New York Bight Indicator Report 2024

MOU # AM10560 NYS DEC & SUNY Stony Brook

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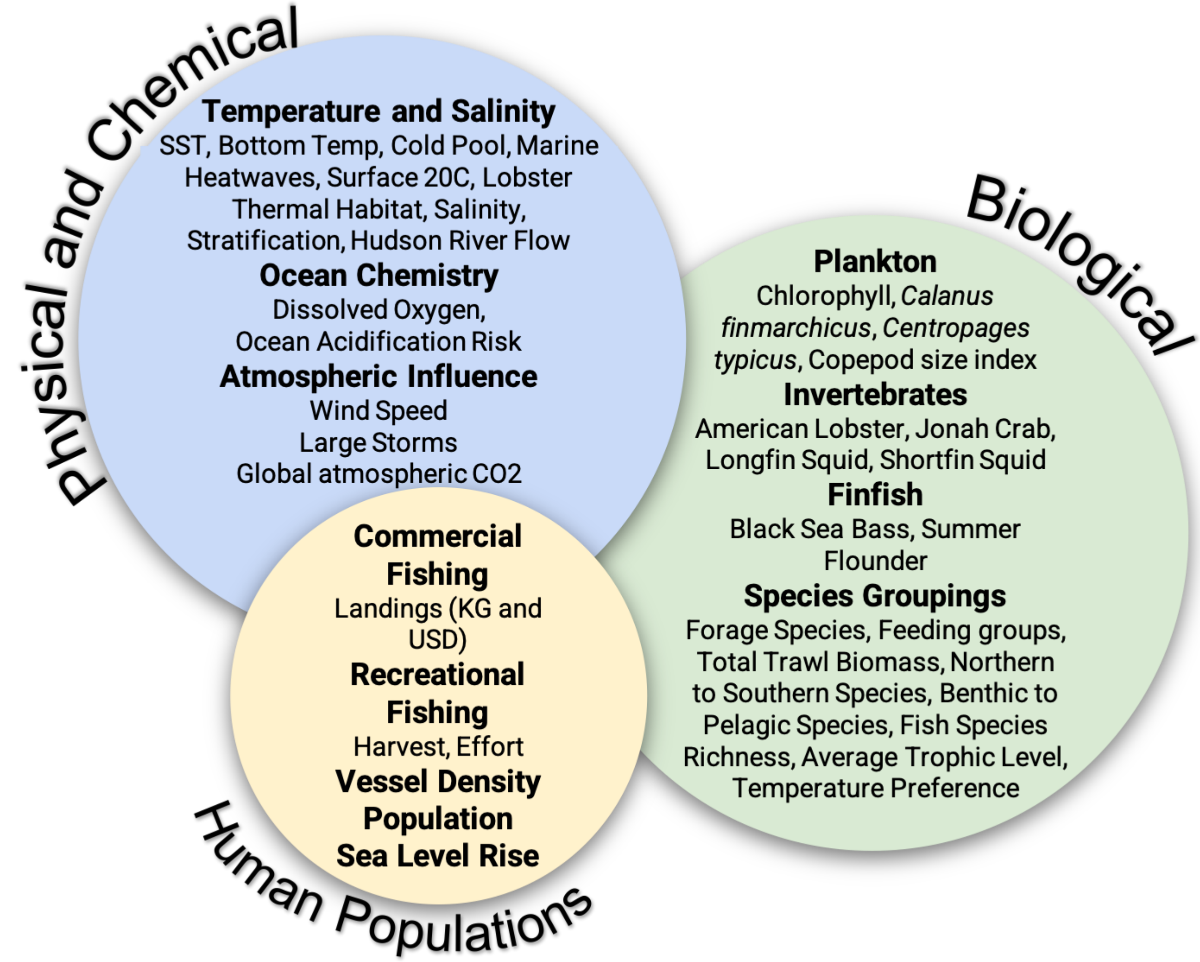

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Indicators at a Glance

The long-term trend column indicates a statistically significant increase or decrease in any linear trend over the whole time series of that indicator. The short- term status is determined by whether the average of the most recent five years of data was above or below the 70th percentile for the time series. A dotted line indicates no significant trend was present.

	Indicator	Long term trend	Short term status	Summary
1	Sea surface temperature	↗	↗	Sea surface temperatures have increased across all seasons. SSTs during the past five years are greater than the 70th percentile of historical SSTs.
2	Marine Heatwave Days	↗	↗	Both surface and bottom heatwave days have increased in the long-term and have been above average in the short-term despite a low value in 2024.
3	Bottom Temperature	↗	↗	Bottom Temperature has increased since the 1960s and have been higher in the short term.
4	Cold Pool	↘	⇢	Cold pool volume has decreased over the long-term. The past five years of cold pool volume is between the 30th and 70th percentiles of all data.
5	Bottom Dissolved Oxygen	⇢	⇢	Bottom dissolved oxygen remained above impaired levels and were slightly higher in 2024 compared to the lowest levels observed so far in 2023.
6	Ocean Acidification Risk	-	-	In development
7	Wind Speed	⇢	⇢	The proportion of days that would trigger a small craft advisory do not show consistent long or short-term trends.
8	Stratification	⇢	⇢	Stratification shows no significant long or short-trends.
9	Hudson River Flow	↗	⇢	Hudson River Flow at Green Island shows an increasing trend in the long-term. Flow has been high for the last 5 years.
10	Salinity	⇢	⇢	Both surface and bottom salinity show no significant trend in the long-term or short-term
11	Global Carbon Dioxide	↗	↗	Global CO_2 emissions continues to increase exponentially in the long and short term
12	Surface 20°C Isotherm	↗	↗	Surface 20°C Isotherm continues to shift to the northeast in summer and offshore in autumn.
13	Lobster Thermal Habitat	⇢	⇢	No long or short-term trends are present in the percentage of New York Bight seafloor thermally inhospitable to lobster.
14	Number of Large Storms	⇢	⇢	No long or short-term trends are present in large storm indicators.

	Indicator	Long term trend	Short term status	Summary
15	Chlorophyll	⇢	↘	Short-term decreases were observed in April, August, September, and November.
16	*Calanus finmarchicus*	⇢	↘	No long-term trend in this cold water copepod, but values were relatively low in the short term. Highest abundance occurs in spring in NYB
17	*Centropages Typicus*	⇢	↘	No long-term trend in this warm water copepod, but abundance is consistently lower than the peak from 1995-2003. Highest abundance occur in summer in NYB
18	Copepod Size Index	⇢	⇢	No long- or short-term trends
19	American Lobster	↘	↘	Both a long-term and short-term decline in American lobster
20	Jonah Crab	⇢	↗	Jonah crab biomass has decreased in spring but increased in the fall in the long term. Only a short-term increase in the fall has been observed indicating changing seasonality
21	Longfin Squid	⇢	↗	Significant decreasing long-term trend in spring and increasing long-term trend in the fall, indicating change in seasonality. Longfin squid biomass has increased in the fall in the short term.
22	Shortfin Squid	↗	⇢	Long-term increase in shortfin squid in spring, but no recent trends
23	Forage Species Biomass	↗	↗	Both a long-term and short-term increase in the fall
24	Aggregate Feeding Groups	⇢	↗	Short term increases were observed for benthivores and planktivores. Long term increases were exhibited by benthos and planktivore groups, as well as a long-term decrease in piscivores.
25	Total Trawl Biomass	⇢	⇢	No long- or short-term trends in total nekton biomass
26	Black Sea Bass	↗	↗	Increases in black sea bass biomass was observed for both the short and long term in both spring and fall.
27	Summer Flounder	↗	↗	Increases in summer flounder biomass was observed for both the short and long term in both spring and fall.
28	Ratio Northern to Southern species	↘	↘	The ratio of northern to southern species has decreased since 1995 for nekton and marine mammals.
29	Ratio Benthic to Pelagic Species	↘	↘	The benthic to pelagic species ratio has decreased in the fall season for both the long and short term.
30	Fish Species Richness	↗	↗	The number of fish species has increased in the short- and long-term trend in both seasons.
31	Average Trophic Level of Fish Community	⇢	⇢	Average trophic level has not demonstrated significant changes.
32	Temperature Preference of Fish Community	↗	↗	The mean temperature preference of the fish community has increased in both the short and long term in both seasons.

	Indicator	Long term trend	Short term status	Summary
33	Commercial Harvest Tons	↘	↘	Commercial landings have decreased in the long term and declined in the last 5 years
34	Commercial Harvest USD	↗	⇢	The value of commercial harvest has increased since the 1960s, but has declined since 2015.
35	Recreational Harvest	↗	↘	There is a long-term decreasing trend for recreationally harvested fish, but an increasing trend for released fish. Both harvest and released fish were lower than average
36	Recreational Effort	↗	↗	Recreational effort as indicated by the number of trips has increased over time especially in charter and party boats.
37	Vessel Density	↗	↗	The number of TEUs at the port of New York and New Jersey have increased in the long-term. Short-term data indicates a high status within the past five years.
38	Human Population	↗	↗	The population of Long Island has increased dramatically since the 1980s, peaked in 2020, has declined to 2019 levels, but still remains above the historic average.
39	Sea Level Rise	↗	↗	Mean sea level has increased in both the long and short term at Battery Park and Montauk, but Montauk has increased at a faster rate.

Executive Summary

The fingerprint of climate change is unmistakable in all metrics of ecosystem status in the NYB. As CO_2 emissions continue to rise globally, surface and bottom water temperatures have increased and the volume of the Mid-Atlantic cold pool, once a refuge for cold-water species, has decreased. The 20°C isotherm, a threshold temperature above which many “cold water” species including American lobster, cannot survive continues to move northward in the spring. However, in the Fall of 2024, its autumn location was completely different from any previous year, indicating a striking change in the oceanography in 2024 that we detected in other indicators. From the autumn of 2023 to the summer of 2024 surface temperature was cooler and the salinity was lower than it has been in the last 3-7 years. The Mid-Atlantic cold pool volume was higher than it has been in the last 3-5 years. The number of heatwave days was also greatly reduced. Both the surface and bottom salinity in the spring of 2024 was the lowest observed on record, but we did not detect any significant changes in bottom dissolved oxygen, stratification, salinity, wind speed, or the number of large storms in 2024.

The indicators of the marine community of the NYB alsoagree with the broader observations in the Northeast US, that the marine community continues to tropicalize. Tropicalization does not necessarily mean we see more tropical species, but is a term used to characterize a temperate ecosystem taking on the characteristics of a more tropical system. The most clear evidence of tropicalization is the presence of more southern or warm water species than northern or cold water species. We would also expect to see a change in the timing of the spring and fall blooms.

Temperate systems tend to have two strong phytoplankton blooms, one in the spring and one in the fall, but tropical systems have a single weak bloom, typically in summer. More tropical systems tend to have higher richness and diversity. We saw most of these climate change signals. The ratio of cold/northern to warm/southern nekton has declined since the 1960s especially in the Fall. Similarly, using strandings data as an indicator of prevalence, we saw a higher rate of strandings of warm water odontocetes and fewer strandings of cold water odontocetes. Fish species richness and the mean temperature of the fish community has increased as well. No long-term trends were seen in chlorophyll, but some decreases were observed in April, August, September and November. A decline in the spring (April) and fall (August, September and November) suggests that either the bloom in these months was not as intense or that the timing of the bloom may have changed. As such, patterns in bloom timing, intensity and duration should be examined. We also see changes in the biomass of some species seasonally which may be related to climate. Longfin squid, one of the most important fisheries for NY state, has decreased in the spring since 2011, but increased in the autumn over time. Its Fall 2023 biomass was the highest ever observed in the time series. With warming a switch from large, lipid-rich copepods such as *Calanus finmarchicus* to smaller warm water species like *Centrapoges typicu*s is predicted. However, we did not detect long-term trends in the ratio of small to large copepod and no long-term trends in *Calanus* or *Centrapages*, the dominant copepods in the NYB. RV Seawolf data suggests that *Calanus* peaks in abundance in spring while *Centropages* peaks in summer, further suggesting that seasonal differences in the appearance of these copepods may make it difficult to track clear trends over time. The changes we document are also a result of changes in fishing intensity in addition to the strong climate signal in the NYB. There have been recent recoveries of the biomass in benthivores and planktivores, but we have not returned to the high biomasses of piscivores seen in the 1960s. This is likely due to the almost complete loss of large, cold water piscivores like Atlantic cod, pollock and haddock in the NYB. American lobster also remains at low levels since the early 2000s following the mass mortality event in Long Island Sound. However, black sea bass, summer flounder and forage species (includes forage fishes and squid) have increased recently in the fall especially in 2022 and 2023.

The current value of New York’s commercial harvest is landings alone is nearly $39 million and as a whole remains below the unsustainable levels of the 1960s. However, it is concerning that the value of commercial harvest has been declining in the last seven years. Recreational effort has increased dramatically since 2000 with much of that effort consisting of party and charter boats The actual harvest from recreational fishers has declined since the early 1980s, largely explained by the much larger number of fish released over that time period. The number of cargo containers in the New York and New Jersey port is roughly double today to what it was in 2005. The population of Long Island has increased since 1970 by about 1 million people, peaking in 2020. However, population has declined over the last 3 years to 2019 levels. Sea level continues to rise and the rate at which sea level is rising has accelerated in recent years, increasing the risk of coastal communities to storm surge and flooding each year. The sea level rise in Montauk is occurring at a faster rate than in Battery Park.

Report Structure

This report is separated into two parts. Part I lists all indicators separated into three subsections, physical and chemical indicators, marine community indicators, and human populations indicators. Part II describes indicators in development. There are several changes to our indicator analysis this year which may change patterns in the figures in this year's report:

1. This year we report the short-term status as the average of the most recent five years of data rather than the short term trend as indicated by nonlinear modeling. If the average is greater than the 70th percentile of all data the status is has an upward arrow and if it is lower the status is a downward arrow.
2. Last year we developed an indicator to better represent the input of water into the New York Bight from the Hudson River using data collected by the PORTS program at the Verrazano Narrows allowing for an approximation of volume transport between Brooklyn and Staten Island. However, this data was not available this year. As such, we reverted to our old data source, the Green Island flow meter to represent output from the Hudson River. The location of this gauge is much further upstream and may not be a good indicator of freshwater flow into the NYB.
3. The number of small craft advisory days are now reported as a proportion of days in each wind category (rather than the average or sum) in each year because the amount of data varied drastically year to year.
4. Bottom temperature was calculated using CTD, XBT, and MBT data, as in years past, but glider data was not included in calculating bottom temperature in this report.
5. We added text to indicate the most recent year with data. This was done to clearly indicate when we do not have data up to 2024 for all indicators. In particular, the NOAA NEFSC trawl survey is available up to Spring 2024, but the survey was not completed because of boat maintenance in Spring 2023 and because of COVID in Fall 2020
6. The chlorophyll data used in this report is from the Copernicus Global Ocean Color database, but in previous years we used the Ocean Colour Climate Change Initiative dataset. Results are qualitatively the same.
7. NOAA tide gauges were explored last year as an indicator of relative sea level rise in Sandy Hook and Montauk. This year we replaced the Sandy Hook gauge with the Battery Park gauge.
8. An indicator using marine mammal stranding data was in development last year. This year we incorporated this as an indicator of the relative proportion of cold water and warm water higher trophic species to complement a similar indicator for mid-trophic level nekton species.
9. Last year we developed an indicator of ocean acidification risk based on a literature review of NYB species thresholds and water samples collected from our shipboard transect survey. We limited this analysis to only 1-2 transects that were consistently sampled. Rather than

repeat this, we are developing a better indicator using both glider and shipboard surveys to better assess risk over a larger area of the NYB. Similarly, we are taking a similar approach to develop an indicator of cold pool volume by combining our glider and shipboard data.

Physical and Chemical Indicators

Summary

As CO_2 emissions continue to rise globally, all metrics of water temperature reveal both long-term increasing trends while the volume of the Mid-Atlantic cold pool, a refuge for cold water species, has decreased since the start of these time series. The 20^{o}C isotherm, a threshold temperature above which many “cold water” species including American lobster, cannot survive or thrive continues to move northward in the spring. However, in the Fall of 2024, it’s autumn location was completely different from any previous year, indicating a striking change in the oceanography that we also detected in other indicators. From the autumn of 2023 to the summer of 2024, surface temperature was cooler and the salinity was lower than it has been in the last 3-7 years. The Mid-Atlantic cold pool volume was higher than it has been in the last 3-5 years. The number of heatwave days was also greatly reduced. Both the surface and bottom salinity in the spring of 2024 was the lowest observed on record. There have been no significant changes in bottom dissolved oxygen, stratification, salinity, wind speed, or the number of large storms.

10	Indicator	Long term trend	Short term status	Summary
1	Sea surface temperature	↗	↗	Sea surface temperatures have increased across all seasons. SSTs during the past five years are greater than the 70th percentile of historical SSTs.

Seasonal Mean Surface Temperature

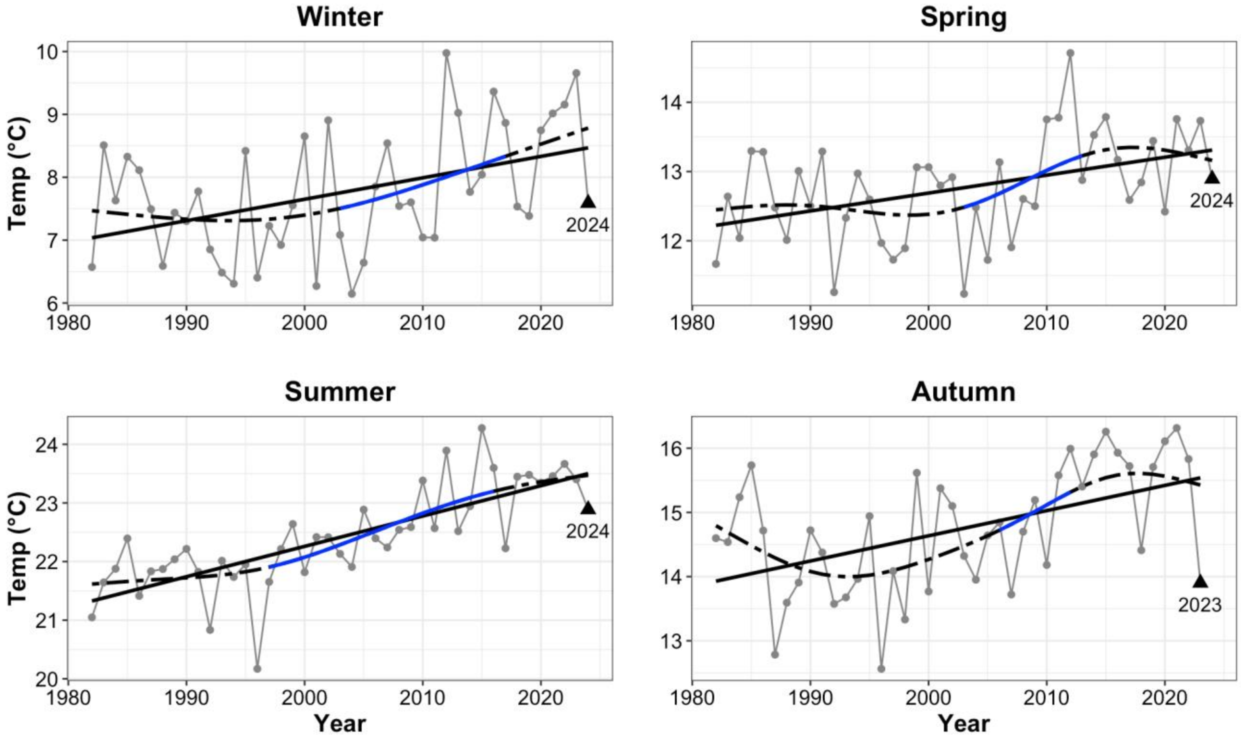


Figure 1: Seasonal mean sea surface temperature from satellite Optimal Interpolation Sea Surface Temperature (OISST).

	Indicator	Long term trend	Short term status	Summary
2	Marine heatwave days	↗	↗	Both surface and bottom heatwave days have increased in the long-term and have been above average in the short-term despite a low value in 2024.

Marine Heatwave Days

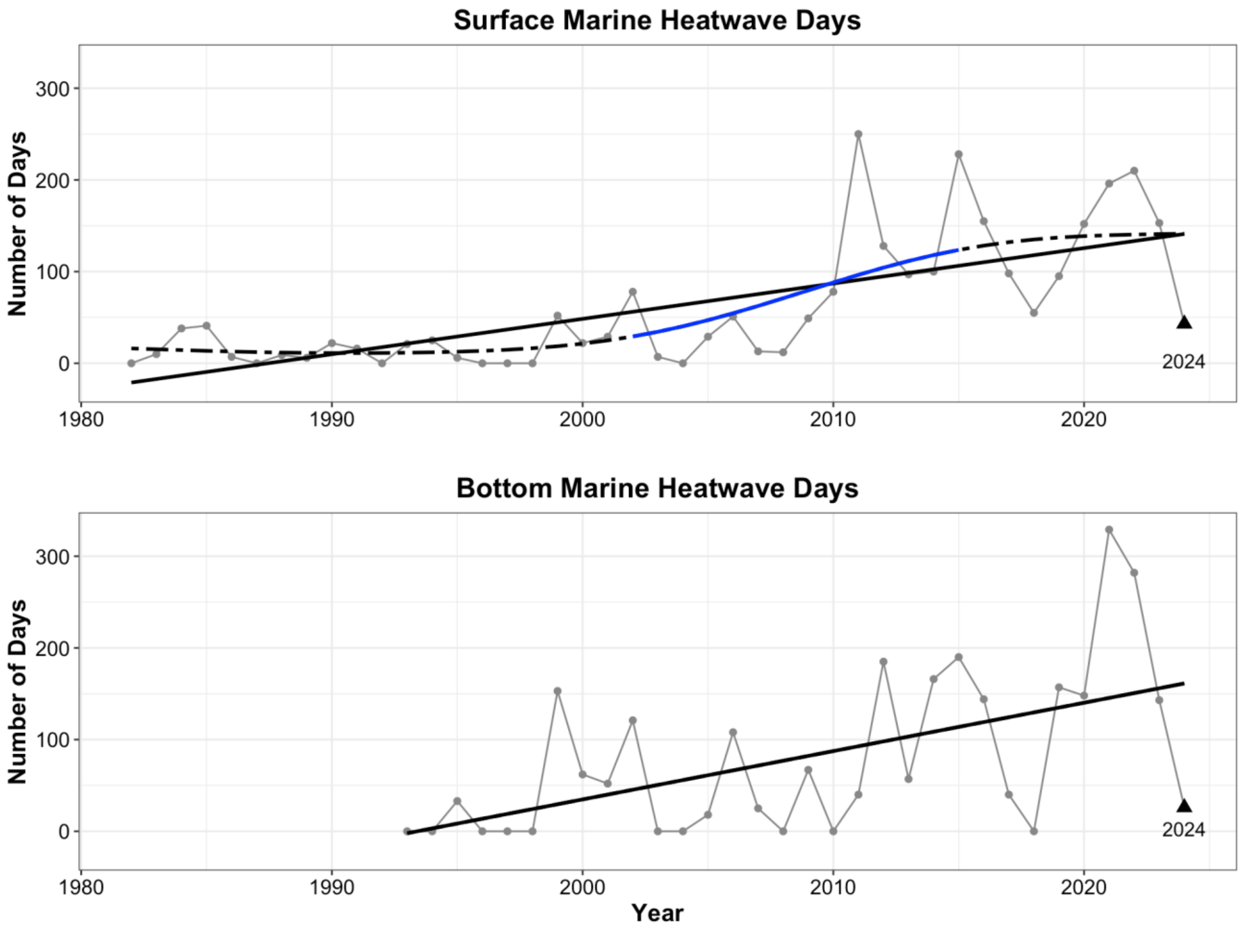


Figure 2: Surface (top) and bottom (bottom) marine heatwave days per year.

	Indicator	Long term trend	Short term status	Summary
3	Bottom Temperature	↗	↗	Bottom Temperature has increased since the 1960s and have been higher in the short term.

Bottom Temperature

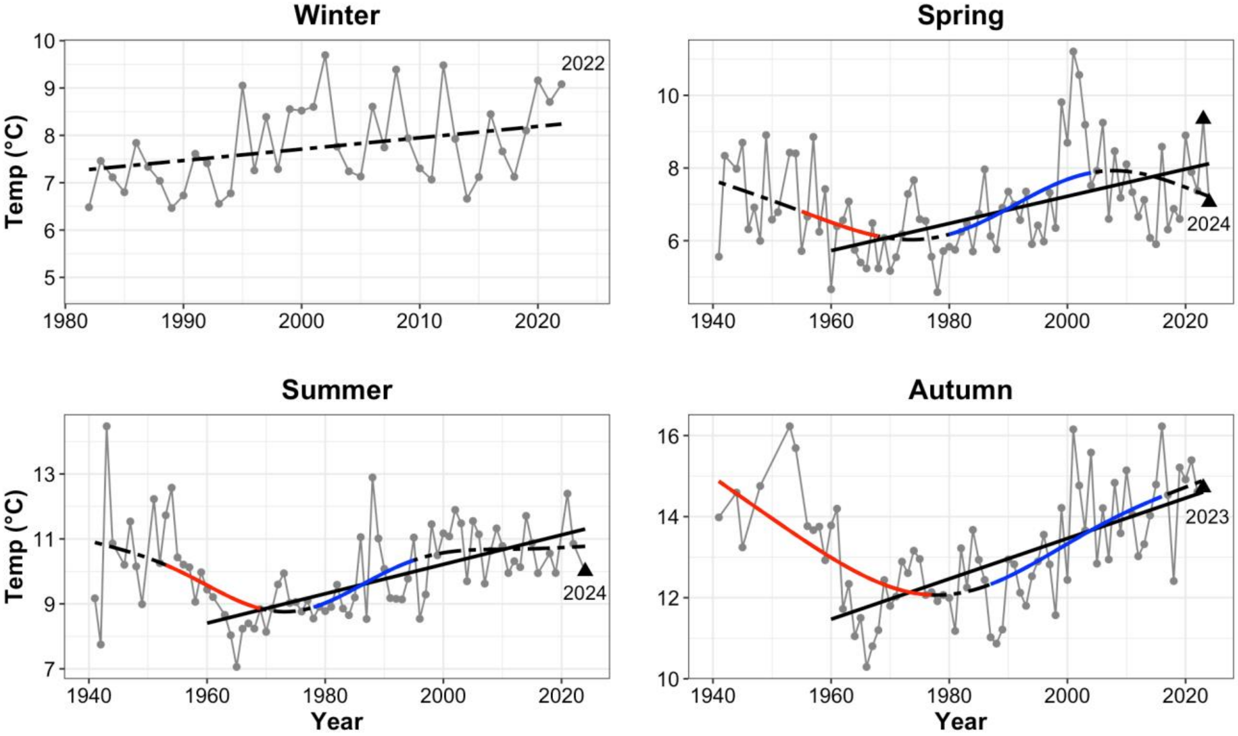


Figure 3: Mean bottom temperature from CTD, XBT, and MBT measurements in the World Ocean Database. Bottom temperature has been increasing since the 1960s across all seasons. The warmer temperatures in the 1940s are likely due to a combination of reduced data availability, data from older Mechanical Bathythermograph (MBT) instruments, and a warmer phase of the Atlantic Meridional Variability.

	Indicator	Long term trend	Short term status	Summary
4	Cold Pool	↘	-->	Cold pool volume has decreased over the long-term. The past five years of cold pool volume is between the 30th and 70th percentiles of all data.

Cold Pool Volume in NYB

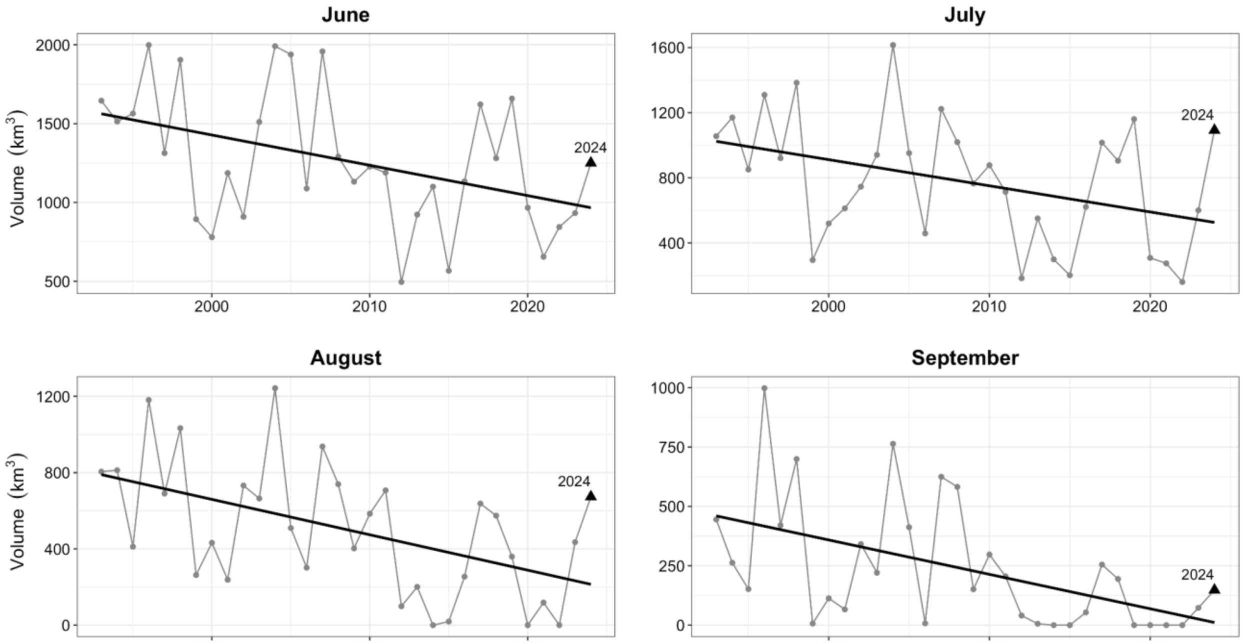


Figure 4: Cold Pool volume in the New York Bight calculated using GLORYS12 reanalysis and analysis data. Plots show trends in summer to fall months, with June, July, August, and September all displaying significant decreasing trends. The cold pool is defined by temp <= 10°C and salinity <= 34 PSU.

	Indicator	Long term trend	Short term status	Summary
5	Bottom Dissolved Oxygen	↘	--->	Bottom DO remained above impaired levels and were slightly higher in 2024 compared to the lowest levels observed so far in 2022-2023

Bottom Dissolved Oxygen

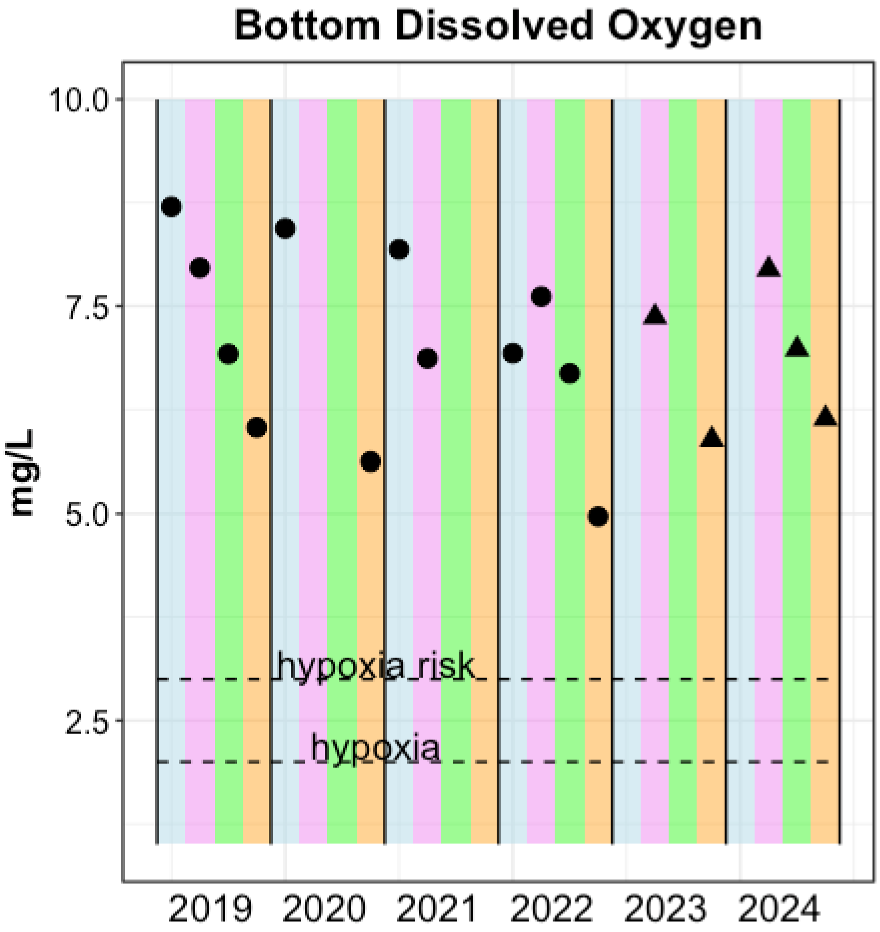
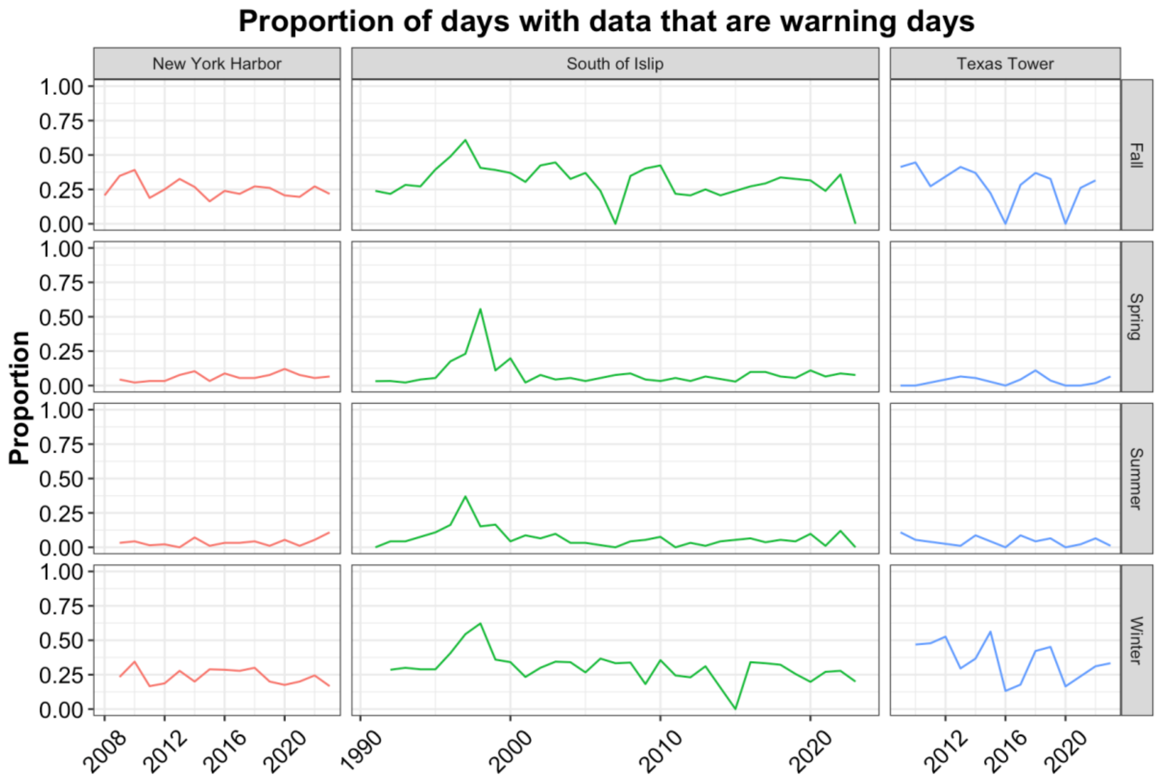


Figure 5: Average bottom dissolved oxygen from CTD data collected along the western most transect on RV Seawolf cruises. Colored shading indicates season: blue is winter, pink is spring, green is summer, orange is fall. The location of the western most transect was moved slightly in 2023 so triangles represent the new location. Winter data area also not collected starting in 2023. Bottom DO decreased steadily from winter to fall in all years.

	Indicator	Long term trend	Short term status	Summary
7	Wind Speed	⇢	⇢	The proportion of days that would trigger a small craft advisory do not show consistent long or short-term trends.

Wind Speed



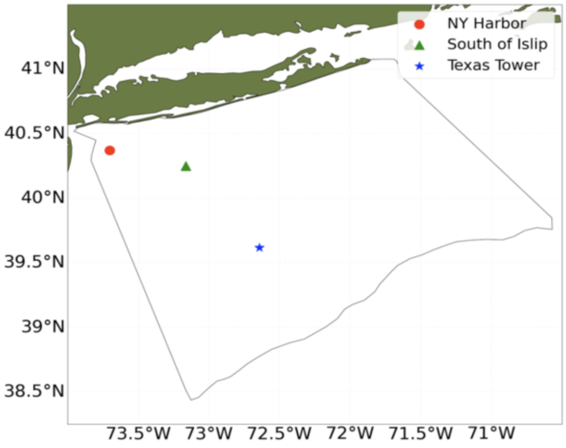


Figure 6: The proportion of days with data from each year where wind speeds would trigger a small craft warning (sustained winds between 18 and 33 knots) by buoy and season. The red line shows the New York Harbor Buoy, the green line a buoy South of Islip, and the blue line the Texas Tower buoy further offshore (see map at left).

	Indicator	Long term trend	Short term status	Summary
8	Stratification	⇢	⇢	Stratification shows no significant long or short-trends.

Stratification

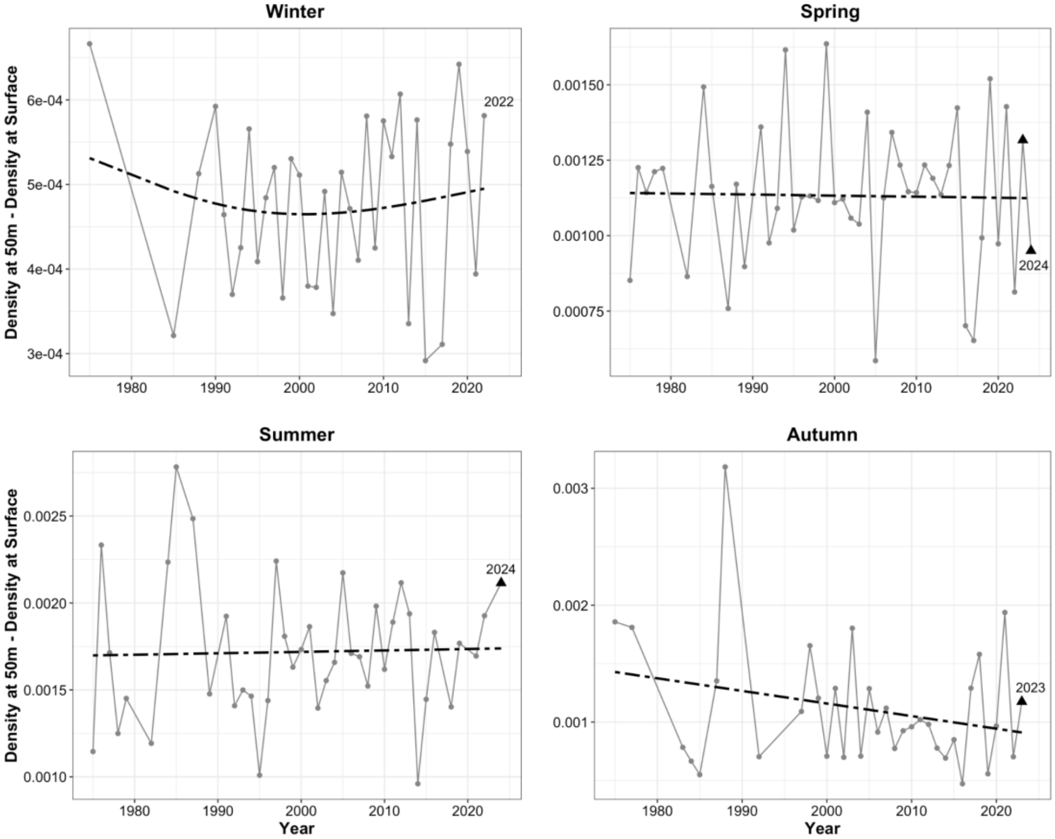


Figure 7: Stratification is highest in the spring and summer and lowest in the winter when the water column is well mixed. No significant trends in stratification are seen in any season. However, from 2007-2015 stratification was consistently above average and from 2014-2018 the stratification index was much lower than average in spring.

	Indicator	Long term trend	Short term status	Summary
9	Hudson River Flow	↗	↗	Hudson River Flow at Green Island shows an increasing trend in the long-term. Flow has been high for the last 5 years.

Hudson River Flow

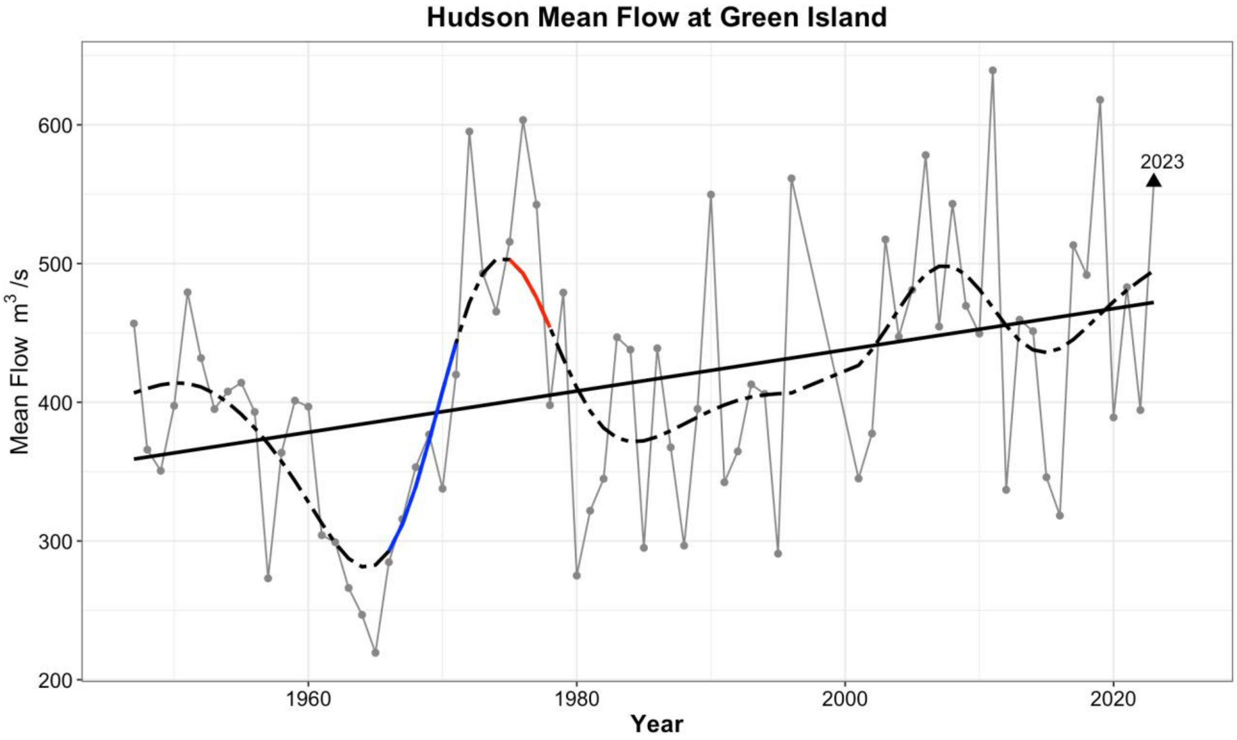


Figure 8: Yearly mean Hudson River flowrate in m^3/s at the Green Island USGS river gauge.

	Indicator	Long term trend	Short term status	Summary
10	Salinity	⇢	⇢	Both surface and bottom salinity show no significant trend in the long-term or short-term

Surface Salinity

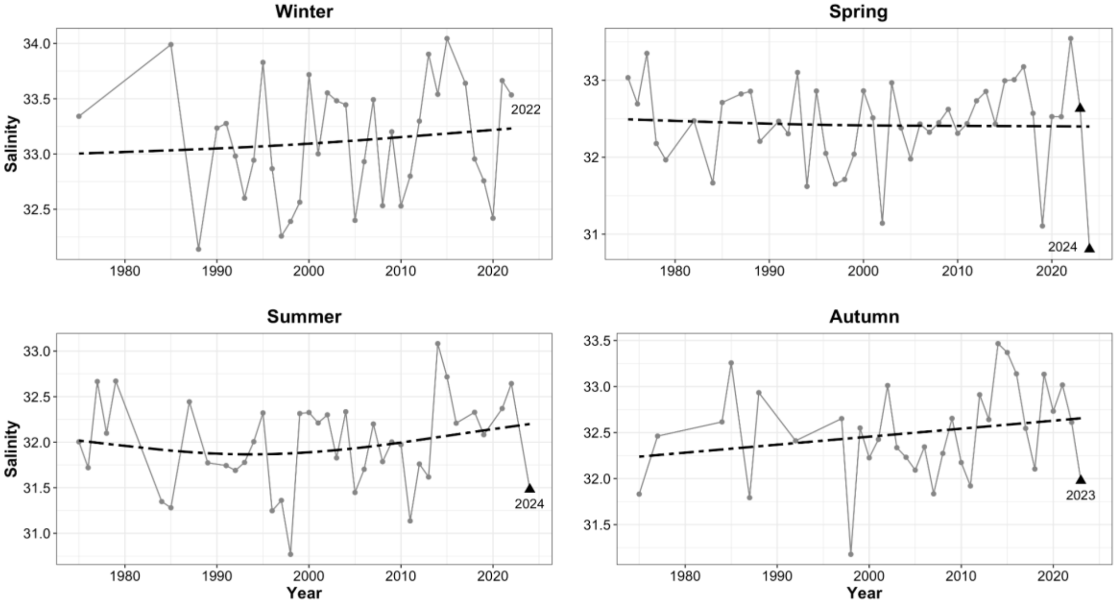


Figure 9 Yearly mean sea surface salinity by season from in-situ measurements.

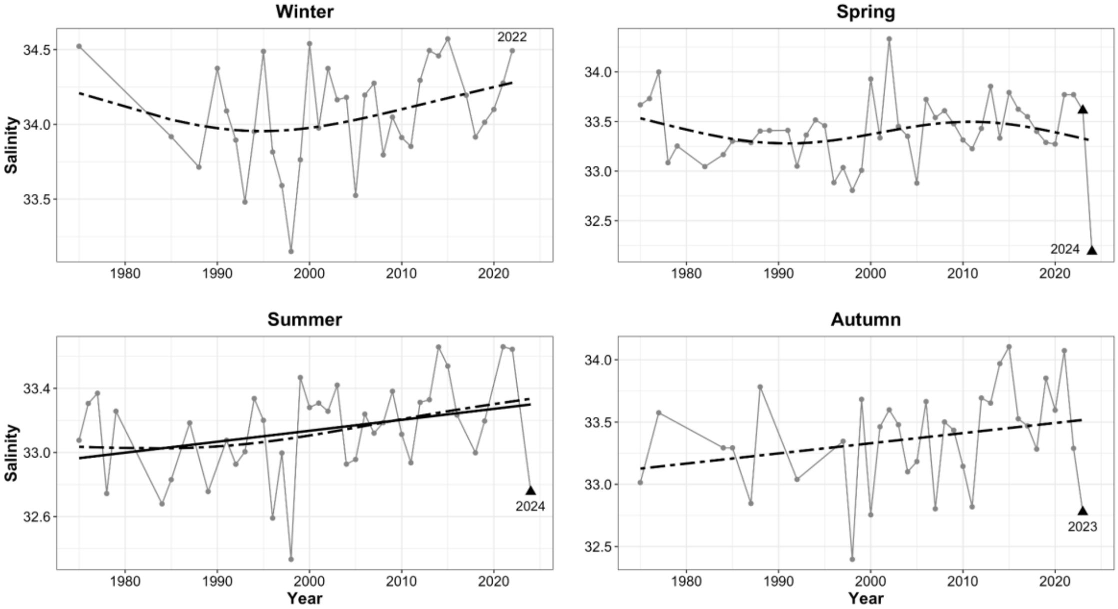


Figure 10: Yearly mean bottom salinity by season from in-situ measurements.

	Indicator	Long term trend	Short term status	Summary
11	Global Carbon Dioxide	↗	↗	Global CO_2 emissions continues to increase exponentially in the long and short term

Global Carbon Dioxide

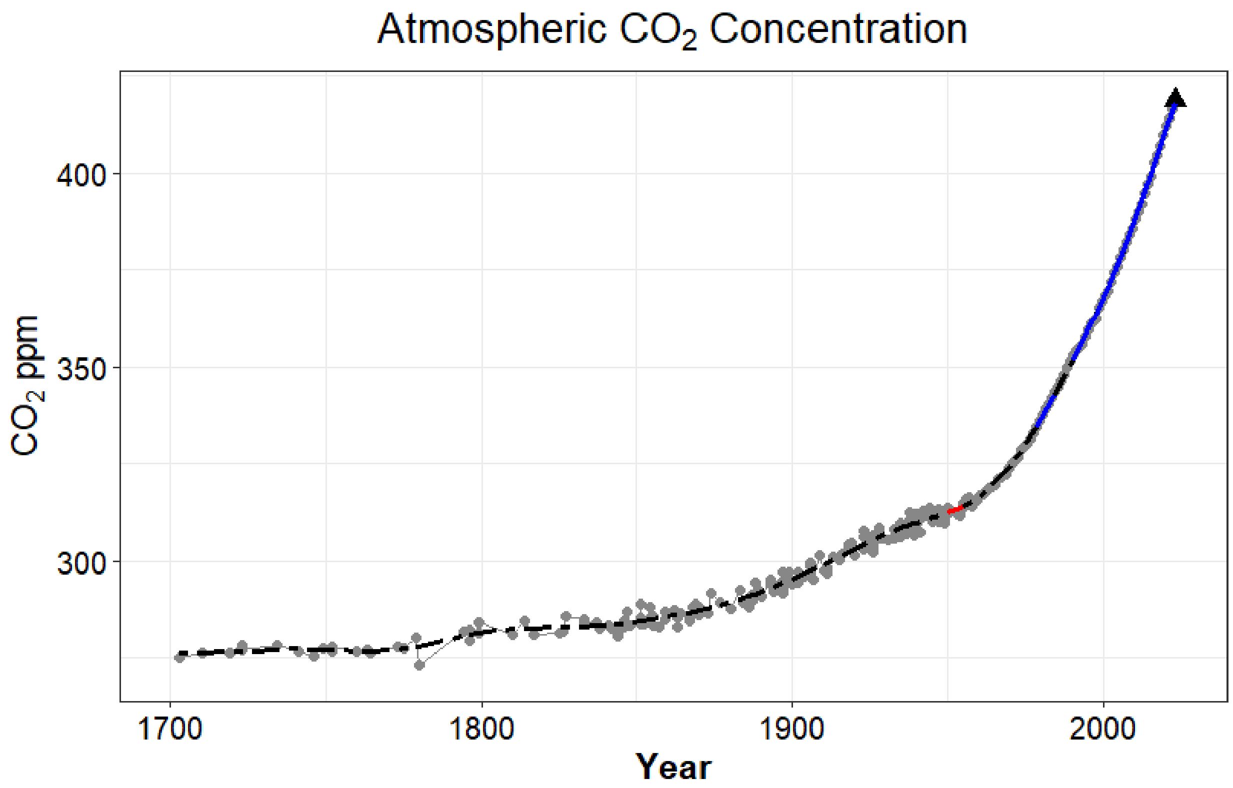


Figure 11: Atmospheric carbon dioxide concentrations from 1700 — 2024. Data are from the Scripps CO_2 Program, which collects data through ice-core measurements, as well as measurements at Mauna Loa and the South Pole for years following 1958. The time series is characterized by exponential growth.

	Indicator	Long term trend	Short term status	Summary
12	Surface 20°C Isotherm	↗	↗	Surface 20°C Isotherm continues to shift to the northeast in summer and offshore in autumn.

Location of Surface 20°C Isotherm

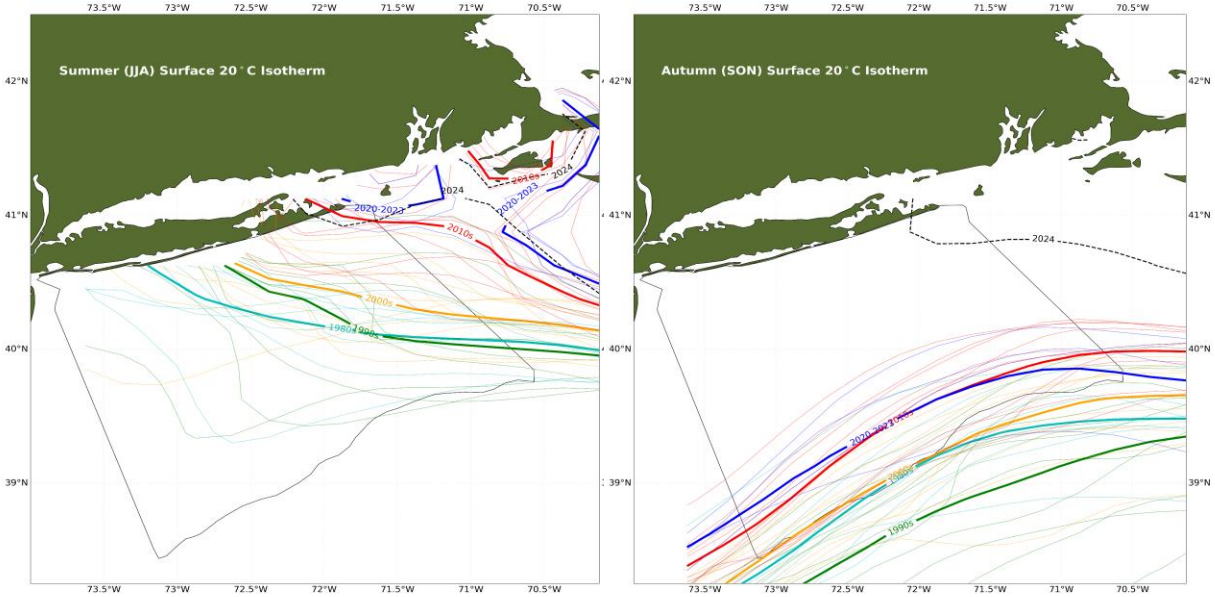


Figure 12: Summer (June, July, August; left panel) and Autumn (September, October, November; (right panel) surface 20°C isotherm. The thick teal line shows the mean position during the 1980s, the green line during the 1990s, the orange line during the 2000s, the red line during the 2010s, the blue line during 2020-2023, and the dashed line represents 2024. Thin colored lines show individual years during year groups.

Northwestward movement of the 20°C isotherm in summer is consistent with the warming trend in this region. Globally, a decrease in species diversity and richness occurs below 20°C, but more relevant to NYB, the 20°C isotherm is the upper lethal limit of American lobster and the temperature commonly used to differentiate between long-finned (colder water species) and short-finned (warmer water species) pilot whales.

	Indicator	Long term trend	Short term status	Summary
13	Lobster Thermal Habitat	⇢	⇢	No long or short-term trends are present in the percentage of New York Bight seafloor thermally inhospitable to lobster.

Lobster Thermal Habitat

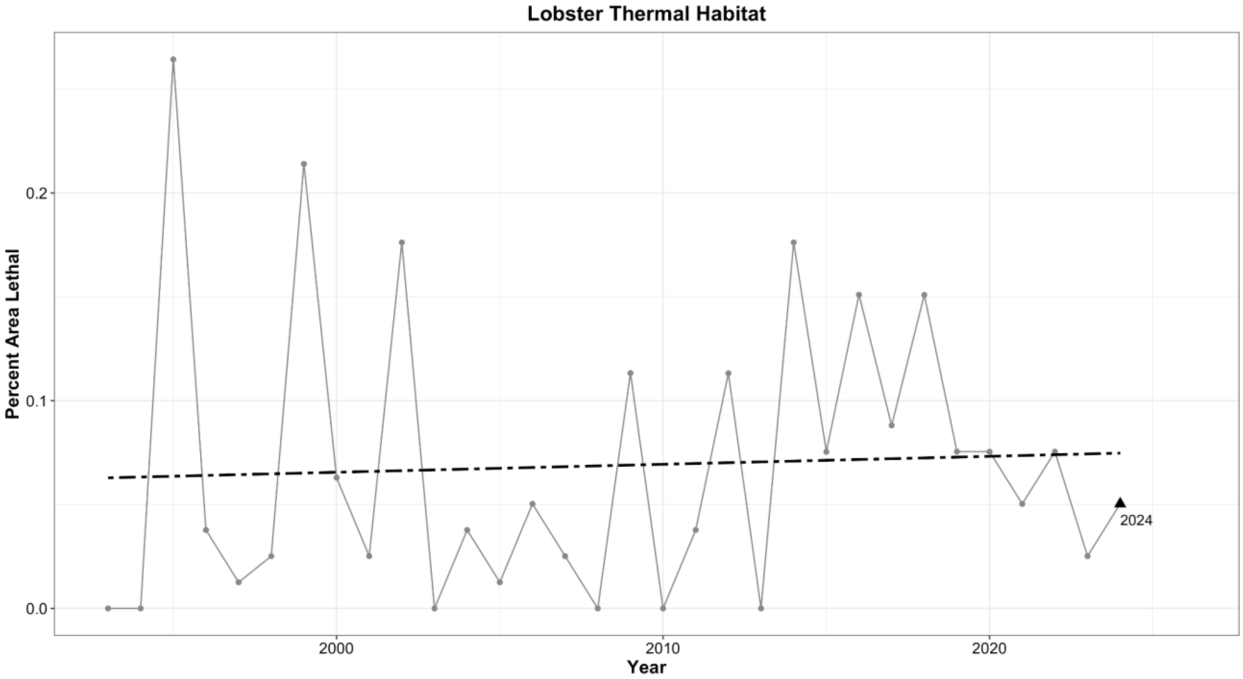


Figure 13: Yearly values for the percentage of the NYB that contains bottom temperatures greater than 20°C (the upper lethal temperature for lobster). The percent lethal area is consistently below 1%.

	Indicator	Long term trend	Short term status	Summary
13	Number of Large Storms	⇢	⇢	No long or short-term trends are present in large storm indicators.

Number of Large Storms

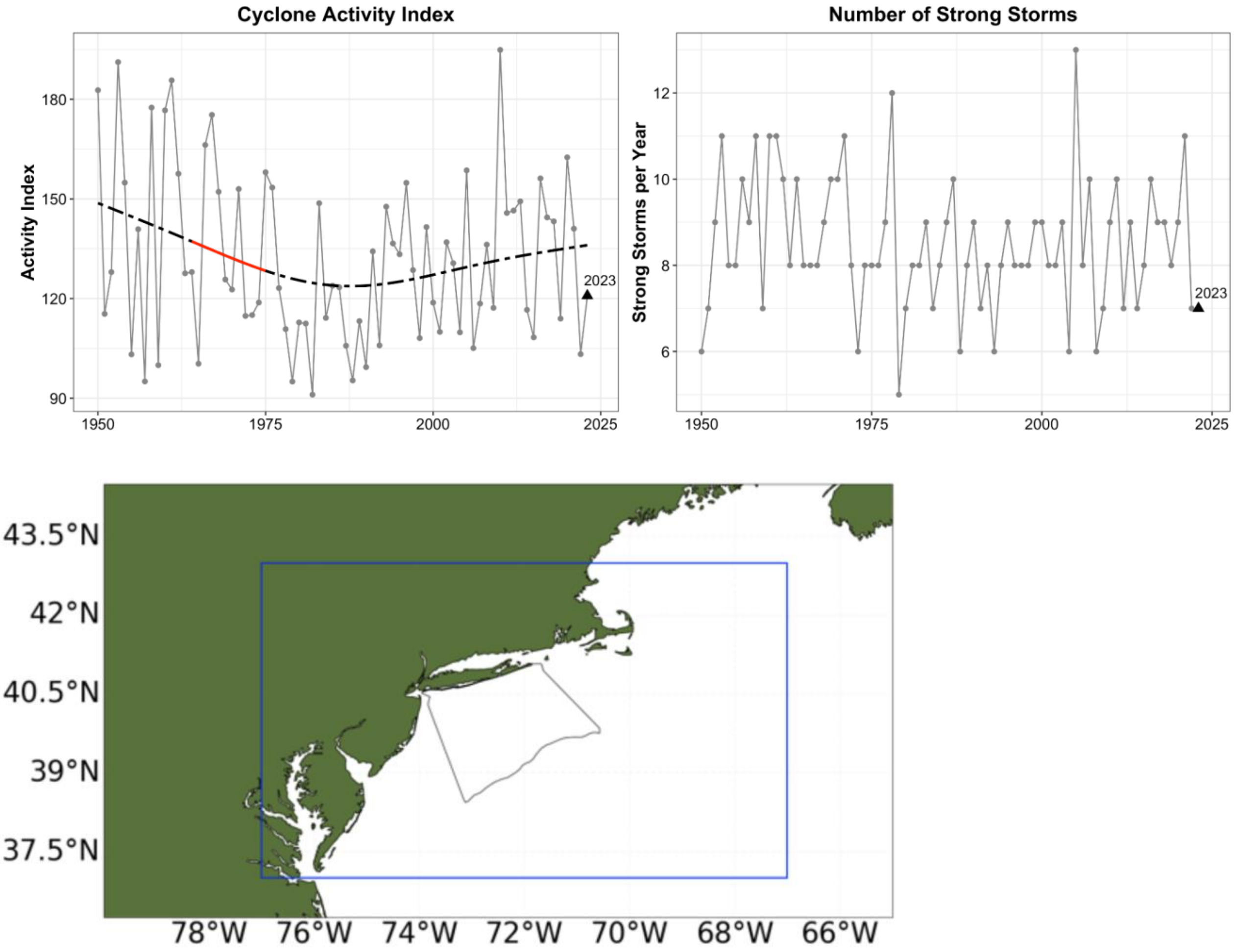


Figure 14: Top Left The cyclone activity index for the New York Bight and surrounding region (from 77°W to 67°W longitude and 37°N to 43°N latitude as shown in the blue box in the map at left; NYB in black line) defined as the number of storms per year times the mean intensity of those storms (Wang et al., 2006). Top Right The number of strong storms defined as the number of cyclones per year within the NYB and surrounding region with a high intensity based on the local pressure gradient. Because the location of the storm is determined by its centroid, and damaging winds, rain, and flooding can also be found outside of the centroid, we use an area larger than the NYB when calculating this indicator.

Marine Community Summary

Summary

The indicators of the marine community of the NYB agree with the broader observations in the Northeast US, that the marine community continues to tropicalize. Tropicalization does not necessarily mean we see more tropical fishes, but refers to the presence of more southern or warm water species than northern or cold water species. This change is most likely caused by the warming water temperatures observed in the physical indicators in the previous section. Warming-induced tropicalization of the system also suggests that we may see an increase in species richness and a change in the timing of the spring and fall blooms characteristic of temperate systems. Indeed, the indicators in this section follow the predictions for an ecosystem experiencing warming. The ratio of cold/northern to warm/southern nekton has declined since the 1960s especially in the Fall. Similarly, we see a higher rate of strandings of tropical and warm water odontocetes and fewer strandings of cold water ondontocetes. Fish species richness and the mean temperature of the fish community has increased as well. No long-term trends were seen in chlorophyll, but some decreases were observed in April, August, September and November. A decline in the spring (April) and fall (August, September and November) suggests that either the bloom in these months is not as intense or that the timing of the bloom may have changed. As such, patterns in bloom timing, intensity and duration should be examined. We also see changes in the presence and abundance of some species seasonally over time which may be related to climate. Longfin squid, one of the most important fisheries for NY state, has decreased in the spring since 2011, but increased in the autumn over time. Its Fall 2023 biomass was the highest ever observed in the time series. With warming a switch from large, lipid-rich copepods such as *Calanus finmarchicus* are predicted and a switch to more tropical or warm water species like *Centrapoges typicu*s. However, we did not detect long-term trends in the ratio of small to large copepod and no long-term trends in *Calanus* or *Centrapages,* the dominant copepods in the NYB. RV Seawolf data suggests that *Calanus* peaks in abundance in spring while *Centropages* peaks in summer, further suggesting that seasonal differences in the appearance of these copepods may make it difficult to track clear trends over time. The changes we document are also a result of changes in fishing intensity in addition to the strong climate signal in the NYB. There have been recent recoveries in the biomass of benthivores and planktivores, but we have not returned to the high biomasses of piscivores seen in the 1960s. This is likely due to the almost complete loss of Atlantic cod, pollock and haddock in the NYB. American lobster also remains at low levels since the early 2000s. However, black sea bass, summer flounder and forage species (includes forage fishes and squid) have increased recently in the fall especially in 2022 and 2023.

	Indicator	Long term trend	Short term status	Summary
15	Chlorophyll	⇢	↘	Short-term decreases were observed in April, August, September, and November.

Monthly Mean Surface Chlorophyll

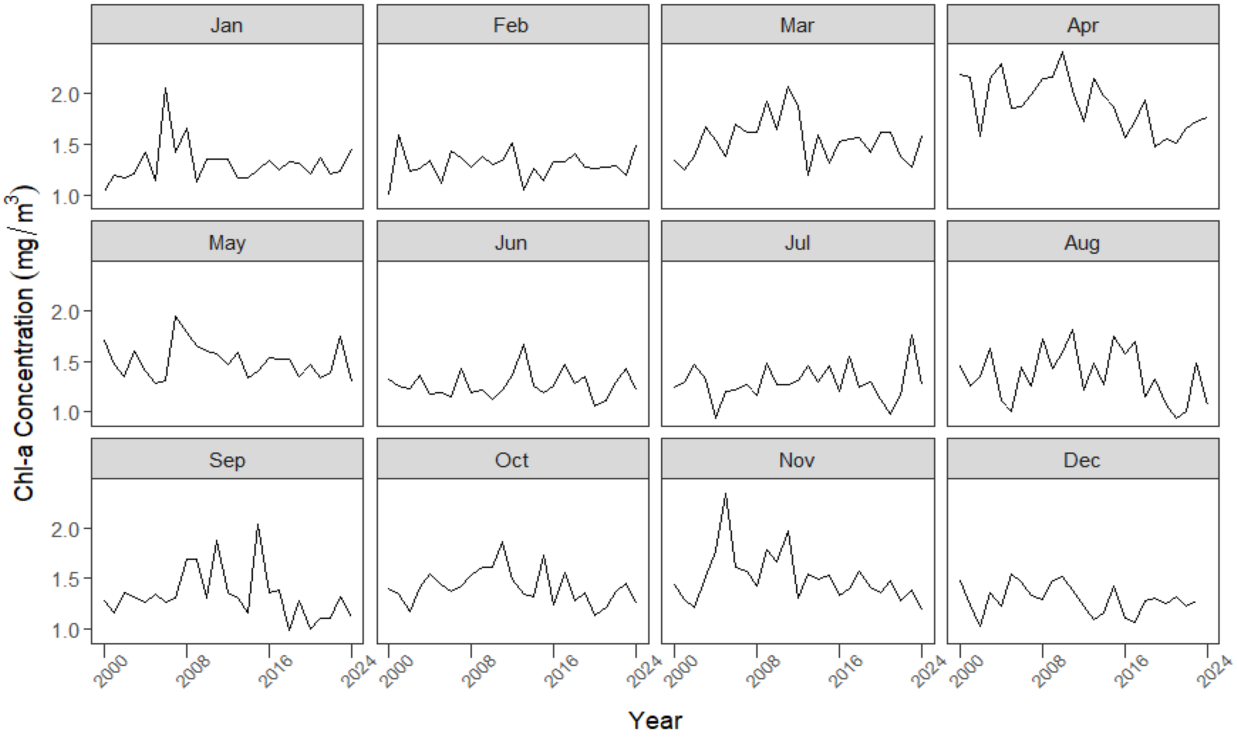


Figure 15: Monthly average chlorophyll-*a* concentrations in the NYB. Data were accessed from the Copernicus Global Ocean Color database.

Calanus finmarchicus abundance

	Indicator	Long term trend	Short term status	Summary
16	*Calanus finmarchicus*	--->	↘	No long-term trend in this cold water copepod, but values were relatively low in the short term. Highest abundance occurs in spring in NYB

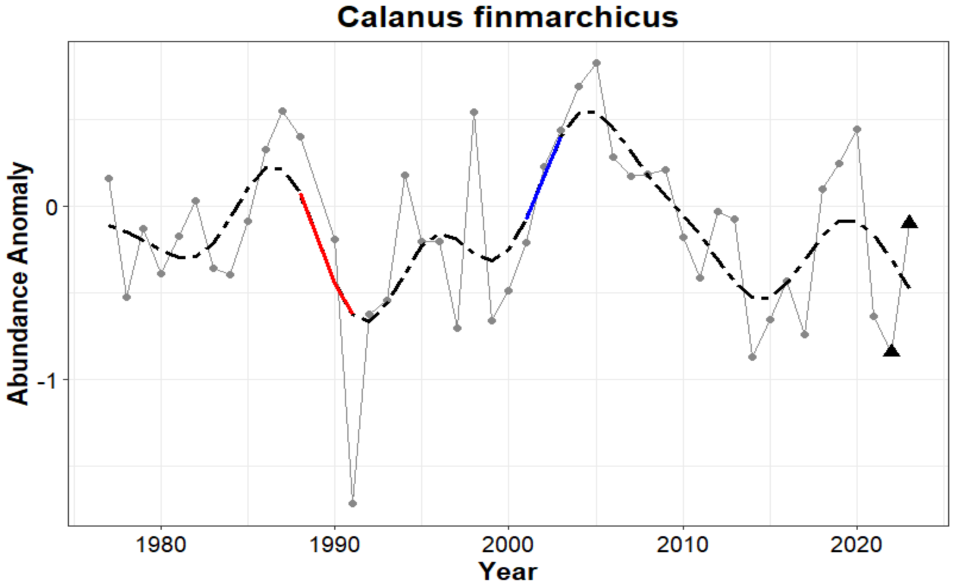


Figure 16: Abundance anomaly of *Calanus finmarchicus*. Time series was developed using data collected in the NYB through the NOAA EcoMon survey.

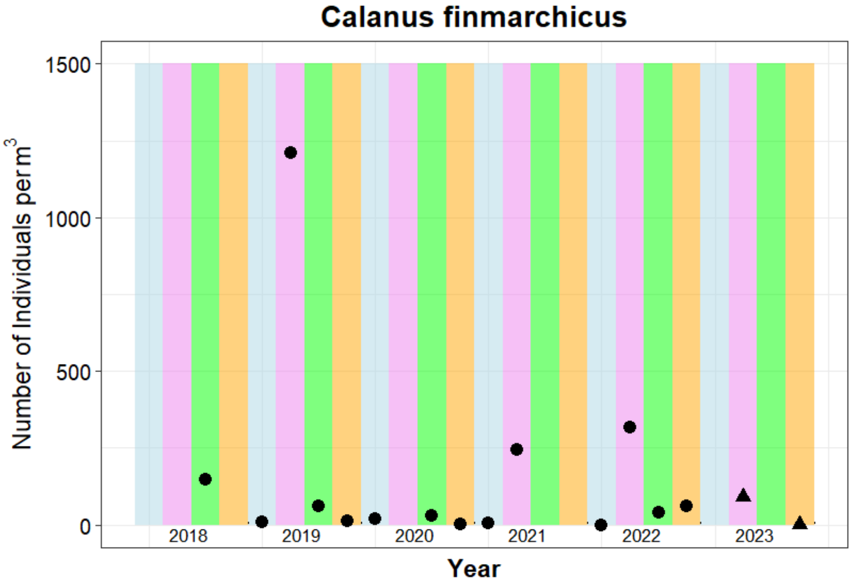


Figure 17: Abundance of Calanus finmarchicus from RV Seawolf zooplankton sampling by season. Blue indicates winter, pink indicates spring, green indicates summer and orange indicates fall. Note that the highest abundances within each year are in spring

Centropages typicus

	Indicator	Long term trend	Short term status	Summary
17	*Centropages Typicus*	⇢	↘	No long-term trend in this warm water copepod, but abundance is consistently lower than the peak from 1995-2003. Highest abundances occur in summer in NYB

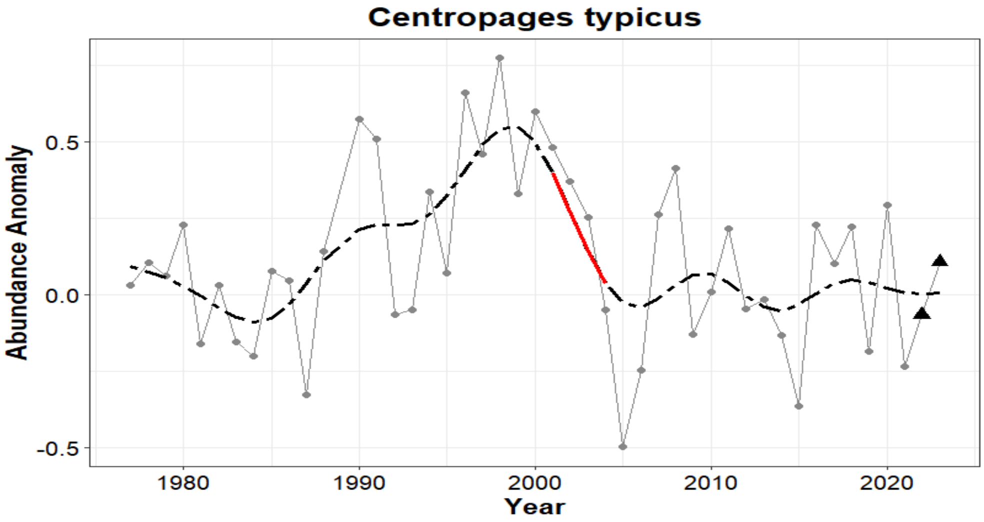


Figure 18: *Centropages typicus* abundance anomaly in the NYB. The time series was developed by data collected through the NOAA EcoMon survey.

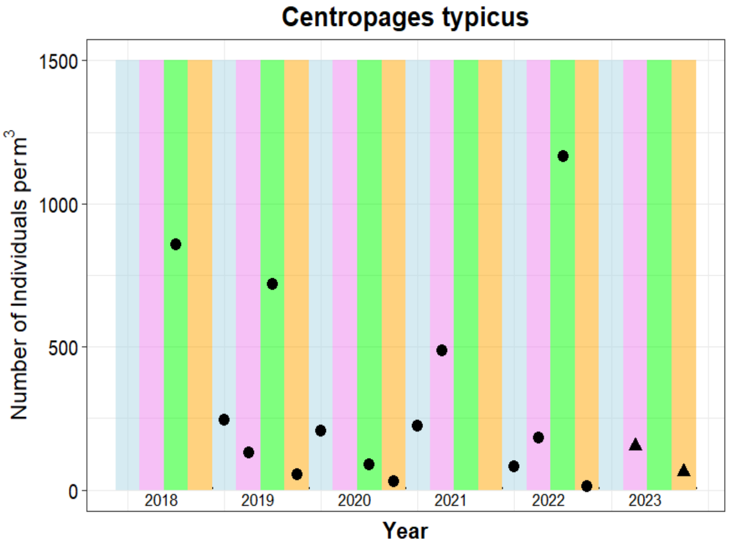


Figure 19: Abundance of *Centropages typicus* from RV Seawolf zooplankton sampling by season. Blue indicates winter, pink indicates spring, green indicates summer and orange indicates fall. Note that the highest abundances within each year are in spring

Copepod Size Index

	Indicator	Long term trend	Short term status	Summary
16	Small/Large Copepod Index	⇢	⇢	No significant long- or short-term trends

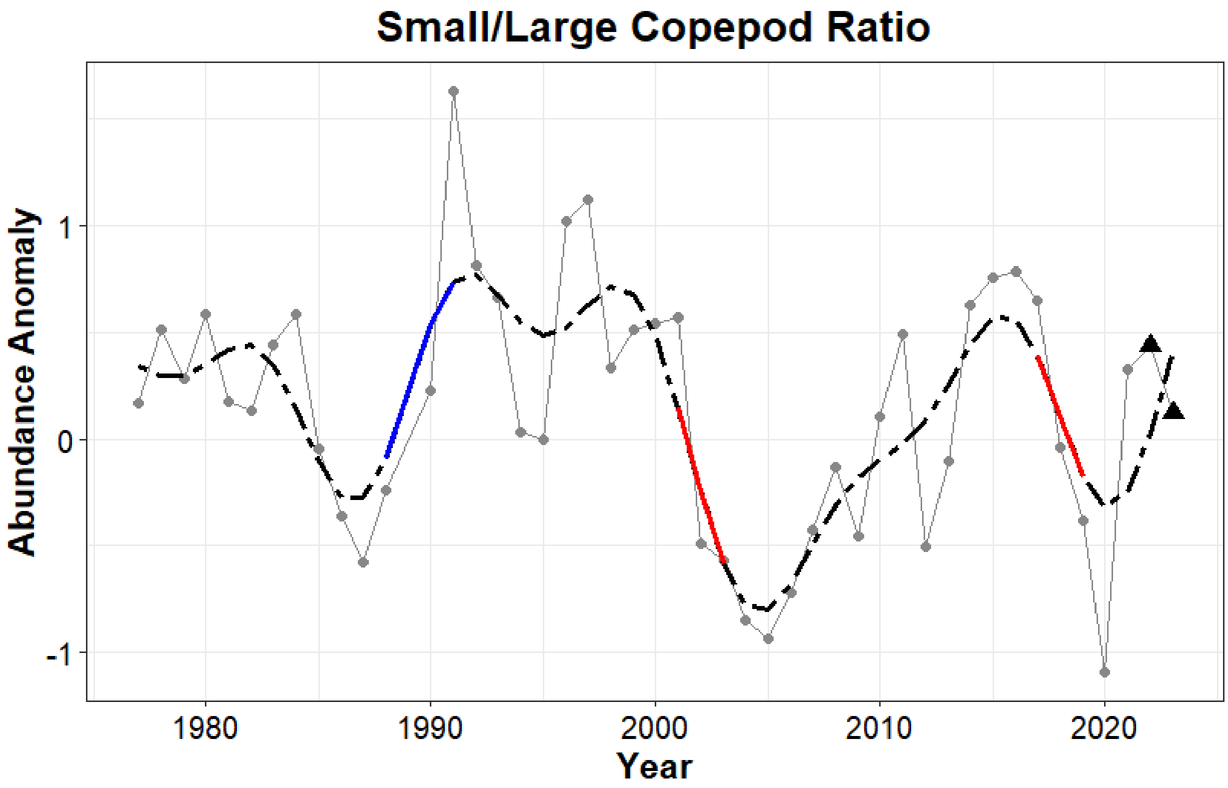


Figure 20: Abundance anomaly of the small to large copepod ratio from the NOAA EcoMon Survey. Small copepod species included *Pseudocalanus* spp., *Centropages typicus*, C*entropages hamatus*, and *Temora longicornis*. The large copepods were constituted by *Calanus finmarchicus*.

American Lobster Biomass

	Indicator	Long term trend	Short term status	Summary
16	American Lobster Biomass	↘	↘	Both a long-term and short-term decline in American lobster

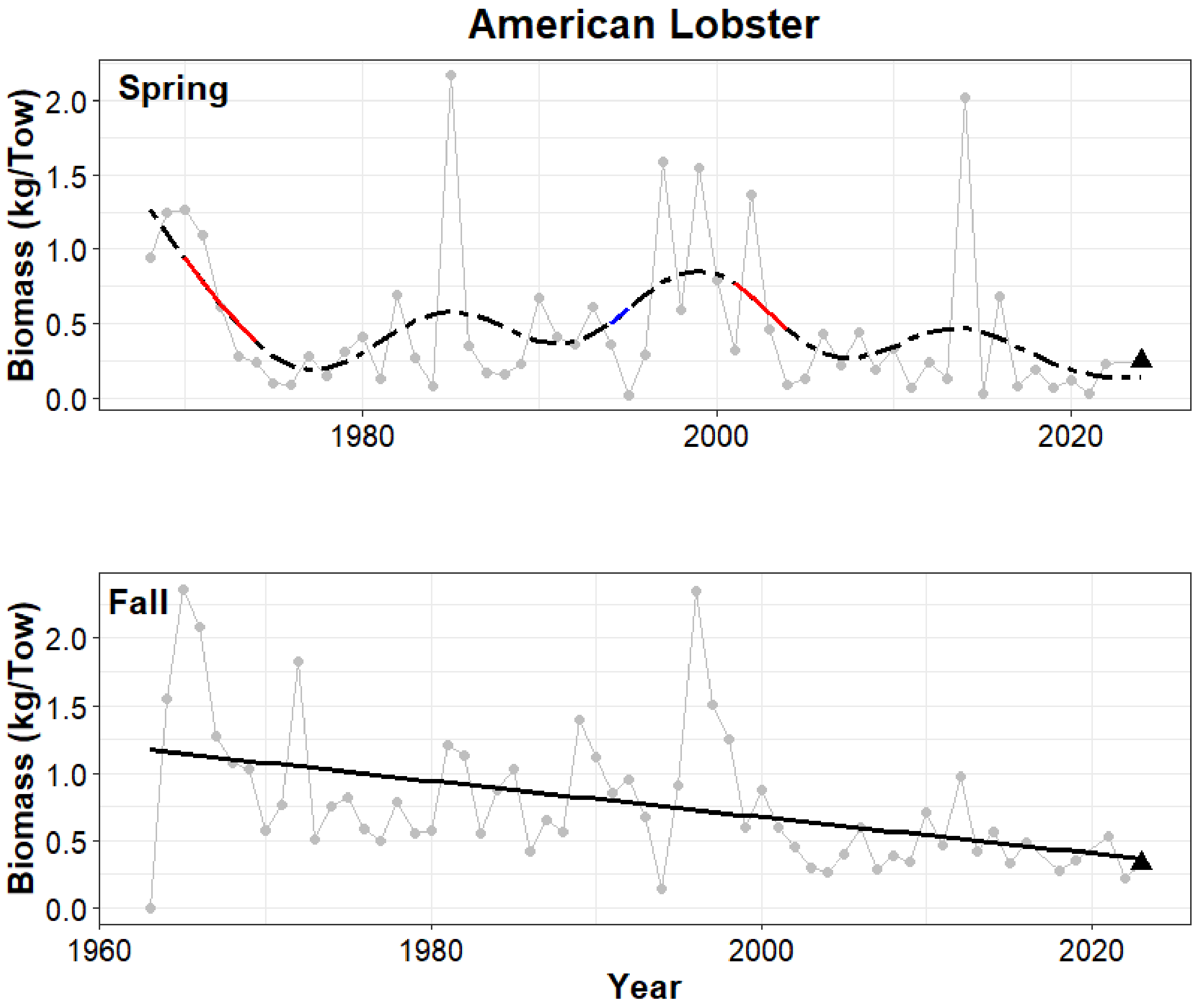


Figure 21: Biomass time series of American lobster (*Homarus americanus*) in spring (top) and fall (bottom) sampling seasons from the NOAA bottom trawl survey.

Jonah Crab Biomass

	Indicator	Long term trend	Short term status	Summary
16	Jonah Crab Biomass	⇢	↗	Jonah crab biomass has decreased in spring but increased in the fall in the long term. Only a short-term increase in the fall has been observed indicating changing seasonality

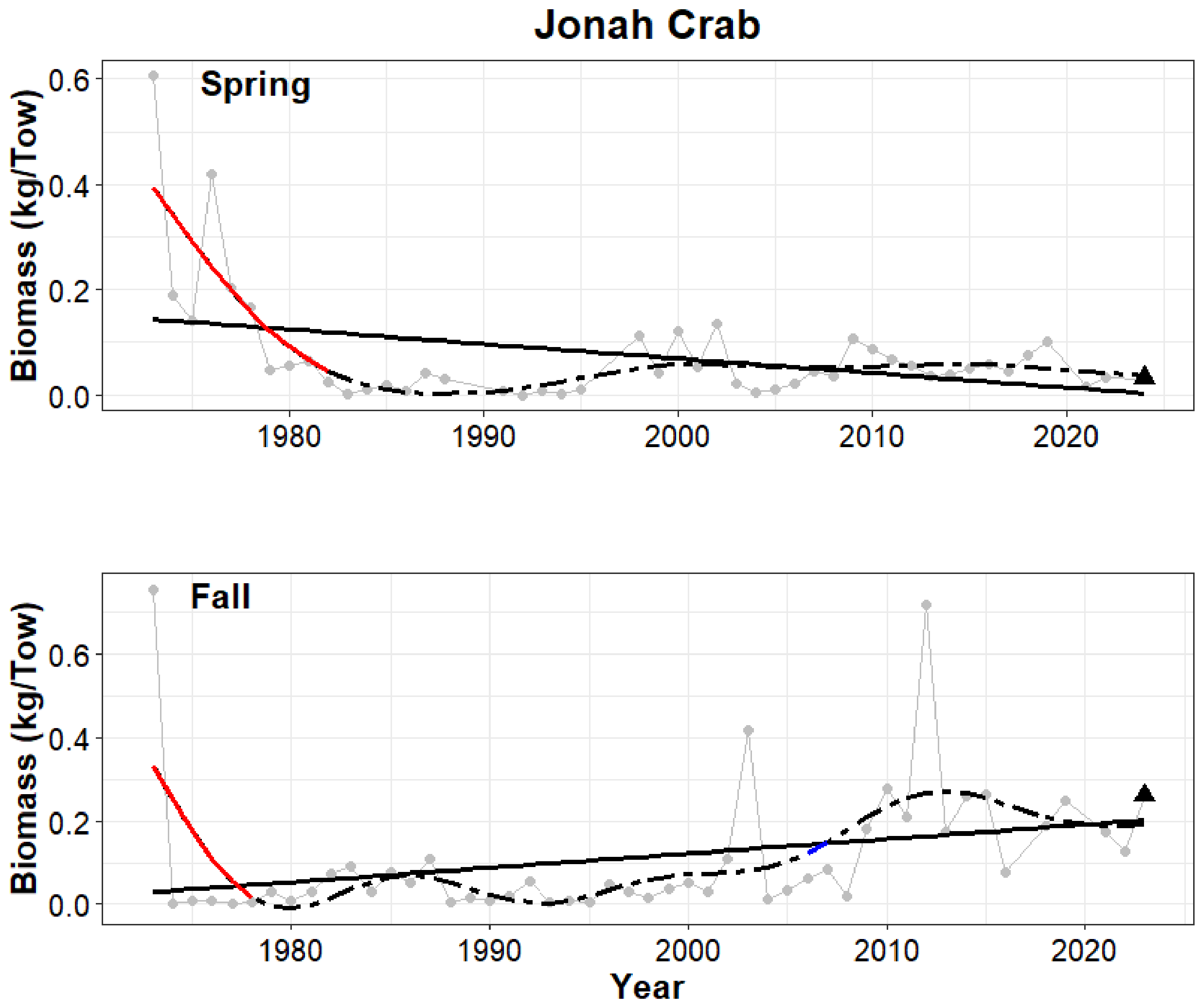


Figure 22: Biomass time series of Jonah crab (*Cancer borealis*) in spring (top) and fall (bottom) sampling seasons from the NOAA bottom trawl survey.

Longfin Squid Biomass

	Indicator	Long term trend	Short term status	Summary
16	Longfin Squid Biomass	⇢	↗	Significant decreasing long-term trend in spring and increasing long-term trend in the fall, indicating change in seasonality. Longfin squid biomass has increased in the fall in the short term.

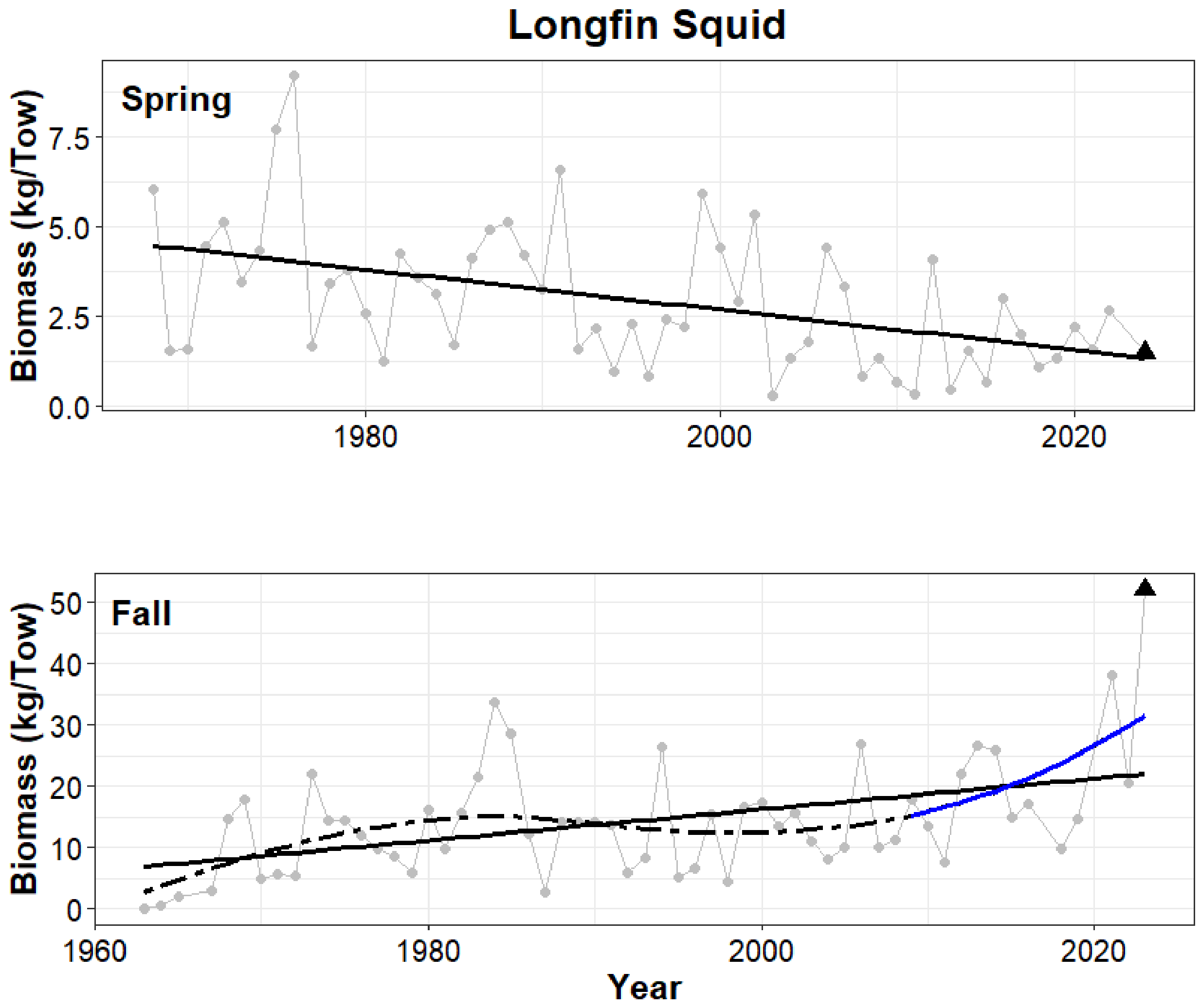


Figure 23: Biomass time series of longfin squid (*Loligo pealeii*) in spring (top) and fall (bottom) sampling seasons from the NOAA bottom trawl survey.

Shortfin Squid Biomass

	Indicator	Long term trend	Short term status	Summary
16	Shortfin Squid Biomass	↗	⇢	Long-term increase in shortfin squid in spring, but no recent trends

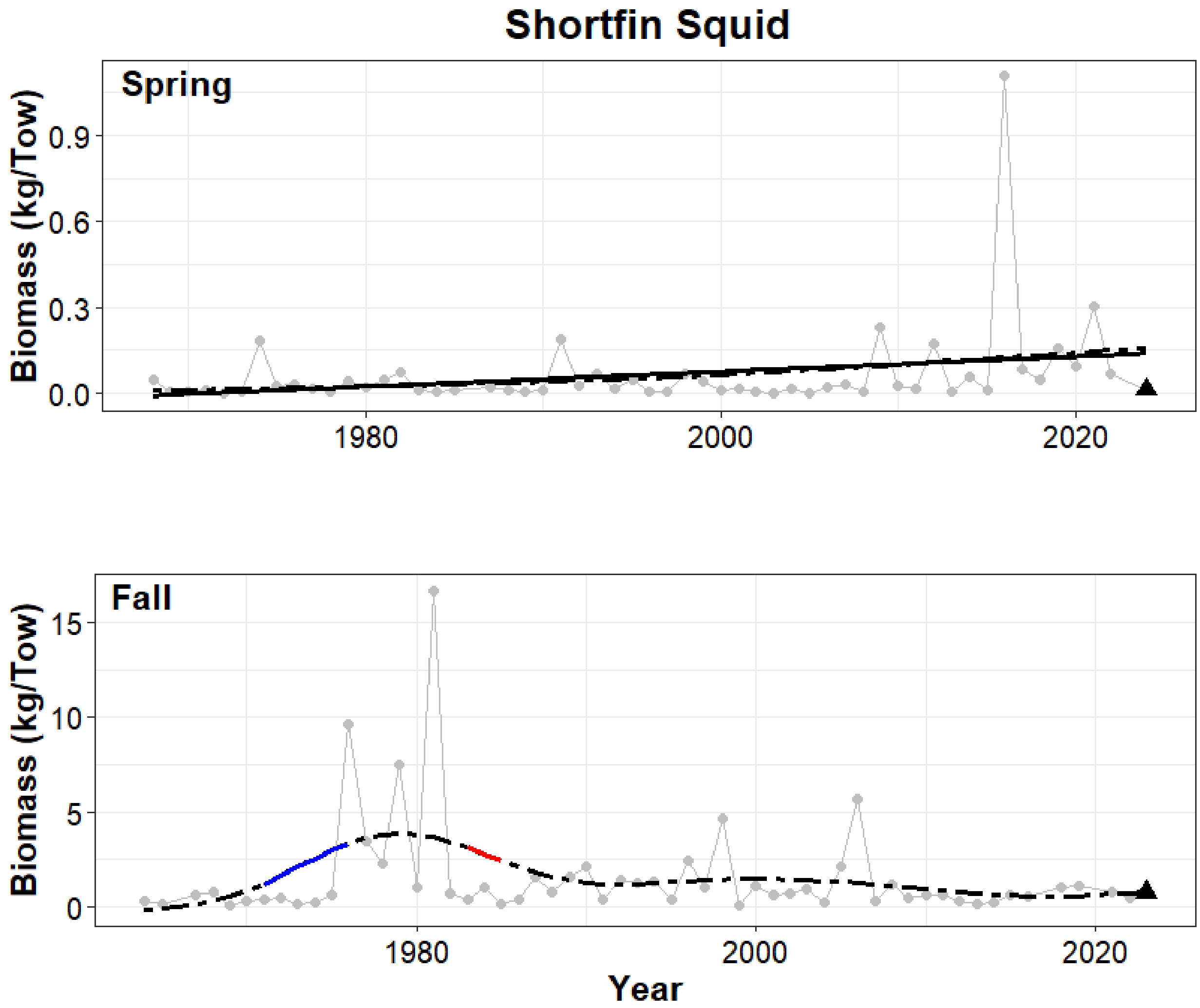


Figure 24: Biomass time series of shortfin squid (*Illex illecebrosus*) in spring (top) and fall (bottom) sampling seasons from the NOAA bottom trawl survey.

Forage Species Biomass

	Indicator	Long term trend	Short term status	Summary
16	Forage Species Biomass	↗	↗	Both al long-term and short-term increase in the fall

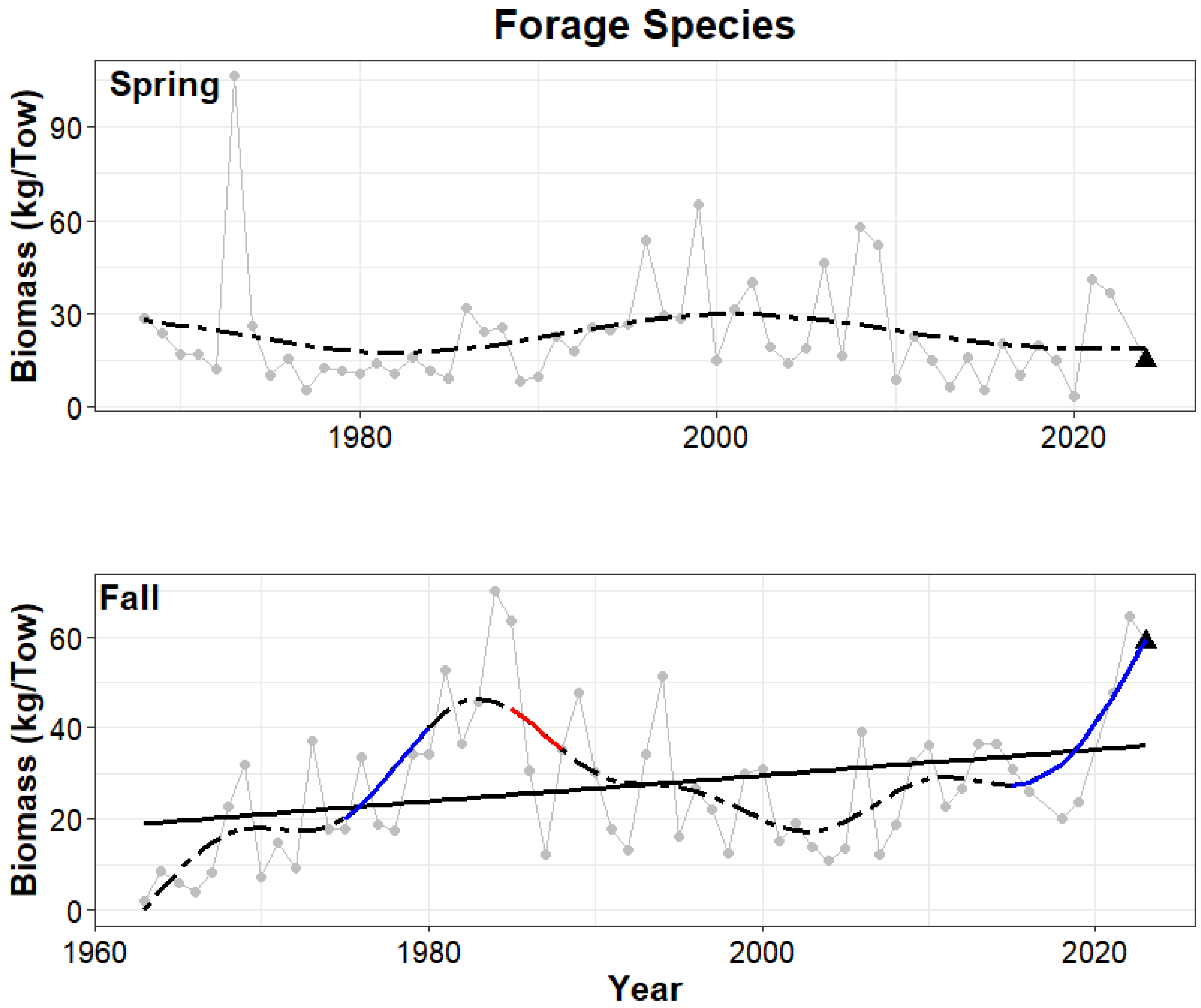


Figure 25: Forage species biomass time series in spring (top) and fall (bottom) sampling seasons from the NOAA bottom trawl survey.

NOAA Foraging Groups Biomass

	Indicator	Long term trend	Short term status	Summary
16	Foraging Groups Biomass	⇢	↗	Short term increases were observed for benthivores and planktivores. Long term increases were exhibited by benthos and planktivore groups, as well as a long-term decrease in piscivores.

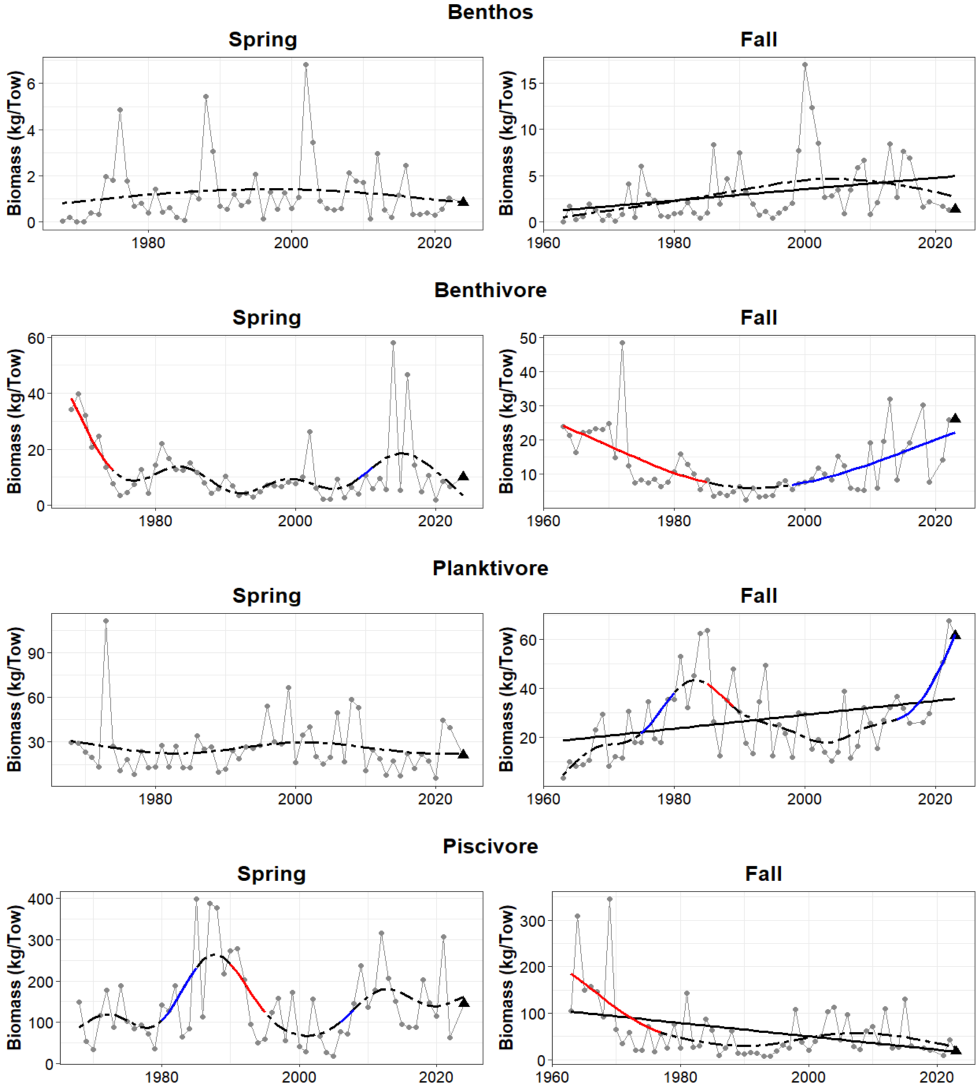


Figure 26: Biomass time series of feeding groups in spring (left) and fall (right) sampling seasons from the NOAA bottom trawl survey. Feeding groups (in descending order) include benthos, benthivores, planktivores, and piscivores.

Total Trawl Biomass

	Indicator	Long term trend	Short term status	Summary
16	Total Trawl Biomass	⇢	⇢	No long- or short-term trends in total nekton biomass

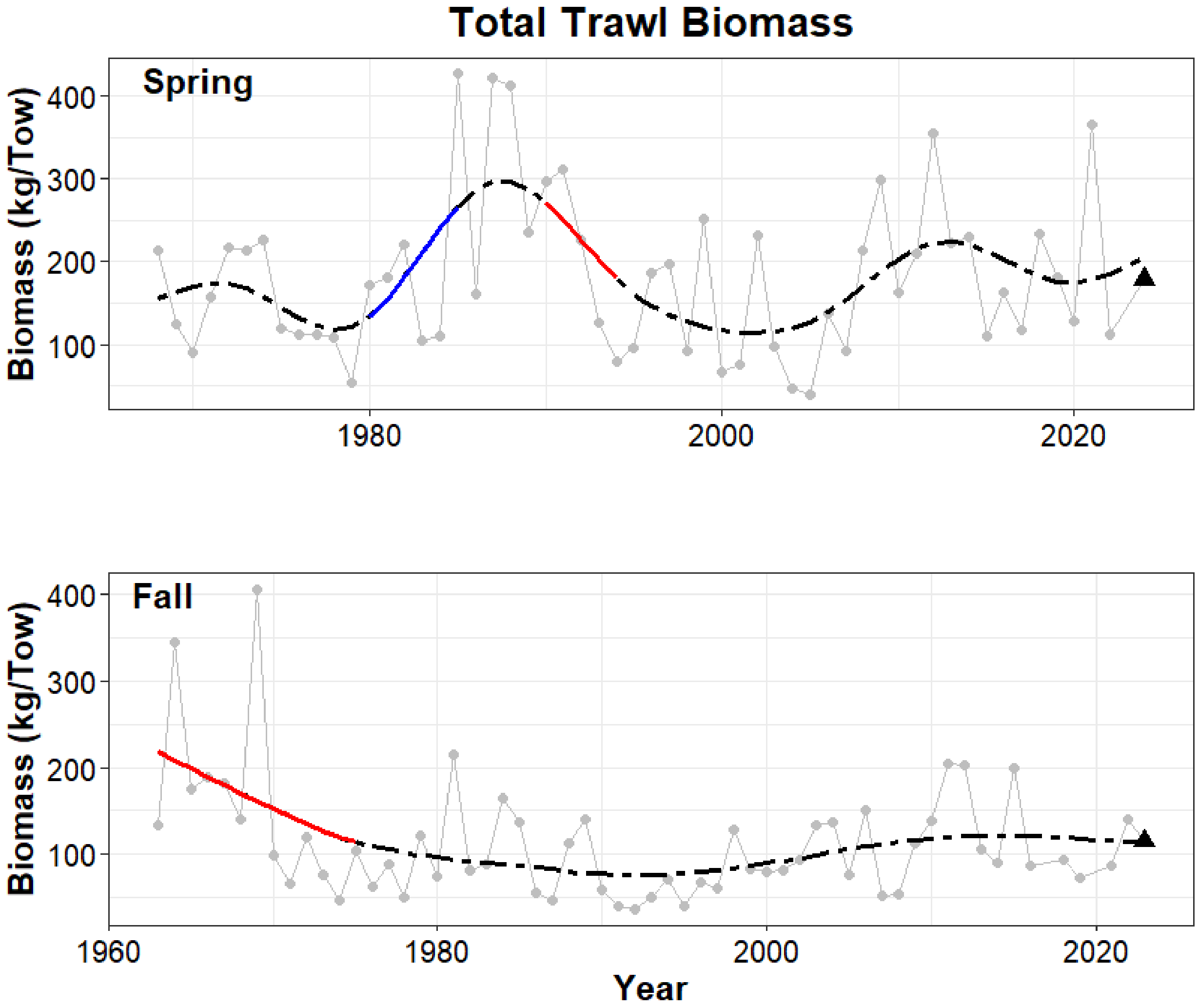


Figure 27: Total biomass collected during spring (top) and fall (bottom) sampling seasons from the NOAA bottom trawl survey.

Black Sea Bass Biomass

	Indicator	Long term trend	Short term status	Summary
16	Black Sea Bass Biomass	↗	↗	Increases in black sea bass biomass was observed for both the short and long term in both spring and fall seasons.

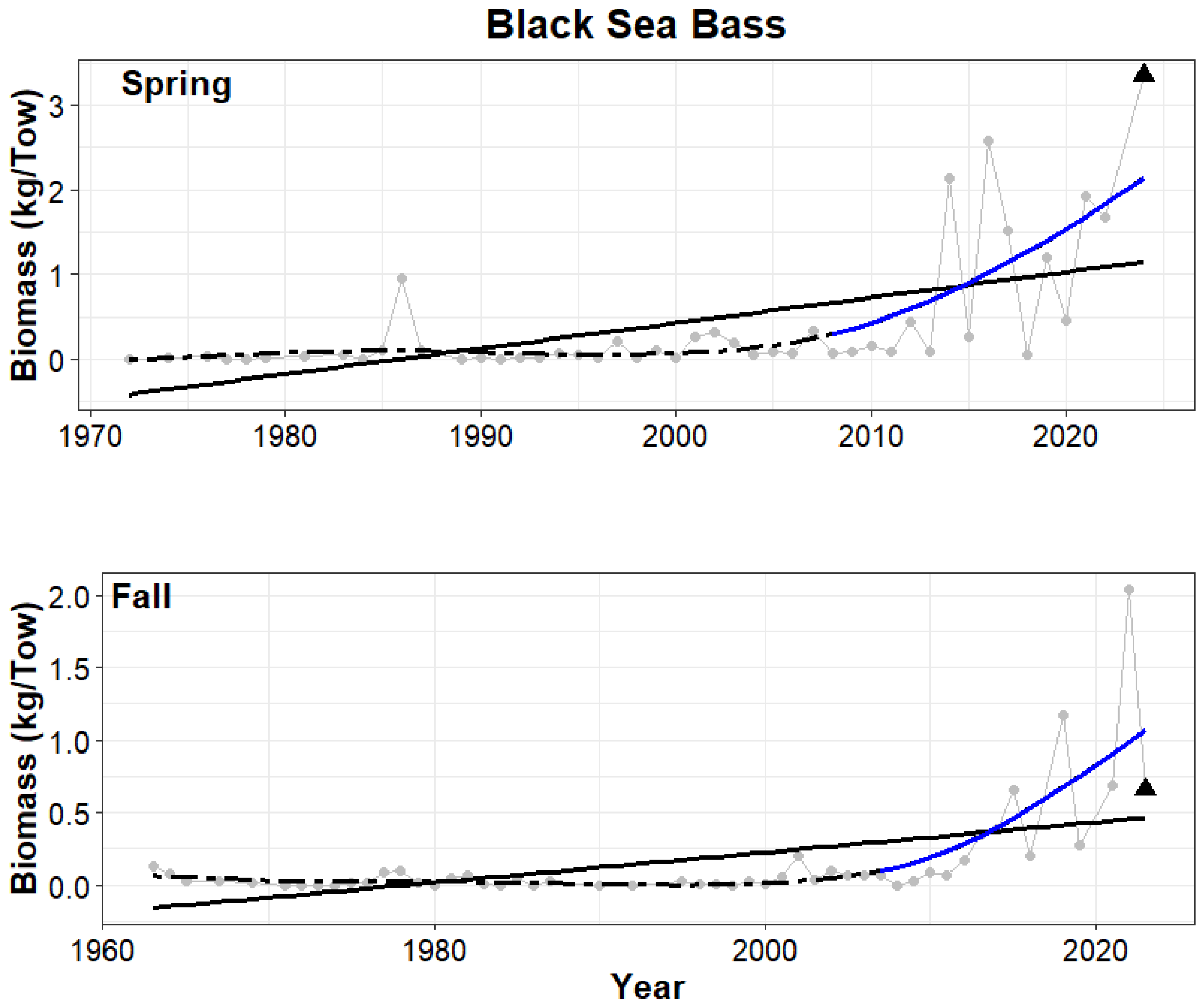


Figure 28: Biomass time series of black sea bass (*Centropristis striata*) in spring (top) and fall (bottom) sampling seasons from the NOAA bottom trawl survey.

Summer Flounder Biomass

	Indicator	Long term trend	Short term status	Summary
16	Summer Flounder Biomass	↗	↗	Increases in summer flounder biomass was observed for both the short and long term in both spring and fall.

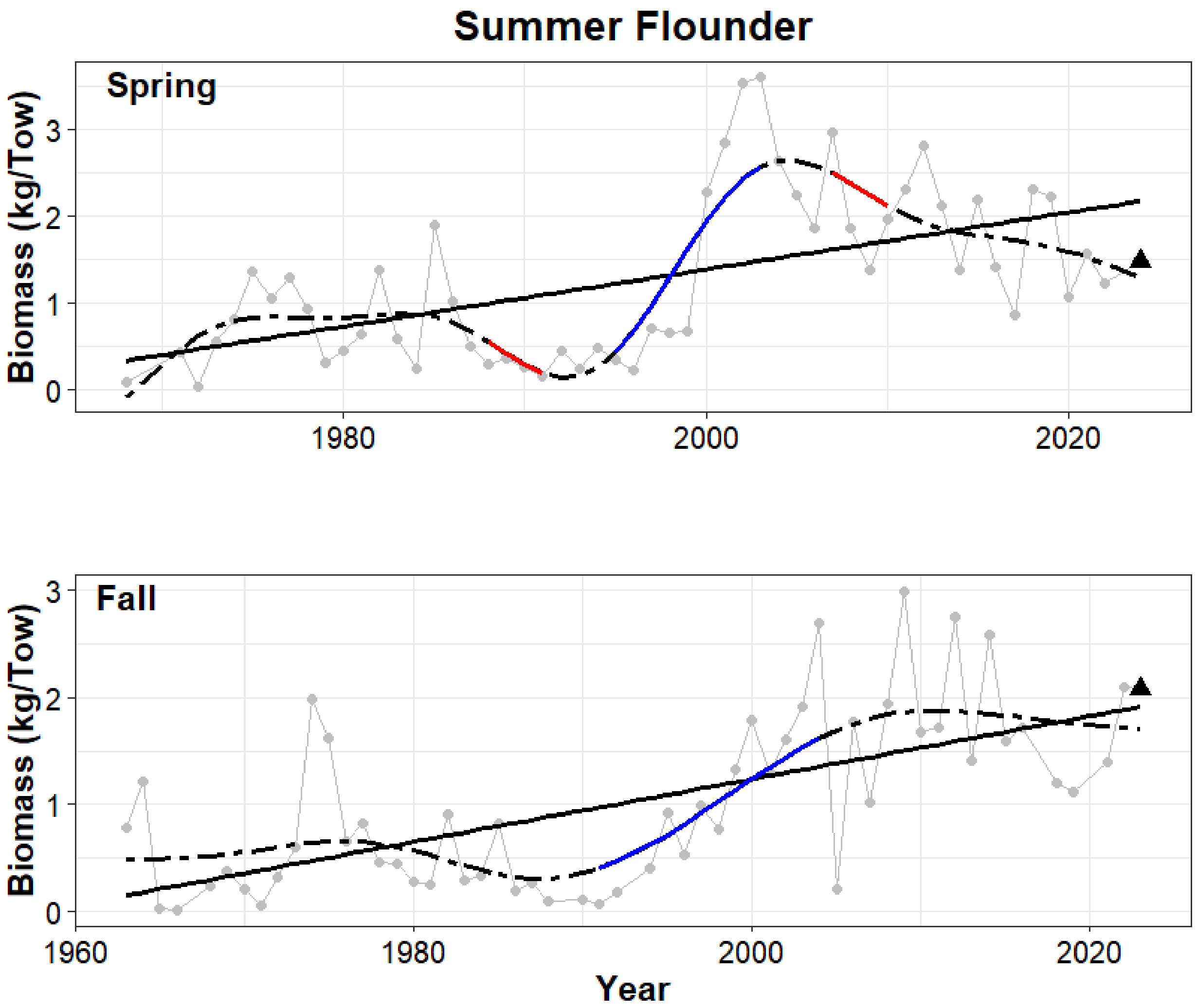


Figure 29: Biomass time series of summer flounder (*Paralichthys dentatus*) in spring (top) and fall (bottom) sampling seasons from the NOAA bottom trawl survey.

Northern to Southern Species Biomass Ratio

	Indicator	Long term trend	Short term status	Summary
16	Northern to Southern Ratio	↘	↘	The ratio of northern to southern species has decreased since 1995 for nekton and marine mammals.

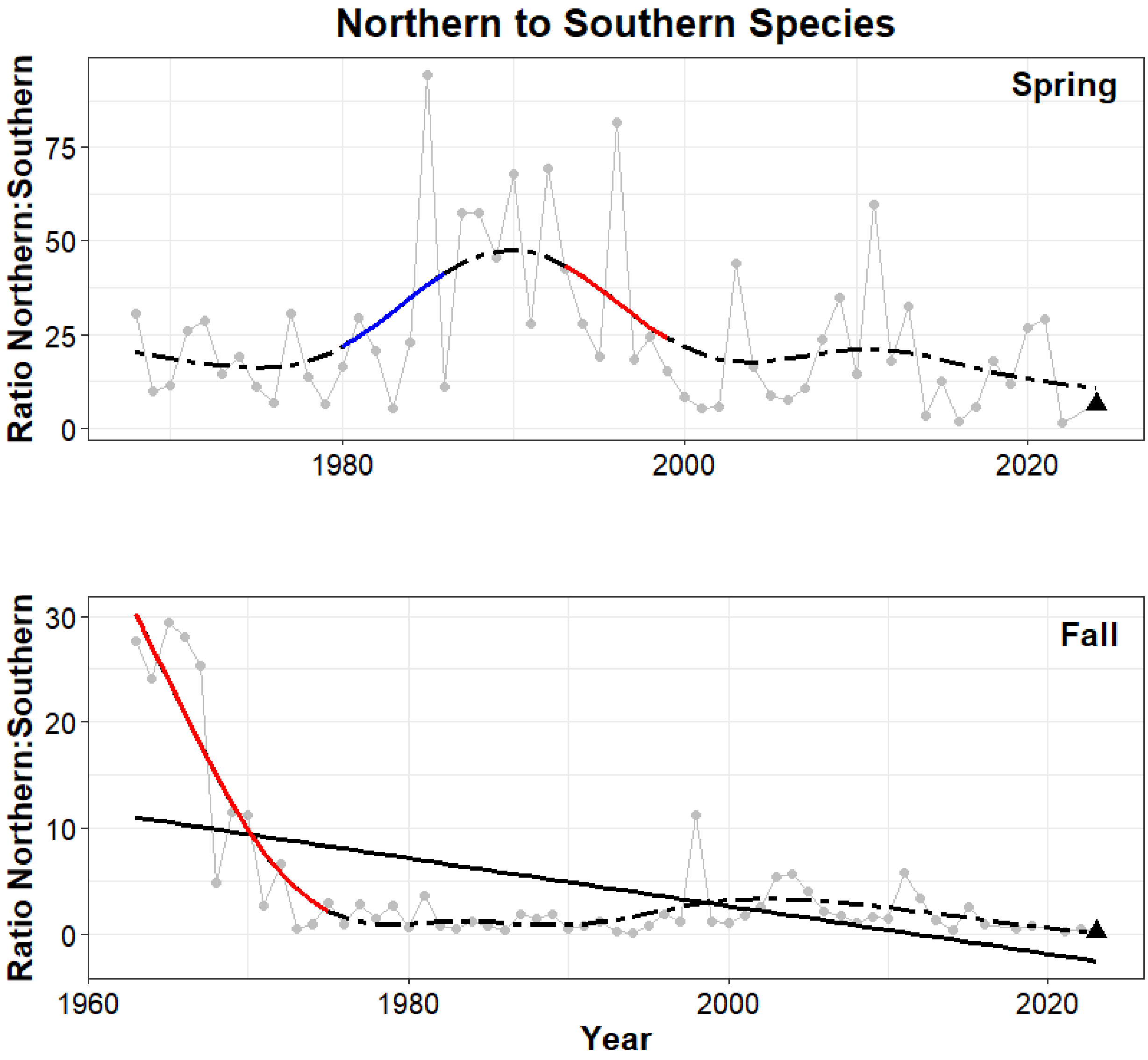


Figure 30: Time series of the ratio of northern to southern species collected during the spring (top) and fall (bottom) sampling seasons from the NOAA bottom trawl survey.

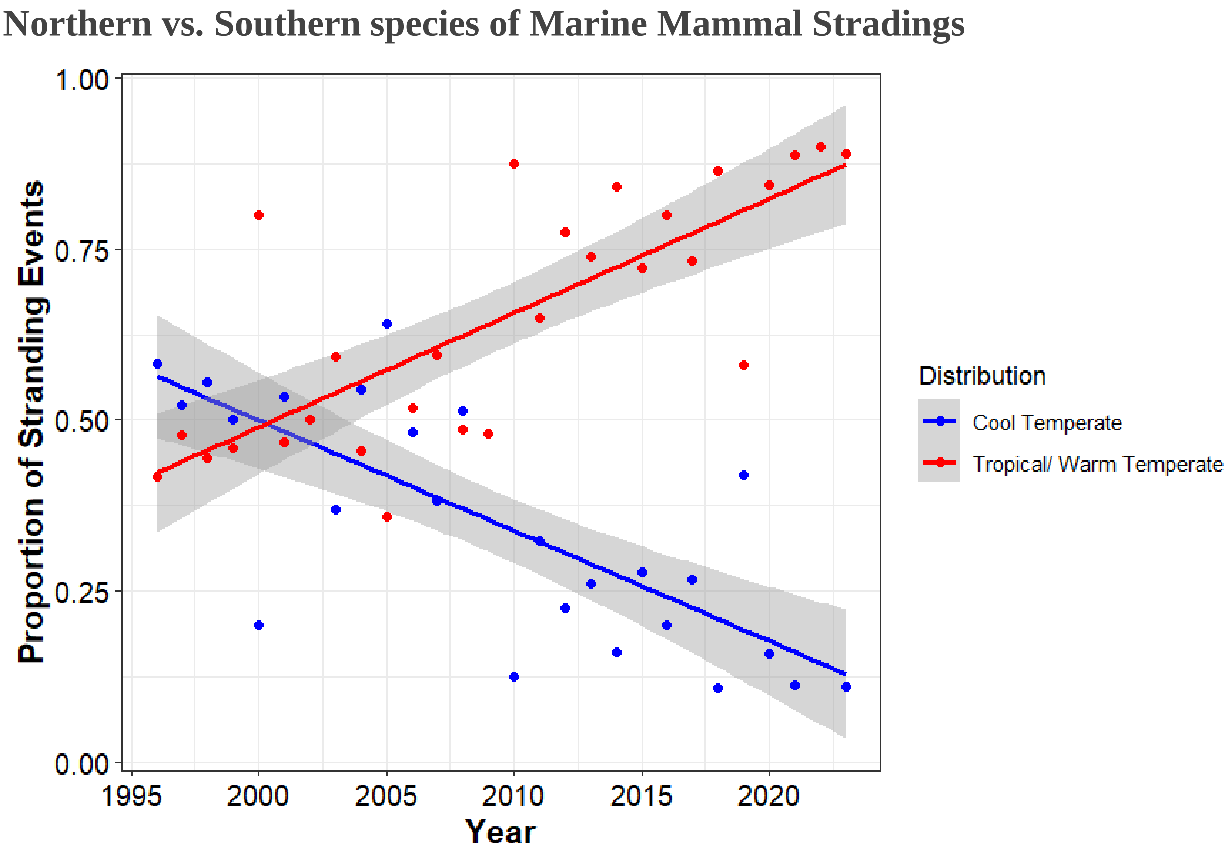


Figure 31: Proportion of stranding events of odontocetes associated with cold water and warm water.

Benthic to Pelagic Ratio

	Indicator	Long term trend	Short term status	Summary
16	Benthic to Pelagic Ratio	↘	↘	The benthic to pelagic species ratio has decreased in the fall season for both the long and short term.

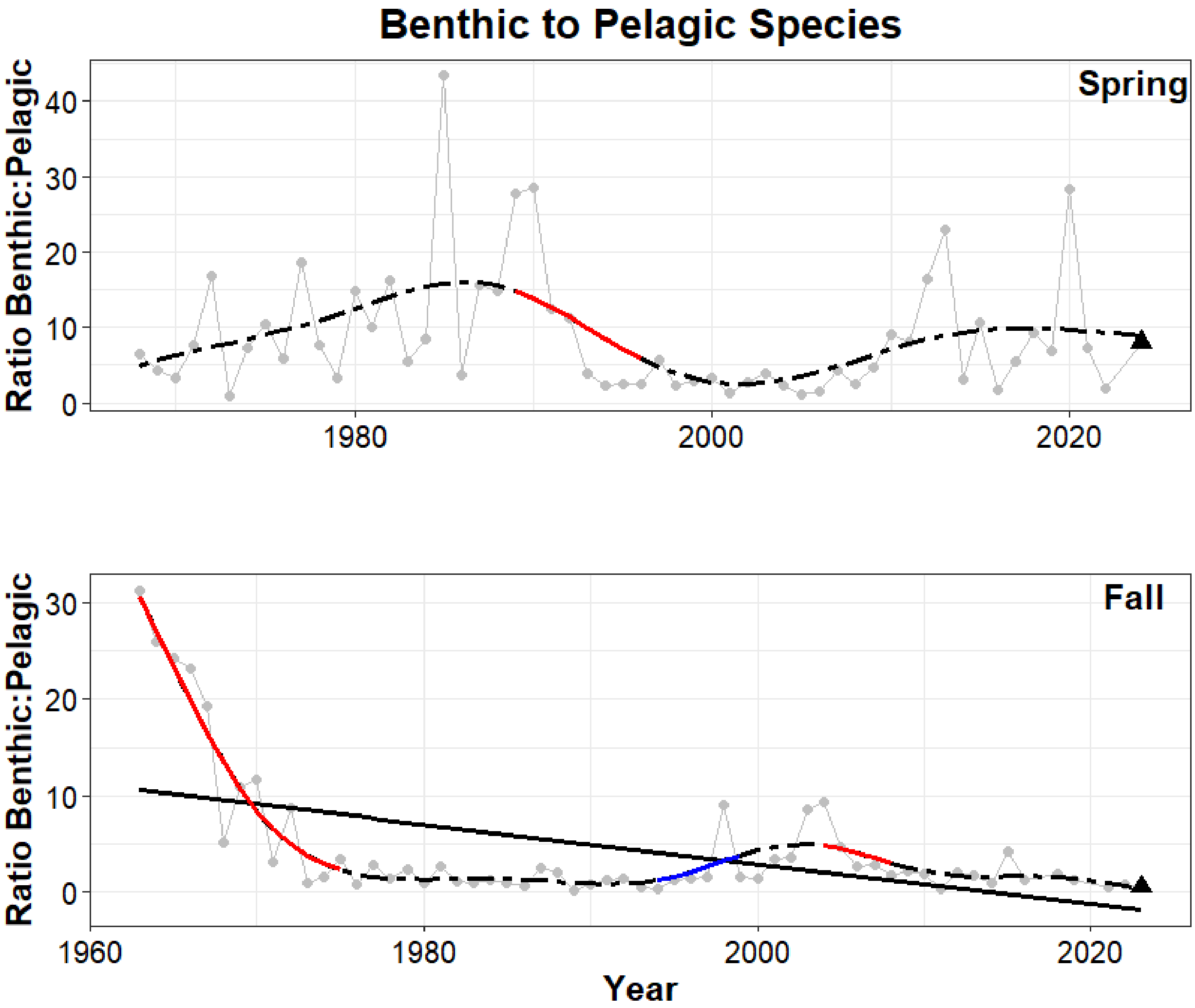


Figure 32: Time series of the benthic to pelagic species ratio in spring (top) and fall (bottom) sampling seasons from the NOAA bottom trawl survey.

Fish Species Richness

	Indicator	Long term trend	Short term status	Summary
16	Fish Species Richness	↗	↗	The number of fish species has increased in the short- and long-term trend in both seasons.

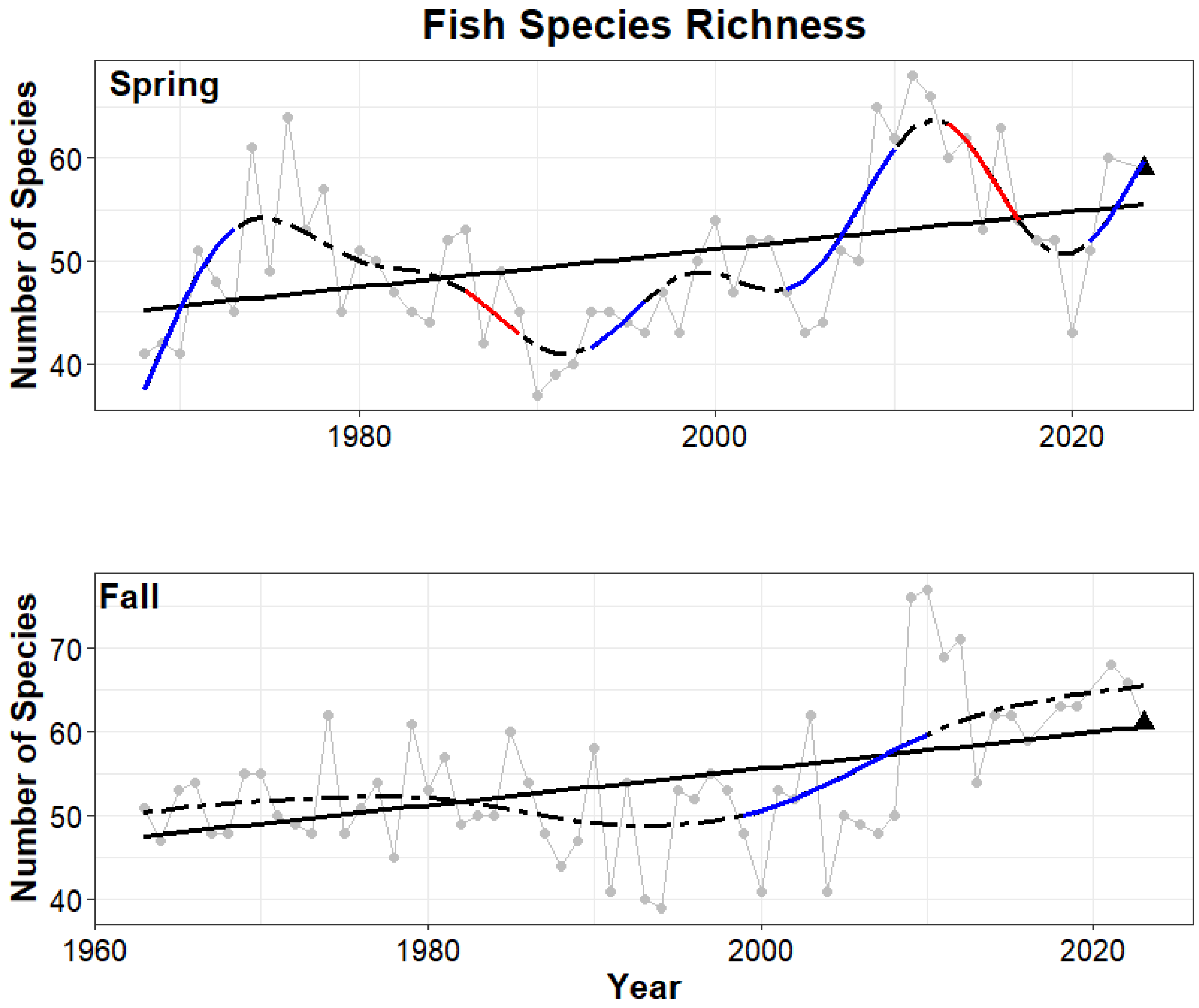


Figure 33: Time series of species richness in spring (top) and fall (bottom) sampling seasons from the NOAA bottom trawl survey.

Average Trophic Level

	Indicator	Long term trend	Short term status	Summary
16	Average Trophic Level	--->	--->	Average trophic level has not demonstrated significant changes.

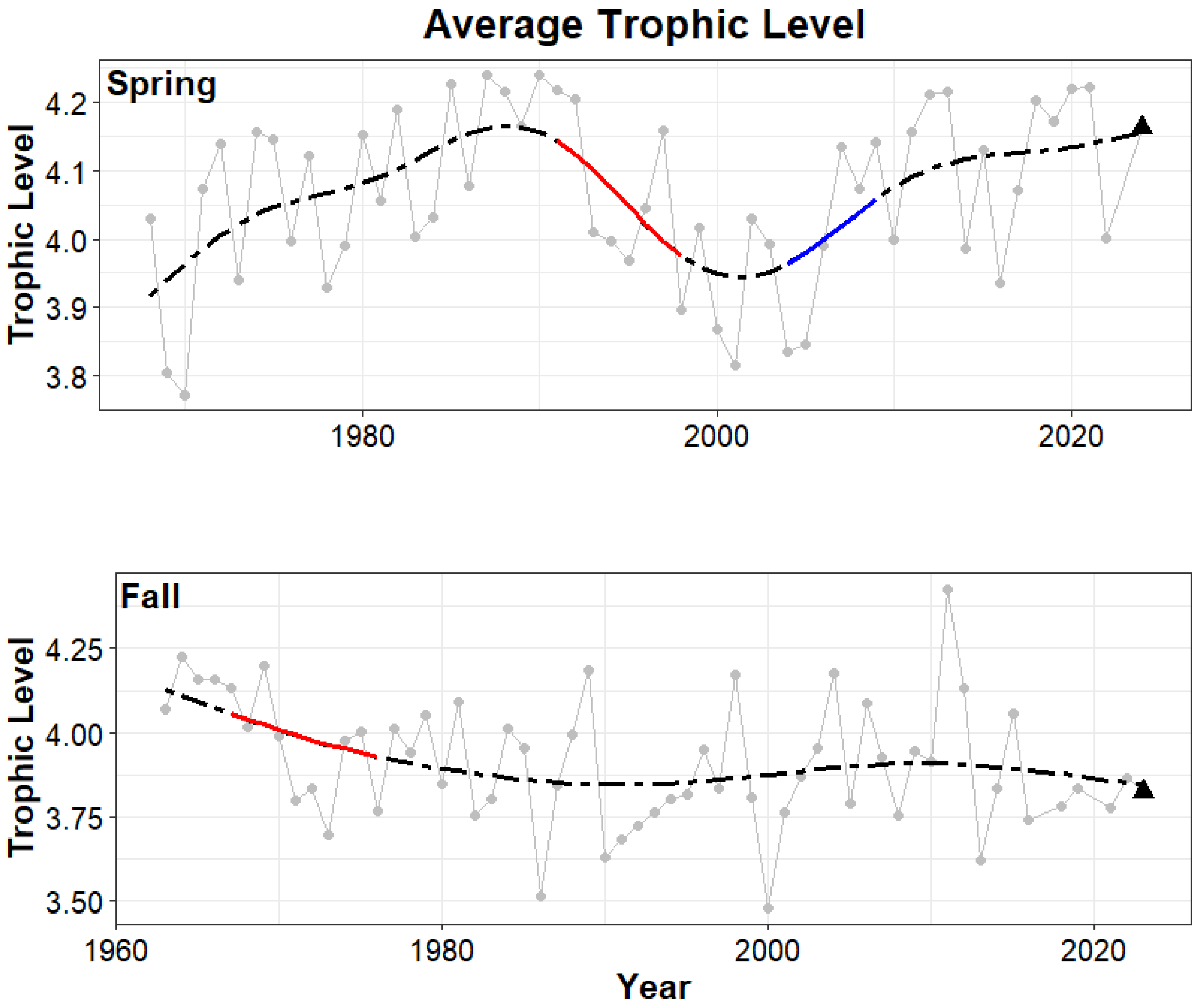


Figure 34: Time series of the average trophic level of species collected during the spring (top) and fall (bottom) sampling seasons of the NOAA bottom trawl survey.

Temperature Preference of Fish Community

	Indicator	Long term trend	Short term status	Summary
16	Temperature Preference	↗	↗	The mean temperature preference of the fish community has increased in both the short and long term in both seasons.

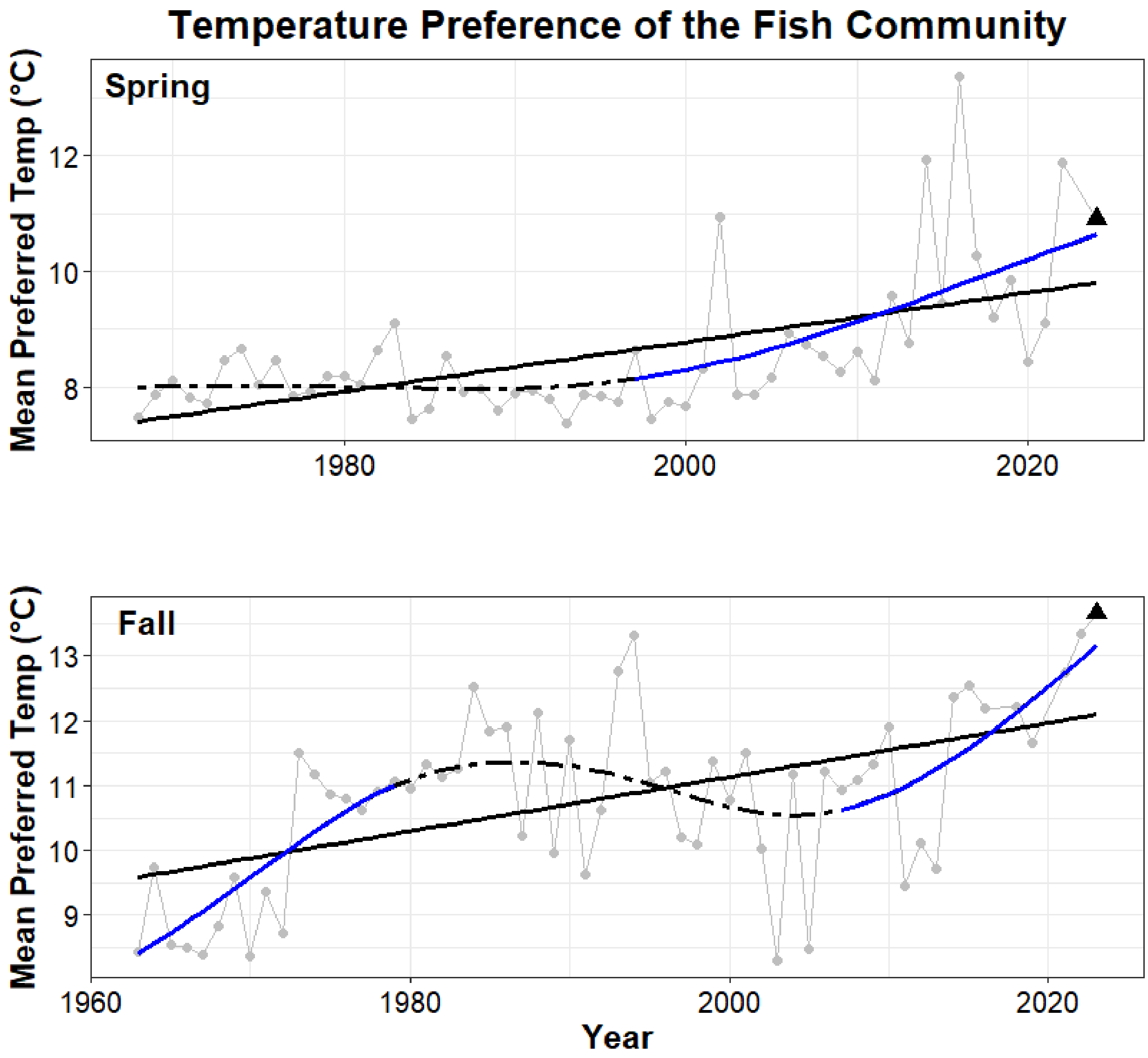


Figure 35: Time series of the temperature preference for species collected during the spring (top) and fall (bottom) sampling seasons of the NOAA bottom trawl survey.

Human Populations

Summary

Commercial harvest remains below the unsustainable levels of the 1960s and were at their lowest level in 2022, the most recent year of data that we obtained. The value of commercial harvest has increased since the 1960s, but has declined in the last seven years. The current value valuation of New York's commercial harvest is nearly $39 million. Recreational harvest has also declined since the early 1980s, when records were first initiated. However, the number of fish released over that time period increased. Recreational effort has increased dramatically since 2000 with much of that effort consisting of party and charter boats. However, in recent years that effort has declined. The number of cargo containers in the New York and New Jersey port has increased steadily since 2005. In 2023, 8 million TEUs passed through that port, roughly double what it was in 2005. The population of Long Island has increased since 1970 by about 1 million people, peaking in 2020. However, population has declined over the last 3 years to 2019 levels. Sea level continues to increase and has accelerated in recent years, increasing the risk of coastal communities to storm surge and flooding each year. The sea level rise in Montauk is occurring at a faster rate than in Battery Park.

Commercial Fisheries Landings

	Indicator	Long term trend	Short term status	Summary
16	Commercial Landings	↘	↘	Commercial landings have decreased in the long term and declined in the last 5 years

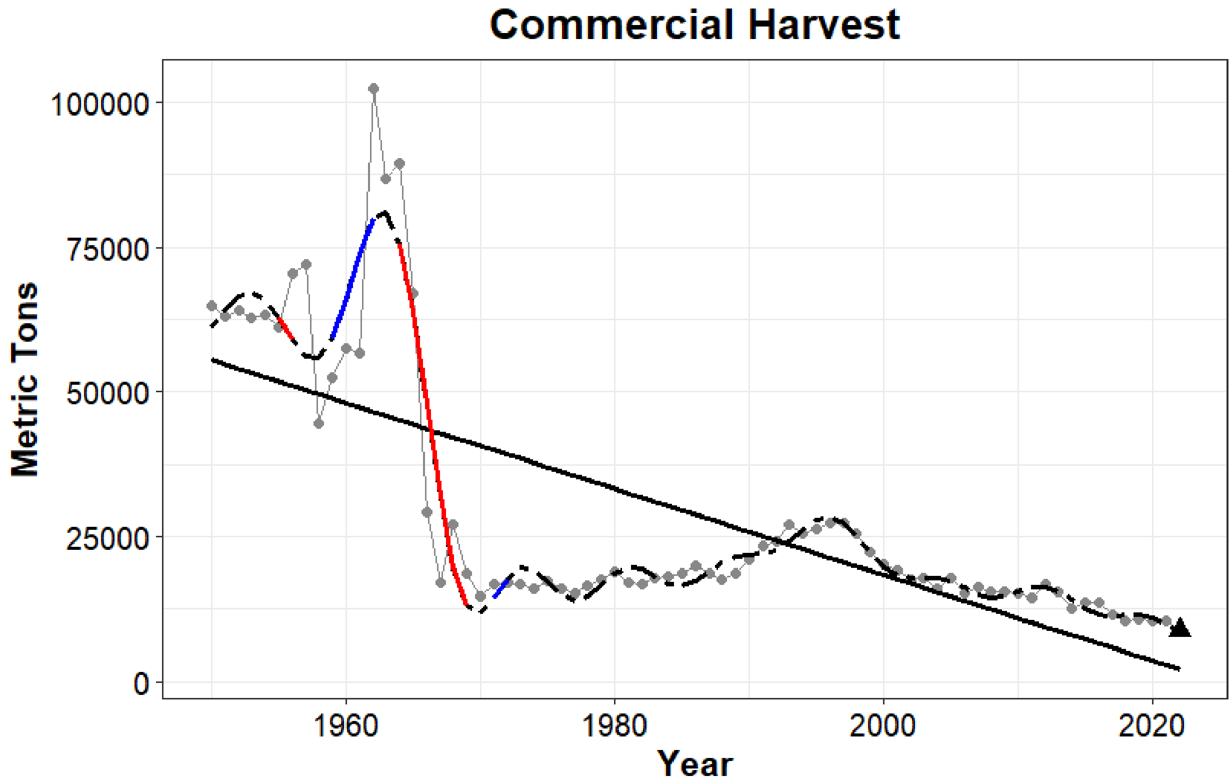


Figure 36: Annual commercial harvest (mT) in the New York Bight region from 1950-2022. Landings decreased precipitously in the 1960’s and have gradually decreased since the 1990’s.

Commercial Landings Value

	Indicator	Long term trend	Short term status	Summary
16	Commercial Landings Value	↗	⇢	The value of commercial landings has increased since the 1960s, but has declined since 2015

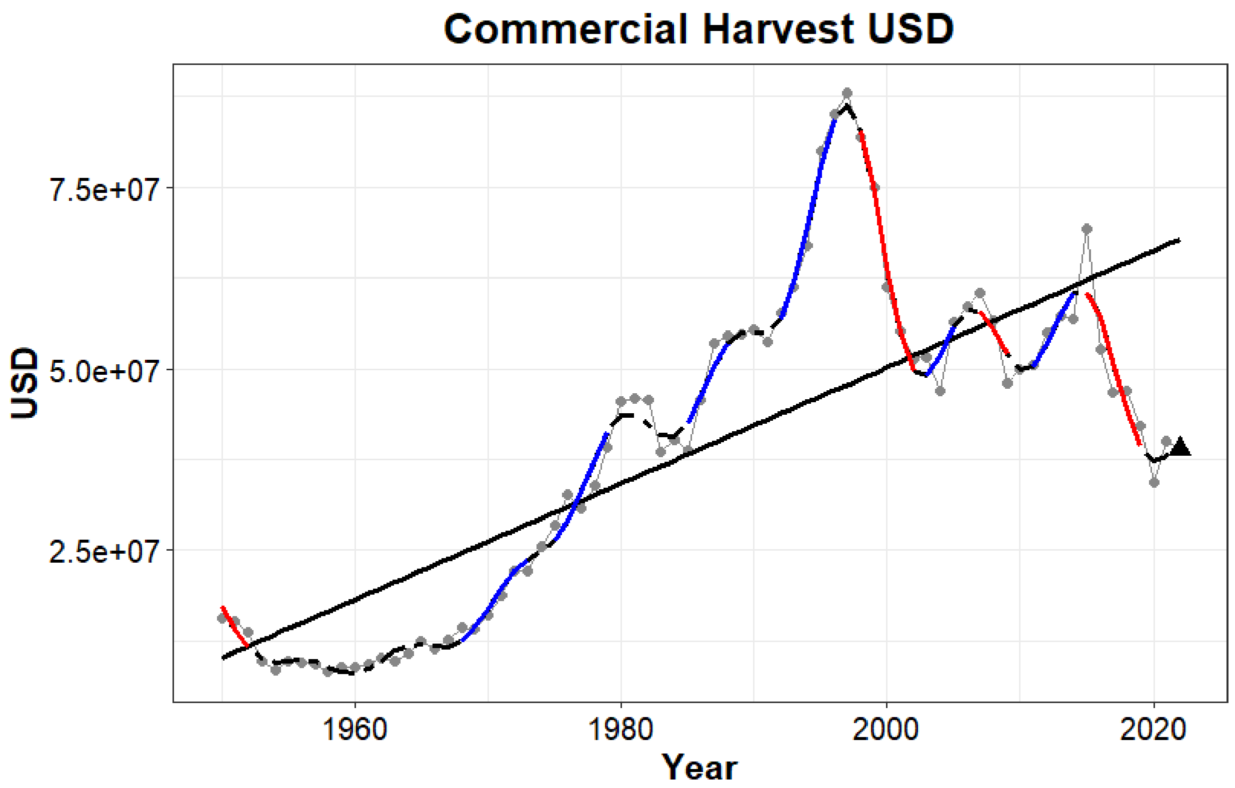


Figure 37: Value of commercial fisheries landings (US dollars) in the New York Bight from 1950- 2022. The total dollar valuation of the region’s commercial fisheries is currently $38,903,641.

Recreational Harvest

	Indicator	Long term trend	Short term status	Summary
16	Recreational Harvest	↗	↘	There is a long-term decreasing trend for recreationally harvested fish, but an increasing trend for released fish. Both harvest and released fish were lower than average

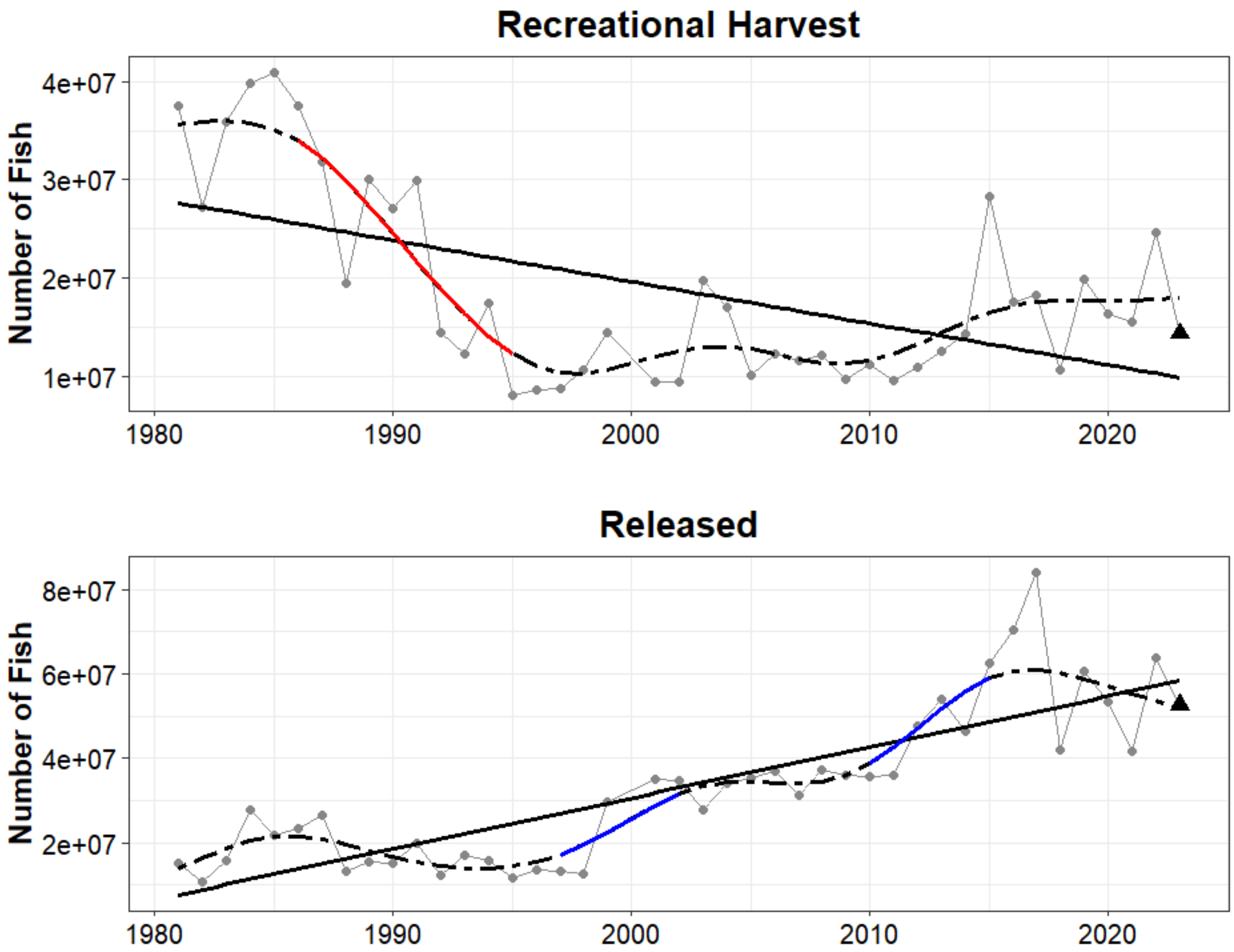


Figure 38 Total number of individual fish harvested (top panel) and released (lower panel) through the recreational fishery from 1981 — 2023. Data were collected by the Marine Recreational Information Program. Both the GAM and linear models demonstrate declines in total harvest, while the number of fish released has increased since 1981.

Recreational Effort

	Indicator	Long term trend	Short term status	Summary
16	Recreational Effort	↗	↗	Recreational effort has increased over time.

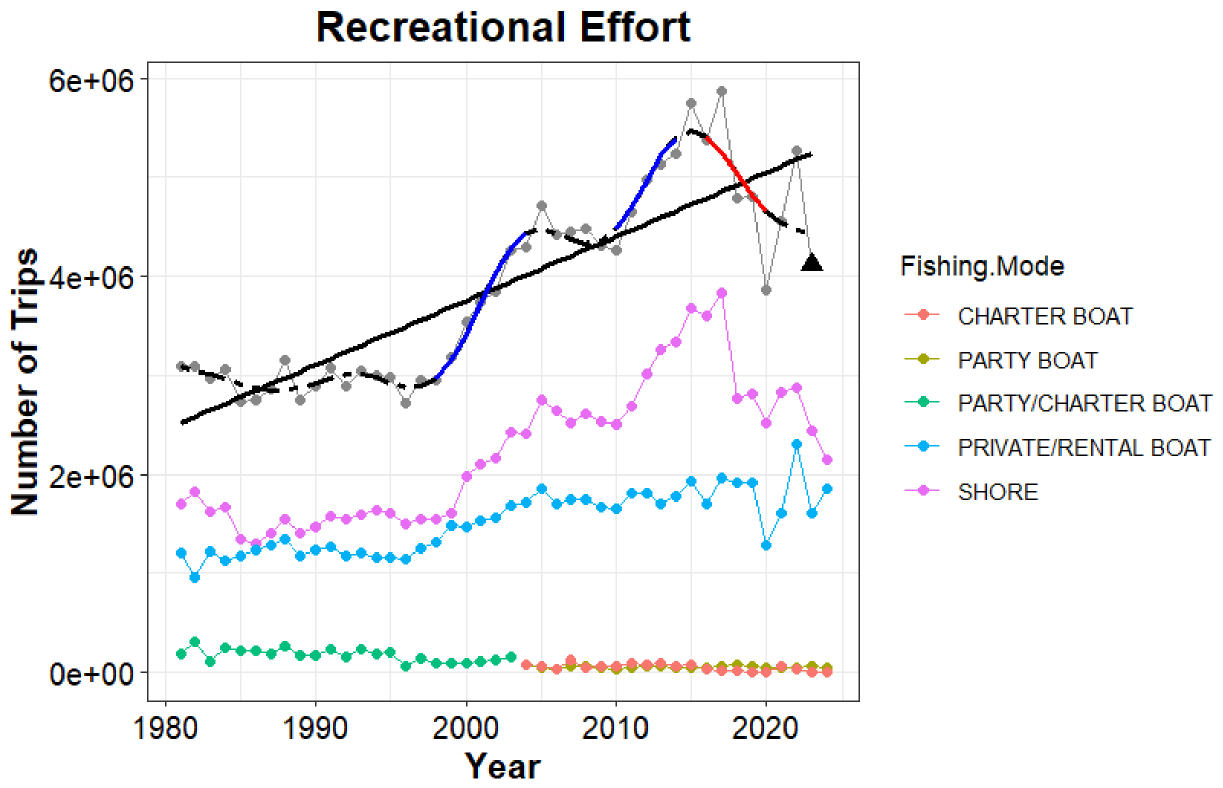


Figure 39 Total recreational fishing effort (grey), described by the number of trips undertaken from 1981- 2023. An overall increase in effort is evident across the time series. Additionally, the data are partitioned by five fishing modes, which include charter boats (orange), party boats (brown), party/charter boat (green), private/rental boat (blue), and shore (purple). Increases in effort are exhibited by the shore and private/rental boat fisheries.

Vessel Density

	Indicator	Long term trend	Short term status	Summary
16	Vessel Density	↗	↗	The number of TEUs at the port of New York and New Jersey have increased in the long-term. Short-term data indicates a high status within the past five years.

Vessel Density

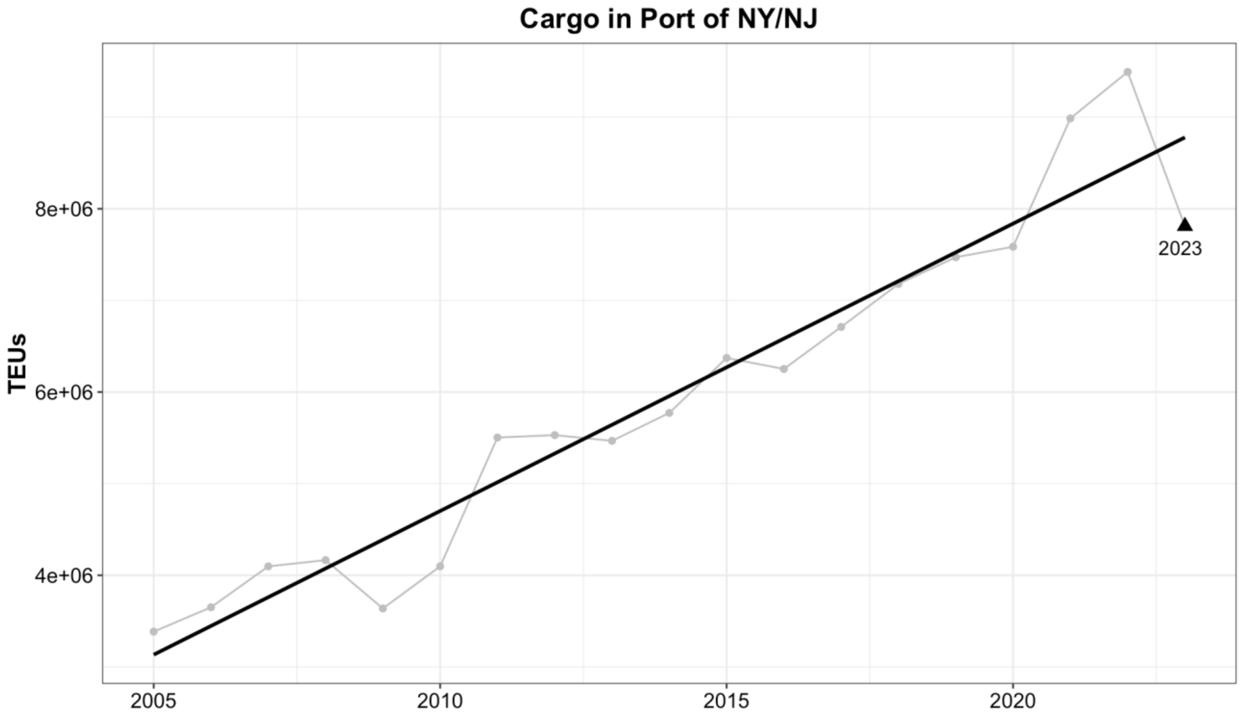


Figure 40 Cargo in the port of New York and New Jersey is defined as the number of twenty-foot equivalent units (TEUs). This unit represents the size of a standard cargo container.

Human Population of Long Island

	Indicator	Long term trend	Short term status	Summary
16	Human population	↗	↗	The population of Long Island has increased dramatically since the 1980s, peaked in 2020, has declined to 2019 levels, but still remains above the historic average.

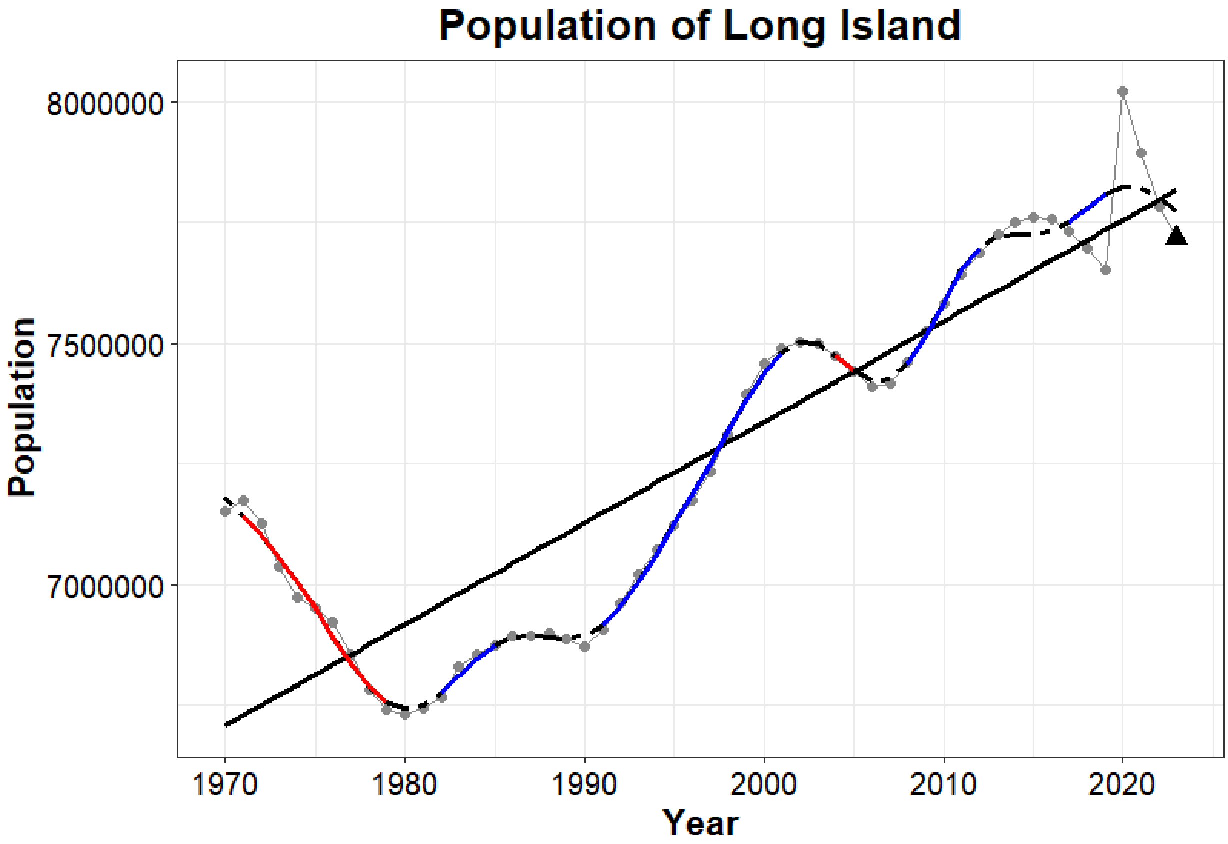


Figure 41 Human population size on Long Island from 1970-2023. The counties of Kings, Queens, Nassau, and Suffolk were included in the analysis. Population size has gradually increased over the last several decades.

Sea Level Rise Risk for Long Island Communities

	Indicator	Long Term Trend	Short Term Status	Summary
39	Sea Level Rise	↗	↗	Mean sea level has increased in both the long and short term at Battery Park and Montauk, but Montauk has increased at a faster rate.

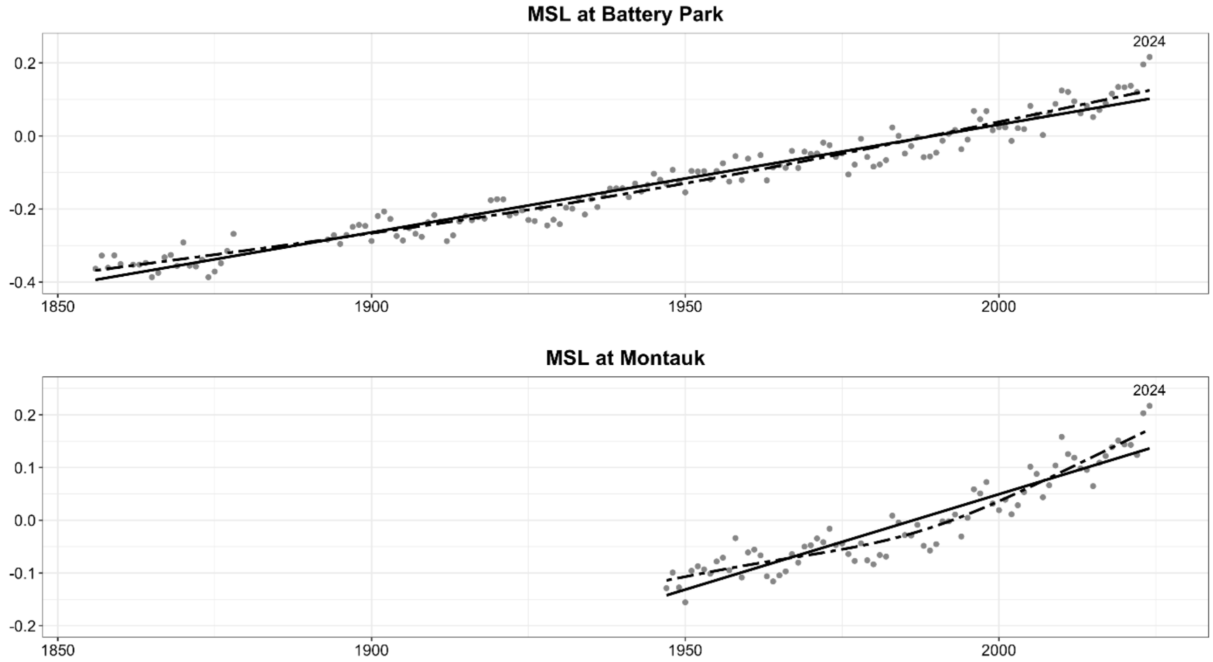


Figure 42: Monthly mean sea level with average seasonal cycle removed. Relative sea level is related to the rise and fall of sea level as well as the rise and fall of land so each guage is referenced locally. The values are in meters relative to the most recent Mean Sea Level datum established by NOAAs National Ocean Service / Center for Operational Oceanographic Products and Services (CO-OPS). The top plot shows relative sea level rise at Battery Park on the western side of New York and the bottom plot shows relative sea level at the Montauk tide gauge on the most eastern tip of Long Island.

The average rate of sea level rise was 2.92 mm/year for The Battery and 3.53 mm/yr for Montauk over the entire time series. However, the rate of sea level rise has accelerated in both areas in recent decades consistent with global observations. The rate of increase from 2003-2015 is about equal to the global average in Battery Park from (3.6 mm/yr from 2006-2015), but the rate at Montauk (4.8 mm/yr) is comparatively faster than the global average (IPCC, 2023). The NYB is located in a known hot-spot of rapid sea level rise (Sallenger et al., 2012). The increase in sea level rise increases the exposure and risk to storm-related seal level rise events.

Ongoing Indicator Development

Ocean acidification risk

Last year we developed an indicator of ocean acidification risk based on a literature review of NYB species thresholds and water samples collected from our shipboard transect survey. We calculated the percent area that was below the aragonite value that was potentially harmful for squid (aragonite <1.7) and pteropods (aragonite < 1.5). We had to limit the analysis to only one transect per sampling event, so only one transect per season per year. We concluded that aragonite values were lowest in the summer and that the area of risk to ocean acidification was highest in the summer months. However, many time periods were missing because of cruises cancelled for weather or maintenance (Figure 43). Our intention was to supplement our water samples with CTD and glider data to have a more complete picture of ocean acidification spatially and temporally. Rather than repeat this exercise this year with only the spring data from 2024, we are focusing our efforts on developing this indicator. Similarly, we are taking a similar approach to develop an indicator of cold pool volume by combining our glider and shipboard data that we can compare to the GLORYS indicator that we include in this report.

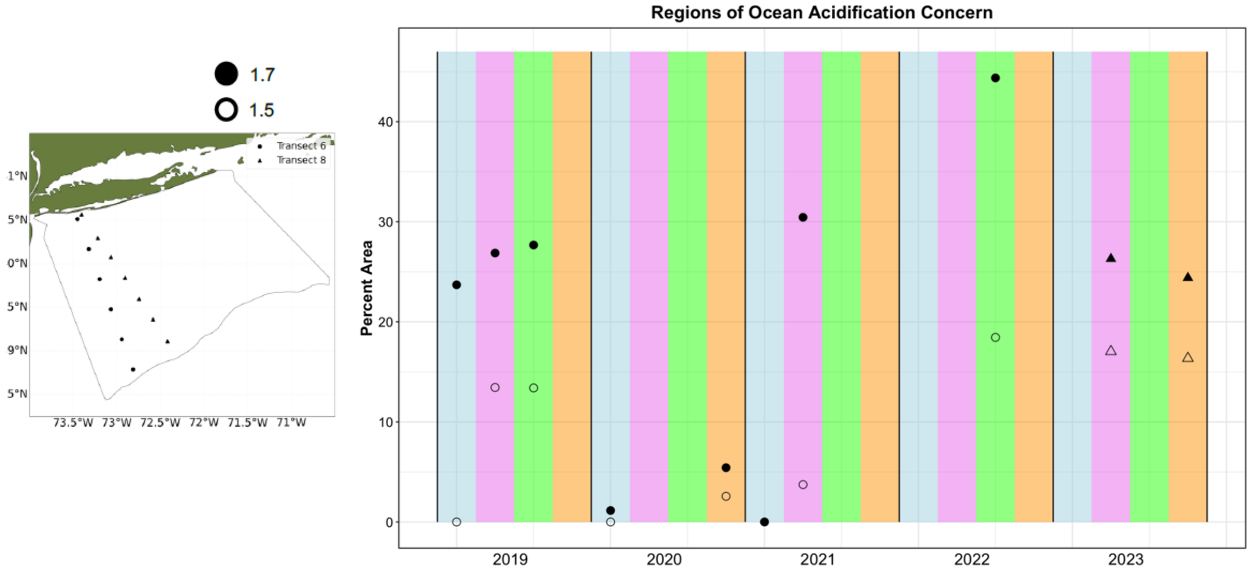


Figure 43: Regions of ocean acidification concern associated with an aragonite saturation state of 1.7 (closed circles and triangles) and 1.5 (open circles and triangles). Colored shading indicates season: blue is winter, pink is spring, green is summer, orange is fall. The summer of 2022 showed the highest percent area lower than 1.7. Values lower than 1.7 indicate regions where acidification which may be detrimental to the growth of longfin squid. In 2023, cruises transect 6 was replaced by transect 8 (map inset at left)

Whale Body Condition

Body condition of upper trophic level species is an indicator of ecosystem health of the New York Bight as these species integrate across multiple trophic levels and across long time frames (Moore 2008, Bossart 2011, Hazen et al. 2019). Baleen whales are capital breeders that separate their breeding and feeding grounds, acquiring and storing energy while on the foraging grounds, and relying on that stored energy for the remainder of the year. Thus, the body condition of baleen whales reflects their energy stores, and changes in baleen whale body condition through time, and between foraging areas, can provide key information on whale health, changes to resource availability, and anthropogenic stressors (Bossart 2011, Bradford et al. 2012, Christiansen et al. 2020, Lemos et al. 2021). We are developing an indicator of baleen whale body condition in the NYB by integrating Unoccupied Aerial Systems (UAS), or drone, measurements with a scalable three-dimensional (3D) model to estimate baleen whale body volume, which provides a holistic means of assessing body volume (Figure 44, Hirtle et al. 2022). We are conducting field studies to quantify the body condition of humpback whales foraging in New York waters to detect and examine interannual changes in body condition. Our comparison of humpback whale body condition for whales foraging in New York waters with those in different foraging areas across the North Atlantic found that whales sampled in New York waters show significantly lower body condition than those sampled in the norther Gulf of Maine (Figure 47, Napoli et al. 2024).

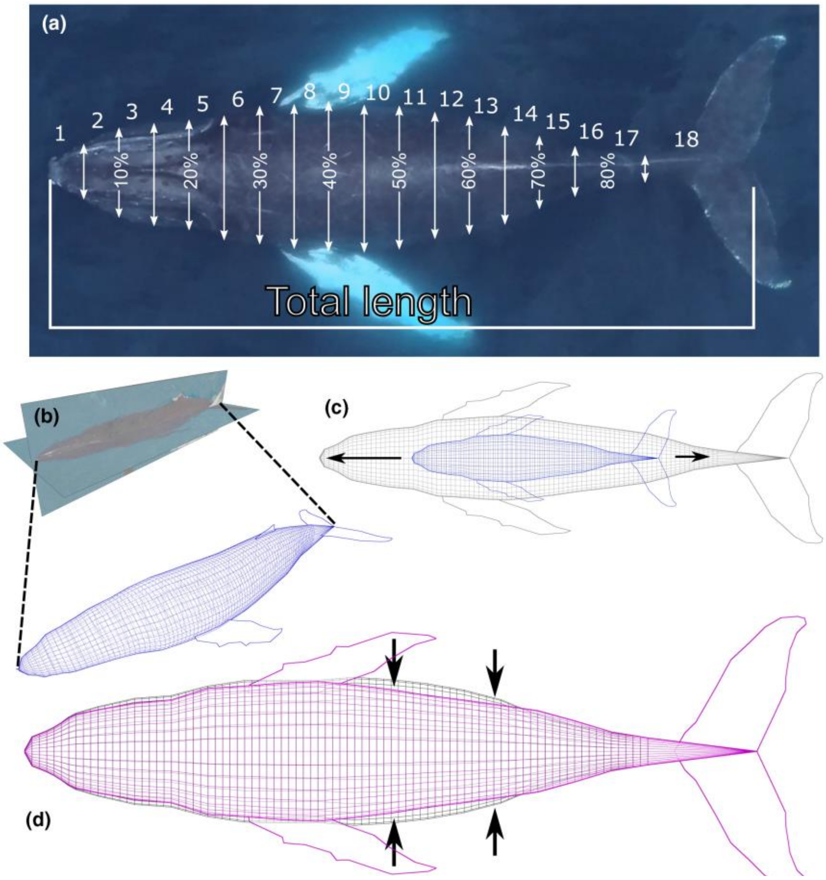


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Figure 44: A workflow diagram of the model scaling process used to generate estimates of body volume, from Hirtle et al. (2022). (a) Width measurements (white arrows) and total length measurements are derived from Unoccupied Aerial System (UAS) images. Numbers between width measurements indicate percent total length from rostrum to fluke notch. Integers 1–18 indicate three-dimensional (3D) body segments corresponding to regions between width measurements. (b) The base 3D model is constructed using dorsal and lateral images. (c) The base model (blue) is scaled to length, conserving model proportions. (d) The model is scaled laterally and dorsoventrally to match corresponding width measurements and height-width ratios, resulting in the final model (purple). Black arrows indicate regions of greatest change relative to the base model

A large proportion of the whales we observe foraging in the NYB are juveniles (Stepanuk et al. 2021), making it important to use a body condition metric that accounts for changes in body volume relative to body size. We are therefore using the significant linear log-log relationship between body volume and body length (whales with a longer body length inherently have a larger body volume) following Christiansen (2020). The body condition index of individual whales is calculated as the residual of this log-log relationship. Positive (negative) values of this index reflect better (worse) body condition than the average whale of the size body length. However, developing reliable values of this metric requires a large sample size so as to have sufficient data to establish a strong relationship between body volume and body length as calculated residuals are strongly dependent on this relationship. We are therefore building up our dataset of baleen whale morphometrics so as to rigorously assess the relationships between body volume and body length, and to assess body condition across years.

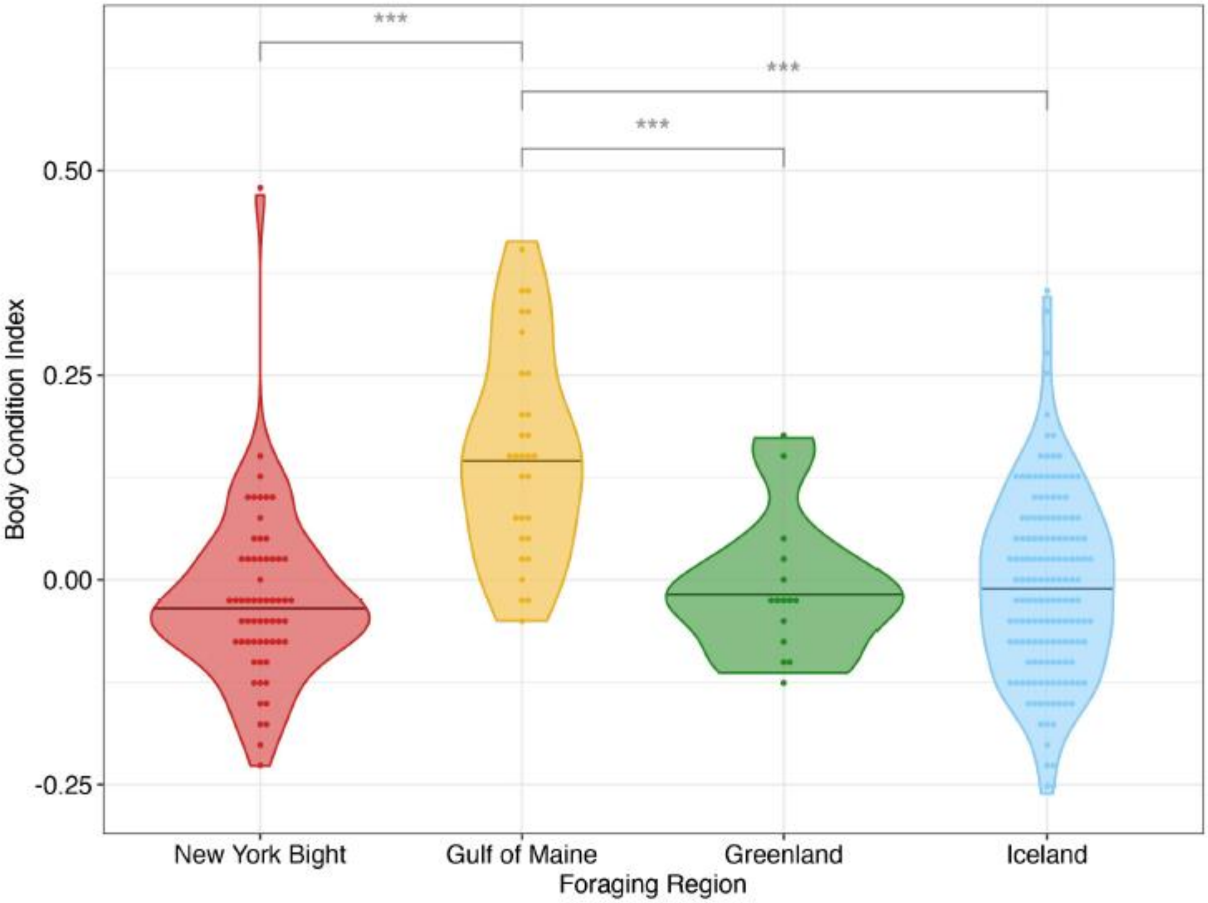

Figure 45: Comparison of body condition index across four North Atlantic ecosystem as described in Napoli et al. (2024).