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Status and trends of the fish community in the Newfoundland Shelf (NAFO Div. 2J3K), Grand Bank (NAFO Div. 3LNO) and Southern Newfoundland Shelf (NAFO Div. 3Ps) Ecosystem Production Units

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Abstract

The Newfoundland shelves marine ecosystems were historically dominated by demersal fishes like Atlantic cod, which were also the cornerstone of the regional fisheries. In the late 1980s and early 1990s these ecosystems experienced an abrupt shift in its community structure. This change was brought about by a combination of a long history of overfishing and rapidly changing environmental conditions. At the same time, shellfish species like northern shrimp and snow crab, saw important increases. In the late 2000s demersal fishes started to show signs of rebuilding. This coincided with a warming trend from the cold conditions of the early 1990s, and a modest build-up of capelin. During this period, demersal invertebrate stocks experienced major declines. By the 2010s, those ecosystems that were dominated by invertebrates were once again dominated by demersal fishes. However, the current demersal fish-dominated communities may not necessarily resemble the pre-collapse ones; warmer water species may become more dominant in the years to come. Despite the build-ups of demersal fishes since the mid-1990s, the total biomass in these ecosystems remains well below the pre-collapse levels, and since the mid 2010s, they are showing signs of reduced productivity, and declines in biomass from precedent years.

Introduction

The ecosystem structure of the Newfoundland and Labrador (NL) bioregion can be described in terms of four Ecosystem Production Units (EPUs): the Labrador Shelf (2GH), the Newfoundland Shelf (2J3K), the Grand Bank (3LNO), and southern Newfoundland (3Ps) (NAFO 2014, 2015, Pepin et al. 2014) (Figure 1). This bioregion has a long history of fishing, and in the early 1990s underwent important changes associated with a regime shift and overfishing (DFO 2006, 2008, 2014, Koen-Alonso et al. 2010, 2013, NAFO 2010, 2014, 2015, 2016, Dawe et al. 2012, Buren et al. 2014, Pedersen et al. 2017, Dempsey et al. 2017).

Although there is limited information on trends in the fish community in the Labrador Shelf (2GH) EPU, regular Research Vessel (RV) multispecies surveys are conducted in the others. This analysis describes changes and trends in the fish community in these ecosystems units.

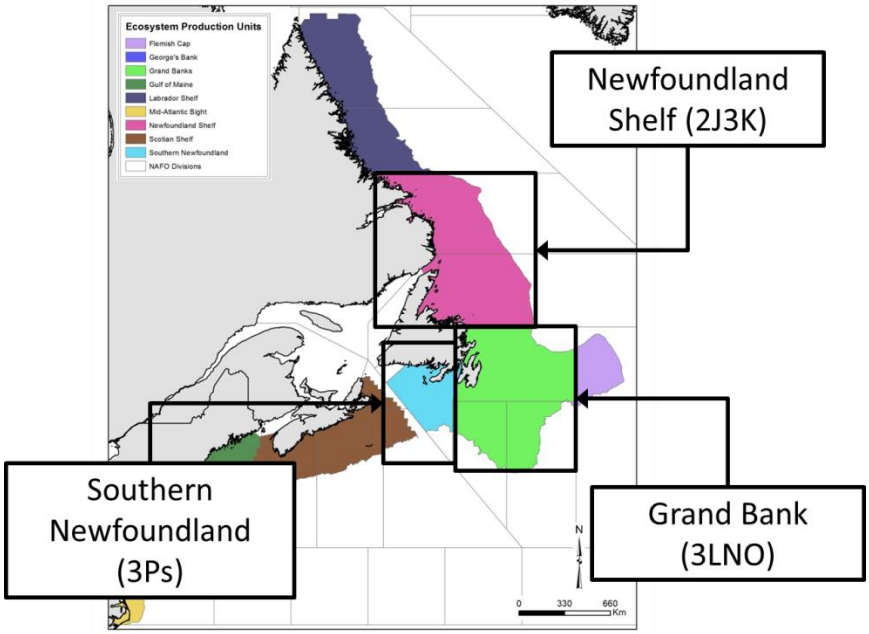

Figure 1. Ecosystem Production Units (EPUs) in the Newfoundland and Labrador (NL) Bioregion considered in this summary: the Newfoundland Shelf (2J3K), the Grand Bank (3LNO), and southern Newfoundland (3Ps).

Materials and Methods

Trends in the fish community were described on the basis of DFO Spring and Fall RV multispecies surveys in 1981-2018, but not all EPUs had full seasonal and/or temporal coverage during this period (Rideout and Ings, 2018). We used standard RV survey indices like RV Biomass and RV Abundance to describe trends in biomass and numbers, and the RV Biomass/RV Abundance Ratio (BA Ratio) to characterize average size of fish. These indices were calculated for core ecosystem strata only; these strata were selected because they have a fairly consistent history of sampling over time, and cover most of the shelf area in these EPUs.

Trends were summarized by fish functional groups defined in terms of general fish size and feeding habits: small, medium, and large benthivores, piscivores, plank-piscivores, planktivores, and shellfish (only commercial species, recorded since 1995). In order to better characterize trends for each functional group, irrespectively of their absolute biomass or abundance, indices were also presented as anomalies, and cumulated anomalies.

DFO RV surveys changed the gear type used in 1995-1996. The gear was switched from an Engel 145 Hi-rise trawl to a Campelen 1800 shrimp trawl (smaller mesh size) in 1995 for the Fall survey and 1996 for the Spring survey (Rideout and Ings, 2018). Reliable recording of commercial shellfish species in the RV surveys only started with the switch to the Campelen gear. Conversion factors between gears only exist for a handful of commercial species, therefore, the integration of the Engel and Campelen periods into a single time series at the fish community level was only possible for the RV Biomass index. In this case, general scaling factors were derived from the existing comparative fishing data for commercial species and the limited data available on non-commercial species (NAFO 2014). These factors were applied at the fish functional group level and allow a coarse scaling between gears to provide a general approximation to the order of magnitude of the changes. Scaling factors were only used for the Newfoundland Shelf (2J3K) and Grand Bank (3LNO) EPUs; work on the reliability of these factors for Southern Newfoundland (3Ps) is still in progress.

Results and Discussion

Newfoundland Shelf (2J3K)

In 2J3K, the collapse in the 1990s involved the entire fish community, and also involved a decline in fish size. After the collapse, the system was highly dominated by shellfish (Figure 2). The changes observed have a coherent internal structure; increases in small fish and shellfish are associated with declines in forage and large fishes (Figure 3). Consistent signals of rebuilding of the groundfish community appeared in the mid-late 2000s; this signal is also associated with an increase in fish size, and also coincided with a modest build-up of capelin. In the 2010s the overall biomass remained relatively stable, but the dominance of groundfishes increased, and shellfish decreased. After 2014 total biomass has shown a decline of around 20-30% from the level observed in the early 2010s (Figure 2), while several functional groups are showing consistent signals of declines in abundance (Figure 4).

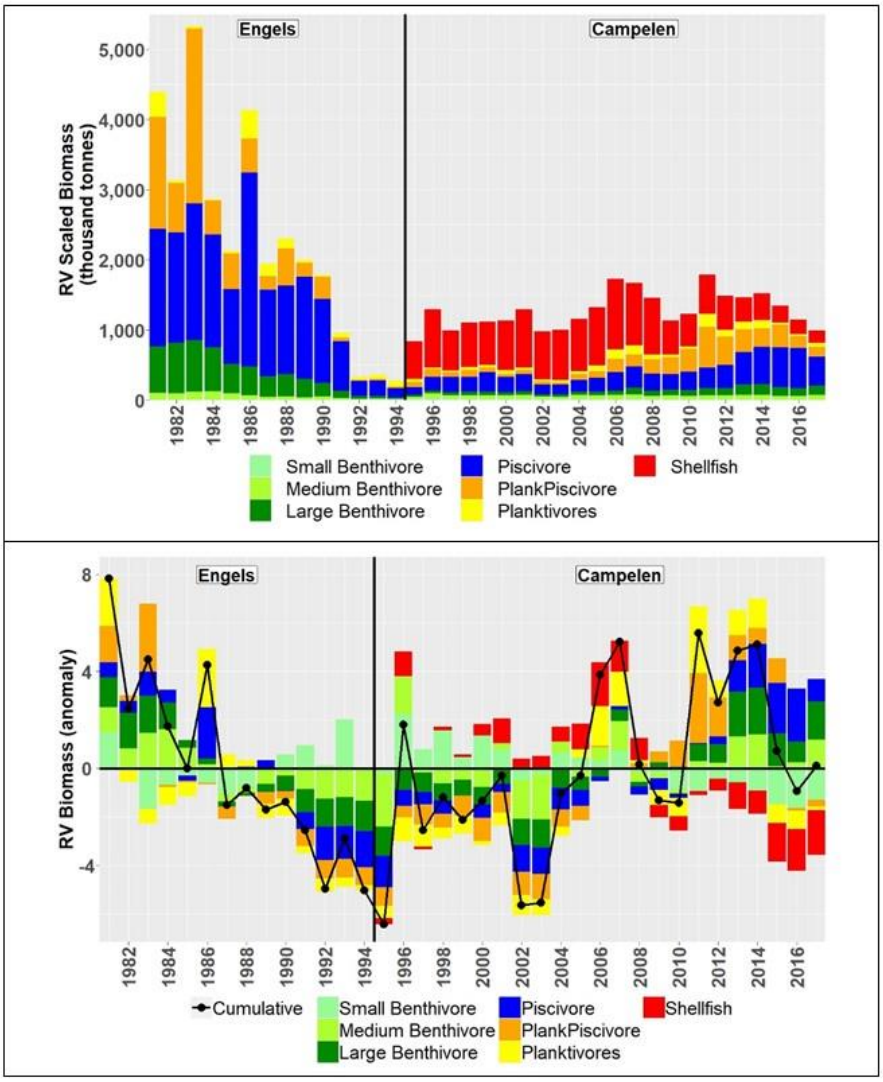

Figure 2. RV Biomass by fish functional groups in the Newfoundland Shelf (NAFO Divs 2J3K) from DFO RV Fall multispecies survey. **Top**: Scaled RV biomass where the earlier part of the time series (when the survey used the Engels gear) has been corrected using coarse scaling factors by fish functional group. These scaling factors are only approximate. Data on commercial shellfish species only started to be consistently recorded during the Campelen period. **Bottom**: Cumulated normalized anomalies of RV Biomass by fish functional groups. Normalization was done within each gear period (Engels and Campelen); magnitudes of the anomalies are not directly comparable.

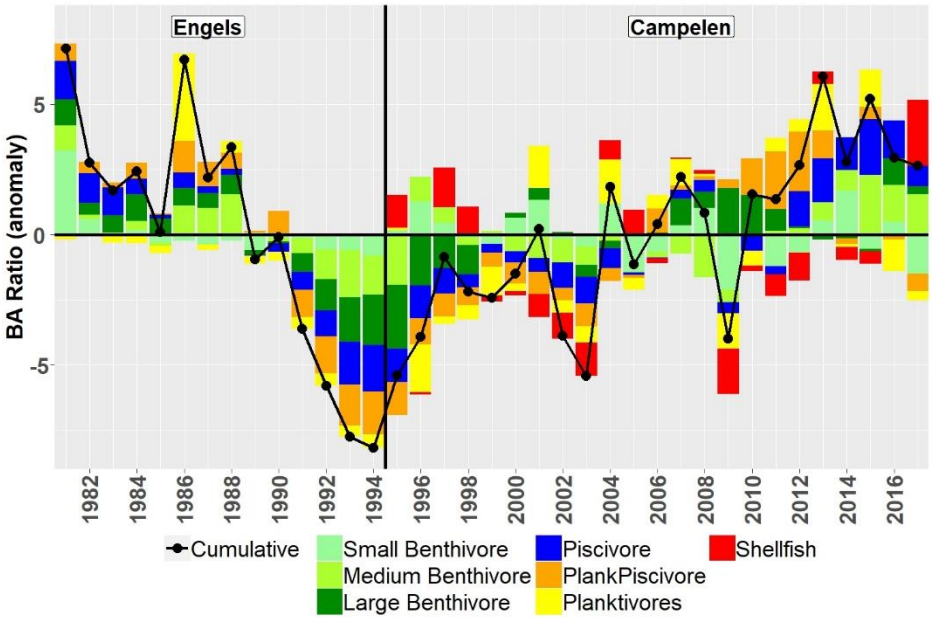

Figure 3. Cumulated anomalies for the RV Biomass/Abundance (BA) Ratio by fish functional groups in the Newfoundland Shelf (NAFO Divs 2J3K) from DFO RV Fall multispecies survey. The BA ratio is a proxy for average fish size in each functional group. Normalization was done within each gear period (Engels and Campelen); magnitudes of the anomalies are not directly comparable.

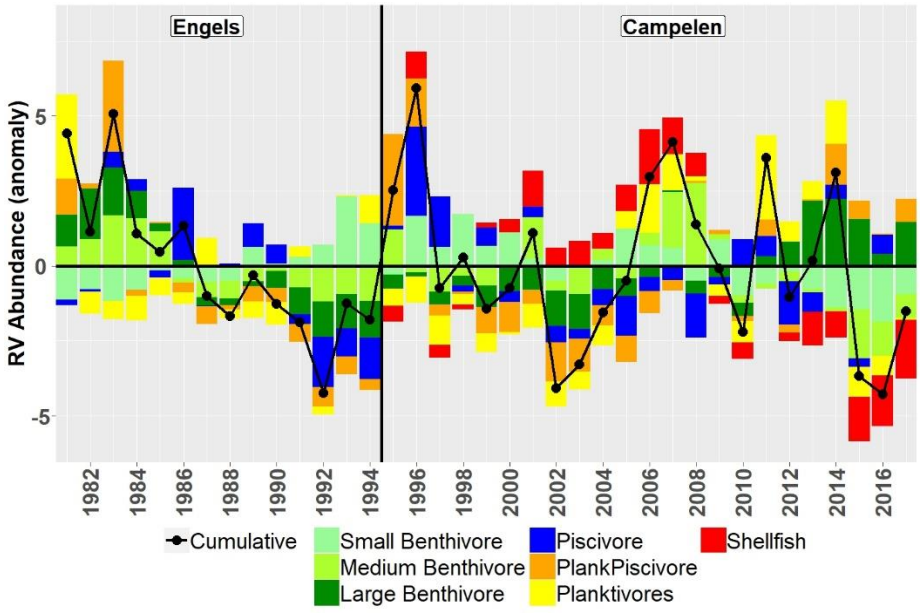

Figure 4. Cumulated anomalies for the RV Abundance by fish functional groups in the Newfoundland Shelf (NAFO Divs 2J3K) from DFO RV Fall multispecies survey. Normalization was done within each gear period (Engels and Campelen); magnitudes of the anomalies are not directly comparable.

Grand Bank (3LNO)

In 3LNO the collapse in the 1990s also involved the entire fish community, and a decline in fish size (Figure 5 and Figure 6), but it was not as severe as in the northern area. This EPU shows a higher dominance of benthivores, and it was never dominated by shellfish. The groundfish community started to show signals of rebuilding around the late 2000s, but piscivores did not regain their dominant role. Overall build-up of groundfishes was initially led by medium benthivores and later by plank-piscivores (Figure 5). In the early

2010s the overall biomass remained relatively stable, but declines have been observed in recent years, with total biomass in 2016-2018 showing a reduction of 30-40% from the early 2010s (Figure 5).

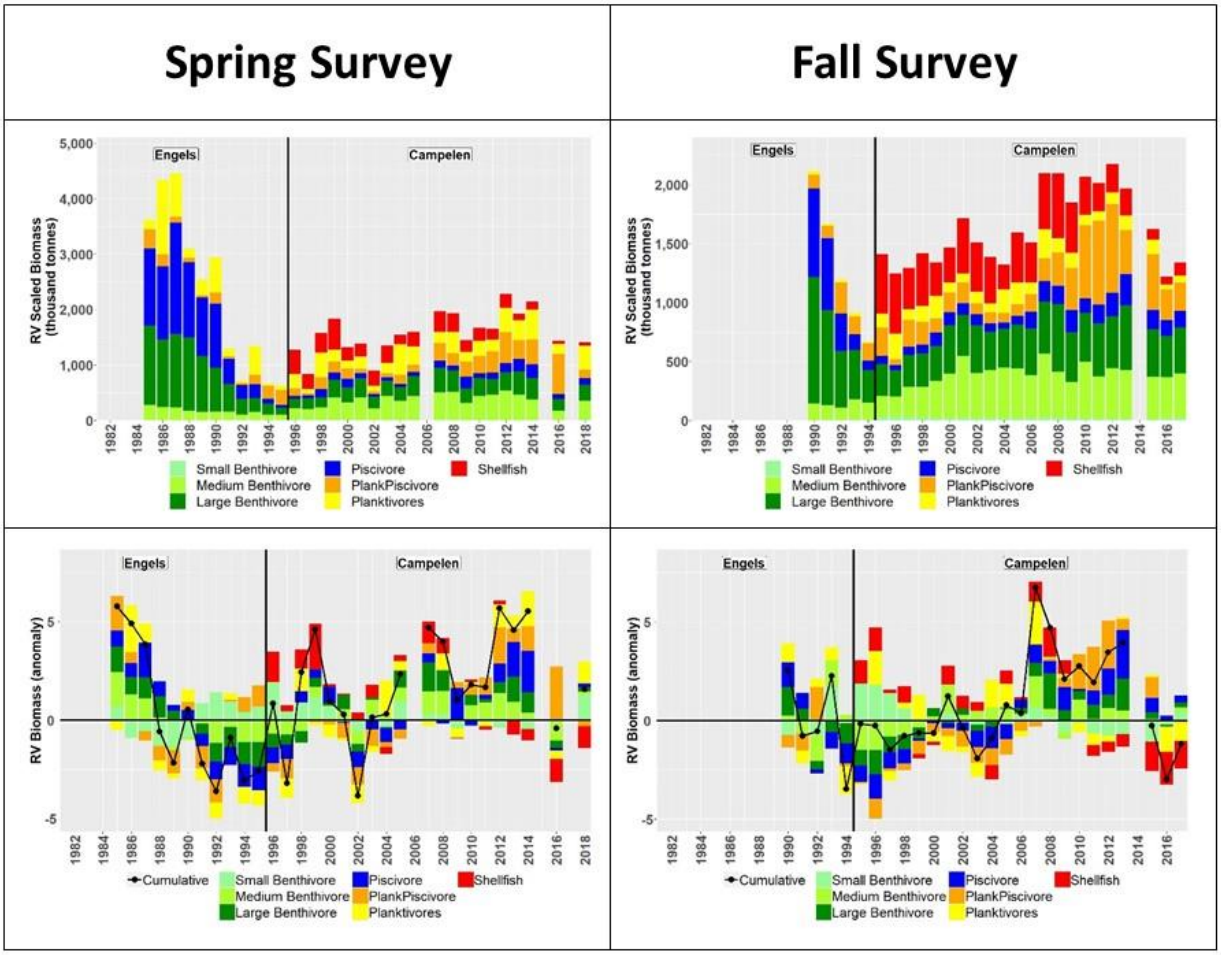

Figure 5. RV Biomass by fish functional groups in the Grand Bank (NAFO Divs 3LNO) from DFO RV Spring and Fall multispecies surveys. **Top**: Scaled RV biomass where the earlier part of the time series (when the survey used the Engels gear) has been corrected using coarse scaling factors by fish functional group. These scaling factors are only approximate. Data on commercial shellfish species only started to be consistently recorded during the Campelen period. **Bottom**: Cumulated normalized anomalies of RV Biomass by fish functional groups. Normalization was done within each gear period (Engels and Campelen); magnitudes of the anomalies are not directly comparable.

Although there was a upward trend in fish size in the late 1990s and early 2000s, fish size has declined since, and has oscillated around the post-collapse average since the late 2000s, showing low values in the most recent years (Figure 6). The recent declines in total biomass and reduced fish sizes is also matched by reduced abundances, with most functional groups showing negative anomalies in 2015-2016, however data from Spring 2018 suggests an increase in abundance anomaly values (Figure 7). Other changes observed during this period is an increase in silver hake (warm water species) among piscivores (especially on the western portion of the Grand Bank, NAFO Div. 3O), and declines in key forage species (e.g. capelin).

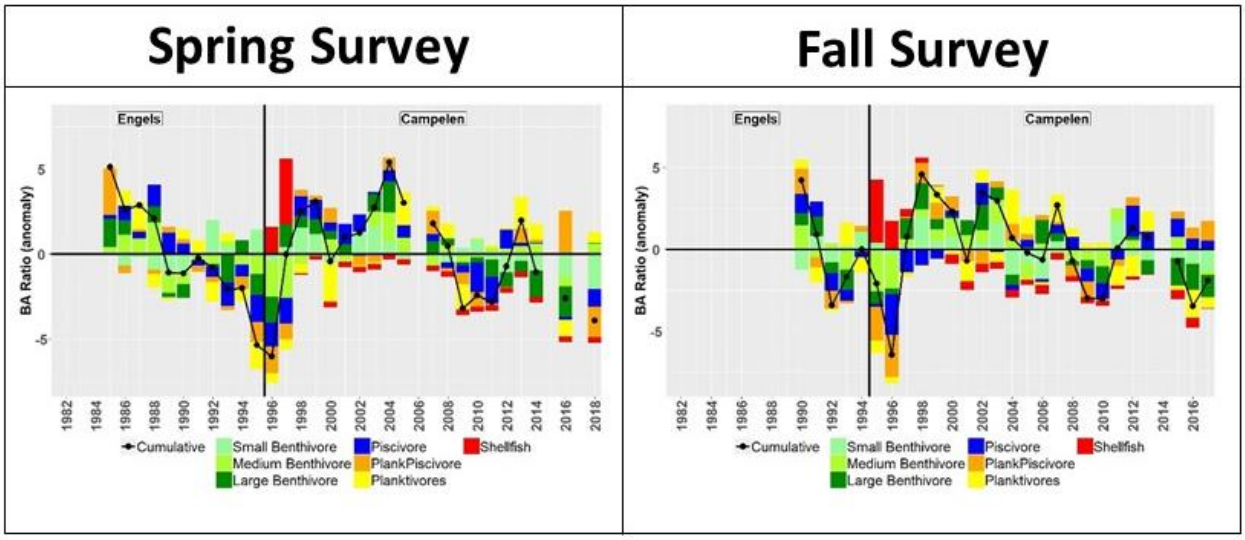

Figure 6. Cumulated anomalies for the RV Biomass/Abundance (BA) Ratio by fish functional groups in the Grand Bank (NAFO Divs 3LNO) from DFO RV Spring and Fall multispecies surveys. Normalization was done within each gear period (Engels and Campelen); magnitudes of the anomalies are not directly comparable.

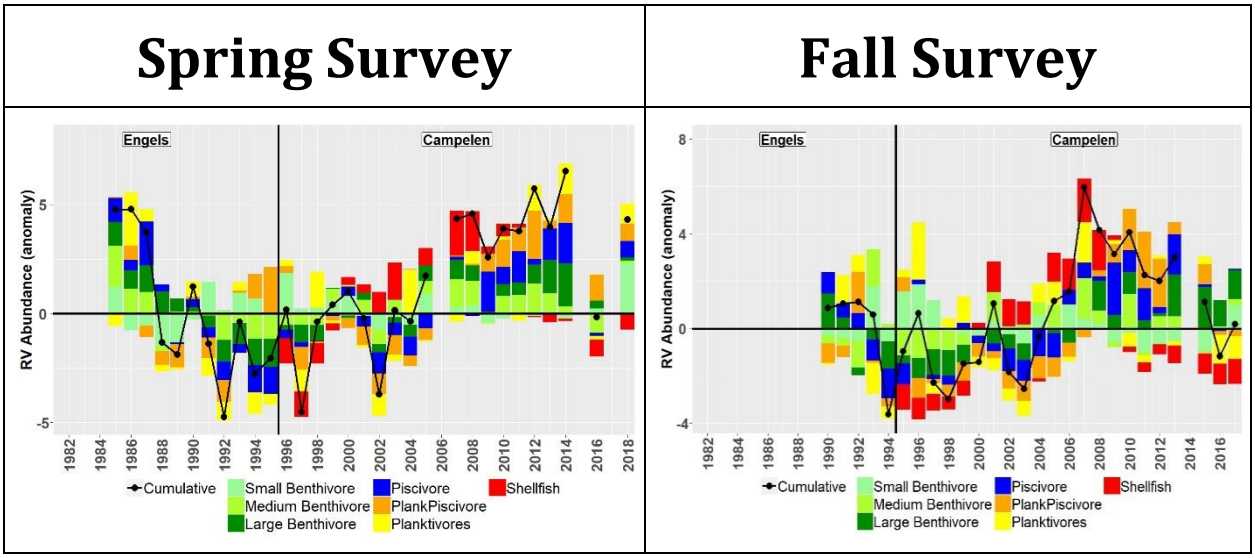

Figure 7. Cumulated anomalies for the RV Abundance by fish functional groups in the Grand Bank (NAFO Divs 3LNO) from DFO RV Spring and Fall multispecies surveys. Normalization was done within each gear period (Engels and Campelen); magnitudes of the anomalies are not directly comparable.

Southern Newfoundland (3Ps)

The decline in the 1990s also involved the entire fish community and included reductions in fish size (Figure 8 and Figure 9). The overall decline seemed less severe than other ecosystem units in this bioregion. Since the mid-late 1990s, the overall biomass of the fish community has not increased significantly, but abundance did (Figure 10). However, both biomass and abundance after 2014 have shown reduced levels in comparison to immediately precedent years (Figure 8 and Figure 10).

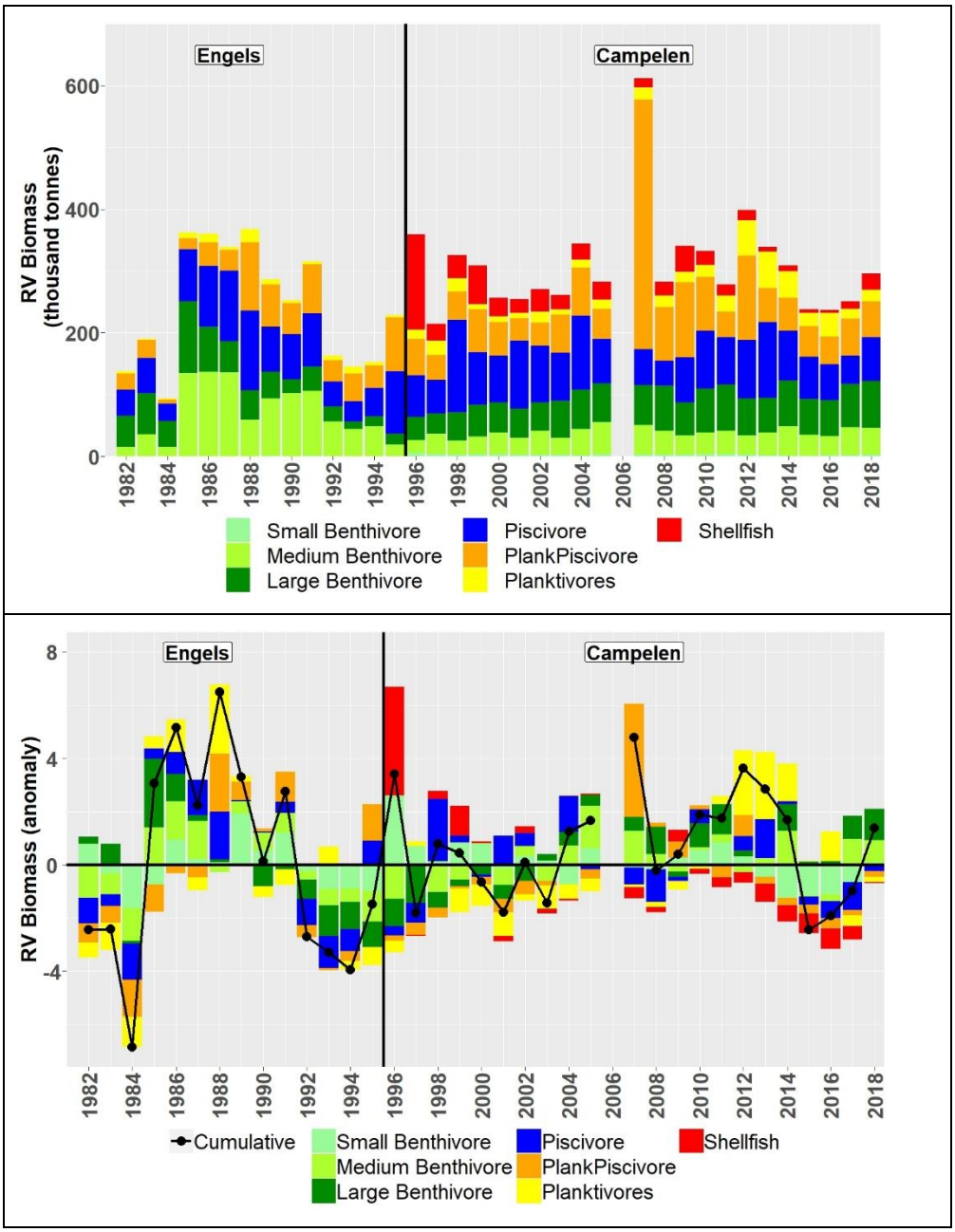

Figure 8. RV Biomass by fish functional groups in Southern Newfoundland (NAFO Sub-Div. 3Ps) from DFO RV Spring multispecies survey. **Top**: RV biomass with indication of the periods where different gears were used in the survey (Engels and Campelen); magnitudes between gear periods are not directly comparable. Data on commercial shellfish species only started to be consistently recorded during the Campelen period. **Bottom**: Cumulated normalized anomalies of RV Biomass by fish functional groups. Normalization was done within each gear period (Engels and Campelen); magnitudes of the anomalies are not directly comparable.

Average fish size as indicated by the BA ratio did not improve in the post collapse period, but showed a further decline in the mid 2000s, and still remains at that lower level (Figure 9). 2018 data has shown an increase in Planktivore size.

Ongoing warming trends, together with the increasing dominance of warm water species (e.g. silver hake), and the reduced fish sizes across fish functional groups suggest that this ecosystem is undergoing structural changes, and potentially experiencing reduced productivity conditions.

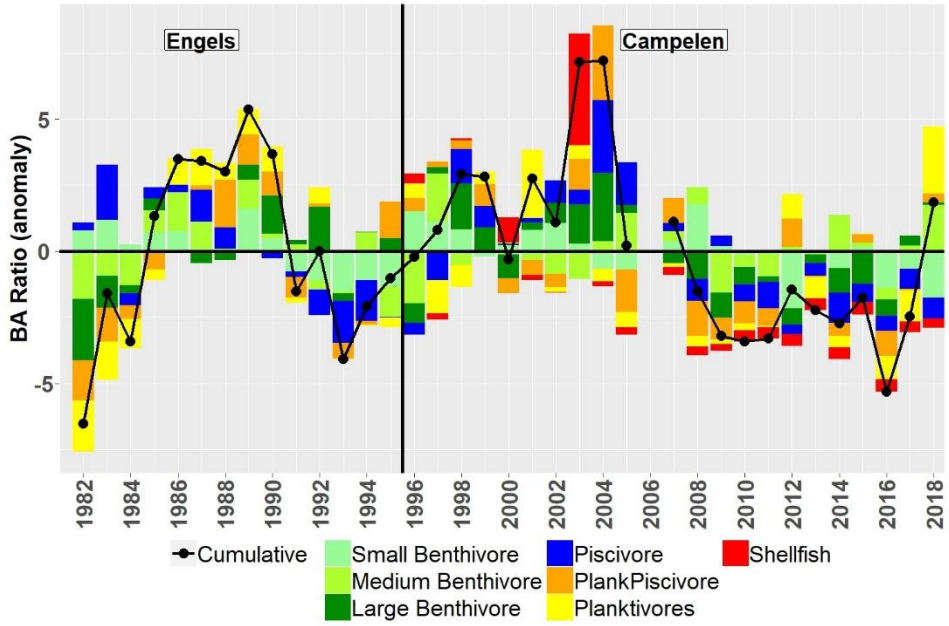

Figure 9. Cumulated anomalies for the RV Biomass/Abundance (BA) Ratio by fish functional Southern Newfoundland (NAFO Sub-Div. 3Ps) from DFO RV Spring multispecies survey. Normalization was done within each gear period (Engels and Campelen); magnitudes of the anomalies are not directly comparable.

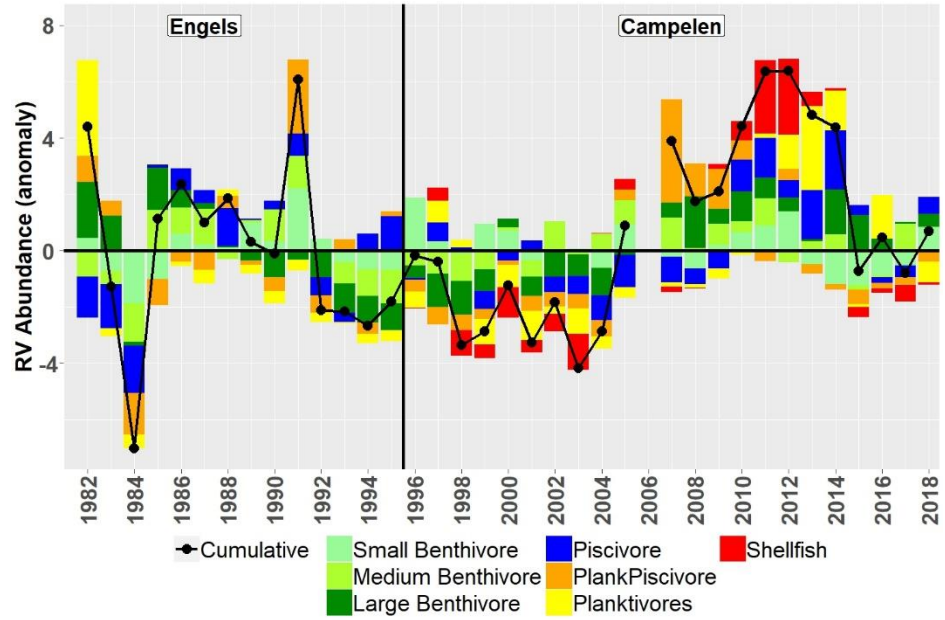

Figure 10. Cumulated anomalies for the RV Abundance by fish functional groups Southern Newfoundland (NAFO Sub-Div. 3Ps) from DFO RV Spring multispecies survey. Normalization was done within each gear period (Engels and Campelen); magnitudes of the anomalies are not directly comparable.

Synoptic comparison across EPUs

Overall, the collapses in the 1990s involved entire fish communities, and included declines in fish size across all EPUs. The collapse was more severe in the north, and less in the southern Newfoundland region. These collapses were accompanied by changes in community structure. Shellfish became a dominant functional group in 2J3K after the collapse, although it increased its dominance in other ecosystems, it never reached the overwhelming dominance observed in the northern region (Figure 11).

The groundfish community started to show signals of rebuilding during the mid-late 2000s, but current levels are still well below pre-collapse levels. The functional groups leading the groundfish rebuilding were not the same across ecosystems; piscivores are important drivers in the northern area, but they have a lesser role in southern ecosystems (Figure 11).

After initial build-ups, finfish biomass was relatively stable in 2010-2014, but recent surveys are indicating a downward trend. This is clearly evident on the Grand Bank (3LNO) EPU. Overall, it appears that the conditions that led to the start of a rebuilding have withered. This may be linked to the simultaneous reductions in capelin and shrimp availability, as well as other changes in ecosystem conditions (e.g. declines in zooplankton levels in recent years).

Silver hake, a warm water species, is increasing its dominance among piscivores. They have become a major component of this functional group in 3Ps, and are increasing in the Grand Bank. This may hint at the changes to be expected under warming conditions; the full extent of these kinds of impacts on these ecosystems remains a matter of investigation.

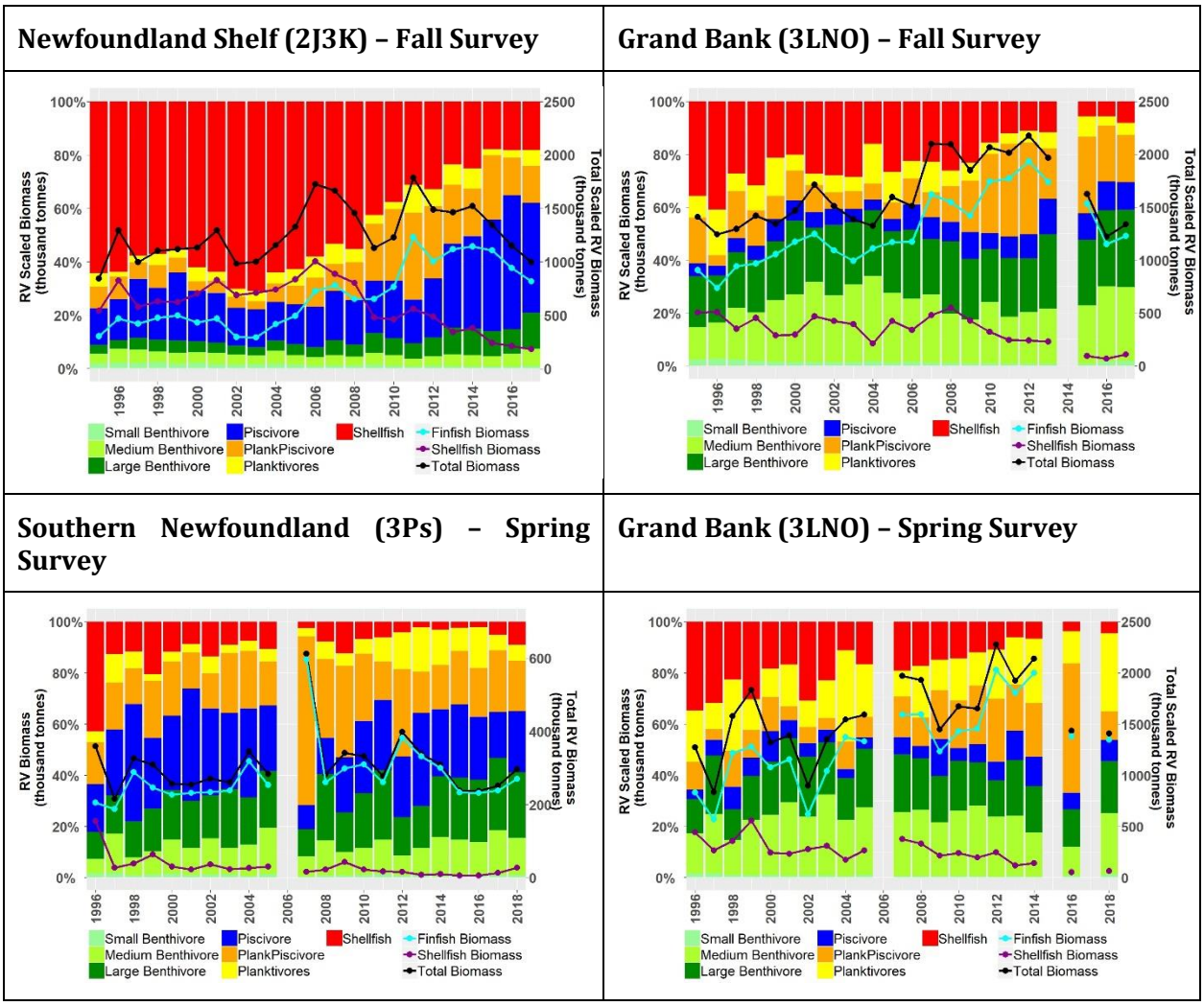

Figure 11. Synoptic comparison of the structure and trends in the fish communities during 1995-2017 among three NL Bioregion EPUs: the Newfoundland Shelf (2J3K), the Grand Bank (3LNO) and Southern Newfoundland (3Ps).

Acknowledgements

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