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Application of Conversion Factors in the Canadian (Newfoundland And Labrador Region) Spring And Autumn Multi-Species RV Bottom Trawl Surveys

by

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Abstract

The introduction of new vessels and minor modifications to the Campelen survey trawl necessitated comparative fishing to determine the difference in relative catchability between previous and new vessel and trawl combinations in the DFO-NL surveys. Going forward, surveys will now be conducted by the CCGS John Cabot and CCGS Capt. Jacques Cartier. Conversion factors have been previously estimated from comparative fishing, estimating species- vessel- and area- specific differences in relative catchability. Here we provide conversion factors estimated for stocks directly considered by NAFO SC, discuss gaps in and extensions of conversions, and outline the application of these conversion factors. Further consideration of implementation will need to continue on a stock by stock basis.

Introduction

Multispecies bottom trawl surveys have been conducted annually in the spring and fall in the Newfoundland and Labrador region using a Campelen 1800 survey trawl aboard the Canadian Coast Guard Ships (CCGS) Teleost, CCGS Alfred Needler and CCGS Wilfred Templeman since autumn 1995. These surveys are used to estimate the distribution and abundance of many fish and invertebrate species, determine species life history characteristics, and track changes in the ecosystem. The CCGS Wilfred Templeman was last used in these surveys in 2008, and the CCGS Alfred Needler and CCGS Teleost were phased out in 2022 and 2023, respectively. Going forward, surveys will be conducted by the Offshore Fishery Science Vessels (OFSVs) CCGS John Cabot and CCGS Capt. Jacques Cartier. More often than not, especially in fall, multiple vessels contribute to a stock index in any given year. The Campelen 1800 survey trawl will continue to be used, with a few modifications (see Wheeland et al. 2024).

Comparative fishing was completed from 2021-2023 to determine differences in catchability between the outgoing vessels fishing the Campelen trawl and the new vessels fishing the modified Campelen trawl. Where sufficient paired tow data permitted, species-specific conversion factors were estimated by season and vessel pair. The outgoing Needler has been shown to have comparable catchability to its sister ship, the Templeman (Cadigan et al. 2006); data from these ships are referred to as “Needler/Templeman” throughout this document. Likewise, the new sister ships Cabot and Cartier exhibit similar fishing performance to each other (DFO 2024). Analyses therefore focused on differences between the Teleost relative to the Cabot and Cartier, and the Needler/Templeman relative to the Cabot and Cartier.

Unfortunately, the early retirement of the Needler limited the amount of paired tow data collected, precluding the estimation of conversion factors for several species, particularly on the Grand Bank (Div. 3LNO) and in

Subdiv. 3Ps. In some cases, the continuity of the historic and contemporary series will be disrupted. Additionally, data collected during the comparative fishing program indicate that the catchability of the Teleost and Needler was not always equal (DFO *in press*) as previously assumed, though differences cannot be directly estimated. Gaps in conversion factors for the Needler/Templeman and/or Teleost series therefore also complicate the continuity of the historic series given the use of mixed vessels in past surveys.

Conversion factors were calculated and reviewed through Canadian Science Advisory Secretariat (CSAS) Regional peer review processes (DFO 2024, DFO *in press*) based on paired tow data collected from 2021-2023. With conversion factors now estimated and gaps identified, attention turns to application of these conversions to the Newfoundland and Labrador (CAN-NL) multispecies survey data.

Methods

Conversion factor application

The application of conversion factors converts data from the old vessels collected during the CAN-NL multispecies surveys to new vessel equivalent catch, and vice versa. Generally, it is recommended to convert catch from the old vessels into units equivalent to the new vessels, with old vessel catch divided by the conversion factor rho (ρ) to obtain new vessel equivalent catch. Alternatively, catch from a new vessel multiplied by ρ obtains old vessel equivalent catch.

Conversion factors applied to set by set catches from the CAN-NL multispecies survey on a species/stock, vessel, and season specific basis. When a length-based conversion has been estimated, this is applied to set-specific catch abundance at length, with catch biomass calculated from converted abundance at length through the application of length: weight relationships. Where applicable, we note here the length weight parameters used in application. When size-aggregated conversions for abundance and biomass are estimated (see shrimp and squid below) these are applied to set by set catch numbers and weights, respectively,

Spatial and seasonal coverage of the paired tows was incomplete and we were unable to estimate conversion factors for all area, season, and vessel combinations in these surveys. Figures 1-4 show the distribution of paired tows by depth and temperature for each vessel series relative to that normally covered in the survey. Further discussion on the representativeness of paired tows can be found in DFO 2024, DFO *in press*, and Trueman et al. *in press.*

We report here where conversion factors have been directly estimated, and where gaps exist we comment on the appropriateness of the extension of these factors to conditions (e.g. area, season) poorly represented or unsampled in the paired tows. Consideration is given to a variety of factors that impact relative catchability including, but not necessarily limited to: bathymetry, depth, temperature, substrate, size composition, distribution, etc.

Sensitivity of indices to vessel mixing in the historic time series

Surveys in the Newfoundland and Labrador Region are designed to be completed by a single vessel (spring) or two survey vessels that begin on the north and south extremes of the survey area and work their way towards each other (autumn). In reality, mechanical, operational, and weather-related issues have resulted in unplanned contributions by additional vessels, and significant differences in the mixing of survey vessels across space and time in the CAN-NL surveys (see Rideout et al. 2024). Data collected during the comparative fishing program indicate that the Teleost and Needler/Templeman did not fish comparably for all species (DFO 2024 *in press*). However, given no direct comparisons between these vessels, we are unable to quantify this possible catchability difference. Decisions therefore need to be made regarding how to treat data from previous years where these vessels substituted for each other or where mixing of the vessels occurred.

A simple empirical exercise was completed to examine the sensitivity of survey biomass index trends to a possible range of differences in catchability between the Teleost and Needler/Templeman in the past Campelen series. This exercise focused on stocks/indices for the Grand Bank (Divs. 3LNO), where the Needler/Templeman have been the primary research vessels, with only sporadic or spatially-limited contributions from the Teleost. Multipliers of 0.5 and 2 were applied to all Teleost catches and indices recalculated. This range of multipliers was used to capture the general scale of the current conversions estimated for finfish to the Cabot/Cartier, though we note this range selection is subjective and this testing does not account for potential size differences. This exercise was primarily completed to inform data use in interim monitoring for stocks in the current meeting. Further exploration is warranted and should be undertaken on a stock-by-stock basis during full assessments.

Results

These results summarize the application of conversion factors derived in DFO 2024, and DFO *in press* as they relate to stocks considered by NAFO Scientific Council. Unless otherwise specified, length is considered here in centimeters and weight in kilograms.

Atlantic Cod in Div. 3NO & Div. 2J3KL
Broad consistency in results from comparative fishing across the CAN-NL spring and fall surveys (DFO 2024), and CAN-Gulf summer survey in Div. 4RS (Benoît et al. 2024) indicate no conversion is required for indices of Atlantic cod across vessels, areas and seasons in the NL multispecies survey using the Campelen or modified Campelen trawl (Wheeland and Trueman*, in press*).

Greenland halibut in SA 2+3KLMNO
Conversions for the spring survey series could not be estimated for the Needler/Templeman series, while data showed no conversion is required for the Teleost spring in Div. 3LNO. Fall conversions were estimated for Div. 2HJ3KL for Teleost, and Div. 3KL Needler/Templeman. Given overlap in size distribution across the survey area, and habitat (including depth and temperature) occupied by Greenland halibut, application of these conversion factors can be extended across Div. 3LNO fall for both series.

The length-based conversion (Table 2) is applied to the fall Teleost set specific catch abundance at length. Converted catch weights (biomass) are then calculated through the application of the following length weight relationship(s):

$$log(weight) = -12.743 + 3.262\ log(length).$$

These parameters were estimated using a spatio-temporal generalized linear mixed model fit to spring and fall survey samples collected from 1996 onward where spatio-temporal deviations from the mean length-weight relationship were assumed to follow an AR1 process. This approach accounts for spatial and temporal dependence in the observations and, as such, should improve estimates of population-level length-weight parameters. This model was fit using the R package sdmTMB (Anderson et al. 2024).

Yellowtail Flounder in Div. 3LNO
A length-based conversion factor (Table 3) was estimated for Yellowtail flounder for the Needler/Templeman series in spring and fall. For the Teleost, there is no significant difference in relative catchability in 3LNO spring, and data are unavailable to determine a conversion factor for fall.

The length-based conversion is applied to the Templeman and Needler set specific catch abundance at length. Converted catch weights are then calculated through the application of a length: weight relationship. Given no evidence of significant changes in weight at length over time, an aggregated length weight relationship for 3LNO by season is to be used, estimated from survey measurements:

$$\text{Spring: } \log(weight) = -11.8967 + 3.056581 \log(length)$$
$$\text{Fall: } \log(weight) = -11.9217 + 3.070019 \log(length)$$

Redfish in Div. 3LN
There is no significant difference in catchability of Redfish between the Teleost and Cabot in 3LNO in spring (Table 1), and indices from these vessels are considered directly comparable. Data were insufficient to estimate conversion factors for Needler/Templeman in spring. Conversion factors estimated for fall (Teleost spring 2HJ3KL fall, Needler/Templeman 3KL fall) are not considered appropriate for application to Div. 3LN.

Length composition of the paired tows was skewed towards small fish not normally detected in this stock area in large numbers. Concerns were also raised about limited sampling in warmer conditions typical of Div. 3N and in slope edge areas. Additionally, possible differences in the relative abundance of *Sebastes fasciatus* and *S. mentella* between the stock area and areas sampled during comparative fishing, as well as interactions between species and depth distribution, increase the level of uncertainty associated with any extension of conversion factor conclusions across areas and seasons.

Redfish in Div. 3O

For Div. 3O Redfish, data were only sufficient to estimate conversion factors for the Teleost spring survey (Table 1). Redfish in Div. 3O occupy warmer waters than the vast majority of areas sampled during the CAN-NL comparative fishing program and there are known differences in size distribution between Div. 3O and Div. 2+3K where comparative fishing occurred. Potential differences in the relative abundance of *S. fasciatus* and *S. mentella*, and differences in distribution may also impact relative catchability. These considerations, and a lack of consistency within estimated conversions for *Sebastes* spp. across space and seasons (DFO 2024, Benoît et al. 2024), preclude the extension of conversion factors into Div. 3O.

American Plaice in Div. 3LNO

For the Teleost, there is no significant difference in relative catchability of American plaice for Div. 3LNO spring. Data are unavailable to determine a conversion factor for fall Teleost or for Needler/Templeman in spring or fall (Table 1). There are known differences in seabed characteristics (bathymetry, substrate), size distribution, and seasonal changes in distribution between the Newfoundland Shelf where comparative fishing occurred, and the Grand Bank. Additionally, previous work has shown that relative catchability of American plaice can vary across Div. 3LNOPs (Cadigan et al. 2022). Together, these considerations preclude the application of conversions estimated for Div. 2+3KL fall to this stock.

Witch Flounder in Div. 2J3KL

Significant length-based conversion factors were estimated for Needler/Templeman (Table 4) and Teleost (Table 5) in fall. The Teleost conversion was estimated for the whole stock area. The Needler/Templeman conversion was estimated for Div. 3KL but is also considered appropriate for application in Div. 2J. No conversion is required for the Teleost in 3LNO spring, and data were insufficient to estimate a spring conversion factor for the Needler/Templeman. The spring survey only covers a portion of this stock (Div. 3L) and is not currently used in the assessment of this stock.

The length-based conversion is applied to set specific catch abundance at length. Converted catch weights (biomass) are then calculated through the application of the following length weight relationship (DFO 2022):

$$\log(weight) = -13.62324 + 3.464\log(length)$$

Witch Flounder in Div. 3NO

For the Teleost, there is no significant difference in relative catchability for Witch flounder across Div. 3LNO spring. Data are unavailable to determine a conversion factor for fall Teleost or for Needler/Templeman in spring or fall in Div. 3NO (Table 1). Similar to American plaice in 3LNO, considerations of habitat coverage and known spatial sensitivity of conversions preclude the application of conversions estimated for Div. 2+3KL to this stock. Additionally, there were significant gaps in the coverage of warm (>4°C) waters in paired tow coverage, missing the thermal habitat typically occupied by this stock.

Roughead Grenadier in SA 2+3

Conversions factors estimated for Div. 3KL fall Needler/Templeman, Div. 2+3KL fall Teleost, and Div. 3LNO spring Teleost showed no significant difference in catchability of Roughead grenadier between vessels. Given this consistency across vessels, seasons, and areas, survey data collected with the new vessels are considered directly comparable to the previous vessels across the DFO-NL surveys for Roughhead grenadier.

White Hake in Div. 3NOPs

Data are insufficient to estimate conversion factors for White hake in 3NOPs, with the exception of Teleost spring which showed no significant difference in relative catchability. Therefore, the new Cabot/Cartier series can be directly compared to the 2014 Div. 3NO, and 2016 Div. 3NOPs indices.

Thorny Skate in Div. 3LNOPs

Data are insufficient to estimate conversion factors for Thorny Skate in Subdiv. 3Ps. In 3LNO, Teleost spring showed a significant length-based conversion (Table 6), while data were insufficient to derive conversion for the Needler/Templeman. The length-based conversion is applied to Teleost spring 3LNO set specific catch abundance at length. Converted catch weights (biomass) are then calculated through the application of the following length weight relationship:

$$\log(weight) = -12.237252 + 3.164412\log(length)$$

Additionally, fall conversions have been estimated for the Teleost and Needler, but are applicable to Div. 2HJ3KL and Div. 3KL respectively. Extension across this stock area is not considered appropriate given differences in habitat and distribution.

Shrimp in Div. 3LNO

Conversions for the spring survey series could not be estimated for the Needler/Templeman series, while data showed no conversion is required for the Teleost spring in Div. 3LNO. Fall conversions were estimated for Div. 3KL Needler/Templeman (Table 7) and Div. 2HJ3KL for Teleost (Table 8). Given consistency in size distribution, depth and temperature occupied by shrimp, use of conversion factors can be extended across Div. 3LNO.

In the current calculation of shrimp indices both the size-aggregated and length-based conversions are applied. The total catch estimates of northern shrimp per set (abundance and biomass) is converted using the appropriate size-aggregated conversion factors for each outgoing vessel. The length-based fall conversion is applied to set specific catch abundance at length. Converted catch weights (biomass) are then calculated through the application of the following length weight relationship (DFO 2013):

$$\text{Male shrimp: weight(g)} = 0.00088 * \text{lt(mm)}^{2.857}$$
$$\text{Female shrimp: weight(g)} = 0.00193 * \text{lt(mm)}^{2.663}$$

Catch abundance and biomass at length were then scaled, based on the proportion per size bin, to the converted total catch estimates to match the total catch within a given survey set.

Capelin in Div. 3NO

Data were insufficient to estimate conversion factors for Capelin in Div. 3NO, with the exception of Teleost spring which showed no significant difference in relative catchability. Bottom-trawling is not a satisfactory basis for the assessment of a pelagic species, and the survey indices are only used to monitor for large-scale fluctuations. This utility is not considered to be impacted by the vessel change.

Northern Shortfin Squid in SA 3+4

Conversion factors for Northern shortfin squid have been estimated for the Teleost fall series in Div. 2HJ3KL (abundance: ρ = 1.30, CI=1.03–1.68) and biomass (ρ = 1.40, CI = 1.12-1.74). All other season, vessel and area combinations were data deficient. Gaps, extension, and impacts have not been assessed at this time but should be considered in ongoing monitoring of this stock. Squid is therefore not listed in Table 1.

Sensitivity of indices to vessel mixing in the historic time series

Figures 5-11 show biomass index trends for seven groundfish stocks with multipliers of 0.5, 1, and 2 applied to all Teleost catches in the historic Campelen series. This is a basic empirical comparison and does not account for potential size-based differences in catchability. This simple test shows that broad survey biomass trends are largely robust to this past vessel mixing. There are species/stock differences related to the previous design of having the Teleost cover the deeper strata of Divs. 3LNO. Therefore the impacts of adjusting Teleost catches is larger for a species like Greenland halibut than it is for a shallow species such as yellowtail flounder. It is also clear that the potential impact of the previous assumption of equal catchability is highest in years when the Teleost was used in a greater proportion of areas typically sampled by the Needler/Templeman. This is particularly evident in 2014, 2016 and 2018 in spring.

Discussion

The introduction of new vessels and minor modifications to the Campelen survey trawl necessitated comparative fishing to determine the difference in relative catchability between previous and new vessel by trawl combinations in the DFO-NL surveys. Where conversion factors have been estimated they are specific to the species, vessel, area, and season for which they were derived, and extension of their use is dependent on a number of factors that can influence catchability (e.g. substrate, depth, size, habitat, behaviour). Here we considered the extension of conversion factors for stocks directly considered by NAFO Scientific Council. Further extension should be considered on an ongoing basis for other single- and multi- species applications of these data.

Implementation of conversion factors aims to balance the reasonable extension of comparative fishing conclusions, added uncertainty, and potential bias. In a number of cases, consistency in habitat characteristics, distribution, and size composition across areas has been used here to justify the application of a conversion factor across a broader area than that sampled by paired tows. For the Needler/Templeman, limited sampling on the Grand Bank was a barrier to conversion factor estimation and extensions. Important slope habitats and warmer waters were largely unsampled, and size distribution of all taxa were not necessarily represented by paired tows that were largely focused in Div. 3K. These data limitations largely preclude the continuation of the spring Needler/Templeman time series (Div. 3LNOPs). Some exceptions were made, such as for yellowtail flounder, for which data represented the limited habitat used by the species, and in cases where broad consistency in results across vessel pairs, space and season supported an extension of conversion factors (Atlantic cod, Roughead grenadier.). Additionally, comparative fishing with the Teleost in Div. 3LNO in spring 2023 allows years when the spring survey was completed with this vessel to be used in series with the new vessels going forward for many stocks.

When conversion factors cannot be estimated or extended, the previous survey time series and series going forward are not directly comparable. How unconverted data are considered in assessments and analyses will be specific to the analytical framework used (e.g. total biomass for surplus production vs. cohort or length-based modelling frameworks) and requires consideration of uncertainty and interpretation.

Previously, the DFO-NL survey indices assumed equal catchability of the Templeman/Needler with the Teleost when vessels were substituted as needed to complete surveys. The comparative fishing program has shown that this assumption is not likely to be broadly true given differences in trawl performance and in the magnitude, shape, and significance of conversions to the new vessels for some species (DFO *in press*). Where conversion factors have been estimated and applied now to the Templeman/Needler and Teleost sets, these are brought into equivalent units, accounting for previous vessel differences. When conversions could not be estimated, data from these vessels (i.e. Templeman/Needler versus Teleost) should no longer be assumed equivalent. While a basic empirical test shown here indicates that broad survey biomass trends are largely robust to this past vessel mixing and sufficient for interim monitoring, potential impact varies with changes in survey coverage by each vessel. Further explorations are recommended to examone the impact of this assumption on the interpretation of previously reported series – including on size- or age-based indices. Going forward, in some cases where multiple vessels were used in a single survey in a single year, the index may no longer be provided if the vessel effect cannot be accounted for or if sets from one vessel are insufficient to provide an index.

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Table 1. Stock-by-stock summary of conversion factor conclusions for the CAN-NL multispecies survey data in spring and fall by vessel. Note that the CCGS Wilfred Templeman and CCGS Alfred Needler are sister ships and considered to have equal catchability. Conversion factor rho (ρ) = 1 indicates equivalent catchability to the new vessels.

Stock	Wilfred Templeman & Alfred Needer		Teleost		Notes on application of conversion factors
	CAN-Spring	CAN-Fall	CAN-Spring	CAN-Fall	
3NO Atlantic Cod	ρ =1	ρ =1	ρ =1	ρ =1	No evidence of differences in relative catchability across area, season, or between vessels.
2+3KLMNO Greenland Halibut	No appropriate conversion factor available.	Extend 3KL conclusion of ρ =1 across the fall survey area.	ρ =1	Extend 2+3KL length-based conversion (Table 2) across the fall survey area.	Application within the MSE may differ from that listed here given difference in process.
3LNO Yellowtail Flounder	Length-based conversion factor. (Table 3)	Length-based conversion factor. (Table 3)	ρ =1	No appropriate conversion factor available.	Length-based conversions for WT and AN applied using seasonal length: weight relationship.
3LN Redfish	No appropriate conversion factor available.	No appropriate conversion factor available.	ρ =1	No appropriate conversion factor available.	Comparative fishing sampling was primarily in Div. 3K. Inconsistency in length composition, distribution, and species composition preclude application of conversion factors to Div. 3LN.
3O Redfish	No appropriate conversion factor available.	No appropriate conversion factor available.	ρ =1	No appropriate conversion factor available.	Conversion factor extensions not supported given differences in factors that may impact relative catchability, e.g. bottom temperature, size distribution, species composition.
3LNO American Plaice	No appropriate conversion factor available.	No appropriate conversion factor available.	ρ =1	No appropriate conversion factor available.	Conversion factor extensions not supported given known spatial sensitivity of catchability for American plaice, e.g. bathymetry, substrate, distribution.

Stock	Wilfred Templeman & Alfred Needder		Teleost		Notes on application of conversion factors
	CAN-Spring	CAN-Fall	CAN-Spring	CAN-Fall	
2J3KL Witch Flounder	No appropriate conversion factor available.	Extend use of 3KL Length-based conversion factor across 2J3KL. (Table 4)	ρ = 1	Length-based conversion factor. (Table 5)	Single length-weight relationship to be applied across all years for 2J3KL.
3NO Witch Flounder	No appropriate conversion factor available.	No appropriate conversion factor available.	ρ =1	No appropriate conversion factor available.	Conversion factor extensions not supported given known spatial sensitivity of catchability for Witch Flounder, e.g. bottom temperature, size distribution.
2+3K Roughead Grenadier	Assume ρ =1 based on consistency across other surveys.	Extend 3KL conclusion of ρ =1 across the fall survey area.	ρ =1	Extend 2+3KL conclusion of ρ =1 across the fall survey area.	No evidence of differences in relative catchability across area, season, or between vessels.
3NOPs White Hake	No appropriate conversion factor available.	No appropriate conversion factor available.	ρ =1 for 3NOPs	No appropriate conversion factor available.	Data deficient in all cases except Spring Teleost
3LNOPs Thorny Skate	No appropriate conversion factor available.	Conversion factor estimated for Div. 3L only. Conversion cannot be extended to 3NOPs.	Length-based conversion for 3LNO. Conversion cannot be extended to 3Ps. (Table 6)	Conversion factor estimated for Div. 3L only. Conversion cannot be extended to 3NOPs.	Extension of conversions estimated for fall Div. 2+3KL not considered appropriate for Div. 3NOPs. Teleost spring conversion not appropriate for extension into 3Ps.
3LNO Shrimp	No appropriate conversion factor available.	Extend use of 3KL length-based conversion factor. (Table 7)	ρ = 1	Extend use of 2HJ3KL length-based conversion factor. (Table 8)	Consistency in size distribution, depth and temperature supports extension of fall conversion factors into 3NO.
3NO Capelin	No appropriate conversion factor available.	No appropriate conversion factor available.	ρ =1	No appropriate conversion factor available.	Use of unconverted data considered sufficient to monitor for large-scale changes in stock size.

Table 2. Conversion factors ± Standard Error (SE) for abundance at length (cm) required for Greenland Halibut (*Reinhardtius hippoglossoides*) for the CCGS Teleost, and CCGS John Cabot/Capt Jacques Cartier for Fall 2HJ3K + 3L.

Length (cm)	Conversion	SE
≤ 9	1.57	0.16
10	1.45	0.12
11	1.35	0.09
12	1.26	0.07
13	1.18	0.06
14	1.12	0.05
15	1.07	0.05
16	1.03	0.05
17	1.00	0.05
18	0.97	0.05
19	0.96	0.04
20	0.95	0.04
21	0.94	0.04
22	0.94	0.04
23	0.94	0.04
24	0.94	0.04
25	0.94	0.04
26	0.94	0.04
27	0.94	0.04
28	0.94	0.04
29	0.94	0.04
30	0.94	0.04
31	0.94	0.04
32	0.94	0.04
33	0.94	0.04
34	0.94	0.04
35	0.95	0.04
36	0.95	0.04
37	0.95	0.04
38	0.96	0.04
39	0.96	0.04
40	0.97	0.04
41	0.97	0.04
42	0.98	0.04
43	0.99	0.04
44	0.99	0.04
45	1.00	0.05
46	1.00	0.05
47	1.00	0.05
48	1.01	0.05
49	1.01	0.05
50	1.01	0.05
51	1.01	0.05
52	1.01	0.06
53	1.01	0.06
54	1.02	0.06
55	1.02	0.07
56	1.02	0.07
57	1.02	0.07
58	1.02	0.08
≥ 59	1.02	0.08

Table 3. Conversion factors ± Standard Error (SE) for abundance at length (cm) required for Yellowtail flounder (*Myzopsetta ferruginea*) to be used for the CCGS Alfred Needler and CCGS John Cabot/Capt. Jacques Cartier Fall 3LNO and Spring 3LNOPs.

Length (cm)	Conversion	SE
≤ 8	0.56	0.18
9	0.62	0.17
10	0.68	0.17
11	0.74	0.17
12	0.81	0.17
13	0.88	0.17
14	0.96	0.17
15	1.04	0.17
16	1.12	0.18
17	1.19	0.19
18	1.27	0.20
19	1.34	0.20
20	1.40	0.21
21	1.46	0.21
22	1.50	0.22
23	1.54	0.22
24	1.56	0.22
25	1.58	0.23
26	1.59	0.22
27	1.58	0.22
28	1.57	0.22
29	1.55	0.22
30	1.52	0.21
31	1.49	0.20
32	1.45	0.20
33	1.40	0.19
34	1.35	0.18
35	1.31	0.18
36	1.26	0.17
37	1.21	0.16
38	1.17	0.16
39	1.13	0.15
40	1.09	0.15
41	1.06	0.15
42	1.03	0.15
43	1.00	0.15
44	0.99	0.15
45	0.98	0.16
46	0.97	0.16
47	0.97	0.17
48	0.98	0.18
49	1.00	0.20
50	1.02	0.22
51	1.05	0.26
52	1.08	0.30
≥ 53	1.12	0.35

Table 4. Conversion factors ± Standard Error (SE) for abundance at length (cm) required for Witch flounder (*Glyptocephalus cynoglossus*) to be used for the CCGS Alfred Needler and CCGS John Cabot/Capt. Jacques Cartier Fall 3KL.

Length (cm)	Conversion	SE
≤ 12	0.65	0.09
13	0.66	0.09
14	0.68	0.09
15	0.69	0.09
16	0.70	0.09
17	0.71	0.09
18	0.72	0.08
19	0.73	0.08
20	0.75	0.08
21	0.76	0.08
22	0.77	0.08
23	0.78	0.08
24	0.80	0.08
25	0.81	0.07
26	0.82	0.07
27	0.84	0.07
28	0.85	0.07
29	0.86	0.07
30	0.88	0.07
31	0.89	0.08
32	0.91	0.08
33	0.92	0.08
34	0.94	0.08
35	0.95	0.08
36	0.97	0.09
37	0.98	0.09
38	1.00	0.09
39	1.02	0.10
40	1.03	0.10
41	1.05	0.11
42	1.07	0.11
43	1.09	0.12
44	1.10	0.13
45	1.12	0.13
46	1.14	0.14
47	1.16	0.15
48	1.18	0.16
49	1.20	0.16
50	1.22	0.17
51	1.24	0.18
≥ 52	1.26	0.19

Table 5. Conversion factors ± Standard Error (SE) for abundance at length (cm) required for Witch flounder (*Glyptocephalus cynoglossus*) to be used for the CCGS Teleost, and CCGS John Cabot/Capt. Jacques Cartier for Fall 2HJ3K + 3L deep.

Length (cm)	Conversion	SE
≤ 10	0.55	0.08
11	0.57	0.08
12	0.58	0.08
13	0.60	0.07
14	0.62	0.07
15	0.64	0.07
16	0.66	0.07
17	0.68	0.06
18	0.70	0.06
19	0.73	0.06
20	0.75	0.07
21	0.77	0.07
22	0.79	0.07
23	0.81	0.07
24	0.82	0.07
25	0.84	0.07
26	0.85	0.07
27	0.87	0.07
28	0.88	0.07
29	0.89	0.07
30	0.90	0.07
31	0.90	0.07
32	0.91	0.07
33	0.92	0.07
34	0.92	0.07
35	0.93	0.07
36	0.94	0.07
37	0.94	0.07
38	0.95	0.07
39	0.95	0.07
40	0.95	0.07
41	0.96	0.07
42	0.96	0.07
43	0.96	0.07
44	0.96	0.08
45	0.96	0.08
46	0.96	0.08
47	0.96	0.09
48	0.95	0.09
49	0.95	0.10
50	0.95	0.11
51	0.95	0.12
52	0.94	0.13
53	0.94	0.14
≥ 54	0.94	0.15

Table 6. Conversion factors ± Standard Error (SE) for abundance at length (cm) required for Thorny Skate (*Amblyraja radiata*) to be used for the CCGS Teleost, and CCGS John Cabot/Capt. Jacques Cartier for spring 3LNO.

Length (cm)	Conversion	SE
≤ 13	0.46	0.10
14	0.47	0.10
15	0.48	0.09
16	0.49	0.09
17	0.50	0.09
18	0.52	0.09
19	0.53	0.09
20	0.54	0.08
21	0.56	0.08
22	0.57	0.08
23	0.58	0.08
24	0.60	0.08
25	0.61	0.08
26	0.62	0.08
27	0.64	0.08
28	0.65	0.08
29	0.67	0.08
30	0.68	0.08
31	0.70	0.08
32	0.71	0.08
33	0.73	0.08
34	0.74	0.09
35	0.75	0.09
36	0.77	0.09
37	0.78	0.09
38	0.79	0.09
39	0.81	0.09
40	0.82	0.10
41	0.83	0.10
42	0.84	0.10
43	0.85	0.10
44	0.86	0.10
45	0.87	0.10
46	0.88	0.10
47	0.89	0.10
48	0.90	0.11
49	0.91	0.11
50	0.92	0.11
51	0.92	0.11
52	0.93	0.11
53	0.93	0.11
54	0.94	0.11
55	0.94	0.10
56	0.95	0.10
57	0.95	0.10
58	0.95	0.10
59	0.95	0.10
60	0.96	0.10
61	0.96	0.10
62	0.96	0.10
63	0.96	0.10
64	0.96	0.10
65	0.96	0.10

Length (cm)	Conversion	SE
66	0.96	0.10
67	0.96	0.10
68	0.96	0.10
69	0.96	0.10
70	0.95	0.10
71	0.95	0.10
72	0.95	0.10
73	0.95	0.10
74	0.95	0.10
75	0.94	0.11
76	0.94	0.11
77	0.94	0.11
78	0.94	0.12
79	0.93	0.12
80	0.93	0.12
81	0.93	0.13
82	0.93	0.13
83	0.92	0.14
84	0.92	0.15
85	0.92	0.15
86	0.92	0.16
87	0.91	0.17
88	0.91	0.17
≥ 89	0.91	0.18

Table 7. Conversion factors ± Standard Error (SE) for abundance at length (carapace length, mm) required for Northern shrimp (*Pandalus borealis*) to be used for the CCGS Alfred Needler and CCGS John Cabot/Capt. Jacques Cartier Fall 3KL.

Length (mm)	**Conversion**	**SE**
≤ 10.5	2.01	0.48
11.0	1.89	0.40
11.5	1.78	0.35
12.0	1.66	0.31
12.5	1.55	0.28
13.0	1.43	0.25
13.5	1.32	0.22
14.0	1.22	0.20
14.5	1.13	0.18
15.0	1.05	0.16
15.5	0.98	0.15
16.0	0.94	0.15
16.5	0.90	0.14
17.0	0.88	0.14
17.5	0.88	0.14
18.0	0.90	0.14
18.5	0.91	0.14
19.0	0.93	0.14
19.5	0.94	0.14
20.0	0.95	0.14
20.5	0.96	0.15
21.0	0.97	0.15
21.5	0.98	0.15
22.0	0.98	0.15
22.5	0.98	0.15
23.0	0.96	0.15
23.5	0.94	0.14
24.0	0.92	0.14
24.5	0.90	0.14
≥ 25.0	0.88	0.14

Table 8. Conversion factors ± Standard Error (SE) for abundance at length (carapace length, mm) required for Northern shrimp (*Pandalus borealis*) to be used for CCGS Teleost, and CCGS John Cabot/Capt. Jacques Cartier for Fall 2HJ3K + 3L deep.

Length (mm)	Conversion	SE
≤ 13.0	1.26	0.10
13.5	1.25	0.10
14.0	1.25	0.09
14.5	1.24	0.09
15.0	1.23	0.08
15.5	1.23	0.07
16.0	1.22	0.07
16.5	1.21	0.06
17.0	1.21	0.06
17.5	1.20	0.05
18.0	1.19	0.05
18.5	1.19	0.05
19.0	1.18	0.04
19.5	1.17	0.04
20.0	1.17	0.04
20.5	1.16	0.04
21.0	1.16	0.04
21.5	1.15	0.05
22.0	1.14	0.05
22.5	1.14	0.05
23.0	1.13	0.06
23.5	1.12	0.06
24.0	1.12	0.06
24.5	1.11	0.07
25.0	1.11	0.07
≥ 25.5	1.10	0.08

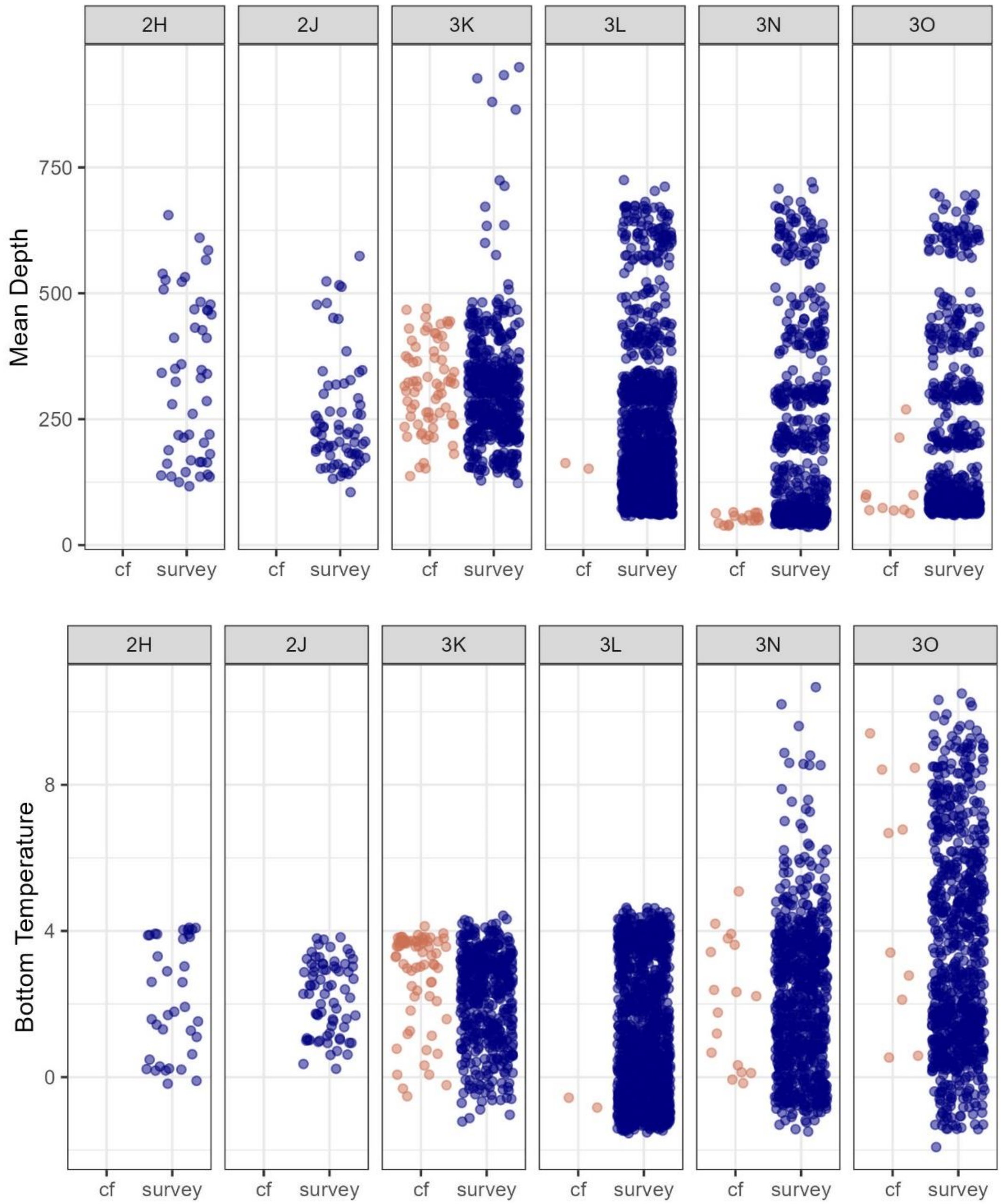

Figure 1. Mean depth (m, top) and bottom temperature (°C, bottom) distribution of comparative fishing (cf) sets (orange) for the vessel *CCGS Alfred Needler* and survey sets (2016-2021, blue) completed by this vessel in each NAFO Division in the NL fall survey.

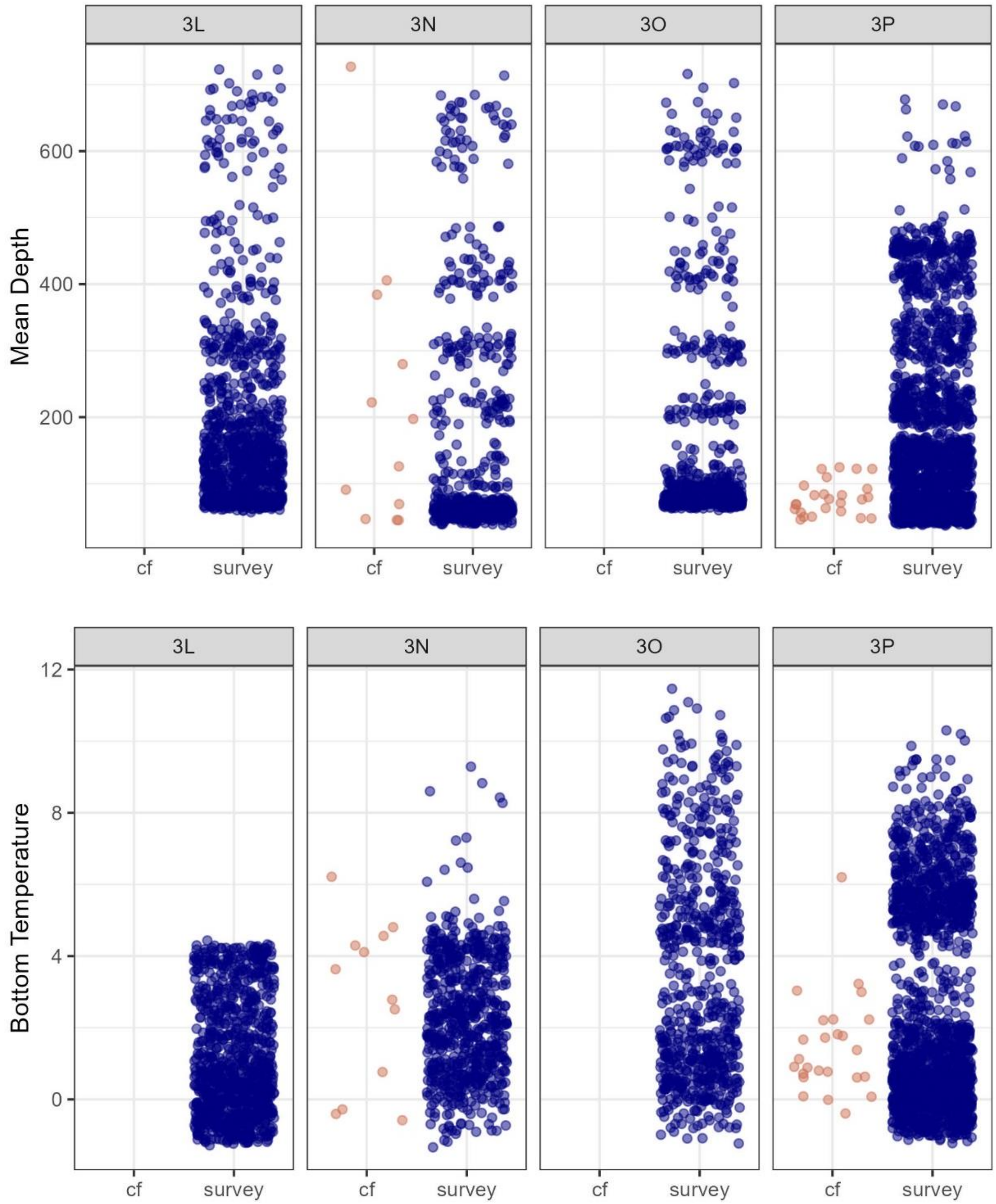

Figure 2. Mean depth (m, top) and bottom temperature (°C, bottom) distribution of comparative fishing (cf) sets (orange) for the vessel *CCGS Alfred Needler* and survey sets (blue) completed by this vessel in each NAFO Division in the NL spring survey in the Campelen series (since 1996).

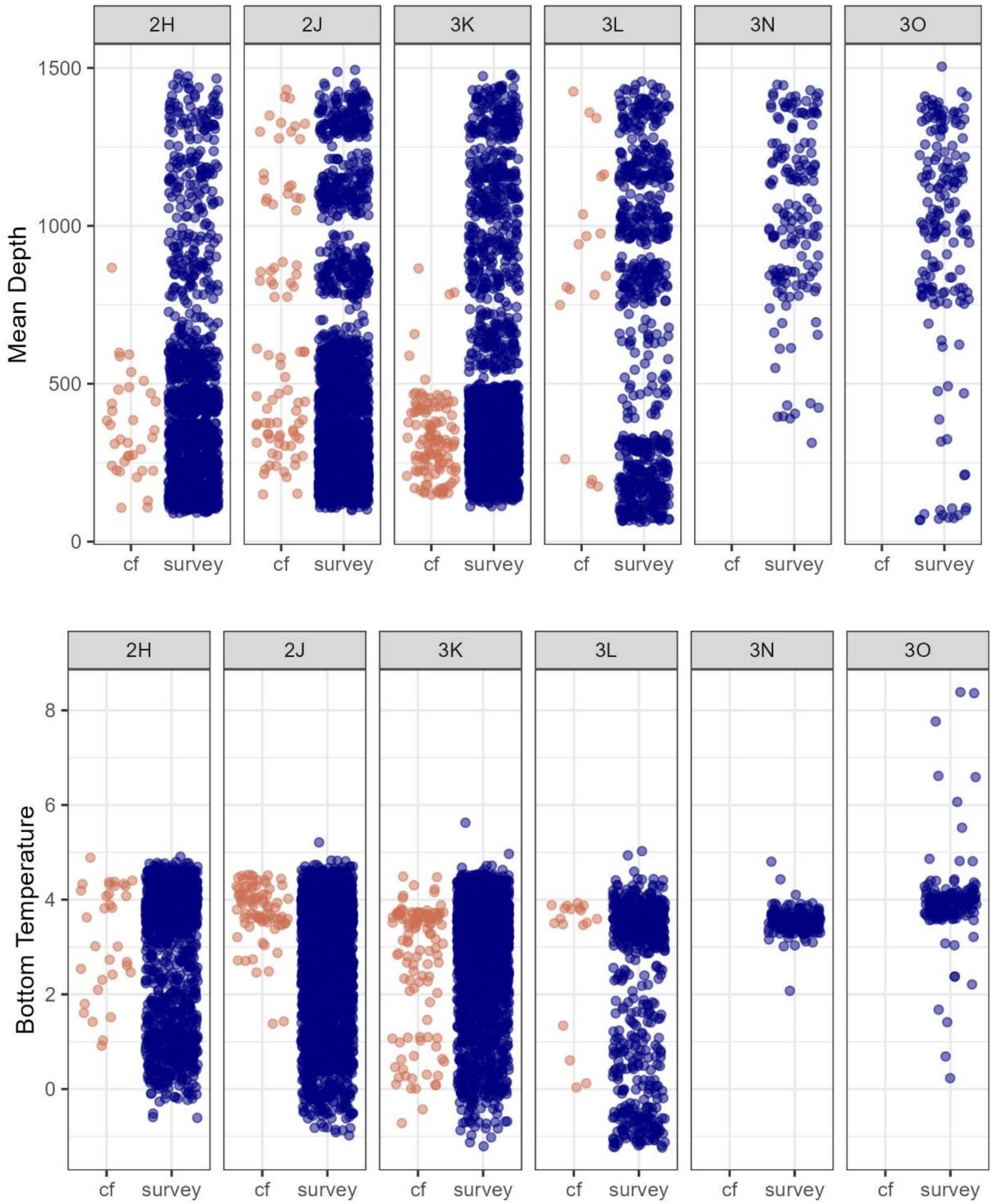

Figure 3. Mean depth (m, top) and bottom temperature (°C, bottom) distribution of comparative fishing (cf) sets (orange) for the vessel *CCGS Teleost* and survey sets (blue) completed by this vessel in each NAFO Division in the NL fall survey during the Campelen series (since 1995).

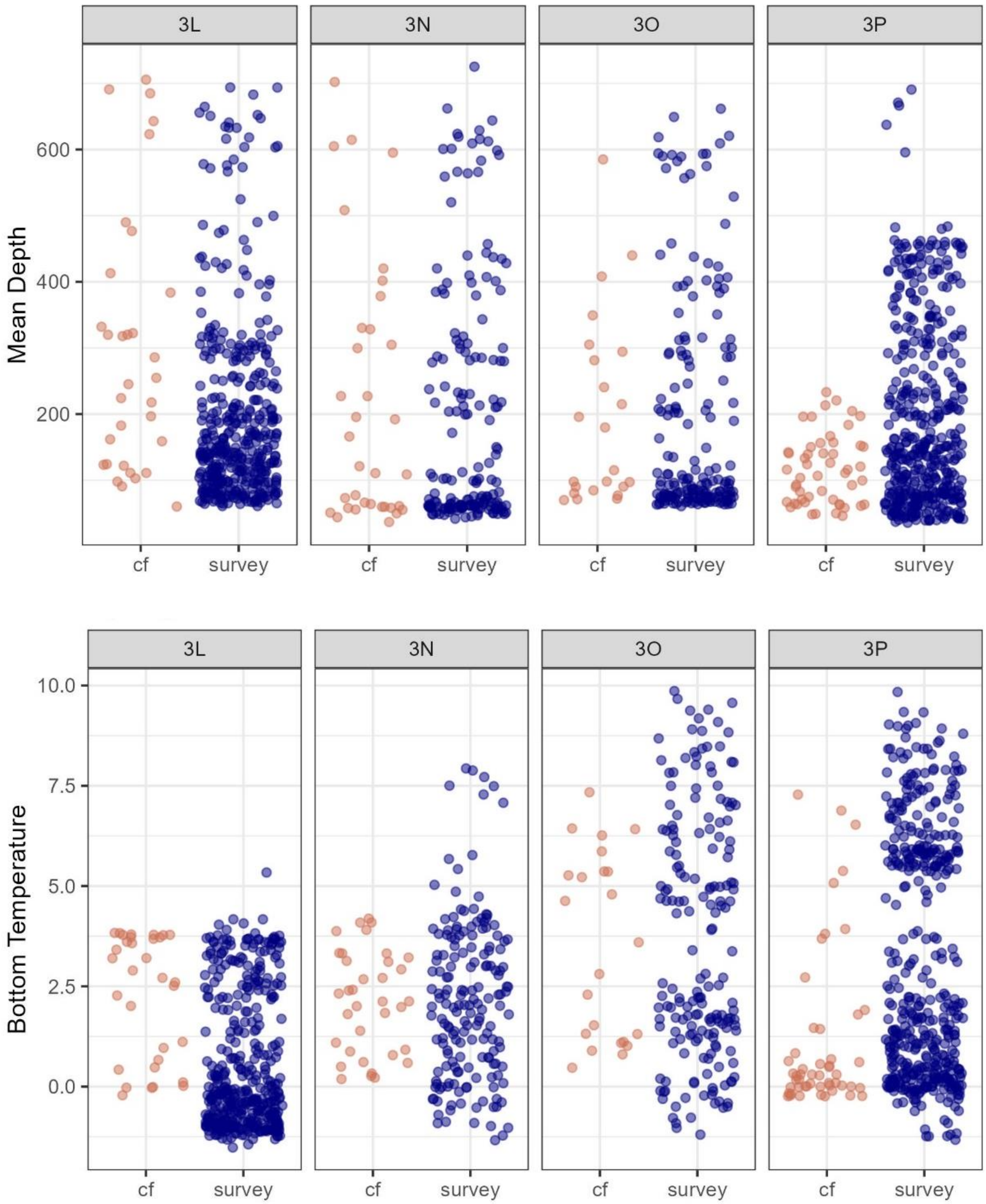

Figure 4. Mean depth (m, top) and bottom temperature (°C, bottom) distribution of comparative fishing (cf) sets (orange) for the vessel *CCGS Teleost* and survey sets (blue) completed by this vessel in each NAFO Division in the NL spring survey Campelen series (since 1996).

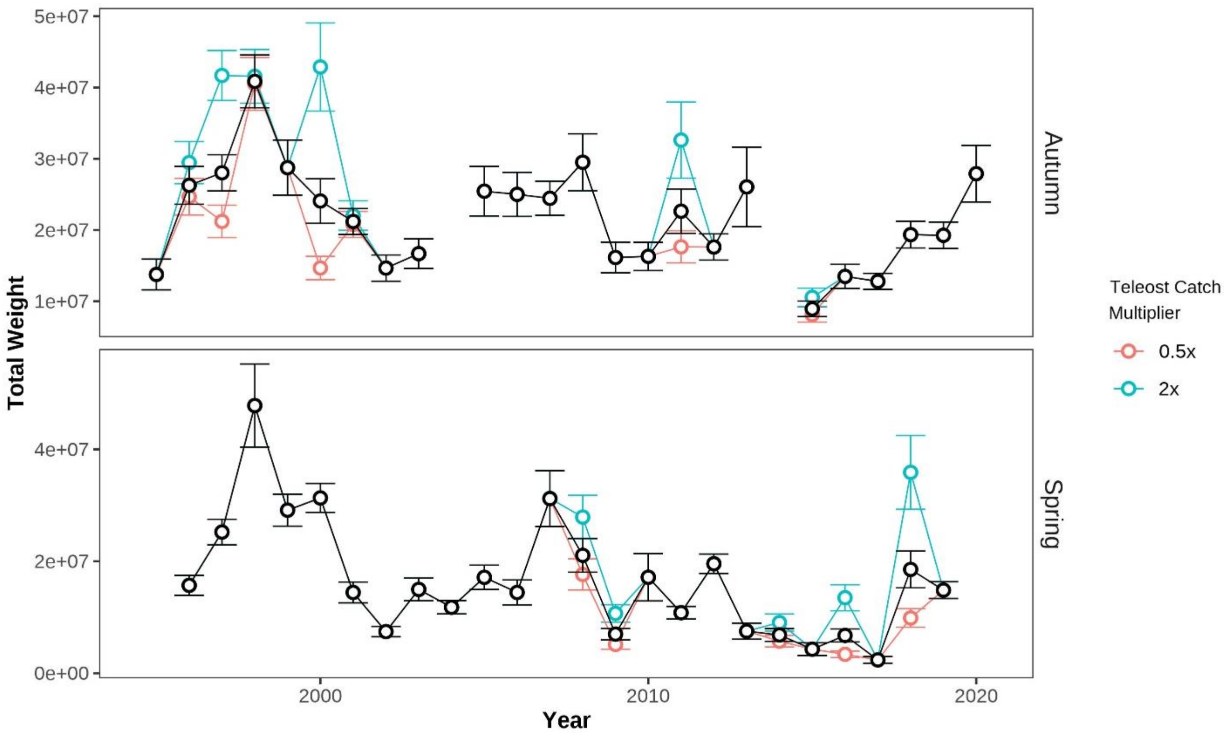

Figure 5. Comparison of stock biomass index trends under 0.5 (red), 1 (black), and 2x (blue) multipliers of Teleost catchability relative to the Needler and Templeman in the Canadian Autumn (top) and spring (bottom) surveys for American plaice in Div. 3LNO.

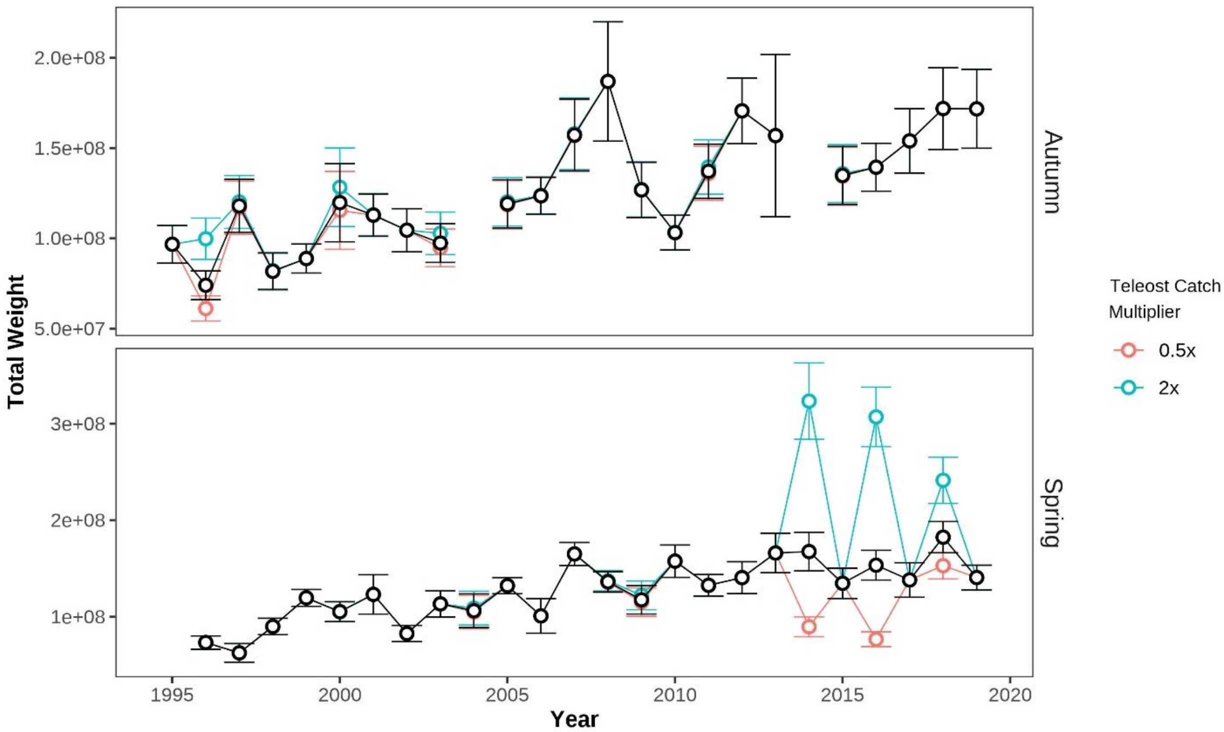

Figure 6. Comparison of stock biomass index trends under 0.5 (red), 1 (black), and 2x (blue) multipliers of Teleost catchability relative to the Needler and Templeman in the Canadian Autumn (top) and spring (bottom) surveys for Thorny Skate in Div. 3LNOPs.

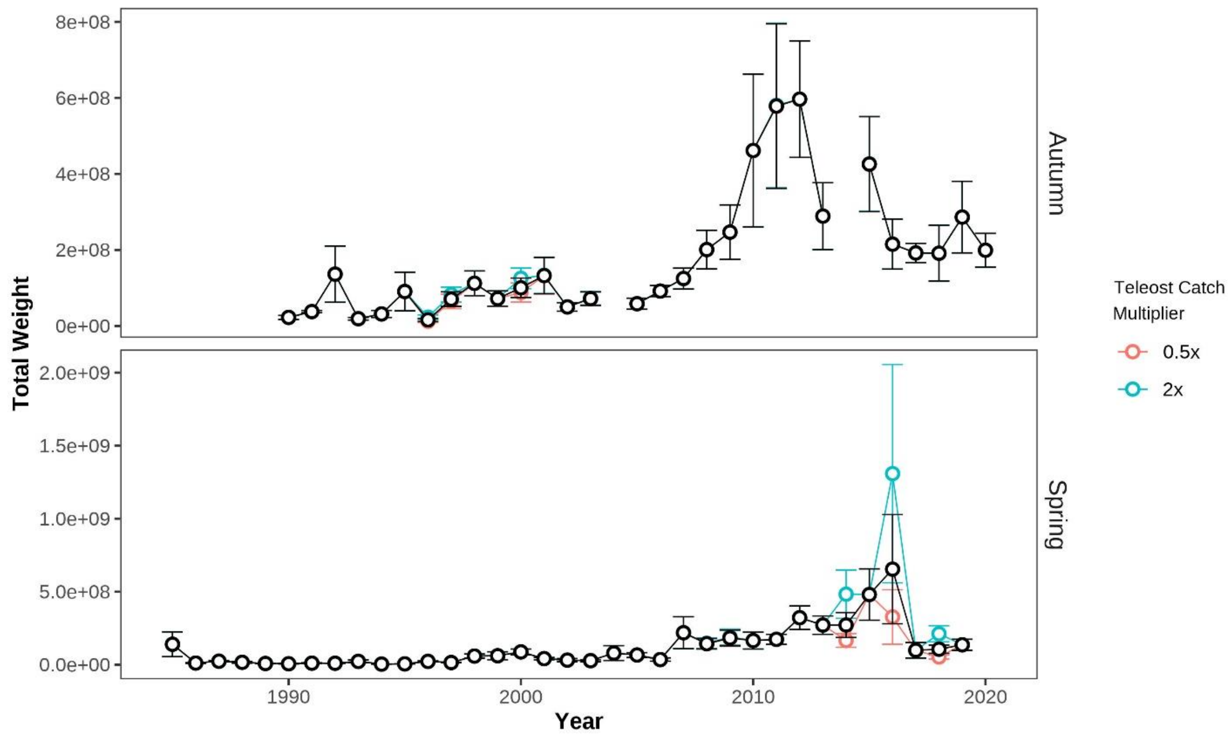

Figure 7. Comparison of stock biomass index trends under 0.5 (red), 1 (black), and 2x (blue) multipliers of Teleost catchability relative to the Needler and Templeman in the Canadian Autumn (top) and spring (bottom) surveys for Redfish in Div. 3LN.

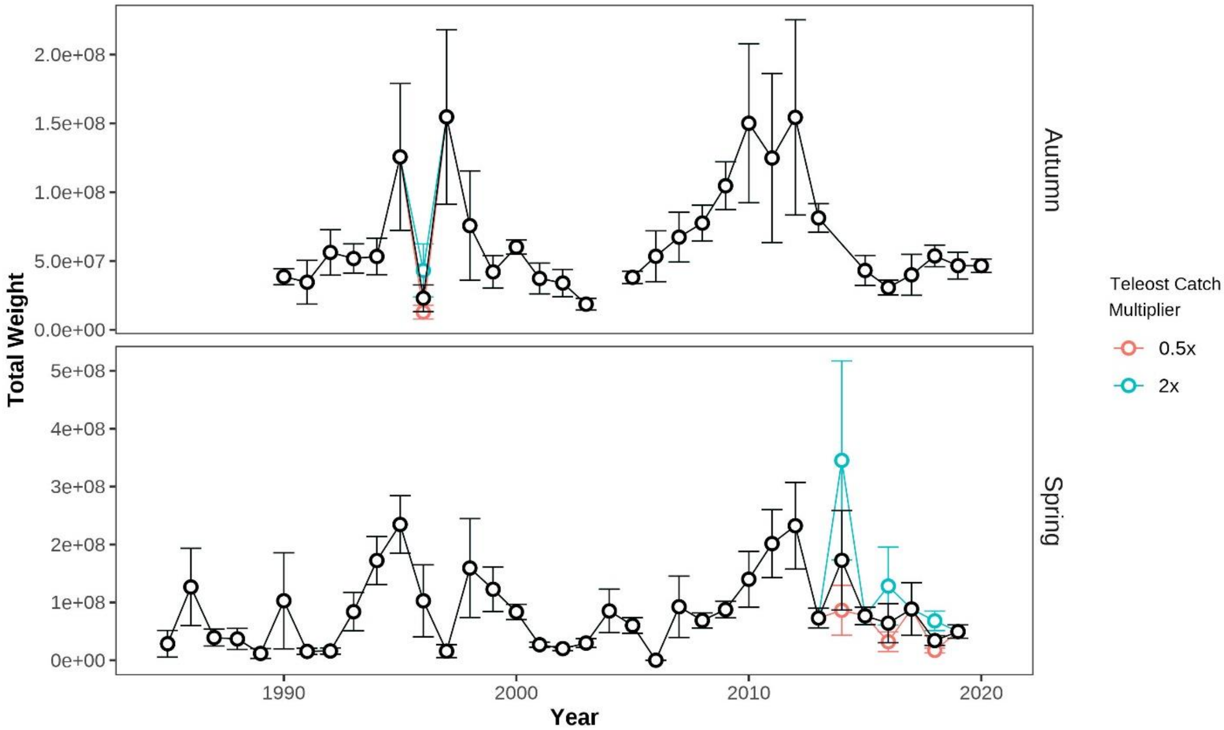

Figure 8. Comparison of stock biomass index trends under 0.5 (red), 1 (black), and 2x (blue) multipliers of Teleost catchability relative to the Needler and Templeman in the Canadian Autumn (top) and spring (bottom) surveys for Redfish in Div. 3O.

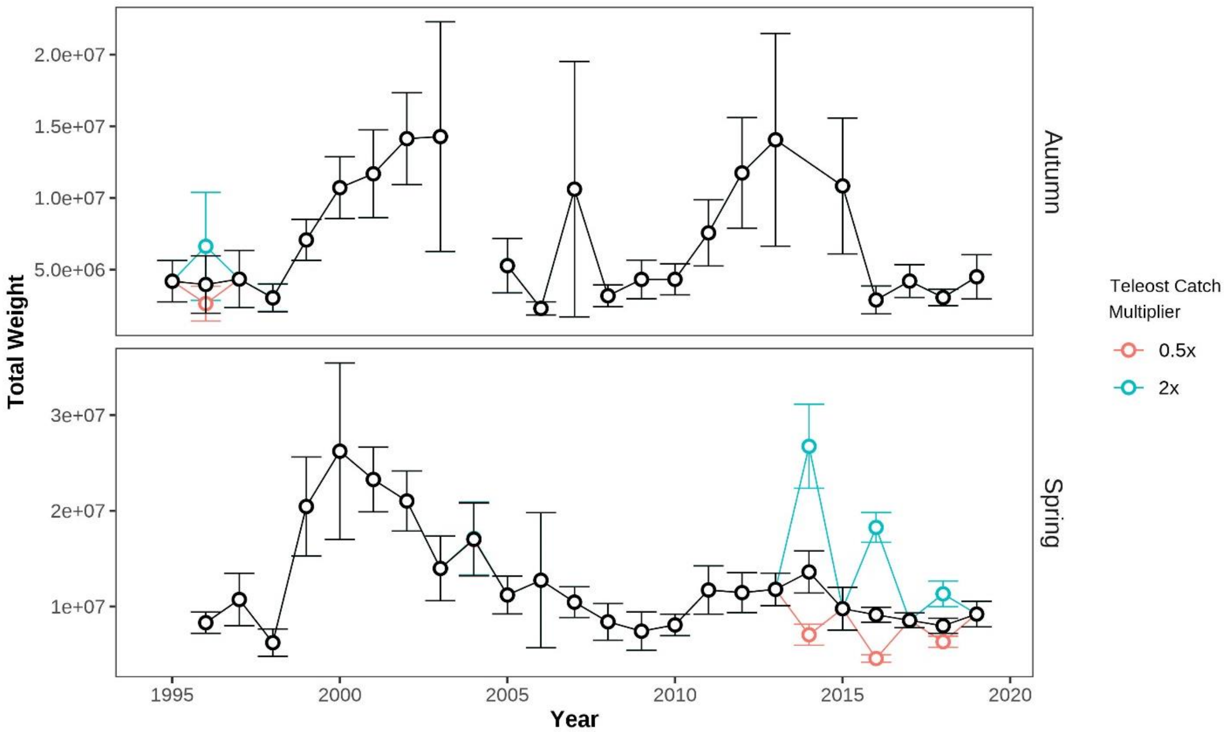

Figure 9. Comparison of stock biomass index trends under 0.5 (red), 1 (black), and 2x (blue) multipliers of Teleost catchability relative to the Needler and Templeman in the Canadian Autumn (top) and spring (bottom) surveys for White hake in Div. 3NOPs.

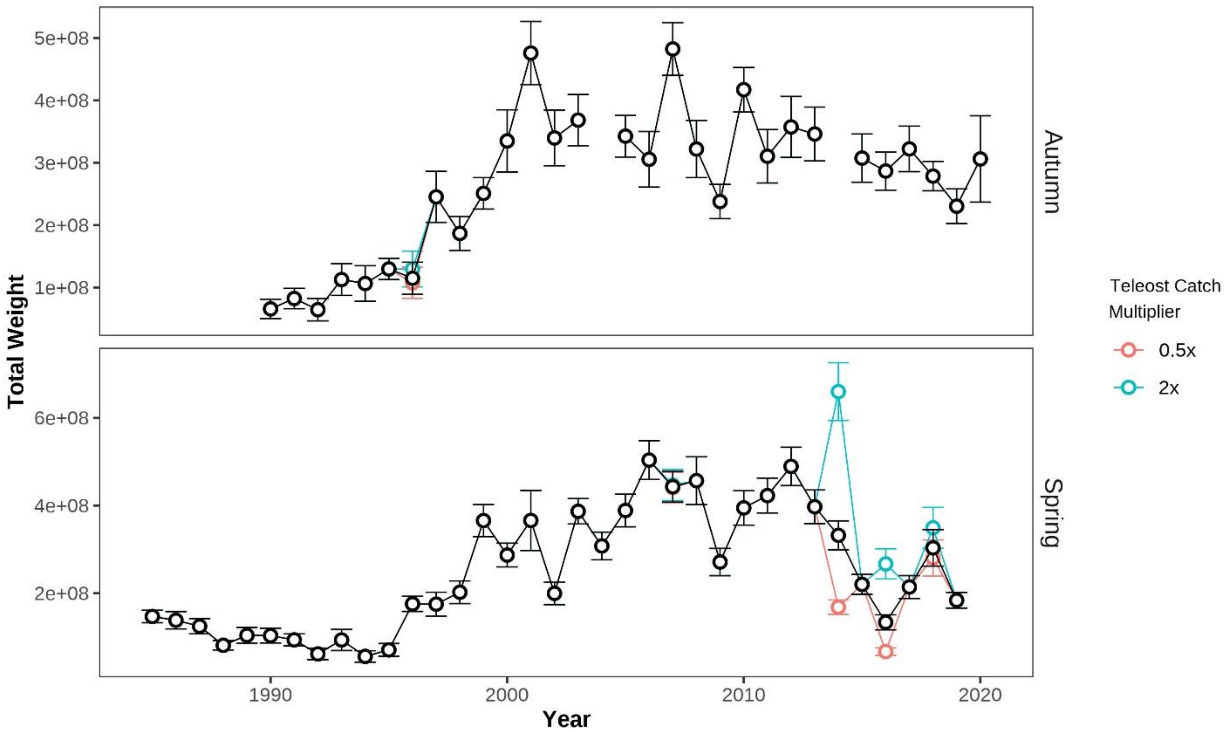

Figure 10. Comparison of stock biomass index trends under 0.5 (red), 1 (black), and 2x (blue) multipliers of Teleost catchability relative to the Needler and Templeman in the Canadian Autumn (top) and spring (bottom) surveys for Yellowtail flounder in Div. 3LNO.

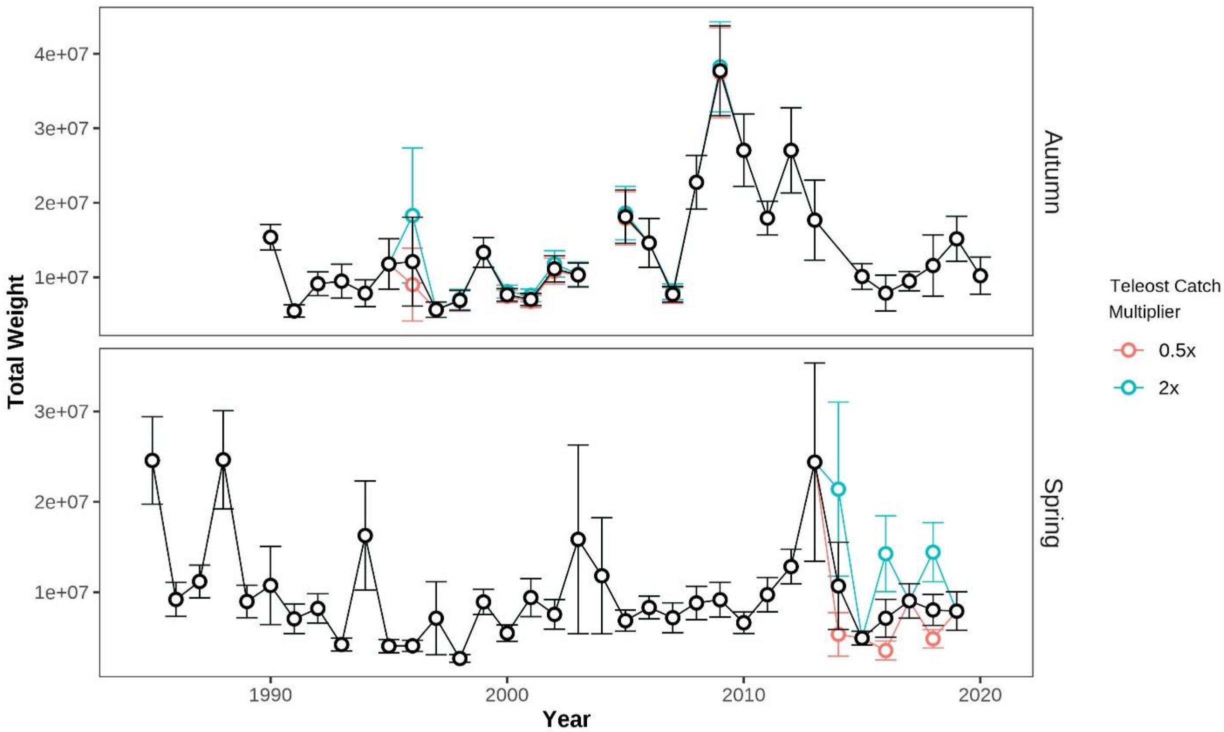

Figure 11. Comparison of stock biomass index trends under 0.5 (red), 1 (black), and 2x (blue) multipliers of Teleost catchability relative to the Needler and Templeman in the Canadian Autumn (top) and spring (bottom) surveys for Witch flounder in Div. 3NO.