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Newfoundland and Labrador Region

Canadian Science Advisory Secretariat
Science Advisory Report 2023/028

ASSESSMENT OF AMERICAN LOBSTER IN NEWFOUNDLAND

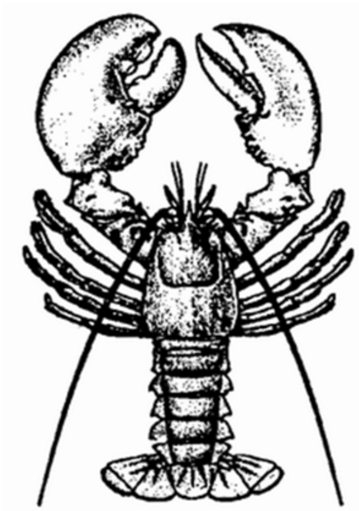

Image: American Lobster (Homarus americanus).

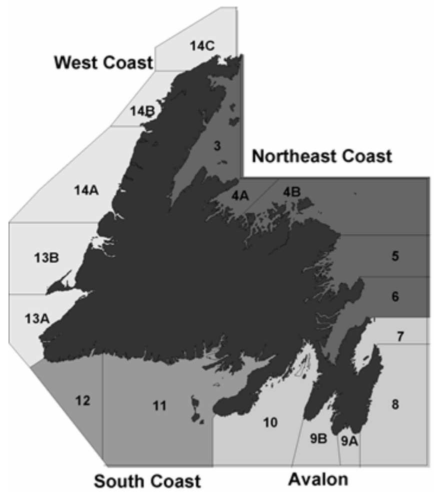

Figure 1. Newfoundland Lobster Fishing Areas (LFAs) 3-14 combined into assessment regions.

Context:

*The American Lobster (*Homarus americanus*) is distributed near shore around the island of Newfoundland and along the Strait of Belle Isle portion of the Labrador coast. Major life-history events (i.e., molting, mating, egg extrusion, and hatching) generally take place during mid-July to mid-September, following the fishing season.*

The fishery is localized and prosecuted from small open boats during an 8–10 week spring fishing season. Traps are set close to shore, at depths generally less than 20 m. Fishing effort is controlled through restrictive licensing and daily trap limits. Regulations prohibit the harvest of undersized (<82.5 mm carapace length [CL]) and ovigerous (egg-bearing) lobster. In addition, there is a voluntary mark-release practice on ovigerous females called v-notching, which involves cutting a shallow mark in the tail fan and subsequently releasing egg-bearing ovigerous females, with notched lobster prohibited from retention thereafter. The number of licenses is currently around 2,300 and trap limits range from 100 to 300 depending on the Lobster Fishing Area (LFA).

This stock was last assessed in 2019 and is currently assessed every three years. The present assessment of this stock was requested by Fisheries and Oceans Canada (DFO) Resource Management to provide current information on the status of the resource to be used in an updated Integrated Fisheries Management Plan. The LFAs were assessed based on four assessment regions: Northeast Coast (LFAs 3-6), Avalon (LFAs 7-10), South Coast (LFAs 11-12), and West Coast (LFAs 13-14) (Figure 1). The key indicators for the assessment are reported landings, fishery catch per unit effort (CPUE), exploitation rate and total mortality in legal-sized lobster, and biomass indices.

This Science Advisory Report (SAR) is from the October 17-18, 2022 Newfoundland and Labrador Regional Peer Review Process on the Stock Assessment of American Lobster in Newfoundland. Additional publications from this meeting will be posted on the Fisheries and Oceans Canada (DFO) Science Advisory Schedule as they become available.

SUMMARY

- As in previous assessments, Lobster Fishing Areas (LFAs) were grouped into four assessment regions: Northeast Coast (LFAs 3-6), Avalon (LFAs 7-10), South Coast (LFAs 11-12), and West Coast (LFAs 13-14). Note the current assessment is primarily based on fishery-dependent data from commercial traps from the 2005–21 time series.
- In 2022 preliminary landings were at the highest in a century (5,780 t); this reflects increasing trends in the Northeast, South and West Coast regions, while reported landings in the Avalon region have remained low. However, reporting rates vary across regions and reported landings likely do not reflect total removals.
- Throughout the time series estimates of exploitation rates are high in all assessment regions (40–70% in 2021).
- Biomass indices have increased to time-series highs in all assessment regions in recent years.
- Short-term recruitment prospects appear steady in the Northeast and Avalon regions and at the highest levels in the time series in the South and West coast regions.
- Recent improvements in recruitment appear to be associated with increasing sea surface temperature in the assessment regions.

BACKGROUND

Species Biology

The American Lobster (*Homarus americanus*) is a decapod crustacean characterized by a life cycle which is predominately benthic. Adult lobsters prefer rocky substrates where they can find shelter, but also live on sand and even muddy bottoms (Jarvis 1989, Dinning and Rochette 2019). In Newfoundland waters, at the northern range of the species distribution, it takes approximately 8–10 years for a newly hatched lobster to reach the minimum legal size (MLS) of 82.5 mm in carapace length (CL) (Ennis 1978, 1980). Lobsters have a total lifespan of more than 30 years (Lawton and Lavalli 1995). Growth is achieved through molting. Frequency of molting decreases with increasing age, with oldest lobsters molting once every few years. Growth is also affected by temperature, with molting frequency tending to increase with warmer water temperature (Fogarty 1989).

Molting and mating occur from July to September and females typically extrude (spawn) eggs roughly one year subsequent to mating. Ovigerous (i.e., egg-bearing) female lobsters carry the eggs in clutches on the underside of their tail, protecting and maintaining the eggs for 9–12 months. Thus, female lobsters are typically characterized by a biennial molt-reproductive cycle (Aiken and Waddy 1982) although smaller mature females sometimes molt and spawn within the same year. Moreover, laboratory studies have shown that large female lobsters (>120 mm CL) can also deviate from the typical biennial molt-reproductive cycle (e.g., successive-year spawning without an intervening molt) (Waddy and Aiken 1986, 1990); however, the size at which large female lobsters in nature can spawn in successive years without an intervening molt may vary from what is observed in laboratory studies (Comeau and Savoie 2002).

Fecundity and egg quality increases with size (Aiken and Waddy 1980). Eggs from larger lobsters tend to contain more energy per unit weight, and larger females tend to release larvae earlier in the season, potentially enhancing growth and survival (Attard and Hudon 1987).

Hatching occurs during a four-month period extending from late May through most of September, and newly hatched pre-larvae undergo an initial molt to Stage 1 before being released by the ovigerous female (Ennis 1995). Once released, the larvae swim upward and undergo a series of three molts during a 4–6 week planktonic phase. During this time, mortality is thought to be greatest. With the third molt, a metamorphosis occurs and the newly developed post-larvae, which resemble miniature adults, are prepared to settle to the benthic environment. Newly settled lobsters progress through several stages before reaching sexual maturity (Lawton and Lavalli 1995).

The adult lobster is thought to have few natural predators and commercial harvesting accounts for most adult mortality. Lobster diet typically consists of rock crab, polychaetes, gastropods, molluscs, echinoderms, and various finfish (Ennis 1973, Scarratt 1980).

The Fishery

The history of the commercial American Lobster fishery in Newfoundland dates back to the early 1870s. The fishery is prosecuted from small open boats during an 8–10 week spring fishing season. Traps are set close to shore, at depths generally less than 20 m. Reported landings peaked at almost 8,000 t in 1889 (Figure 2). Early documentation indicates that all lobsters captured were landed and processed by small canning operations that existed around the coast. A stock collapse occurred in the mid-1920s, after which the fishery was closed for three years (1925–27). The fishery reopened in 1928, and reported landings reached over 2,000 t, but dropped sharply the following year. In the early 1930s, shipment of live animals to United States (US) markets commenced, and regulations protecting undersize and ovigerous animals were strictly enforced. By the early 1950s, essentially all landed lobsters were shipped to the US, and the fishery has remained a live-market industry since. Effort was largely uncontrolled up to 1976, at which point a limited entry licensing policy was implemented, and daily trap limits were regulated (Ennis et al. 1997).

Following a 17-year period of general decline reaching 1,200 t in 1972, reported landings increased to about 2,600 t in 1979 (Figure 2). This trend was consistent with those of other Atlantic regions and was attributed to a period of strong recruitment associated with persistent favorable environmental/ecological factors which are still not fully understood. This general increasing trend in Newfoundland landings continued through the 1980s. In January 1986, a new geographical management system was introduced. Lobster fishing districts, which were implemented in 1910, were replaced by Lobster Fishing Areas, or LFAs (Figure 1). A conversion to uniform trap limits, which differ between LFAs, was implemented for all LFAs between the late 1980s and early 1990s.

In 1995, the Fisheries Resource Conservation Council (FRCC) published “A conservation framework for Atlantic lobster”. In this report, the FRCC expressed concerns about the future viability of Atlantic Canada’s lobster stocks, suggesting that high exploitation rates, combined with the considerable harvesting of immature animals could result in decreased egg production and recruitment failure in periods characterized by adverse environmental conditions (FRCC 1995). The report suggested several methods for increasing egg production and reducing exploitation rates, some of which were incorporated into subsequent management plans for the lobster fishery in Newfoundland. Over the course of the 1998–2002 management plan, there was a 25% reduction in licenses in the Newfoundland lobster fishery, and the minimum legal size for retention was increased from 81 mm CL to 82.5 mm CL in May of 1998. Additionally, a maximum legal-size restriction of 127 mm CL was implemented for west coast LFAs (note this restriction was discontinued in 2013). Reductions in trap limits, season lengths, and licenses issued were put in place and deemed necessary by fishery managers. The Atlantic

Lobster Sustainability Measures Program (ALSM) and a Lobster Enterprise Retirement Program (LERP) were implemented in 2010 and 2011, respectively. Together these programs have led to license and trap limit reductions in the Newfoundland lobster fishery, particularly in the South and West Coast regions.

There are currently about 2,300 licenses with trap limits varying from 100 to 300 per licensed fisher, depending on LFA. Traps must possess vents which allow undersized lobsters to escape. The lobster fishery is managed by input controls including number of days fished (i.e., seasons), daily trap limits, minimum CL for retention, and prohibition on landing berried or v-notched female lobsters. V-notching is a voluntary mark-release practice which involves cutting a shallow mark (v-notch) in the tail fan of an ovigerous female. The v-notch is retained for multiple molts and v-notched females are prohibited from retention in the fishery. The practice serves to protect proven spawners even when they are not brooding eggs externally.

Total reported landings for Newfoundland have increased from approximately 1,900 t in 2010 to the highest level in a century with landings of 5,780 t in 2022 (Figure 2). This reflects increasing trends in the Northeast, South and West Coast regions while the landings in the Avalon region have remained low (Figure 3).

Specifically, the landings in the Northeast Coast region increased from 160 t in 2018 to 430 t in 2022; in the Avalon region the landings decreased from 228 t in 2018 to 71 t in 2022. In the South Coast and West Coast regions the landings showed an overall increase from 1,446 t and 1,705 t, respectively in 2018 to 1,744 t and 3,536 t, in 2022 (Figure 3).

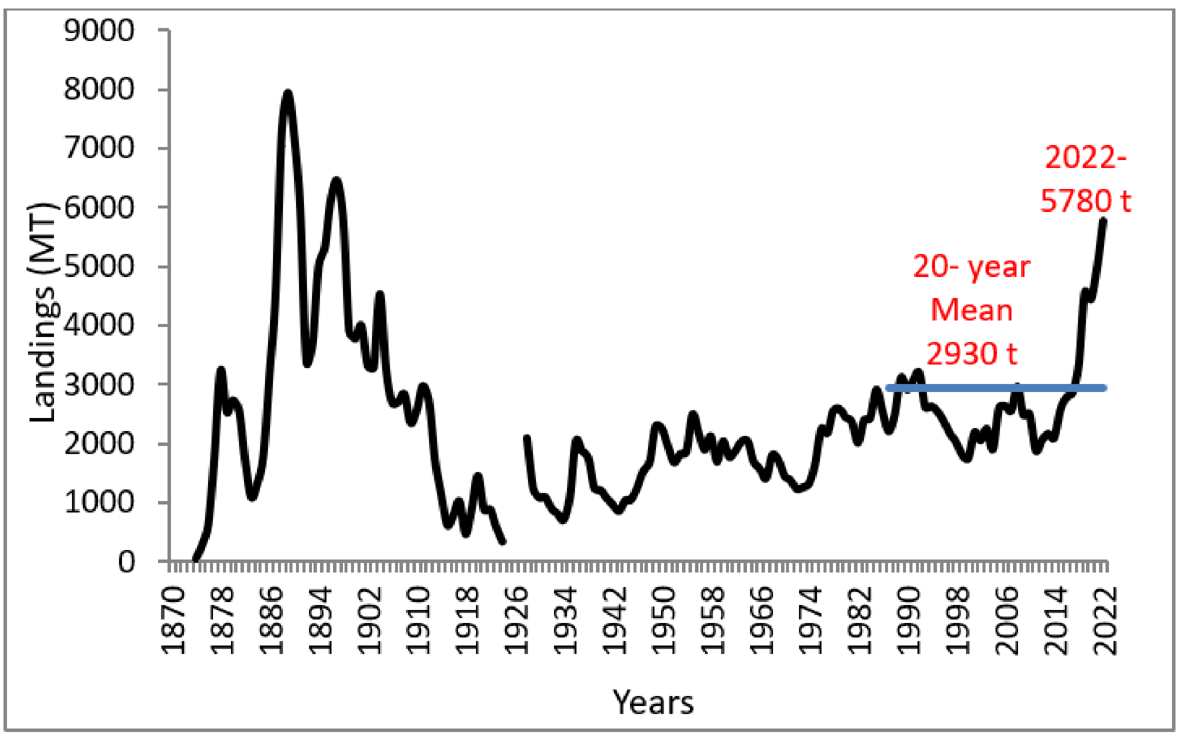

Figure 2. Reported landings (metric tons [MT]) for the Newfoundland lobster fishery from the mid-1870s to 2022 including the 20-year mean, and landings from 2022. Reported landings for 2022 are preliminary and are based on catch and effort reports up to October 4, 2022.

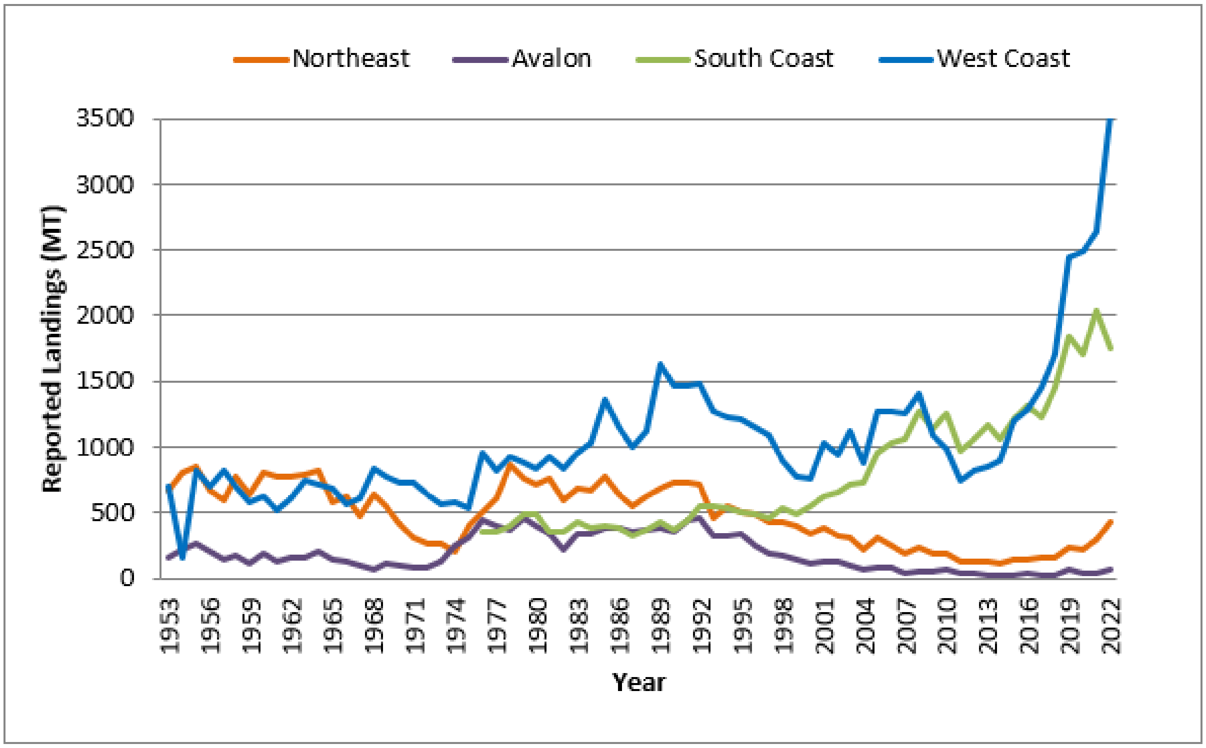

Figure 3. Reported landings, 1953–2022, in the Northeast, Avalon, South Coast, and West Coast Assessment regions.

ASSESSMENT

The Newfoundland American Lobster assessment was completed for four assessment regions, which are a geographical grouping of LFAs: Northeast (LFAs 3-6), Avalon (LFAs 7-10), South Coast (LFAs 11-12), and West Coast (LFAs 13-14) (Figure 1). The available data are mainly fishery-dependent, and each LFA/region has varying data sources including reported landings, DFO logbooks, Fish Food and Allied Workers Union (FFAW) index logbooks, and at-sea sampling data. In recent years, there has been lobster trap survey data collected at four locations throughout the province. Although no time series of survey data were used in stock status interpretation, these survey data were used to develop a selectivity curve for size-specific capture efficiency to apply to the commercial sampling data from commercial pots.

Population Dynamics

At-sea sampling data were used to generate size-frequency distributions of number of lobster per trap (by sex) for males, ovigerous females, old v-notched/ovigerous females, non-ovigerous females, and old v-notched/non-ovigerous females for each region from 2012 to 2021 (Figure 4).

With respect to the size structure within each of the four regions, there was a larger range of sizes caught in the Northeast and Avalon regions, with more lobster surviving to attain larger sizes (i.e., more than 92 mm CL); in the South Coast and West Coast regions, there was little sign of lobster surviving to larger sizes (Figure 4). This suggests higher fishing pressure on the South and West Coast regions, relative to the Northeast and Avalon regions.

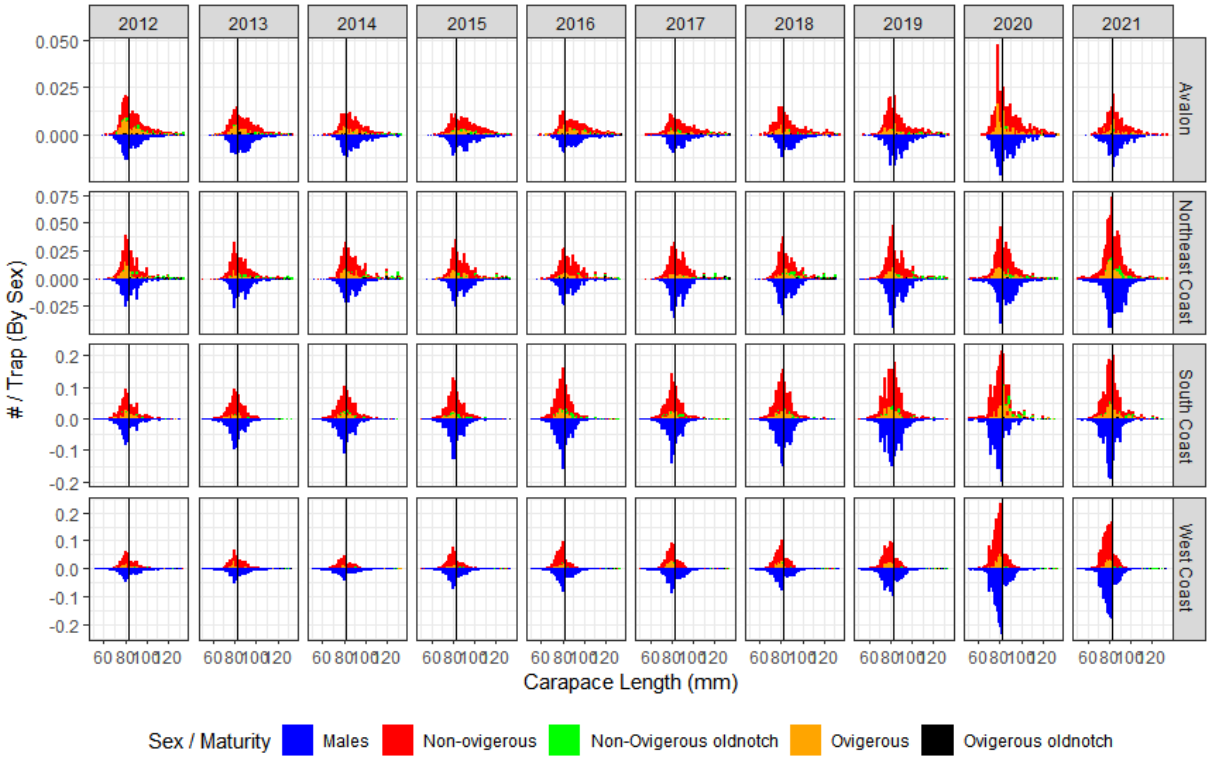

Figure 4. Annual distributions of number of lobsters per trap for males (bottom half of each panel) and females (top half of each panel) from at-sea sampling data in each of the four regions, 2012 to 2021. The black vertical line represents the minimum legal size Information on males (blue), while displayed on the negative y-axis, represent positive abundance indices.

The sex ratios of the lobster population were also calculated based on the at-sea sampling data, which demonstrated a higher proportion of females. This was particularly evident in the larger lobster in the South and West Coast regions (Figure 5).

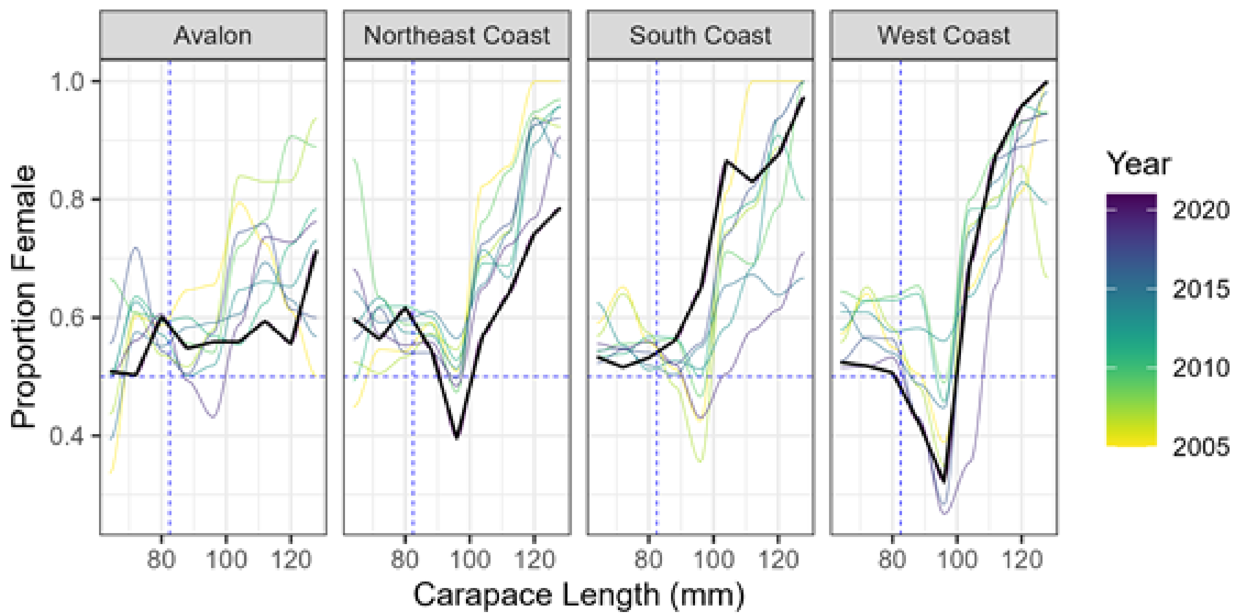

Figure 5. Annual sex ratios (proportion of females to males) from at-sea sampling data for all years (2004–21) over the size range within each region. The black line represents the sex ratio from 2022.Vertical blue dotted line represents minimum legal size (82.5 mm CL), horizontal blue dotted line highlights 0.5 proportion.

Catch Per Unit Effort

FFAW index logbook data, available since 2004, were used to compute mean Catch Per Unit Effort (CPUE) (i.e., number of lobsters caught per trap), annually within regions. CPUE was also calculated from the DFO mandatory logbooks (2010 to 2021), and comparisons with FFAW index logbook data showed similar trends within the four regions (Figure 6). For this assessment, fishery CPUE was standardized for each region using a generalized additive model (GAMM). This model used source (DFO and FFAW index harvester) and LFA as random effects along with a main effect explanatory variable of calendar day and year interaction to standardize the catch rate index.

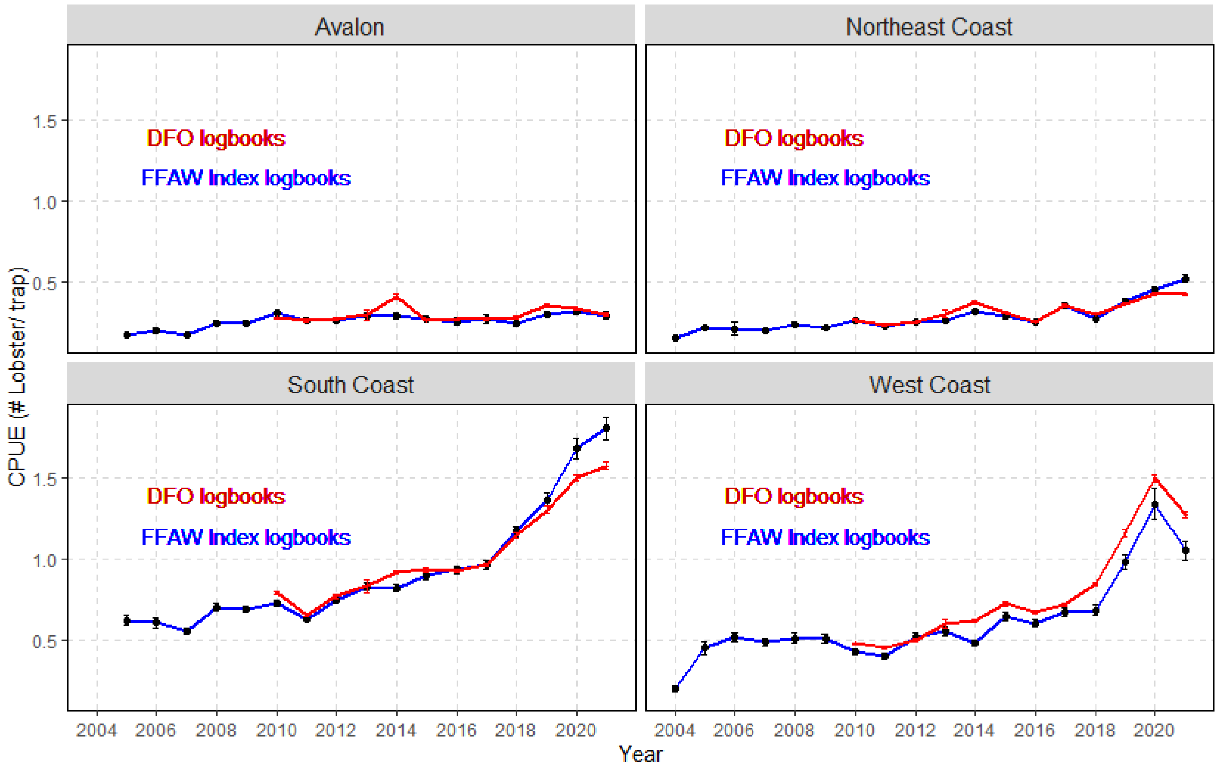

Figure 6. Mean Unstandardized CPUE (# of lobster / trap) from the FFAW (index fisher) logbooks, 2004–21, and DFO logbooks, 2010–21, in the four regions.

Throughout the time series, the highest mean CPUE values were from the South Coast and West Coast regions, with increasing trends in both regions and mean CPUEs of 1.25 to 1.6 lobsters/trap in 2021. The mean CPUE remained stable at approximately 0.25 lobsters/trap in the Avalon region and increased in the Northeast region from 0.25 lobsters/trap in 2018 to 0.5 lobsters/trap in 2021 (Figure 7).

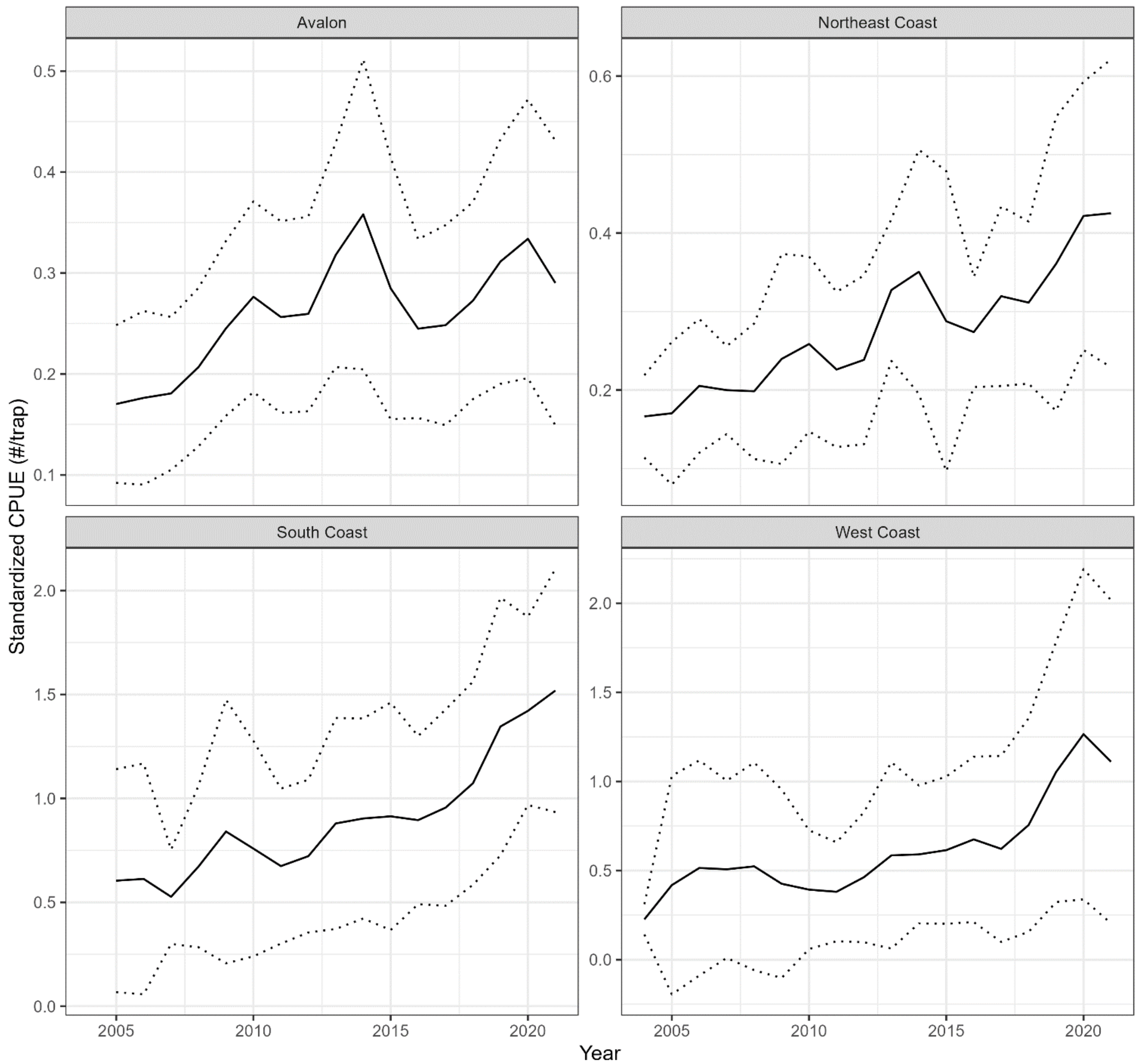

Figure 7. Standardized fishery CPUE from 2004 to 2021 in each region (solid line). Dotted lines represent 95% confidence intervals.

Adjusted Landings

In past assessments, reported landings have been shown to be an underestimate in all assessment regions, particularly in the Avalon and Northeast Coast regions. Reported landings are based on purchase slips that are supplied to DFO by buyers and do not account for local sales. For calculation of exploitable biomass, reported landings were re-scaled based on an adjustment factor (*Af*) defined as the ratio of the number of harvesters reporting (at least one) sales to the number of harvesters registering for a fishing license in any given LFA each year, with the *Af* subsequently used as a denominator in the ratio equation (reported landings / *Af*) to re-scale the landings (Figure 8).

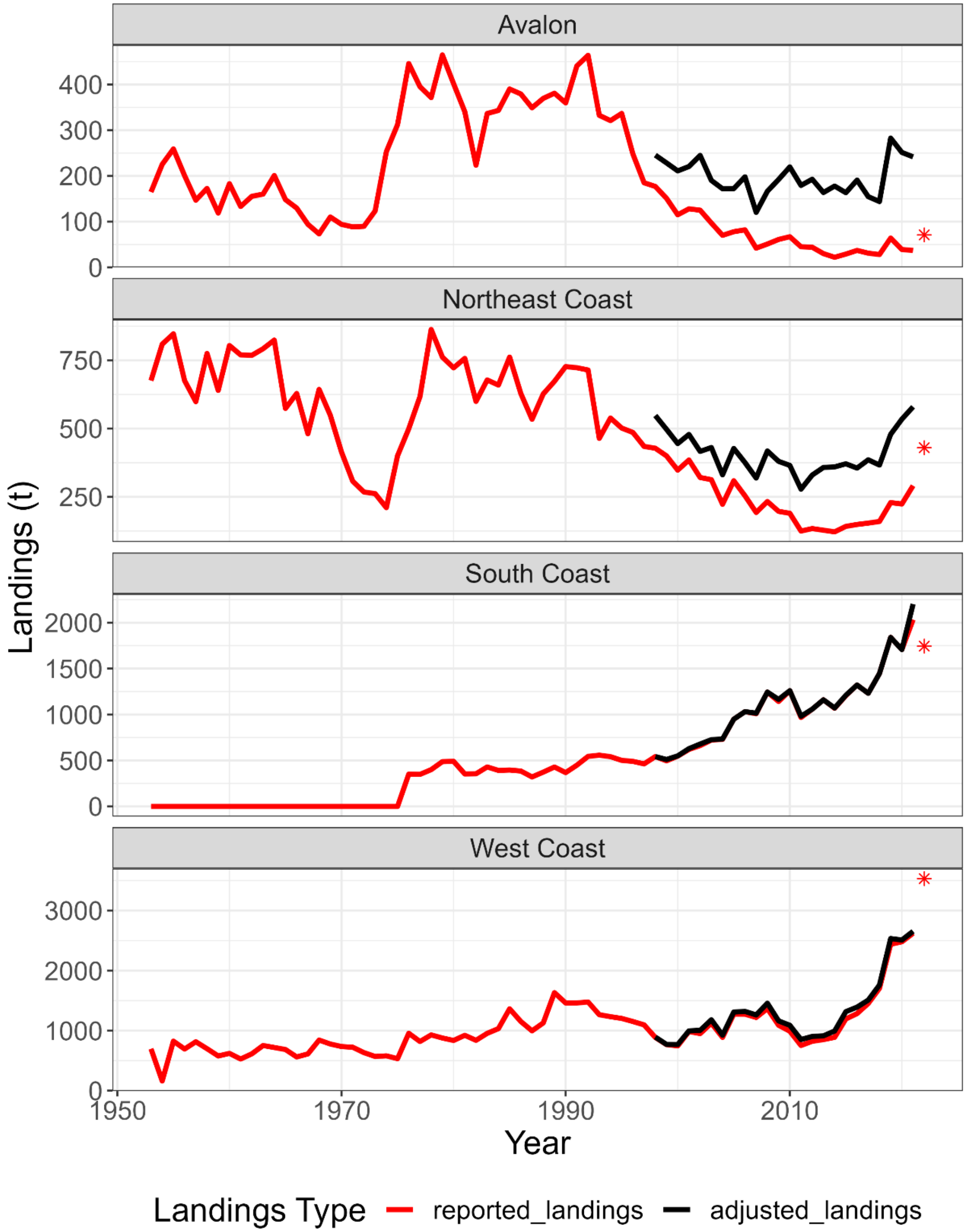

Figure 8. Reported (red line) versus adjusted (black line) landings 1984 to 2022. Red star denotes preliminary landings in 2022.

Recruitment Index

A mixture analysis undertaken on the selectivity-adjusted size composition data from at-sea sampling showed a refined modal group of lobster at 68–78 mm CL in all regions. This modal group was not affected by fishing mortality thus was used to define a recruitment index for the assessment. The recruitment index has increased slightly in the Northeast Coast region in recent years and has remained low over the time series in the Avalon region. In the South and West Coast regions the recruitment index for males and females has increased with a pronounced increase in the females in recent years (Figure 9).

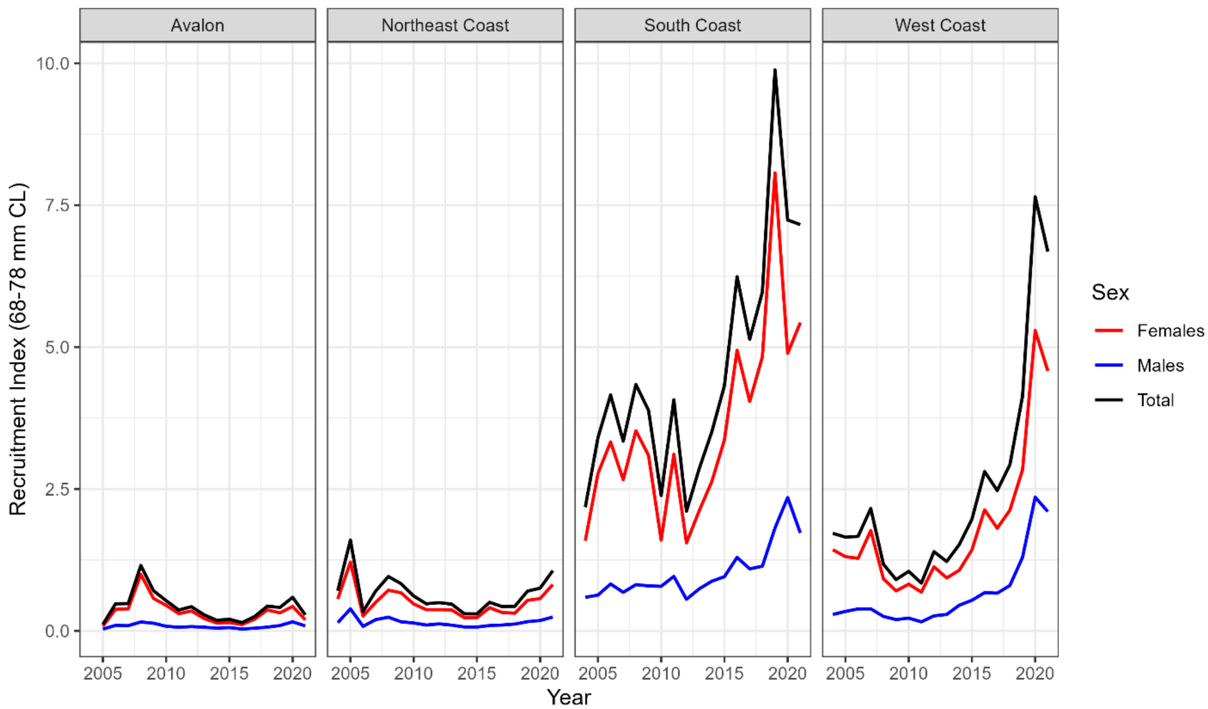

Figure 9. Recruitment Index of 68–78 mm CL lobster by year, sex, and region. Index based on selectivity-adjusted commercial trap data.

Length Converted Catch Curves

Length converted catch curves (LCCC) were used to estimate total mortality in legal-sized lobster. Length to relative age conversions were based on sex specific von Bertalanffy growth curves from Ennis et al. (1986). However, due to particular uncertainty in the growth function of females in that study, and no need for precision in our estimations (i.e., relative ages), averages were approximated for the two sexes combined and approximated ages at length were applied to both sexes in the selectivity-adjusted at-sea sampling (commercial trap) data (note S=1 in these sizes) as the basis of length-converted catch curves.

Annual catch curves were applied to catch rates of lobster ranging 82–116 mm CL in each region, by sex. This corresponded to relative ages of about 8.5–18 years. Catch rates (number/trap) of individual CL groups for 82–116 mm CL lobster were natural-log transformed and a temporal rate representing the difference in estimated age from one size increment to the next was applied based on the difference in relative age from the present to preceding length bin. The slope of each linear regression was used to estimate total instantaneous mortality rate which was subsequently transformed into an annual index for assessment (Figure 10).

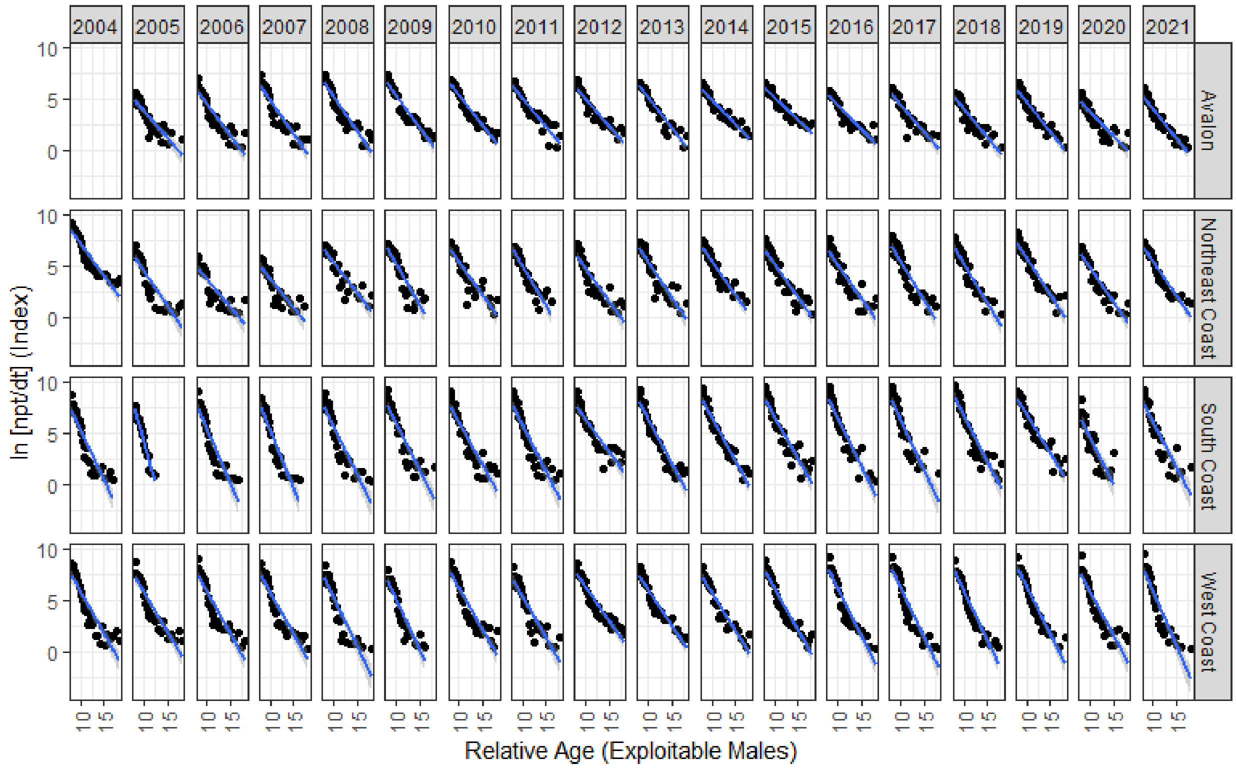

Figure 10. Length-converted catch curves. Linear regressions of ln (npt/dt) versus relative ages for legal-sized males by year and region. npt refers to number per trap and dt is difference in estimated age from one size increment to the next. A simple loess regression curve (blue line) was fit to the sex-specific mortality indices.

Mortality

Males showed higher annual mortality rates than females and mortality rates were higher overall in the South and West Coast regions than in the Avalon or Northeast Coast regions (Figure 11). The higher mortality in males likely reflects both the skewed sex ratios in NL lobster populations, with more females present, as well as some protection afforded to females such as prohibitions on landing berried females and v-notching.

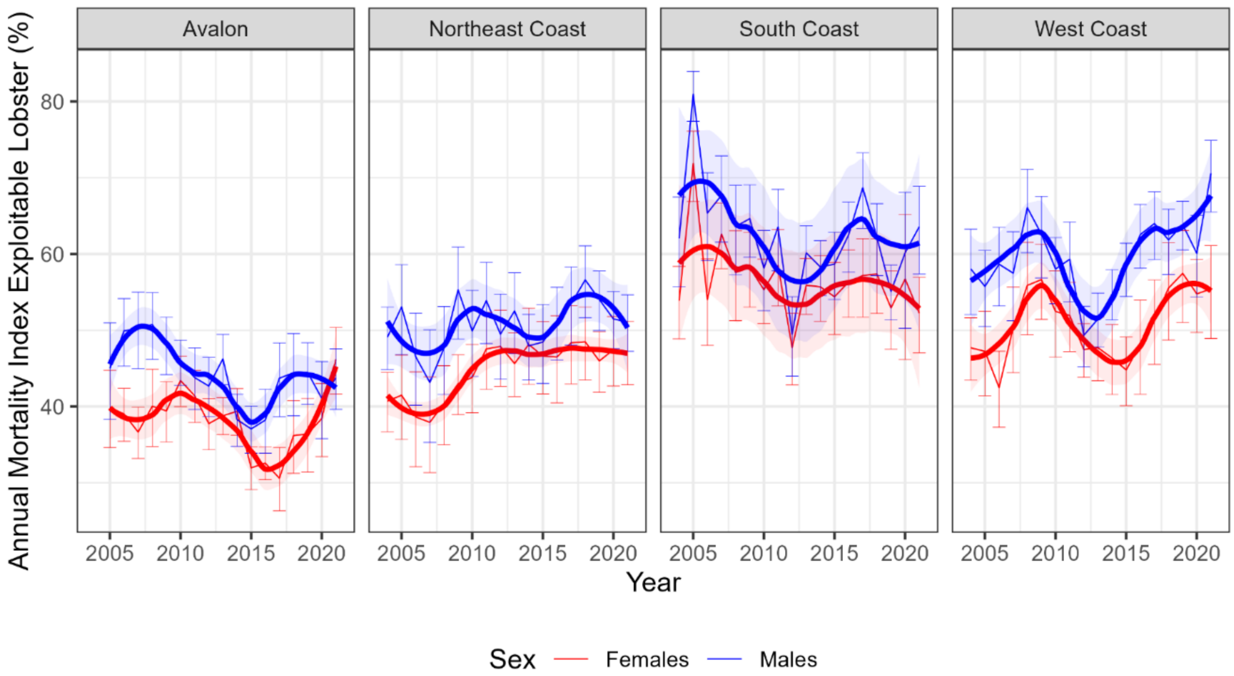

Figure 11. Total annual mortality index by sex, year, and region, estimated from length converted catch curve linear regressions on legal-sized lobster. Error bars represent 95% confidence intervals.

Biomass Index

Indices of biomass for legal-sized lobster (by sex) were derived from the total annual mortality estimates in conjunction with adjusted landings information and an additional estimated parameter of annual natural mortality rate, which was estimated at 5%. To estimate landings by sex, proportions of males and females in the legal-sized catch from the at-sea sampling data by region and year were calculated and applied to the adjusted landings.

Legal-size biomass was estimated to be higher in females than males in all regions and years (Figure 12), likely reflecting the skewed sex ratios and additional protections afforded to females in the fishery. The analysis showed that biomass has grown to different extents in all regions in recent years, with only the Avalon region not showing progressive increases since 2017. In the Avalon region, the total biomass index has ranged from about 450–900 t from 2018–21, in the Northeast Coast it has increased from about 625–1,400 t during that time, while the South Coast and West Coasts increased from about 2,800–4,500 t and 3,500–5,000 t, respectively, during the 2018 to 2021 period.

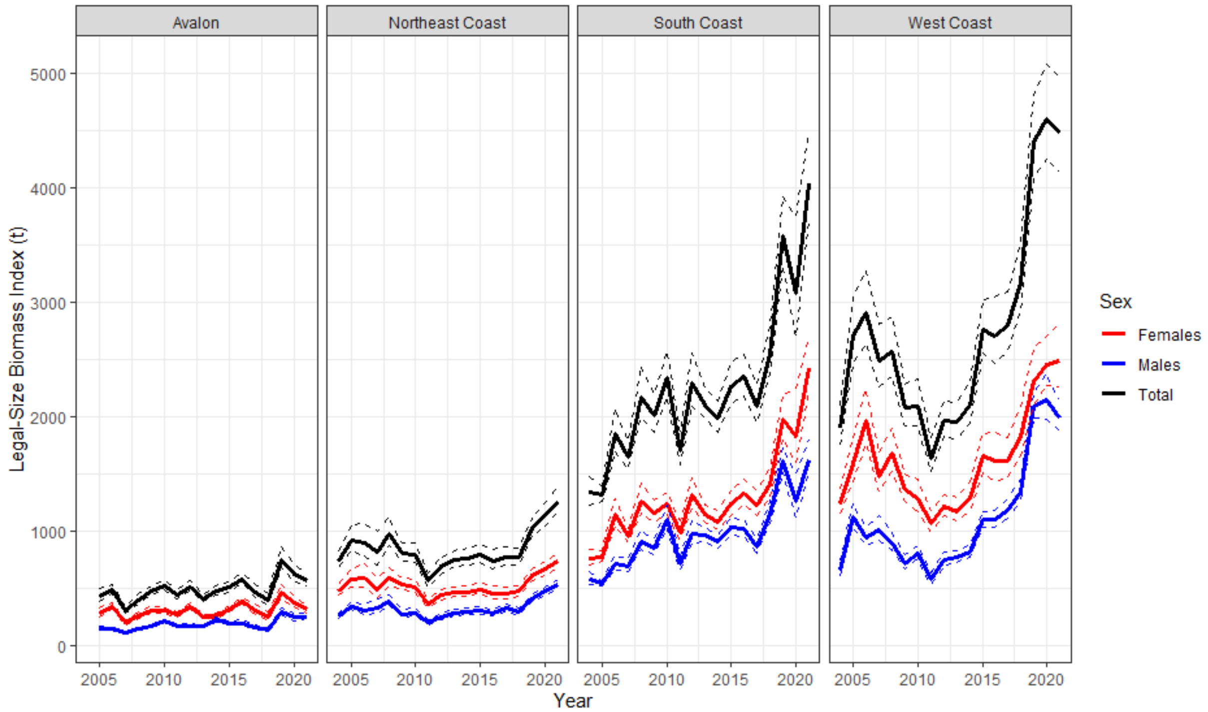

Figure 12. Length-converted catch curve biomass index (t) of legal-size lobster based on adjusted landings estimates by sex, year, and region (solid line). Dotted lines represent 95% confidence intervals.

Exploitation Rate

Exploitation rate indices based on LCCC-derived biomass (landings / biomass) estimates closely reflected trends in total mortality, being higher in the South and West Coast regions than in the Avalon and Northeast Coast regions and higher in males than females (Figure 13). In 2021, total (sex-combined) exploitation rate indices were 42.9%, 46.5%, 54.1%, and 59.2% in the Avalon, Northeast Coast, South Coast, and West Coast regions, respectively.

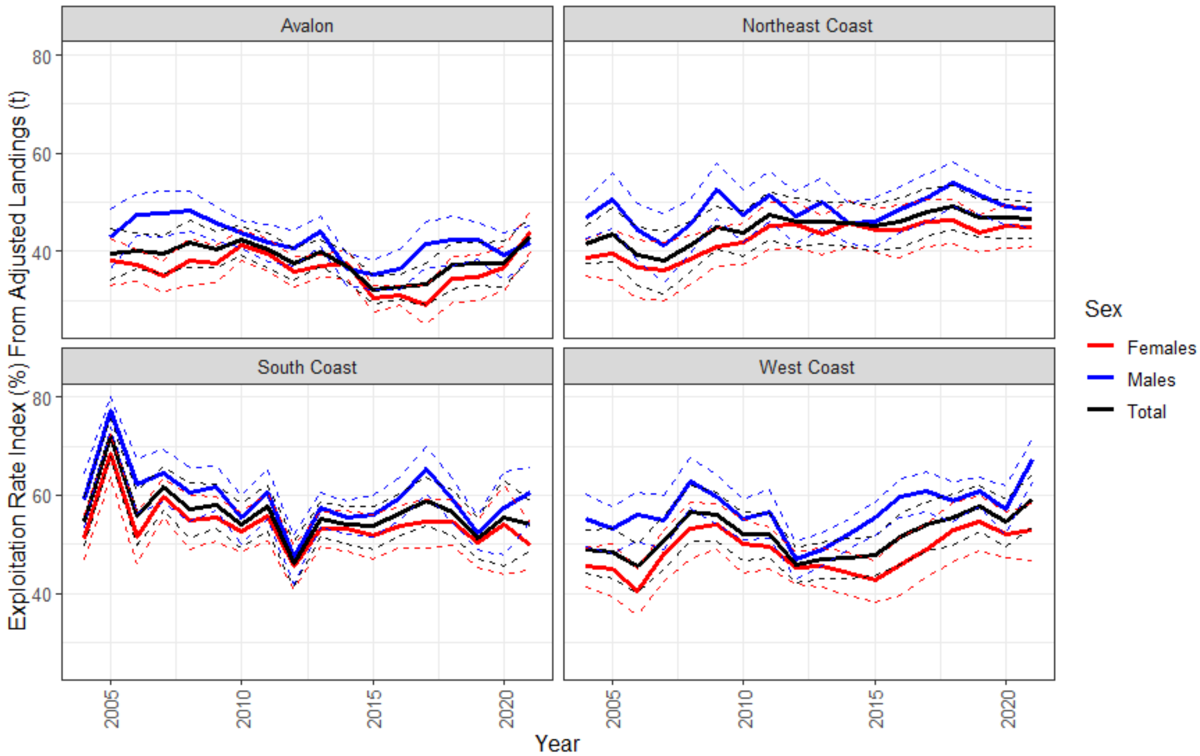

Figure 13. Length-converted catch curve exploitation rate index based on adjusted landings estimates by sex, year, and region (solid line). Dotted lines represent 95% confidence intervals.

Sources of Uncertainty

The assessment is mainly based on fishery-dependent data. Reported landings are based on purchase slips that are supplied to Fisheries and Oceans Canada by buyers and do not account for local sales, poaching, and handling mortalities that can occur prior to the sale of the catch. The extent of local sales, in particular, can be considerable and varies by location and year. Therefore, is it difficult to obtain an estimate of total annual removals for any given year.

With respect to the use of mainly fishery-dependent data in this assessment, potential effects of year-to-year differences in spatial and temporal coverage are unknown. Differences in catchability among sizes and categories (i.e., immature versus sexually mature; v-notched versus not notched), as well as density-dependent effects, can complicate the interpretation of both at-sea sampling and logbook data. Environmental conditions, soak time, and changes in type of fishing gear (size, materials) can also affect catchability. There are vast changes in relative amounts of size categories over the fishing season; therefore, size data aggregated over the entire fishing season are difficult to interpret.

There is uncertainty in how the landings were adjusted for this assessment and the potential impacts this could have on the biomass estimates. However, this concern is largely offset by minimal difference between reported and adjusted landings in the dominant West and South Coast regions, thus overall stock-level biomass indices should be relatively robust against this issue. In addition, the length-weight relationship data sources are dated (from the 1980s), which may affect interpretation of the analysis for this assessment.

CONCLUSIONS

The population size structure within each of the four regions showed a larger range of sizes caught in the Northeast Coast and Avalon regions, with more lobster surviving to attain larger sizes (i.e., more than 92 mm CL); in the South Coast and West Coast regions, there was little sign of lobster surviving to larger sizes. This suggests higher fishing pressure on the South and West Coast regions, relative to the Northeast and Avalon regions. Overall CPUE (standardized) has increased in all four assessment regions.

Despite showing signs of high exploitation rates in most areas, all key indicators are consistent in showing sustained signs of growth throughout all assessment regions. Short-term recruitment prospects appear steady in the Northeast and Avalon regions and at the highest levels in the time series in the South and West Coast regions.

OTHER CONSIDERATIONS

Ecosystem Considerations

Summer sea surface temperature has increased since 1981 over the four geographical regions, characterized by a low in the early-1990s and a high in the early-2010s (Figure 14). This has led to more favorable oceanographic habitat conditions for American Lobster including recent improvements in recruitment prospects.

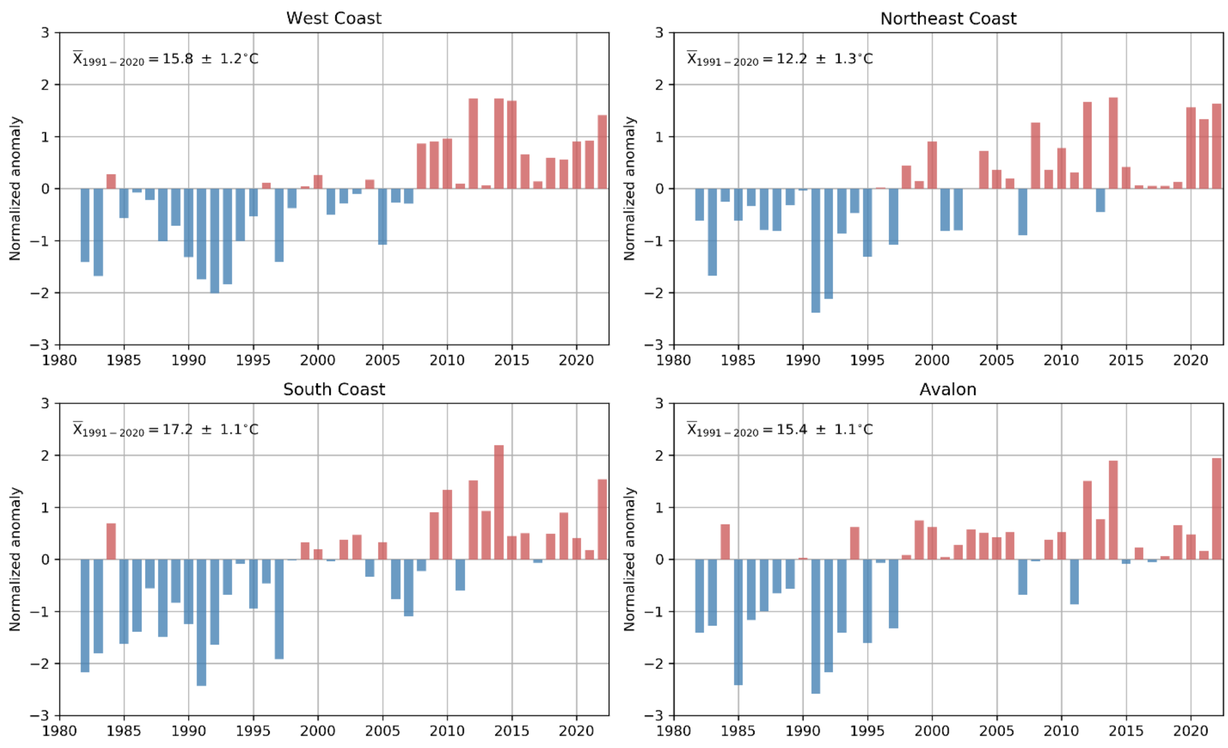

Figure 14. Normalized anomalies of the mean sea surface temperature (SST) for the warmest week of the year in the four assessment regions, 1981–2022. The normalized anomalies are expressed as the departure (by standard deviation increment) from the 1981–2010 climatological average. The climatological average and standard deviation for each region is shown in the upper left of each panel. Data are from the National Oceanic and Atmospheric Administration High-resolution Blended Analysis of Daily SST on 1/4 deg. global grid (Reynolds et al. 2007). Only grid points in the regions truncated at 46°N and 51°W are considered.

Management Considerations

Since mandatory DFO logbooks were implemented in 2010, there have been some years characterized by low return rates. In recent years, the rates have improved in some areas as a result of more follow-up and reminders to harvesters to ensure logbooks are provided to DFO. It is recommended to continue follow-up efforts to ensure consistent and accurate logbook returns. In order to account for changes in fishing gear and address concerns of catchability, DFO logbooks should collect detailed data pertaining to gear specifications (e.g., trap type, trap size, and the size of entrance rings).

A preliminary yield per recruit analysis was calculated and showed the long-term yield to be at or above 35–40% exploitation rate, which is both beyond and near the harvest rate level in all four regions.

LIST OF MEETING PARTICIPANTS

Name	Affiliation
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Laurie Hawkins	DFO-NL – Resource Management
Martin Henri	DFO-NL – Resource Management
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Cynthia McKenzie	DFO-NL – Science
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Mildred Skinner	Fish, Food and Allied Workers Union
Renae Butler	Association of Seafood Producers
Mable McDonald	Qalipu Development Corporation
Guillermo Martin	Irish Marine Institute
Arnault LeBris	Memorial University – Marine Institute
Paul Snelgrove	Memorial University – Marine Institute

SOURCES OF INFORMATION

This Science Advisory Report (SAR) is from the Newfoundland and Labrador Regional Peer Review Process on the Stock Assessment of American Lobster in Newfoundland held on October 17-18, 2022. Additional publications from this meeting will be posted on the Fisheries and Oceans Canada (DFO) Science Advisory Schedule as they become available.

Aiken, D.E., and Waddy, S.L. 1980. Reproductive Biology. In: The Biology and Management of Lobsters Vol. I: Physiology and Behavior. Edited by J.S. Cobb and B.F. Philips. Academic Press. New York. Pp 215–276.

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