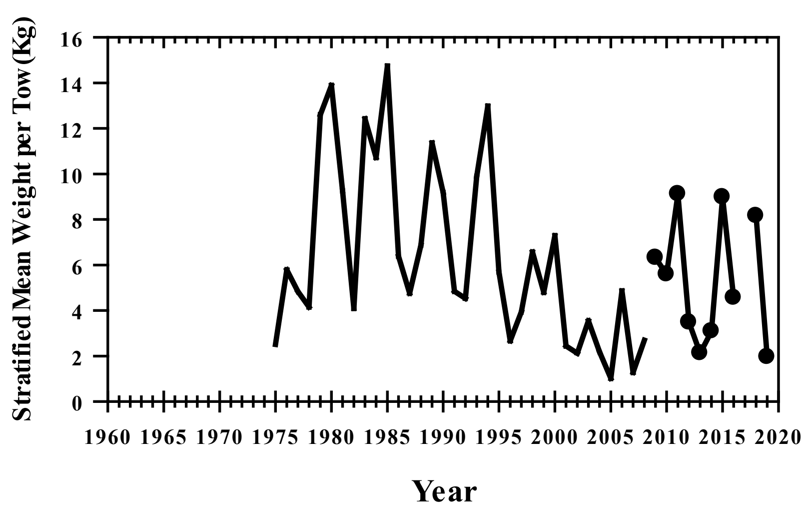

Figure 24. NEFSC autumn bottom trawl survey biomass indices for butterfish.

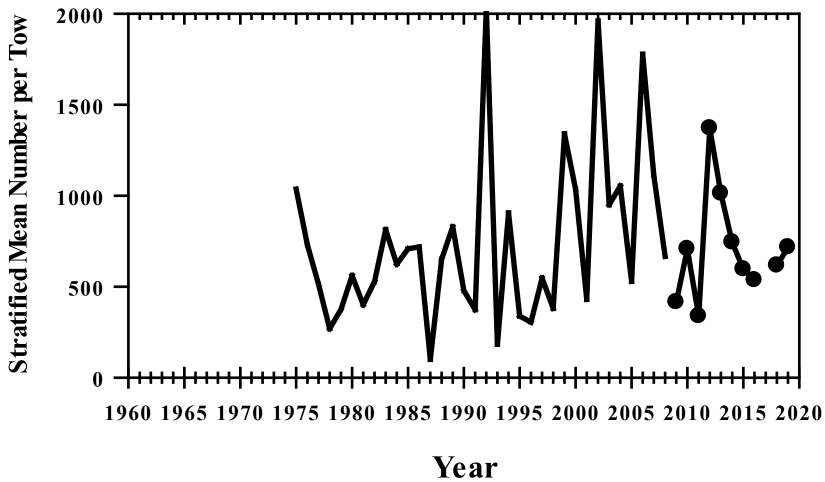

Figure 25. NEFSC autumn bottom trawl survey abundance indices for longfin inshore squid.

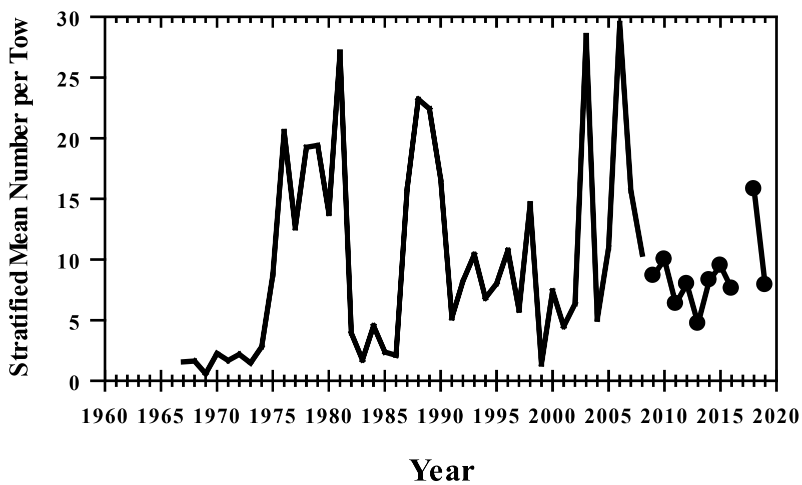

Figure 26. NEFSC autumn bottom trawl survey abundance indices for northern shortfin squid.

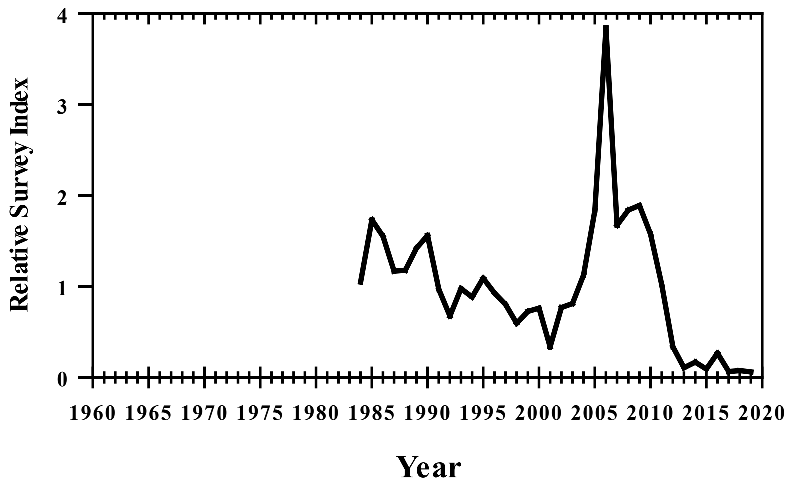

Figure 27. ASMFC summer shrimp survey biomass indices scaled to the mean for northern shrimp.

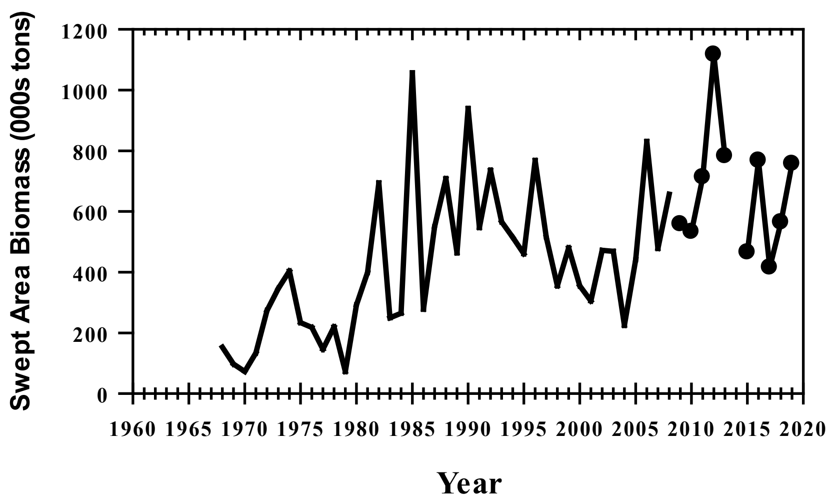

Figure 28. NEFSC spring bottom trawl survey biomass indices for spiny dogfish.

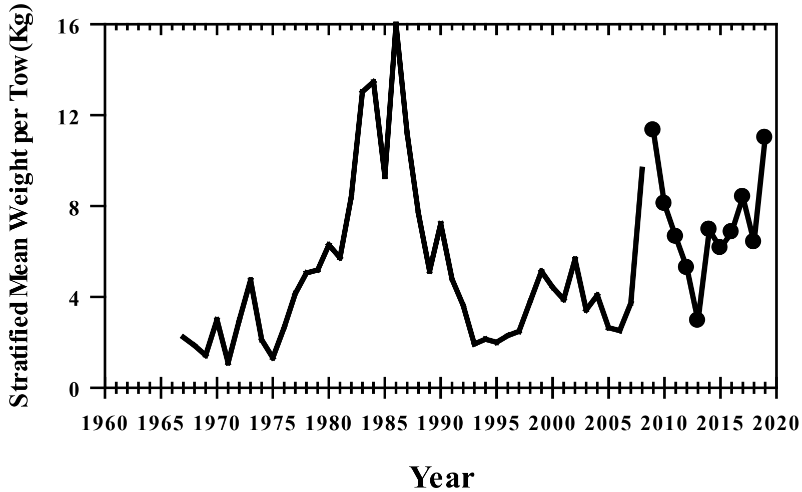

Figure 29. NEFSC autumn bottom trawl survey biomass indices for winter skate.

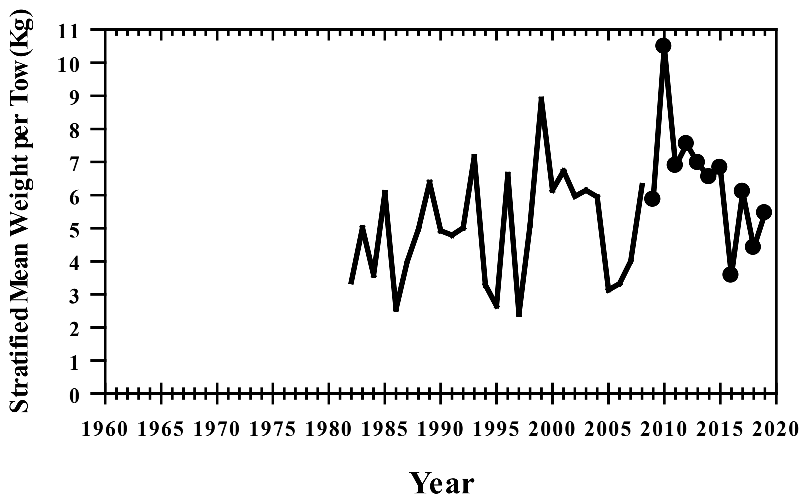

Figure 30. NEFSC spring bottom trawl survey biomass indices for little skate.

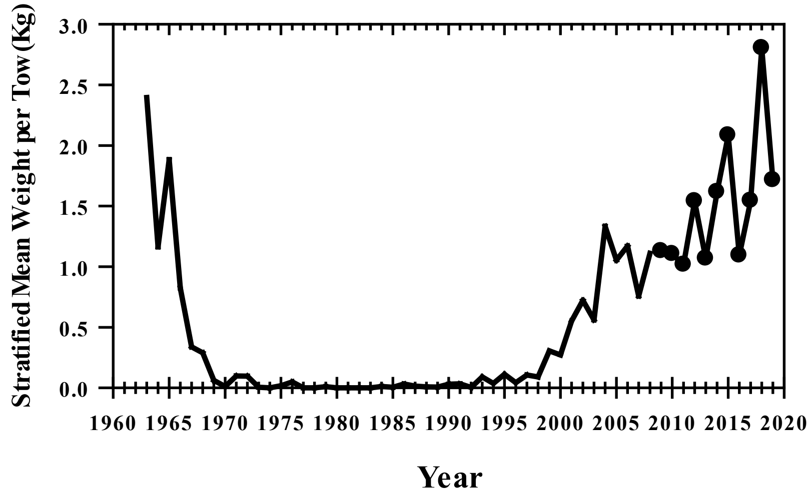

Figure 31. NEFSC autumn bottom trawl survey biomass indices for barndoor skate.

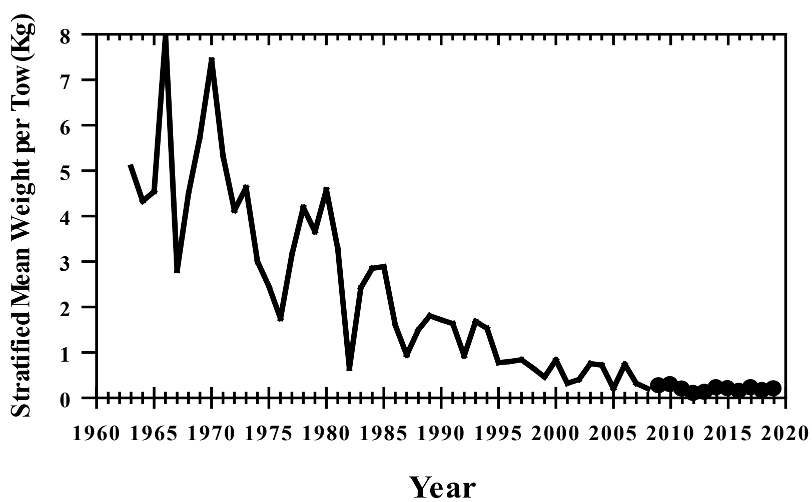

Figure 32. NEFSC autumn bottom trawl survey biomass indices for thorny skate.

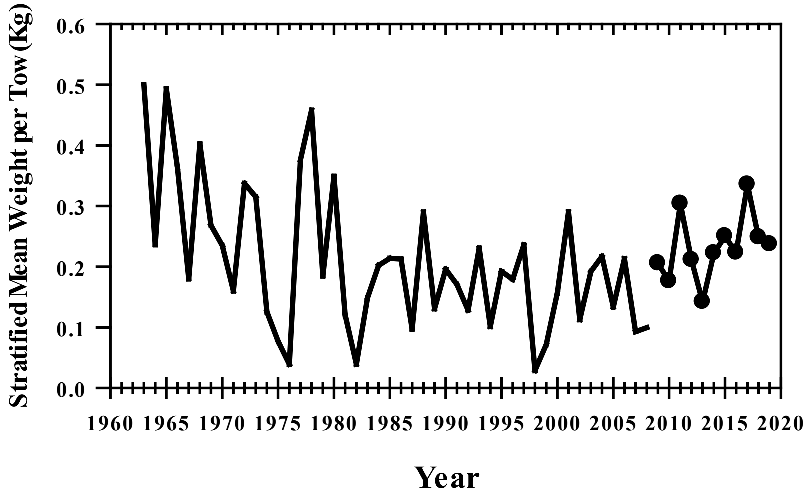

Figure 33. NEFSC autumn bottom trawl survey biomass indices for smooth skate.

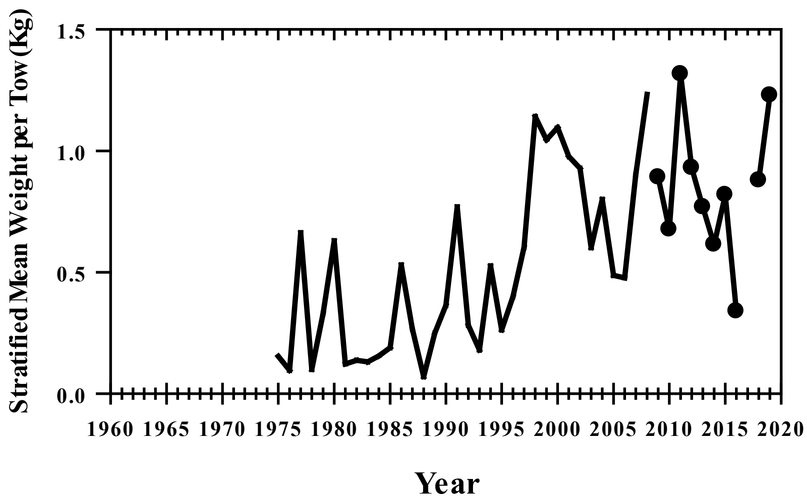

Figure 34. NEFSC autumn bottom trawl survey biomass indices for clearnose skate.

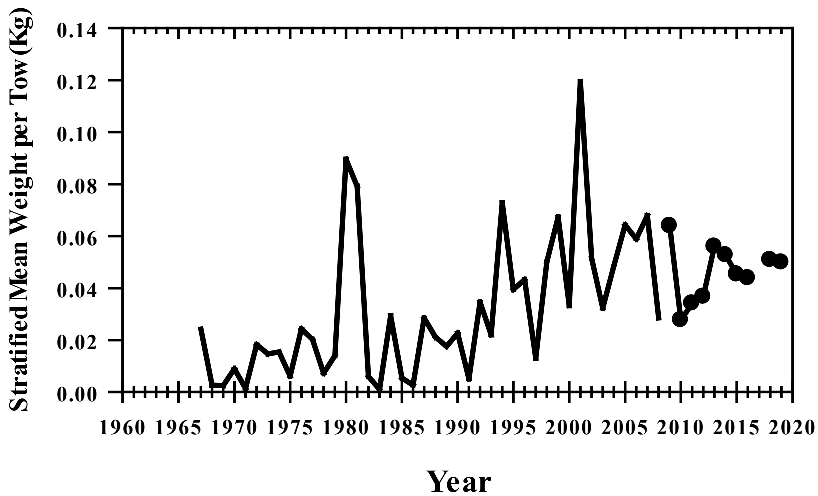

Figure 35. NEFSC autumn bottom trawl survey biomass indices for rosette skate.