Fisheries and Oceans Canada / Pêches et Océans Canada
Ecosystems and Oceans Science / Sciences des écosystèmes et des océans

Canadian Science Advisory Secretariat (CSAS)

Research Document 2026/056

Newfoundland and Labrador Region

Standardized Indices and Biological Information for 3Ps Cod from the Sentinel Gillnet and Linetrawl Surveys using the 'Rsentinel' R-Package

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August 2026

Foreword

This series documents the scientific basis for the evaluation of aquatic resources and ecosystems in Canada. As such, it addresses the issues of the day in the time frames required and the documents it contains are not intended as definitive statements on the subjects addressed but rather as progress reports on ongoing investigations.

Published by:

Fisheries and Oceans Canada
Canadian Science Advisory Secretariat
200 Kent Street
Ottawa ON K1A 0E6

http://www.dfo-mpo.gc.ca/csas-sccs/
DFO.CSAS-SCAS.MPO@dfo-mpo.gc.ca

ISSN 1919-5044
ISBN 978-1-100-00133-3 Cat. No. Fs70-5/2026-056E-PDF

Correct citation for this publication:

Kumar, R., Varkey, D.A., Parsons, D.M., Wheeland, L., and Skanes, K. 2026. Standardized Indices and Biological Information for 3Ps Cod from the Sentinel Gillnet and Linetrawl Surveys using the 'Rsentinel' R-Package. DFO Can. Sci. Advis. Sec. Res. Doc. 2026/056. iv + 36 p.

Aussi disponible en français :

Kumar, R., Varkey, D.A., Parsons, D.M., Wheeland, L., et Skanes, K. 2026. Indices normalisés et renseignements biologiques pour la morue de la sous-division 3Ps provenant des relevés par pêche sentinelle au filet maillant et à la palangre au moyen du progiciel R « Rsentinel ». Secr. can. des avis sci. du MPO. Doc. de rech. 2026/056. iv + 37 p.

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ABSTRACT

This document presents standardized indices and biological information for Atlantic Cod (*Gadus morhua*) populations in Northwest Atlantic Fisheries Organization (NAFO) Subdivision 3Ps, based on data from the Sentinel survey. It describes trends in standardized indices obtained from gillnets (GN) and linetrawls (LT), as well as biological metrics such as Fulton's condition factor (K), the Gonadosomatic Index (GSI), the Hepatosomatic Index (HSI), and Weight-at-age (Wa), and demonstrates how the 'Rsentinel' R-package aids in analyzing these trends.

Monthly analyses of K suggest that Atlantic Cod are in optimal condition during the latter half of the year, with the highest K values in July, August, and September. The monthly GSI pattern indicates peak spawning activity in the spring and early summer. The HSI values for females and males consistently exceed 3, with females showing slightly higher values, reflecting healthy liver condition. High variability in mean Wa over the years is largely due to small sample sizes, particularly for the youngest and oldest fish. For fish aged 7 and older, there has been a general decline in Wa over the time series.

For standardized index calculations for both gears (5.5 inch GN and LT), only samples from sets deployed between June and November are currently used. However, a substantial number of sets deployed in December were excluded but could potentially be incorporated in the index calculations. Trends at fixed sites closely mirror those at experimental sites for both gears, suggesting the potential for integrating data from both sites into index calculations. This similarity indicates that the Sentinel data are informative. Except for a few years, fish caught in LT exceed those caught in GN. The age-aggregated catch rate shows that experimental sites generally had higher catch rates than fixed sites for both gears. For GN, the highest catch rate was in 1997, with 29 fish per net at fixed sites and 35 fish per net at experimental sites. However, by 2022, this dropped to around 5 fish per net at both site types. Similarly, for LT, the peak catch rate occurred in 1995, with 189 fish per 1,000 hooks at fixed sites and 224 fish per 1,000 hooks at experimental sites. By 2022, this decreased to approximately 62 fish per 1,000 hooks at fixed sites and 67 fish per 1,000 hooks at experimental sites. Atlantic Cod landings (all gear types combined) dropped sharply from over 200 t in 1995 to below 50 t by 1999, followed by a gradual decline with minor fluctuations, reaching about 11 t in 2022. The overall trend highlights a long-term decrease in landings. The 5.5 inch GN typically catches fish between 50–80 cm, while LT catch fish starting around 30 cm. The size ranges of fish caught with each gear type seems to be consistent year over year. Bubble plots based on standardized indices show the Sentinel survey can track some cohorts across years.

1. INTRODUCTION

1.1. THE HISTORY OF THE SENTINEL PROGRAM

Since the 1970s, Research Vessel (RV) multi-species stratified bottom-trawl surveys have been monitoring Atlantic Cod (*Gadus morhua*) stocks, including the Northern cod in Northwest Atlantic Fisheries Organization (NAFO) Divisions 2J3KL and 3Ps cod in NAFO Subdivision 3Ps. However, these surveys, being research trawl-based, do not cover the inshore areas where these stocks are also distributed. Recognizing the need to monitor stock trends in these inshore areas, particularly after major declines in both stocks in the early 1990s, Sentinel surveys were initiated in 1995. Although the Fisheries and Oceans Canada (DFO) RV survey encompasses much of the stock area, changes in biomass and age composition of cod raised questions about conditions in the nearshore areas, which are not covered by the survey.

Sentinel survey projects were formally announced by the Minister of DFO in October 1994. The Sentinel surveys in the Newfoundland and Labrador (NL) Region of DFO were an extension of the index fishermen’s project from the Northern cod Science Project Program, with modifications to allow for scientific activities achievable only under a fishing moratorium (1995 – 98). Three industry groups were involved with the Sentinel survey program: the Fish Food and Allied Workers (FFAW), the Fogo Island Cooperative, and the Petty Harbour co-op. In recent years, the Petty Harbour co-op has focused its work on cod tagging under the Fisheries Science Collaborative Program (FSCP) funding and no longer engaged in Sentinel work. The primary collectors of data in the Sentinel survey were inshore fish harvesters. Through consultations with inshore fish harvesters and fisheries organizations, traditional inshore fishing grounds were identified and mapped. To minimize inter-annual variability in data collection, participants were expected to remain with the survey over multiple years.

The goals of the collaborative project were to develop indices of relative abundance (i.e., catch rates) for resource assessments; to incorporate the knowledge of inshore fish harvesters into the resource assessment process; to evaluate inter-annual variability in resource distribution over inshore areas; and to collect information on key biological parameters used in assessments (e.g., fish length, sex, otoliths to determine fish age, cod stomach contents). The catch per unit effort (CPUE) from these surveys were standardized for spatial and seasonal effects and used to inform assessments for the two Atlantic Cod stocks. Furthermore, sampling (lengths and weights) is used to present information on biological aspects such as fish condition within the population.

1.2. SPATIAL COVERAGE OF THE PROGRAM

In winter 1995, the pilot project was started in NAFO subdivision 3Ps at 14 sites and ran for 15 weeks. In autumn 1995, the program was expanded to 2J3KL with 53 sites from Black Tickle to Point Lance. Since 1995, 115 participants from 2J3KL and 33 from 3Ps were involved in the program (Figures 6.1 and 6.2). These sites have been fished annually from January to December, although the bulk of the activity is in the autumn season.

1.3. SAMPLING DESIGN

Fishing enterprises from St. Bride’s to Burgeo participate in the Sentinel fisheries survey in NAFO Subdivision 3Ps. Survey participants receive training in scientific sampling, equipment use, and resource assessment. Fishing is conducted at one fixed site (control site) and at least one experimental site. Fixed sites have predetermined locations based on historical fishing areas and gear-use patterns, while experimental sites vary within a designated area. Each day, up to half of the fishing gear is deployed at the control site, with the remaining gear used at the experimental site(s). Surveys typically last 9-12 weeks annually, averaging 10 weeks since 2005. Harvesters using large-mesh gillnets (GN, 5.5 inch) deploy up to six 50-fathom monofilament nets, with a maximum of three fleets per day. Linetrawl (LT) harvesters use two tubs of bait hooks daily, each containing about 500 hooks. Additionally, a small-mesh GN (3.25 inch) is deployed at selected sites at least once a week. The total annual removal of Atlantic Cod is calculated from data collected at both control and experimental sites (Mello and Simpson 2022).

From each fishing event, a full record of the metadata of the samples is collected. Log sheets record set location (latitude and longitude), start and soak times, number of cod and other species (by-catch) caught and discarded, and key environmental conditions such as wind direction and speed, cloud cover, tidal conditions, water temperature at depth, and other notes (Figure 6.3). Catches are sorted by species. All cod are measured for total length (TL) (by sex), and otoliths are collected from a length-stratified subset (Figure 6.4) of the sample to enable development of age-length keys. Additionally, up to 100 whole Atlantic Cod are collected from various locations, frozen and sent bi-weekly to DFO in St. John's, NL, for detailed biological measurements, including TL, gutted weight, and liver and gonad weights (Mello and Simpson 2022).

1.4. GEARS USED IN THE SURVEY

Catch was estimated by weight and a subsample of fish was measured for length and biological measurements. Four gear types have been used over the course of the Sentinel survey:

- Cod Trap (1995 – 2001, no longer used).
- Handline (1997 – 2002, no longer used)
- Gillnet: 5.5 inch and 3.25 inch mesh (Continuous use since 1995)
- Linetrawl (Continuous use since 1995)

1.5. ANALYSIS OF INFORMATION COLLECTED

Sentinel data have been included in cod assessments since 1995. Information is presented in both raw (unstandardized) and standardized form, accounting for site and seasonal effects (modeled).The following main information is obtained from Sentinel data:

- Catch rates: Number of fish per net or per 1,000 hooks
- Age-aggregated and age-disaggregated indices
- Length frequencies
- By-catch information
- Biological condition:
  - Fulton's condition factor (K)
  - Gonadosomatic Index (GSI)
  - Hepatosomatic Index (HSI)
  - Mean Weight-at-age (Wa)

2. METHODS

2.1. DATA PROCESSING

Annual Sentinel survey catch data are stored in a Microsoft Access database, containing information such as metadata, length frequencies (LFs), and by-catch details. Weight analysis of the subsamples for biological information (lengths, weights, and ages) and otolith-based aging analyses are performed at DFO.

2.1.1. Aging the Length-Frequency Data

The first step in Sentinel data analysis is compiling all the aging data both from the otolith analysis and the weight analysis each year. The second step focuses on processing the LF data extracted from the Sentinel database and, ultimately, converting it into age-frequency data. These are complex processes that are broken down into several key steps, as outlined below:

1. the logs of the LF data are associated to the trip metadata,
2. the LF data for males and females are added to calculate totals by length bin,
3. the haul date and set date are used to calculate month, quarter, and soak times,
4. the LF information is aggregated into 3 cm and 5 cm bins.

Ages are assigned to LF data by linking the LF with the age-length keys developed from otolith and weight analysis of samples from the Sentinel surveys. The data are merged at five different hierarchies starting with the closest sampling available both for location and time blocks such as quarterly, half-yearly, and yearly. The five steps in the merging are as follows:

1. First Merge: by variables (Gear, NAFO Division, Unit area, Year, Half-year, Quarter-year);
2. Second Merge: by variables (Gear, NAFO Division, Unit area, Year, Half-year);
3. Third Merge: by variables (Gear, NAFO Division, Unit area, Year);
4. Fourth Merge: by variables (Gear, NAFO Division, Year, Half-year, Quarter-year);
5. Fifth Merge: by variables (Gear, NAFO Division, Year, Fish Length–bin=5 cm LF).

After the merging process is complete, the LF records that were not aged are checked for any inconsistencies, such as a large number of records missed by the aging process for any year or length bin. The five step merging process generates the set of aged data from the surveys.

2.1.2. Creating a Complete Data Set

A complete data set is created by combining the aged data with all the records for fishing events where no cod were captured.

2.1.3. Final Quality Control of Data

In the final step, the following filters are applied to the data prior to sending the data to the standardization model:

- fishing events from only June to November are retained for the analysis
- for the GN data, only data from fishing events where the soak times are between and including 12 and 32 hours are retained
- for the LT, only fishing events with soak times of 24 hours and less are included

- all data are summarized to the month level
- the enterprise and month combination are removed when 5 or less fish were caught in the whole time period in either survey.

2.2. MODEL DESCRIPTION

Poisson models with a logarithmic link were fitted with the variables month and age as 'nested effects': month was nested within 'seqcode' and age was nested within year. In the Sentinel catch database, a seqcode is a sequential identifier code assigned to a participant or enterprise in the Sentinel fishery survey, based on their fishing site from north to south. If a participant opts out or is replaced by a new participant allowed to fish at the same site, a new, unique seqcode is assigned to the new participant. Therefore, seqcode captures both fishing site and individual effects.

Assuming that Y is the number of fish caught per Sentinel net, and it follows a Poisson distribution with mean rate λ: $Y_i \sim \text{Poisson}(\lambda_i)$, then the relationship between λ_i and the predictors is modelled using the log link function.

$$log(\lambda_i) = \beta_{seqcode} \cdot [\text{month \%in\% seqcode}]_i + \beta_{\text{year}} \cdot [\text{age\%in\%year}]_i + log(gear)_i \qquad (2.1)$$

where $\beta_{seqcode}$ represents the coefficient capturing the interaction between month and seqcode, facilitating the estimation of distinct coefficients for each month level within its corresponding seqcode group; similarly, β_{year} represents the interaction between age and year, allowing for separate coefficient estimates for each age level within its respective year group. The $log(gear)_i$, log of gear amount, is the offset term for modelling rates (numbers per net/hook). As noted, $Y_i \sim \text{Poisson}(\lambda_i)$, therefore, the estimated probability for Y_i is given by:

$$\hat{P}(Y_i = y) = \frac{\hat{\lambda}_i^y e^{-\hat{\lambda}_i}}{y!}, \quad \text{where } i = 0,1,2,\ldots \qquad (2.2)$$

We use the Generalized Linear Model (GLM) function in R to model the Y. After optimizing the betas, least squares means (LS means) also known as estimated marginal means (emmeans) are calculated for each age in a year (age%in%year) with confidence limits, using the emmeans function of the R package emmeans. Least squares means are adjusted means that account for the effects of other variables. They provide a balanced estimate of group means, allowing comparisons while considering covariate influences and interaction effects in a model. The structure of the model input data (Table 2.1), R codes for GLM and LS means for the age-disaggregated model, and a snippet of the final output (Table 2.2) are as follows:

Table 2.1: The structure of the input data to be used in the standardization.

type	gear	gearMesh	div	seqcode	month	year	age	gearamt	n	logamt
F	5	5140	3P	116	6	1995	3	24	0	3.178
F	5	5140	3P	116	6	1995	4	24	0	3.178
F	5	5140	3P	116	6	1995	5	24	58	3.178
F	5	5140	3P	116	6	1995	6	24	143	3.178
F	5	5140	3P	116	6	1995	7	24	103	3.178
F	5	5140	3P	116	6	1995	8	24	39	3.178

The following R code is a snippet from the ‘Rsentinel’ package, demonstrating how the standardization model is implemented within the package. It shows fitting a Poisson GLM and calculating the LS means.

```
myfit <-  glm(n~-1+month %in% seqcode + age %in% year+offset(logamt),
          family=poisson(link="log"),na.action="na.exclude", data=data)

lsMeans <- emmeans::emmeans(update(myfit,.~. +seqcode), ~age %in% year,adjust="none")
```

The ‘Rsentinel‘ package generates several outputs, including model diagnostics and plots. However, the output primarily used in the assessment is the age-wise yearly standardized indices, an example of which is presented in the table below.

Table 2.2: Shows the first few rows of the standardized indices, demonstrating the typical output structure.

year	age	estimate	lower	upper	stock	gearMesh	gearType
1995	3	0.018	0.004	0.072	3P	5140	F
1995	4	0.075	0.038	0.150	3P	5140	F
1995	5	3.947	3.427	4.546	3P	5140	F
1995	6	8.569	7.575	9.695	3P	5140	F
1995	7	5.214	4.562	5.959	3P	5140	F
1995	8	2.437	2.078	2.858	3P	5140	F

For the age-aggregated model, aging data are not necessary. To accommodate this, we can simply exclude the [age%in%year] component from Equation (2.1), leaving the rest of the equation unchanged. Consequently, the LS means solely provides estimates of the annual catch rate, accounting only for month effects within each sequence code.

Model fit was examined using statistical significance of the effects included, and the distribution of residuals.

2.3. THE ‘RSENTINEL’ PACKAGE

An R package known as ‘Rsentinel’ was developed to streamline the complete Sentinel analysis process. This package reads catch data for all years directly from the Sentinel database, reads the aging files for all years directly from the given directory, runs the model to produce the standardized indices, processes the biological information and generates the final output with comprehensive diagnostics. Previously, the analysis was carried out in SAS, requiring the execution of large scripts across multiple pages, which was time-consuming and resource-intensive. The Rsentinel package streamlines this process by saving time and cutting costs by eliminating the need for expensive SAS licenses. It also reduces the effort involved in extracting data from the database for SAS scripts and running multiple scripts for the models and biological information. Furthermore, it facilitates result reproducibility and paves the way for more extensive analyses, making it advantageous for the growing community of R users in DFO.

In the Rsentinel package, several stepwise functions are available for analysis. Among these functions, the most important ones are:

- readAging()= facilitates reading of all aging files, processes them and makes them tidy.

- readDataBase()= reads the entire Sentinel catch from the database and prepares the results for subsequent steps.
- makeModelData()= carries out all five stages of merging and generates age-based catch data.
- runModel()= executes the analysis, encompassing GLM, LS means, and various model diagnostics.
- makePlot() = produces a number of plots for results and model diagnostics.
- bcMeanWt()= produces bias-corrected mean Wa.

In addition to the above mentioned functions, there are a collection of convenient ‘runAll’ wrapper functions to facilitate the entire analysis process. For instance, users can execute a comprehensive Sentinel analysis by simply executing the following code:

```
dtbase <-"data-raw/2022 Sentinel 28Mar23.accdb"
ageDir <-"data-raw/SentinelAgingData"

results5140 <- runAll_DB(dirAging =ageDir,
                fileDB=dtbase,
                stock="3Ps",
                gearMesh=5140,
                maxYear = 2022,
                gearType="F")
```

Aging fish through otoliths is a time- and labor-intensive procedure, and at times, there may be delays in obtaining aging data for a specific year. The Rsentinel package is equipped to generate yearly age-aggregated indices, even when aging data are unavailable for a particular year, by employing the following series of runAll functions:

```
dtbase <-"data-raw/2022 Sentinel 28Mar23.accdb"
results5140_agg <-
runAll_Agg(fileDB=dtbase,gearMesh=5140,gearType="F",maxYear=2022,stock="3Ps")
```

The descriptions of the functions above are provided as examples to illustrate their usage, but the Rsentinel package includes detailed help files for utilizing these functions and many others.

2.4. BIOLOGICAL INDICES

2.4.1. Fulton’s Condition Factor (K)

Fulton’s Condition Factor (K), also known as the Fulton’s K or K factor, is a formula used to assess the overall condition of a fish. It quantifies the relationship between fish length and weight, providing valuable insight into its health and nutritional status.

$$\mathrm{K} = \frac{\text{Gutted Body Weight(g)}}{\text{Total length(cm)}^3} \times 100 \qquad (2.3)$$

The result is a dimensionless value that quantifies how much the fish weight is related to fish length. When $K = 1$, it indicates that fish weight is in perfect proportion to length. A significant decrease in K may indicate stressors affecting the fish, such as disease, poor feeding conditions, or environmental degradation.

2.4.2. Gonadosomatic Index (GSI)

The GSI value is used to assess the reproductive status of fish. It quantifies the relative size of the gonads in comparison to the weight of the whole fish; the equation below used gutted body weight. The result is typically expressed as a percentage, representing the proportion of the body weight that the gonads constitute. This index is useful in assessing the reproductive condition of fish, with higher GSI values indicating a greater investment in reproduction by the fish.

$$\text{GSI} = \frac{\text{Weight of Gonad (g)}}{\text{Gutted Body Weight (g)}} \times 100 \qquad (2.4)$$

2.4.3. Hepatosomatic Index (HSI)

The HSI is used to assess the relative size of a fish liver (hepatopancreas) in comparison to the weight of the whole fish; the equation below used gutted body weight. Like GSI for gonads, the HSI (typically expressed as a percentage) is used to monitor and understand the health and condition of the liver in fish, which is essential for assessing the impact of environmental factors, pollutants, and diseases on the liver function of fish populations.

$$\text{HSI} = \frac{\text{Weight of Liver (g)}}{\text{Gutted Body Weight(g)}} \times 100 \qquad (2.5)$$

2.4.4. Bias-Corrected Mean Weight-at-age (Wa)

Bias in Wa estimation is introduced when calculating Wa from length-stratified samples. The bias-corrected Wa was calculated by incorporating the number of Sentinel catch records for each length stratum and the number of fish sub-sampled for aging from that stratum (Morgan and Hoenig 1997).

3. RESULTS

3.1. SUMMARY OF SURVEY AND INPUTS

The number of fishing enterprises participating in the Sentinel program has decreased steadily since 2003 (Figure 6.5), and this has affected the number of sets in the survey across all gear types. The GN fishery has remained fairly stable since 2010, however, there has been a decline in activity in the LT fishery in recent years. In several communities, new participants were able to maintain continuity in the survey, and each new participant was assigned a distinct seqcode (Figure 6.6). A detailed view of the number of survey deployments across the different communities involved in the program is available in Tables 7.1 to 7.3.

Sentinel fishery activity is predominantly between June to November, the months used for standardization purposes (Figure 6.7). Among all the gears, LT captures the largest number of cod, followed by the 5.5 inch mesh GN (Figure 6.8), except for a couple of years (2021 and 2022) when the number of fish caught with LT was lower than what was caught with the GN. Cod total predicted landings, combining all gears, experienced a steep drop from over 200 t in 1995 to below 50 t by 1999. This was followed by a more gradual decline, with minor fluctuations, reaching about 11 t in 2022 (Figure 6.9). The overall trend indicates a long-term reduction in landings. The unstandardized indices show similar trends between the fixed and experimental sites. In recent years, the indices show an increasing trend in the GN but a decreasing trend in the LT (Figure 6.10). Length frequencies are shown in Figure 6.11. Two modes are clear in the 3.25 inch GN, as is characteristic of small-mesh GN. The 5.5 inch GN typically catch fish between 50–80 cm, while the LT catches tend to start around 30 cm. The sizes present in each gear are largely consistent year over year.

After various steps of quality checks and the application of age-length keys, the aged data used for standardization are presented in Figures 6.12 and 6.13. There is high variability and many years with no records for age 3 fish in the 5.5 inch GN; thus the standardized index for age 3 GN is not used in the 3Ps cod assessment model.

3.2. STANDARDISED INDICES FOR SENTINEL 5.5 INCH GN AND SENTINEL LT FOR 3PS COD

The residual plots do not show any concerning patterns for either GN or LT standardization models (Figures 6.14 to 6.17). Bubble plots from the standardized indices show that the Sentinel survey is able to track some cohorts across years (Figures 6.18 and 6.19). Catch rate trends are very similar for both the fixed and experimental sites for the age-aggregated index and index-at-age for both gears (Figures 6.20 and 6.21). The catch rate for 5.5 inch GN reveals comparable annual patterns across ages 4 to 10. Initially, there is a rising trend during the early years, with the highest catch rates observed in the early phase of the Sentinel program. Subsequently, catch rates experienced a sharp decline by the early 2000s and then stabilized. In recent years, there has been an increase in catch rates, especially for the older ages. For LT, the same decline in catch rates by the early 2000s is noted in ages 6 and above but is not as prominent as what was observed in GN fishery. Both gears also show an increase in indices for ages 8 and above in the recent years, but to different magnitudes. A comparison of the aggregate indices (Figure 6.21) from GN and LT is difficult because the sharp decline in the indices for GN in the early phase masks the variation in this index series.

The mean standardized catch rate across the different gears is provided in Tables 7.4 to 7.6.

3.3. BIOLOGICAL INDICES

3.3.1. Fulton’s Condition Factor (K)

The results show temporal trends in the mean Fulton’s K for Atlantic Cod over the time series. The dataset is comprised of data for the years 1995 – 2022, with observations for both male and female cod. It is evident that there is some variation in K over time (Figure 6.22). In the early years, K values show fluctuations, with females generally having slightly higher K values compared to males. K values seem to stabilize in the mid-2000s for both sexes, but decline in the latter half of the decade. From around 2010 – 15, K values remain low for both sexes. In recent years, K values have exhibited some recovery, although they remain lower than earlier periods. The monthly analysis of K values indicates that Atlantic Cod experience optimal condition during the latter half of the year, reaching their highest K values in the months of July, August, and September (Figure 6.23). There is a decreasing trend in K from January to late spring. There is some variation between the sexes, but overall, K values for both sexes are consistent throughout the year. Further analysis, considering factors such as feeding patterns, diet information, spawning, and environmental changes, could provide a more comprehensive understanding of the seasonal dynamics in the condition of Atlantic Cod.

3.3.2. Gonadosomatic Index (GSI)

The annual GSI trends for both females and males show some fluctuations but remain stable overall (Figure 6.22). In 2020, the GSI index for males and females appear to be opposite, but this was a year where sampling was affected by the COVID-19 pandemic, resulting in a significantly reduced number of sampled fish. The average sample size in 2017 – 19 was 131 males and 128 females annually, but in 2020, the count was merely 6 males and 11 females. Monthly variations in GSI are reflective of the reproductive cycles in the cod population, influenced by environmental and biological factors. GSI values are relatively low in January and February but increase in the spring and early summer (April to June), reaching peak values in June (Figure 6.23). This period signifies heightened reproductive activity and is therefore an indicative of the spawning season. The data also indicate that both male and female cod follow a similar monthly pattern, although there may be slight variations in the timing and magnitude of GSI fluctuations. These patterns provide valuable insights into the timing of reproductive events and the species' response to seasonal changes in Subdivision 3Ps.

3.3.3. Hepatosomatic Index (HSI)

The HSI values demonstrate a stable pattern across the time series, with most values remaining within a narrow range. The HSI values are slightly higher for female cod, but values for both sexes are consistently higher than 3 (Figure 6.22), indicating overall healthy liver condition (Dutil et al. 1995). Over the past 10–12 years, the majority of HSI values fall within the 3-6% range, but there are instances where HSI values slightly exceed this range. These fluctuations are likely influenced by seasonal and environmental factors, as well as variations in prey availability and feeding patterns that impact liver health. Regarding the monthly HSI, there is an upward trend observed from June to August, followed by a subsequent decrease (Figure 6.23).

3.3.4. Bias-Corrected Mean Weight-at-Age (Wa)

Mean Wa for fish ages 5–10 caught in the Sentinel survey is presented in Figure 6.24 for males and females. High variability in these estimates year over year is largely attributed to small sample sizes, particularly for the youngest and oldest fish. For ages 7+ there has been a general decrease in Wa over the time series (1997 – 2022).

4. DISCUSSION

The transition from SAS to R, along with the development of the Rsentinel package for Sentinel data analysis, marks a significant advancement by reducing analysis time and effort while ensuring reproducible results.

For the standardized index calculation for both gear types (5.5 inch GN and LT), catches from sets deployed between June and November are used. However, a significant number of sets are also deployed in December, which are currently omitted but could potentially be included in the calculation. The trends observed in fixed sites closely mirror those in experimental sites for both gears, suggesting that the data are informative and highlighting the potential for integrating both sites into index calculations. Additionally, both gears generally show similar trends, with the highest catch rates observed in the early phase of the program.

Fulton's K was generally lower between 2010 – 19 but has improved in the last 2–3 years. High variability in weight is largely attributed to small sample sizes. For ages 7 and older, there has been a general decrease in Wa over the time series.

The occurrence of multiple zero values in a Poisson regression model suggests the potential need for considering a zero-inflated regression model. Implementing a zero-inflated model would allow for a better fit by accounting for the overabundance of zeros, which standard Poisson regression might not handle effectively. This approach might result in a model that is more representative of the data, leading to a more reliable standardized index.

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6. FIGURES

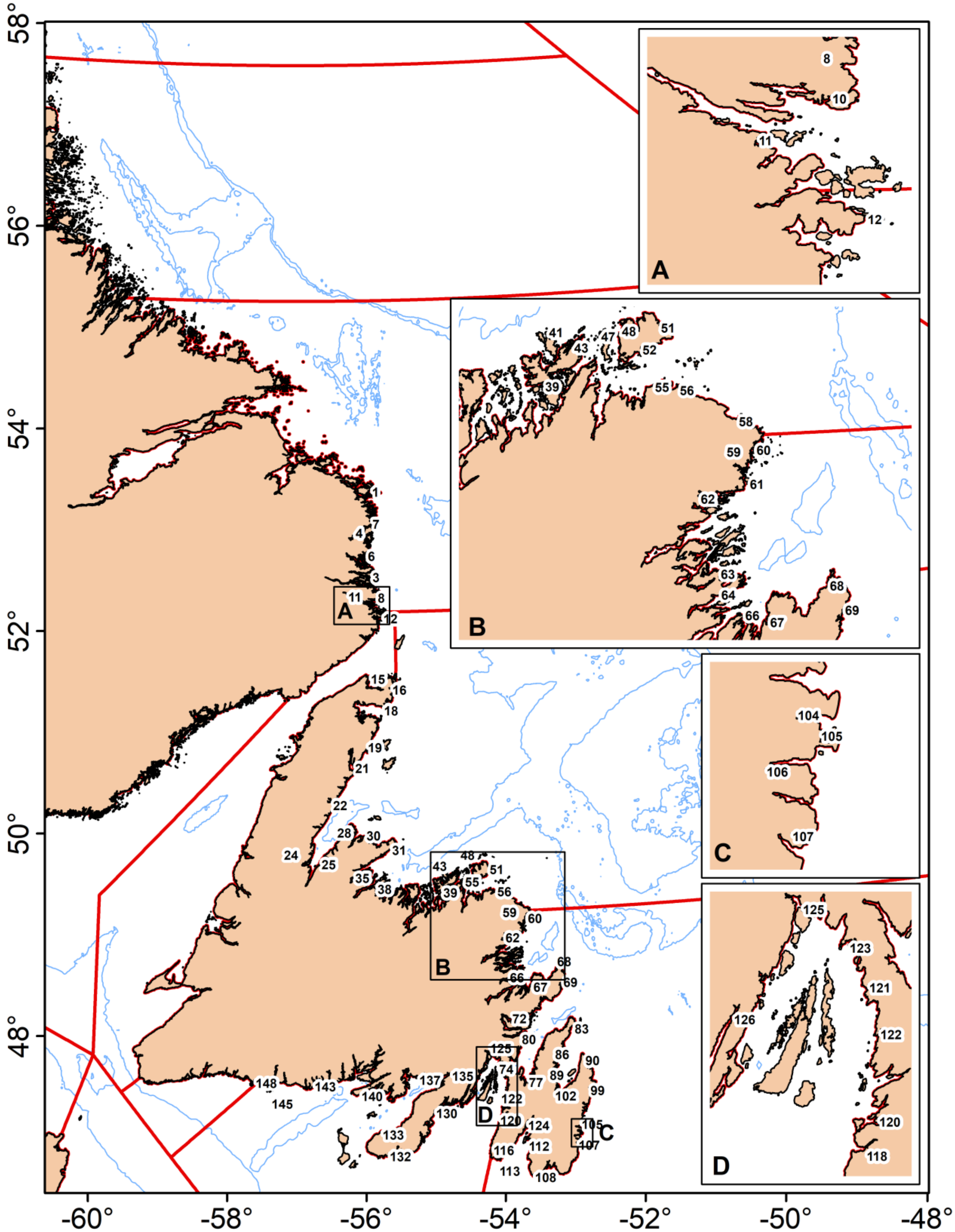


Figure 6.1: Distribution of all Sentinel sites in NAFO Divisions 2J3KL and Subdivision 3Ps.

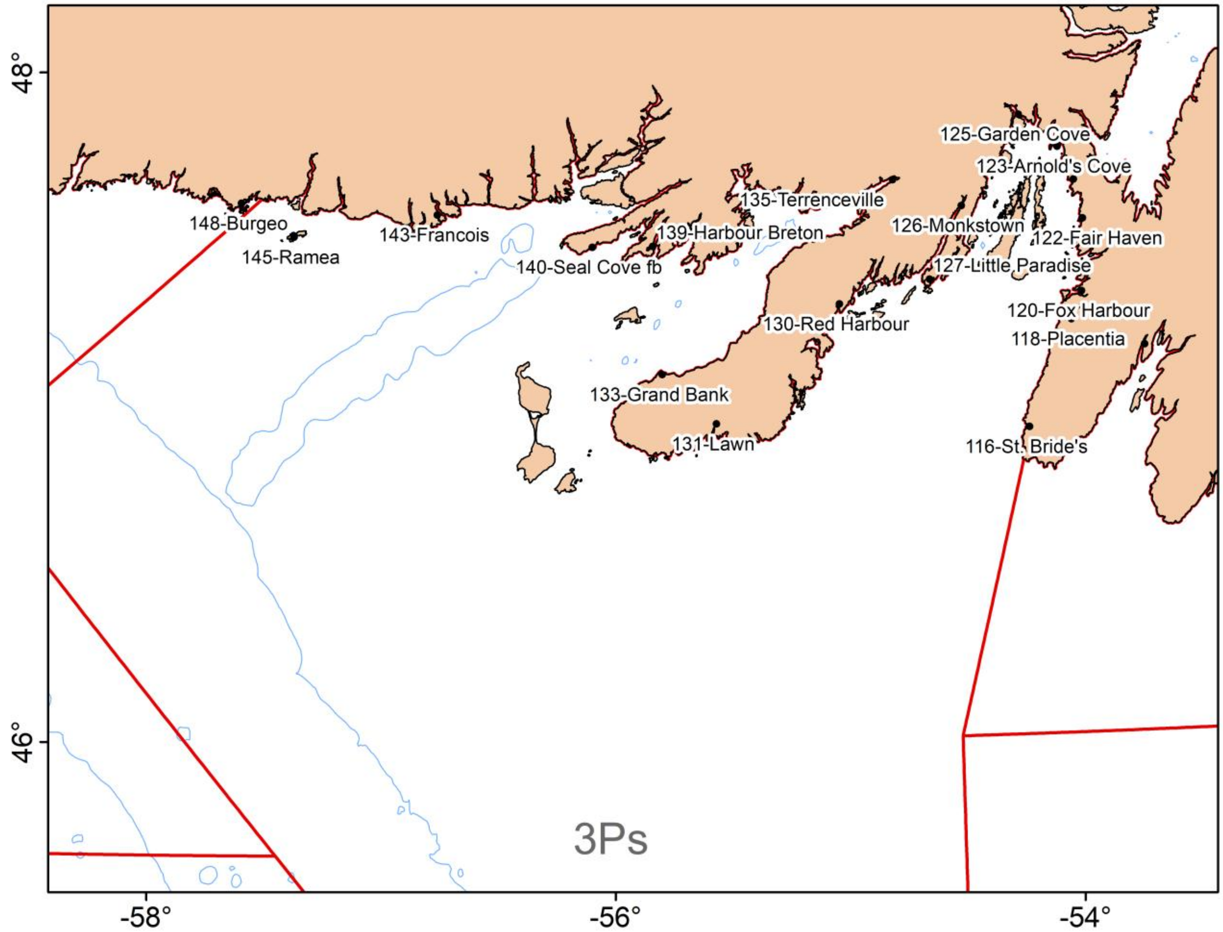
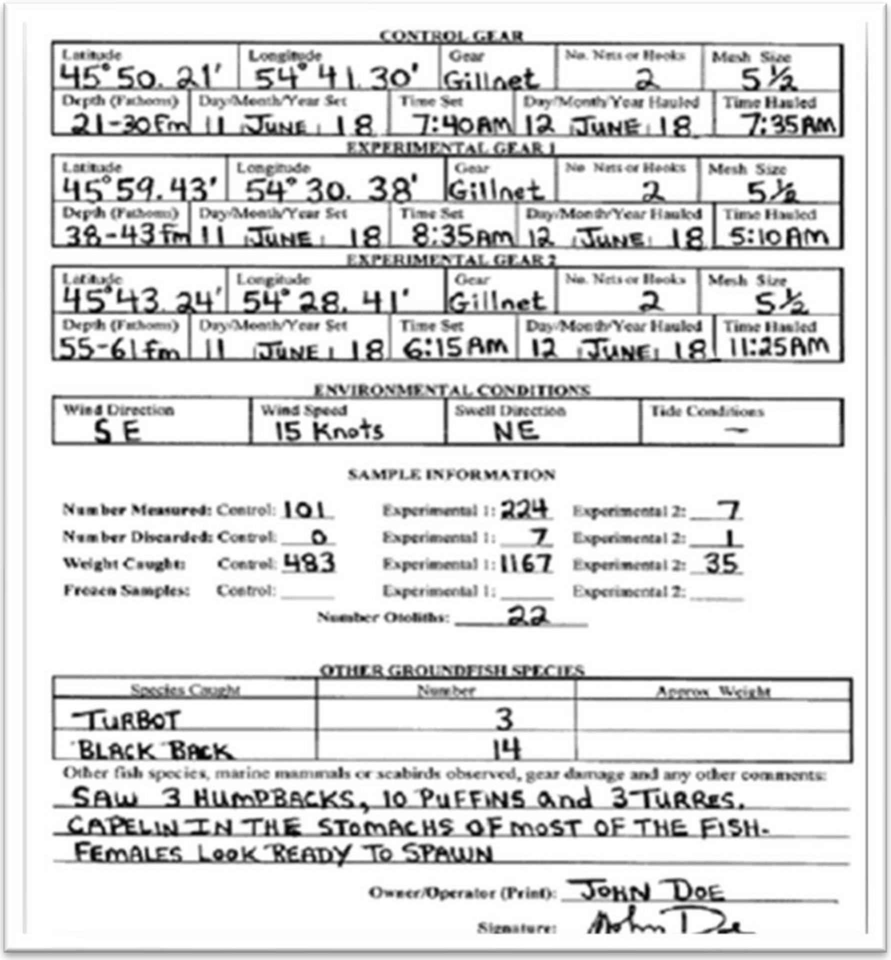


Figure 6.2: Distribution of Sentinel sites in NAFO Subdivision 3Ps.



CONTROL GEAR

Latitude	Longitude	Gear	No. Nets or Hooks	Mesh Size
45°50.21'	54°41.30'	Gillnet	2	5½

Depth (Fathoms)	Day/Month/Year Set	Time Set	Day/Month/Year Hauled	Time Hauled
21-30Fm	11 JUNE 18	7:40AM	12 JUNE 18	7:35AM

EXPERIMENTAL GEAR 1

Latitude	Longitude	Gear	No. Nets or Hooks	Mesh Size
45°59.43'	54°30.38'	Gillnet	2	5½

Depth (Fathoms)	Day/Month/Year Set	Time Set	Day/Month/Year Hauled	Time Hauled
38-43Fm	11 JUNE 18	8:35AM	12 JUNE 18	5:10AM

EXPERIMENTAL GEAR 2

Latitude	Longitude	Gear	No. Nets or Hooks	Mesh Size
45°43.24'	54°28.41'	Gillnet	2	5½

Depth (Fathoms)	Day/Month/Year Set	Time Set	Day/Month/Year Hauled	Time Hauled
55-61fm	11 JUNE 18	6:15AM	12 JUNE 18	11:25AM

ENVIRONMENTAL CONDITIONS

Wind Direction	Wind Speed	Swell Direction	Tide Conditions
SE	15 Knots	NE	—

SAMPLE INFORMATION

Number Measured: Control: 101 Experimental 1: 224 Experimental 2: 7

Number Discarded: Control: 0 Experimental 1: 7 Experimental 2: 1

Weight Caught: Control: 483 Experimental 1: 1167 Experimental 2: 35

Frozen Samples: Control: ____ Experimental 1: ____ Experimental 2: ____

Number Otoliths: 22

OTHER GROUNDFISH SPECIES

Species Caught	Number	Approx. Weight
TURBOT	3	
BLACK BACK	14	

Other fish species, marine mammals or seabirds observed, gear damage and any other comments:

SAW 3 HUMPBACKS, 10 PUFFINS and 3 TURRES.
CAPELIN IN THE STOMACHS OF MOST OF THE FISH.
FEMALES LOOK READY TO SPAWN

Owner/Operator (Print): JOHN DOE

Signature: John Doe

Figure 6.3: Log sheet to record meta-data on Sentinel sampling event.

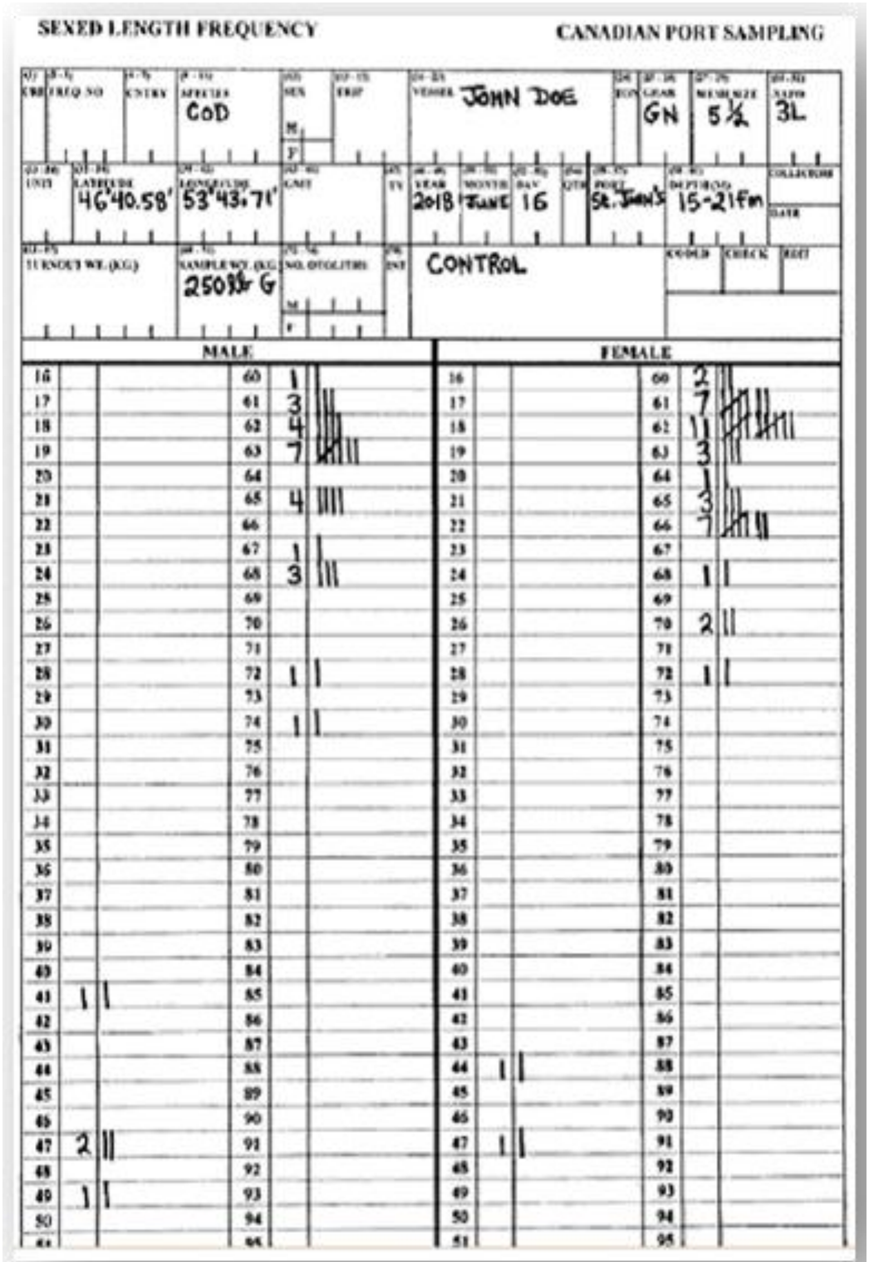


Figure 6.4: Log sheet to record cod length frequency from the Sentinel sampling event.

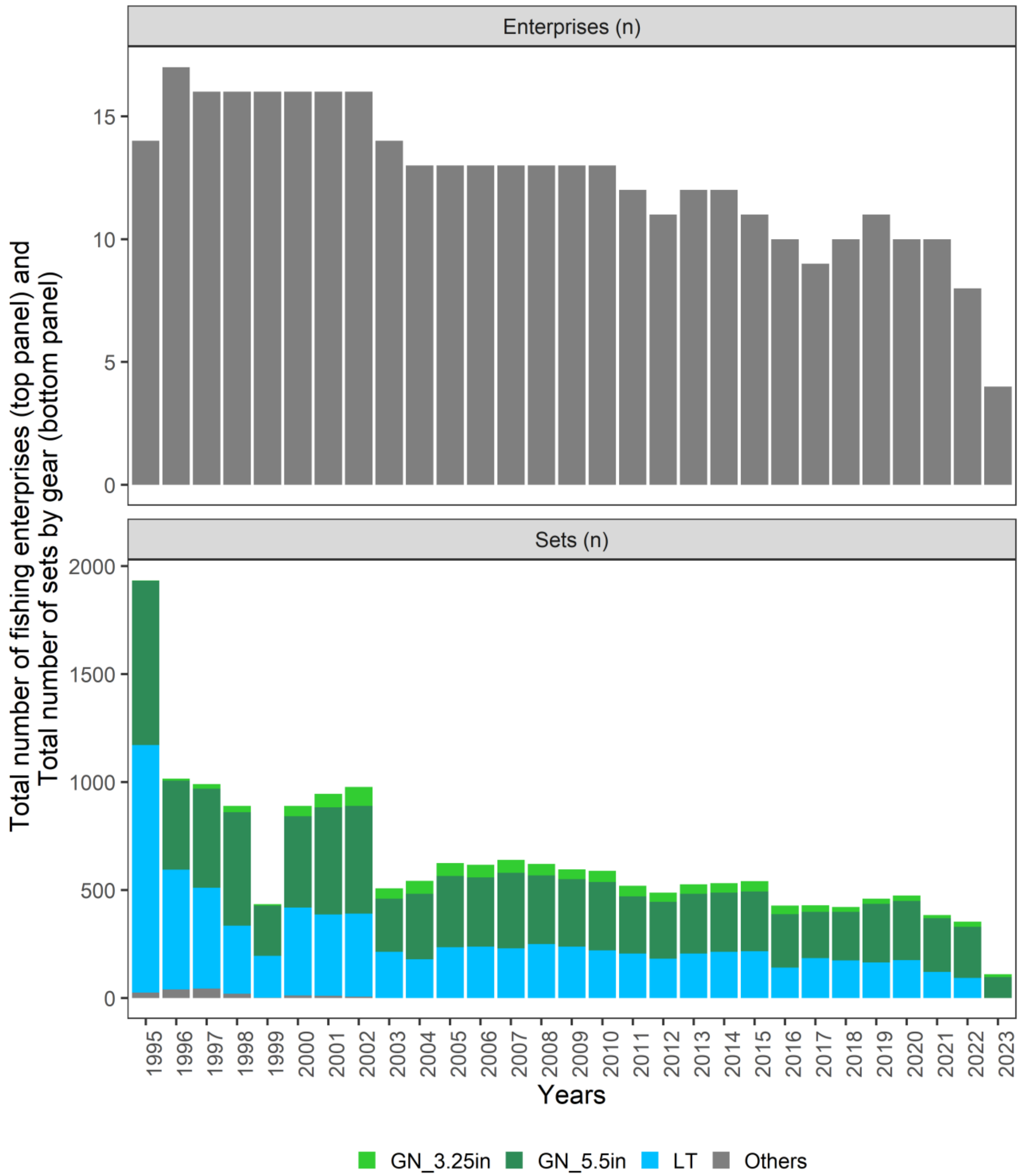


Figure 6.5: The number of annual participation of fishing enterprises in the Sentinel survey from 1995 – 2023. The colors in the bottom panel represent the different types of gear used in total sets for each year. Note that data for the terminal year may be incomplete.

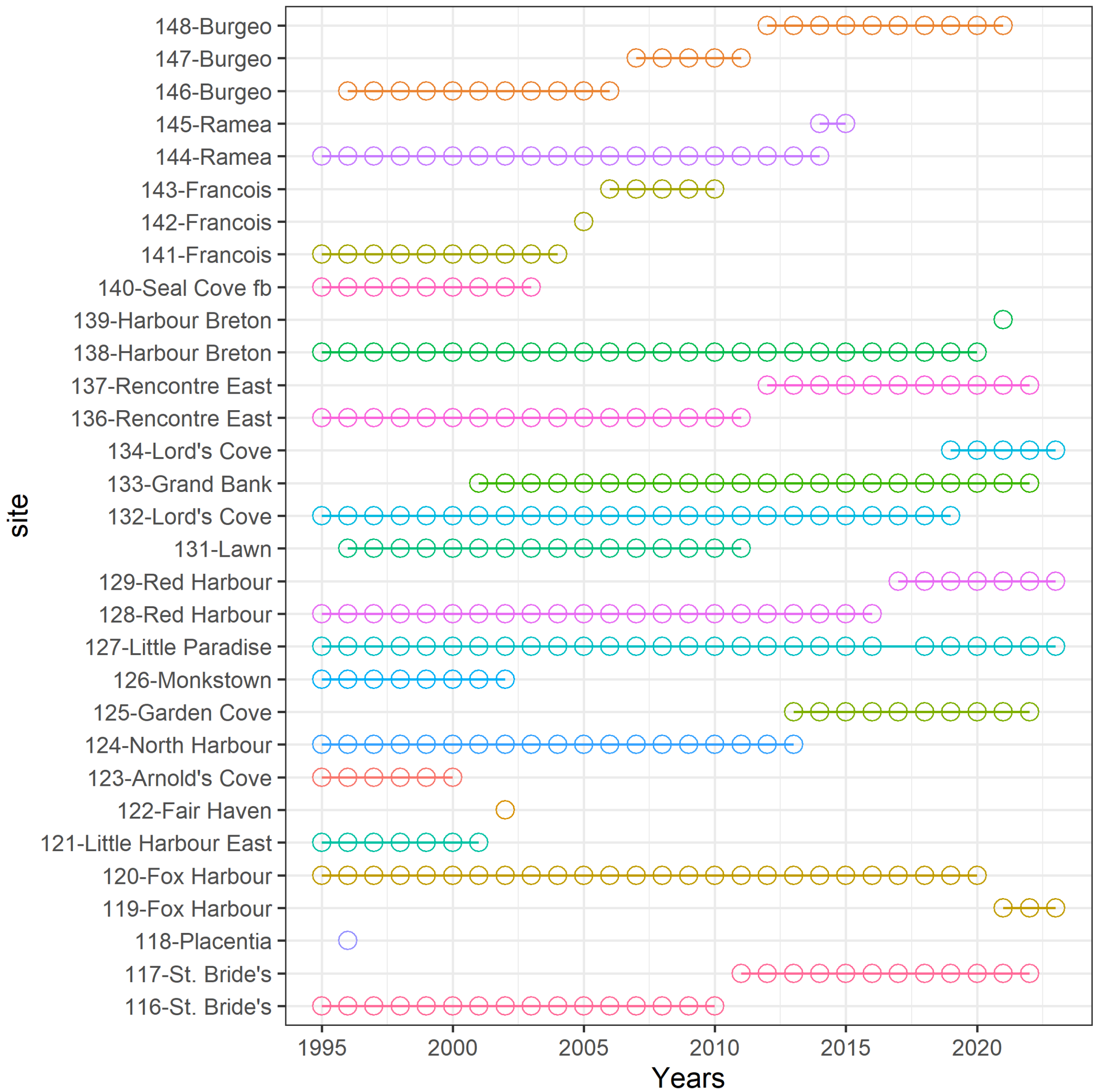


Figure 6.6: Fishing enterprises' commencement and conclusion years of participation in the Sentinel survey, regardless of the gear types employed, spanning from 1995 – 2023. Note that data for the terminal year may be incomplete.

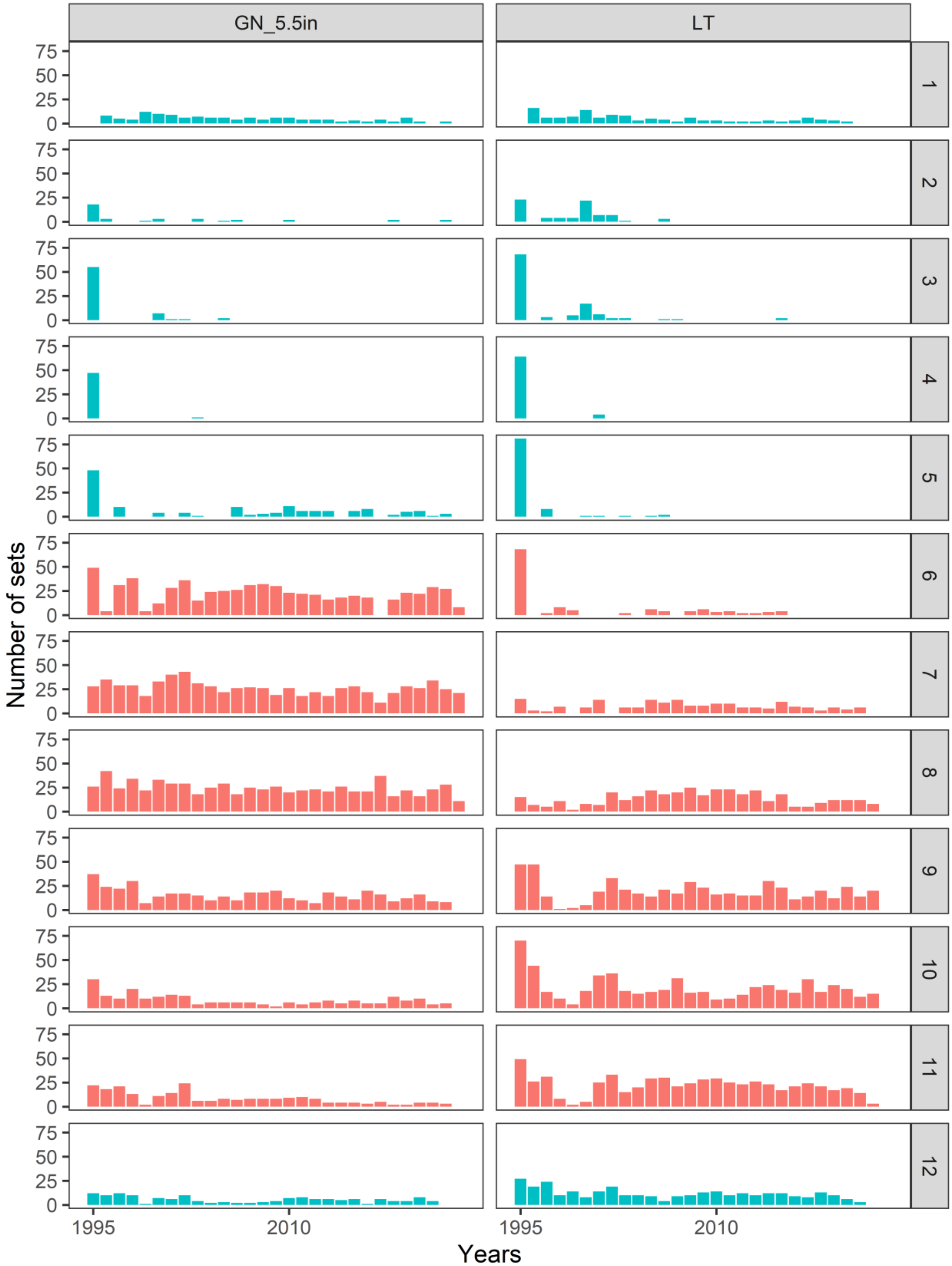


Figure 6.7: Number of sets by month for fixed gears spanning from 1995 – 2023. The data used for the standardization of catch rates were collected from June to November (shown in red). Note that data for the terminal year may be incomplete.

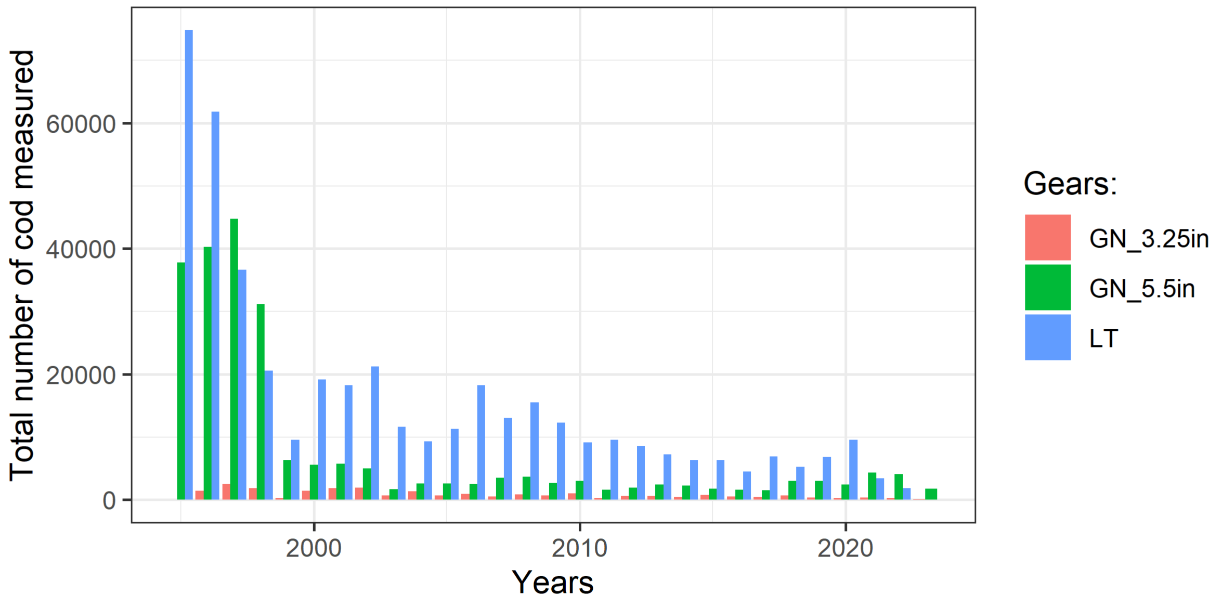


Figure 6.8: Yearly count of the number of Atlantic Cod caught, encompassing both fixed and experimental sets, categorized by gear. Note that data for the terminal year may be incomplete.

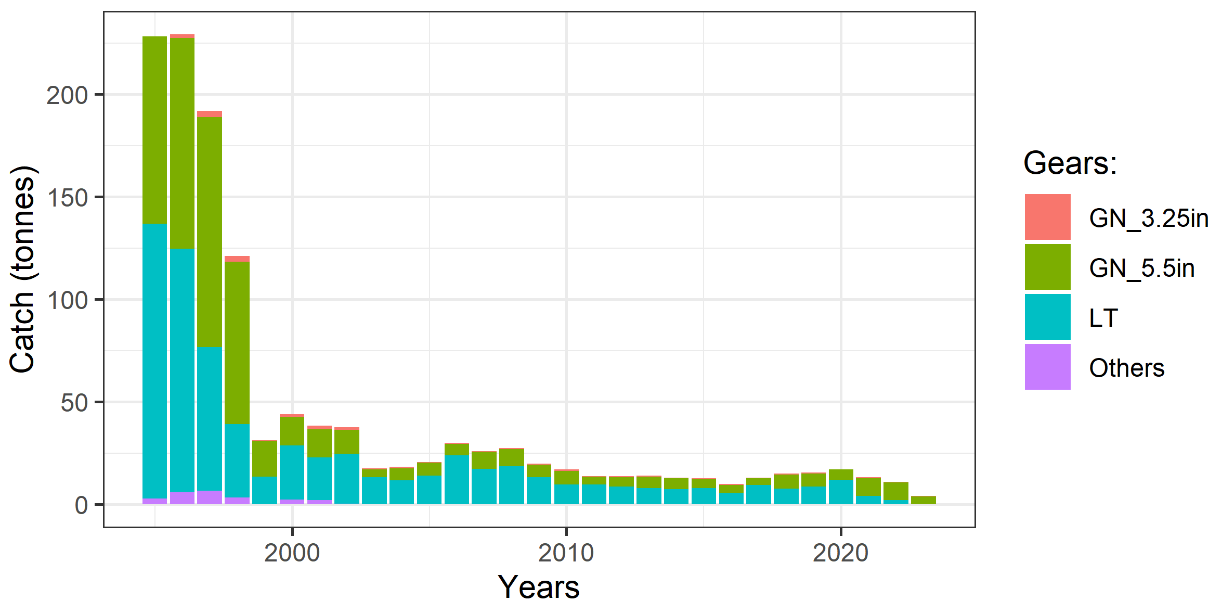


Figure 6.9: Total Atlantic Cod predicted landings, encompassing both fixed and experimental sets, categorized by gears. Note that data for the terminal year may be incomplete.

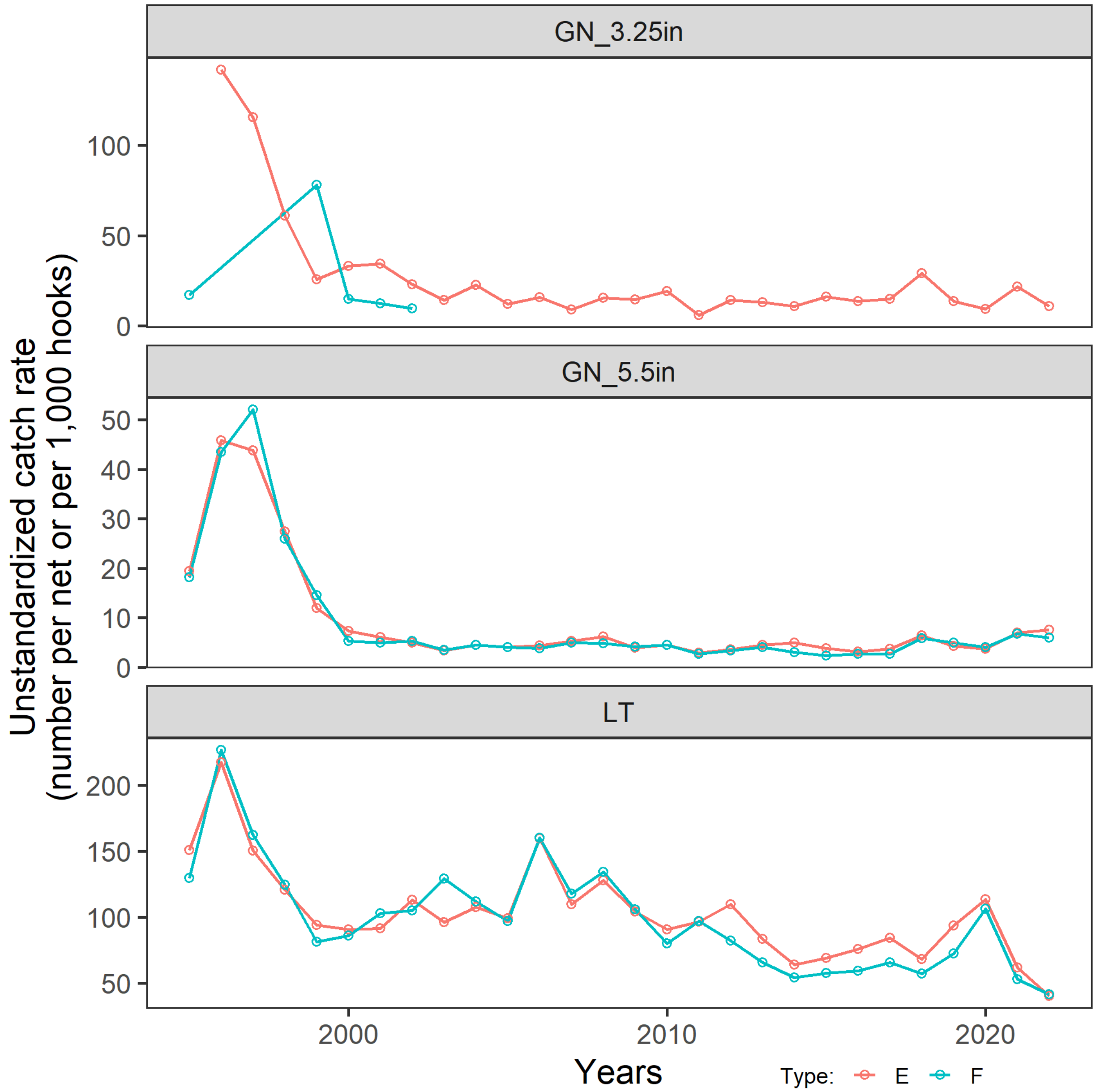


Figure 6.10: Annual unstandardized catch rates categorized by gear and site type: fixed (F) or experimental (E). Catch rates are measured per tow for gillnets and per 1,000 hooks for linetrawl. The line for sets at F sites is shown in green and at E sites is shown in red. Note that data for the terminal year may be incomplete.

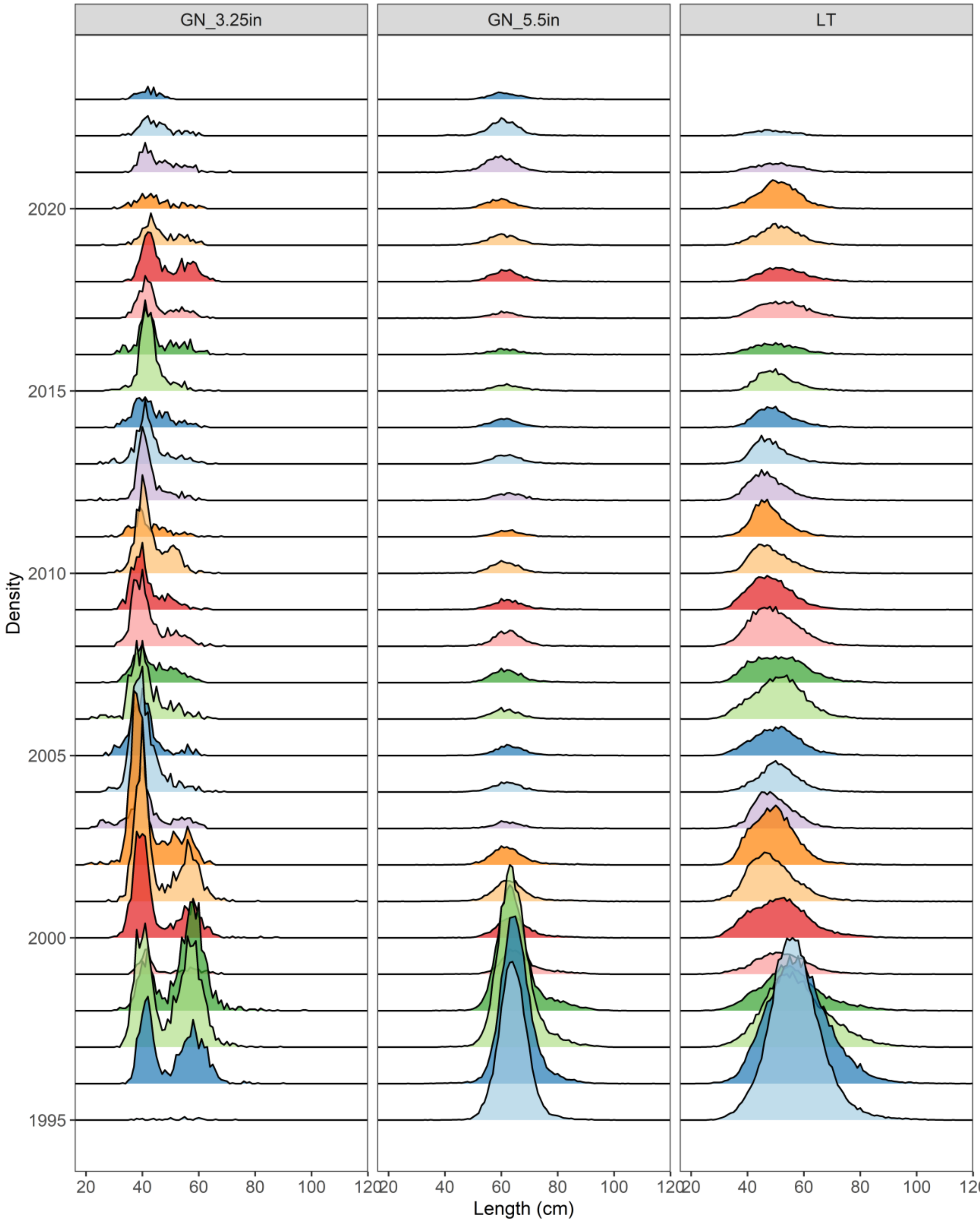


Figure 6.11: Density plot for number of fish caught in each length bin by gear type. The total count reflects the combined number of fish caught in both fixed and experimental sets. Note that the scale is relative within each gear category, and that data for the terminal year may be incomplete.

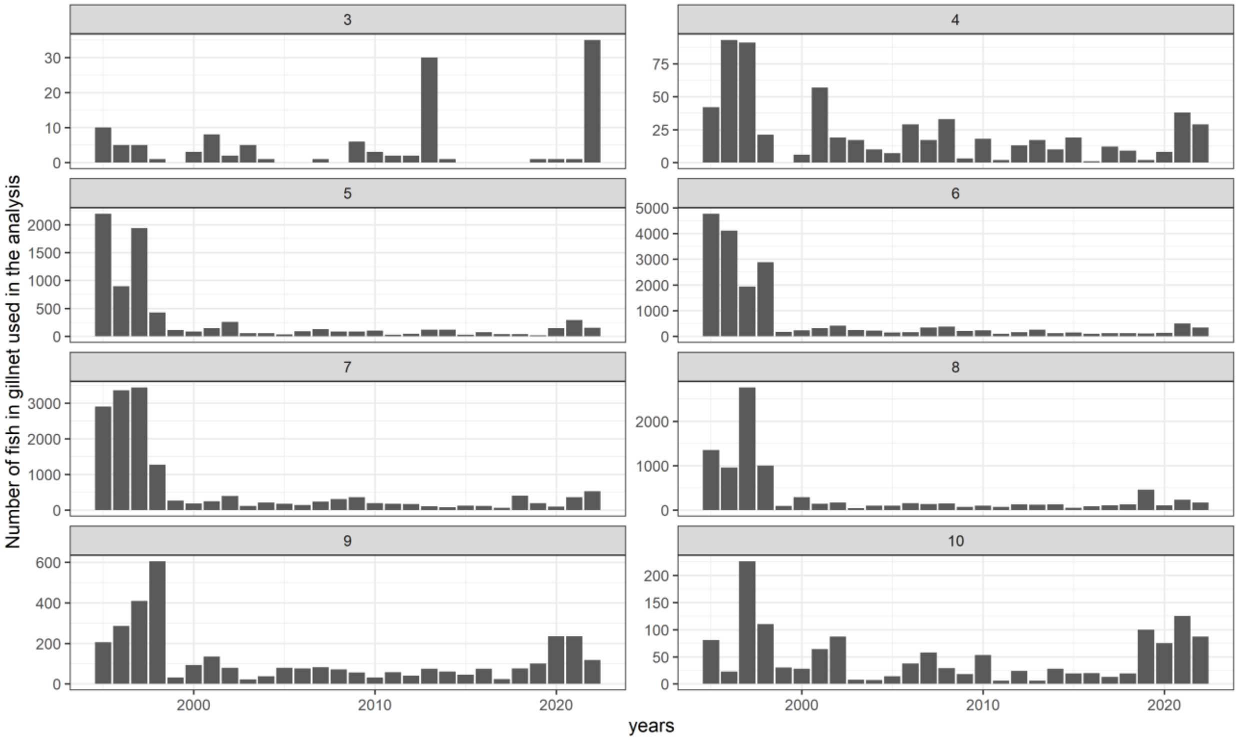


Figure 6.12: Total number of fish in 5.5 inch gillnet used for generating standardized indices. Panels show fish ages.

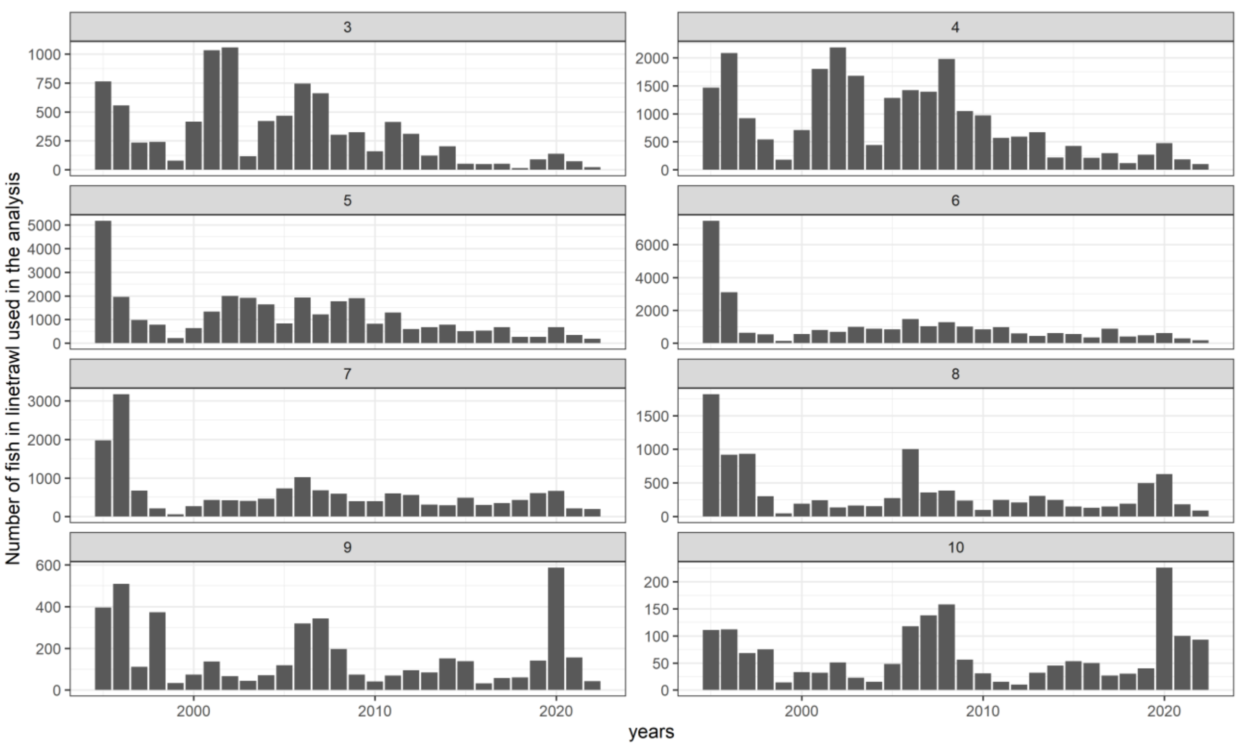


Figure 6.13: Total number of fish in linetrawl used for generating standardized indices. Panels show fish ages.

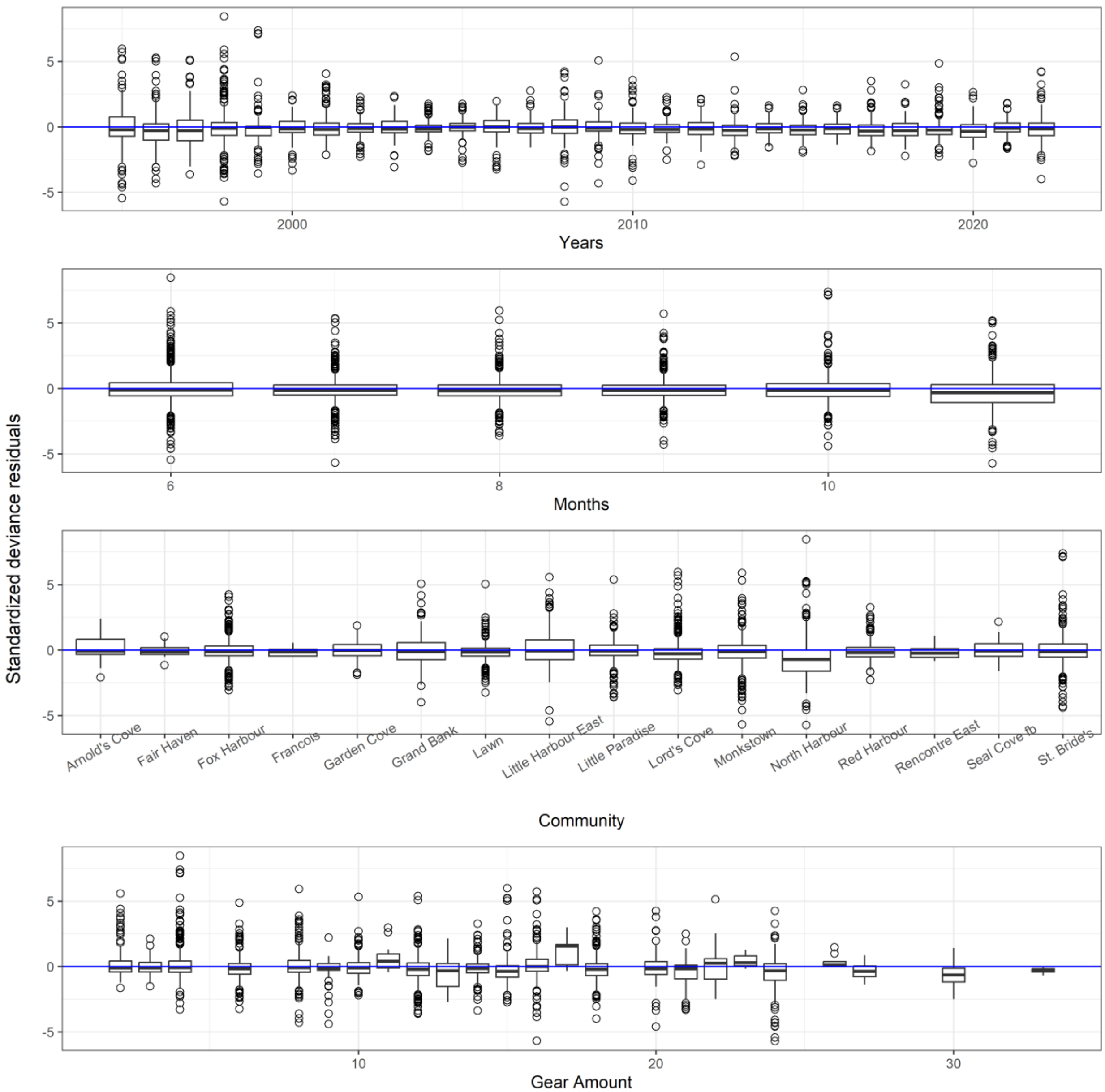


Figure 6.14: Standardized deviance residuals against years, months, community, and gear amount (fishing effort) for 5.5 inch fixed gillnet.

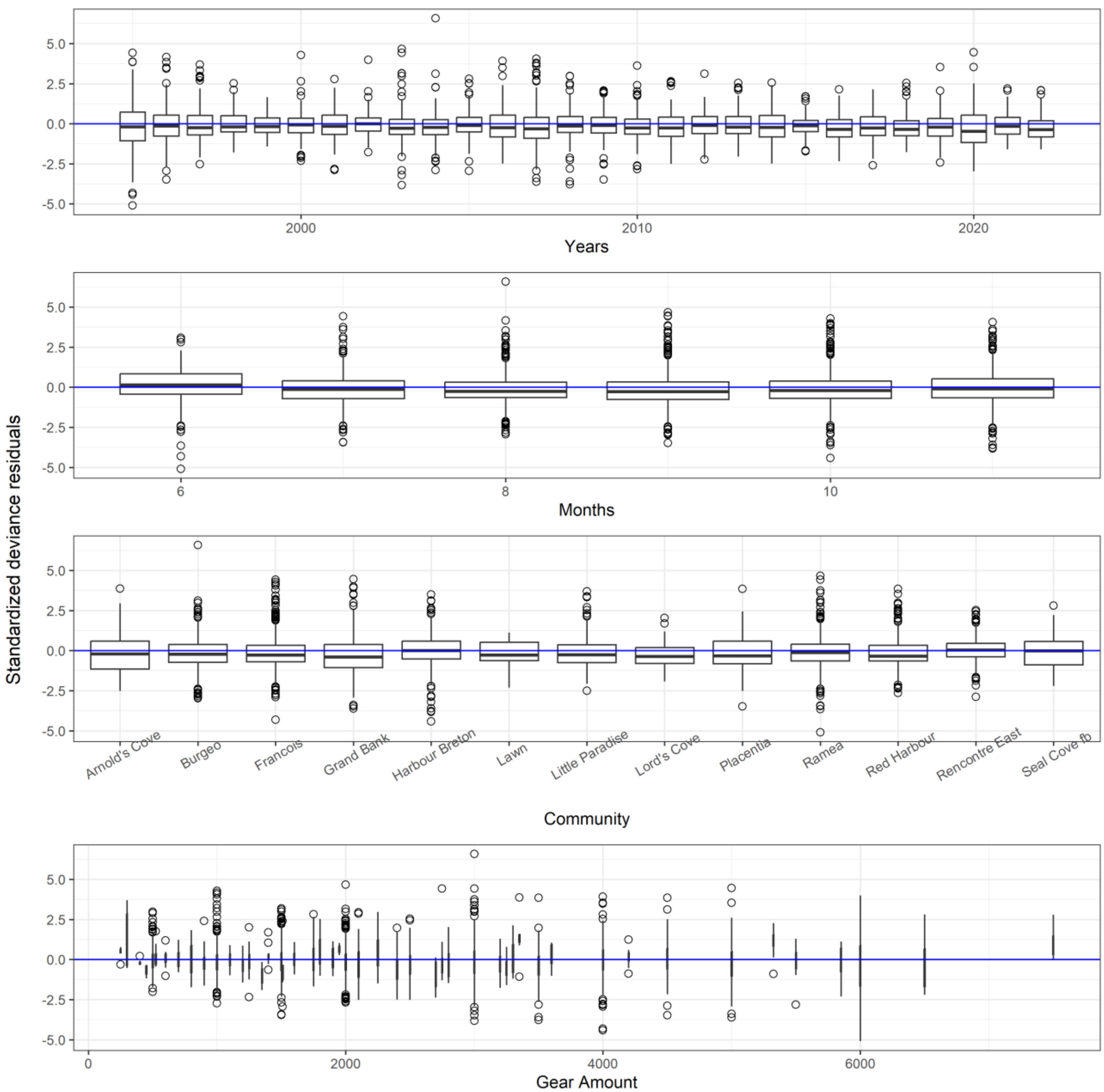


Figure 6.15: Standardized deviance residuals against years, months, community, and gear amount (fishing effort) for linetrawl.

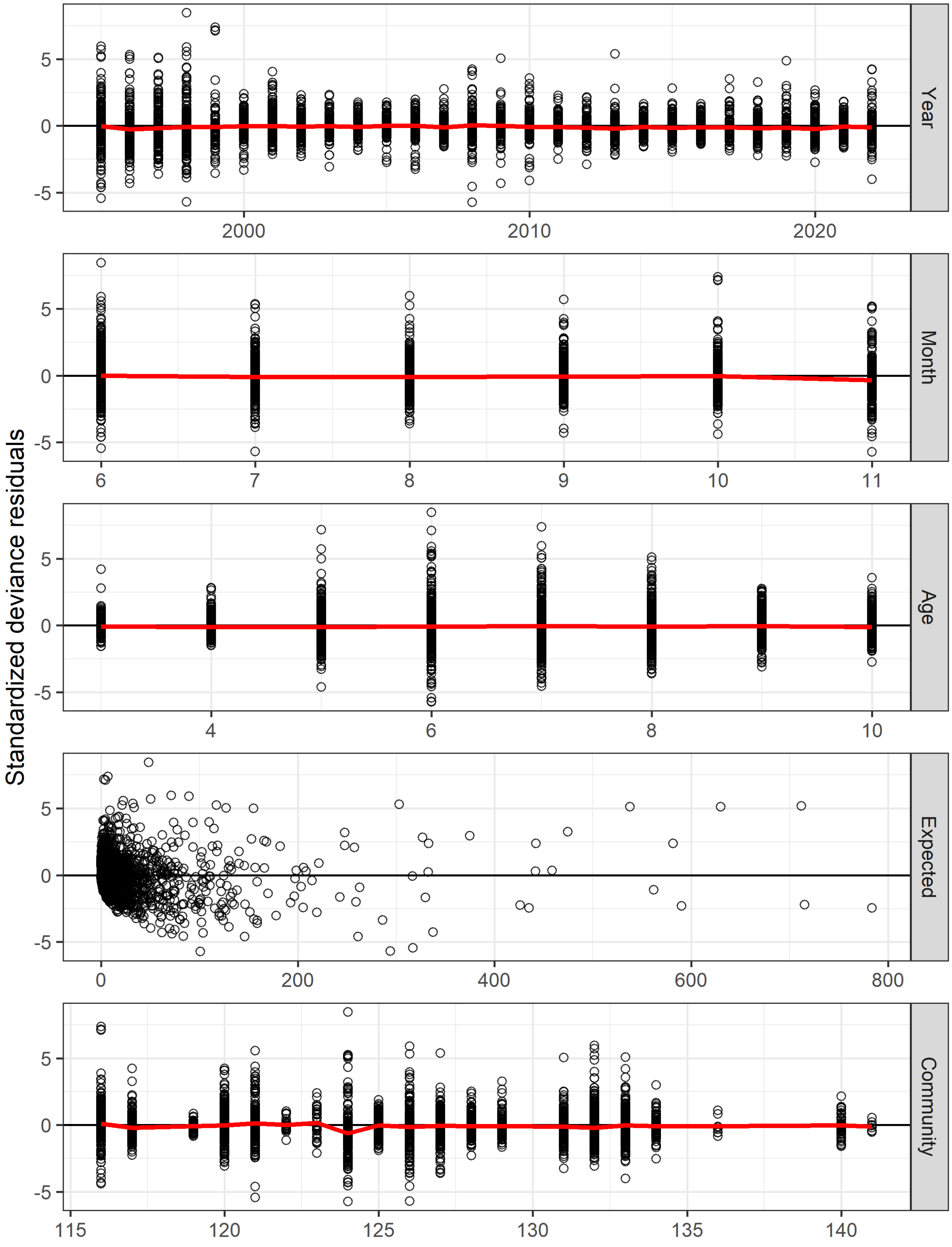


Figure 6.16: Standardized deviance residuals against years, months, ages, expected values, and community for 5.5 inch fixed gillnet.

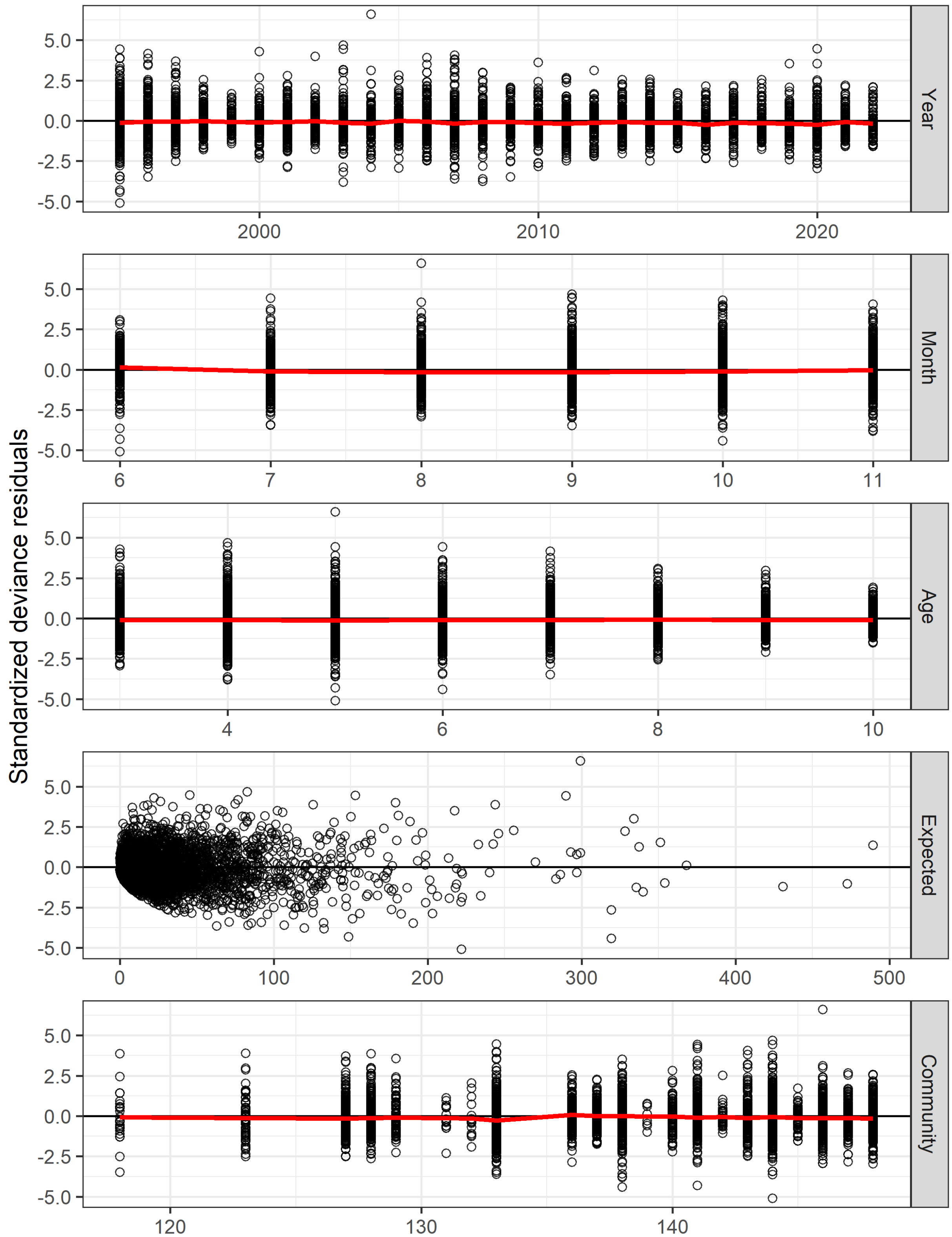


Figure 6.17: Standardized deviance residuals against years, months, ages, expected values, and community for linetrawl.

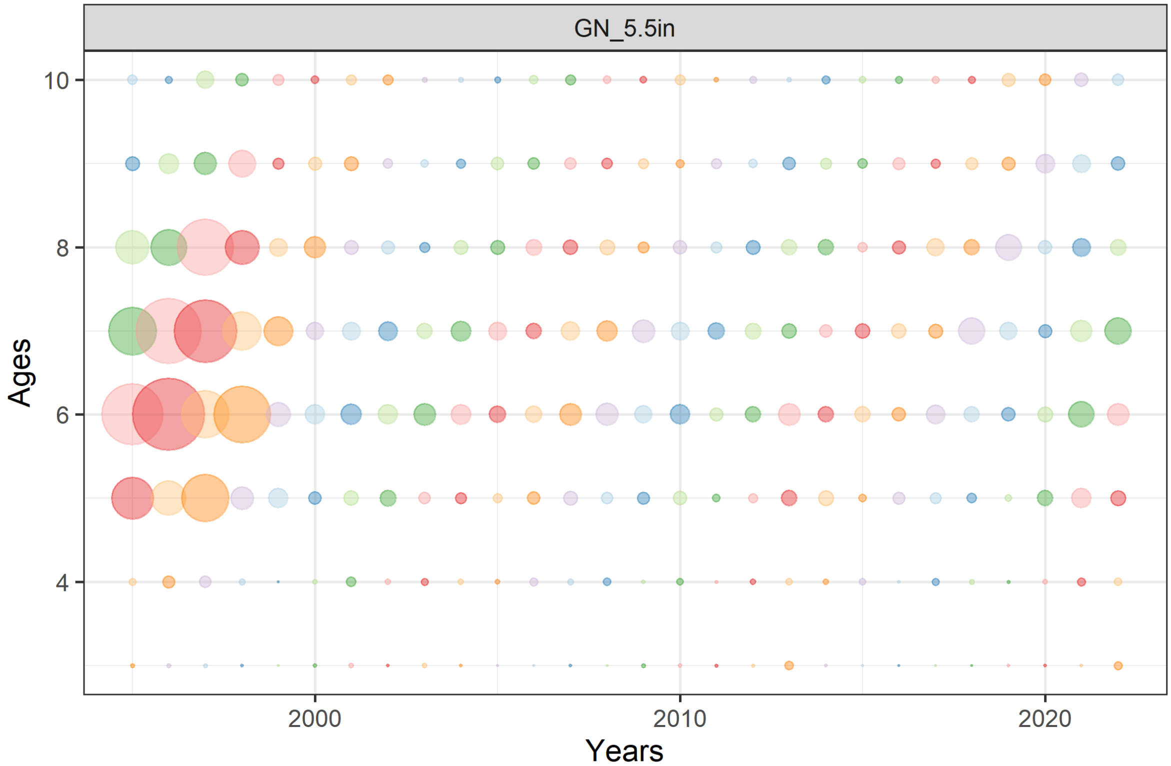


Figure 6.18: Bubble plot based on standardized catch rates for 5.5 inch gillnet from fixed sites.

Figure 6.19: Bubble plot based on standardized catch rates for linetrawl from fixed sites.

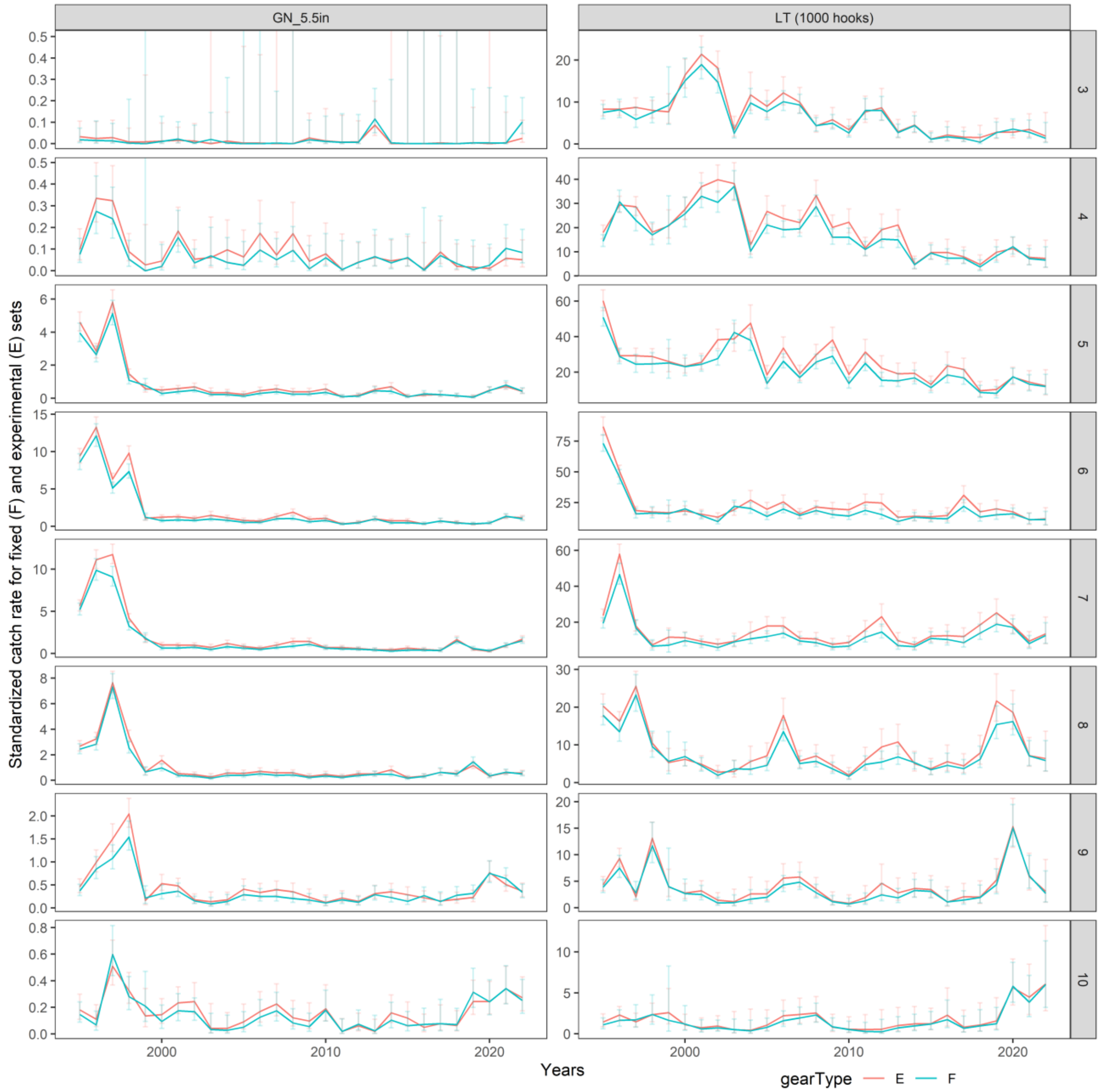


Figure 6.20: Standardized catch rate for 5.5 inch gillnet and linetrawl (per 1,000 hooks) for experimental (E) and fixed (F) sites. The line for sets at F sites is shown in green and at E sites is shown in red.

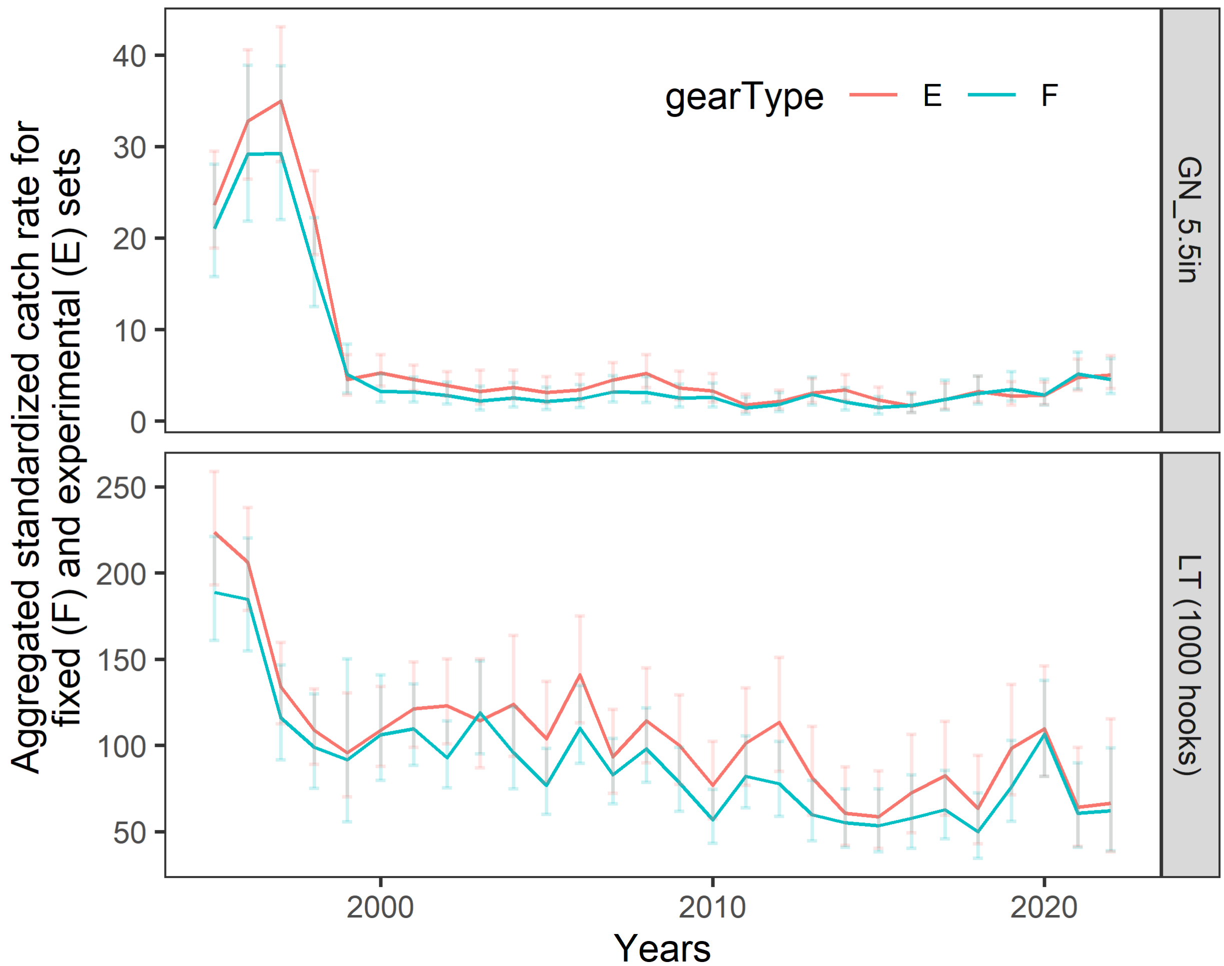


Figure 6.21: Aggregated standardized catch rate for 5.5 inch gillnet and linetrawl (per 1,000 hooks) for experimental (E) and fixed (F) sites. The line for sets at F sites is shown in green and at E sites is shown in red. Note that fish of all lengths were considered in the calculations.

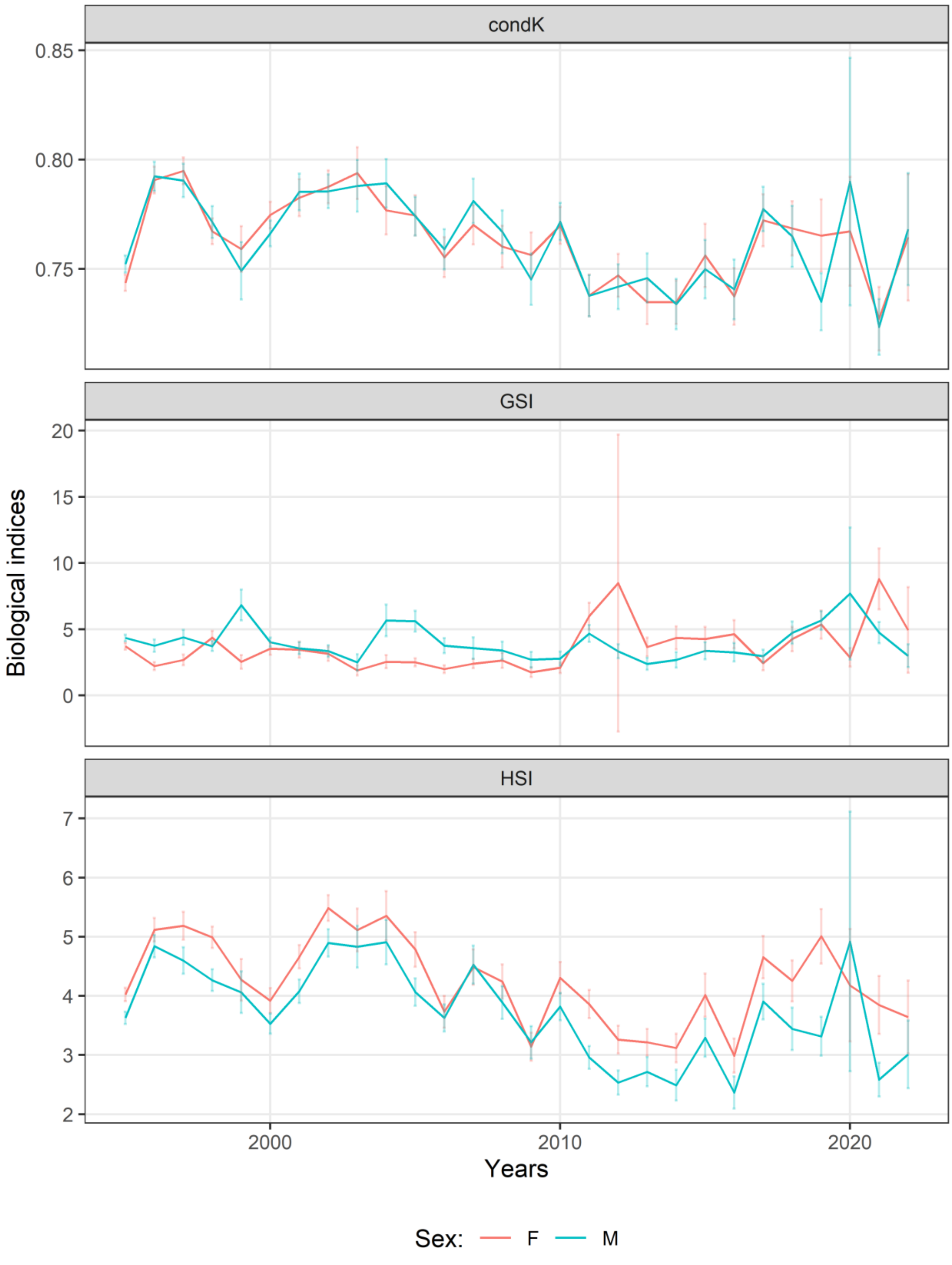


Figure 6.22: Yearly trends in mean Fulton's Condition Factor (K), Hepatosomatic Index (HSI), and Gonadosomatic Index (GSI) by sex in Atlantic Cod from Sentinel surveys in 3Ps. GSI and HSI are represented as percentages.

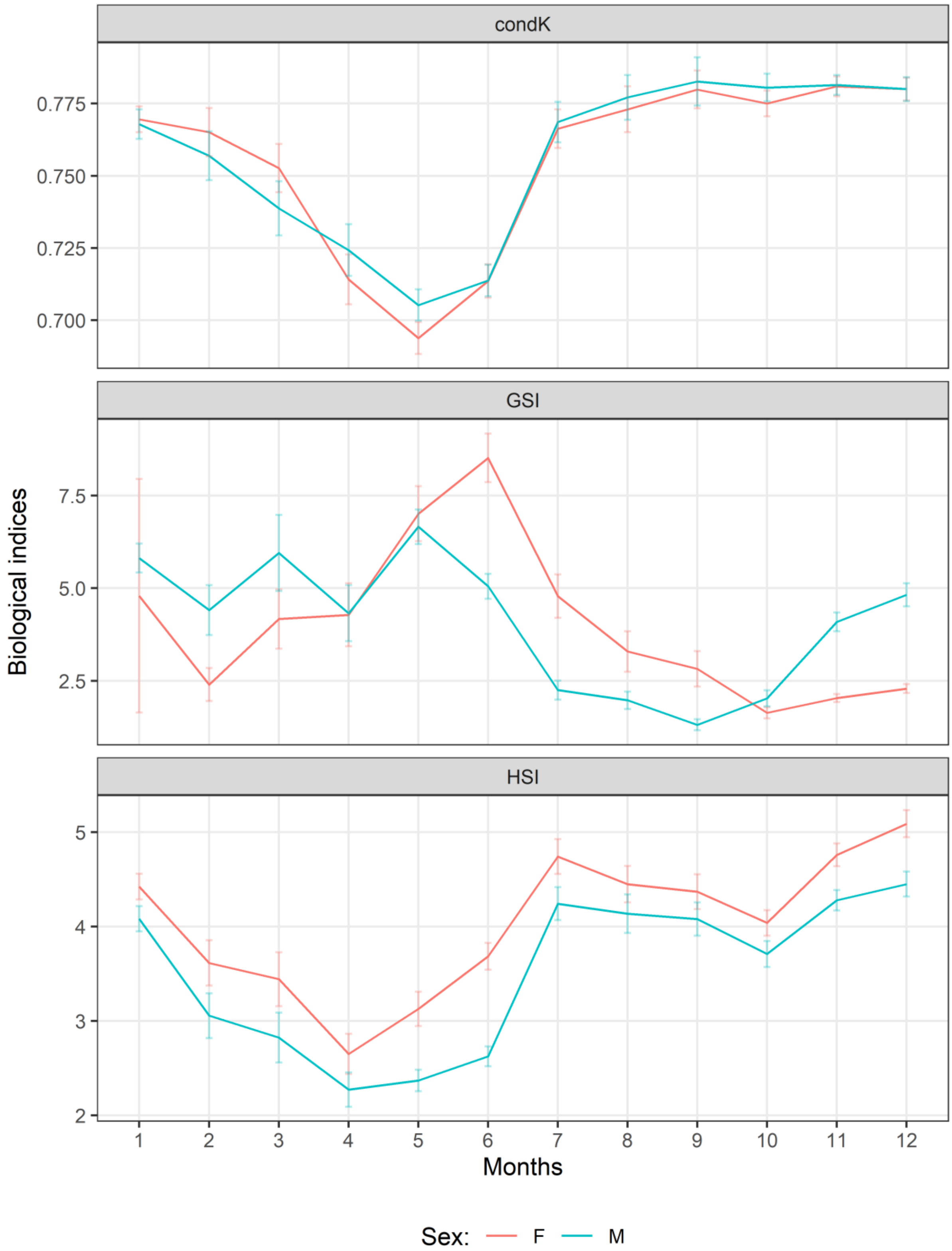


Figure 6.23: Monthly trends in mean Fulton's Condition Factor (K), Hepatosomatic Index (HSI), and Gonadosomatic Index (GSI) by sex in Atlantic Cod from Sentinel surveys in 3Ps. GSI and HSI are represented as percentages.

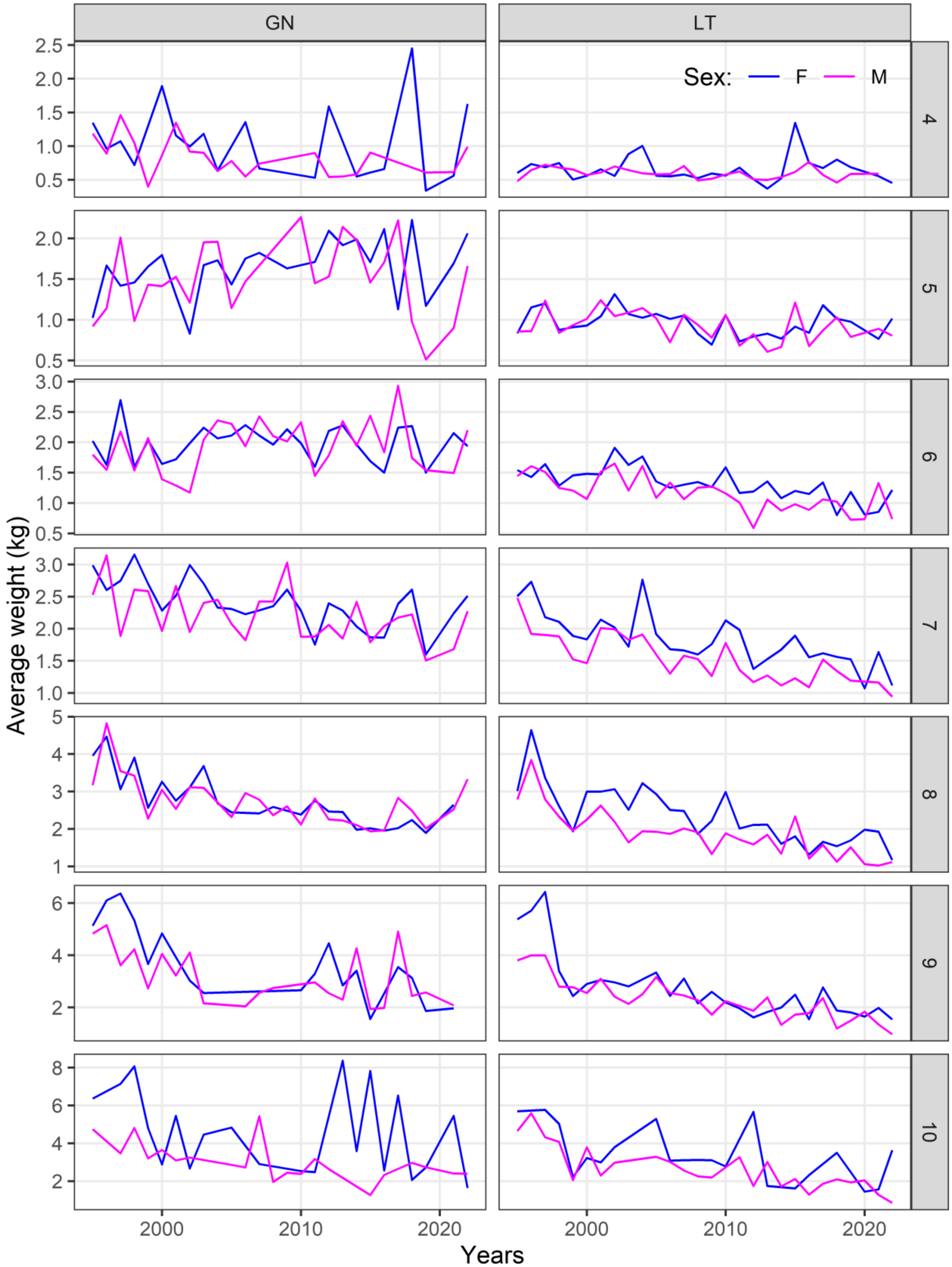


Figure 6.24: Mean Weight-at-age (Wa) from Sentinel surveys by gear type and by sex. The line for sex females are shown in blue and males are shown in red.

7. TABLES

Table 7.1: Annual total count of Sentinel survey deployments by community for 3.25 inch GN, encompassing sets with zero catches. The value is the number of fixed sets with the number of experimental sets in parenthesis. A '-' indicates no deployment.

Year	Little Hr. East	North Hr.	Lawn	St. Bride's	Little Paradise	Fair Haven	Lord's Cove	Red Hr.	Garden Cove
1995	1(0)	1(0)	-	-	-	-	-	-	-
1996	0(5)	0(5)	-	-	-	-	-	-	-
1997	0(7)	0(7)	0(7)	0(1)	-	-	-	-	-
1998	0(8)	0(4)	0(6)	0(11)	-	-	-	-	-
1999	0(1)	1(0)	0(4)	-	-	-	-	-	-
2000	3(16)	8(10)	0(4)	0(7)	-	-	-	-	-
2001	0(15)	8(5)	0(19)	0(9)	6(0)	-	-	-	-
2002	-	4(4)	0(20)	0(20)	2(4)	0(8)	1(19)	0(6)	-
2003	-	0(8)	0(10)	0(9)	0(6)	-	0(12)	0(2)	-
2004	-	0(5)	0(18)	0(11)	0(6)	-	0(16)	0(4)	-
2005	-	0(11)	0(16)	0(11)	0(6)	-	0(16)	-	-
2006	-	0(8)	0(18)	0(10)	0(8)	-	0(15)	-	-
2007	-	0(8)	0(11)	0(10)	0(10)	-	0(20)	0(1)	-
2008	-	0(9)	0(10)	0(9)	0(6)	-	0(20)	-	-
2009	-	0(9)	-	0(7)	0(10)	-	0(20)	-	-
2010	-	0(12)	-	-	0(12)	-	0(20)	0(8)	-
2011	-	0(10)	-	-	0(14)	-	0(20)	0(5)	-
2012	-	0(10)	-	-	0(10)	-	0(20)	0(2)	-
2013	-	0(2)	-	-	0(14)	-	0(20)	-	0(7)
2014	-	-	-	-	0(14)	-	0(20)	-	0(9)
2015	-	-	-	-	0(15)	-	0(20)	0(2)	0(11)
2016	-	-	-	-	0(11)	-	0(20)	-	0(9)
2017	-	-	-	-	-	-	0(20)	-	0(10)
2018	-	-	-	-	0(12)	-	0(2)	-	0(9)
2019	-	-	-	-	0(12)	-	-	-	0(12)
2020	-	-	-	-	0(14)	-	-	-	0(11)
2021	-	-	-	-	0(7)	-	-	-	0(8)
2022	-	-	-	-	0(14)	-	-	-	0(9)

Table 7.2: Annual total count of Sentinel survey deployments by community for 5.5 inch GN, encompassing sets with zero catches. The value is the number of fixed sets with the number of experimental sets in parenthesis. A '-' indicates no deployment.

Year	Arnold's Cove	Fox Hr.	Little Hr. East	Lord's Cove	Monkstown	North Hr.	St. Bride's	Lawn	Little Paradise	Red Hr.	Rencontre East	Seal Cove fb	Hr. Breton	Grand Bank	Fair Haven	Francois	Garden Cove
1995	2(2)	67(78)	74(82)	20(19)	73(72)	55(56)	81(79)	-	-	-	-	-	-	-	-	-	-
1996	-	32(56)	15(16)	16(23)	23(46)	24(39)	29(55)	16(16)	2(4)	-	-	-	-	-	-	-	-
1997	4(4)	24(47)	20(24)	16(24)	24(48)	23(36)	25(44)	22(40)	6(11)	0(12)	0(2)	0(3)	-	-	-	-	-
1998	9(12)	24(47)	15(25)	16(32)	24(48)	15(29)	23(46)	23(42)	9(20)	8(16)	6(12)	6(18)	-	-	-	-	-
1999	0(2)	12(24)	5(4)	12(24)	12(24)	6(12)	2(0)	11(21)	8(16)	5(10)	-	4(18)	0(1)	-	-	-	-
2000	8(12)	16(32)	17(20)	16(32)	19(38)	19(36)	15(27)	20(40)	10(20)	3(18)	-	3(3)	-	-	-	-	-
2001	-	20(40)	11(41)	20(40)	20(40)	15(27)	18(36)	20(39)	10(20)	4(12)	-	12(28)	-	8(16)	-	-	-
2002	-	20(40)	-	20(38)	20(40)	16(18)	20(39)	20(39)	8(16)	8(15)	-	13(14)	-	8(15)	28(35)	2(6)	-
2003	-	16(32)	-	12(23)	-	18(19)	31(19)	10(16)	6(12)	2(4)	-	4(4)	-	6(12)	-	-	-
2004	-	18(36)	-	18(36)	-	14(11)	13(25)	18(36)	12(24)	6(12)	-	-	-	8(16)	-	-	-
2005	-	18(36)	-	18(35)	-	20(24)	16(34)	18(34)	10(20)	8(16)	-	-	-	8(15)	-	-	-
2006	-	18(36)	-	18(35)	-	15(18)	18(36)	18(36)	12(24)	6(12)	-	-	-	6(12)	-	-	-
2007	-	20(40)	-	20(40)	-	16(16)	20(40)	19(29)	16(32)	8(15)	-	-	-	6(12)	-	-	-
2008	-	20(40)	-	20(40)	-	17(17)	18(36)	22(22)	12(24)	6(5)	-	-	-	6(12)	-	-	-
2009	-	20(40)	-	20(39)	-	18(19)	14(28)	20(20)	13(28)	8(8)	-	-	-	6(12)	-	-	-
2010	-	20(40)	-	20(40)	-	24(25)	10(20)	18(18)	12(24)	8(8)	-	-	-	10(20)	-	-	-
2011	-	20(40)	-	18(39)	-	22(20)	16(16)	3(3)	14(28)	7(7)	-	-	-	4(8)	-	-	-
2012	-	19(38)	-	20(40)	-	20(19)	18(18)	-	10(20)	5(5)	-	-	-	11(20)	-	-	-
2013	-	20(40)	-	20(39)	-	4(4)	17(18)	-	14(28)	2(2)	-	-	-	6(10)	-	-	18(36)
2014	-	19(39)	-	20(40)	-	-	18(18)	-	14(28)	4(4)	-	-	-	6(8)	-	-	19(38)
2015	-	20(40)	-	20(20)	-	-	16(16)	-	16(32)	4(4)	-	-	-	10(16)	-	-	21(42)
2016	-	19(40)	-	20(20)	-	-	18(18)	-	14(28)	2(2)	-	-	-	10(4)	-	-	17(36)
2017	-	20(39)	-	20(20)	-	-	16(16)	-	-	8(16)	-	-	-	-	-	-	20(40)
2018	-	20(40)	-	2(2)	-	-	14(14)	-	14(28)	10(10)	-	-	-	8(8)	-	-	18(36)
2019	-	20(40)	-	20(19)	-	-	16(16)	-	12(24)	10(10)	-	-	-	8(4)	-	-	24(48)
2020	-	18(36)	-	20(20)	-	-	20(20)	-	14(28)	10(10)	-	-	-	6(6)	-	-	22(44)
2021	-	20(22)	-	20(20)	-	-	16(16)	-	14(28)	10(10)	-	-	-	12(12)	-	-	16(32)
2022	-	20(20)	-	19(19)	-	-	16(16)	-	14(28)	10(10)	-	-	-	6(6)	-	-	18(36)

Table 7.3: Annual total count of Sentinel survey deployments by community for LT, encompassing sets with zero catches. The value is the number of fixed sets with the number of experimental sets in parenthesis. A '-' indicates no deployment.

Year	Arnold's Cove	Francois	Hr. Breton	Little Paradise	Lord's Cove	Ramea	Red Hr.	Rencontre East	Seal Cove fb	Burgeo	Lawn	Placentia	Grand Bank
1995	72(75)	77(104)	64(90)	27(25)	4(4)	92(109)	14(17)	87(87)	90(109)	-	-	-	-
1996	30(33)	12(54)	9(30)	12(20)	-	9(37)	7(23)	25(71)	16(55)	9(37)	12(13)	21(20)	-
1997	29(32)	12(62)	7(20)	8(19)	-	17(79)	4(13)	15(49)	12(29)	12(48)	-	-	-
1998	3(3)	12(56)	7(21)	4(6)	-	10(50)	2(5)	11(45)	4(14)	12(50)	-	-	-
1999	4(1)	4(26)	10(21)	2(9)	-	6(32)	2(3)	7(29)	4(6)	6(22)	-	-	-
2000	16(6)	8(44)	10(35)	5(9)	-	15(73)	4(4)	15(75)	23(29)	8(28)	-	-	-
2001	-	16(19)	8(23)	11(16)	-	37(55)	3(11)	28(43)	3(3)	13(51)	-	-	18(18)
2002	-	11(11)	19(34)	17(17)	2(2)	29(53)	12(16)	24(36)	6(15)	21(24)	-	-	18(18)
2003	-	15(10)	16(18)	8(10)	-	13(33)	7(7)	10(10)	0(1)	17(19)	-	-	10(10)
2004	-	5(5)	15(15)	6(10)	-	12(24)	11(0)	16(16)	-	12(12)	-	-	10(10)
2005	-	21(21)	16(17)	8(8)	-	18(26)	10(2)	20(20)	-	14(14)	-	-	10(10)
2006	-	19(19)	14(14)	6(6)	-	17(27)	11(5)	16(16)	-	22(22)	-	-	12(12)
2007	-	14(14)	14(14)	4(4)	-	21(28)	12(5)	18(18)	-	20(20)	-	-	12(12)
2008	-	16(16)	15(16)	8(8)	-	21(29)	13(10)	17(17)	-	18(18)	-	-	14(14)
2009	-	11(11)	17(17)	5(7)	-	20(28)	11(5)	18(18)	-	19(22)	-	-	14(14)
2010	-	13(14)	18(19)	-	-	20(28)	11(5)	18(18)	-	20(20)	-	-	7(9)
2011	-	-	18(18)	6(6)	-	20(28)	12(6)	18(18)	-	20(20)	-	-	7(8)
2012	-	-	18(18)	-	-	20(28)	14(4)	20(20)	-	12(12)	-	-	8(8)
2013	-	-	16(16)	-	-	20(26)	18(10)	20(20)	-	17(17)	-	-	14(11)
2014	-	-	20(20)	6(6)	-	20(28)	15(2)	20(20)	-	16(16)	-	-	14(10)
2015	-	-	19(19)	6(6)	-	22(26)	16(14)	20(20)	-	16(16)	-	-	10(6)
2016	-	-	16(15)	4(4)	-	-	4(4)	20(20)	-	18(18)	-	-	10(7)
2017	-	-	22(22)	-	-	-	12(12)	20(20)	-	20(20)	-	-	19(17)
2018	-	-	20(20)	8(8)	-	-	10(10)	20(20)	-	17(17)	-	-	12(12)
2019	-	-	21(22)	8(7)	-	-	10(10)	20(19)	-	13(13)	-	-	12(10)
2020	-	-	21(22)	6(6)	-	-	10(10)	18(18)	-	18(18)	-	-	14(14)
2021	-	-	6(6)	6(6)	-	-	8(8)	20(20)	-	13(13)	-	-	8(7)
2022	-	-	-	6(6)	-	-	10(10)	16(16)	-	-	-	-	14(14)

Table 7.4: Mean standardized catch rate for 5.5 inch GN from the Sentinel survey for fixed sites by age.

Year	3	4	5	6	7	8	9	10
1995	0.018	0.075	3.947	8.569	5.214	2.437	0.370	0.146
1996	0.015	0.274	2.638	12.110	9.887	2.827	0.843	0.068
1997	0.013	0.241	5.125	5.120	9.090	7.305	1.079	0.598
1998	0.003	0.053	1.093	7.346	3.250	2.544	1.538	0.280
1999	0.000	0.000	0.773	1.240	1.839	0.662	0.216	0.209
2000	0.010	0.020	0.288	0.763	0.629	0.977	0.311	0.094
2001	0.022	0.154	0.398	0.858	0.671	0.379	0.365	0.173
2002	0.004	0.036	0.491	0.791	0.755	0.325	0.151	0.166
2003	0.020	0.069	0.231	1.000	0.482	0.170	0.089	0.032
2004	0.004	0.038	0.220	0.816	0.805	0.391	0.140	0.027
2005	0.000	0.026	0.135	0.555	0.647	0.380	0.289	0.051
2006	0.000	0.096	0.294	0.526	0.483	0.510	0.251	0.126
2007	0.003	0.051	0.384	1.014	0.711	0.402	0.249	0.174
2008	0.000	0.094	0.243	1.073	0.887	0.429	0.203	0.083
2009	0.018	0.009	0.253	0.619	1.101	0.217	0.171	0.055
2010	0.010	0.060	0.349	0.796	0.648	0.339	0.107	0.178
2011	0.006	0.006	0.093	0.305	0.557	0.224	0.177	0.019
2012	0.006	0.039	0.137	0.473	0.507	0.388	0.124	0.073
2013	0.115	0.065	0.459	0.999	0.417	0.467	0.287	0.023
2014	0.004	0.037	0.426	0.463	0.294	0.478	0.224	0.103
2015	0.000	0.061	0.090	0.487	0.403	0.161	0.145	0.061
2016	0.000	0.004	0.269	0.355	0.406	0.305	0.269	0.072
2017	0.000	0.070	0.223	0.728	0.364	0.622	0.141	0.076
2018	0.000	0.033	0.150	0.460	1.474	0.482	0.277	0.069
2019	0.003	0.006	0.060	0.348	0.602	1.445	0.316	0.313
2020	0.003	0.026	0.467	0.454	0.331	0.348	0.753	0.241
2021	0.003	0.104	0.794	1.359	0.980	0.639	0.641	0.341
2022	0.101	0.084	0.437	1.006	1.518	0.495	0.338	0.252

Table 7.5: Mean standardized catch rate for LT (per 1,000 hooks) from the Sentinel survey for fixed sites by age.

Year	3	4	5	6	7	8	9	10
1995	7.516	14.403	50.852	73.212	19.354	17.861	3.891	1.091
1996	8.161	30.687	28.760	45.640	46.596	13.513	7.499	1.647
1997	5.890	23.011	24.434	15.898	16.722	23.286	2.795	1.697
1998	7.507	16.993	24.688	16.522	6.659	9.549	11.716	2.356
1999	9.260	20.981	25.200	16.058	7.150	5.626	3.985	1.641
2000	15.089	25.752	23.141	19.877	9.757	6.892	2.684	1.197
2001	18.919	33.002	24.468	14.523	7.857	4.469	2.509	0.586
2002	14.739	30.438	27.696	9.617	5.832	1.921	0.919	0.710
2003	2.542	37.114	42.309	21.994	8.975	3.647	0.973	0.508
2004	9.779	10.244	37.910	20.232	10.755	3.554	1.649	0.348
2005	7.690	21.123	13.648	13.747	12.014	4.571	1.964	0.792
2006	10.064	19.143	26.076	19.750	13.814	13.517	4.317	1.592
2007	9.271	19.539	16.996	14.468	9.524	5.043	4.818	1.938
2008	4.381	28.736	25.646	18.596	8.631	5.628	2.858	2.292
2009	4.965	16.039	29.008	15.291	6.080	3.636	1.130	0.855
2010	2.643	16.107	13.664	14.030	6.649	1.629	0.682	0.515
2011	7.985	10.962	24.998	18.656	11.542	4.795	1.334	0.290
2012	7.983	15.220	15.451	15.271	14.499	5.460	2.446	0.258
2013	2.728	14.938	15.117	9.772	6.955	6.820	1.878	0.716
2014	4.360	4.661	16.754	13.145	6.315	5.284	3.265	0.967
2015	1.139	9.468	11.344	12.237	10.965	3.394	3.082	1.184
2016	1.705	7.343	18.409	11.797	10.370	4.594	1.114	1.740
2017	1.295	7.347	16.761	22.041	8.617	3.686	1.444	0.672
2018	0.422	3.794	8.560	13.327	13.910	6.193	1.945	0.973
2019	2.721	8.286	8.069	15.026	18.828	15.397	4.390	1.237
2020	3.561	12.142	17.367	15.882	17.085	16.215	15.036	5.789
2021	2.785	7.193	13.227	11.254	8.122	7.039	6.033	3.867
2022	1.362	6.549	11.931	11.088	12.644	5.836	2.723	6.030

Table 7.6: Mean aggregated standardized catch rate for 5.5 inch GN (per net) and LT (per 1,000 hooks) from the Sentinel survey for fixed and experimental sites.

Year	Fixed GN	Exp. GN	Fixed LT	Exp. LT
1995	21.057031	23.611108	188.77258	223.57273
1996	29.154191	32.774983	184.60236	206.07582
1997	29.238855	34.938366	115.95609	134.05816
1998	16.677041	22.304550	98.81320	108.74979
1999	5.081394	4.565475	91.63618	95.86435
2000	3.257214	5.274975	106.13538	108.70829
2001	3.158446	4.516448	109.59789	121.32053
2002	2.813990	3.861608	92.90730	123.10908
2003	2.172284	3.227349	119.08149	114.37965
2004	2.532518	3.663865	95.78162	123.82457
2005	2.164201	3.103937	76.88701	104.00684
2006	2.406981	3.377600	109.93382	140.83487
2007	3.196715	4.507387	83.01086	93.46244
2008	3.141099	5.174149	97.95018	114.17095
2009	2.516545	3.600467	78.38163	100.20454
2010	2.555111	3.300079	56.88274	76.83594
2011	1.450963	1.748964	82.13211	101.32013
2012	1.825490	2.140346	77.75433	113.44339
2013	2.911828	3.052105	59.79525	81.24346
2014	2.091480	3.393670	55.32720	60.68688
2015	1.465598	2.307079	53.60569	58.66489
2016	1.715057	1.673252	57.87488	72.49081
2017	2.340421	2.369165	62.79908	82.44069
2018	3.026534	3.214496	50.11136	63.69840
2019	3.445193	2.763710	76.06675	98.39943
2020	2.842334	2.786924	106.43834	109.54765
2021	5.139130	4.754451	60.70972	64.14087
2022	4.525168	5.030135	62.03074	66.56257