Serial No. N7606 **NAFO SCS Doc. 24/066**

SCIENTIFIC COUNCIL MEETING –SEPTEMBER 2024

A brief overview of the estimation of *Illex illecebrosus* catch conversion factors, by Fisheries and Oceans Canada, based on data from comparative fishing experiments conducted during the 2022-2023 July Division 4VWX bottom trawl surveys.

by

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Abstract

Relative biomass (stratified mean kg per tow) and abundance (stratified mean number per tow) indices derived with data from the July Division 4VWX bottom trawl surveys are the most representative measure of *Illex illecebrosus* biomass in NAFO Subareas 3+4 because of the survey's spatiotemporal coverage. As a result, these indices are used to determine the annual status of this Northern Stock Component for NAFO stock assessments. However, during 2021-2023, these indices could not be computed because conversion factors needed to adjust for catchability differences between the outgoing and new Canadian research survey vessels (and their associated differences in trawl gears and haul protocols) were not available. This document provides a brief overview of the methods used to derive the *I. illecebrosus* catch conversion factors estimated by DFO staffs and their values, because although the conversion factors were available as of 2024, the DFO report that describes the details of how they were derived is not available yet.

1.0 Introduction

Since 1970, multispecies bottom trawl surveys have been conducted annually on the Scotian Shelf, during July in Division 4VWX, by staffs from the Maritimes Region of Fisheries and Oceans Canada (DFO). Relative biomass (stratified mean kg per tow) and abundance (stratified mean number per tow) indices derived with data from the July Division 4VWX bottom trawl surveys are the most representative measure of *Illex illecebrosus* biomass in NAFO Subareas 3+4 because of the survey's spatiotemporal coverage (Hendrickson and Showell 2019). As a result, biomass indices from this survey are used to determine the annual status of this Northern Stock Component during NAFO stock assessments. However, during 2021-2023, these indices could not be computed because conversion factors needed to adjust for catchability differences between the outgoing and new Canadian research survey vessels (and their associated differences in trawl gears and haul protocols) were not available. This document provides the *I. illecebrosus* catch conversion factors estimated by DFO staffs and a brief overview of the methods used to derive them because the associated DFO report is not available yet and this information is needed to explain how the 2023 biomass index was derived for inclusion in this year's Interim Monitoring Report.

2.0 Methods

2.1 Comparative Fishing Experiments

During 2022 and 2023, comparative fishing experiments were conducted during the July Division 4VWX (Fig. 1) surveys, between the outgoing Canadian survey vessel, the *CCGS Teleost*, and the new survey vessel, the *CCGS Capt. Jacques Cartier*. Paired-gear hauls were conducted at sites selected as part of the routine stratified random design for these bottom trawl surveys. The standard survey protocols used for setting and hauling the trawl gear and biological sampling of the *I. illecebrosus* catch and length data were followed (Hendrickson and Showell 2019). Data from the fishing experiments were used to estimate the relative catch efficiencies of these survey vessels and their associated differences in trawl gears. In previous Div. 4VWX surveys, the *CCGS Teleost* fished with a Western IIA trawl and conducted standard hauls of 30 min at 3.5 knots, whereas in future surveys, the *CCGS Capt. Jacques Cartier* will fish with a slightly modified version of the Northeast Fisheries Science Center Ecosystem Survey Trawl (NEST) and conduct standard hauls of 15 min at 3.0 knots. During the comparative fishing experiments, both vessels fished with their respective gear types and standard hauls of 15 minutes at 3.0 knots. Although a similar fishing experiment was attempted in 2021, the *CCGS Teleost* had mechanical problems and was unable to participate. Sampling coverage of *I. illecebrosus* habitat by the *CCGS Capt. Jacques Cartier* was inadequate and would have required nonexistent conversion factors regardless. Thus, the 2021 biomass and abundance indices were not computed. Similar to the 2021 survey, inadequate sampling coverage of *I. illecebrosus* habitat (Fig. 2) also prevented calculation of the 2022 survey indices. The 2024 survey indices were not available in time for the September SC meeting. However, preliminary swept-area biomass estimates from two other summer surveys that cover a smaller portion of *I. illecebrosus* habitat are available annually and were also included; the June Div. 3NO survey (EU-Spain) and the July Div. 3M survey (EU-Spain and Portugal).

2.2 Data Analysis

In summary, relative catch efficiency was estimated between vessel-gear pairs where at least one individual was caught, using statistical models initially developed for analysis of data from comparative fishing experiments conducted during the Northeast Fisheries Science Center spring and fall bottom trawl surveys (Miller *et al*. 2010 and Miller 2013). These methods were recently used to estimate catch conversion factors for *I. illecebrosus* and other species caught in the 2021 and 2022 comparative fishing experiments conducted during the DFO Div. 4RST bottom trawl surveys (Benoît *et al*. 2024).

For *I. illecebrosus* count data, both binomial and beta-binomial mixed effects models were fitted to catch numbers-at-length by 1-cm mantle length bin. Details of the model descriptions, fitting, selection and validation are described in Benoît *et al*. 2024. Normally, biomass values adjusted for the change in relative catchability are derived by applying a length-weight conversion to the length-specific catch numbers. However, because individual measurements were not consistently collected during all survey hauls, relative catchabilities for size-aggregated catch weights were required. For such estimates, catch weights were assumed to be a Tweedie-distributed random variable (Benoît *et al*. 2024) using the glmm TMB function (Brooks *et al*. 2017) with the option family = tweedie specified.. Akaike Information Criterion (AIC) and Bayesian Information Criterion (BIC) were used as model selection criteria and residuals from the fitted models were examined for the presence of diel and other non-random patterns.

3.0 Results and Discussion

Data included in the model analyses were from 101 valid paired hauls where at least one individual was caught during the combined 2022 and 2023 comparative fishing experiments. The beta-binomial model BB4 provided the best fit (Table 1) and the length-disaggregated conversion factors are presented in Table 2 and Fig. 3. Examination of the residuals from the selected fitted model did not indicate a need for the inclusion of a diel factor in the model. The DFO CSAS document that will be released soon should serve as the definitive

source for estimates of the *I. illecebrosus* catch conversion factors for the July Div. 4VWX surveys from 2021 onward.

4.0 References

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5.0 Acknowledgements

Throughout my years as the NAFO Designated Expert for Northern Shortfin Squid in Subareas 3+4. I would not have been able to conduct the squid assessments without the gracious assistance from multiple DFO scientists. I am extremely grateful to Mike McMahon, who always provided me with either the data or the specific BIO staff contacts who could help me obtain the data from the DFO Maritimes Region that I needed to conduct the NAFO *Illex* stock assessments. I am very grateful to the following DFO scientists who never said no (but probably thought about doing so) to my nagging data requests regarding the Div. 4VWX surveys: Mark Showell, Eric Brunsdon, Ryan Martin, Jamie Emberley and Yihao Yin. I also deeply appreciate the generous assistance from the following DFO scientists who always fulfilled my *Illex illecebrosus* data requests from other DFO Regions: Hugues Benoît, Daniel Ricard, Hugo Bourdages, Krista Baker, Earl Dawe, Bill Brody, and Rick Rideout. Given that this is my last assessment, I also want to express my deep gratitude to my NAFO colleagues, Diana Gonzalez and Antonio Vazquez, who kindly made the time to provide me with *I. illecebrosus* survey data every year. I wish all of you the very best in the years ahead!

Table 1. Beta (B) and beta-binomial (BB) mixed effects model fits to *Illex illecebrosus* catch count data based on delta Aikaike's Information Criterion (AIC) and delta Bayesian Information Criterion (BIC) values (best fit model is bold-faced). Catch data were collected during comparative fishing experiments conducted during the 2022 and 2023 Div. 4VWX bottom trawl surveys to compute vessel-gear conversion factors for the survey .

Model Name	AIC	delta_AIC	BIC	delta_BIC
BI0	3646	2083	3651	2063
BI1	1684	121	1693	105
BI2	3292	1729	3306	1718
BI3	1637	74	1655	68
BI4	NA	NA	NA	NA
BB0	1775	212	1784	196
BB1	1583	20	1596	9
BB2	1767	204	1785	197
BB3	1717	154	1744	157
BB4	**1565**	**2**	**1588**	**0**
BB5	1563	0	1595	7
BB6	NA	NA	NA	NA
BB7	NA	NA	NA	NA

Table 2. Length-disaggregated conversion factors estimated for *Illex illecebrosus* catches in comparative fishing experiments conducted by Fisheries and Oceans Canada (DFO) during the 2022 and 2023 July Division 4VWX bottom trawl surveys. These values were were applied to the 2023 survey catches of the new survey vessel, the *CCGS Capt. Jacques Cartier*, in order to standardize its catches of *I. illecebrosus* with those of the *CCGS Teleost* prior to calculation of the 2023 survey index.

Dorsal Mantle Length (cm)	Relative Catch Efficiency
3	0.188
4	0.191
5	0.190
6	0.191
7	0.233
8	0.286
9	0.350
10	0.422
11	0.508
12	0.589
13	0.680
14	0.771
15	0.864
16	0.956
17	1.053
18	1.141
19	1.223
20	1.279
21	1.305
22	1.307
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29	1.307
30	1.305

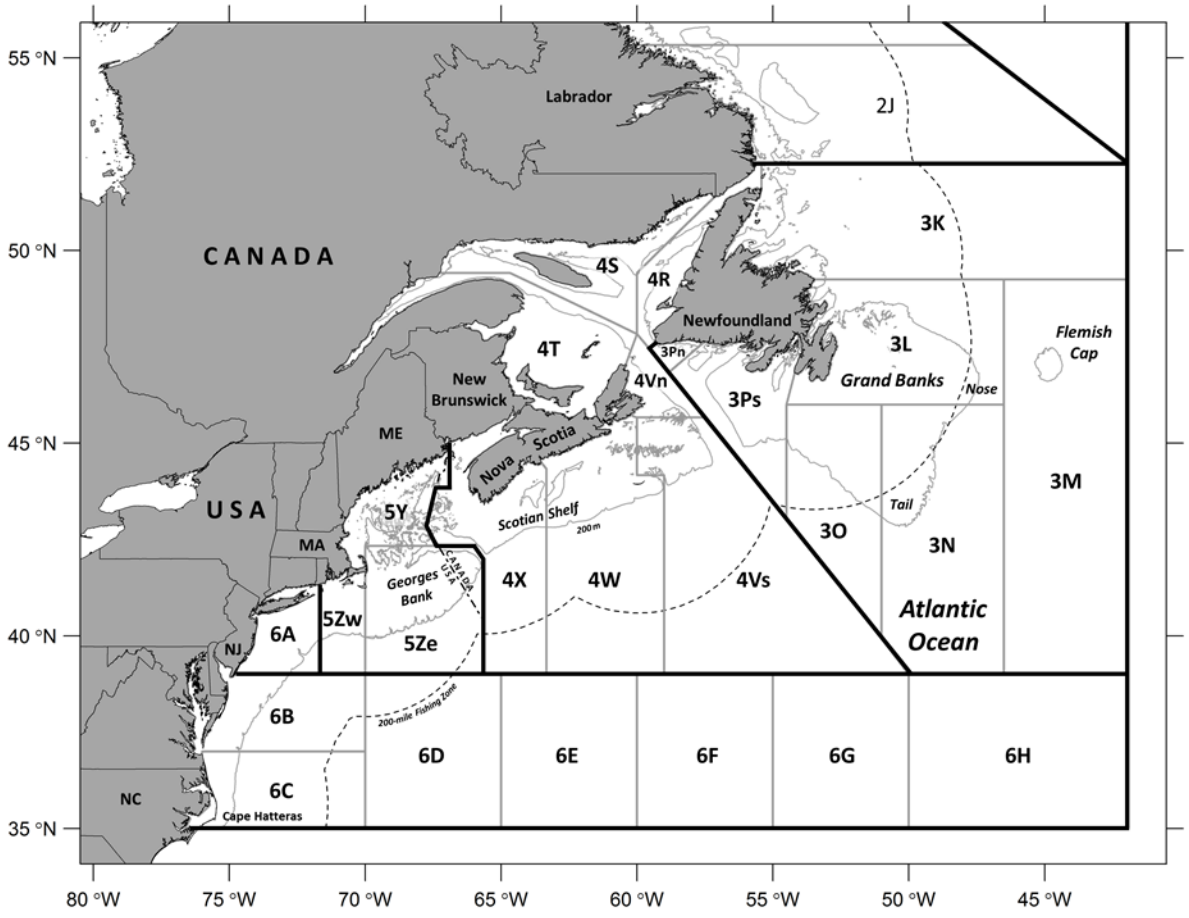

Figure 1. Northwest Atlantic Fisheries Organization (NAFO) nominal catch reporting areas, Subareas 3-6 (thick black lines) and associated Divisions (grey lines), for fisheries operating in the Northwest Atlantic Ocean. Fishing that occurs in portions of the Divisions located seaward of the 200-nautical mile Exclusive Economic Zones (EEZs, dashed line) of the USA and Canada are regulated by NAFO.

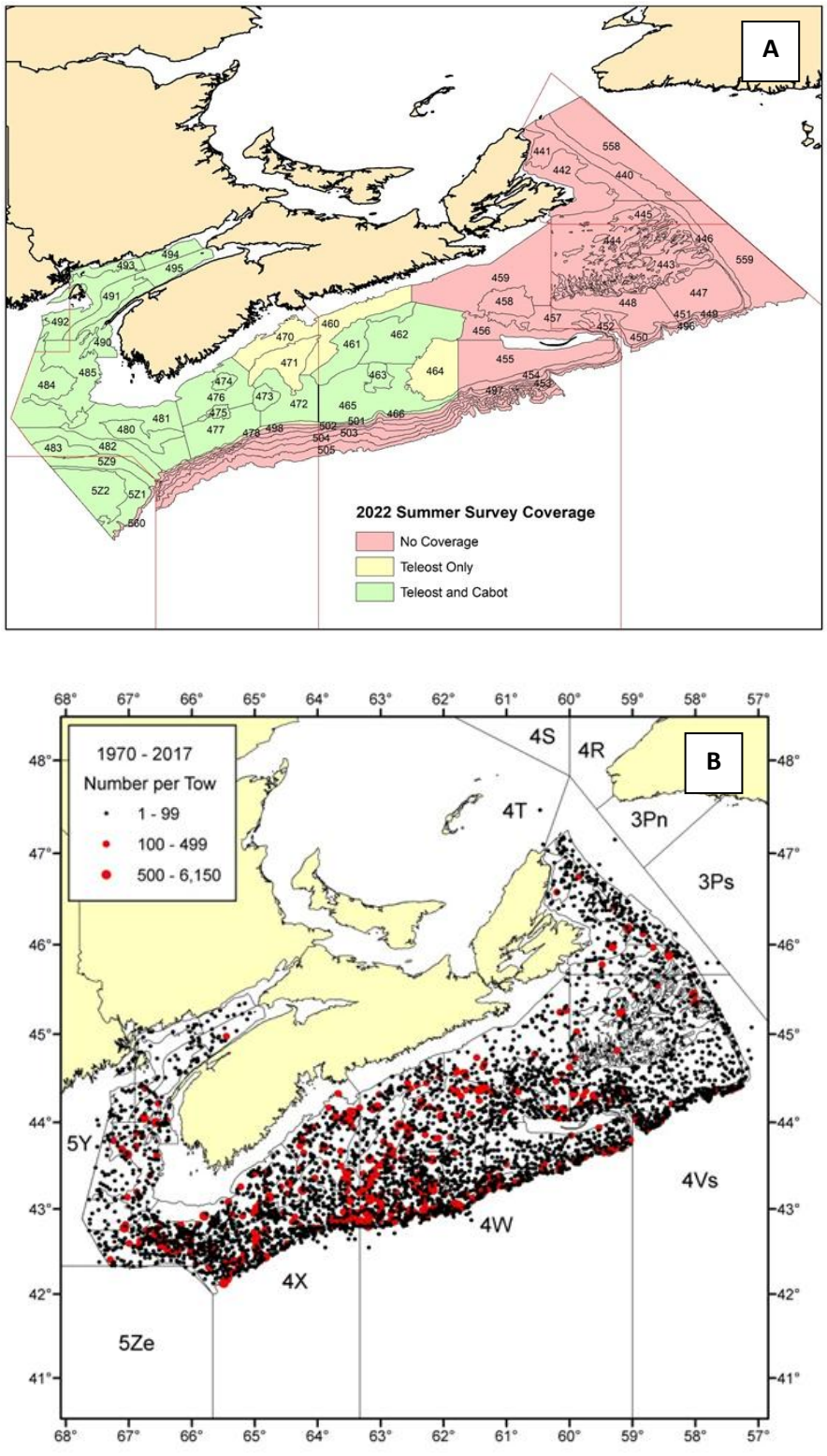

Figure 2. Maps showing (A) sampling coverage of the July Division 4VWX bottom trawl survey strata, by Division, during 2022 in relation to (B) the distribution (number per standard tow) of *Illex illecebrosus*, by Division, during 1970 - 2017.