Northwest Atlantic Fisheries Organization

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United States Research Report for 2023

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, in 2010 and in 2020. 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 2009-2023 were converted from the FSV *Henry B. Bigelow* catches (weights) to RV *Albatross IV* catches (weights) using either a single conversion factor or length-specific conversion factors which have only been estimated for some species. Consequently, 2009-2023 survey data points should be interpreted cautiously, and these values may change in the future as new methodologies are considered. The 2009-2023 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, 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, 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 do not include 2020 surveys. The spring survey in 2023 only sampled stations on Georges Bank and only conducted operations during daytime hours. Therefore, any species that use the spring survey have not been updated.

Since 2012, the United States has been transferred quota for Div. 3LNO yellowtail flounder from Canada and, from 2012-2021 at least one vessel fished in the area. In 2023, the US did not have a vessel fish in the NAFO Regulatory Area.

1. Atlantic Cod

United States commercial landings of Atlantic cod (*Gadus morhua*) in 2023 were 836 mt, a 25% increase from the 2022 landings of 668 mt.

Northeast Fisheries Science Center (NEFSC) research vessel survey biomass indices of Eastern Gulf of Maine cod remain low and for the last three years, no cod have been caught in the area (Figure 1). The biomass indices for Western Gulf of Maine cod remain below time series mean levels (Figure 2) 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 3). The biomass indices for Southern New England cod are low and no cod have been caught in the area during the last two years (Figure 4).

2. Haddock

United States commercial landings of haddock (*Melanogrammus aeglefinus*) in 2023 were 5,156 mt, a 9% decrease from the 2022 landings of 5,686 mt.

Northeast Fisheries Science Center (NEFSC) research vessel survey biomass indices in the Gulf of Maine have declined from recent historical high levels and are below the time series average in the fall survey (Figure 5). The NEFSC research vessel survey biomass indices for the Georges Bank stock have declined from recent historic high levels; the fall biomass indices are below the time series average (Figure 6).

3. Redfish

USA commercial landings of Acadian redfish (*Sebastes fasciatus*) decreased by 17% from 3,789 mt in 2022 to 3,162 mt in 2023. Fall research vessel survey biomass indices generally increased from the mid-1990s to a record-high index value of 77.05 kg/tow in 2010 (Figure 7). The survey biomass indices have generally decreased since the peak in 2010. Most recently, the survey biomass indices decreased by 79% from 22.80 kg/tow in 2022 to 4.87 kg/tow in 2023.

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

USA commercial landings of pollock (*Pollachius virens*) increased by 2% from 3,330 mt in 2022 to 3,402 mt in 2023. Fall research vessel survey biomass indices generally increased from the mid-1990s through 2005, before decreasing in 2006 (Figure 8). The survey biomass indices have been variable since 2006, reaching a record-low of 0.18 kg/tow in 2009. Most recently, the index decreased by 62% from 2.24 kg/tow in 2022 to 0.86 kg/tow in 2023.

5. White Hake

Nominal USA landings of white hake (*Urophycis tenuis*) from NAFO Subareas 5 and 6 increased by 21% from 1,619 mt in 2022 to 1,952 mt in 2023. Research vessel survey indices declined during the 1990s and increased in 2000 due to good recruitment of the 1998 year class. The indices were generally been variable since 2001 (Figure 9).

6. Yellowtail Flounder

USA landings of yellowtail flounder (*Limanda ferruginea*) from NAFO subareas 5 and 6 were 283 mt in 2023, a 25% increase from 2022 landings of 227 mt.

The NEFSC autumn survey biomass index in the Gulf of Maine has generally been variable since 2008. Most recently, the index decreased by 82% from 7.6 kg/tow in 2022 to 1.4 kg/tow in 2023 (Figure 10). On Georges Bank, the NEFSC autumn survey has remained low since 2015 and was the lowest in the time series in 2022 before doubling in 2023 (Figure 11). The Southern New England-Mid Atlantic yellowtail NEFSC autumn survey index is also low and remained low (Figure 12).

7. Other Flounders

USA commercial landings of flounders (other than yellowtail flounder and Atlantic halibut) from Subareas 3-6 in 2023 totaled 8,411 mt, 11% higher than in 2022. Summer flounder (*Paralichthys dentatus*; 71%), American plaice (*Hippoglossoides platessoides*; 14%), witch flounder (*Glyptocephalus cynoglossus*; 11%), winter flounder (*Pseudopleuronectes americanus*; 4% 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 2023. Compared to 2022, commercial landings in 2023 were higher for windowpane flounder (74%), American plaice (67%), witch flounder (21%), winter flounder (19%), and for summer flounder (3%). In 2023, there was no catch from Div. 3N by US vessels.

Research vessel survey indices in 2023 increased slightly for American plaice, witch flounder, and southern windowpane and decreased for Georges Bank winter flounder while northern windowpane remained relatively unchanged. There is no 2023 survey information for summer flounder; the 2023 spring survey did not sample the strata used for summer flounder indices (Figures 12-18).

8. Atlantic halibut

USA landings of Atlantic halibut (*Hippoglossus hippoglossus*) in the Gulf of Maine-Georges Bank region increased 28% from 27.7 mt in 2022 to 35.4 mt in 2023. Research vessel survey indices have little trend and high interannual variability due to the low capture rate of Atlantic halibut (Figure 19). 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 – 2023 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 decreased compared to 2022. In 2023, US commercial landings of silver hake totaled 4,459 mt, a 1% difference compared to 2022 of 4,497 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 157% from 16.05 kg/tow in 2021 to 41.00 kg/tow in 2022 before decreasing by 30% to 29.0 kg/tow in 2023 (Figure 20). In the south, the NEFSC autumn survey index has been stable since 2000. Most recently, the autumn index increased by 34% from 1.37 kg/tow in 2022 to 1.83 kg/tow in 2023 (Figure 21).

10. Red Hake

USA landings of red hake (*Urophycis chuss*) increased 5% in 2023, from 253 mt in 2022 to 266 mt in 2023. Research vessel survey biomass indices for the Gulf of Maine - Northern Georges Bank stock increased after the early 1970s then declined in the early 2000s, but have increased in recent years (Figure 22). In 2022, the NEFSC spring biomass index was 6.5 kg/tow, the highest in the 1968-2022 time series. Indices for the Southern Georges Bank - Mid-Atlantic stock declined in the 1990s and in most years have remained below 1 kg/tow (Figure 23). The 2023 spring survey did not cover either stock.

11. Butterfish

USA landings of butterfish (*Peprilus triacanthus*) increased 153% from 717 mt in 2022 to 1,816 mt in

2023. There is large interannual variation in fall research vessel survey biomass indices. Since switching to the FSV Henry B. Bigelow in 2009, biomass indices have ranged from a high of 29.9 kg/tow in 2023 to a low of 2.5 kg/tow in 2019, averaging 8.8 kg/tow annually. Biomass in 2017 was NA due to limited sampling of butterfish strata; as well as in 2020 due to COVID-19 restrictions causing the cancelation of the survey (Figure 24).

12. Spiny Dogfish

USA landings of spiny dogfish (*Squalus acanthias*) increased by 0.9% from 4,928 mt in 2022 to 4,971 mt in 2023. Survey indices of males and females combined, which are highly variable, generally declined between the early 1990s and 2005, but increased sharply in 2006 and have since generally remained high (Figure 23). The indices for males and females are also plotted separately and show diverging patterns. The male index has been stable and then increased in the last few years. The female index tends to drive the overall index showing a decline between the early 1990s and 2005 and then increasing. The 2022 index for females is the lowest in the time series. The 2023 spring survey did not cover the stock area.

13. Skates

USA nominal landings of skates increased 8% from 9,633 mt in 2022 to 10,415 mt in 2023. The landings are sold as wings for human consumption and as bait for the lobster fishery. Landings have increasingly been reported by species, however 573 mt were reported as unclassified in 2022, an decrease from 5.9% to 5.3% of the total.

Winter Skate

Winter skate (*Leucoraja ocellata*) reported landings increased by 9.8% between 2021 and 2022 from 5,672 mt to 6,226 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 24) 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 and generally remained at a slightly higher level with some peaks in 2009, 2019, and 2023, the highest value in the time series.

Little Skate

Reported landings of little skate (*Leucoraja erinacea*) decreased 12.5% from 2022 to 2023 from 3,056 mt to 2,675 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 but the 2021-2022 values are lower than 2017-2019 (Figure 25). The spring survey in 2023 did not cover the stock area for little skate.

Barndoor Skate

Landings of barndoor skate (*Dipturus laevis*) were allowed starting in 2018. Reported landings increased 51% between 2022 and 2023 from 146 mt to 220 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 early1960s and were the highest in the time series in 2018 (Figure 26). While the subsequent years are lower than 2018, the values remain similar to those in the early 1960s.

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 increased from 0.01 mt in 2022 to 0.7 mt in 2023. 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 27).

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 increased by 351% between 2022 and 2023 from 158.3 mt to 713.4 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 2016 (Figure 28). The last three years are lower than 2014-2019.

Clearnose Skate

Clearnose skate (*Raja eglanteria*) reported landings increased by 5% between 2022 and 2023 from 24.8 mt to 26.2 mt. There were no indices available for 2017 since the strata set was not covered. Indices generally increased between 1995 and 2010 (Figure 29) but have been mostly stable over the last decade.

Rosette Skate

Rosette skate (*Leucoraja garmani*) reported landings were zero in 2022 and 2023. There were no indices available for 2017 since the strata set was not covered and 2020 was cancelled due to COVID-19 restrictions. Indices generally increased between 1995 and 2010 (Figure 30) were stable and then declined in 2023.

B. Special Research Studies

1. Environmental Studies

A total of 1142 CTD (conductivity, temperature, depth) profiles were collected and processed by the Northeast Fisheries Science Center (NEFSC) in 2023 over the course of 10 cruises. Of this total, 1,048 CTD profiles were obtained within NAFO Subareas 5 and 6, and 82 profiles were 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/new-england-mid-atlantic/science-data/ecosystem-monitoring-northeast-us-continental-shelf-survey. Data are publicly available from the World Ocean Database maintained by NOAA's National Centers for Environmental Information and via the ERDDAP server maintained by NOAA's Northeast Fisheries Science Center at: https://comet.nefsc.noaa.gov/erddap/tabledap/ocdbs_v_erddap1.html.

Hourly bottom temperature records were obtained by participants in the Environmental Monitors on Lobster Traps program at 15 fixed locations/depths around the Gulf of Maine and Southern New England Shelf. The results indicate that bottom temperatures in the spring and summer of 2023 were generally close to or slightly below the long term average, while bottom temperatures in the fall were generally > 1°C above the long term average. Data from this program are available on the NEFSC ERDDAP Server. Real-time bottom temperatures have now been reported from over 80 commercial fishing vessels on approximately 6,100 sensor deployments from various locations and depths in 2023, bringing the program total to nearly 30,000 sensor deployments since 2015. The 2023 deployments

spanned the continental shelf off the Northeastern United States with 38% in NAFO SubArea 5 and 62% in NAFO SubArea 6. Observations took place at depths between 10m and 259m. Observations from both fixed and mobile gear are assimilated into two different ocean forecast models (Doppio and NECOFS). Each week, participating industry members receive up to date bottom temperature forecasts for the region as well as a graphical spatial representation of forecast performance over the previous month. All data from the realtime program are available in tabulated form (updated every 15 minutes) on the Gulf of Maine Lobster Foundation's legacy server and some of the data are now available on the Gulf of Maine Lobster Foundation's ERDDAP Server. We continue our efforts to modernize sensor systems in the field and migrate data from the legacy system to the new database and ERDDAP Server.

b) Plankton Studies

Throughout the 2023 calendar year, 1,164 plankton tows were conducted across three survey types. Each of these survey types covered a portion of the continental shelf between Cape Hatteras, North Carolina, and the Gulf of Maine at different times of the year. These surveys include Bottom Trawl (Spring/Fall) with 410, Ecosystem Monitoring Survey (Spring/Summer/Fall) with 691 and Long-Term Ecological Research with 63. Of those 1,164 plankton tows 83 were collected in NAFO subarea 4, 689 in subarea 5 and 341 in subarea 6. All tows were conducted using an array of 61 and 20 cm bongo nets simultaneously. Samples from the 61 cm bongo nets were collected and preserved to study zooplankton and ichthyoplankton distribution and abundance, while the 20 cm nets provided larval fish and egg samples for further research. In addition to the plankton samples collected during each survey, pteropods and dissolved inorganic carbon water samples were also collected during ecosystem monitoring surveys to explore the biogenic effects of increased acidity on calcium carbonate shell formation.

c) Benthic Studies

No field work done for 2023.

2. Biological Studies

a) Fish Species

Flatfishes: During 2015-2020, we implemented work on the plasticity of responses to high and variable thermal regimes and CO_2, and the degree of intraspecific, inter-population differences in resilience to these climate-related environmental changes. In 2023, we interpreted these results in the context of differences in thermal and CO_2 regimes between stocks that experience contrasting levels of environmental *in situ*. In 2019, we began a study of responses to elevated thermal and CO_2 regimes for summer flounder (*Paralichthys dentatus*) offspring drawn from parents collected in New Jersey, near the northerly limits of its geographic range. The effort examined the early life-stage (ELS) responses to a large number of distinct thermal and CO_2 regimes. Regarding thermal regimes, we used a large number of distinct constant thermal regimes on embryos (N=20 regimes) and larvae / young juveniles (N=11) as well as two seasonally varying regimes for larvae and young juveniles. Responses included effects on viability, growth, and development. Up to 12 different constant CO_2 regimes were also evaluated under three different constant thermal regimes. A similar evaluation of effects of constant and variable thermal and CO_2 regimes on winter flounder (*Psuedopleuronectes americanus*) was conducted in the winter 2019-2020.

Labrids. During 2022-2023 we initiated an aquaculture-related project on tautog (*Tautoga onitis*), funded by the Northeast Regional Aquaculture Center and Joint Project Agreement between the USA (NOAA) and the Republic of Korea (East Sea Fisheries Research Institute). Tautog is a candidate for aquaculture in the Northeast USA. It is a spring-spawning, cold-water wrasse (Labridae) that occupies inshore benthic waters with a high density of bottom structure. This research is addressing three fundamental questions about tautog ELS that are central to identifying optimal culture conditions for the production of juveniles. First, how does egg quality vary within the spawning season and among

individual females? Second, what thermal regimes during the embryonic and larval life-periods maximize production of hatchlings and juveniles? Third, how does the density and quality (enrichment) of live feed, and the stocking density of larvae impact the number and quality of tautog entering the juvenile life stage? In 2023, three temporally displaced spawning tautog cohorts are being used to address these and related questions. To date, inter-female differences in egg sizes are being documented, and the thermal tolerances of their embryos, the functional form of embryonic period duration, the temperature-dependent size at hatch, and survival to hatch under a 14 °C temperature range were described and reported at the Annual Larval Fish Conference. Juveniles produced in the larval experiments, as well as bulk rearing containers, were used to supply our project collaborator at Ward Aquafarms, in Megansett Harbor, Massachusetts. Those juveniles were used in initial observations of juvenile grow-out efficiencies. In 2024 we will enhance the 2023 experiments with measurements of individual respiration rates across the ELS. Further, we are targeting a tenfold increase in the number of juveniles supplied to Ward Aquafarms. These data will be used as a basis of a bioeconomic model of tautog production in order to scope the feasibility of intensive tautog aquaculture.

Sturgeons: Macro-phenotypic data on effects of thermal regimes and of contaminants that were collected during 2014-2017 were further analyzed in 2023 for publication.

Forage fish. A set of studies on Atlantic silverside, *Menidia menidia*, continued through 2019. Those studies focused on effects of climate (thermal and CO_2 variations), hypoxia, and parentage on key traits of the 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 the fertilization rate of Atlantic silverside as the response variable. A clear, negative trend in fertilization rate occurred with increasing degrees of hypoxia.

Indicator species of toxicity. A study on the potential effects of contaminated sediments on finfish was initiated in 2020 and continued through 2023. 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 focused 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 experiments on the embryos and young larvae. The study includes fish populations and sediments from target (contaminated) and reference locations. The team participated with NYU colleagues in studies of per- and polyfluoroalkyl substances (PFAS). Using Atlantic silverside and mummichog (*Fundulus heteroclitus*) embryos as test subjects, the team compared the relative toxicities of three PFAS types among embryos from one (silverside) or three (mummichog) source populations.

Fish Reproduction and Condition

Detailed sampling of fish collected from NEFSC Cooperative Research Study Fleet program continued in 2023. Monthly samples of American plaice (total N=250) were obtained, January through May to complete a 12 month series of gonad histology, fecundity and detailed estimates of energetic condition. Additional samples of winter flounder (206), yellowtail flounder (93), and haddock (86) were sampled for histology, energetic condition, and fecundity.

The NEFSC analysis of forage fish energy content continued in 2023 using samples collected from spring and fall bottom trawl surveys. The study focuses on the following species; Atlantic herring, alewife, silver hake, butterfish, northern sandlance, Atlantic mackerel, longfin inshore squid, and northern shortfin squid. Energy density was predicted from the percent dry weight using previously determined relationships. Samples have been analyzed for proximate composition and energy density from the fall 2022 (n=666) and spring 2023 (n=258) bottom trawl surveys. Results are summarized in the annual State of the Ecosystem Report for the Northeast U.S. shelf.

b) Resource Survey Cruises

During 2023, 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 and Ocean Quahog dredge survey. In aggregate, the survey staff efforts totaled 108 research and charter vessel sea days. NOAA scientific and contract staff involvement in the various cruises totaled 1,162 person sea days. ESB cruises occupied 641 stations in an area extending from Cape Hatteras, North Carolina to Nova Scotia. A total of 232,901 length measurements were recorded, representing 1,075,147 individuals from 404 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 2023 to fulfill special survey sampling requests from 39 NOAA and university investigators. This sampling included 8,253 feeding ecology observations, collection of 13,231 aging structures, and acquisition of 33,143 samples/specimens to support additional shore-based research. Additionally, the HabCam cruise tracks from the scallop survey completed 13 nm, collecting a total of 54 thousand image pairs.

Monitoring marine species abundance and distribution is paramount for sustaining their populations and the fisheries these species support. Adjustments or alternative methods to current fisheries independent surveys are needed to improve efficiency, data quality, and adapt to future sampling challenges that will result from offshore wind development. In 2023, the Advanced Technology Program of the Ecosystem Surveys Branch partnered with the Woods Hole Oceanographic Institute to begin testing of a Long-Range Autonomous Underwater Vehicle, an uncrewed underwater vehicle (UUV) developed by the Monterey Bay Aquarium Research Institute (MBARI_LRAUV). The goal of this endeavor was to develop an uncrewed underwater vehicle that can provide similar or enhanced optical abundance and size composition data for Atlantic sea scallops currently collected as part of the HabCam survey, and develop a sampling method for areas that will soon be inaccessible to the towed HabCam system.

The MBARI-LRAUV represents a crossover between a glider and UUV, having both buoyancy control and a thruster. The MBARI-LRAUV was equipped with an optical payload, containing the same cameras and lights, and many of the sensors as the HabCam survey, to allow for comparability in methods and designs. Test trials of the MBARI-LRAUV in 2023 highlighted the capabilities of the required image data collection, but also the ability for the vehicle to maintain a constant height above the seafloor through its survey. Research plans with the MBARI-LRAUV in 2024 include testing side-by-side with the HabCam survey in the spatiotemporal footprint of the annual HabCam survey to begin comparisons in scallop abundance and size estimates. Such comparisons will allow for ensuring that the MBARI-LRAUV data streams can be integrated into those currently used to inform the Atlantic sea scallop stock assessment. Additional testing of MBARI-LRAUV endurance and capabilities will be investigated during 2024 surveys and research cruises.

¬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 2023, FBP staff provided ages for over 42,100 otoliths from 22 species. The top species by number aged were haddock (5,391), black sea bass (3,838), scup (3,835), and tilefish (3,644). Large numbers of silver hake, redfish, white hake, and summer flounder (combined total 10,622) 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 2023, 114 intra-reader precision tests were conducted across 21 species.

3. Inter-agency exchanges: For transboundary stocks, the FBP exchanges age structures with other laboratories. In 2023, 1 inter-agency exchange was conducted for haddock with the St. Andrews Biological Station (Fisheries and Oceans Canada).

d) Food Web Dynamics

The NEFSC collections of fish diet data as part of a long-term (since 1973) monitoring program continued in 2023. Along with these data, 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 (South-Atlantic Bight to Scotian shelf) during the NEFSC bottom trawl survey. Estimates of prey volume and composition were made primarily at sea for selected species. During 2023, stomachs from 1,561 individuals and 40 species were examined in the spring (Georges Bank only), and 6,708 individuals and 50 species were examined in the fall (entire continental shelf). Diet sampling emphasized Gadiformes, elasmobranchs, small pelagics, flatfishes, and lesser-known species.

The time series of fish diet spans 51 years (1973-2023). The majority of the time series is available for analysis, including data from over 710,000 stomach samples and over 160 predators. Processing of the 2023 bottom trawl survey diet data is scheduled for completion in 2024.

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 2023, stomachs from juveniles (<=12 cm) 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 were offered once per year in the winter prior to the spring trawl survey. These workshops continued remotely and in person in 2023 and provided class discussions, photos of specimens, and archived samples as aids for prey identification in association with the bottom 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 making fish diet metadata publically accessible; examining the trophic impact of species across marine habitats; understanding the overlap

and ecological consequences of predation, bottom fishing effort, and fishing effort displacement relative to fish stock rebuilding and planning for wind energy areas; assessing trophic guilds across the North Atlantic; and incorporating fish consumption into stock assessments.

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. Morphometric data and biological samples for life history studies of coastal and pelagic shark species were collected opportunistically from incidental mortality events during survey and commercial fishery operations and beach strandings. Recreational shark tournaments have provided the majority of pelagic shark samples in the past, but APP staff were unable to attend the limited tournament opportunities available in 2023 to collect samples. Many tournaments have not come back following initial cancellations in 2020 due to the COVID-19 pandemic. Life history studies provide biological reference points used during the Southeast Data Assessment and Review (SEDAR) process for coastal species and the International Commission for the Conservation of Atlantic Tunas (ICCAT) pelagic shark assessments. Additionally, morphometric data collected were used in a 2023 collaborative publication in Marine Fisheries Review lead by APP, which provides length-length and length-weight conversions for 33 Atlantic shark species. These conversions have already been used to support the assessment and management work for federally managed Atlantic shark species.

Members of the Cooperative Shark Tagging Program (CSTP), involving thousands of volunteer recreational and commercial fishers, biologists, 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 2023. Over 320,000 fish including 52 shark species have been tagged since this program was initiated in 1962 and recaptures include 33 of the shark species tagged. In 2023, CSTP mark-recapture and growth data were used to inform the 2023 ICCAT assessment for blue sharks (*Prionace glauca*) concerning stock identification and age and growth estimates. This work was detailed in two working papers presented during the ICCAT Blue Shark Data Preparatory Meeting in 2023. Additionally, an integrative data approach to modeling the migratory patterns of the shortfin mako (*Isurus oxyrinchus*) incorporating CSTP data was presented during the 2023 American Elasmobranch Society Meeting.

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 in 2023. 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 2023, 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. Additionally, NEFSC staff conducted COASTSPAN surveys in Delaware Bay in 2023. Results from 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 2023. In addition, food habits and catch data from sharks caught during the Delaware Bay COASTSPAN survey were used to characterize the ecological role of sharks within the Bay and this work was presented during the 2023 American Elasmobranch Society Meeting. Additionally, COASTSPAN morphometric data were used in the 2023 Fishery Bulletin publication previously discussed on morphometric conversions.

The NEFSC Coastal Shark Bottom Longline Survey (CSBLS) began in 1986 and is conducted every two to three years. This is a coast-wide (Florida to the Mid-Atlantic) fishery-independent survey that monitors large coastal shark populations in the U.S. Atlantic Ocean. Additional survey objectives are to investigate the distribution, abundance, and species composition of sharks; tag sharks for migration studies; inject, with tetracycline, tagged sharks whenever feasible for age validation studies; collect biological samples for age and growth, food habits, and reproductive studies; and collect

morphometric data. In 2023, a presentation on the index standardization of CSBLS catch data using habitat suitability and spatiotemporal modeling to improve model fit and biological plausibility of scalloped hammerhead estimates was presented during the 2023 American Elasmobranch Society Meeting. Additionally, CSBLS morphometric data were used in the 2023 Fishery Bulletin publication previously discussed on morphometric conversions.

APP staff, with SEFSC collaboration, studied the use of Fourier transform near infrared spectroscopy (FT-NIRS) as a tool to age northwest Atlantic blue sharks and presented results during the 2023 American Elasmobranch Society Meeting. FT-NIRS is an emerging method to estimate age of marine fishes. This study assessed the efficacy of FT-NIRS to predict age and fork length (FL) of blue sharks from laser scans of their vertebrae. Spectral data from 188 vertebrae were collected via scanning with a FT-NIR spectrometer using two different sample presentations - whole centra placed rostro-caudal side down and half centra placed cut side down - to determine the best technique for enhancing signal to noise. Traditionally estimated ages and specimen FL (cm) were assigned to resulting spectra and partial least squares regression were used to create predictive models of age and FL based on spectral data. FT-NIRS models using whole centra estimated age to within 1.6 years (R2 = 74.42, Root Mean Square Error (RMSE) = 1.63 years) of traditional ages, and estimated FL to within 15 cm (R2 = 93.7, RMSE = 14.7 cm) of measured lengths. However, accuracy of FT-NIRS ages using whole centra declined after about age 8, at which point FT-NIRS predicted ages severely underestimated traditional age, likely due to centrum diameter exceeding the spectrometer window. Results from half centra are pending. Scanning time averaged 1.1 minutes per centrum, hence FT-NIRS ages can be produced in a fraction of the time required to generate traditional ages. However, sample presentation using whole centra may reduce accuracy of age predictions, potentially limiting the utility of this technique for larger-bodied sharks.

In 2023, APP staff with coauthors from the New England Aquarium, INSPIRE Environmental, Oregon State University, and the Greater Atlantic Regional Fisheries Office published a synthesis of the information, knowledge gaps, and research recommendations for the effects of offshore wind development on highly migratory species (HMS) in a NOAA Technical Report. Offshore wind energy installations help mitigate the growing impacts of climate change by increasing the use of renewable energy, but these installations are not without their own impacts on marine resources and their associated fisheries. There is research progress in assessing the impacts of offshore wind development on various fishery resources, but there is little emphasis on studies concerning highly migratory species. This is likely due to the perception that such species, with their high mobility, may be less susceptible to the direct effects of stressors associated with offshore wind construction and operation. While prolonged exposure to localized, acute stressors may be mitigated by these species' ability to avoid disturbed areas as compared to more sedentary species, there remains a number of mechanisms by which HMS may be affected. Offshore wind development is likely to affect the distribution, localized abundance, ecology, and behavior of HMS, as well as other species they interact with as predators and prey. Further, given the broad distribution of HMS essential fish habitat in the northwest Atlantic, localized effects of offshore wind may affect populations far beyond wind energy area boundaries. Effects reviewed include electromagnetic fields, acoustic stressors, changes in hydrodynamics, the influence of artificial structures on distribution, and potential disruptions to migration and feeding/foraging. This synthesis will help fisheries managers and relevant agencies assess the potential magnitude and direction of impacts on HMS and their associated fisheries in the U.S. Atlantic and provides a roadmap for marine scientists prioritizing data collection in this emerging area of research.

APP staff published two manuscripts in Fishery Bulletin on tiger sharks (*Galeocerdo cuvier*) in 2023. The first publication combined NEFSC and SEFSC reproductive data on tiger sharks in the northwest Atlantic to update reproductive parameters. Data collected through anatomical dissection, from 48 female and 66 male tiger sharks were used to assess stage of maturity. The fork length (FL) of examined females and males ranged from 88 to 318 cm and from 84 to 349 cm, respectively. Median length at maturity (L50) was calculated by using binomial maturity data from dissections in addition to maturity assignments based on clasper condition examination of 320 males (46–280 cm FL) and published

maturity data for 14 males (170– 313 cm FL) and 28 females (242–312 cm FL). Further, sex-specific median age at maturity (A50) was calculated by using direct age estimates and the aforementioned binomial maturity data from the dissected specimens. Females reached L50 at 261.4 cm FL and A50 at 11.6 years. Males reached L50 at 258.9 cm FL and A50 at 9.5 years. These updated reproductive parameters were used in the second tiger shark publication to provide cut off sizes for the life stages used in determining the distribution of the tiger shark in the North Atlantic Ocean by season, sex, and life stage. This study was based on tag and recapture data using both fishery-dependent and -independent tag (sample size [n]=10,516) and recapture (n=762) records for sharks caught in the North Atlantic Ocean during 1963–2018. Tiger sharks were caught over a wide area from the Grand Banks of Newfoundland, Canada, south to Brazil and from coastal to offshore waters and into the eastern North Atlantic Ocean. A broad nursery area and a potential birthing area were identified on the continental shelf between Florida and Georgia based on the repeated presence of neonates in summer across years and of the recapture of multiple tagged young-of-the-year sharks from the same location over a period of at least 2 years. Seasonal north–south movements were observed in all life stages, and 14 immature sharks were found to have migrated from the western to the eastern North Atlantic Ocean. This study provides the first evidence that juvenile tiger sharks make transatlantic migrations, and as early as two years of age.

In 2023, APP staff worked in cooperation with staff from Arizona State University and Fisheries and Oceans Canada to publish a study using reproductive hormones extracted from archived muscle tissue in porbeagles (*Lamna nasus*) to assess their maturity and reproductive status in Frontiers in Marine Science. While lethal sampling can be the most effective technique to collect critical reproductive data for elasmobranchs, non-lethal techniques need to be validated for future use. Concentrations of reproductive hormones in plasma and muscle have been found to correlate to sexual maturity and/or reproductive cycles in oviparous as well as yolk-sac, placental, and histotrophic viviparous elasmobranchs, offering a potentially non-lethal technique to study reproduction. However, reproductive hormone analysis is scant for oophagous sharks. This study utilized muscle tissues from porbeagles that were dissected for other life history studies and were stored frozen for up to 37 years to quantify testosterone (T) and estradiol (E2) concentrations in relation to previously-known maturity and reproductive stage. A total of 207 samples (92 males, 115 females) from porbeagles ranging in size from 80 to 256.5 cm fork length were analyzed. Muscle T and E2 concentrations were related to maturity and reproductive stage in porbeagles, with the highest T concentrations found in mature males during the spermatogenic season (summer) and the highest E2 concentrations found in gravid females. These results suggest muscle hormone concentrations have the potential to serve as a non-lethal proxy of reproductive stage in oophagous sharks. This study also demonstrates the value of specimen sharing and the potential for continued use of stored vertebral muscle tissue for reproductive hormone analysis in order to optimize the amount of data gained from biological samples. Future use of these methods would be particularly valuable for threatened species for which lethal sampling is restricted.

f) Marine Mammals

Right whale cruises were conducted on the R/V Gloria Michelle to collect photo id, biological and physical oceanographic data in the area wind energy lease areas and near sighted right whales (*Eubalaena glacialis*). 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 video plankton recorder (VPR) data to quantify zooplankton at particular depths in the water column. Lastly, we collected echosounding data over 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 is being compared with similar data collected from 2020 through 2024. We are summarizing species abundance and distribution in southern New England, and are collaborating with University of Massachusetts at Dartmouth to assess energy density of collected zooplankton. We also have had contractors working on the analysis and processing of acoustic data collected, which is still underway.

A North Atlantic right whale research cruise was conducted aboard a contract research vessel. Semper Offshore provided the M/V Warren Junior for this effort. The cruise was conducted in offshore waters of New England during May and June of 2023. The research activities included: Suction-cup tagging using uncrewed aerial systems to investigate the feeding ecology of right whales, zooplankton collection around feeding right whales to augment the study of feeding ecology, passive acoustics was used to help locate animals in the area or during night time hours, sUAS was utilized for photogrammetry which will be incorporated into a broad range of health assessment tools, photo-id for the ongoing contribution to the catalog, biopsy sampling that is contributed to the ongoing genetic assessment of the population, and dimethyl sulfide sampling which is being investigated as an indicator of right whale presence.

In 2023, scientists participated in the WHOI Irminger oceanographic cruise aboard the R/V Neil Armstrong. An observer used the ship as a platform of opportunity to survey for North Atlantic right whales from Reykjavik, Iceland to Woods Hole from August 22 to September 21 2023.

NEFSC also had a marine mammal observer onboard the R/V Neil Armstrong to search for North Atlantic right whales while WHOI conducted Oceanographic research in and around Nags Head Virginia, departing and returning to Woods Hole from October 23 to November 5 2023.

The North Atlantic Right Whale Sighting Survey (NARWSS) is a NOAA Fisheries program that conducts aerial surveys for 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 and residency. In 2023, NARWSS flew 573 hours over 107 surveys in US waters from New Jersey to the Canadian border, and detected 553 right whales (including duplicates of the same individual). In Canada, NARWSS flew 72 hours over 16 surveys in 2023 in the Gulf of St Lawrence, and detected 220 right whales (including duplicates of the same individual).

Annually, research trips using the NOAA NEFSC's small vessel R/V Selkie (24' Safeboat), are conducted on good weather days in the NARW calving grounds in the winter (Jan/Feb) and in Cape Cod Bay during the spring (March-May). In 2023, the surveys in the southeast during the calving season focused on photogrammetry of North Atlantic right whale mother/calf pairs. Selkie crew also biopsy sampled, took vessel-based images, and acted as support vessel for one disentanglement event. From late March through early May, the R/V Selkie was used in Cape Cod Bay when North Atlantic right whales were present and mostly feeding. Vessel-based images were taken of all right whales encountered. Photogrammetry images, using an uncrewed aerial system, were taken of most mother and calf pairs when encountered. Any animals that had not previously been biopsy sampled or were targeted for other studies were sampled. All right whale images were contributed to the North Atlantic Right Whale catalog. Work continued with the New England Aquarium and University of Rhode Island to update the North Atlantic Right Whale Individual ID catalog and right whale sightings databases.

As part of the Atlantic Marine Assessment Program for Protected Species (AMAPPS), the Northeast Fisheries Science Center (NEFSC) and Southeast Fisheries Science Center (SEFSC) conducted an aerial survey on the continental shelf waters of the US east coast, from Nova Scotia, Canada to the Florida Keys, U.S.A. We conducted the survey during 1 March – 15 May 2023 aboard a NOAA Twin Otter aircraft at an altitude of 600 feet and a speed of 100-110 knots over ground on tracklines oriented approximately perpendicular to the shoreline. The main goal of this survey was to collect data to estimate the distribution and abundance of marine mammals and sea turtles in the U.S. east coast. We designed the survey for analysis using Distance sampling and a two-team (independent observer) approach to correct for perception bias in resulting abundance estimates. We surveyed 10,797 km of on-effort tracklines and detected 582 marine mammal sightings of 13 identified species comprising of 2,740 individuals. Thirty percent of the marine mammal sightings were harbor porpoises (*Phocoena phocoena*); while 38% of the individuals were common dolphins (*Delphinus delphis*). Of interest are the 9 North Atlantic right whales and 13 Cuvier's beaked whales (*Ziphius cavirostris*) we saw. We detected 564 sightings sea turtles that comprised of 715 animals. Unidentified turtles comprised 52% of all turtle sightings, followed by loggerhead turtles (*Caretta caretta*) with 40%. We also detected 120

sightings of seals, comprising 532 animals. Opportunistically, we recorded 9 species of sharks, rays, and other fish.

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 2023 included gill nets, otter trawls, mid-water otter trawls, mid-water pair trawls, scallop trawls, scallop dredges, purse seines, and some pot traps.

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.

Gear Research - on-demand/ropeless:

In 2023, the NEFSC Gear Research Team continued to test on-demand systems in the lobster fishery in an effort to reduce large whale and sea turtle entanglements. The risk of a large whale becoming entangled in the American lobster and Jonah crab fisheries is decreased by on-demand systems that remove the vertical line in the water column. In August of 2023, our science center was granted an exempted fishing permit allowing up to 200 vessels to assist in testing and improving on-demand gear systems - this followed a 2022 permit that allowed collaboration with up to 100 vessels. Our testing of these systems, which we have been developing in collaboration with fishermen and manufacturers, will continue and expand thanks to this effort. The Gear Lending Library, which we maintain to provide fishermen and researchers with on-demand systems to test and develop, has grown to include over 400 systems from nine different manufacturers aboard 37 different fishing vessels. The 2023 season completed 2,794 hauls from 32 different fishermen. From February 1 through April 30, 2023, 12 of our federally permitted collaborating commercial fishermen completed more than 500 hauls of on-demand gear within the boundaries of the restricted areas that were subject to seasonal closures due to the presence of North Atlantic Right Whales. They fished in state and federal waters within the South Island Restricted Area and the Massachusetts Restricted Area, both of which prohibit vertical line fishing gear. Due to the absence of surface buoys on the on-demand gear, the bottom-set trap/pot gear was not marked at the surface of the water during this time. To aid in gear location and to let surrounding vessels know that gear is present on the bottom, we are also testing gear marking systems that make use of GPS points or other subsurface markings. On-demand gear hauls have improved over the past four fishing seasons, with greater success and fewer failures. The rate of successful on-demand gear hauls has risen from 64% to 88% collectively, with higher success by experienced collaborators using well-tested system designs. This steady increase in success suggests that on-demand solutions, with adequate training and monitoring, could reduce the entanglement of protected species in vertical lines and provide flexibility for fishing operations in locations with high whale abundance.

Passive 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 and offshore wind farm development; (2) monitor cetacean species 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.

Throughout 2023, we deployed SoundTrap recorders at 50 sites along the East Coast from the Gulf of Maine to Florida Keys, including 19 sites (also deployed with FPODs) in the Southern New England Wind Energy Areas, covering Cox's Ledge and Nantucket Shoals to monitor for North Atlantic right whales, Atlantic Cod (Gadus morhua), Harbor Porpoises (Phocoena phocoena), as well as other mysticetes and odontocetes. Long-term NOAA Noise Reference Station recorders continue to collect data in the Stellwagen Bank National Marine Sanctuary and offshore of Georges Bank. Four

manuscripts were published that described the baseline marine mammal presence and soundscape of the Southern New England Offshore Wind Energy Area, with additional details on the persistence of North Atlantic right whale presence, demographics of sperm whales (Physeter macrocephalus), and distribution of harbor porpoises. More work is being conducted to quantify and describe the anthropogenic sounds that are recorded within this and other wind energy areas.

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; 7

real-time monitoring buoys operated by WHOI and colleagues are also active along the east coast. Detections from these real-time platforms are being used to trigger North Atlantic right whale Slow Zones; results can be found at http://dcs.whoi.edu. As part of the AMAPPS program, analyses of the distributions of sperm whales, beaked whales (Ziphiidae), 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 include improving classification methods of passive acoustic data, niche partitioning and community structure of cetaceans, as well as describing the acoustic and diving behavior of odontocetes. The NEFSC Passive Acoustics Research Branch also works in collaboration on projects in Australia Marine Parks and Hong Kong Harbor to describe soundscapes and assess illegal vessel activity. Work continues on the development of the Passive Acoustic Cetacean Map (PACM, https://apps-nefsc.fisheries.noaa.gov/pacm/#/), namely to migrate its existing structure into the Cloud for increased flexibility and national use. For more information on our projects and publications, please visit

https://www.fisheries.noaa.gov/new-england-mid-atlantic/endangered-species-

conservation/passive-acoustic-research-atlantic-ocean.

Pinnipeds:

The NEFSC conducts research on wild populations of gray (Halichoerus grypus) and harbor (Phoca vitulina)seals in the Northwest Atlantic in collaboration with several other non-profit, academic, and government partners working under the NEFSC pinniped research permit. Research includes broad-based surveys to estimate population abundance as well as focused work on individual live or dead animals to study health, diet, movements, and behavior. In 2023 the NEFSC partnered with the Oceans Unmanned and the National Ocean Service Remote Sensing Division to survey pups born on Muskeget Island using unmanned aircraft. Pup counts will contribute to a time series of the number of pups born on the island to estimate rates of increase in the region since the early 1990s. We also conducted drone surveys of gray seal haulouts around Cape Cod to estimate the proportion of animals entangled in gear or debris. In collaboration with several other organizations, the NEFSC captured a total of 78 juvenile gray seals for studies of health, diet, and movements. From each animal teams collected weight, morphometrics, swabs, whisker, lanugo, skin, blood, flipper tags, and if age-appropriate, a blubber biopsy. In addition, teams deployed a total of 17 satellite tags and 8 acoustic tags. These data are currently being analyzed to investigate movements and foraging behaviors of gray seals over a 5-year period prior to the start of wind energy development.

Work continued in 2023 collecting and analyzing diet data from harbor and gray seals using an interdisciplinary approach that includes the use of hard part remains, fatty acids and DNA methodologies. A manuscript was submitted to Frontiers in Conservation Science describing 'What bycatch tells about the diet of harbor and gray seals and overlap with commercial fishermen' (Lyssikatos and Wenzel, 2024). A complimentary Master of Science Thesis from the University of New England was also completed. It documented a 'Diet comparison between gray seal and harbor seal through analysis of chime and fecal matter within the intestine', by Taylor Gibson. The Gibson Thesis is important because the dietary DNA (dDNA) data will be joined with Lyssikatos and Wenzel (2024)

to compare diet inferences from fecal DNA extractions to stomach hard part remains from the same individual carcasses obtained from bycatch events. We also continued to develop the Northeastern US (NEUS) fatty acid signature (FAS) libraries in collaboration with researchers at the University of Dalhousie and Maritime Canada Department of Fisheries and Oceans. The NEUS prey library (now complete) includes 983 FAS records from 47 different species and the predator library (still being developed) now includes 267 FAS records (138 harbor seal and 129 gray seal). Analysis of the NEUS prey FAS data is presently underway and will be compared to the Canadian shelf FAS prey libraries collected during the early 1990's and a more recent library for select species collected in 2020 and 2021. The pilot dDNA feasibility study that was reported last year, utilizing meta-barcoding methods on 1) fecal matter recovered from the colon and 2) stomach contents from bycaught animals, 3) seal scat from haul out locations and 4) scat from rehabilitated animals held in captivity, is still ongoing. We added environmental DNA (eDNA) to our seal diet research program in 2023 to investigate the feasibility of detecting seals and their primary prey from surface and bottom seawater samples in Southern New England's outer continental shelf (concurrent with passive acoustic monitoring and satellite telemetry detections from tagged gray seals). This is a dynamic high use habitat undergoing rapid change due to climate and wind generated renewable energy development. In September 2023 we trialed a semi-automated water sampler with two different filter pore sizes and target water volumes using a traditional Niskin bottle hydrocast design. Our seal diet research program continues to have the long-term aim of integrating results from an interdisciplinary research program to support cross-validation (hard parts, FAS, dDNA) studies comparing results from the full array of biological samples obtained from the same individuals and their habitat (eDNA) to improve our knowledge of seal foraging in the Gulf of Maine, Georges Bank and mid-Atlantic ecosystems.

Bycatch estimation of harbor (Phoca vitulina), gray (Halichoerus grypus), harp (Pagophilus groenlandicus), and hooded (Cystophora cristata) seals in the Mid-Atlantic Gillnet, Northeast Sink Gillnet, and Northeast and mid-Atlantic bottom trawl fisheries was conducted in 2023 and reported in 2024 US Atlantic Marine Mammal Stock Assessment Reports.

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 calendar year 2023, the Turtle Ecology team completed several field work trips. We collaborated with the Coonamessett Farm Foundation in March for loggerhead satellite tagging aboard the F/V Salvation off Hatteras, North Carolina. Nine loggerheads and 1 Kemp's Ridley were successfully tagged during this trip. We collaborated with CFF from June 5 - 10 for loggerhead satellite tagging aboard the F/V Kathy Ann in the Mid-Atlantic Bight. Fifteen loggerheads were successfully tagged during this trip. The team also attached two flipper tags and inserted a PIT tag (for identification purposes) in each of the loggerhead turtles. Biological samples (blood and skin) were collected for future biochemistry, stable isotope, and genetic analyses conducted by research collaborators. From August 19 - 28, the NEFSC and SEFSC collaborated for leatherback satellite tagging, departing from Woods Hole, Massachusetts aboard the M/V Scarlet Isabella with support from R/V Coriacea. Most of this trip was spent in waters south of Nantucket, where 17 leatherback sea turtles were successfully tagged. Flipper and PIT (microchip) tags were applied in addition to the satellite tag. Blood and tissue samples were taken for biochemistry and genetic analyses, and fat depth measurements were also conducted. The main goals of this cruise were to continue collecting leatherback surfacing behavior and build upon our knowledge of coastal leatherback sea turtle movements and habitat use, including with respect to connectivity with Marine Protected Areas. Understanding the proportion of time leatherbacks spend at the surface of the water and how that might vary seasonally and/or spatially provides necessary corrections for availability of the turtles to be counted during AMAPPS (Atlantic Marine Assessment Program for Protected Species) aerial surveys intended to estimate abundance. In addition, characterizing relative importance of different habitats and vertical use of the water column for leatherbacks in the region is essential for determining overlap with and impacts of wind energy

development and fishing activities. In addition to fieldwork, the team continued developing the Oracle database that stores the satellite tag data and associated metadata. The team also made considerable progress on 3 manuscripts. One manuscript is in review (Rogers et al: Investigating leatherback surface behavior using a novel tag design and machine learning); one has been published in 2023 (Hatch et al 2023: Evaluating simple measures of spatial-temporal overlap as a proxy for encounter risk between a protected species and commercial fishery); and one has been published in 2024 (Rider et al 2024: Where the leatherbacks roam: Movement behavior analyses reveal novel foraging locations of leatherback sea turtles along the Northwest Atlantic shelf).

3. Studies of Fishing Operations

In 2023, the NEFSC utilized fisheries observers, at-sea monitors and electronic monitoring to collect data on commercial fishing activity, support catch accounting and compliance monitoring. As part of the Northeast Fisheries Observer Program, observers were deployed on 2,059 trips. 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 148 marine mammal incidental takes, 211 seabird incidental takes and 11 sea turtle 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.

The At-Sea Monitoring Program deployed at-sea monitors (ASMs) on 2,294 commercial trips participating in the Northeast multispecies groundfish fishery for quota monitoring purposes. On these trips, there were 189 marine mammal and 41 seabird incidental takes documented.

The NEFSC's Electronic Monitoring Program has been implemented in the Northeast multispecies groundfish fishery as a voluntary alternative to ASMs and to audit vessel logbook data. Three hundred sixty one trips and 1028 gear retrievals were reviewed. Protected species incidental take interactions are not documented as part of the EM program.

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

In the sink anchored gillnet fishery, 382 trips were observed with a total of 1,365 gear retrievals recorded by observers. There were 107 observed marine mammal takes; including 78 gray seals, 9 harbor seals, one harp seal, 9 harbor porpoises, four common dolphins, one bottlenose dolphin and one humpback whale. There were 129 observed seabird takes; including 97 great shearwaters and 12 red-throated loons.

At-sea monitors observed 576 trips in the sink anchored gillnet fishery with 2,067 gear retrievals. There were 146 observed marine mammal takes; including 86 gray seals, 35 harbor seals, and 9 harbor porpoises. There were 19 observed seabird incidental takes; including 10 common murres.

Electronic monitoring was utilized on 28 gillnet trips and 182 gear retrievals.

b. Float Drift Gillnet Fishery

There were 9 floating drift gillnet trips with 48 gear retrievals observed in 2023. There was one observed Kemp's ridley sea turtle observed in this fishery.

No At-Sea Monitors deployed on float drift gillnet trips in 2023.

c. Otter Trawl Fisheries

In the bottom otter trawl fishery 957 trips and 6,886 gear retrievals were observed. In addition, there were 7 midwater trawl trips with 25 gear retrievals, nine haddock separator trawl trips with 211 gear retrievals, and 35 twin trawl trips with 262 gear retrievals observed in 2023. There were also 7 observed trips on vessels using large mesh belly panel trawl nets with 40 gear retrievals. One trip was observed in the scallop bottom otter trawl fishery. For the bottom otter trawl fishery, there were 35 observed marine mammal takes (22 common dolphins, 7 gray seals, 4 bottlenose dolphins, and 2 harbor seals), 10 sea turtle takes (7 loggerhead, two leatherback and one Kemp's ridley) and 16 seabird takes. On the midwater trawl trips there was one Northern gannet take observed. There was one common dolphin take documented in the twin trawl fishery.

At-sea monitors deployed on 1,664 bottom otter trawl trips with 19,022 gear retrievals, 29 haddock separator trawl trips with 918 gear retrievals, and 2 Ruhle trawl trips with 4 gear retrievals. At-sea monitors observed 39 marine mammal incidental takes on bottom otter trawl trips; including seven common dolphins, 9 gray seals, 7 white-sided dolphins, 4 harbor porpoises, and 4 harbor seals. Twenty one seabird takes were documented by ASMs in the bottom otter trawl fishery. ASMs documented one white-sided dolphin and one gray seal on haddock separator trawl trips.

Electronic monitoring was utilized on 311 bottom trawl trips and 740 gear retrievals.

d. Sea Scallop Dredge Fishery

In the sea scallop dredge fishery, 386 trips were observed with a total of 20,737 gear retrievals. There were 60 seabird takes observed (including 48 great shearwaters) and one common dolphin.

e. Scottish Seine Fishery

No Scottish seine trips were covered by observers or at-sea monitors in 2023.

f. Drift Sink Gillnet Fishery

In the drift sink gillnet fishery in 2023, observers deployed on 70 trips with a total of 341 gear retrievals. There was one common murre observed take in this fishery.

Four drift sink gillnet trips with 14 gear retrievals were covered in 2023 by at-sea monitors. There were no protected species incidental takes documented on these trips.

g. Anchored Floating Gillnet Fishery

Five anchored floating gillnet trips and 5 gear retrievals were observed in 2023. No incidental takes occurred on these trips.

No at-sea monitors deployed on anchored floating gillnet trips in 2023.

h. Mid-water Pair Trawl Fishery

In 2023, there were four mid-water pair trawl trips observed with 16 gear retrievals. There were no marine mammal, sea turtle or seabird takes observed in this fishery.

No at-sea monitors deployed on mid-water pair trawl trips in 2023.

i. Bottom Longline Fishery

In the bottom longline fishery in 2023, there were 27 trips observed with a total of 172 gear retrievals. Six great shearwater takes were observed in the bottom longline fishery.

At-sea monitors covered 17 bottom longline trips with 48 gear retrievals in 2023. There was one Northern Fulmar and 2 unidentified seals incidental takes observed.

Electronic monitoring was utilized on 14 bottom longline trips and 78 gear retrievals.

j. Beach Haul Seine Fishery

No beach haul seine trips were covered by observers or at-sea monitors in 2023.

k. Pound Net Fishery

No pound net trips were covered by observers or at-sea monitors in 2023.

l. Handline/Trolling Fisheries

In 2023, there were 17 handline trips with 192 gear retrievals observed. There were no takes observed in the handline fishery. Other observed fisheries using line gear include two troll line trips with 42 gear retrievals and four auto-jig handline trips with 60 gear retrievals. No protected species incidental takes were observed in any of the aforementioned line fisheries.

At-sea monitors observed two handline trips and two gear retrievals with no protected species takes documented.

Electronic monitoring was utilized on 12 trips using handline gear and 28 gear retrievals reviewed.

m. Herring Purse Seine Fishery

In 2023, no herring purse seine trips were observed.

No herring purse seine trips were covered by at-sea monitors in 2023.

n. Menhaden Purse Seine Fishery

Observers deployed on 12 menhaden purse seine trips with 17 gear retrievals observed in 2023. No protected species incidental takes were observed on these trips.

No menhaden purse seine trips were covered by at-sea monitors in 2023.

o. Tuna Purse Seine Fishery

No commercial tuna purse seine activity occurred in 2023.

p. Pot / Trap Fisheries

In 2023, observers deployed on 28 lobster pot trips with 627 gear retrievals, 28 fish pot trips with 303 gear retrievals, 20 conch pot trips with 217 gear retrievals and 18 crab pot trips with 175 gear retrievals. There were no marine mammal, sea turtle or seabird takes observed 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 ASMs in 2023.

q. Beam Trawl Fisheries

No beam trawl trips were covered by observers or at-sea monitors in 2023.

r. Clam Dredge Fishery

There were 31 clam dredge trips with 1200 gear retrievals observed in 2023. There were no observed takes of marine mammals, sea turtles or seabirds on these trips.

No clam dredge trips were covered by ASMs in 2023.

s. Other Dredge Fisheries

No other dredge trips were covered by observers or at-sea monitors in 2023.

4. Observer estimation of catch on NAFO Subarea 3 trips

The United States did not have any trips in NAFO Subarea 3.

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,. mManagement 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 and revised catch advice 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 assessment process.The Management Track process is designed to develop, review and approve updated stock assessments for use in management (e.g. specification setting).

In 2023, Research Track Assessments were completed for the four recently established cod stocks (eastern Gulf of Maine, Georges Bank, southern New England, and western Gulf of Maine) and black sea bass (Gulf of Maine/Cape Hatteras). Research Track Assessment Working Groups continued their work on golden tilefish, yellowtail flounder, Atlantic sea scallop, and Atlantic herring.

In addition, the Management Track produced updated stock assessments in 2023 for bluefish, deep sea red crab, longfin inshore squid, scup, summer flounder, Acadian redfish, Atlantic mackerel, red hake (north and south), silver and offshore hake (north and south), skate complex (barndoor skate, clearnose skate, little skate, rosette skate, smooth skate, thorny skate, and winter skate), spiny dogfish, and windowpane flounder (north and south). The U.S. also coordinated with Canada to develop and review stock assessments through the Transboundary Resources Assessment Committee (TRAC) process, including 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 remained low with both smolt escapement and ocean survival rates challenging recovery of the species. 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 support ESA, U.S. Atlantic Salmon Assessment Committee, International Council for the Exploration of the Seas (ICES) and North Atlantic Salmon Conservation Organization (NASCO) domestic and international science and management efforts.

Field research in 2023 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. Sampling is continuing and a manuscript was recently submitted for review, which summarizes the trophic ecology of nearshore groundfish with a particular focus on the contribution of diadromous fishes to their diets. 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 to support NASCO management efforts. Lastly, starting in 2018, salmon have been captured, tagged with popoff satellite tags (PSAT) and released at their feeding grounds at West Greenland. To date over 200 PSAT tagged salmon have been released and 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

Industry-Based Gulf of Maine Bottom Longline Survey

During 2022 staff from the NEFSC Cooperative Research Branch completed the Gulf of Maine bottom longline survey (BLLS) 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 groundfish and data-poor species. The survey covers the western Gulf of Maine across the central 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 2022 completing 92 stations in total in the spring (April-May) and fall (Oct-Nov) with 46 vessel days at sea on two chartered commercial vessels. A total of 20,544 lengths were measured representing 22,434 individual organisms. Biological sampling of 1,498 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

n the northeast US, the Northeast Fisheries Science Center's Study Fleet program (Jones et al. 2022) has greatly enhanced the collection of high-resolution catch, effort, and environmental data by fishing captains. This has resulted in an extensive time series of fine-scale catch and effort information that has accumulated over the past fifteen years, providing a valuable resource for regional scientists and managers. This data set is similar to the information gathered by the NEFSC's observer program and can be used to answer a variety of research questions related to catch rates, environmental drivers, and fishery dynamics. In 2023, our focus was on developing standardized CPUE time series to support the stock assessments of black sea bass (Centropristis striata) and golden tilefish (Lopholatilus chamaeleonticeps). These efforts will continue in 2024 with the publication of peer-

reviewed papers on the topic of commercial CPUE standardization. The fine-scale catch and effort data, combined with advancements in logbook hardware and software, enable us to study fishery dynamics and environmental impacts more accurately than ever before. With these tools, we can enhance ongoing science and management in the region.

Application of fishery data to evaluate operational conflicts with wind developments

In 2023, the Northeast Fisheries Science Center's Study Fleet rogram's fine-scale fishery data played a crucial role in improving our understanding of fishery footprints and potential spatial conflicts with planned offshore wind energy developments. Specifically, we explored the time series of fine-scale effort information for the summer flounder fishery (Paralichthys dentatus). Results indicate that the Study Fleet data set improves the accuracy of estimates of the impact of offshore wind energy development on fishing operations. By characterizing the true footprint of individual fishing trips and effort events and providing higher coverage in fisheries likely to be impacted, the fine-scale effort information collected by the Study Fleet proved to be an important resource. In 2024 a publication will be developed that compares results from the fluke fishery to those for the longfin squid (Allen-Jacobson et al. 2023), as well as other fisheries. In addition to this research, the NEFSC has worked to develop a reproducible workflow for providing data to Study Fleet participants to help inform the region's compensatory mitigation programs (i.e., the compensation of fishermen by wind development companies for impacts to fishing operations).

Biological sampling of longfin inshore squid (Doryteuthis pealeii)

The longfin inshore squid (Doryteuthis pealeii) is an ecologically and economically important species in the northeast USA, supporting a commercial fishery valued at over $60 million in 2022. However, the assessment and management of this species is hampered by a limited understanding of its life history and population dynamics. The Northeast Fisheries Science Center's Cooperative Research Branch is working to improve knowledge on the stock by collaborating with commercial squid fishermen to collect squid samples weekly from spring 2023 to spring 2025. This cooperative effort, called the Squid Biological Sampling program (SQUIBS), collects approximately 300 individual longfin squid each week from commercial fishing vessel partners. To date, over 10,000 squid have been processed at the NEFSC's Narragansett Laboratory. Using an electronic data collection system, each squid is weighed, measured, and dissected to examine and measure reproductive organs and traits to determine organism sex and maturity level. Additionally, tissue samples and statoliths are collected weekly from a subsample of these squid for genetic analyses and aging, respectively. The fishing vessels collecting squid for this program provide the precise coordinates and date/time at which the squid were collected. This information enables analysts to explore spatial and temporal trends at the scales relevant for this short-lived and highly dynamic species. Data from this project are loaded into the NEFSC Oracle database and are provided directly to the Longfin Squid Working Group for use in the 2026 Longfin Squid Stock Assessment.

Engaging Shortfin Squid (*Illex illecebrosus*) Processors in Filling Biological Data Gaps Using Electronic Technology

The life history and population dynamics of the northern shortfin squid (*Illex illecebrosus*) are poorly understood due to a paucity of data, yet the species supports a productive fishery on the northwest Atlantic continental shelf. The Shortfin Squid Electronic Size Monitoring Project (ILXSM) was developed in 2021 to address the need for individual shortfin squid size and weights throughout the fishing season, which are key for understanding the ingress, egress, growth, and reproduction of this semelparous species. To achieve this goal, the ILXSM team developed an electronic data collection system that can be used by the region's shortfin squid processors to collect biological data during the vessel offload process. In 2023, six shortfin squid processors used Big Fin Scientific electronic fish measuring boards, Marel digital Bluetooth scales, and a ruggedized Samsung tablets running the BioLogical Information System Software (BLISS)
to efficiently collect paired mantle lengths and gram weights for a subsample of squid from each

vessel offload. These data are uploaded to NEFSC databases for scientific analysis and downloaded by processors for use in sales and marketing. In 2023, processors collected over 30,000 shortfin squid mantle lengths and body weights. A technical memorandum (*Mercer A, Moser J, Swiader Jr T, Salois S. 2023. Design, implementation, and results of a collaborative shortfin squid (Illex illecebrosus) electronic size monitoring pilot project. US Dept Commer Northeast Fish Sci Cent Tech Memo 311*) detailing the methodology and preliminary results from this project was published in 2023. This project plays a critical role in documenting rapidly changing dynamics of the shortfin squid population and promotes long-term conservation of this valuable fishery resource.

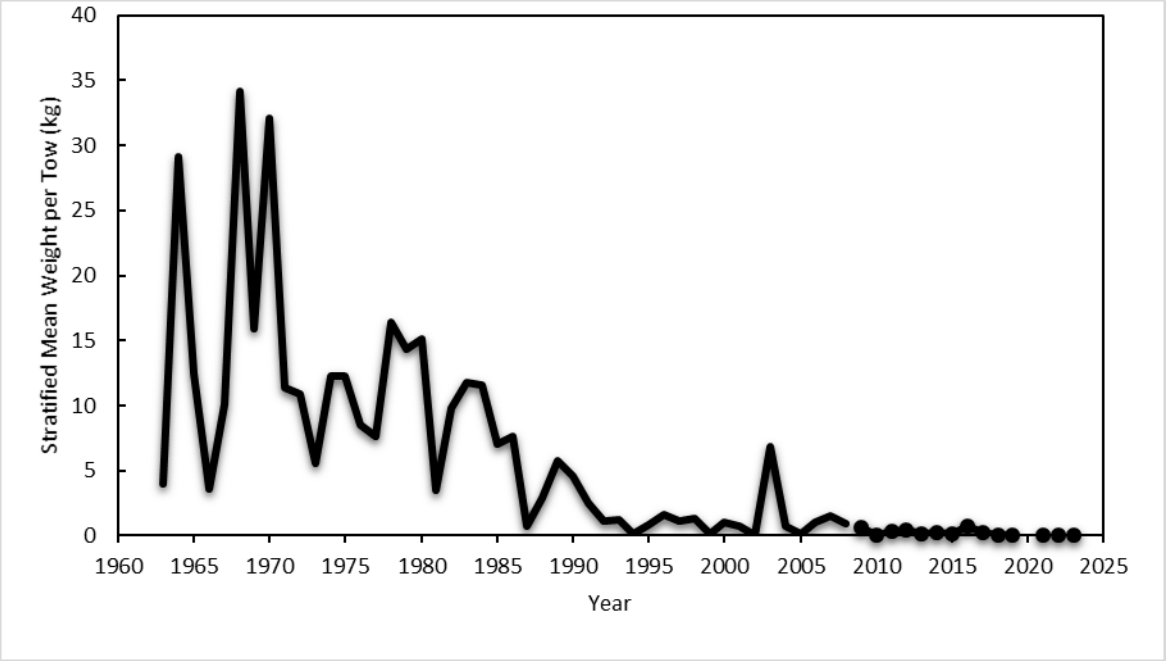

Figure 1. NEFSC autumn bottom trawl survey biomass indices for Eastern Gulf of Maine cod.

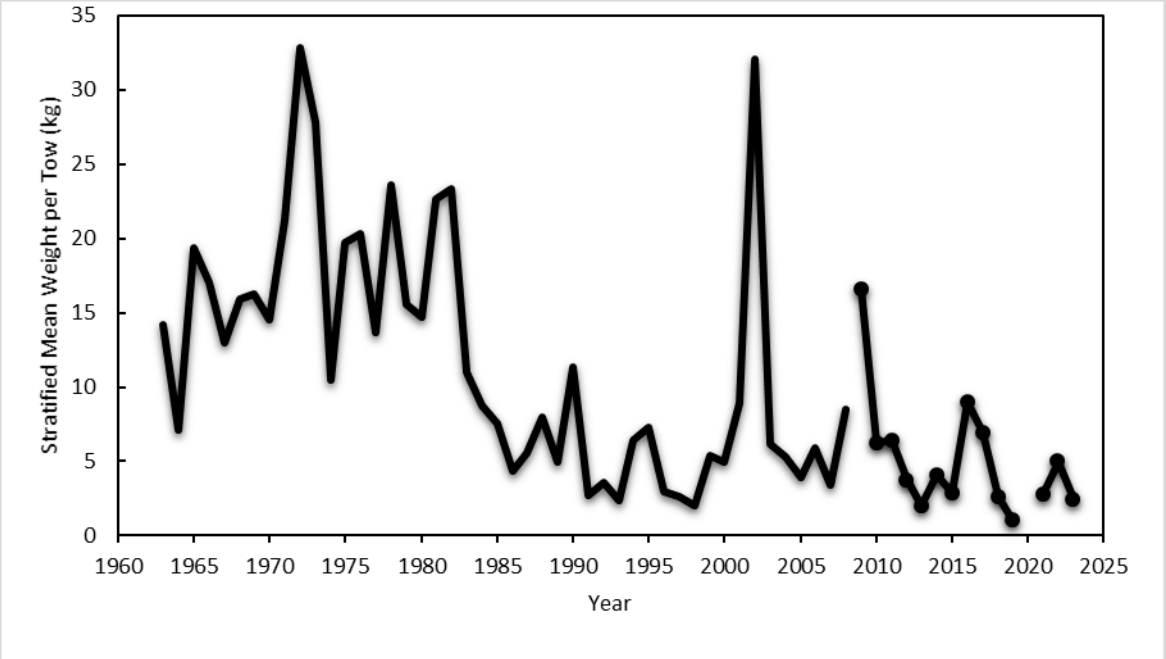

Figure 2. NEFSC autumn bottom trawl survey biomass indices for Western Gulf of Maine cod.

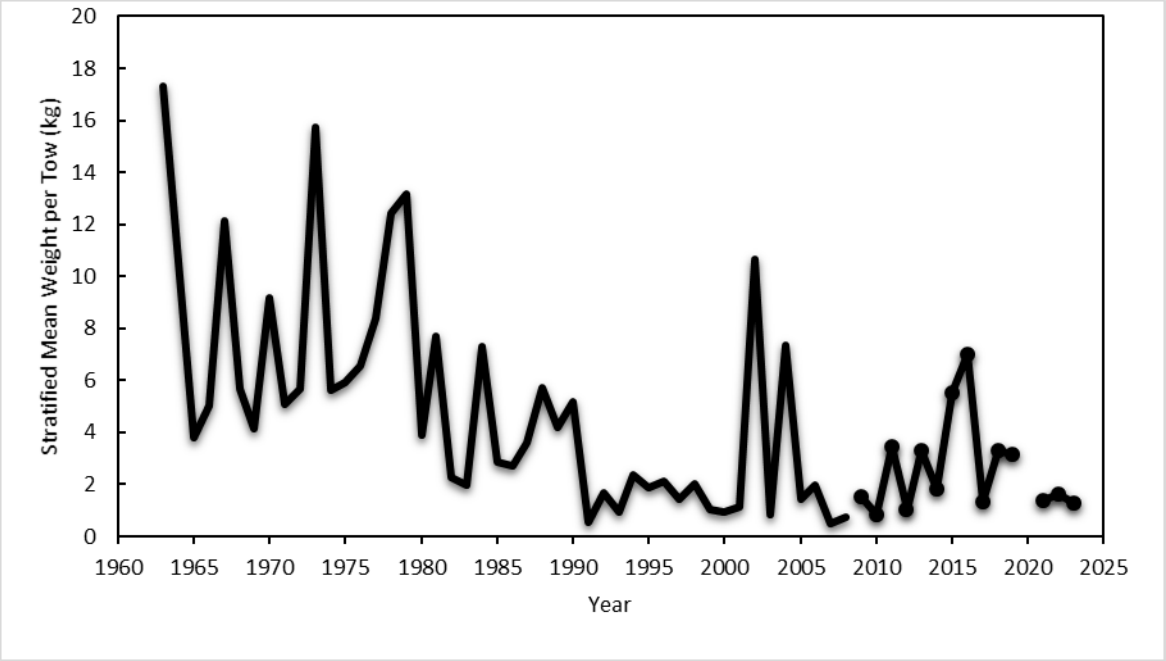

Figure 3. NEFSC autumn bottom trawl survey biomass indices for Georges Bank cod.

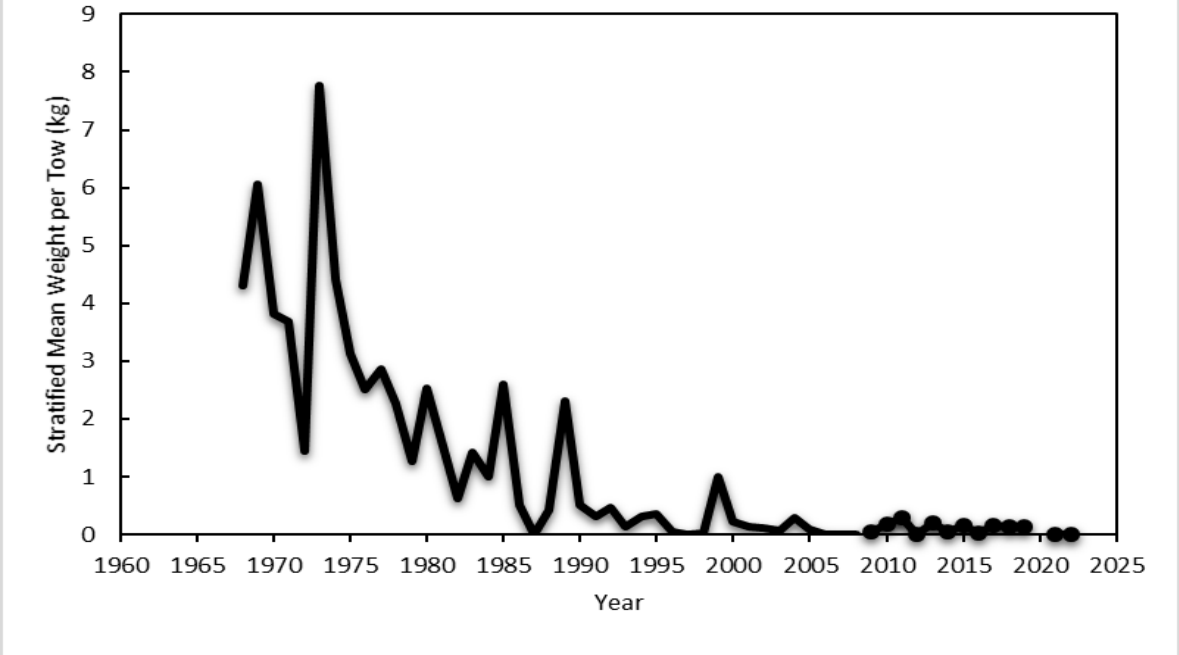

Figure 4. NEFSC spring bottom trawl survey biomass indices for Southern New England cod. The survey in 2023 did not cover the area for Southern New England cod.

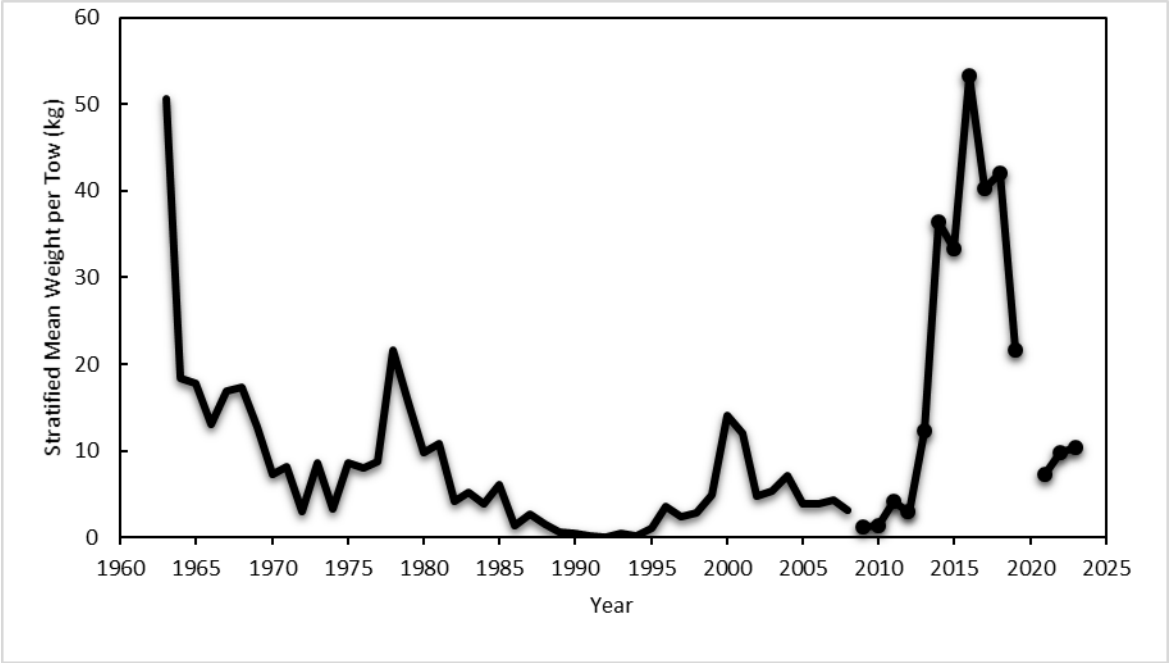

Figure 5. NEFSC autumn bottom trawl survey biomass indices for Gulf of Maine haddock.

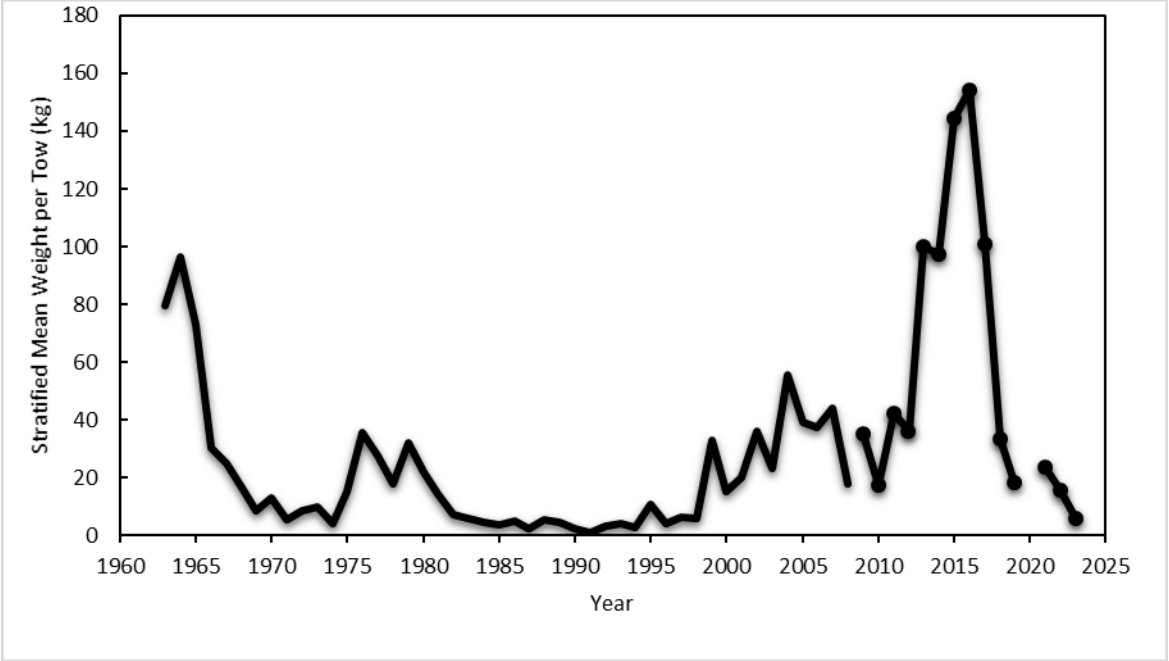

Figure 6. NEFSC autumn bottom trawl survey biomass indices for Georges Bank haddock.

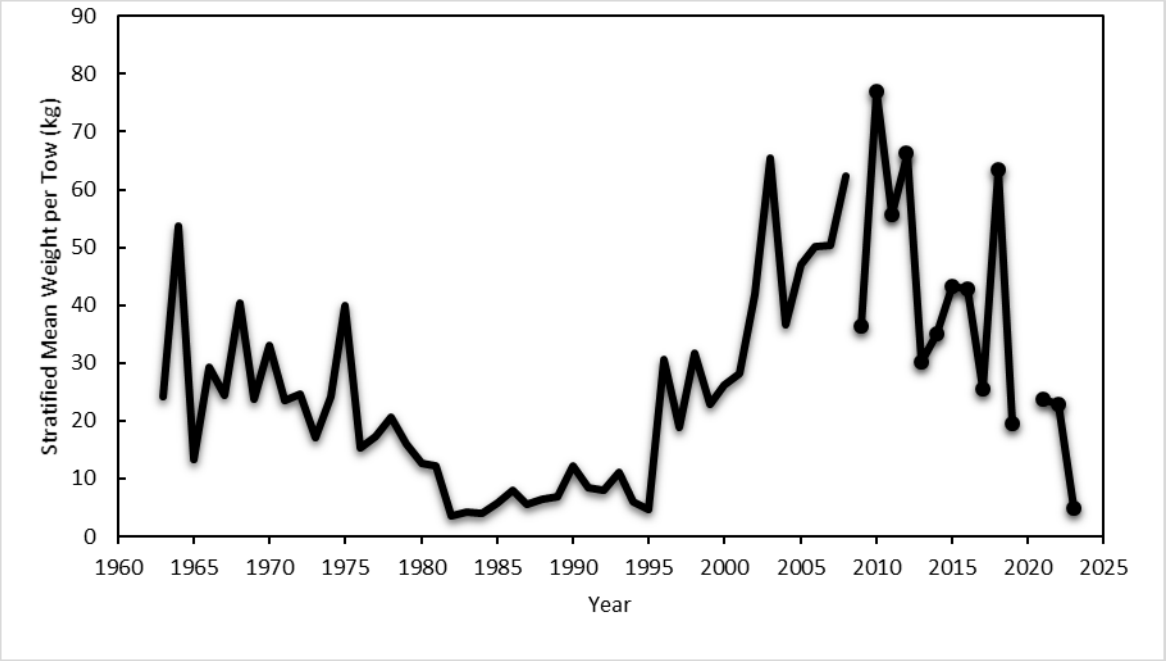

Figure 7. NEFSC autumn bottom trawl survey biomass indices for Acadian redfish.

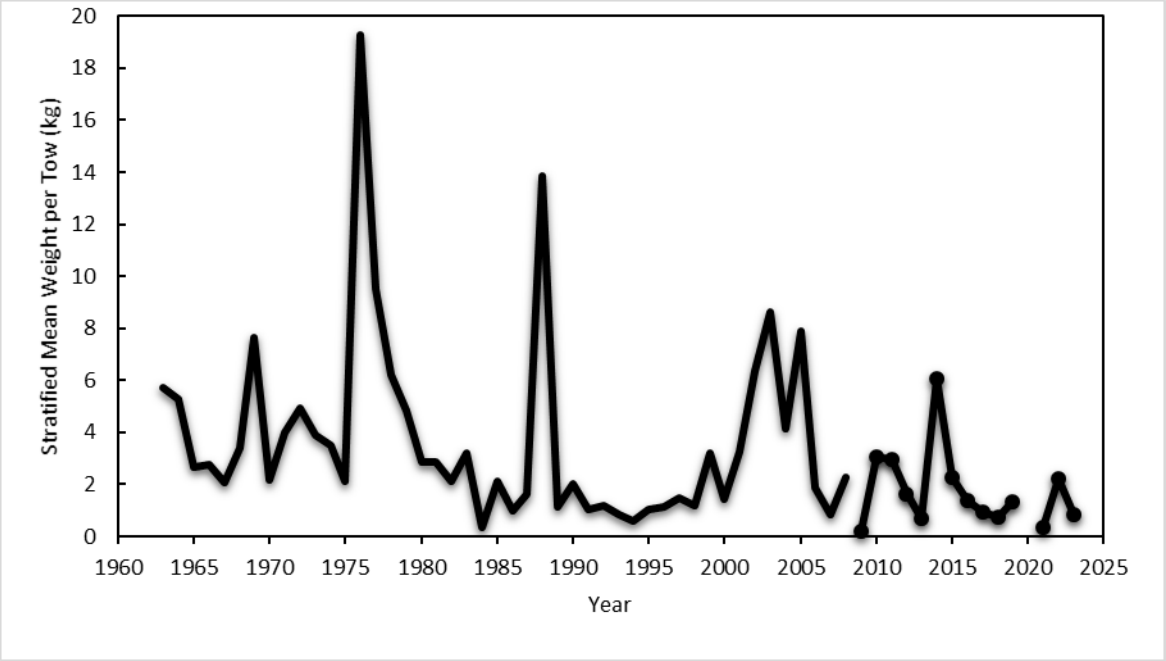

Figure 8. NEFSC autumn bottom trawl survey biomass indices for pollock.

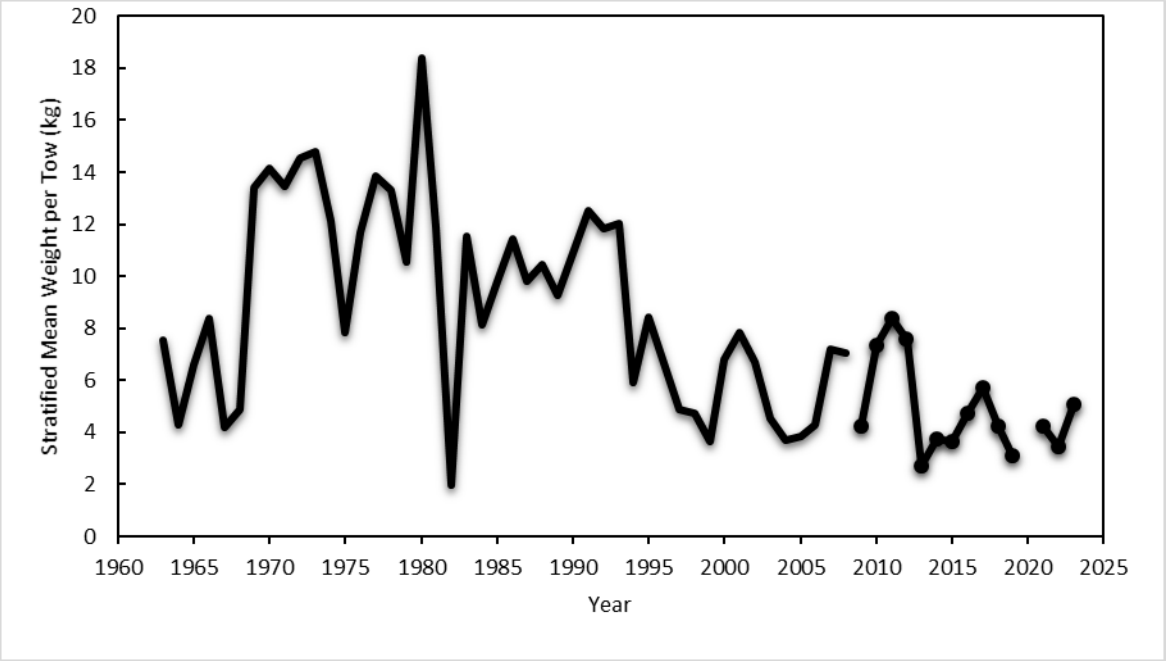

Figure 9. NEFSC autumn bottom trawl survey biomass indices for white hake.

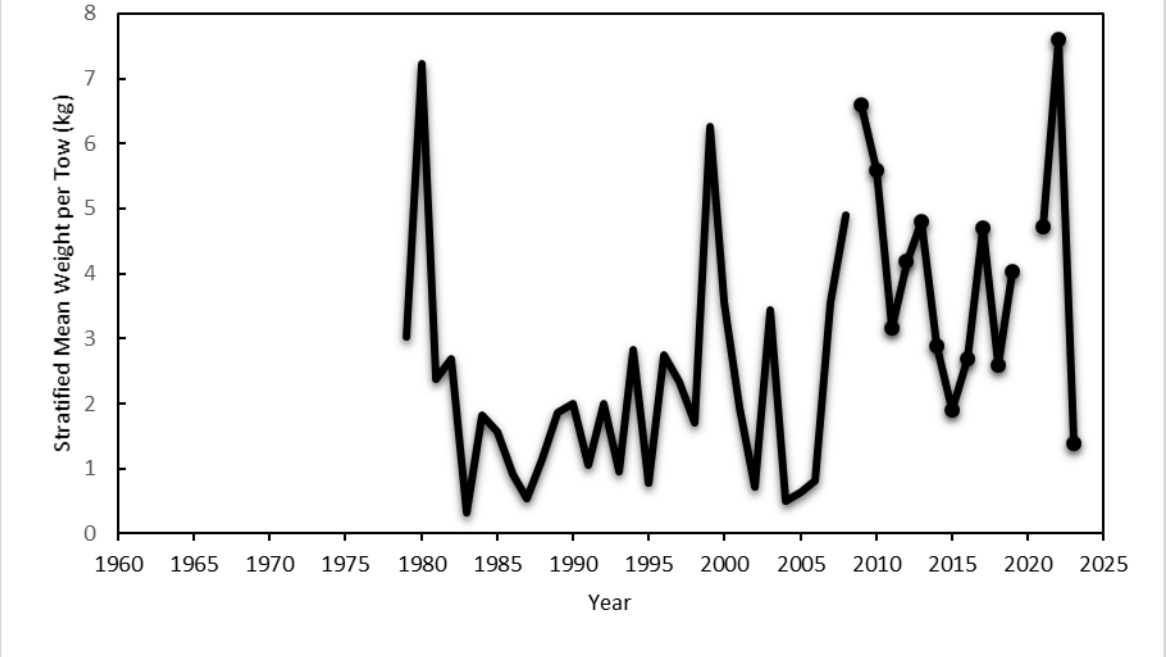

Figure 10. NEFSC autumn bottom trawl survey biomass indices for Cape Cod-Gulf of Maine yellowtail flounder.

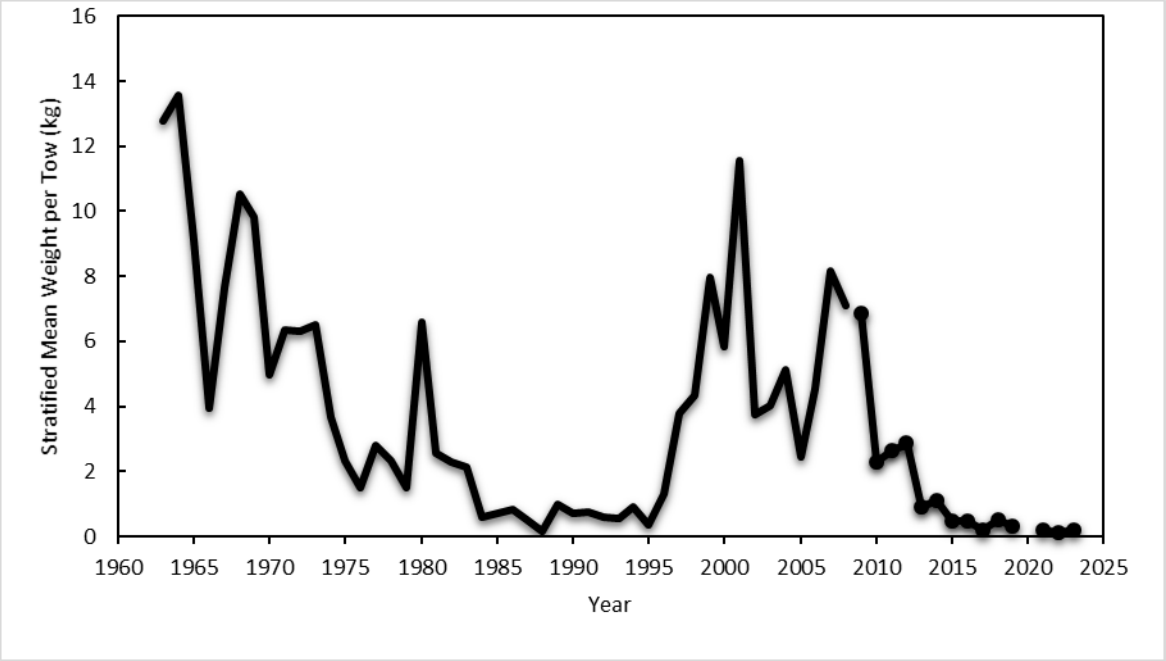

Figure 11. NEFSC autumn bottom trawl survey biomass indices for Georges Bank yellowtail flounder.

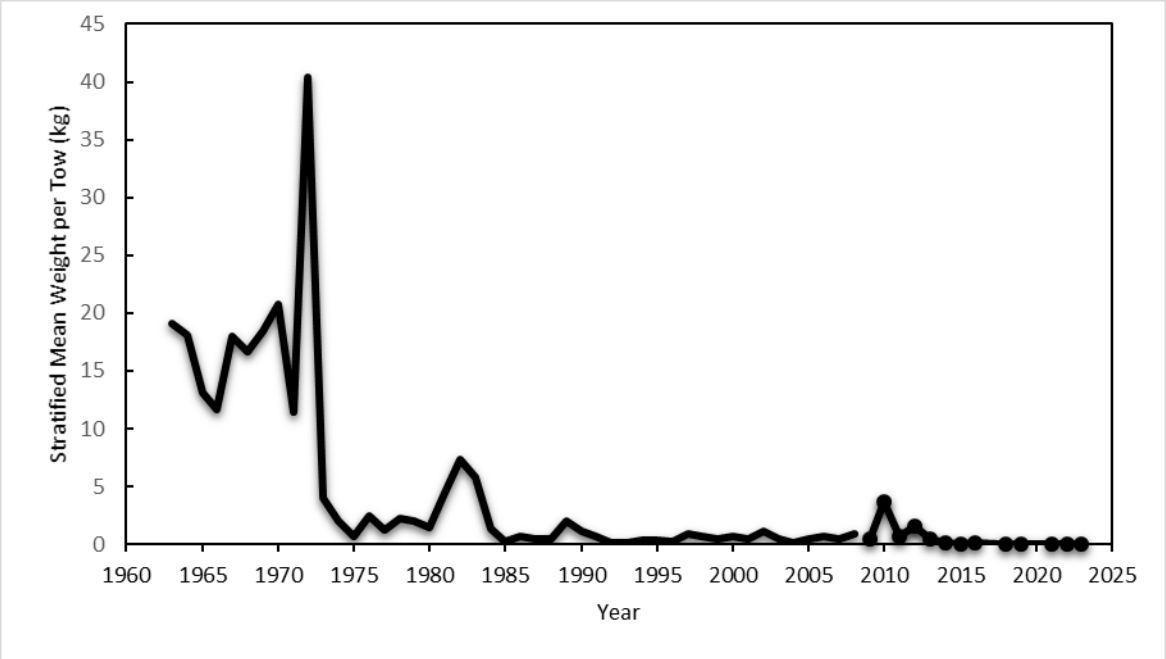

Figure 12. NEFSC autumn bottom trawl survey biomass indices for Southern New England-Mid-Atlantic yellowtail flounder.

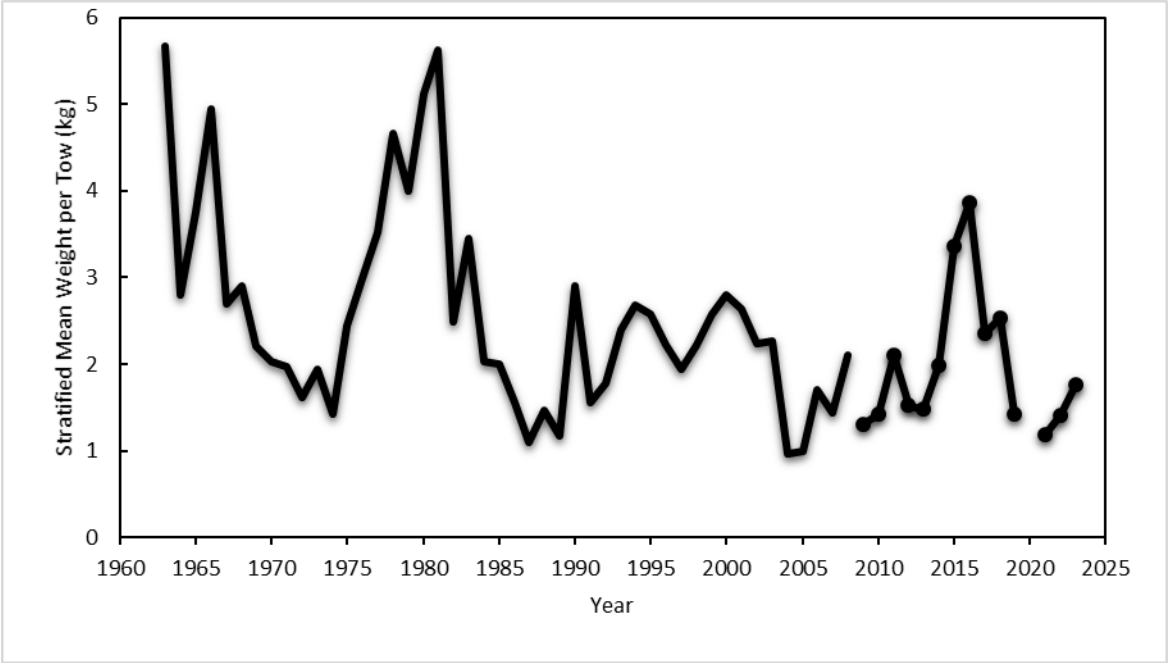

Figure 13. NEFSC autumn bottom trawl survey biomass indices for American plaice.

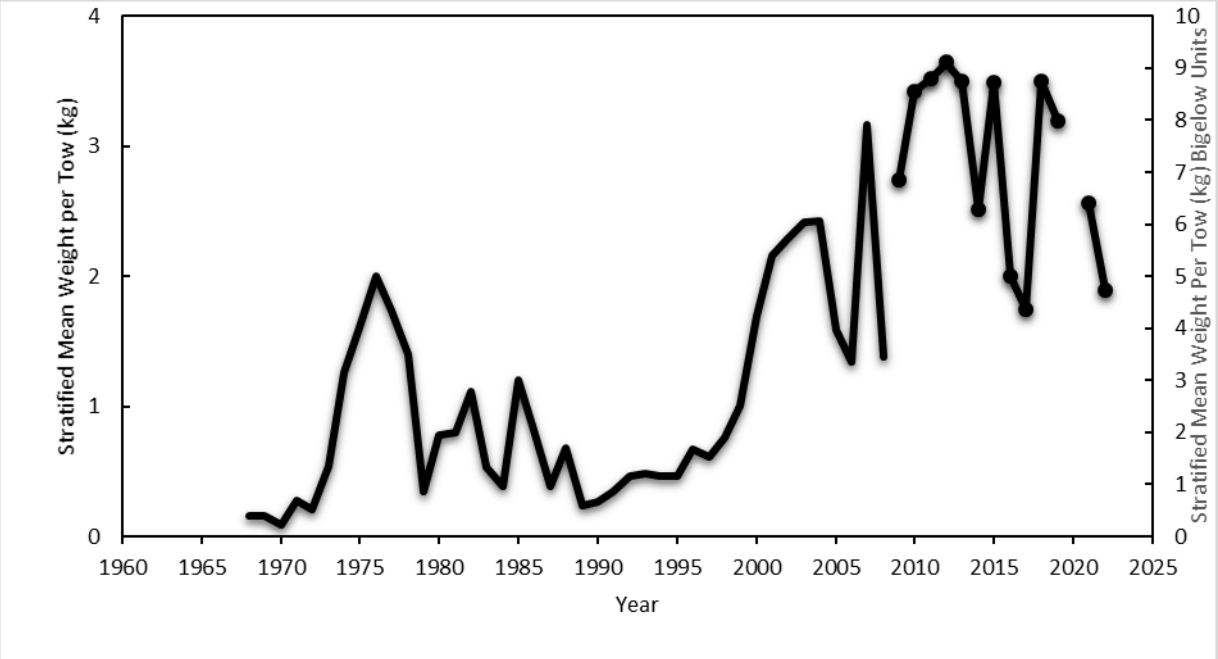

Figure 14. NEFSC spring bottom trawl survey biomass indices for summer flounder Data from 2009-2022 have not been calibrated to the earlier time series and are plotted on the right axis. The survey in 2023 did not cover the area for summer flounder.

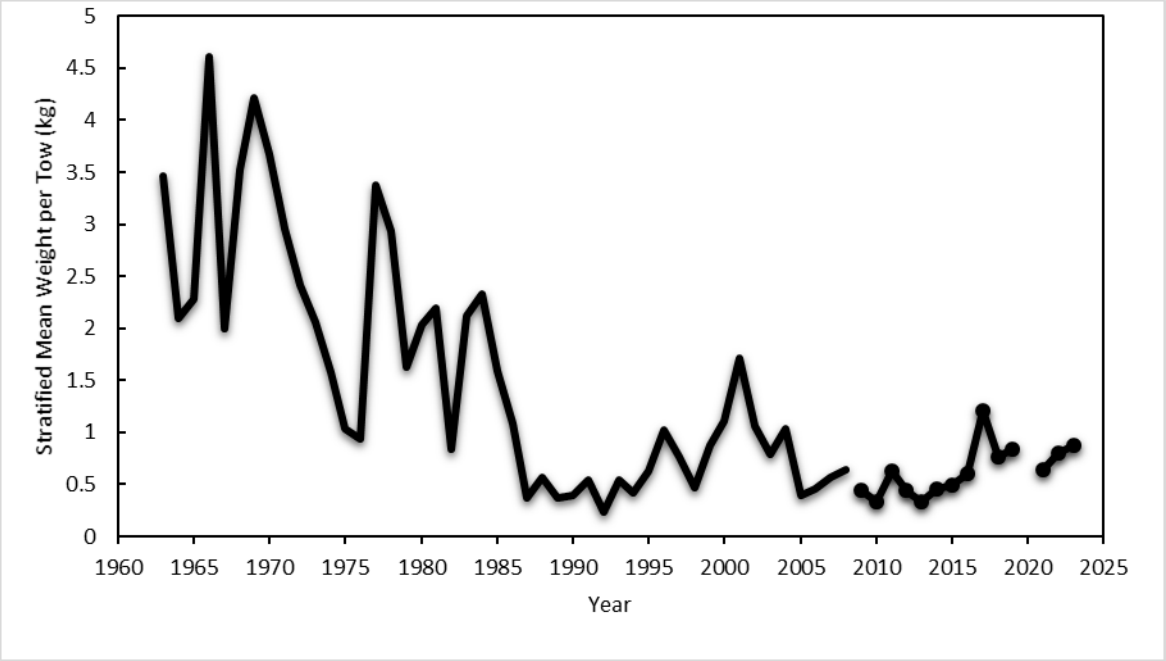

Figure 15. NEFSC autumn bottom trawl survey biomass indices for witch flounder.

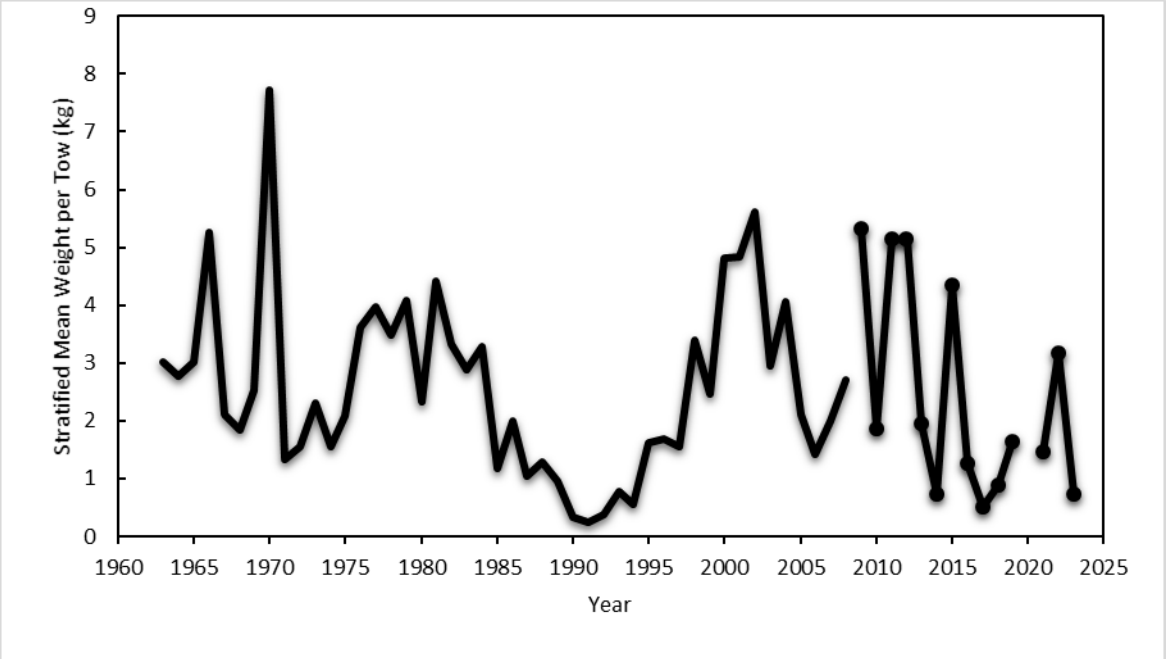

Figure 16. NEFSC autumn bottom trawl survey biomass indices for Georges Bank winter flounder.

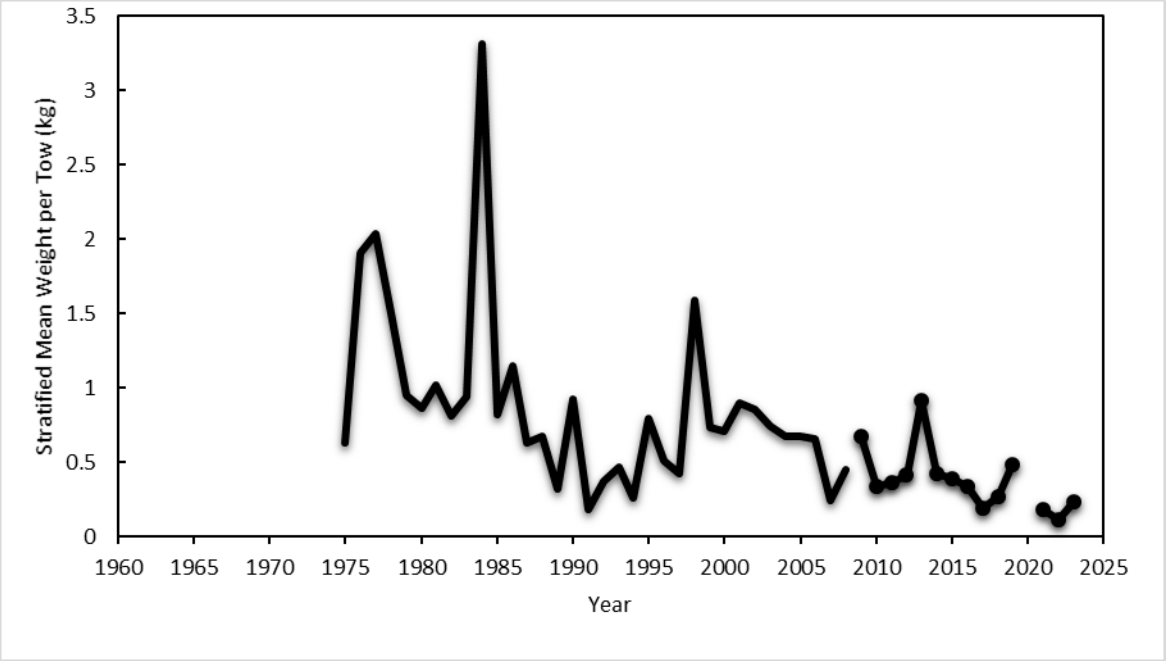

Figure 17. NEFSC autumn bottom trawl survey biomass indices for northern windowpane flounder.

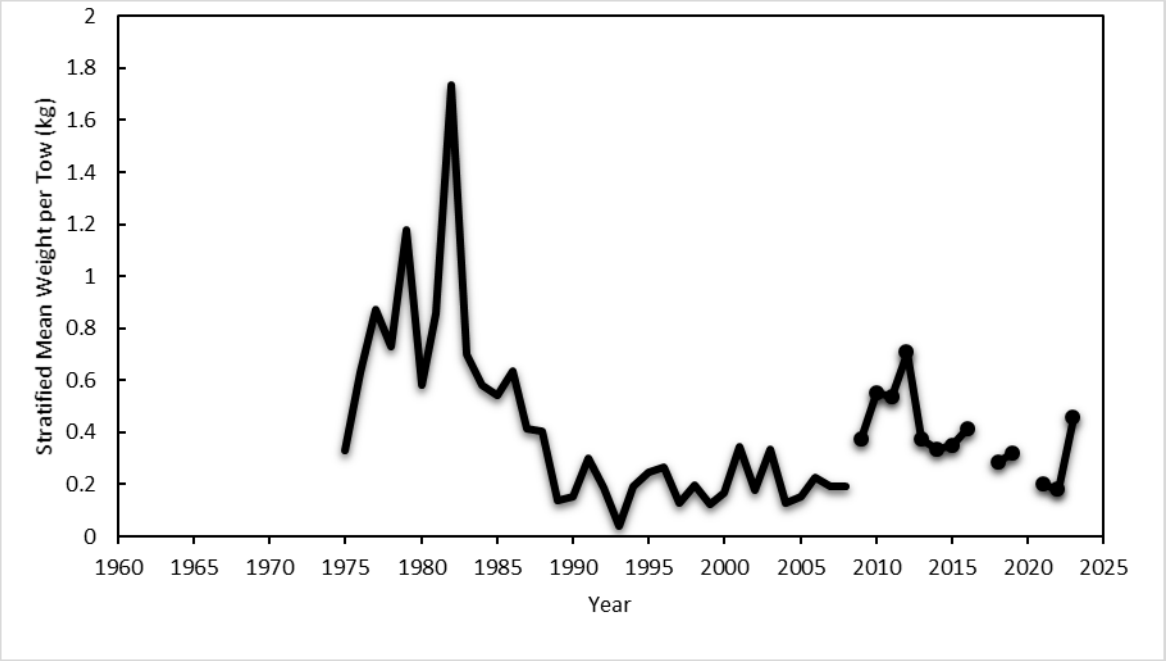

Figure 18. NEFSC autumn bottom trawl survey biomass indices for southern windowpane flounder.

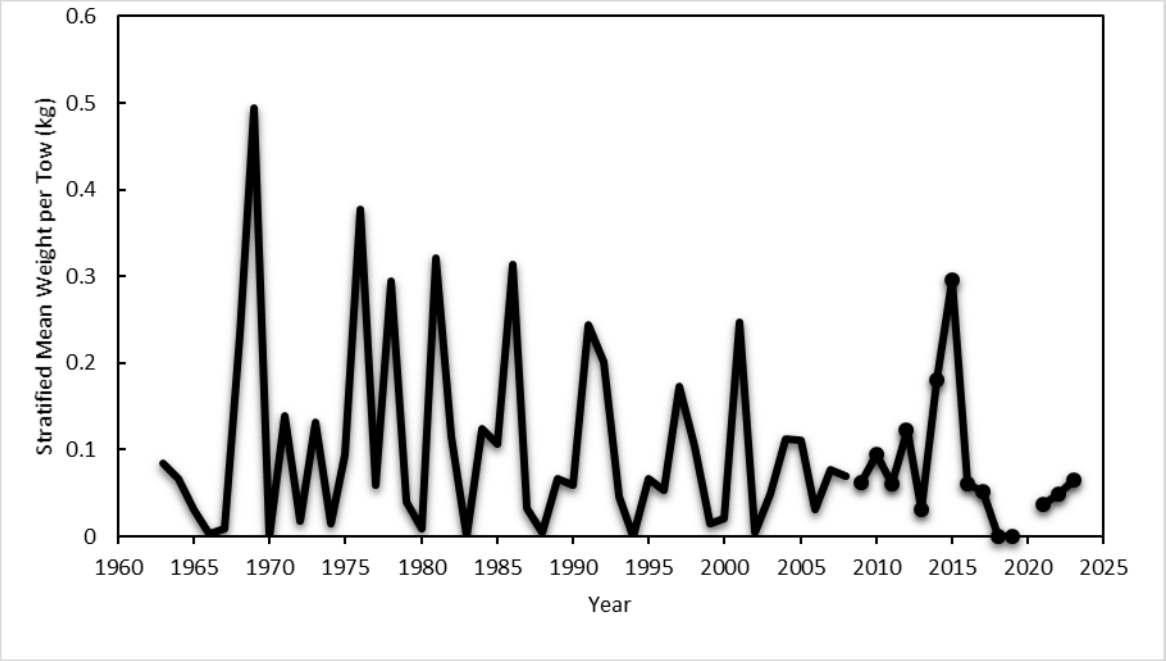

Figure 19. NEFSC autumn bottom trawl survey biomass indices for Atlantic halibut.

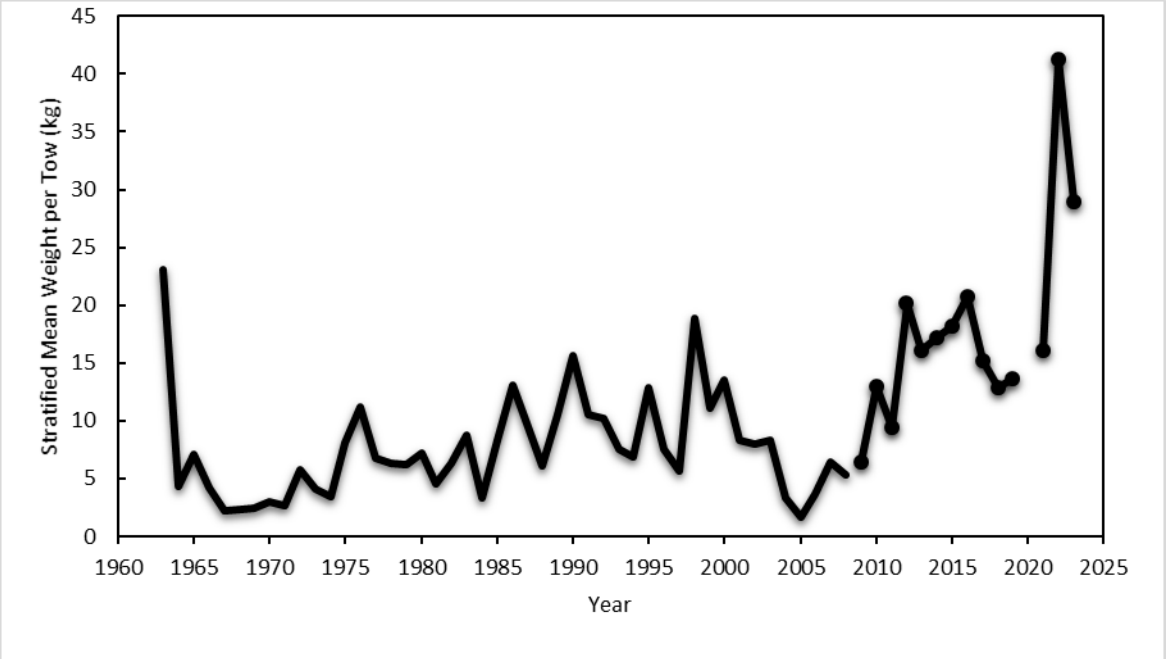

Figure 20. NEFSC autumn bottom trawl survey biomass indices for northern silver hake.

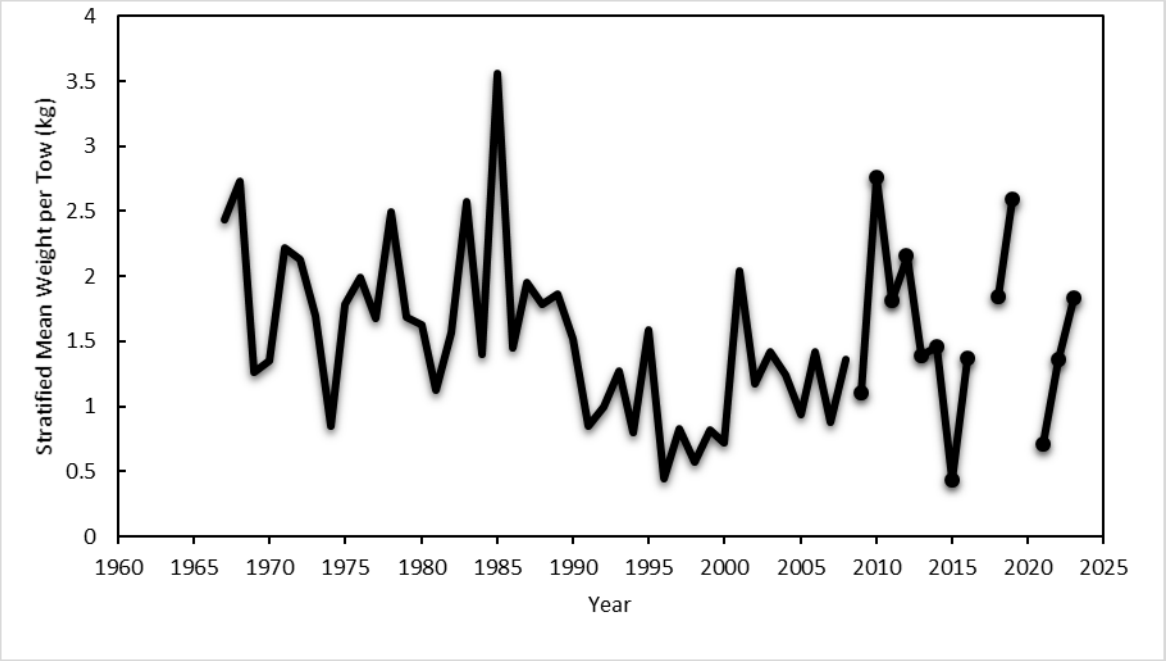

Figure 21. NEFSC autumn bottom trawl survey biomass indices for southern silver hake.

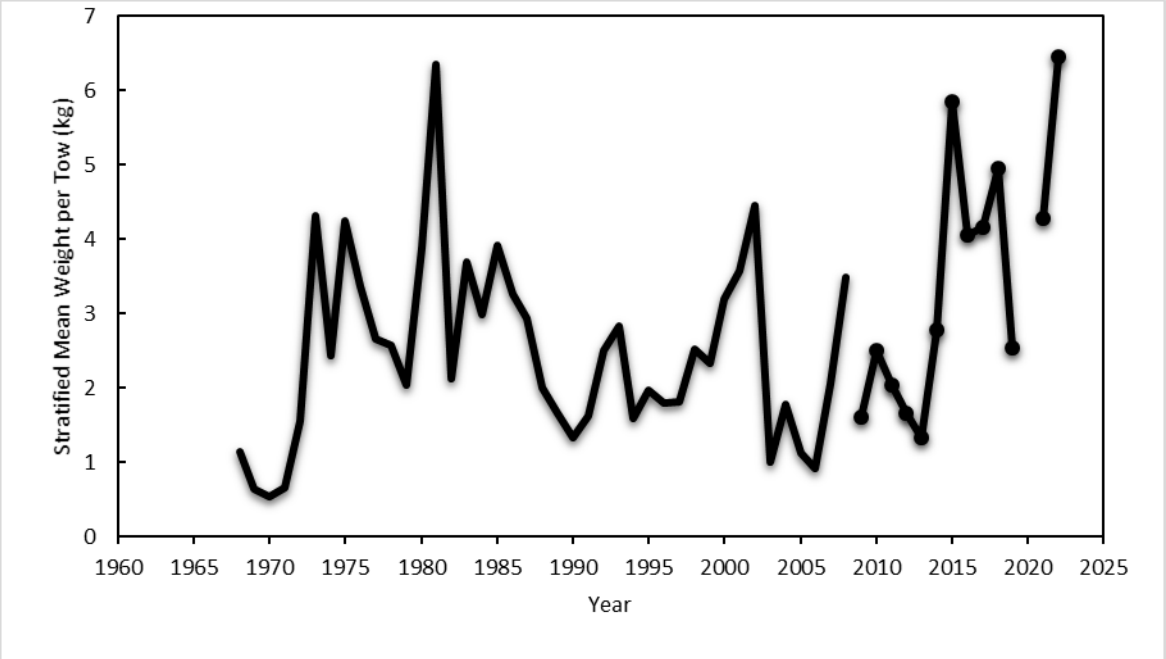

Figure 22. NEFSC spring bottom trawl survey biomass indices for northern red hake. The spring survey in 2023 was incomplete.

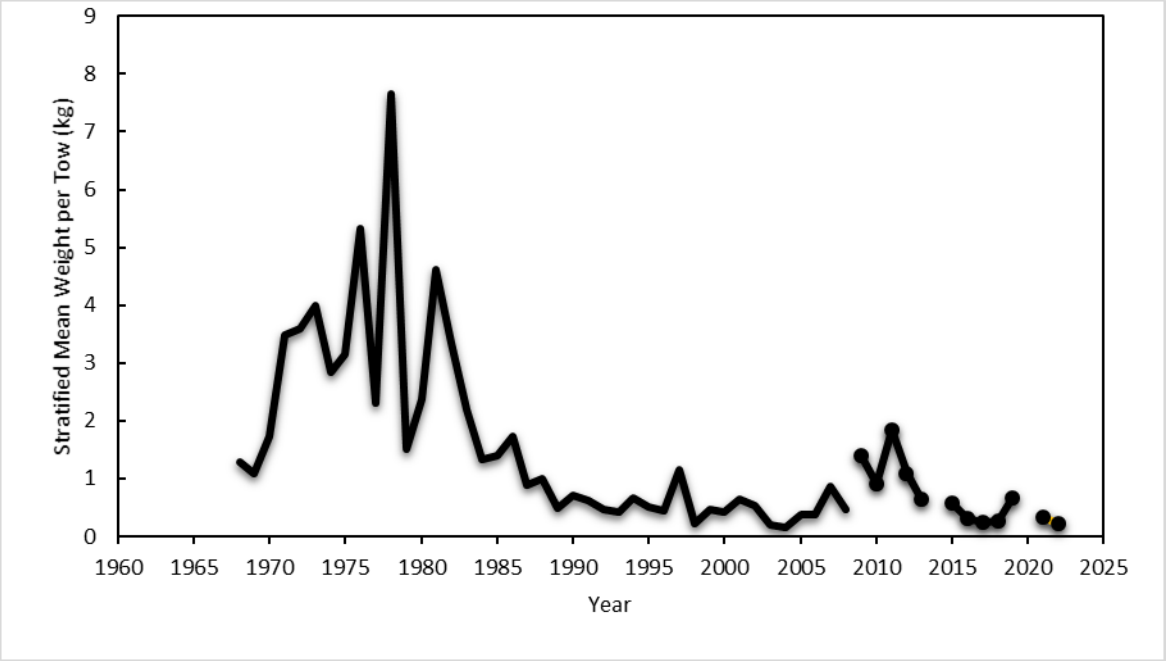

Figure 23. NEFSC spring bottom trawl survey biomass indices for southern red hake. The spring survey in 2023 was incomplete.

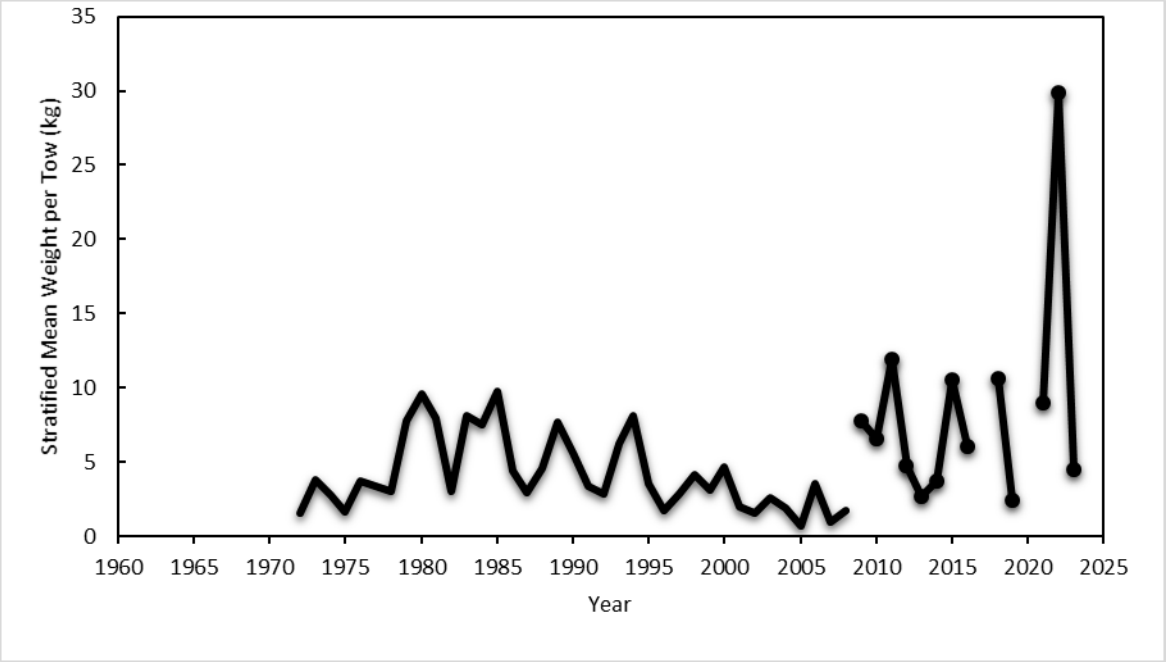

Figure 24. NEFSC autumn bottom trawl survey biomass indices for butterfish.

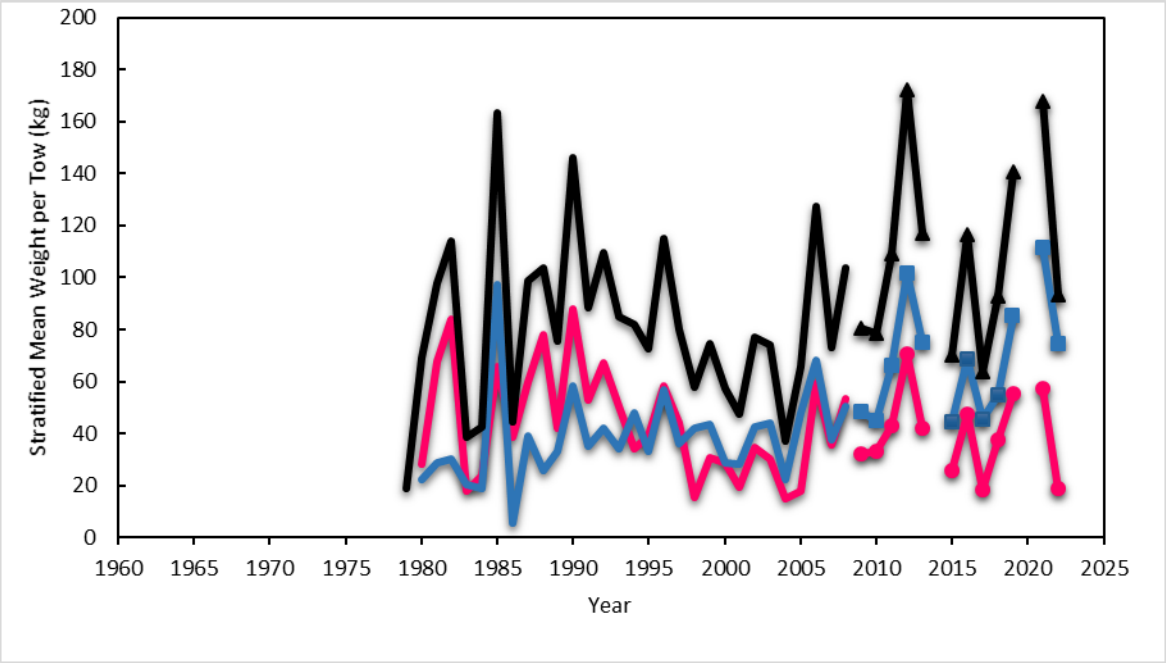

Figure 25. NEFSC spring bottom trawl survey biomass indices for spiny dogfish. The black line with triangles is the total biomass, the blue line with the squares is male biomass and the pink line with circles is female biomass. The survey in 2023 did not cover the area for spiny dogfish.

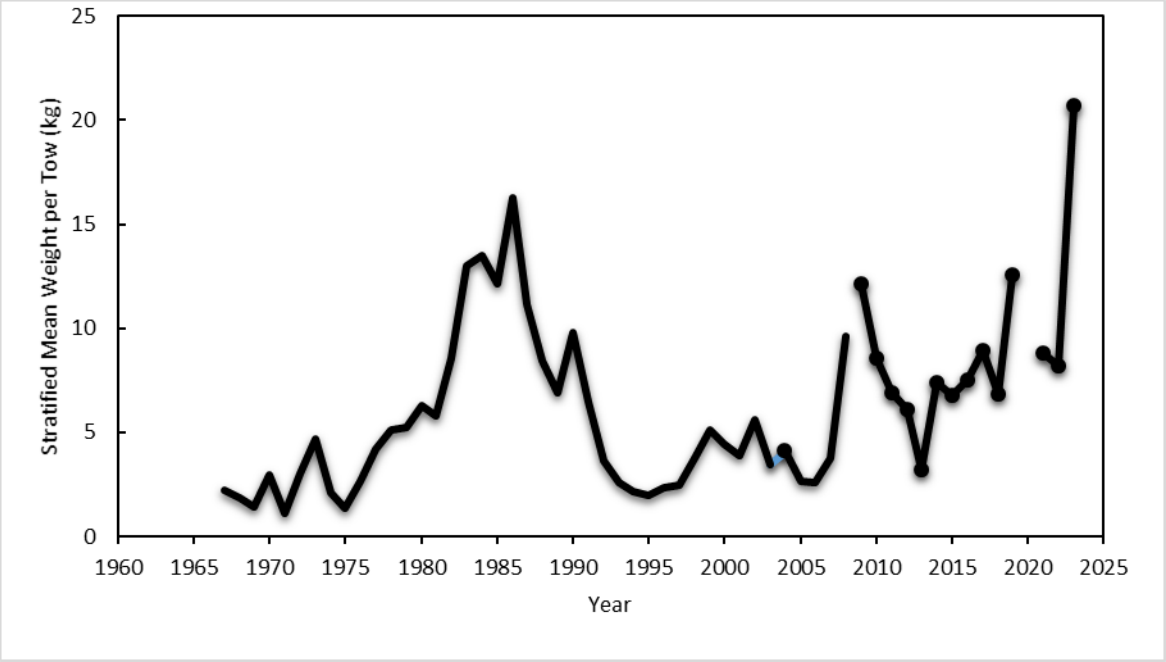

Figure 26. NEFSC autumn bottom trawl survey biomass indices for winter skate.

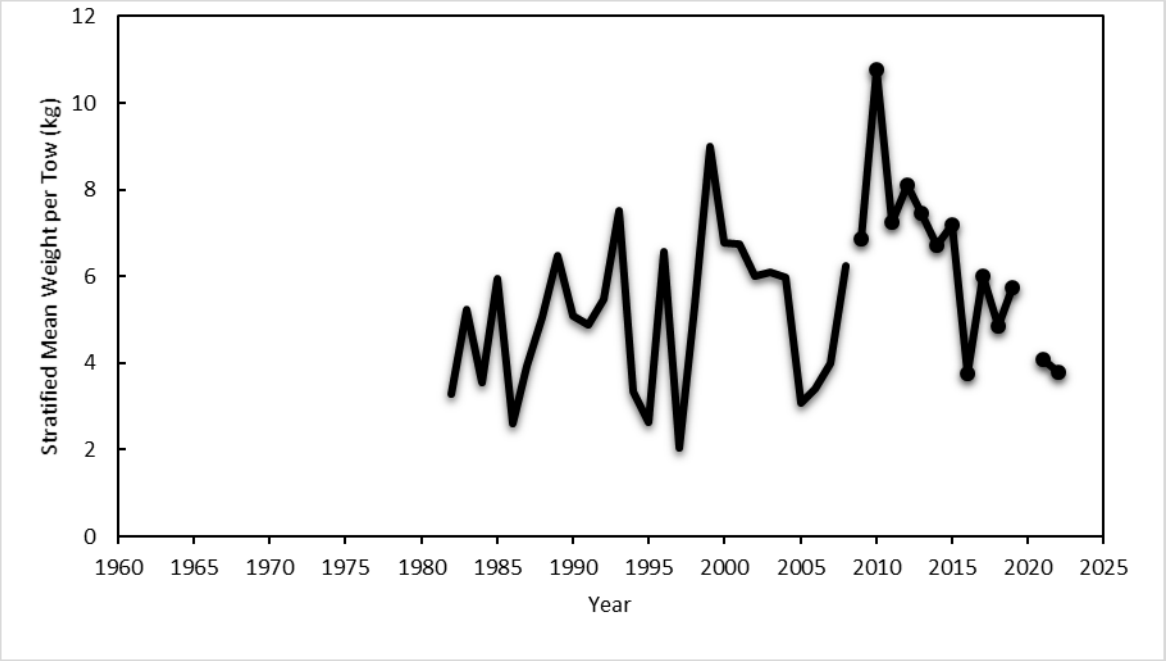

Figure 27. NEFSC spring bottom trawl survey biomass indices for little skate. The survey in 2023 did not cover the area for little skate.

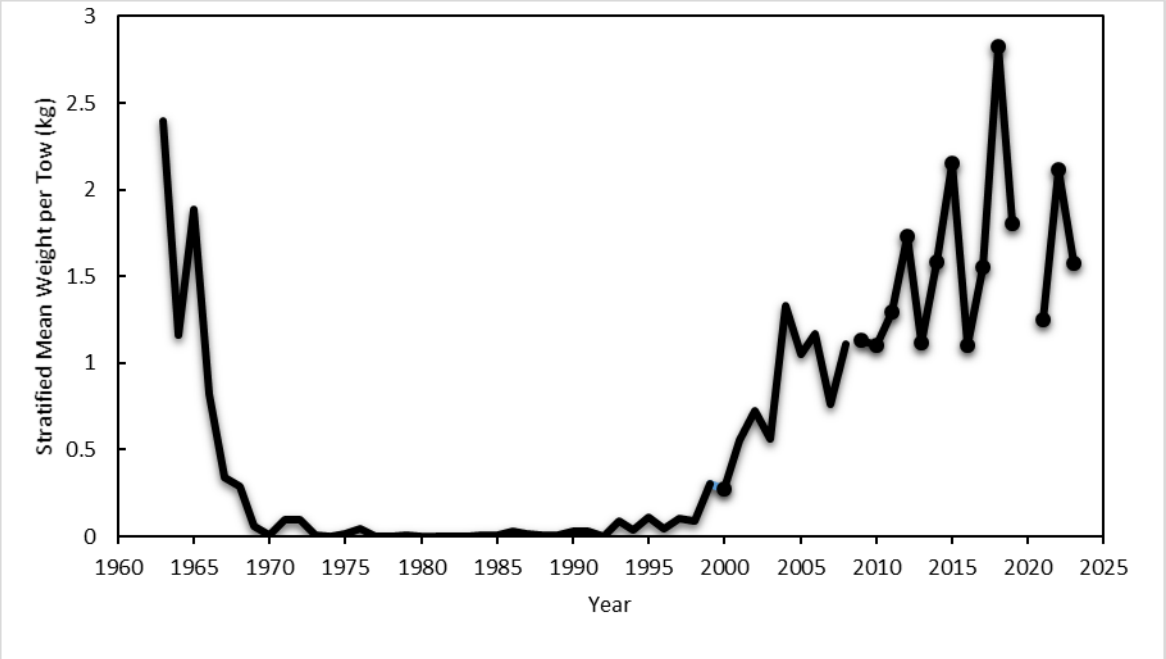

Figure 28. NEFSC autumn bottom trawl survey biomass indices for barndoor skate.

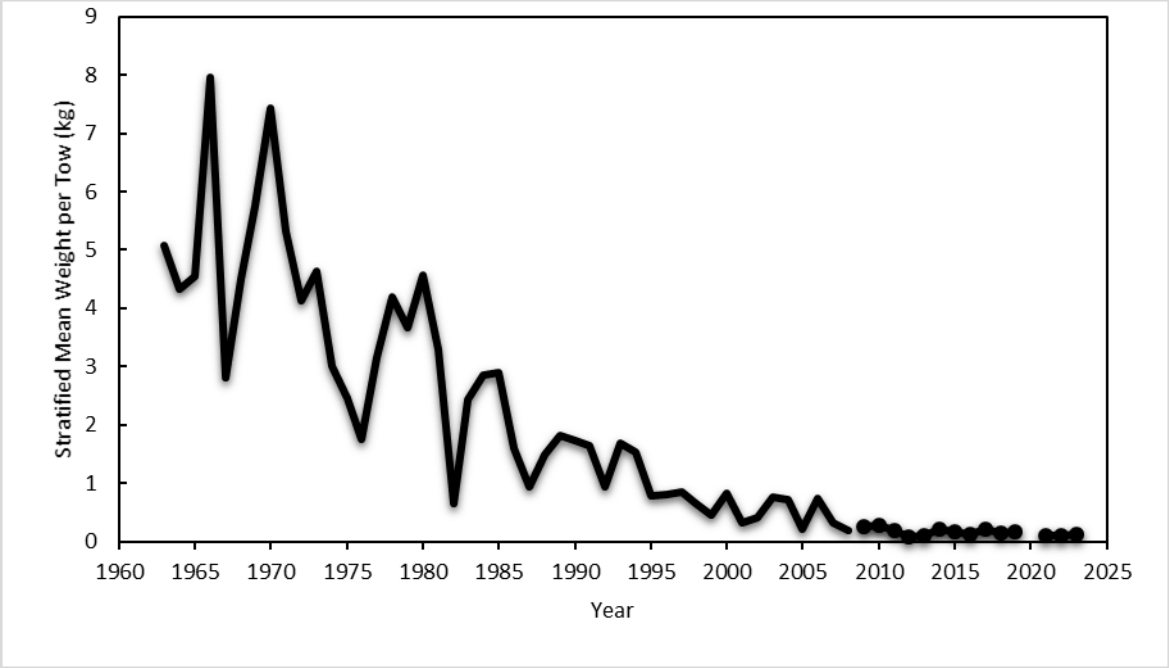

Figure 29. NEFSC autumn bottom trawl survey biomass indices for thorny skate.

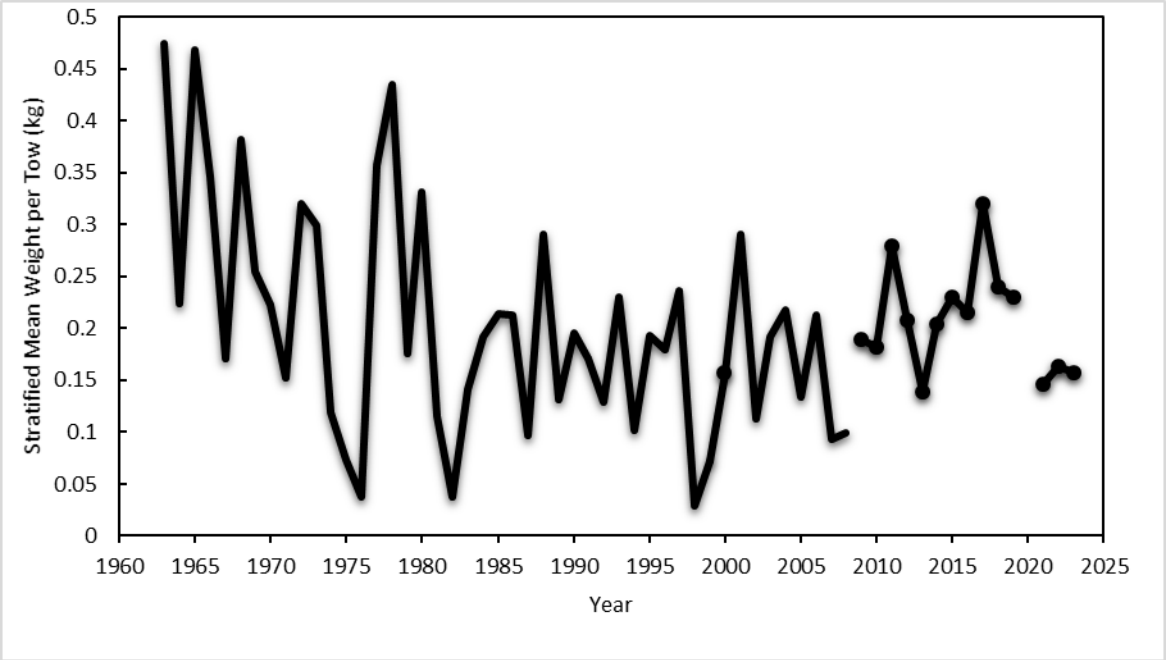

Figure 30. NEFSC autumn bottom trawl survey biomass indices for smooth skate.

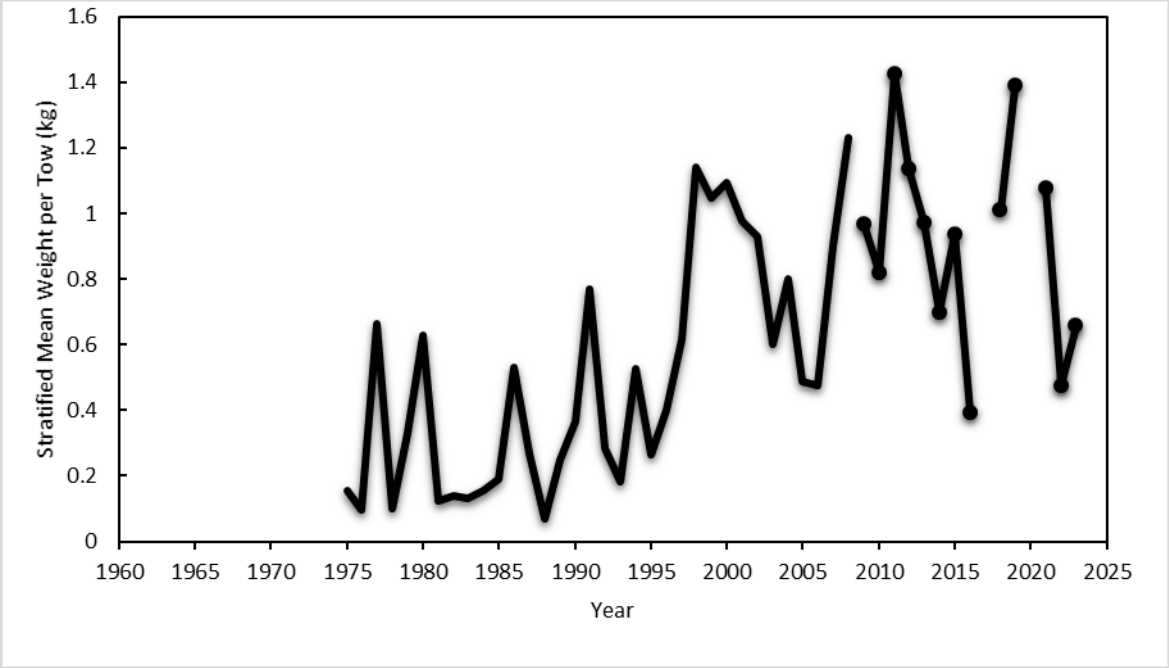

Figure 31. NEFSC autumn bottom trawl survey biomass indices for clearnose skate.

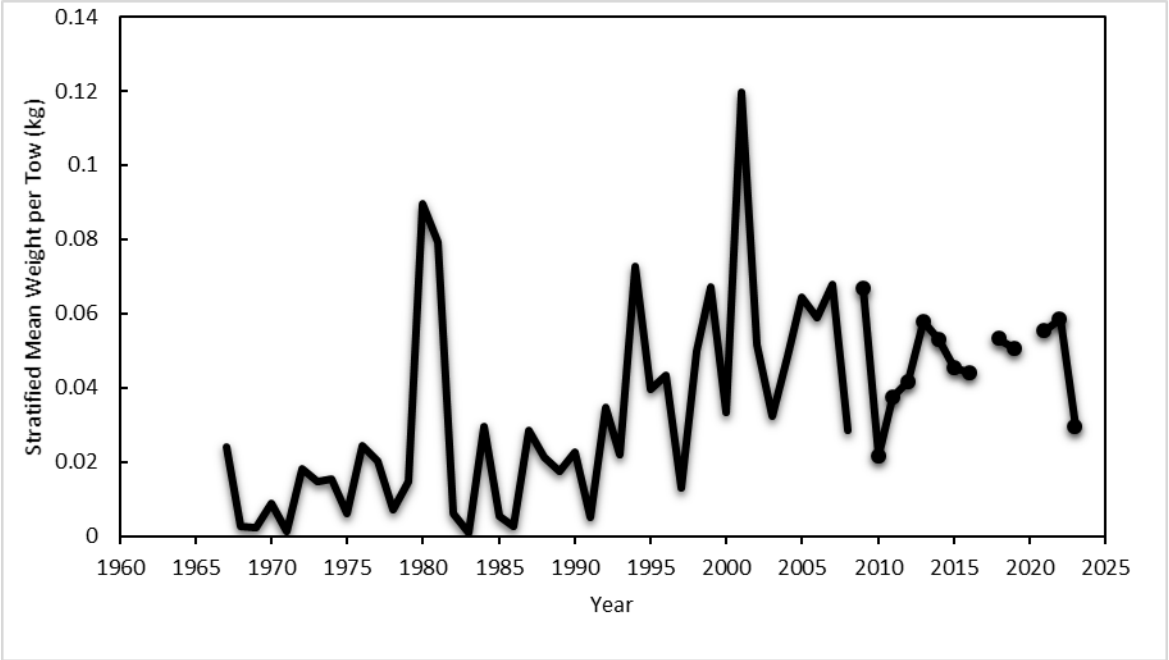

Figure 32. NEFSC autumn bottom trawl survey biomass indices for rosette skate.