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Science Advisory Report 2024/002

NEWFOUNDLAND & LABRADOR COMPARATIVE FISHING ANALYSIS – PART I

Image: The new Offshore Fishery Science Vessels (OFSVs).

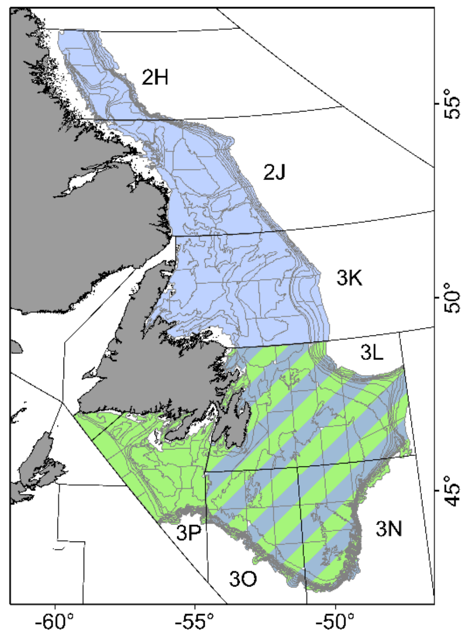

Figure 1. Map of the Newfoundland and Labrador Region Multispecies bottom trawl survey areas in spring (green) and fall (blue). Grey lines indicate survey strata.

Context:

Multispecies bottom trawl surveys have been conducted annually in the spring and fall in the Newfoundland and Labrador (NL) Region aboard the Canadian Coast Guard Ship (CCGS) Teleost *and CCGS* Alfred Needler *(or its sister ship the CCGS Wilfred Templeman [Warren et al. 1997]) since 1995 using a Campelen 1800 survey trawl. These surveys are used to estimate the distribution and abundance of many fish and invertebrate species, to determine species life history characteristics, and form the basis of a number of ecosystem indicators. The CCGS* Alfred Needler *and CCGS* Teleost *will no longer be used for these surveys after 2022 and 2023, respectively, and will be replaced by new Offshore Fishery Science Vessels (OFSVs), the CCGS* John Cabot *and CCGS* Capt. Jacques Cartier*. Comparative fishing (i.e., direct side by side comparison between the old and new vessels) has been ongoing since 2021. This is a standard approach for determining differences in catchability between the outgoing vessels with the standard Campelen trawl and the new vessels with the modified Campelen trawl.*

Analysis and review of this program will occur across two Canadian Science Advisory Secretariat (CSAS) processes to quantify conversion factors: Part I – Spring and Fall 2021 (i.e., this report) and 2022 data, and Part II – Spring 2023 data and additional analyses. Gaps identified in Part I will be addressed in Part II and on an ongoing basis as data permit. The utilization of conversion factors or *lack of suitable conversion factors determined in these meetings will be discussed during subsequent Regional Assessment Processes.*

This Science Advisory Report (SAR) is from the July 10-13, 2023 Newfoundland & Labrador Comparative Fishing Analysis – Part 1 Regional Peer Review, and summarizes the main scientific advice from this meeting. A number of data sources and analyses were explored over the course of the meeting. These, as well as further details on analyses contained herein, can be found in the CSAS Research Document Series. Additional publications from this meeting will be posted on the Fisheries and Oceans Canada (DFO) Science Advisory Schedule as they become available.

SUMMARY

- A comparative fishing program was undertaken in the Newfoundland and Labrador (NL) Region in the fall of 2021 and spring and fall of 2022 to quantify differences in catchability between the outgoing vessels Canadian Coast Guard Ship (CCGS) *Alfred Needler* and CCGS *Teleost* with the new Offshore Fishery Science Vessels (OFSVs) CCGS *John Cabot* and CCGS *Capt. Jacques Cartier*.
- Conversion factors to calibrate multispecies survey catches were estimated for the CCGS *Teleost* fall survey in Northwest Atlantic Fisheries Organization (NAFO) Divisions (Div.) 2HJ3KL and CCGS *Alfred Needler* fall survey in Div. 3KL. Conversion factors are intended to be applied to the vessel, season, and area for which they were derived and are not interchangeable between the CCGS *Teleost* and CCGS *Alfred Needler* time-series.
- For the CCGS *Teleost*, conversion factors were defined for 14 taxa including 2 with significant length effects, 18 taxa showed no significant difference in relative catchability, and 9 evaluated taxa had insufficient data to determine if a conversion factor is appropriate.
- For the CCGS *Alfred Needler*, conversion factors were defined for 15 taxa including 6 with significant length effects, 17 taxa showed no significant difference in relative catchability, and 12 evaluated taxa had insufficient data to determine if a conversion factor is appropriate.
- Sample size and spatial coverage of paired tows are generally insufficient to estimate standard conversion factors for the CCGS *Alfred Needler* survey time-series in Div. 3LNOPs in the spring or in Div. 3NO in the fall. With the CCGS *Alfred Needler* already decommissioned (i.e., no additional comparative fishing possible), data collected in 3NOPs by the new vessels will represent the beginning of a new time series for the majority of species and will not be directly comparable to the previous time series.
- Consistency in environmental and biological characteristics across seasons allowed a unique approach to estimating a conversion factor for Yellowtail Flounder applicable across the Div. 3LNO fall and 3LNOPs spring CCGS *Alfred Needler* time-series.
- Data gaps exist for small Atlantic Cod and small Snow Crab in the CCGS *Teleost* comparative fishing program. Conversion factors have been estimated for larger individuals and will be re-evaluated for the full length range following the fall 2023 comparative fishing program.
- An additional data gap in the CCGS *Teleost* comparative fishing program exists for deep water species including Greenland Halibut. Conversion factors have not been estimated at this time but will be evaluated following the fall 2023 comparative fishing program.

BACKGROUND

The NL Region is transitioning the vessels it uses for annual multispecies trawl surveys, moving from the CCGS *Teleost* (hereafter, "*Teleost*") and CCGS *Alfred Needler* ("*Needler*") to new Offshore Fishery Science Vessels (OFSVs) the CCGS *Capt. Jacques Cartier* ("*Cartier*") and the CCGS *John Cabot* ("*Cabot*"). In addition to changing vessels, minor modifications (described in Wheeland et al. 2023a) to the standard Campelen 1800 survey trawl's (Walsh et al. 2009) net and footgear were completed in 2020 for use in the survey going forward. Changing vessels and equipment can affect how fish and other organisms are caught – including species composition in survey tows as well as the numbers and size distribution of each species – which changes how the data are interpreted. To ensure continuity in the survey time-series it is necessary to quantify differences in catch from the new OFSVs (*Cabot* and *Cartier*) relative to the outgoing vessels (*Teleost* and *Needler*) and do so here through comparative fishing. This comparative fishing program involves side-by-side survey trawling ("paired tows") between the old and new vessels, collecting data necessary to quantify differences in catch amounts and composition (e.g., by species, size, etc.), and estimating species and vessel specific conversion factors.

Multispecies Survey

There are two annual multispecies surveys in the NL Region: spring, and fall. Data from these surveys are used to inform stock assessments and associated scientific advice for fisheries management, ecosystem assessments, monitoring of species at risk, marine conservation monitoring, and a variety of research programs. The NL fall multispecies survey covers NAFO Div. 2HJ3KLNO (Figure 2), extending from the Labrador Shelf in the North to the Grand Bank in the South (see Rideout et al. 2022 and references therein). This survey has been completed with the *Teleost* (Div. 2HJ3K + 3L strata ≥750 m) and *Needler* or equivalent (see Warren et al 1997) (Div. 3KLNO) since the mid-1990s. The NL spring multispecies survey covers NAFO Div. 3LNOP and has been completed primarily with the *Needler* since the mid-1990s, though the *Teleost* has been used as a substitute in some divisions and years when the *Needler* was unavailable. The *Needler* surveys depths to 732 m in Div. 3LNOPs, and to 750 m in Div. 3K, while the *Teleost* covers depths to 1,500 m in Div. 2HJ3KL.

Comparative Fishing

Paired tows were completed between the *Needler* and the *Cabot* in the spring and fall of 2022, and between the *Teleost* and the *Cabot* and *Cartier* in the fall of 2021 and 2022. Full details of the comparative program are described in Wheeland et al. 2023b and Trueman et al. in prep[1]. Vessels were instructed to tow side by side using standardized protocols at a distance of 0.5 nautical miles apart, alternating port and starboard arrangement. If fishing grounds did not allow for side by side (e.g., steep slopes or rough bottom), options were available for vessels to fish single file or one then the other depending on suitability of fishing grounds.

Paired sampling was planned in, and partially covered, all NAFO Divisions normally sampled within the multispecies survey. The original comparative program design used a "shadow survey" approach, with stations (set locations) randomly allocated following the standard survey design (Thiess et al. 2018). In the fall of 2021 and spring of 2022, full shadow surveys were

[1] Trueman, S., Benoît, H., Munro, H., Nguyen, T., Novaczek, E., Skanes, K., Walsh, S. Wheeland, L., and Yin, Y. In prep. Results of comparative fishing between the CCGS *Teleost* and CCGS *Alfred Needler* with the CCGS *John Cabot* and CCGS *Capt. Jacques Cartier* in the Newfoundland and Labrador Region in 2021 and 2022. DFO Can. Sci. Advis. Sec. Res. Doc.

allocated, but areas sampled were limited and primarily determined by vessel availability. Due to issues with vessel availability the original full shadow survey design had to be scaled back, leading to the implementation of a representative areas and priority species targeted design. In the fall of 2022, concerns around vessel availability and efficiency led to the implementation of a targeted design and cancellation of the stratified-random survey. In the targeted approach, a representative subset of strata within the normal survey area were selected and prioritized based on the prevalence of priority species, distribution of fish functional groups, species diversity and richness, and characteristics of the physical environment (e.g., depth, slope vs. bank).

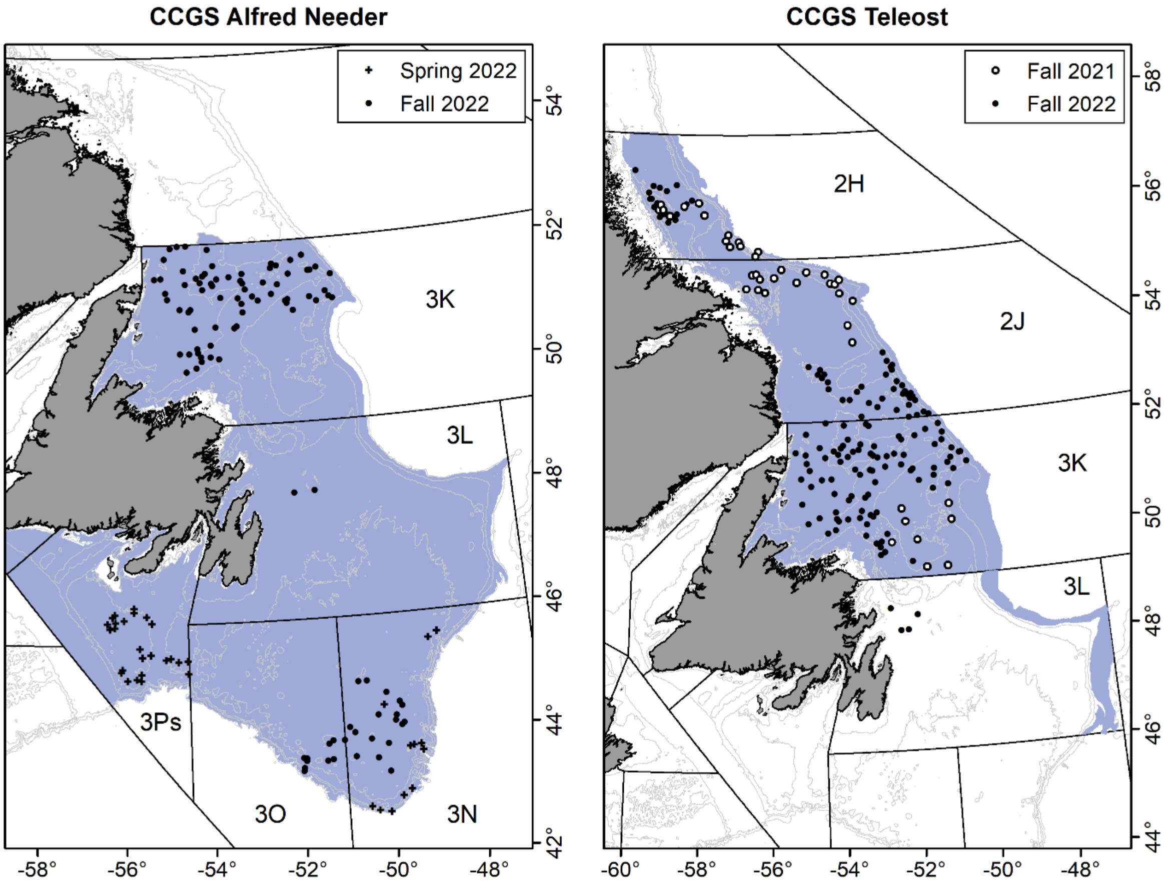

Figure 2. Map of paired tow locations for the CCGS Alfred Needler *(left) and CCGS* Teleost *(right) with the new OFSVs. Blue shaded area indicates the typical survey area covered by each vessel, with spring (Div. 3LNOP) and fall (Div. 3KLNO) areas combined for the* Needler*. Depth contours are shown at 100, 300, 500 and 1,000 m.*

ANALYSIS

Trawl geometry, including door and wing spread, trawl opening and clearance, was measured during paired tows using SCANMAR hydroacoustic trawl instrumentation. Trawl geometry and performance of the *Needler* showed considerable differences when compared to that of the other three vessels – *Teleost*, *Cabot*, and *Cartier* – which was expected given the difference in vessels power and winch systems. The *Needler* was characterized by smaller door spread, lower wing spread, longer tow duration, and slower tow speed particularly at trawl haul-back.

The standard and modified Campelen trawl geometry were very comparable among and between the *Teleost* and the new vessels, *Cabot* and *Cartier*. The new vessels are sister ships and are considered here to be interchangeable; measurements of trawl performance and geometry support this conclusion.

For comparative fishing, the *Teleost* was paired with the *Cabot* or the *Cartier* during the fall, with 197 successful paired tows completed across the two years (Table 1). Analyses of benthic habitat parameters – including metrics of substrate, bathymetry, geomorphology, and current – indicate that the areas sampled for *Teleost* comparative fishing well represented the range of conditions in the broader survey area normally covered by this vessel in the fall (Div. 2HJ3KL). *Teleost* data are used here to estimate conversion factors applicable across the fall *Teleost* series. However, comparative fishing could not be completed in depths beyond 1,000 m due to temporary vessel winch restrictions and conversions have yet to be estimated for several deep-water species (e.g., Greenland Halibut, Roughhead Grenadier). These restrictions have since been resolved, and the inclusion of sets from 1,000–1,500 m is planned for the fall 2023 comparative fishing program, after which comparative fishing data for these deep species will be revisited.

The *Needler* was paired with the *Cabot* in 2022, with 37 successful paired tows completed in the spring, and 100 in the fall (Table 1). The comparative program for the *Needler* was incomplete due to major mechanical issues, and sample size is limited in most areas. Paired sampling completed for the *Needler* in Div. 3K well represented the broader survey area in this Division. Fall data from Div. 3K were combined with Div. 3LNO to estimate conversion factors that are considered applicable to Div. 3KL; sets on the top of the bank in Div. 3NO are used here as a proxy for conditions on top of the bank in Div. 3L.

On the Grand Bank (Div. 3LNO) in fall and across the survey area (Div. 3LNOPs) in spring, depth and habitat complexity sampled by the *Needler* paired tows was severely truncated and thus was not representative of the broader survey area. Paired tow sample size and coverage is insufficient to estimate reliable conversion factors for the spring *Needler* series and direct application of fall conversion factors on the Grand Bank is limited. With the *Needler* already decommissioned additional comparative fishing is not possible. In the absence of conversion factors, data collected in Div. 3LNOPs for spring, and in Div. 3NO for fall, by the new vessels will represent the beginning of a new time series for the majority of species.

Table 1. Summary of paired data availability and application.

Season	Vessel	Paired tow sample size (Division)	Notes	Application
Spring	CCGS *Alfred Needler*	25 (3Ps) 12 (3N)	Insufficient data for conversions. Small sample size combined with severe truncation of depth and habitat complexity sampled.	For Yellowtail Flounder in Div. 3LNOPs, when combined with fall.
Fall	CCGS *Alfred Needler*	71 (3K) 2 (3L) 17 (3N) 10 (3O)	Paired tows in Div. 3K covered the normal survey conditions in this area. Small sample size, severe truncation of depth and habitat	Conversions directly applicable to Div. 3KL. For Yellowtail Flounder in Div. 3LNO, when combined with spring.

Season	Vessel	Paired tow sample size (Division)	Notes	Application
			complexity sampled on the Grand Bank (Div. 3LNO).	Further application must be supported by additional analyses which should include consistency in environmental and biological conditions.
Fall	CCGS *Teleost*	34 (2H) 61 (2J) 98 (3K) 4 (3L)	Data combined from 2021 and 2022. *Teleost* paired with the *Cabot* (17 sets) or *Cartier* (180 sets). No sampling 1,000–1,500 m. Conversion factors are not estimated here for species considered to notably extend into these deep water – this will be addressed in Part 2.	Across the standard *Teleost* fall survey area (Div. 2HJ3K, plus 3L strata ≥732 m).

Analyses of paired tows between old and new vessels without the application of any conversion factors indicate that the old and new vessels sampled similar species composition and richness. However, the *Needler* and *Teleost* sampled an overall lower diversity when compared with the *Cabot* and *Cartier*, with differences in species diversity (Shannon-Weaver) and evenness (Pielou's) within the paired data. These differences were small but significant, and likely driven by differences in weight of taxa (i.e., proportion) and not number of species within paired sets.

Estimating Conversion Factors

In the analysis of comparative fishing data, the goal is to estimate the relative fishing efficiency by numbers and/or weight between a pair of vessel-gear combinations. A suite of 13 binomial and beta-binomial models (Table 2) with various assumptions for length and station (i.e., set location) effects on the relative catch efficiency were fit for all species with sufficient sample size (minimum 25 paired tows) and length information to estimate size-disaggregated conversion factors for catch numbers by length. Length here was measured as total (cm), fork (cm), or anal length (mm) depending on the species of finfish, carapace length (mm) for shrimp, and carapace width (mm) for crab. Length was included in the models as a fixed effect and applied as a smoothing effect based on a general additive smooth function, for both model types. For the beta-binomial models the same smooth construct is also applied to the over-dispersion parameter. The station effect was included as a random effect on the intercept to accommodate different underlying densities of species across sets sampled, and in the more complicated models (BI4 and BB6) included on the smoother to allow for a station and length interaction effect. However, to accurately model this interaction requires a large amount of data and there were very few cases of either BI4 or BB6 converging for species in the NL data set. Full model formulation is detailed in Yin and Benoît 2022, with the conversion factor $\rho(l)$, the quantity of interest, defined as the ratio of catchabilities between vessels A and B at length l.

Table 2. Summary of the suite of binomial (BI) and beta-binomial (BB) models indicating how length and station effects were incorporated. Length is included as a fixed effect on the smoother, and in the case of BB models on the over-dispersion parameter (n/a for BI models). Where there is no length effect, relative catch efficiency is assumed to be constant across size. The station effect is modeled as a random effect applied to the intercept, without interaction with the length effect, or added to both the intercept and smoother to allow for interaction between the two effects. Models increase in complexity with increasing number within the BI and BB models.

Model type	Model name	Length effect on the smoother?	Length effect on the over-dispersion parameter?	Station effect on the intercept?	Station effect on the smoother?
Binomial	BI0	no	n/a	no	no
Binomial	BI1	no	n/a	yes	no
Binomial	BI2	yes	n/a	no	no
Binomial	BI3	yes	n/a	yes	no
Binomial	BI4	yes	n/a	yes	yes
Beta-binomial	BB0	no	no	no	no
Beta-binomial	BB1	no	no	yes	no
Beta-binomial	BB2	yes	no	no	no
Beta-binomial	BB3	yes	no	no	no
Beta-binomial	BB4	yes	no	yes	no
Beta-binomial	BB5	yes	yes	yes	no
Beta-binomial	BB6	yes	no	yes	yes

For species with smaller sample size (minimum 15 paired tows) and/or where length information is not available, conversion factors are estimated for catches aggregated across all sizes (“size-aggregated models”). The same model formulation as above are used for catch number conversions (i.e., abundance) however, the binomial and beta-binomial models are not appropriate for catch weight (biomass). Instead, analysis of size aggregated catch weights employs the following model, which assumes a Tweedie (TW) distributed error:

$$W_{i,v} \sim TW(\mu_{i,v}, \varphi, \tau)$$
$$E[W_{i,v}] = \mu_{i,v} = \exp(v + \delta_i + o_{i,v})$$
$$Var[W_{i,v}] = \varphi(\mu_{i,v})^{\tau}$$

where $W_{i,v}$ is the catch weight at station *i* by vessel *v*, TW is the specification of the Tweedie distribution, $\mu_{i,v}$ is the expected catch weight at station *i* for vessel *v*, φ is the dispersion parameter of the Tweedie distribution, p is a power parameter, restricted to the interval 1< τ <2

(Dunn and Smyth 2005), *v* is the fixed vessel effect, where *exp*(*v*) = p, δ_i is a random effect that accounts for the biomass at station *i*, and $o_{i,v}$ is the offset.

The conversion factors are defined as an estimate of relative catch efficiency (ρ), or catch efficiency at length $\rho(l)$ with the conversion factor being the ratio of catchabilities between the old and new vessels. When ρ <1 indicates the new vessels catch a greater amount, while a ρ >1 indicates the new vessel catches less. Catchability between vessels is equal when ρ = 1, and in this case conversion of catches between vessels is not required. For size-disaggregated models, when the 95% confidence interval (CI) of a rho estimate overlapped with one across the conversion factor function this was considered not significant, and the adoption of a conversion factor is not recommended. When a size-based conversion is recommended, the conversion factor estimate from the 0.5 and 99.5 length percentiles should be used as a constant below or above those lengths, respectively, in order to account for very low sample size at these extreme lengths. The application of conversion factors converts data from the old vessels to new vessel equivalent catch, and vice versa, with catch from new vessel multiplied by ρ to obtain old vessel equivalent catch.

For size aggregated models (weights and numbers), a conversion factor is considered significant when ρ <0.05 and the CI does not overlap with 1. For species where one of the two conversions was significant, the corresponding metric was considered significant if ρ <0.1 regardless of if the CIs overlapped with 1, otherwise only the conversion significant at ρ <0.05 is recommended to be applied.

Where a conversion factor has been estimated for a group of taxa, this factor is applicable only at the grouped level and should not be applied to a single species within the group. Any taxa not specifically mentioned in these analyses was not present in the comparative fishing data set, or did not meet the minimum sample size requirements, and relative catch efficiency cannot be evaluated.

CCGS *Teleost*

For the CCGS *Teleost*, conversion factors (Table 3) were defined for 14 taxa including 2 with significant length effects, 18 taxa showed no significant difference in relative catchability, and 9 evaluated taxa had insufficient data to determine if a conversion factor is appropriate. Conversions estimated here are considered directly applicable across the standard *Teleost* fall survey.

Nine taxa met the minimum sample size requirement for size aggregated analysis (present in at least 15 pairs) but conversions could not be estimated due to insufficient data for Longfin Hake, Common Lumpfish, Snakeblenny, Wrymouth, hard corals, amphipods, euphausiids, sessile tunicates, and Spiny Crab.

Table 3. Conversion factor (ρ) recommendations and estimates with 95% CIs for catch aggregated conversions for the Teleost *fall series. (-) indicates a conversion was not significant. Estimates of the conversion factor at length $\rho(l)$ for species where a size-based conversion was supported are presented in Figure 3. All conversions here are appropriate for use across the standard fall* Teleost *survey area.*

Species or taxa group	Size effects considered?	Recommendation	$\rho\ (CI)$ numbers	$\rho\ (CI)$ weight
American Plaice	yes	No conversion required	-	-
Atlantic Cod 20 cm +*	yes	No conversion required	-	-
Thorny Skate	yes	No conversion required	-	-
Witch Flounder	yes	Significant size-based conversion	See Figure 3	Apply conversion to catch numbers at length
Striped Wolffish	yes	No conversion required	-	-
Spotted Wolffish	yes	No significant length effect. Conversion required for abundance and biomass	0.65 (0.54–0.79)	0.76 (0.46–1.24)
Redfish	yes	No conversion required	-	-
Snow Crab 40 mm+*	yes	No significant size effect, but conversion required for abundance. Catch-aggregated weight conversion not estimated for the partial length range	0.54 (0.44–0.67)	Apply conversion to catch numbers at length
Northern Shrimp	yes	Significant size-based conversion	See Figure 3	Apply conversion to catch numbers at length
Alligatorfish and poachers	no	No conversion required	-	-
Arctic Cod	no	No conversion required	-	-
Capelin	no	Conversions required on abundance and biomass	1.45 (1.14–1.84)	1.48 (1.19–1.85)
Eelpouts	no	Conversions required on abundance and biomass	0.9 (0.8–1.01)	0.79 (0.70–0.89)

Species or taxa group	Size effects considered?	Recommendation	$\rho\ (CI)$ numbers	$\rho\ (CI)$ weight
Fourline Snakeblenny	no	No conversion required	-	-
Rocklings	no	Conversion required on biomass	-	0.69 (0.52–0.92)
Sculpins	no	No conversion required	-	-
Seasnails	no	No conversion required	-	-
Shannies	no	Conversion required on biomass and abundance	1.58 (0.98–2.54)	1.50 (1.03–2.19)
Northern Wolffish	no	No conversion required	-	-
Annelids and polychaetes	no	No conversion required	-	-
Cephalopods	no	No conversion required. Grouping excludes illex and gonatus squid	-	-
Gastropods	no	Conversion required on biomass	-	0.53 (0.36–0.80)
Sea anemones	no	Conversion required on biomass	-	0.67 (0.54–0.84)
Pycnogonids	no	Conversion required on abundance	1.94 (1.15–3.26)	**
Squid (Illex and Gonatus)	no	Conversions required on abundance and biomass	1.30 (1.03–1.68)	1.40 (1.12–1.74)
Striped Shrimp	no	No conversion required	-	1.37 (0.94–2.00)
Toad Crab	no	No conversion required	-	-
Basket stars	no	No conversion required on biomass	Paired count data not available	-
Brittle stars	no	No conversion required on biomass	Paired count data not available	-
Scyphozoans	no	Conversion required on biomass	Paired count data not available	0.85 (0.73–0.99)

Species or taxa group	Size effects considered?	Recommendation	ρ (CI) numbers	ρ (CI) weight
Soft corals	no	Conversion required on biomass	Paired count data not available	2.13 (1.42–3.20)
Sponges	no	No conversion required	Paired count data not available	-

* Conversion factor for the full length range will be reviewed following fall 2023 comparative fishing.
** Resolution on weight data is insufficient to estimate relative catch efficiency.

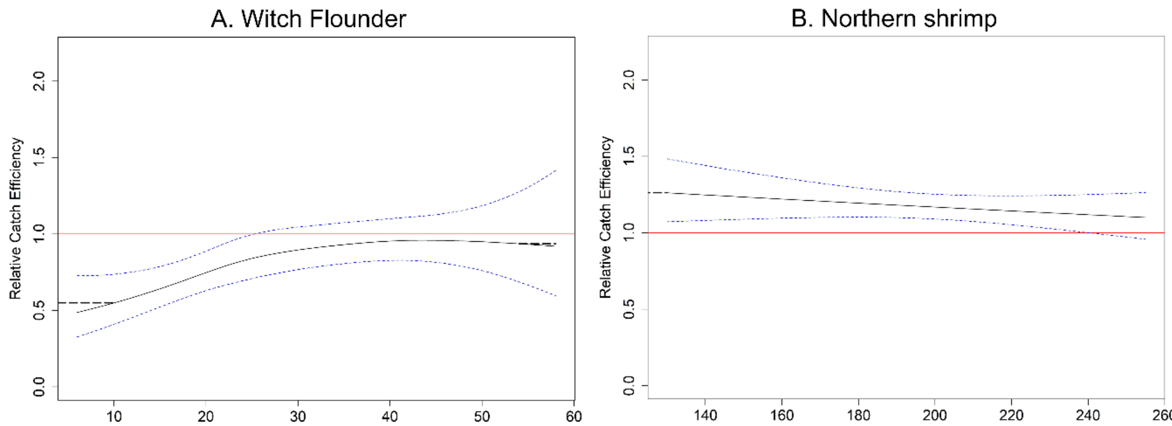

Figure 3. Length-based estimates of relative catch efficiency with 95% CIs for (A) Witch Flounder (total length, cm, full length range) and (B) Northern Shrimp (carapace length, mm, 2.5–97.5 percentile length range). Dashed lines on (A) indicate the constant conversion below the 0.5 and above the 99.5 length percentiles.

CCGS *Alfred Needler*

For the CCGS *Alfred Needler,* conversion factors (Table 4) were defined for 15 taxa including 6 with significant length effects, 17 taxa showed no significant difference in relative catchability, and 12 evaluated taxa had insufficient data to determine if a conversion factor is appropriate. These conversion factors are considered directly applicable to fall Div. 3KL, with the exception of Yellowtail Flounder which is applicable across Div. 3LNOPs spring and fall (see Special Case: Yellowtail Flounder). Further application must be supported by additional analyses which should include consistency in environmental and biological conditions between seasons and/or areas.

The minimum sample size requirement for size aggregated analysis was met by 12 species or taxa groupings (present in at least 15 pairs) but conversions could not be estimated due to insufficient data and/or inappropriate spatial representation of paired data for Silver Hake, White Hake, grenadiers, Snake Blenny, Sea Raven, Common Lumpfish, annelids and polychaetes, amphipods, cephalopods (excluding *Illex* and *Gonatus* squid), sessile tunicates, soft corals, and bryozoans.

Table 4. Conversion factor (ρ) recommendations and estimates with 95% CIs for size aggregated conversions for the Needler *fall series. (-) indicates a conversion was not significant. Estimates of the conversion factor at length $\rho(l)$ for species where a size-based conversion was supported are presented in Figure 4. All* Needler *conversions here are for use in Div. 3KL Fall, with the exception of Yellowtail flounder (spring or fall 3LNOPs).*

Species or taxa group	Size effects considered?	Recommendation	ρ (CI) numbers	ρ (CI) weight[2]
American Plaice	yes	Significant size-based conversion	See Figure 4	Apply conversion to catch numbers at length
Atlantic Cod	yes	No conversion required	-	-
Thorny Skate	yes	No conversion required	-	-
Witch Flounder	yes	Significant size-based conversion	See Figure 4	Apply conversion to catch numbers at length
Roughhead Grenadier	yes	No conversion required	-	-
Greenland Halibut	yes	No conversion required	-	-
Redfish	yes	Significant size-based conversion	See Figure 4	Apply conversion to catch numbers at length
Yellowtail Flounder	yes	Significant size-based conversion	See Figure 4	Apply conversion to catch numbers at length
Snow Crab	yes	Significant size-based conversion	See Figure 4	Apply conversion to catch numbers at length
Northern Shrimp	yes	Significant size-based conversion	See Figure 4	Apply conversion to catch numbers at length
Alligatorfish and poachers	no	No conversion required	-	-
Arctic Cod	no	No conversion required	-	-
Barracudina	no	No conversion required	-	-

[2] Erratum August 2024: Biomass conversions corrected in table, previous values were the inverse.

Species or taxa group	Size effects considered?	Recommendation	$\rho\ (CI)$ numbers	$\rho\ (CI)$ weight[2]
Capelin	no	No conversion required	-	-
Eelpouts	no	Conversions required on abundance and biomass	0.71 (0.60–0.83)	0.81 (0.7-0.93)
Lanternfishes	no	No conversion required	-	-
Rockling spp.	no	Conversion required on biomass	-	0.71 (0.51-0.99)
Sculpins	no	Conversions required on abundance and biomass	0.68 (0.49–0.94)	0.51 (0.38-0.69)
Seasnails	no	No conversion required	-	-
Shannies	no	Conversion required on biomass and abundance	0.55 (0.31–0.96)	0.52 (0.34-0.8)
Spotted Wolffish	no	No conversion required	-	-
Striped Wolffish	no	No conversion required	-	-
Wrymouth	no	Conversion required on biomass and abundance	0.56 (0.32–0.98)	0.55 (0.31-0.99)
Gastropods	no	Conversion required on biomass; and abundance	0.57 (0.34–0.93)	0.28 (0.16-0.51)
Sea anemones	no	Conversion required on abundance.	0.65 (0.45–0.93)	-
Squid (*Illex*. and *Gonatus* spp.)	no	Conversions required on abundance and biomass	2.09 (1.42–3.08)	1.52 (1.09-2.12)
Striped Shrimp	no	No conversion required	-	0.67 (0.41-1.11)
Toad Crab	no	No conversion required	-	-
Basket stars	no	No conversion required	Paired count data not available	-
Brittle stars	no	Conversion required on biomass	Paired count data not available	0.51 (0.33-0.79)
Scyphozoans	no	No conversion required	Paired count data not available	-

Species or taxa group	Size effects considered?	Recommendation	$\rho\ (CI)$ numbers	$\rho\ (CI)$ weight[2]
Sponge	no	No conversion required	Paired count data not available	-

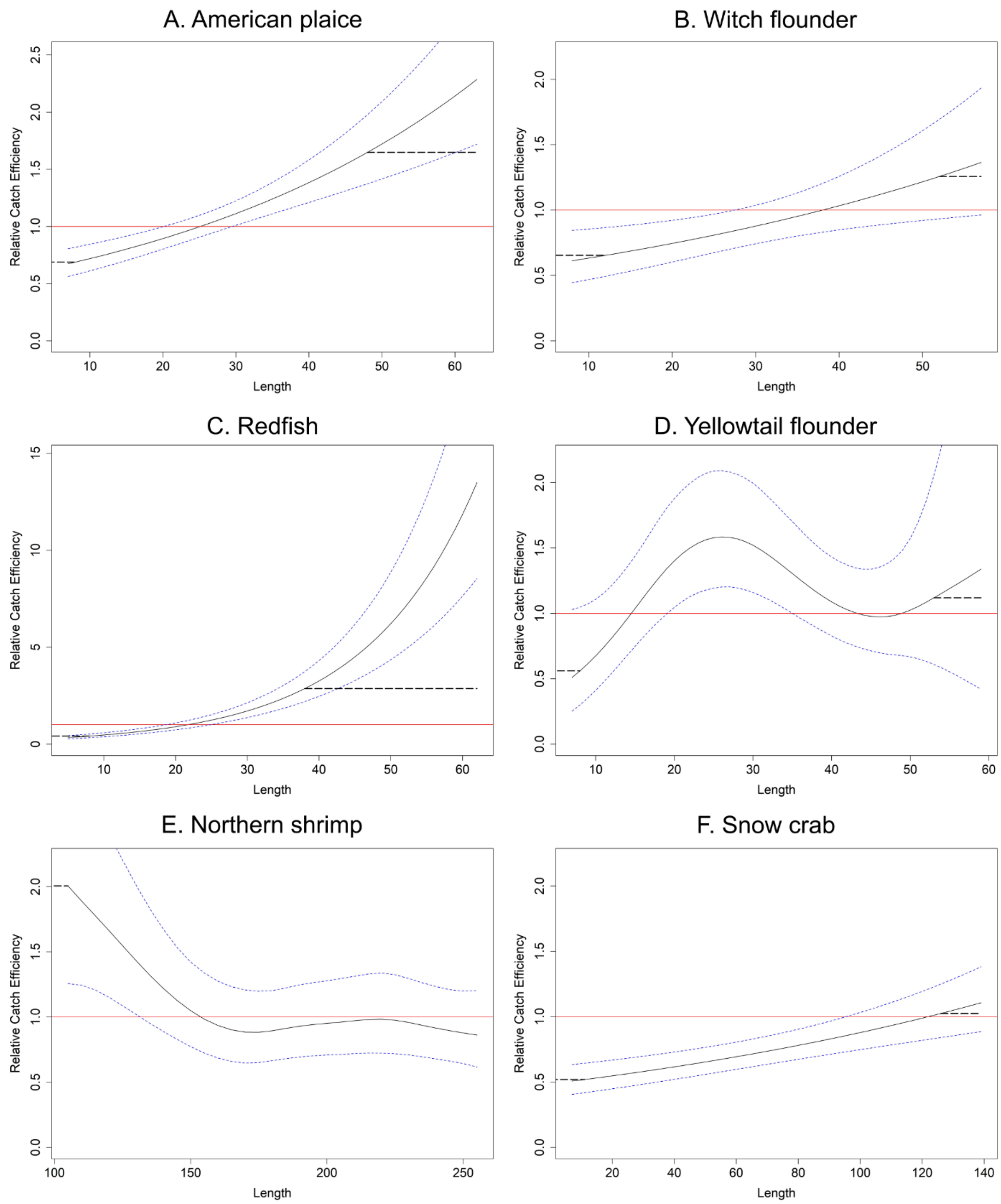

Figure 4. Length-based estimates of relative catch efficiency with 95% CIs for (A) American plaice (total length, cm), (B) Witch Flounder (total length, cm), (C) Redfish (total length, cm), (D) Yellowtail Flounder (total length, cm), (E) Northern Shrimp (carapace length, mm), (F) Snow Crab (carapace width, mm). Dashed lines indicate the constant conversion below the 0.5 and above the 99.5 length percentiles.

Special Case: Yellowtail Flounder

For Yellowtail Flounder only, paired sets for the *Needler* have been combined from the fall and spring of 2022 to estimate conversion factors for use in either season and across Div. 3LNOPs. Given the species limited distribution (spatially and by depth, see for example Maddock Parsons et al. 2021), along with limited variation in habitat, paired tows in the spring (Div. 3N, Subdiv. 3Ps) and in the fall on the Grand Bank (Div. 3LNO) – while limited in scope and sample size – are considered to represent the conditions normally surveyed for this species. In addition, consistency between seasons in the spatial distribution, temperature and depth occupied, body condition (Fulton's condition factor, K), and size (length distribution and weight at length) of Yellowtail Flounder supported the combining of spring and fall data (Figure 5). It was noted that spawning condition varies between these two seasons, and there are known differences in behaviour (activity level) and catchability of flatfish during the spawning season (e.g., Solmundsson et al. 2003), however this would affect both vessels within a pair and season and was not considered reason enough to preclude the combining of seasons for the estimation of conversion factors. Model residuals were examined by season and did not indicate any significant effect of season on conversion factors for this species.

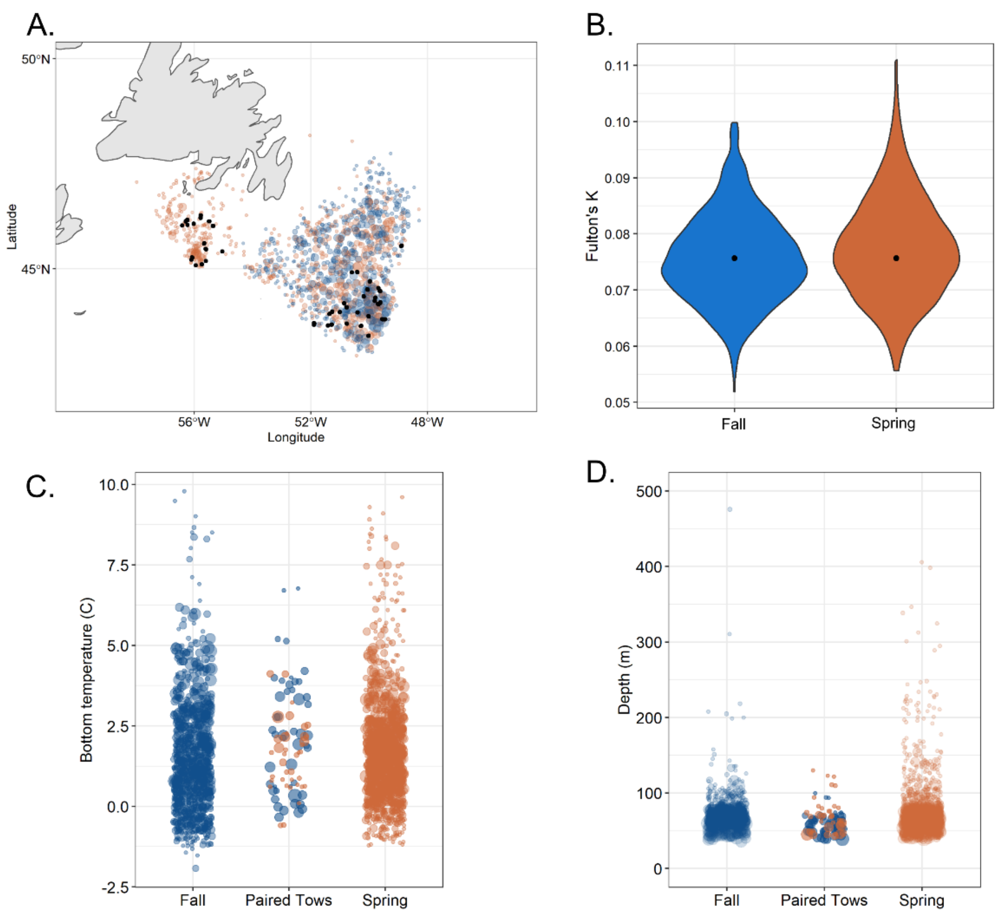

Figure 5. (A) Distribution of paired tows (black) relative to Yellowtail Flounder catches in the standard multispecies survey from 2016–21 in Div. 3LNOPs in spring (orange) and Div. 3LNO in fall (blue). (B) Fulton's K metric of fish condition in fall and spring. Bottom temperature (C) and depth (D) occupied by Yellowtail Flounder in fall and spring, and in the paired tows completed during the comparative fishing program in 2022. Dot sizes are proportional to catch numbers per tow.

Sources of Uncertainty

Most non-commercial finfish were frozen at-sea and are processed in the lab. At the time of this meeting length data were not available and these species were analyzed for size aggregated conversion factors only. Widespread discrepancies between the directionality of biomass and abundance size aggregated conversions for *Needler* taxa where both weight and number conversions were significant suggest an underlying size-based effect that we are unable to quantify at this time. Further analyses are recommended as length data become available.

Simulations (Yin and Benoît 2022) indicate that data limitations (i.e., insufficient sampling across the population length range in paired sets) can lead to an inability of the size disaggregated models used here to properly estimate a length-based conversion. For models where no significant size effect has been estimated this may be, in some cases, an inability to detect this effect. However, given that data were more limited to the *Needler* pairs, and size-based were more prevalent for this vessel, this is not considered to be a widespread issue within our analyses.

Sample size was limited in the comparative fishing program for the *Teleost* in waters <150 m. This is not broadly considered to be a significant gap in the paired dataset, however additional paired tows have been recommended to collect a more representative dataset for small Atlantic Cod and small Snow Crab which are likely to be found in the shallow areas that were underrepresented in the current dataset.

There is an unquantified human dimension to comparative fishing, and more broadly within any trawl survey program. Differences (e.g., tow time, tow speed, resolution of species identification) can occur between fishing officers and science crews and cannot be directly accounted for (ICES 2009). Standardization of fishing and sampling protocols and thorough training on these is the best way to minimize these effects both within a comparative program and going forward.

Research Recommendations

During this meeting recommendations were made for the fall 2023 at-sea program and further analyses for the next comparative fishing peer review process in the NL Region, as follows:

- The fall 2023 comparative fishing program should undertake paired tows at depths 1,000–1,500 m to complete coverage of the standard depth range of the survey, and complete additional paired tows in shallow water targeting small Atlantic Cod and small Snow Crab.
- The use of trawl bottom contact sensors on the *Teleost* and *Cabot* is recommended for any paired work in the fall of 2023 to further compare gear performance.
- Calculate conversion factors for the *Teleost* for deep water taxa not addressed in Part 1 (e.g., Greenland Halibut, Roughead grenadier).
- Re-evaluate the conversion factors estimates for Atlantic Cod and Snow Crab considering the full size range of these species following the collection of additional paired data in shallow waters.
- A number of taxa groupings should be further refined as/if data allow (e.g., further split by habitat or size classes), including: Non-pandalid shrimps, echinoderms, bivalves, and eels. Additional groupings (e.g., functional groups) may be explored to support specific data use at broader taxonomic resolution.
- As frozen samples are processed, sufficient length data may become available to test for size-based conversions in some species only considered so far in size aggregated

analyses. These should be revisited on an ongoing basis and will be included in Part 2 if data availability permits.

More broadly, conversion factors calculated here include estimates of uncertainty. It is recommended that these uncertainties be included in their application whenever possible.

CONCLUSION

Conversion factors to calibrate multispecies survey catches were estimated for the CCGS *Teleost* fall survey in Div. 2HJ3KL, the CCGS *Alfred Needler* fall survey in Div. 3KL, and for Yellowtail flounder on the *Needler* across spring and fall in Div. 3LNOPs. Conversion factors are intended to be applied to the vessel, season, and area for which they were derived. Further application must be supported by additional analyses which should include consistency in environmental, seasonal, and biological conditions, and trawl performance. Conversion factors are not interchangeable between the CCGS *Teleost* and CCGS Alfred *Needler* time-series.

Sample size and spatial coverage of paired tows are insufficient to estimate standard conversion factors for the CCGS Alfred *Needler* survey time-series in Div. 3LNOPs in the spring or in Div. 3NO in the fall (with the exception of Yellowtail flounder). With the CCGS *Alfred Needler* already decommissioned (i.e., no additional comparative fishing possible), data collected in Div. 3NOPs by the new vessels will represent the beginning of a new time-series for the majority of species and will not be directly comparable to the previous time series.

OTHER CONSIDERATIONS

The information provided in this SAR and associated Research Document covers the conclusions and analysis conducted for one of two planned CSAS Regional Peer Review processes for analyses of the NL comparative fishing program. Data collection is still ongoing into the fall of 2023 and analyses continue. For a full understanding of the comparative fishing program and implementation of conversion factors, readers are encouraged to consult all current and future publications related to the project, to ensure decisions made are based on the most up-to-date documentation.

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SOURCES OF INFORMATION

This Science Advisory Report is from the July 10-13 Newfoundland & Labrador Comparative Fishing Analysis – Part 1 Regional Peer Review. Additional publications from this meeting will be posted on the Fisheries and Oceans Canada (DFO) Science Advisory Schedule as they become available.

Dunn, P.K., and Smyth, G.K. 2005. Series evaluation of Tweedie exponential dispersion model densities. Stat. Comput. 15: 267–280.

ICES 2009. Report of the Study Group on Survey Trawl Standardization (SGSTS). ICES CM 2009/FTC:09: 127 p.

Maddock Parsons, D., Rideout, R., and Rogers, R. Divisions 3LNO Yellowtail Flounder (*Limanda ferruginea*) in the 2018-2020 Canadian Stratified Bottom Trawl Surveys. Serial No. N7187. NAFO SCR Doc. 21/09. 36 p.

Rideout, R.M., Rogers, B., Wheeland, L., and Koen-Alonso, M. 2022. Temporal And Spatial Coverage Of Canadian (Newfoundland And Labrador Region) Spring And Autumn Multi-Species RV Bottom Trawl Surveys, With An Emphasis On Surveys Conducted In 2021. Serial No. N7271. NAFO SCR Doc. No. 22/007. 46 p.

Solmundsson, J., Karlsson, H., and Palsson, J. 2003. Sexual differences in spawning behaviour and catchability of plaice (*Pleuronectes platessa*) west of Iceland. Fish. Res. 61(1–3): 57–71.

Thiess, M.E., Benoit, H., Clark, D.S., Fong, K., Mello, L.G.S., Mowbray, F., Pepin, P., Cadigan, N.G., Miller, T., Thirkell, D., and Wheeland, L. 2018. Proceedings of the National Comparative Trawl Workshop, November 28-30, 2017, Nanaimo, BC. Can. Tech. Rep. Fish. Aquat. Sci. 3254: x + 40 p.

Walsh, S.J., Hickey, W.H., Porter, J., Delouche H., and McCallum, B.R. 2009. NAFC Survey Trawl Operations Manual: Version 1.0. Fisheries and Oceans, Northwest Atlantic Fisheries Centre, Newfoundland Region, St. John's.

Warren, W., Brodie, W., Stansbury, D., Walsh, S., Morgan, J., and Orr, D. 1997. Analysis of the 1996 Comparative Fishing Trial between the *Alfred Needler* with the Engel 145 trawl and the *Wilfred Templeman* with the Campelen 1800 trawl. Serial No. N2902. NAFO SCR Doc. 97/68. 12 p.

Wheeland, L., Trueman, S., and Rideout, R.M. 2023a. Coverage of the 2022 Canadian (Newfoundland And Labrador Region) Multi-Species RV Bottom Trawl Survey with notes on Comparative Fishing. Serial No. N7431. NAFO SCR Doc. 23/042. 27 p.

Wheeland, L., Skanes, K., and Trueman, S. 2023b. Summary of Comparative Fishing Data Collected in Newfoundland & Labrador from 2021-2022. Can. Tech. Rep. Fish. Aquat. Sci. 3579: iv + 132 p.

Yin, Y., and Benoît, H.P. 2022. A Comprehensive Simulation Study of A Class of Analysis Methods for Paired-Tow Comparative Fishing Experiments. Can. Tech. Rep. Fish. Aquat. Sci. 3466: vi + 99 p.

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