2025 Ecosystem Summary Report pilot for the Eastern Scotian Shelf (ESS)

Maritimes EBFM WG

2025-02-20

Contents

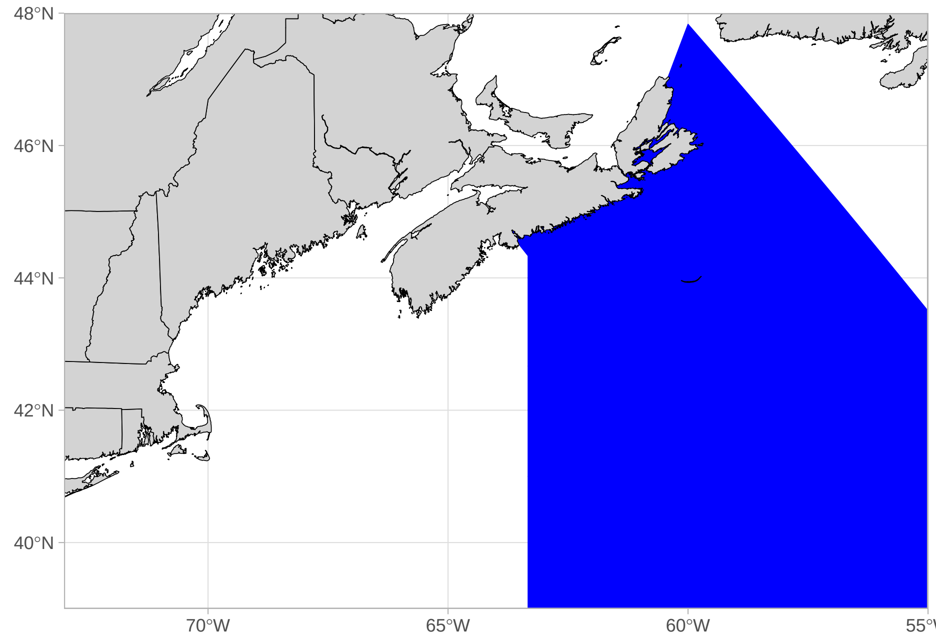

Figure 1: Eastern Scotian Shelf (ESS) Management area

Introduction

About this report

This Ecosystem Summary Report supports DFO's efforts to incorporate ecosystem approaches into Fisheries Science and Resource Management in the Maritimes Region. The purpose of this report is to synthesize ecosystem information to inform an ecosystem approach, as highlighted in the modernized Fisheries Act (2019; Bill C-68). It aligns objectives broadly to those of the Maritimes Ecosystem Based Management Framework, and regional/area-based objectives that contribute to Scientific Advice and Management Plans or other Harvest Strategies. The aim of this Ecosystem Summary Report is to provide an integrative suite of ecosystem indicators relevant to a specific fisheries management area that can support Ecosystem Approaches to Fisheries Management (EAFM) and Ecosystem Based Fisheries Management (EBFM) at DFO.

Report structure

This report outlines ecosystem objectives related to a specific management area (Table 1), and reviews relevant ecosystem indicator trends and the status of the most recent year(s) relative to a reference point (if available) or a long-term average. The results are synthesized to outline potential implications for the management area examined, but not specifically related to a focal stock or species. Where relevant this document provides links to reports and resources for details and methodology. This report summarizes general ecosystem trends to support integration of ecosystem information and expertise into Science Advice (e.g. stock assessment) or Resource Management (e.g. Integrated Fisheries Management Plans), but is intended for a variety of users.

This is a summary of the best available information describing the ecosystem specific to management areas within the Maritimes Region.

Ecosystem Objectives

The Ecosystem objectives outline the ecosystem context and considerations for this management area.

Table 1: Ecosystem objectives related to EBM Framework Pillar, Management Components, and Indicators.

Pillar	Management Component	Ecosystem Objective	Indicators
A. Pressures and stressors	Climate and Oceanography	Monitor key signals within the environment and ecosystem	NAO, SST anomaly, Bottom Temp anomaly, SST, Bottom Temp, DO, Stratification, Salinity
A. Pressures and stressors	Longer-term Climate Change	Effective action and adaptation on climate change is taken	Future projection model outputs
B. Ecological	Commercial Fishery	Maintain fishing pressure consistent with the ecosystem's ability to recover	Fishing pressure, Commercial landings
B. Ecological	Habitat	Habitat and habitat features are conserved, protected, maintained, and restored	Depth>75 fathoms, Sediment
B. Ecological	Productivity	Do not cause unacceptable reduction to productivity	Nitrate, Chlorophyll, Bloom statistic, C.finmarchicus, Zooplankton biomass
B. Ecological	Productivity	Ecosystem structure and functioning is promoted and conserved	Large Fish Indicator, predator index
B. Ecological	Biodiversity	Biodiversity is conserved, maintained, and restored to preserve the structure and natural resilience of aquatic ecosystems	Shannon Diversity Index, Margalef Richness, Heips Evenness, Guild-level biomass
B. Ecological	Non-Target species	Unintended or incidental mortality for all species is controlled	NA for this report
C. Economic	Commercial Fishery	Aquatic resources are managed to foster long term, viable, prosperous and sustainable livelihoods for all users	Landings values
D. Social-Cultural	NA for this report	NA for this report	NA for this report
E. Governance	NA for this report	NA for this report	NA for this report

A. Pressures and Stressors

Climate and oceanography

The ESS area is strongly influenced by natural variability of the climate system (e.g., North Atlantic Oscillation) and, therefore, long-term monitoring is needed to determine how anthropogenic climate change is affecting ocean temperatures.

North Atlantic Oscillation Index

Hebert et al. 2024 (see Section 2.1)

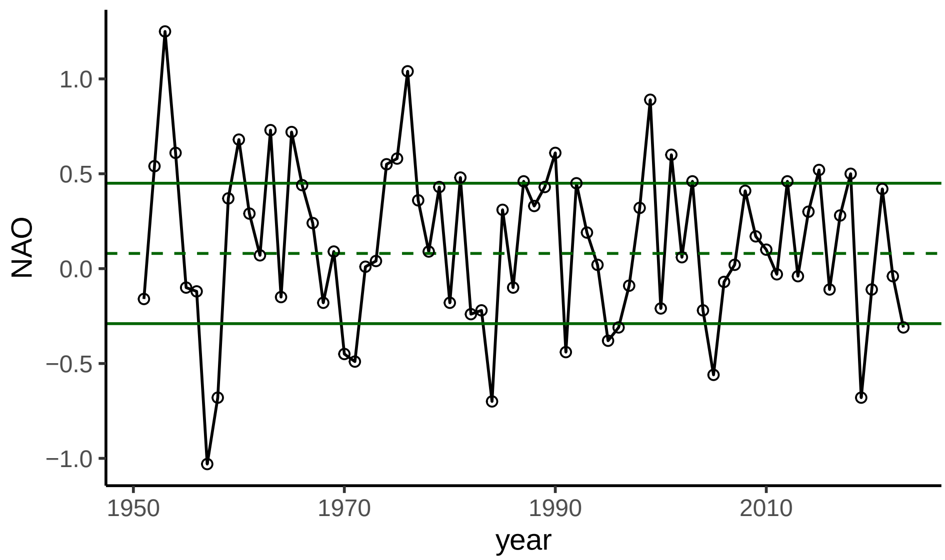

Figure 2: The North Atlantic Oscillation (NAO) index, defined as the winter (December, January, February, March) 500 mb pressure Principal Component Analysis which is representative of the difference between the Icelandic low and Azores high. Climatological mean is shown as the dashed line, solid lines are ± standard deviation (SD).

- In 2023, the winter (December–March) North Atlantic Oscillation (NAO) index was below the 1991 – 2020 mean, –0.31 (–0.84 SD). A high NAO index corresponds to an intensification of the pressure difference between the Icelandic Low and the Azores High. Strong northwest winds, cold air and sea temperatures, and heavy ice in the Labrador Sea and on the NL shelf areas, are usually associated with a high positive NAO index (Colbourne et al. 1994; Drinkwater 1996). The opposite response (warm, salty conditions) occurs during years with a negative NAO index (Petrie 2007).
- The NAO has been shown to strongly affect bottom temperature distributions throughout the region from the Labrador Shelf to the Gulf of Maine (Petrie 2007). The response is bimodal, the product of direct and advective effects, with positive (negative) NAO generally corresponding to colder- (warmer-) than-normal bottom temperatures over the Labrador-Newfoundland Shelf, the Gulf of St. Lawrence, and the Eastern Scotian Shelf, and warmer- (colder-) than-normal conditions on the Central and Western Scotian Shelf and in the Gulf of Maine.

Sea Surface Temperature Anomaly

Temperature anomalies are the deviations from the long-term means, or as standardized anomalies they are the anomaly divided by the Standard Deviation (SD). If the data permit, the long-term means and SDs are calculated for the 30-year base period of 1991–2020. The use of standardized anomalies and the same base period allow direct comparison of anomalies among sites and variables. Hebert et al. 2024 (see Section 3)

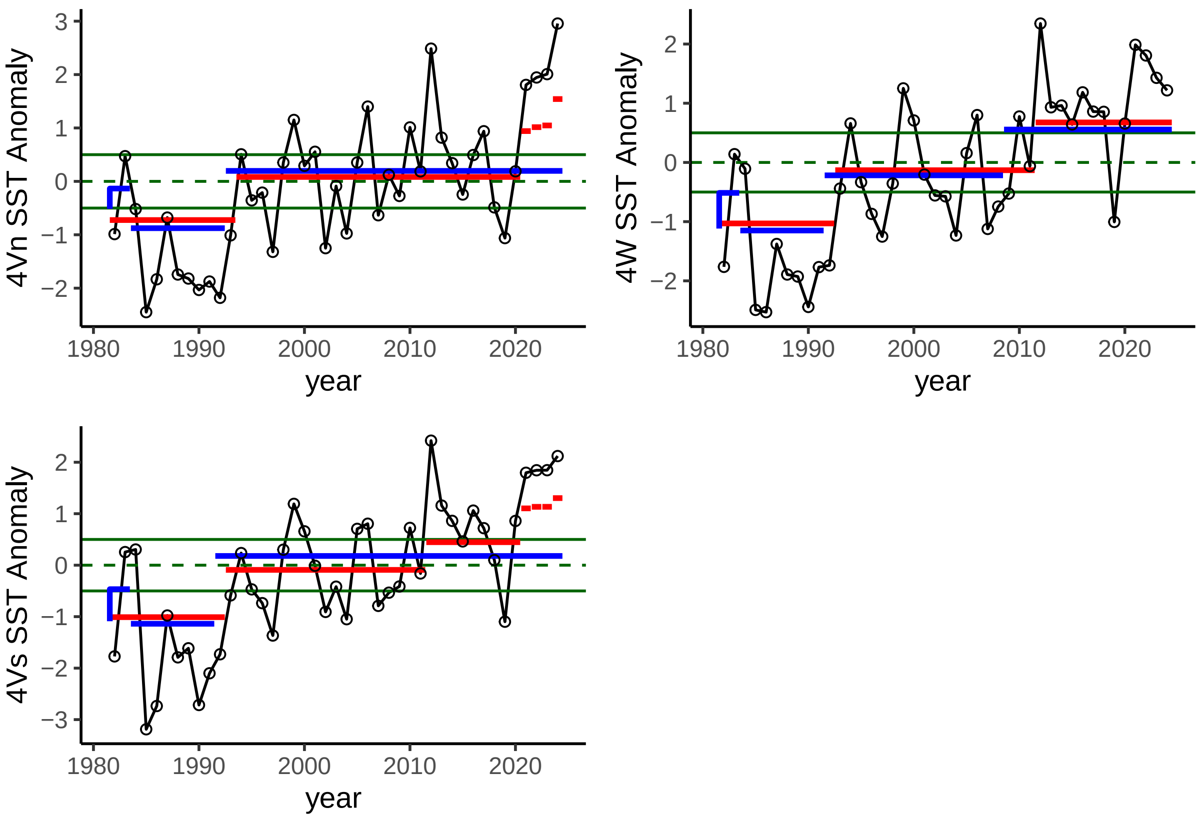

Figure 3: The annual sea-surface-temperature normalized anomaly for NAFO regions within the ESS derived from satellite imagery compared to their long-term monthly means. Horizontal solid lines represent ± stanard deviation (SD) for the 1991-2020 period. Regime shift analysis results from running the method forwards and backwards on the time series depicted by the blue and red horizontal lines, respectively.

- The annual SST anomalies during 2023 were higher than average and SST remained above normal, with the last three years being the three warmest years in the ESS. A regime shift algorithm to detect a step change using mean levels was applied to the annual time-series (Rodionov 2004). Over the length of the record, the temperature has three distinct periods at all regions, a relatively cooler period from 1982 to 1993, near the climatological mean from 1994 to 2011, and a relatively warmer period from 2012 to present.

Bottom Temperature Anomaly

Hebert et al. 2024 (see Section 8.2)

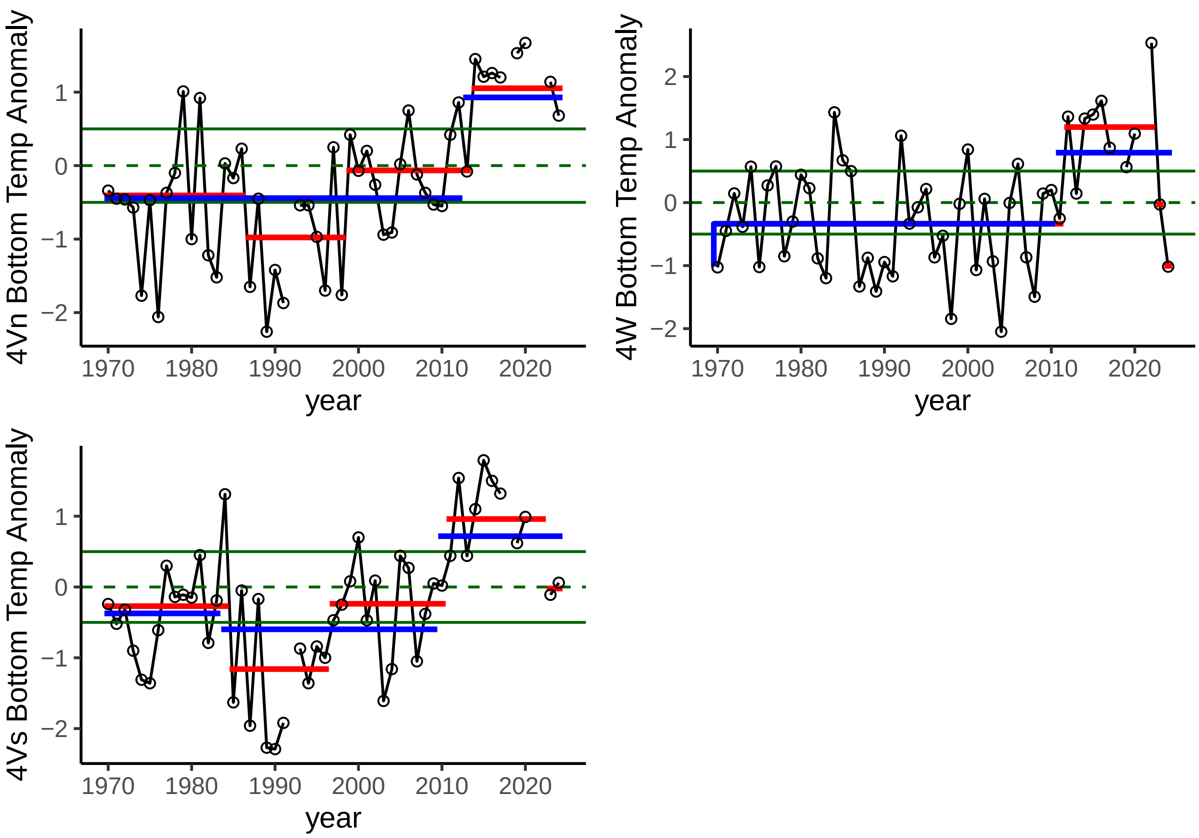

Figure 4: Time series of July bottom-temperature anomalies for NAFO regions within the ESS. The dashed horizontal line is the 1991-2020 mean and solid lines represent ± stanard deviation (SD). Regime shift analysis results from running the method forwards and backwards on the time series depicted by the blue and red horizontal lines, respectively.

- The near-bottom temperature anomalies for 2023 showed a decreasing trends across NAFO 4Vn, 4Vs, and 4W areas. While the northern part of the ESS (NAFO 4Vn) is in a warmer bottom temperature regime since 2012, The southeast portion of the ESS (NAFO 4Vs) is in the normal range in 2022-2023. On southwest portion of the ESS (NAFO 4W) bottom temperatures were showing cooling trends below normal for 2023. All regions show elevated bottom temperatures from years 2010-2021.

Sea Surface Temperature (SST), Bottom Temperature

Casault et al. 2020

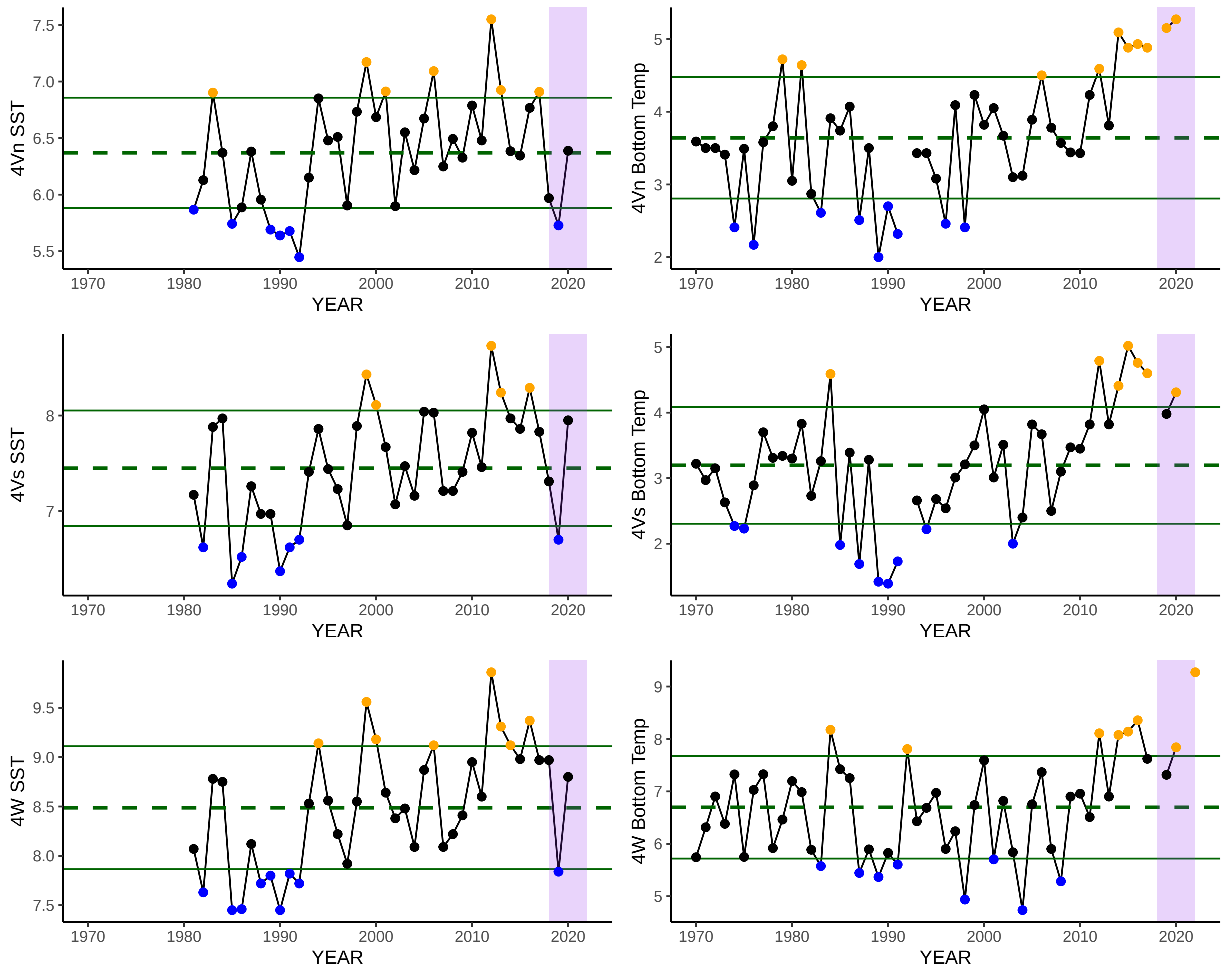

Figure 5: Sea Surface Temperature from satellite and Bottom temperature from fixed stations for 4Vn, 4Vs, 4W. Dashed lines denote the long-term mean.

- SST and bottom temperature data are only available until 2020, and awaiting updates.
- Over the past two decades, the Scotian Shelf has incurred rapid warming due to the increased dominance of Warm Slope Water.
- SST in the ESS area between 2016-2020 is within the reference period mean (1991-2020), indicating average sea temperatures in the ESS over recent years. However bottom temperature in ESS has generally remained higher than average.

Dissolved Oxygen, stratification, salinity

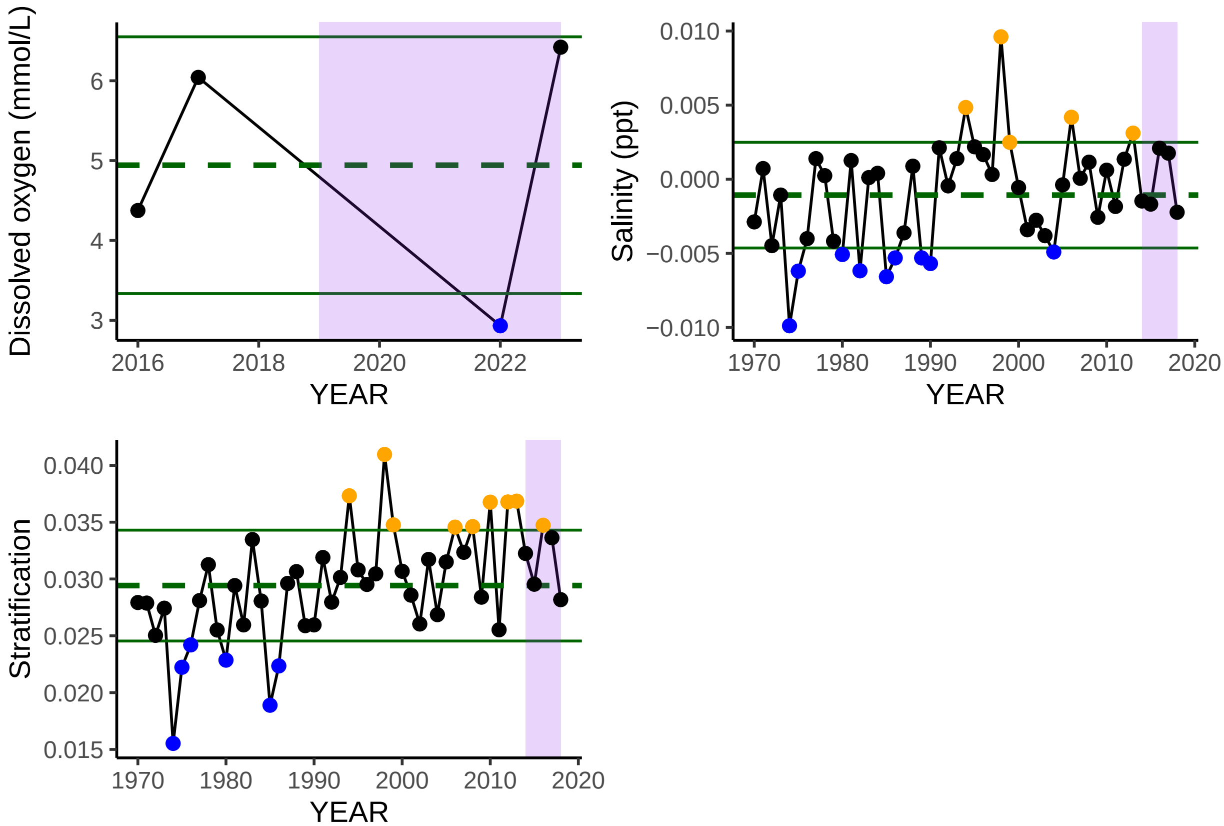

Figure 6: Dissolved oxygen (mmol/L) from winkler bottle measurements for the ESS. Stratification and salinity (ppt) for the ESS from 1970-2018. Dashed lines denote the long-term mean, solid lines denote .

- Direct measurement for dissolved oxygen (DO) from Winkler bottle measures indicate that dissolved oxygen for the late winter (February) were high (6.4 mmol/L) in the ESS, but within normal range. Measures of DO for from 2022 were taken from a late survey that occurred in the Fall (October) and could account for the lower readings.

- Salinity and stratification have been generally higher, with more years above the long-term mean in the ESS since the early 1990s. In later years (2018), both were slightly below the long-term mean, but within a normal range. These trends are consistent with SST trends for the ESS

Longer-term climate change

Ocean model long-term forecast and projections provide a general expectation of how the world may change. Ocean model projections use low and high emissions pathways as future scenarios to frame expectations of the future ocean climate.

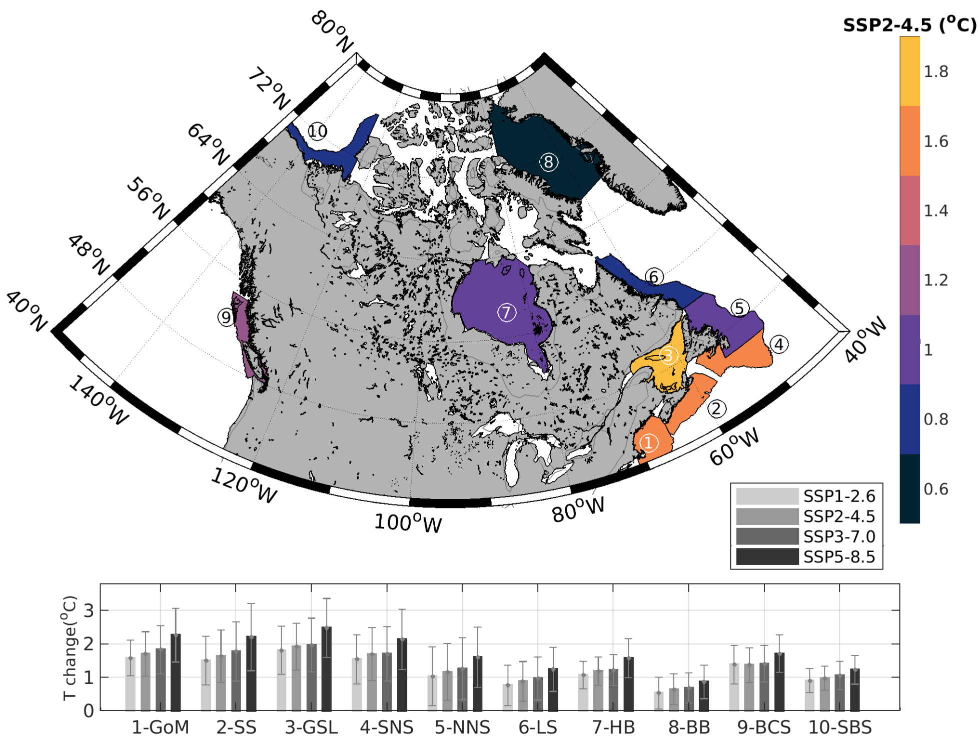

Figure 7: Future scenarios for sea surface temperature changes.

- In the ESS by 2050, the onset of spring is expected to occur 3-4 weeks earlier than present day and the growing season is expected to last 4-6 weeks longer (Brickman & Shackell, 2024)
- Projected changes in sea surface temperature (2040-2059 relative to present day) for the Scotian Shelf and Gulf of Maine range from approximately 1.5 to 2.5°C (based on IPCC scenarios SSP2-4.5 to SSP5-8.5) (Wang et al, 2024).
- With a rapidly changing ocean, we can expect shifts in productivity and distribution in the ESS, as well as shifts in the seasonal timing of their reproductive cycles.
- By 2100, under both low and high emissions scenario, most marine species across the Canadian portion of the NW Atlantic are from moderate to high climate risk, and indeed, are at a lower risk compared to many areas around the globe, especially tropical ecosystems. While the NW Atlantic is warming rapidly, the resident species are, on average, widespread across the seascape, and are accustomed to a wider range of temperatures (Boyce et al. 2024).
- However, formerly commercial but now depleted species will be at much greater risk due to their low population sizes (Boyce et al. 2024, see Fig 5 for list).

B. Ecological

Commercial Fishery

Fishing Pressure

Bundy et al. 2017 (see Table S4 for definitions, see Table S5 for species categories)

This indicator measures the level of exploitation or total fishing pressure at the ecosystem level (Landings/Biomass). Change in this indicator can result from change in biomass, landings or both.

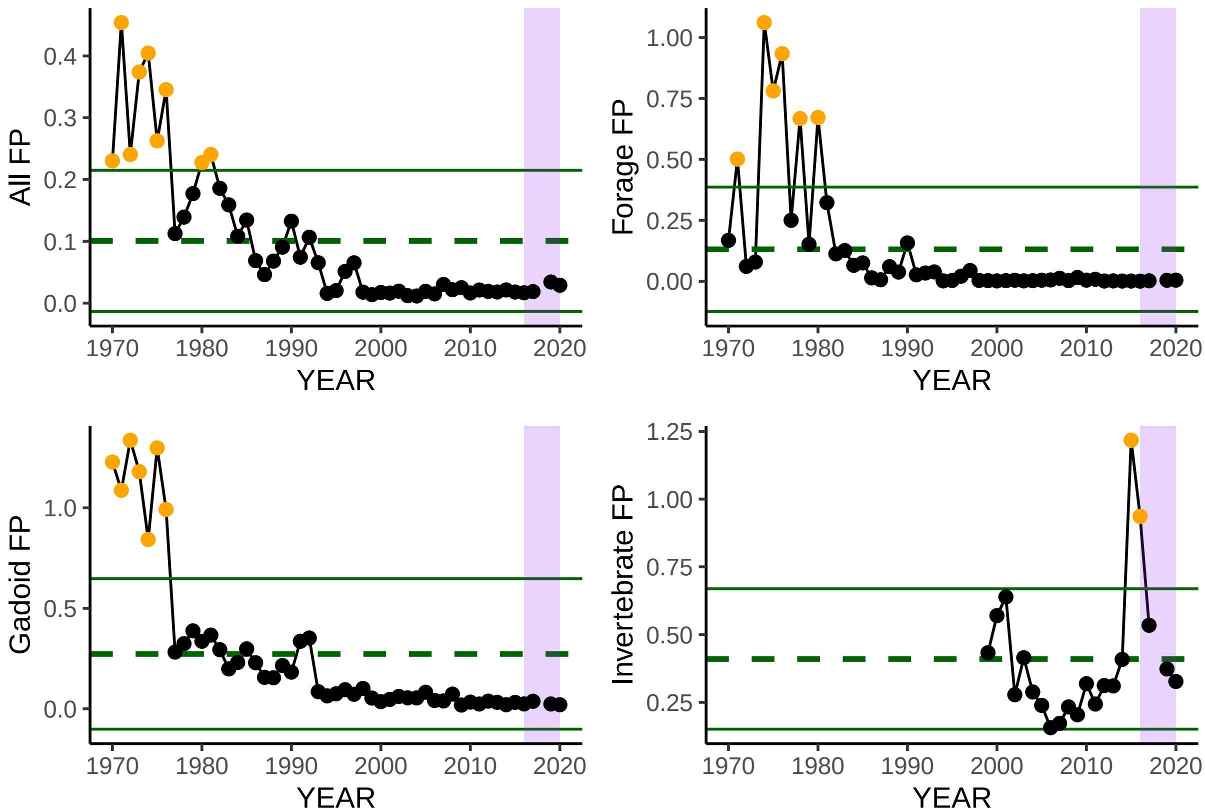

Figure 8: Fishing Pressure (FP) calculated from DFO Summer Research Vessel survey. Data have been corrected for catchability with the exception of invertebrates. Dashed lines denote long-term means, solid green lines denote ± stanard deviation (SD) from the available timeseries. Purple, shaded areas represent the latest 5 years of available, robust data.

- The 2018 fishing pressures (removed to better reflect the long-term means) are artificially high due to the lack of Summer Research Vessel survey in the ESS for that year, while landings remained stable.
- The latest robust estimates of overall fishing pressure in the ESS (2020) has been below the long-term average since around 1995.
- Fishing pressure on gadoids and forage fish in the ESS have been below the long-term mean since the 1990s. In contrast, fishing pressure on invertebrates has been close to the long-term average in recent years.

Commercial Landings

Bundy et al. 2017 (see Table S4 for definitions, see Table S5 for species categories)

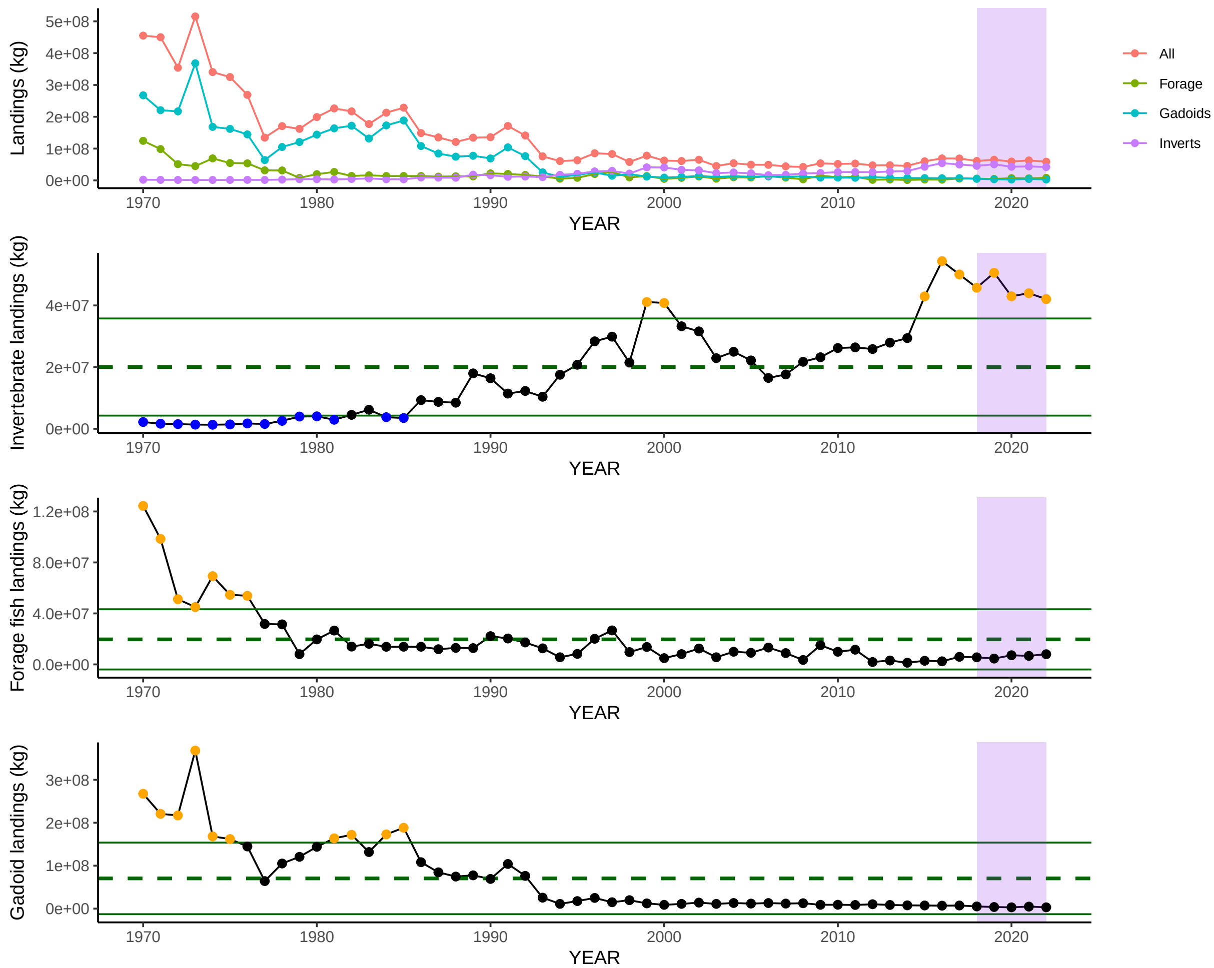

Figure 9: Commercial landings (kg) collected from NAFO, ZIF and MARFIS databases for species categories in the ESS. Dashed lines represent the mean, solid green lines denote ± stanard deviation (SD). Purple, shaded areas are the latest 5 years of available data.

- Commercial fisheries landings for forage fish and gadoids have generally been below the long-term average since the 2000s.
- Invertebrates landings have been increasing over time, but have been in decreasing over the last 5 years (but remain above the long-term mean). These trends coincide with shifting availability of species in the area.

Habitat

Depth > 75 fathoms and Depth > 100 fathoms

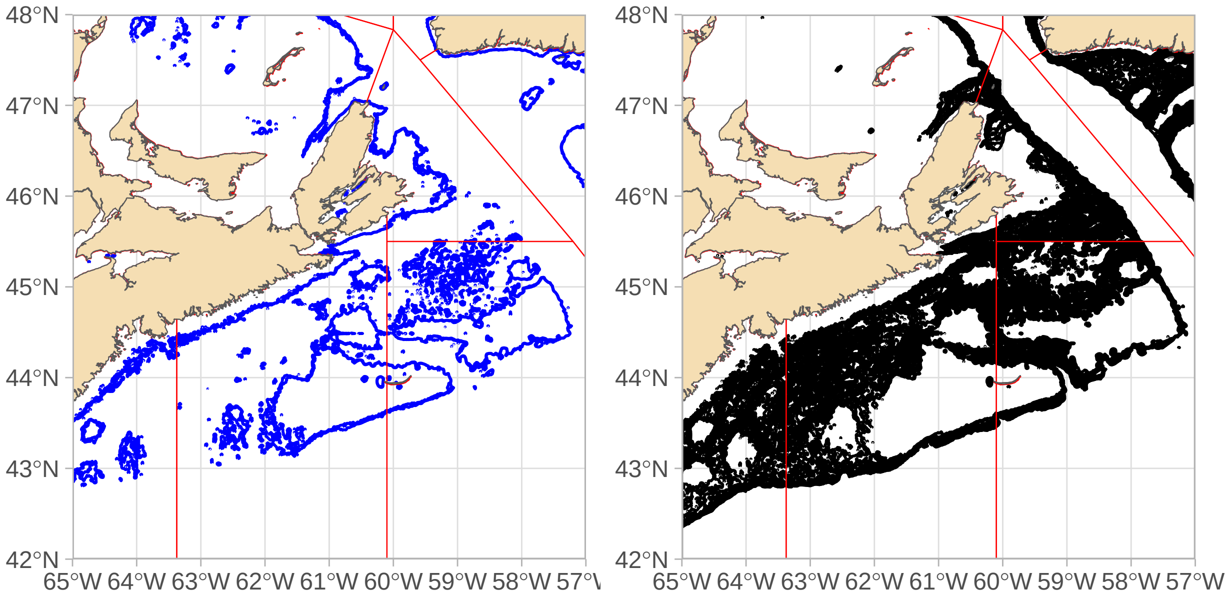

Figure 10: Shrimp Fishing Areas (red lines) and bathymetries for the ESS. Blue lines indicate depth > 75 fathoms (left), Black lines indicate depth > 100 fathoms (right).

Sediment

in development

Productivity

Productivity relates to the amount of energy or biomass generated in an ecosystem, providing energy to consumers. A number of factors play a role in primary and secondary production including nitrate, chlorophyll, bloom statistics, *Calanus finmarchicus* biomass, and zooplankton biomass.

Nitrate, Chlorophyll, Bloom stats, *Calanus finmarchicus*, Zooplankton Biomass

Casault et al. 2024

The amount of available nutrient supply for phytoplankton production is represented by surface (0-50 m) and subsurface (50-150 m) nutrient concentrations

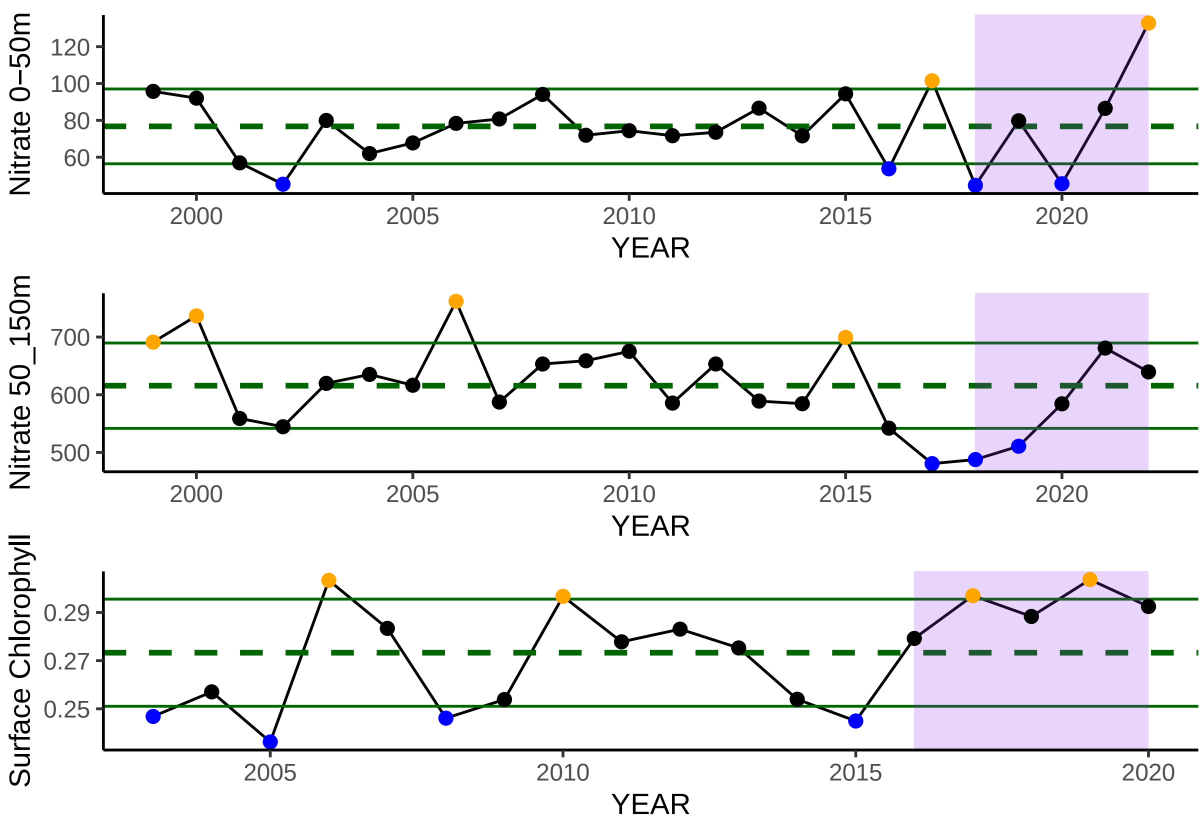

Figure 11: Nitrate 0-50m, Nitrate 50-150, from Louisburg Line (LL), Chlorophyll (surface) from the Eastern Scotian Shelf. Dashed lines represent the mean, solid green lines denote ± stanard deviation (SD). Purple, shaded areas are the latest 5 years of available data.

- Although recent warming would suggest a shift to higher nutrient concentrations across the Scotian Shelf (SS) region, recent evaluation of the long-term trends in nutrient availability across the SS has actually shown a decrease in nutrient availability since 2010, the onset of this warming period.
- In the most recent year, surface Chlorophyll in the ESS has been high.

Bloom statistics

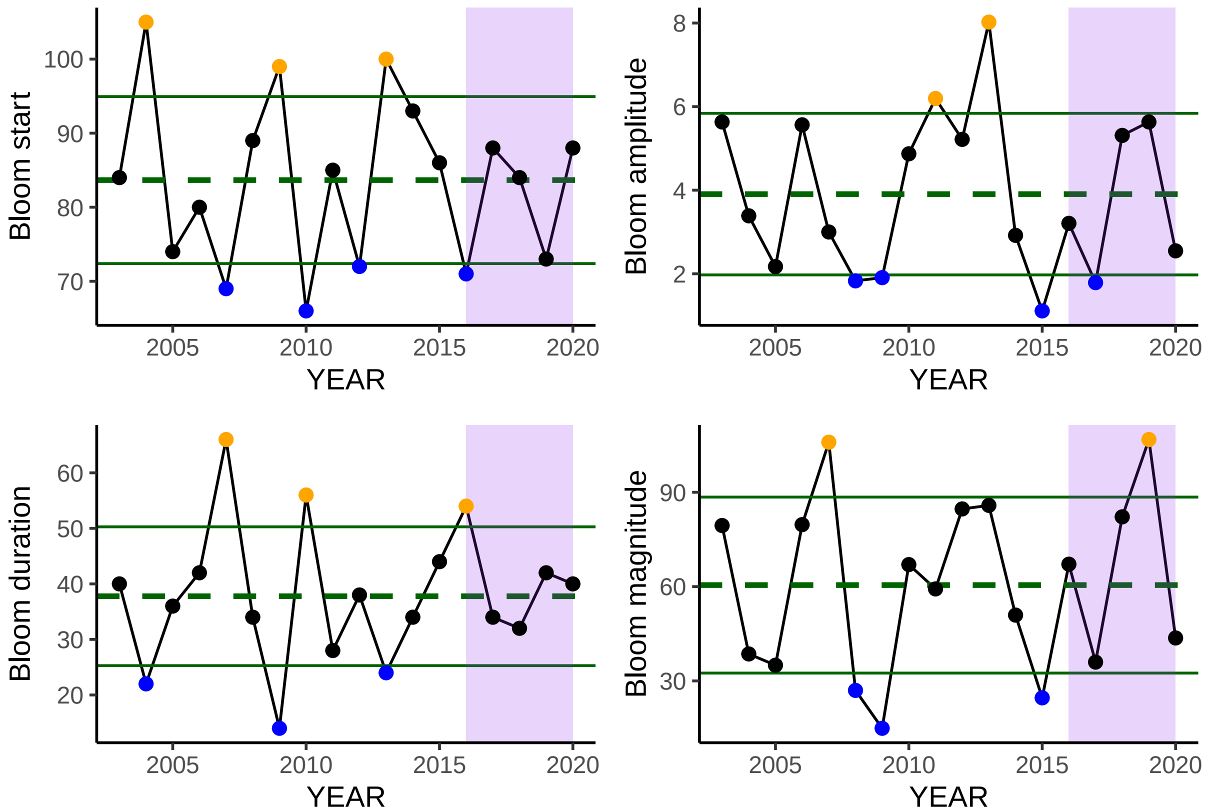

Figure 12: Bloom statistics,for the ESS. Dashed lines representent the mean, solid green lines denote ± stanard deviation (SD) . Purple, shaded areas are the latest 5 years of available data.

- In the ESS bloom statistics are generally within the long-term mean range for 2020, and show no trend over time.

***Calanus finmarchicus*, Zooplankton Biomass**

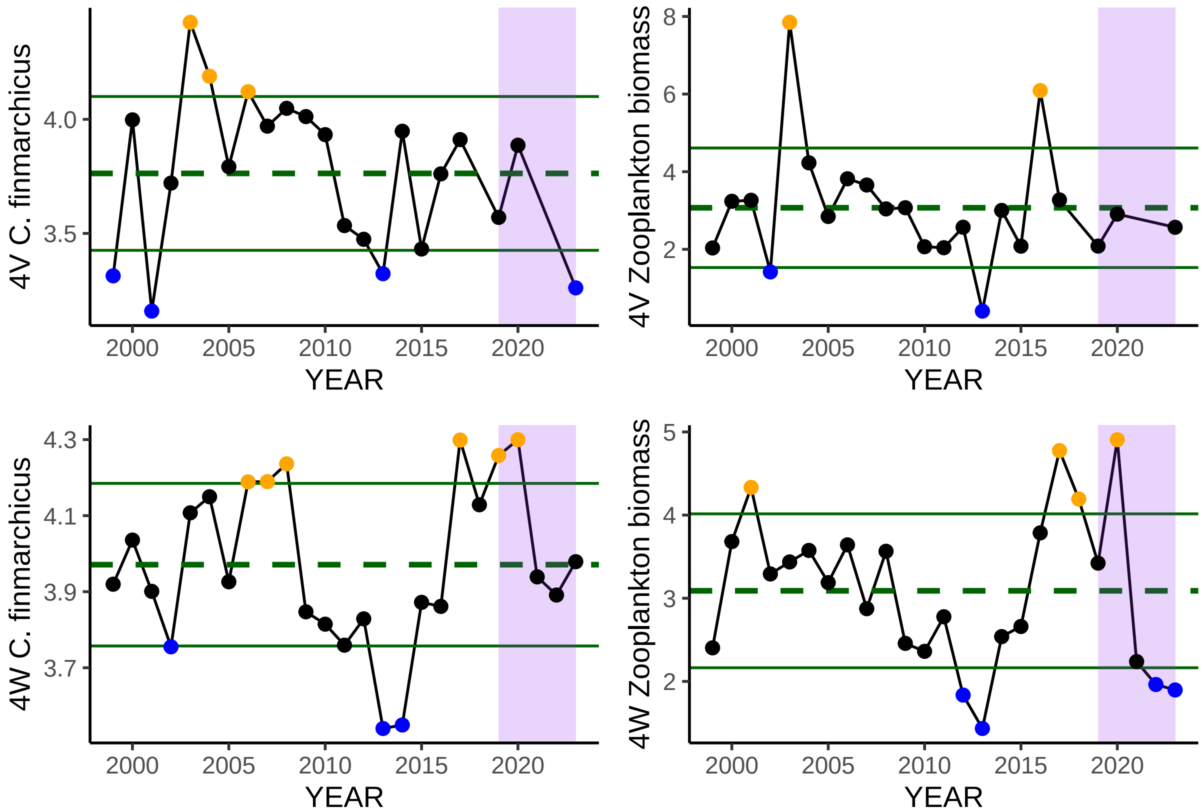

Figure 13: *C.finmarchicus*, and meso zooplankton biomass (dry weight), from NAFO regions within the ESS. Dashed lines represent the mean, solid green lines denote ± stanard deviation (SD). Purple, shaded areas are the latest 5 years of available data.

- The most recent estimates in NAFO 4V of biomass of *C. finmarchicus* has been lower than the long-term average in 2023, while abundances in NAFO 4W are average.
- Most recent estimates of zooplankton biomass has average in NAFO 4V, but below the longeterm average in NAFO 4W since 2022.

Large Fish Indicator (LFI)

Bundy et al. 2017 (see Table S4 for definitions and details)

LFI is an estimate of the proportion of large fish in the community or proportion of biomass occupying the top predator trophic-level (Greenstreet and Rogers 2006).

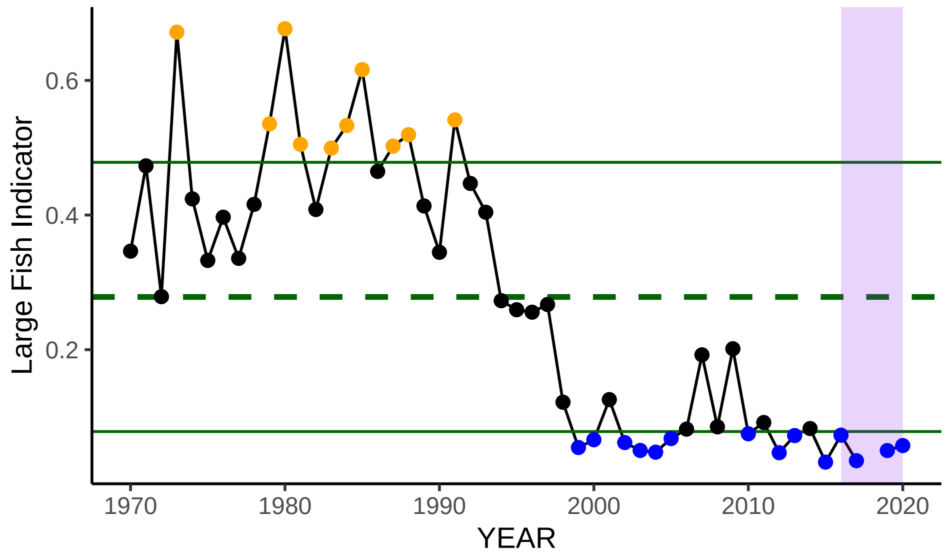

Figure 14: Large fish indicator from RV survey data that has been corrected for catchability. Dashed lines represent the mean, solid green lines denote ± stanard deviation (SD). Purple, shaded areas are the latest 5 years of available data.

- LFI in the ESS area has varied over time across two periods pre and post the mid 1990s. Latest four years indicate that LFI is below the long-term mean and indicate that structure and functioning of the ESS ecosystem may be unbalanced with a lower proportion of large fish to small fish in the ecological community.

Predator index

in development

Biodiversity

Biodiversity is described as the variety and variability among living organisms from all sources (CBD). It is linked to ecosystem resilience and plays an important role in maintaining functionality and productivity of ecosystems. Biodiversity can relate to genetic, species, guild and ecosystem diversity.

Shannon Diversity Index, Margalef Richness, Heip's Evenness

Bundy et al. 2017 (see Table S4)

Shannon Diversity Index accounts for both abundance and evenness of species present in a community. Margalef Richness measures the number of species present accounting for sampling effects. Heips Evenness measures how equally the species richness contributes to the total abundance or biomass of the community. Due to improvements in species identification over time, long-term Shannon Diversity and Margalef richness can be misleading. Only years 2000-2020 were used here.

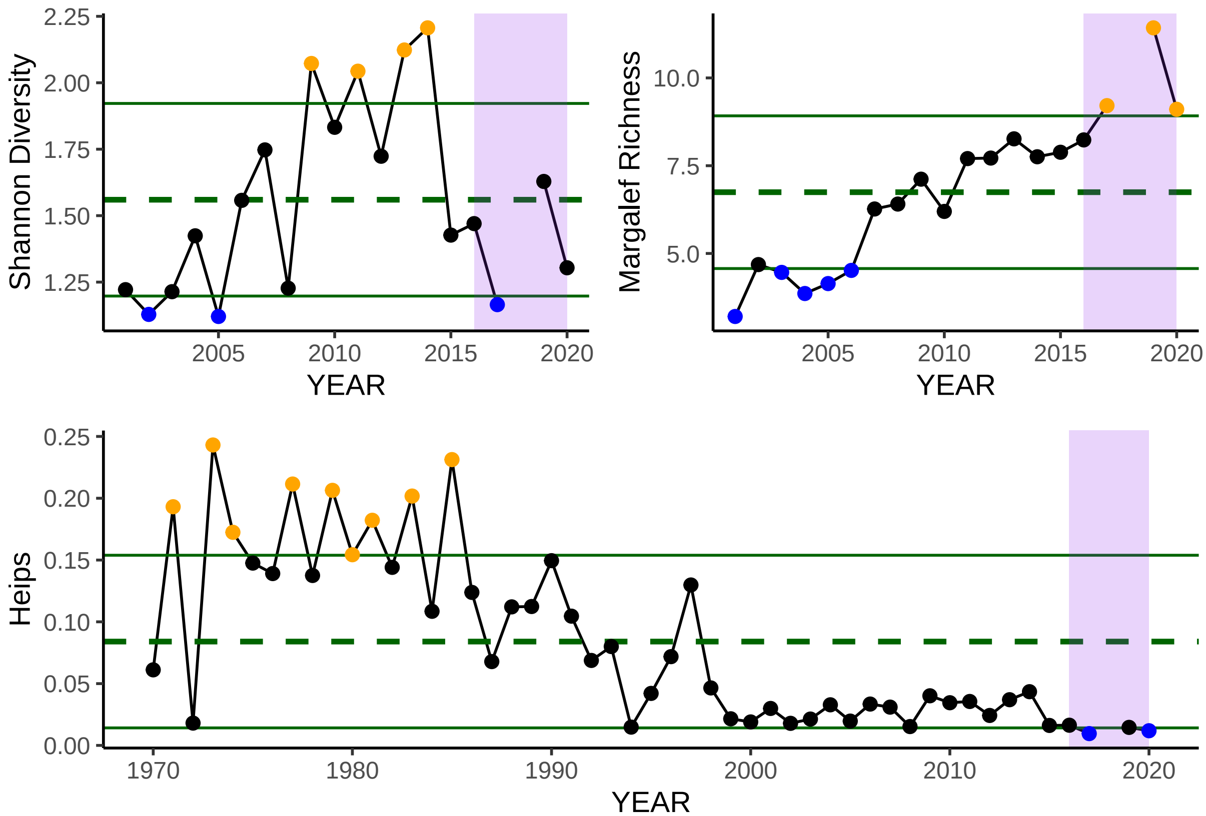

Figure 15: Shannon diversity Index, Margalef Richness, Hieps Evenness measured from data collected from DFO's Summer RV survey and has been corrected for catchability.Dashed lines represent the mean, solid green lines denote ± standard deviation (SD). Purple, shaded areas are the latest 5 years of available data.

- Anomalous low values in 2018 are due to lack of RV survey data for the ESS, and have been removed.
- Biodversity measures through time in the ESS indicate that the ESS is currently generally composed of fewer dominant species. While improving sampling protocols in the RV surveys have increased Margalef Richness over the last 5 years, the species diversity has been lower (lower mean range) in the

last 5 years. Heips evenness has been relatively low since the 2000s, the low values (<0.2) is consistent with a community with generally fewer, species that are highly abundant.

Guild-level Biomass

Bundy et al. 2017 (see Table S4 for definitions, see Table S5 for species categories)

Guild-level biomasses address structural attributes of food webs, and can also serve as proxies for ecosystem functioning (Tam et al. 2017).This indicator includes multiple guilds for fish and invertebrates from the RV Survey.

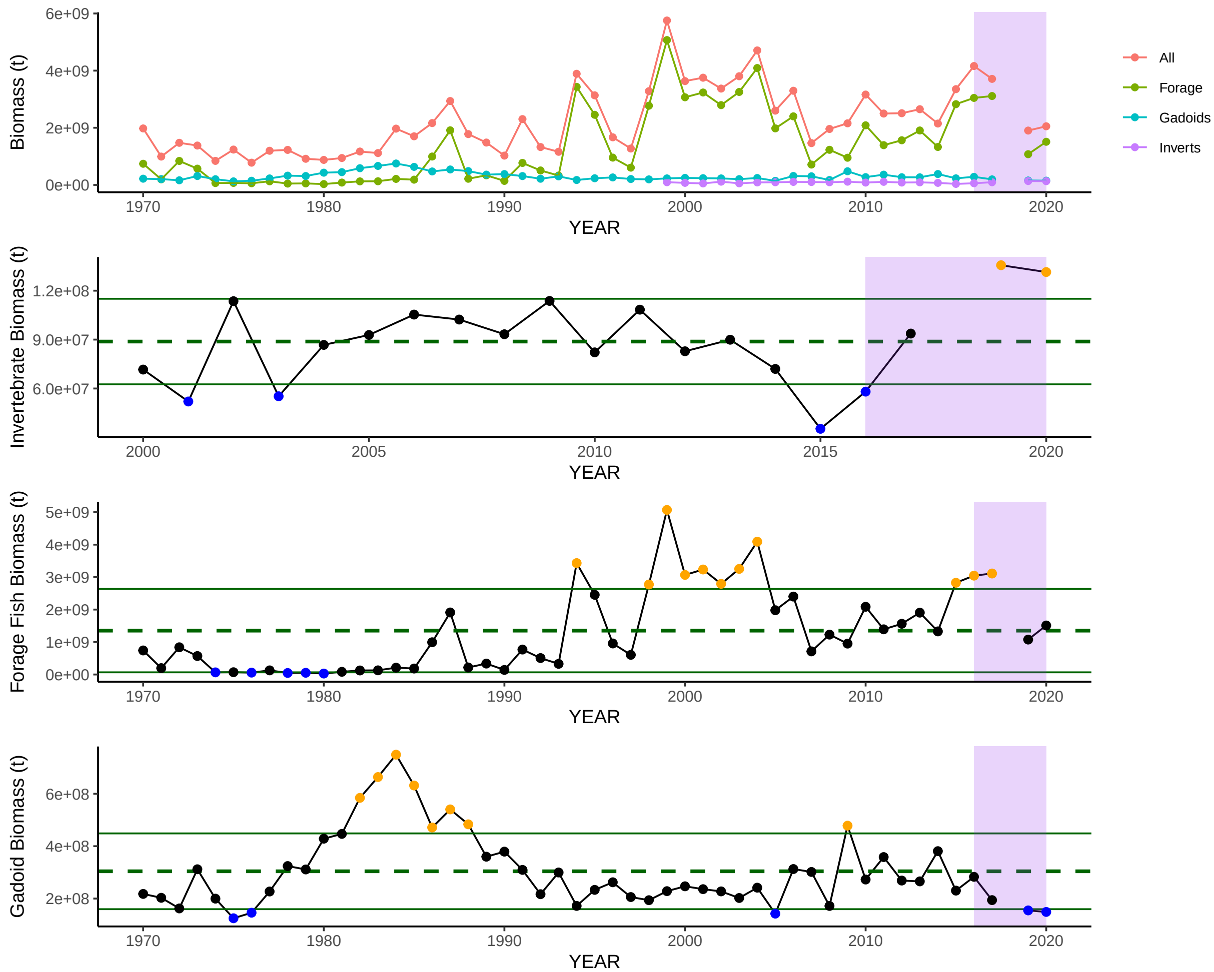

Figure 16: Total biomass and guild-level biomasses for fish catagories from DFO's Summer RV survey which have been corrected for catchability. Invertebrate estimates are not corrected for catchability. Dashed lines represent the mean, solid green lines denote ± stanard deviation (SD). Purple, shaded areas are the latest 5 years of available data.

- Anomalous low values in 2018 are due to lack of RV survey data for the ESS, and have been removed.
- Generally, due to low catchability of invertebrates in the RV survey, invertebrates are likely underestimated, but trends are considered reliable.
- Total biomass of all commercial fish species combined are generally decreasing over the last 5 years, with both invertebrates and forage fish experiencing decreases in the most recent year.

- Since the collapse of gadoids in the lates 1980s and early 1990s, biomass has been low. It increased to vary around the long-term mean from the mid 2000s to mid 2010s, but has declined since.
- Forage fish have been relatively stable in the ESS with annual biomass within or above the long-term mean since the mid-1980s. In the last couple years forage fish biomass has been close to the long-term mean.

Non-Target Species

In development

C. Economic

Commercial Fishery

Landed value (CAD) by species catagory

This is the landed value of groups of species for the ESS region. Exploration of this data was based on published overviews of Canadian Seafisheries landings.

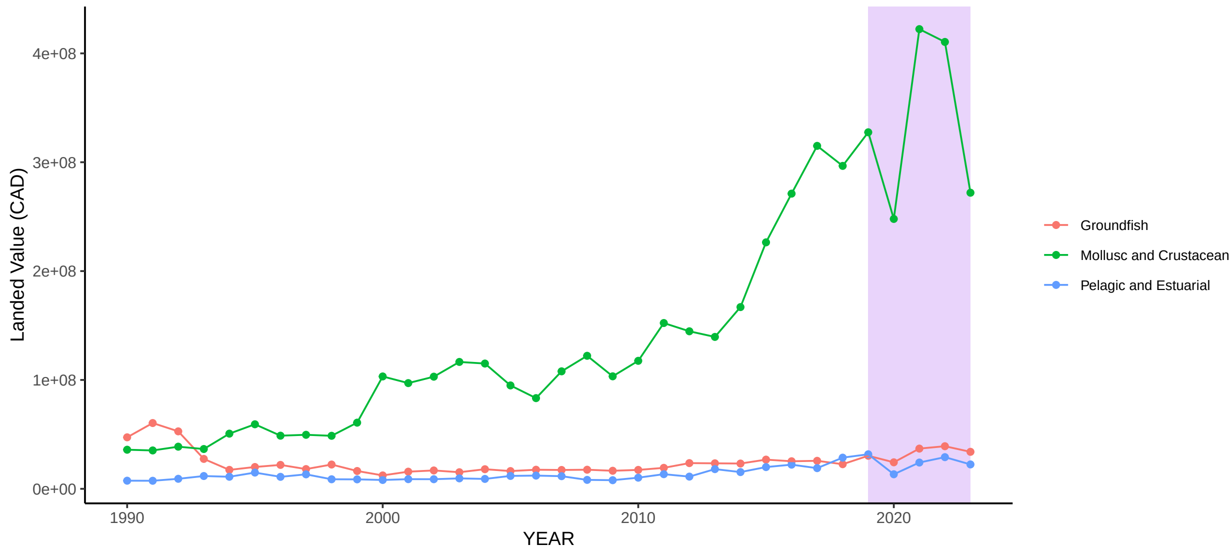

Figure 17: Landed value of species categories since 1990 for the Eastern Scotian Shelf. Area in purple is preliminary data and subject to change.

- Historical trends indicate that groundfish had higher landed value in the 1990s than mollusc and crustaceans or pelagic and estuarial fish in the ESS, but recent landings are dominated by mollusc and crustaceans.
- In the last 5 years, the landed value of mollusc and crustaceans in the ESS have fluctuated while still remaining high. Although conservation concerns for many invertebrate species is low, variability in landed value could have impacts to coastal communities. In contrast, recent 5 year landed values of groundfish and pelagic groups have remained stable in the ESS.

D. Social-Cultural

currently unavailable

E. Governance

currently unavailable