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Do spatial coverage issues in the 2019 Canadian (NL) RV bottom trawl surveys influence the suitability of survey indices for use in NAFO stock assessments?

by

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Abstract

In 2019 NAFO Scientific Council proposed guidelines to standardize the evaluation of the suitability of RV surveys with spatial coverage issues for inclusion in analyses (stock assessments, HCR, etc) that form the basis for scientific advice. These criteria are used here to evaluate Canadian (NL) RV surveys, which have been prone to spatial coverage issues in recent years. In 2019, the Canadian spring survey had only minor coverage issues and therefore all stock indices based on these data should be considered appropriate for subsequent assessments. In the 2019 Canadian autumn survey, however, there were major coverage issues, with a total of 50 incomplete strata (primarily in deep-water on the edge of the shelf). These missed strata had little to no influence on survey indices for most of the fish resources assessed by NAFO SC (3NO Cod, 3LNO American Plaice, 3LNO Yellowtail Flounder, 3NO Witch Flounder, 3LN Redfish, 3O Redfish, 3NOPs White Hake, 3LNOPs Thorney Skate). The missed strata, however, typically accounted for most of the biomass index (~75%) for Roughhead Grenadier and therefore the 2019 autumn survey should not be used in future assessments of this stock. For Greenland halibut, the 2019 autumn survey point for Divs. 2J3K was considered "questionable" since an average of 12% of the survey biomass was found in the missed strata in previous years. Further examination revealed that MWPT was only minimally influenced (1%) by the incomplete strata and therefore the 2019 data point for Divs. 2J3K should be considered suitable for the harvest control rule currently being used for this stock. However, differential biases in the age-disaggregated data (with younger ages biased high and older ages, including the 10+ age group, biased low) and trends over time in the extent of the bias for some ages (especially for older ages) caused by the strata missed in 2019 raise concerns about the use of the 2019 data for any age-based assessment model.

Introduction

Shortcomings in spatial coverage of the Canadian spring and autumn RV surveys have been commonplace in recent years and have generated debate as to whether these survey points should be considered representative of stock status and included in the various assessments performed by SC. In 2019, in response to a review of how SC has previously treated these questionable RV survey points (Rideout and Wheeland 2019), STACREC recommended (NAFO 2019) that "*a consistent approach to determining if an incomplete survey can be considered as an index for a particular stock be developed*". It was also recommended that "*the STACREC report should contain, after the general survey presentation, a summary of the decisions and conclusions, stock by stock, regarding whether the survey can be used as a stock index for that year*" and that "*the mean proportion (over time) of total survey biomass in the survey strata missed that year should be calculated*".

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Proposed initial guidelines regarding the evaluation of survey points with missing strata based on the mean proportion of total survey biomass in those strata were as follows:

> • *If it is <10% : the survey index of that year is most likely acceptable.*
> • *If it is between 10% and 20% : the survey index of that year is questionable and needs to be examined carefully before deciding whether it is acceptable.*
> • *If it is >20% : the survey index of that year is most likely not acceptable. Any decision to accept it would require a clear and well justified rationale.*

It was also noted that "*These are preliminary guidelines and sampling biases may also be relevant in the considerations for each specific stock and survey. In particular, the finer structure of the indices needs to be considered if they are used disaggregated by age or length in stock assessments.*"

Rideout and Ings (2020) noted significant spatial coverage issues once again in the 2019 Canadian RV bottom trawl surveys, especially the autumn survey. The above preliminary guidelines are therefore applied here to evaluate whether the 2019 survey indices are appropriate to be used in subsequent stock assessments and the provision of scientific advice by SC.

Methods

Only the Campelen time series were examined (i.e. 1995 – present for the autumn, 1996 – present for the spring). Strata that were incomplete in the 2019 surveys were removed from all other years in the time series and the stratified estimates of biomass were recalculated in order to determine the proportion of biomass typically found in the incomplete strata for each NAFO fish stock. As per NAFO (2019), Canadian RV data points for 2019 were considered representative for the individual stocks if less than 10% of the biomass was typically found within the incomplete strata in those surveys. If more than 20% of the biomass was typically in those incomplete strata then the survey point was rejected. When the value was between 10 and 20% a closer examination of the data was required, which involved an examination of indices disaggregated by length and/or age.

Results

The Canadian (NL) spring survey had reduced set density in several strata but only a single stratum (stratum 718 in NAFO Division 3O) was incomplete (Fig. 1). In contrast, the Canadian (NL) autumn survey (Fig. 1) had many coverage issues in 2019, including a total of 50 incomplete strata in Div. 2H (938-943,955,931-936,964), Div. 2J (219-221, 225-226, 231-233, 236), Div. 3K (629, 642-649, 652-654), and Div. 3L (737-751). None of the fish resources currently assessed by NAFO currently use data from Div. 2H. In Divisions 2J3KL the incomplete strata were mostly deep-water strata on the edge of the shelf (i.e. generally >730 m but with a few missed strata as shallow as 400 m). All strata in Divs. 3N and 3O were completed (but note that the survey design for these Divs. no longer includes strata deeper than 730 m).

Excluding the single stratum that was incomplete in the 2019 spring survey from the entire time series did not noticeably influence survey trends (Fig. 2) and generally accounted for 2% or less of the total estimated annual biomass (Fig. 3). Because the incomplete strata in the autumn survey were generally deep strata, the impact of excluding these strata from the survey time series was relatively low (<1% of average annual biomass) for species that generally inhabit shallower depths, including cod, American plaice and yellowtail flounder (Fig. 2).

The impact of the strata missed in the autumn of 2019 was greater for deeper distributed species such as Roughhead grenadier and Greenland halibut. The mean annual proportion of Roughhead grenadier survey biomass in the incomplete strata in Divs. 2J3K was nearly 0.75 (Fig. 3, Fig. 4). Bubble plots of catch distributions from the autumn RV survey confirm that the majority of catches of Roughhead Grenadier in previous years have been located within these incomplete strata (Fig. 5). Other survey indices also

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demonstrated large drops when data from the 2019 incomplete strata were excluded from previous years (Fig. 6). Nevertheless, the trends in these data are very similar, as is evident when converted to standardized anomalies for each time series (Fig. 7). Estimates of MNPT at length were largely influenced by exclusion of data in the 2019 incomplete strata (Fig. 8).

The proportion of Greenland halibut survey biomass typically found in the strata that were incomplete in the 2019 autumn survey was greater than 0.12 (Figs. 2-4), suggesting that further examination of the data were necessary in order to evaluate the reliability of this survey point for this stock (NAFO 2019). The relative size of survey catches of Greenland halibut typically found in these strata are demonstrated in Fig. 9. Examining additional survey indices (total abundance, MNPT, MWPT) for Greenland halibut in Divs. 2J3K revealed that the impact of the incomplete strata in 2019 on these indices was <10% on average (Fig. 10). Excluding data from these strata in previous years resulted in slightly higher estimates of MNPT (Fig. 10). Trends in the data with and without the strata missed in 2019 are very similar, as is evident when converted to standardized anomalies for each time series (Fig. 11). An examination of MNPT at age (Fig. 12) showed that eliminating the 2019 missed strata from all years commonly resulted in slight overestimations for many ages (e.g. especially ages 1 to 5). Replotting the same data grouped by age (Fig. 13) demonstrated that the oldest ages (i.e. ages 9 and 10+) were biased in the opposite direction (i.e. were underestimated) when the 2019 missed strata were dropped from all years.

Discussion

In 2019, NAFO Scientific Council (SC) proposed standard criteria to evaluate whether research vessel bottom trawl surveys with spatial coverage issues are still suitable for inclusion in SC stock assessments (NAFO 2019). Canadian RV surveys have repeatedly had spatial coverage issues in recent years (Rideout and Ings 2020). In 2019 the Canadian spring RV survey had nearly full coverage (only one incomplete stratum) and the analyses presented here suggest that all spring survey-based indices should be considered reliable for use in subsequent stock assessments. In the 2019 Canadian autumn survey, however, there were major coverage issues, with a total of 50 incomplete strata (primarily in deep-water on the edge of the shelf) in NAFO Divs. 2HJ and 3KL. Most of the fish resources assessed by NAFO SC are distributed primarily shallower than the incomplete strata (or in Divisions that did not have incomplete strata) and therefore 2019 autumn survey indices for these stocks (3NO Cod, 3LNO American Plaice, 3LNO Yellowtail Flounder, 3NO Witch Flounder, 3LN Redfish, 3O Redfish, 3NOPs White Hake, 3LNOPs Thorney Skate) would be minimally (<1%) or not at all impacted by coverage issues and should be considered reliable estimates for the purposes of resource assessment.

Roughhead Grenadier and Greenland Halibut, however, are generally deep-water species and therefore the incomplete strata in 2019 are a bigger concern than for other NAFO stocks. For Roughhead Grenadier the majority (>70% on average) of the survey-estimated stock biomass in most years is found within the strata that were incomplete in the 2019 autumn survey and therefore this survey year should not be used to estimate stock status. This marks the second year in a row that the Canadian autumn RV survey was concluded to be unsuitable to assess this species due to spatial coverage issues. Trouble completing deep strata in the Canadian survey in recent years coupled with the fact that the current assessment for this stock is based on a qualitative examination of survey indices and catch data (i.e. there is no size or age-based analytical assessment model) might suggest a need/potential to re-evaluate whether or not this stock could be effectively monitored based on a set of shallower index strata. Certainly very similar trends in the standardized anomalies of survey indices with and without the strata missed in 2019 might suggest some utility in monitoring stock status based on the shallower survey strata.

For Greenland halibut the autumn survey data is divided into two indices, one for shallow strata in Divs. 3LNO and one for Divs. 2J3K. The indices for 3LNO were not influenced by the incomplete strata. However, for Divs. 2J3K the amount of survey-estimated stock biomass typically found in the 2019 incomplete strata was ~12%. According to the preliminary guidelines for evaluating survey points with spatial coverage issues (NAFO 2019), this survey point/year is "*questionable and needs to be examined carefully before deciding whether it is acceptable*". No guidelines were suggested for these further examinations. Here, an examination of other indices (total abundance, MNPT, MWPT) for 2J3K Greenland halibut revealed that those indices were

less impacted by the incomplete strata than the total biomass index. There was a general increase in MNPT by ~ 8% when data from the 2019 missed strata were excluded from all years. The MWPT in particular appears to be minimally influenced (1%) by the incomplete strata and therefore the 2019 data point for Divs. 2J3K is probably acceptable for inclusion in the harvest control rule currently being used for this stock.

From the perspective of potential impacts of survey coverage issues on an age-based assessment model for Greenland halibut it is necessary to also examine age disaggregated survey indices. The analyses presented here suggest that excluding the strata missed in the 2019 autumn survey resulted in slightly higher estimates of MNPT for younger ages (i.e. ages 1-5). In contrast, the numbers at age were biased low for older ages, especially ages 9 and 10+. The differential biases between young and old fish are consistent with ontogenic-related depth changes for this species (Wheeland and Morgan 2020) but may be a concern when it comes to the potential impact of using the 2019 survey in an age-based assessment and for our perception of stock demographics. Indeed the MNPT at older ages are low relative to younger ages (and to the overall MNPT) and therefore there is an inclination to dismiss the importance of these differences. However, the current practice for this stock is to use the 10+ biomass as an estimate of SSB (NAFO 2017) and therefore an examination of these older ages may be particularly important. Certainly if the same criteria for evaluating aggregated indices (NAFO 2019) are applied to these disaggregated indices (i.e. a difference of 10-20% is questionable and a difference of >20% is rejected), the utility of the 2019 data would be questionable or rejected for most ages and the 2019 autumn survey data would likely be considered unreliable for use in an age-based assessment. It is also noted that the bias in the disaggregated indices has changed over time (particularly for older ages), likely in response to species changes in distribution and changes in the relative importance of the 2019 missed strata.

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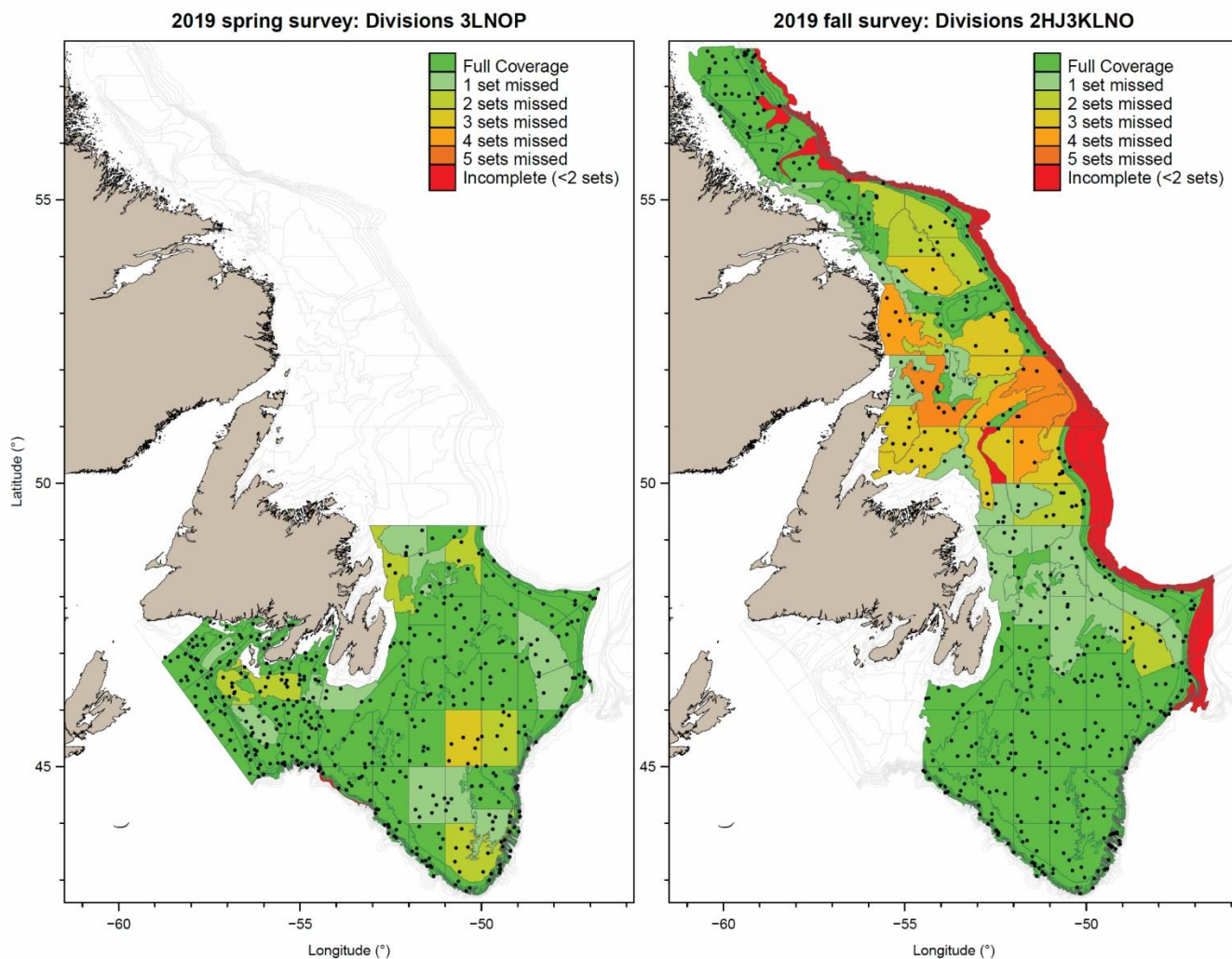
Figure 1. Spatial coverage of the 2019 Canadian (NL Region) spring and autumn RV bottom trawl surveys. Circles = fishing set midpoint location; Strata are coloured based on the number of fishing sets completed relative to the number intended. Red strata were incomplete (i.e. <2 sets).
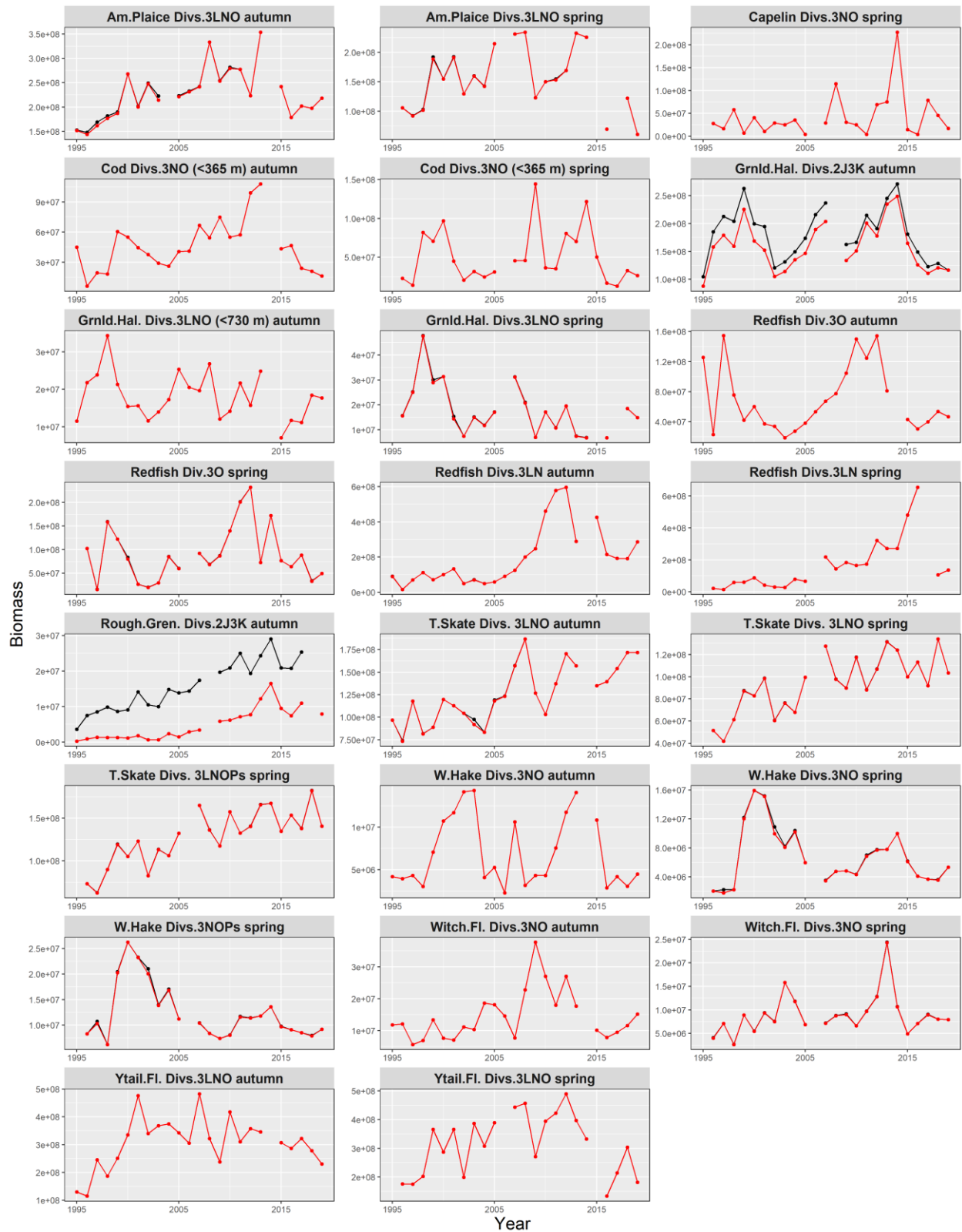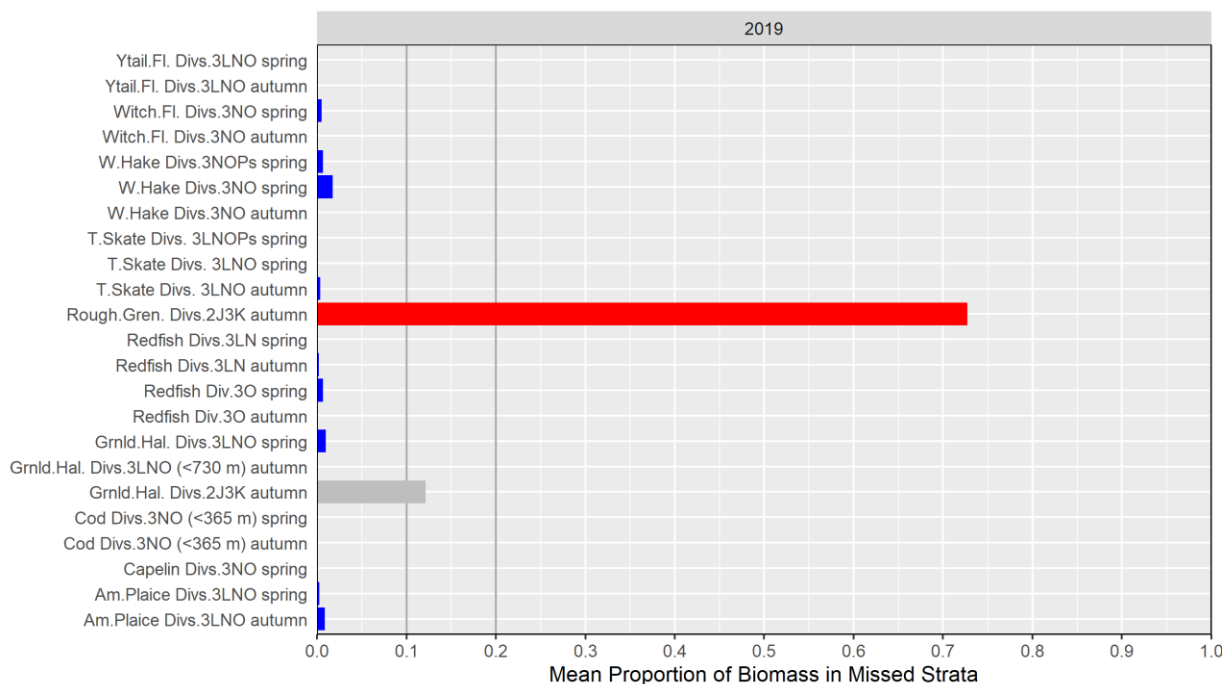
Figure 2. Canadian (NL) survey biomass indices for NAFO fish stocks (Black = indices used in assessments; Red = indices excluding strata in all years that were incomplete in the 2019 surveys).
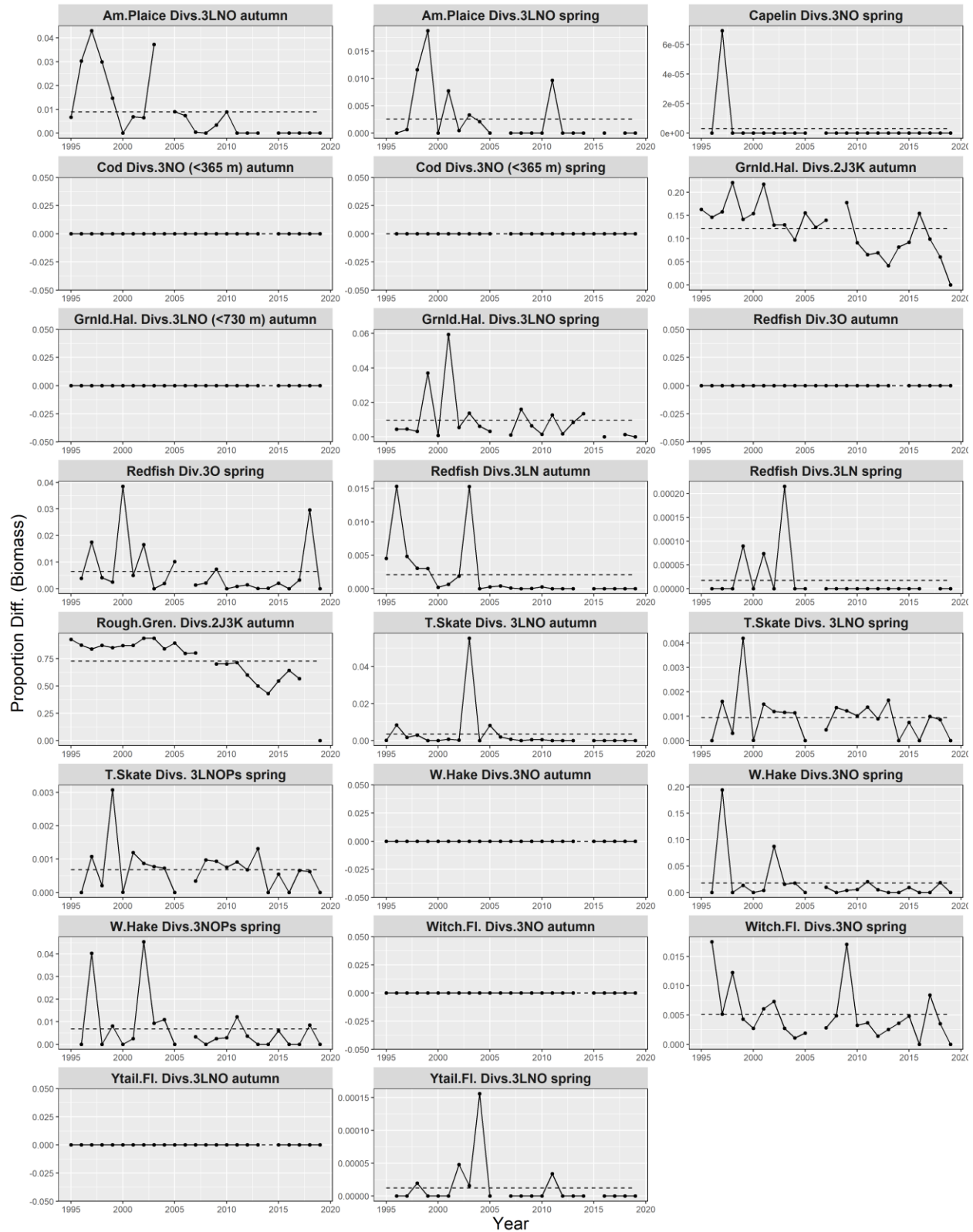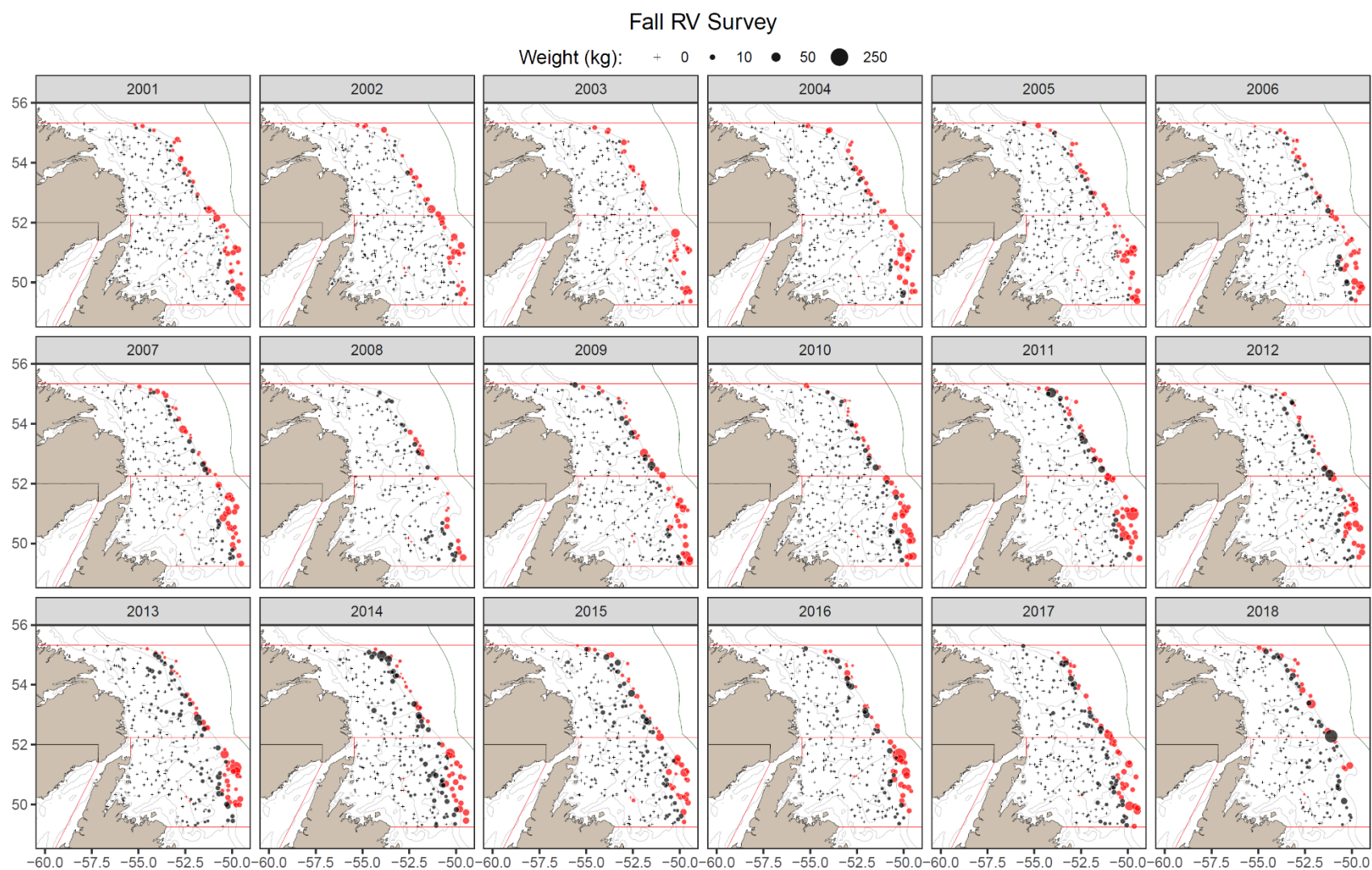
Figure 3. Proportion of biomass typically found in the strata that were incomplete in 2019 Canadian (NL) RV surveys (dashed line represents the time series average).

Figure 4. Summary of the mean proportion of biomass typically found in the strata that were incomplete in 2019 Canadian (NL) RV surveys.

Figure 5. Canadian Autumn RV survey catches of Roughhead Grenadier in Divs. 2J3K. Red symbols indicate survey catches within those strata that were incomplete in the 2019 survey.
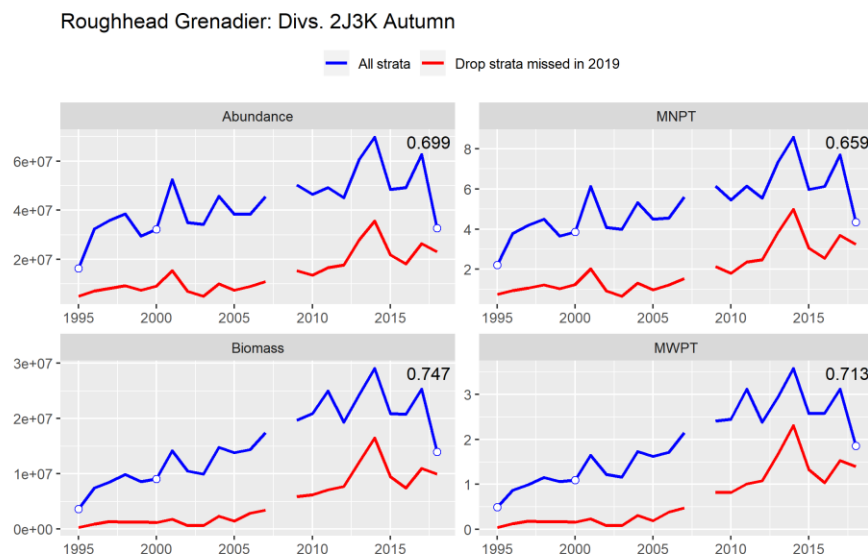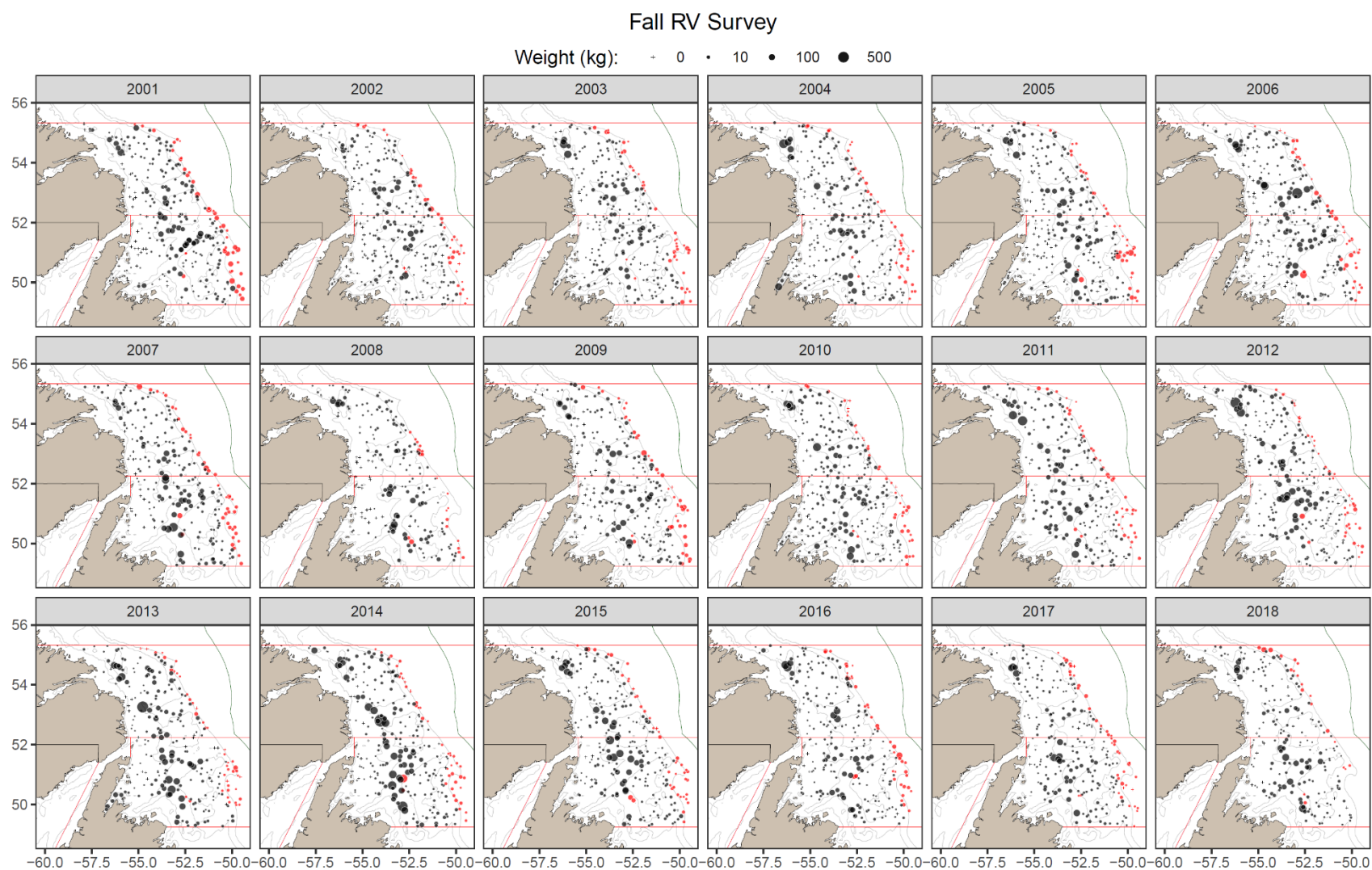
Figure 6. Canadian (NL) autumn RV survey indices for Roughhead Grenadier in Divs. 2J3K. Indices are calculated based on all available strata (blue) and then recalculated after excluding the strata from all years that were incomplete in the 2019 survey (red). The number in the top right corner is the mean proportional difference between the two time series. The major issue in the 2019 survey was the failure to complete deep strata and so years where there were also coverage issues for deep strata (indicated by open symbols) were not included in the calculation of mean proportional difference.
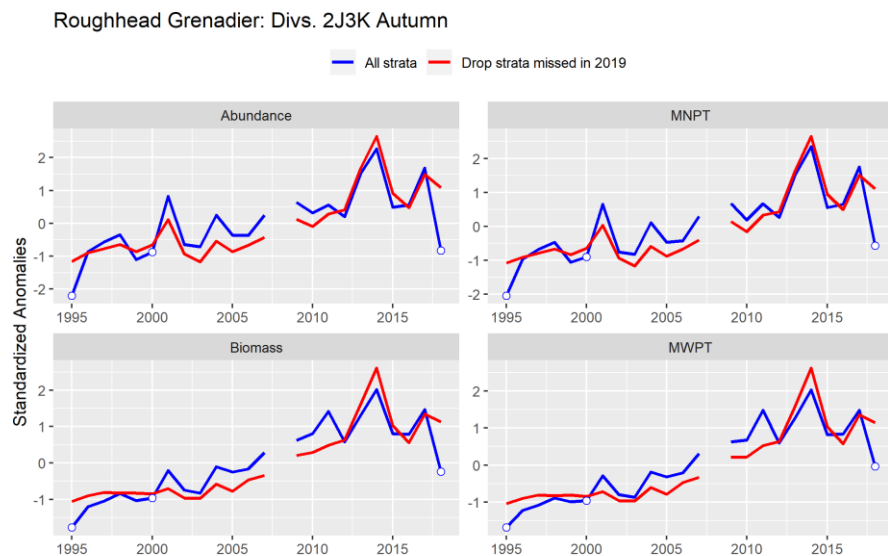

Figure 7. Standardized anomalies for Canadian (NL) autumn RV survey indices for Roughhead Grenadier in Divs. 2J3K. Anomalies are based on indices (blue) and without (red) strata that were incomplete in the 2019 survey. The major issue in the 2019 survey was the failure to complete deep strata and so years where there were also coverage issues for deep strata are indicated by open symbols.
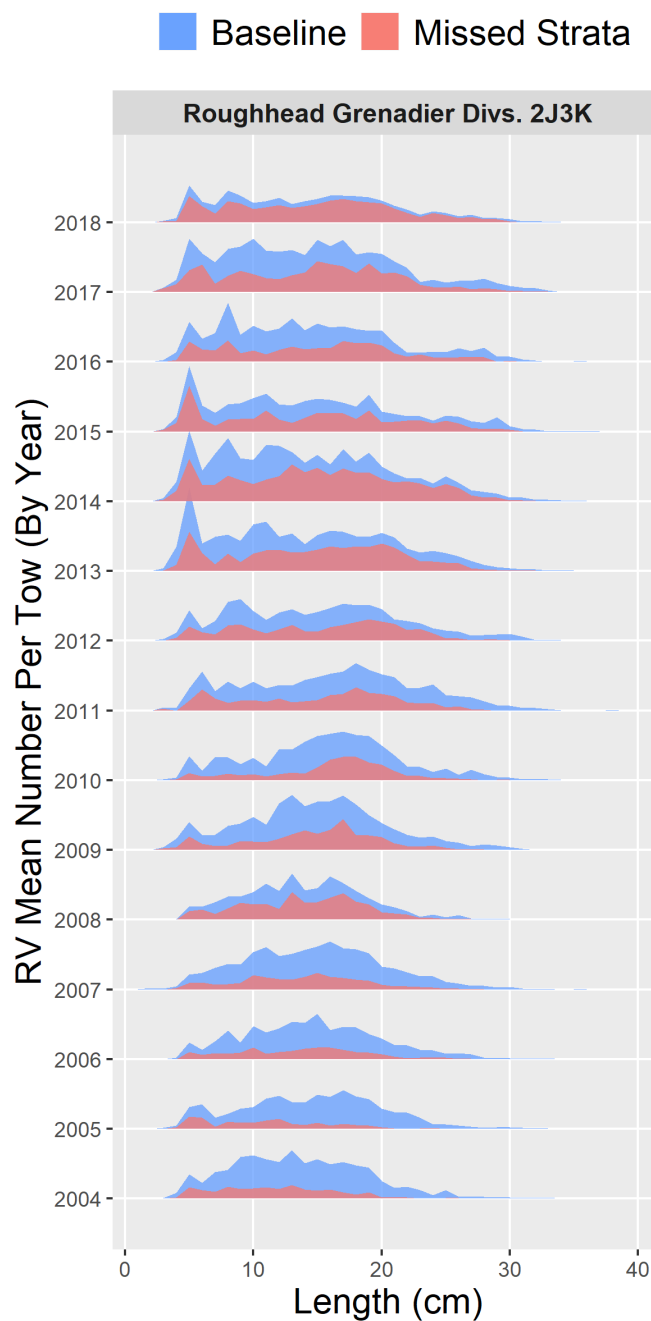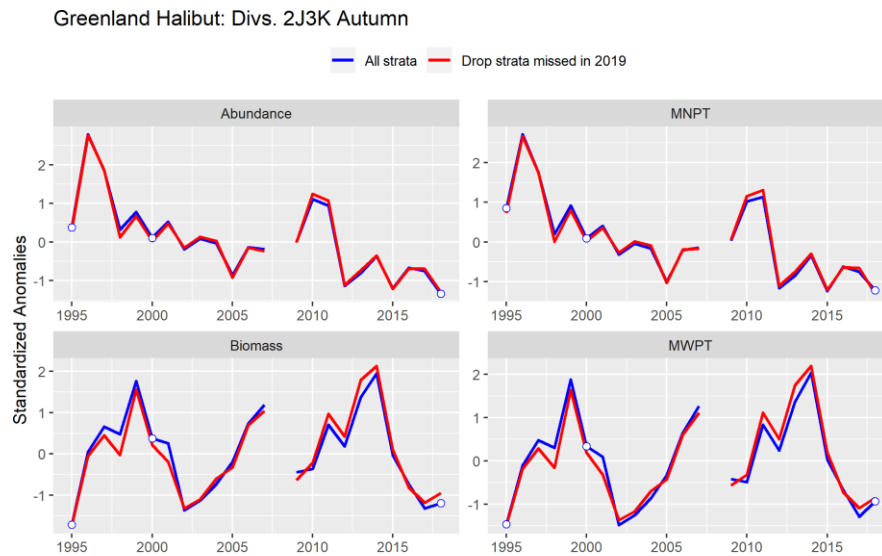
Figure 8. Canadian (NL) RV survey MNPT at length indices for Roughhead Grenadier in Divs. 2J3K. Indices are calculated based on all available strata (blue) and then recalculated after excluding the strata from all years that were incomplete in the 2019 survey (red).

Fall RV Survey

Weight (kg): + 0 · 10 ● 100 ● 500

Figure 9. Canadian Autumn RV survey catches of Greenland halibut in Divs. 2J3K. Red symbols indicate survey catches within those strata that were incomplete in the 2019 survey.
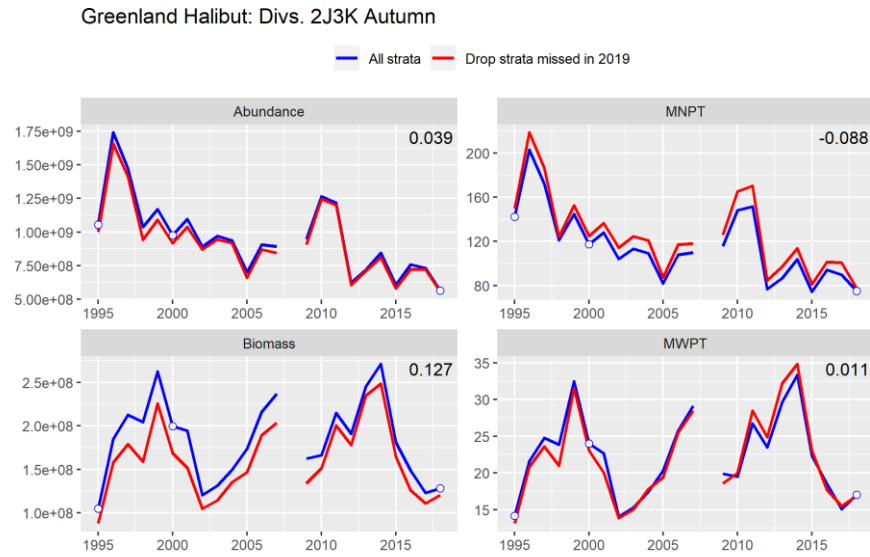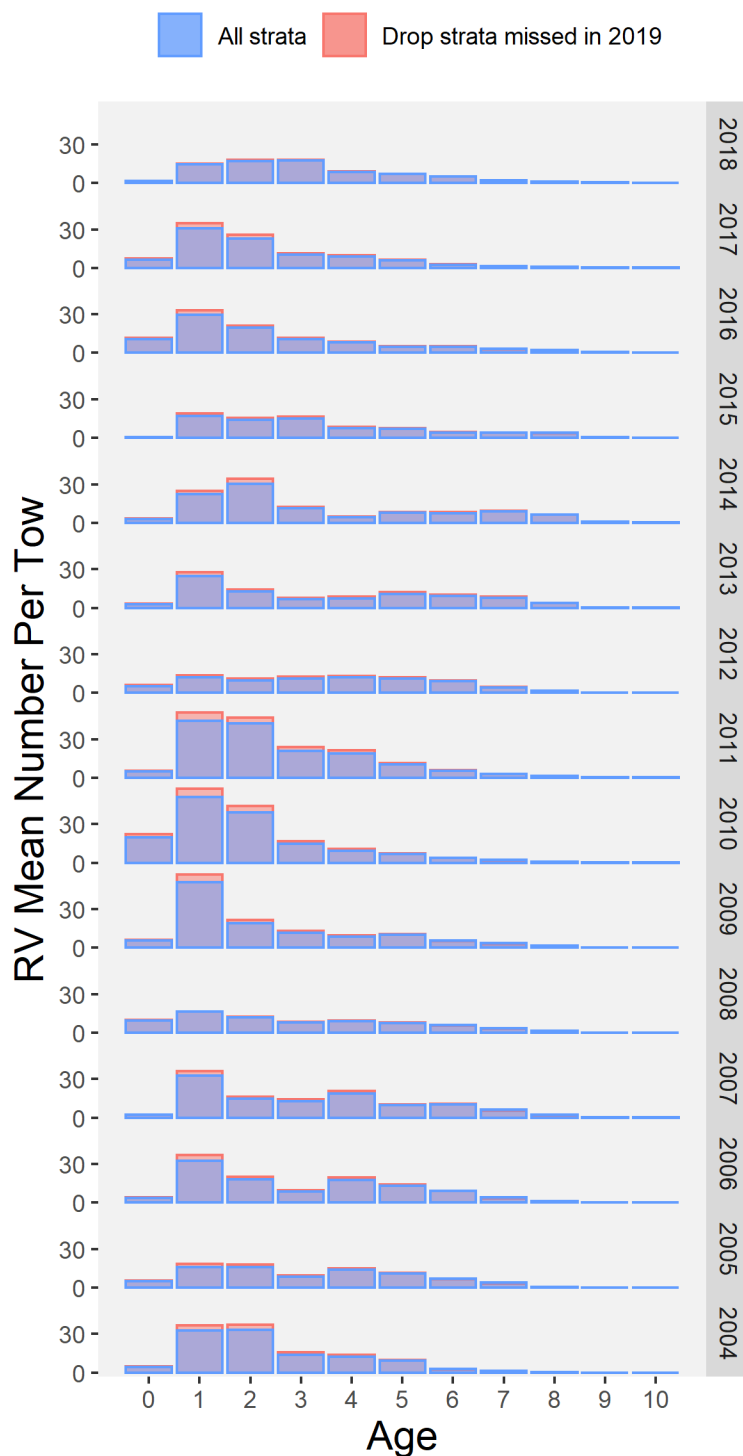
Figure 10. Canadian (NL) autumn RV survey indices for Greenland halibut in Divs. 2J3K. Indices are calculated based on all available strata (blue) and then recalculated after excluding the strata from all years that were incomplete in the 2019 survey (red). The number in the top right corner is the mean proportional difference between the two time series. The major issue in the 2019 survey was the failure to complete deep strata and so years where there were also coverage issues for deep strata (indicated by open symbols) were not included in the calculation of mean proportional difference.

Figure 11. Standardized anomalies for Canadian (NL) autumn RV survey indices for Greenland halibut in Divs. 2J3K. Anomalies are based on indices (blue) and without (red) strata that were incomplete in the 2019 survey. The major issue in the 2019 survey was the failure to complete deep strata and so years where there were also coverage issues for deep strata are indicated by open symbols.
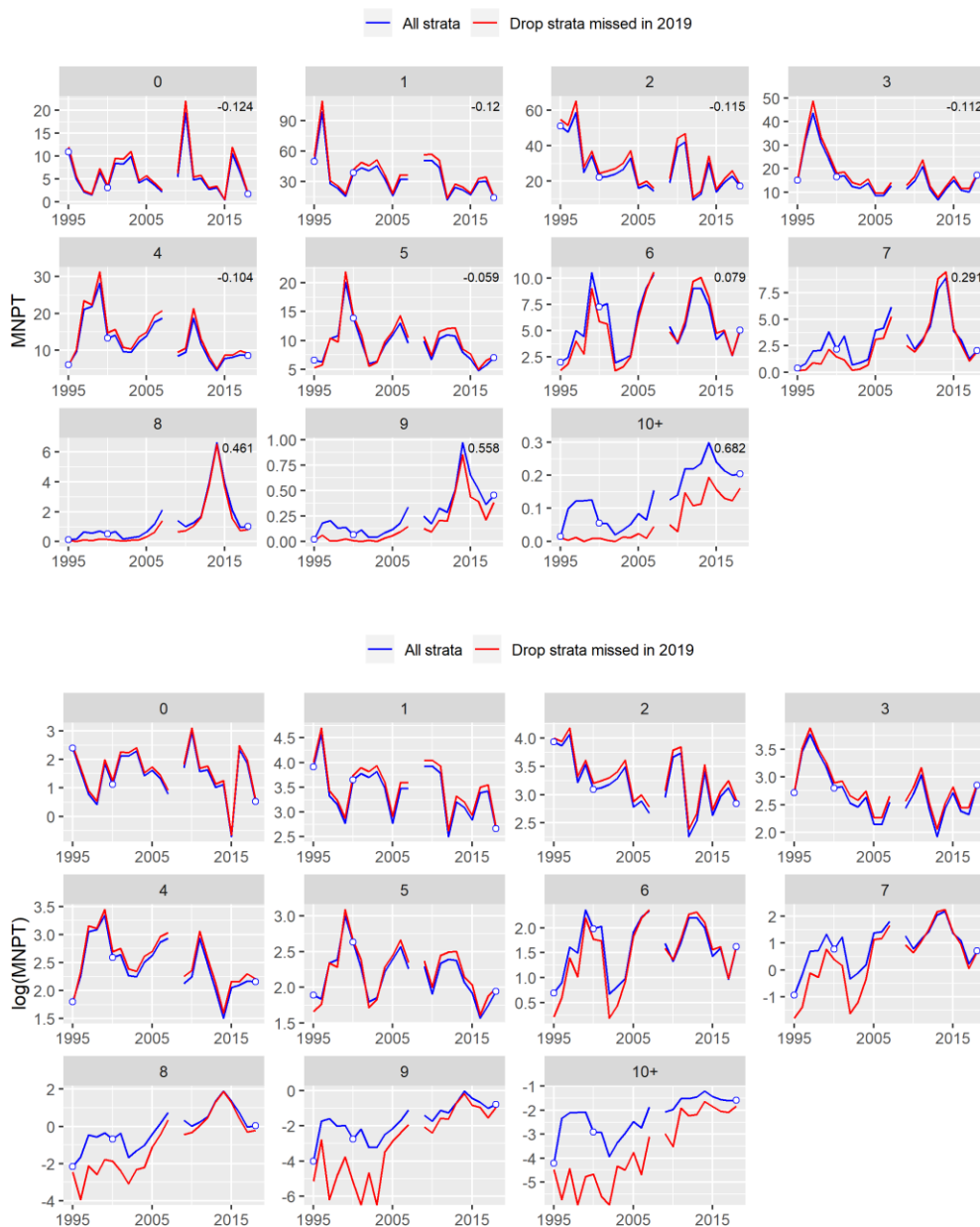
Greenland Halibut: Divs. 2J3K Autumn

Figure 12. Canadian (NL) RV survey MNPT at age indices for Greenland halibut in Divs. 2J3K. Indices are calculated based on all available strata (blue) and then recalculated after excluding the strata from all years that were incomplete in the 2019 survey (red).

Figure 13. Canadian (NL) RV survey MNPT (top) and log MNPT (bottom) at age indices for Greenland halibut in Divs. 2J3K grouped by age. Indices are calculated based on all available strata (blue) and then recalculated after excluding the strata from all years that were incomplete in the 2019 survey (red). Values in the top right had corner represent the mean proportional difference between the time series (note that years with spatial coverage issues, indicated by open symbols, were not included in the calculation).