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In or out? A review of decisions made by Scientific Council to include or exclude Canadian survey data points with reduced spatial coverage.

by

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Abstract

Introduction

The expansive spatial scale of the area covered by Canadian (Newfoundland and Labrador Region) research vessel surveys, coupled with ageing research vessels, often provide challenges for the completion of these surveys. When problems occur, sufficient extra vessel time is not always available since these vessels are also shared with other Fisheries and Oceans Canada Regions. As a result, several Canadian spring and autumn surveys over the past couple of decades have not been able to achieve complete coverage of the intended survey areas (see Rideout and Ings 2019).

When survey coverage issues arise, decisions must subsequently be made on a stock-by-stock basis regarding whether or not the missed areas were important enough for the individual species assessments to render the indices estimated from that survey year to be invalid. For fish stocks assessed by NAFO, these decisions are made within NAFO SC. However, SC does not have set criteria for accepting or rejecting survey points. These decisions are made during individual stock assessments without much consideration of, or reflection on, the criteria used to make decisions on the exclusion of survey points in previous years or for other stocks. With an increase in the frequency of incomplete Canadian surveys in recent years, there is a need to examine the consistency with which NAFO SC deals with RV surveys with coverage issues. Here we review the years with coverage issues in the Canadian spring and autumn surveys and the decisions to include/exclude these survey points from the various NAFO assessments.

Methods

Only the campelen time series were examined (i.e. 1995 – present for the autumn, 1996 – present for the spring). For each NAFO fish stock with an assessment informed by these surveys, years with coverage issues were identified. There was some level of subjectivity in this selection, but in general these were years that had (usually multiple) incomplete strata in areas within the normal distribution range of the species. For each of the years identified as having coverage issues, the incomplete strata from that year were also removed from all other years that did not have coverage issues and the stratified estimates of biomass were recalculated. The proportional difference between these stratified estimates and those calculated using all available strata were then determined.

Consideration of the inclusion or exclusion of inshore strata, or fall surveys that missed deep water strata (>731m) in NAFO Divs. 3LNO have not been included here. Inshore strata have been excluded from the survey allocation since 2007, though some strata are opportunistically sampled in years when time allows, or weather restricts vessel operation from offshore areas for a portion of the survey. The deep 3L strata are more often missed than completed in recent years, with complete coverage of this area in just four years since 2004 (2007, 2009, 2010, 2014). Deep strata in 3NO were only sampled in 2000-2002, 2005, 2007, and 2009, and are no longer included in the survey design. Coverage of these inshore and deep areas has been addressed in individual stock assessments where applicable.

Results

At least one stratum was missed in 10 years of the spring survey in the campelen time series, but the largest issues were encountered in 2006, 2015 and 2018 (Table 1), with 34, 15 and 31 strata missed respectively. For the autumn survey, at least one stratum was missed in 14 years of the campelen time series, but the major issues were encountered in 1995, 2004, 2008, 2014 and 2018 (Table 1), with 12, 11, 11, 50 and 12 strata missed respectively. These totals do not include inshore strata or deepwater strata (>731 m) in 3L, since these were not included in the analyses. In years where one to two strata are missing this is typically due to a lack of trawlable bottom (e.g. slopes too steep, depth too variable, bottom very rough) at the allocated station and/or unsuccessful tows (e.g. damage to the trawl, hooked on bottom) which prevent sufficient sampling, rather than vessel issues or insufficient survey time.

Three spring survey years were identified where coverage issues might influence the assessment of yellowtail flounder (Fig. 1): 2006, 2015 and 2017. The strata missed in 2006 and 2015 accounted for 8.6% and 6.9% on average, respectively of the survey biomass in other years. The strata missed in 2017, on the other hand were not important to the yellowtail flounder assessment, accounting for much less than 1% of the survey biomass in other years. For the autumn survey (Fig. 2), there were two years examined with respect to the impact of missed strata on the 3LNO yellowtail flounder assessment: 1999 and 2014. In 1999 only one strata was missed within the area inhabited by yellowtail flounder but this stratum accounted for much less than 1% of the biomass in other years. In 2014, however, all strata in Divs. 3NO were incomplete and these strata accounted for an average of 93% of the biomass of yellowtail flounder in the autumn survey in other years.

Four spring survey years were explored with respect to the assessment for American plaice: 2006, 2015, 2017, 2018. The strata missed in 2006, 2015 and 2017 (Fig. 3) accounted for an average of 21%, 10% and 17% respectively of the biomass in other years. Only three strata were missed in the northern part of Div. 3L in 2018 and these accounted for an average of less than 2% of the biomass in other years. For the autumn survey, three years were examined, one where only one stratum was missed (2000), one where 10 strata were missed in 3L (2004) and one where all of Divs. 3NO were missed (2014). The one stratum missed in 2000 accounted for 1% of the American plaice biomass in other autumn surveys, while the strata missed in 2004 and 2014 accounted for 10% and 72% of the biomass in other years (Fig. 4).

The Greenland halibut assessment uses a spring survey index from Divs. 3LNO and an autumn index from Divs. 2J (along with indices from non-Canadian surveys). For the spring survey in Divs. 3LNO, strata missed in 2006, 2015, 2017 and 2018 (Fig. 5) accounted for an average of 17%, 38%, 83% and 6% of the biomass in

other years. For the autumn survey in Divs. 2J3K, strata missed in 1995, 2000, 2009 and 2018 accounted for 4%, 1%, 7% and 9% of the biomass in other years (Fig. 6).

For Atlantic cod in Divs. 3NO the only spring survey examined was from 2006, when 17 strata were missed from each of Div. 3N and 3O (Fig. 7). The strata missed in this survey year accounted for 50% of the biomass in other years. The autumn 2014 survey did not complete any strata in Divs. 3NO; as the entire stock area was missed the impact of missing these strata in other years would be 100% of the biomass (not plotted).

The 2006 spring survey was examined for Divs. 3NO witch flounder as well (Fig. 8), with the strata missed accounting for an average of 72% of the biomass in other years. Because the distribution of this species is often highly concentrated along the shelf edge, years with only 4 (1999) or even only a single stratum (2016, 2017) missed in this area were examined (Fig. 9), with these strata accounting for an average of 2-3% of the biomass in other years. The complete survey area was missed in the 2014 autumn survey.

For redfish in Div. 3O the strata missed in 2006 accounted for >99% of the biomass in other years (Fig. 10), as this species is typically concentrated on the shelf edge. For the1996 autumn survey the four strata that were missed accounted for an average of 33% of the redfish biomass in other autumn survey years (Fig. 11). Div. 3O was not covered at all in autumn of 2014.

For redfish in Divs. 3LN the strata missed in the 2006, 2015 and 2017 spring surveys (Fig. 12) accounted for an average of 57%, 20% and 47% respectively of the biomass in other years. The strata missed in spring 2018, on the other hand, did not appear to be important for redfish, accounting for less than 1% on average of the biomass in other years. The strata missed in the 2004 autumn survey accounted for almost an average of 11% of the biomass in other years. In 2014, none of the strata in Div. 3N were completed, with these strata accounting for an average of 68% of the biomass of redfish in other survey years (Fig. 13).

For thorny skate in Divs. 3LNO the strata missed in the 2006, 2015, 2017 and 2018 spring surveys (Fig. 14) accounted for an average of 29%, 7%, 12% and 1% of the biomass, respectively, observed in other years. Strata missed in the 2004 and 2014 autumn surveys accounted for an average of 4% and 86% of the biomass of thorny skate in other autumn survey years (Fig. 15). Note that this stock is assessed as Divs. 3NLOPs, and values here may not directly reflect those presented within the stock assessment.

For white hake in Divs. 3NO the strata missed in 2006 accounted for an average of almost 96% of the biomass observed in other years (Fig. 16). In the 1996 autumn survey, the strata that were missed accounted for an average of nearly 12% of the biomass of white hake in other years (Fig. 17). Note that this stock is assessed as Divs. 3NLOPs, and values here may not directly reflect those presented within the stock assessment.

The roughhead grenadier assessment does not use data from the Canadian spring RV survey due to the fact that this is a deepwater species and the spring survey does not cover strata deeper than 732 m. From the autumn survey the assessment uses a biomass index from Divs. 2J3K. In 1995, 2000, 2006 and 2018 the strata missed in the autumn survey in Divs. 2J3K accounted for an average of 18%, 4%, 42% and 57% of the biomass of roughhead grenadier in all other years (Fig. 18).

The consistency by which NAFO SC has made decisions to include or exclude RV surveys with reduced spatial coverage from the various NAFO SC stock assessments can be evaluated by plotting the average amount (Fig. 19), or maximum amount (Fig. 20) of biomass in missed strata from all the stock-survey-year combinations together on a single plot. Some inconsistencies become apparent. For example, survey years where the strata that were missed generally account for less than 10% of the biomass for that stock in other years are generally included in the assessment. On the other hand, there were also survey years where missed strata that accounted for less than 10% of the biomass resulted in that survey year not being included in the assessment for 3LNO yellowtail flounder, 3LNO American plaice, and SA2+3 Greenland halibut. Also, while missing strata that accounted for more than 20% of the biomass for a given stock were typically not included in the respective assessments, there were instances for redfish stocks where such data points were included. Inconsistencies within stocks were also present. For Greenland halibut in Divs. 2J3K, the strata missed in 2008 typically accounted for more of the stock's biomass than those strata missed in 2018. However, the

decision was made to include the 2018 point in the assessment, whereas the 2008 survey point was not accepted.

Discussion

The analyses presented here were a first look at previous decisions by NAFO SC to use or not use Canadian RV survey points with spatial coverage issues. The results demonstrate general consistencies but also some inconsistencies both among and within stocks with respect to the decisions that have been previously made. It is important to note, however, that the current document only examines the typical contribution of missing strata to the overall stock estimate of biomass, and do not account for changes in distribution of a stock over time. There may have been other reasons considered (e.g. spatial continuity of the missed strata, degree of concentration of a stock's distribution, age-disaggregated impacts) for excluding or including these surveys at the time that SC evaluated them that are not considered here. Nevertheless, the compilation of these data could mark an important first step to developing more standardized procedures/criteria for evaluating the appropriateness of including RV surveys with spatial coverage issues.

Acknowledgements

The Canadian multi-species survey dataset would not exist without extensive efforts on the part of the Fisheries and Oceans Canada scientific sampling teams as well as the crews of the CCGS Teleost and CCGS A. Needler.

References

Rideout, R.M., Ings, D.W. 2019. 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 2018. NAFO SCR 19/015.

Table 1 Number of missed strata (excluding inshore strata and deep water >731m in 3LNO), by division, for years where incomplete survey coverage was examined for stock(s) within this report. (-) indicates the division is not surveyed in that season.

Season	Year	Number of Incomplete Strata				
		Div. 2J	Div. 3K	Div. 3L	Div. 3N	Div. 3O
Spring	1997	-	-	0	1	0
	2006	-	-	0	17	17
	2008	-	-	2	0	0
	2010	-	-	2	0	0
	2011	-	-	1	0	1
	2012	-	-	1	1	0
	2015	-	-	15	0	0
	2016	-	-	0	0	2
	2017	-	-	31	1	0
	2018	-	-	3	0	0
Fall	1995	10	2	0	0	0
	1996	0	0	1	0	4
	1997	0	0	0	0	1
	1999	0	0	0	1	1
	2000	0	4	1	0	0
	2004	0	0	10	1	0
	2006	0	1	0	0	1
	2008	5	6	0	0	0
	2009	0	0	0	0	1
	2010	0	0	0	2	0
	2011	1	0	1	0	0
	2014	0	0	0	26	24
	2016	0	2	0	0	1
	2018	2	9	1	0	0

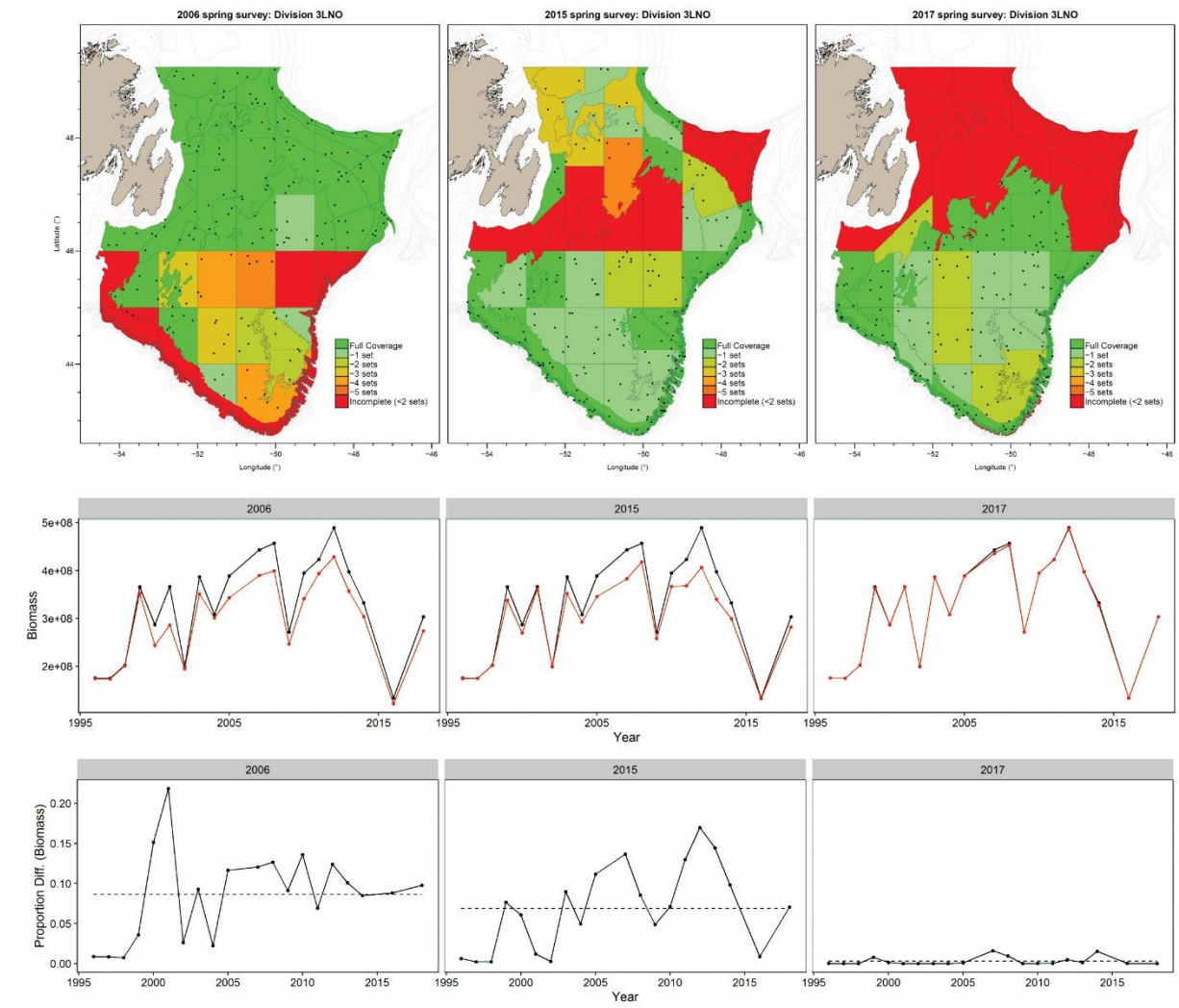

Figure 1. Yellowtail flounder in Divs. 3LNO spring. Three years with survey coverage issues (red in the top plots indicates incomplete strata) were explored: 2006, 2015, 2017. The current assessment excludes 2006 and 2015 but includes 2017. The line plots show the impact that excluding the strata missed in each of these years has on the estimate of survey biomass (middle plots) and the proportion of the biomass attributed to these strata (as well as the mean proportion) (lower plots).

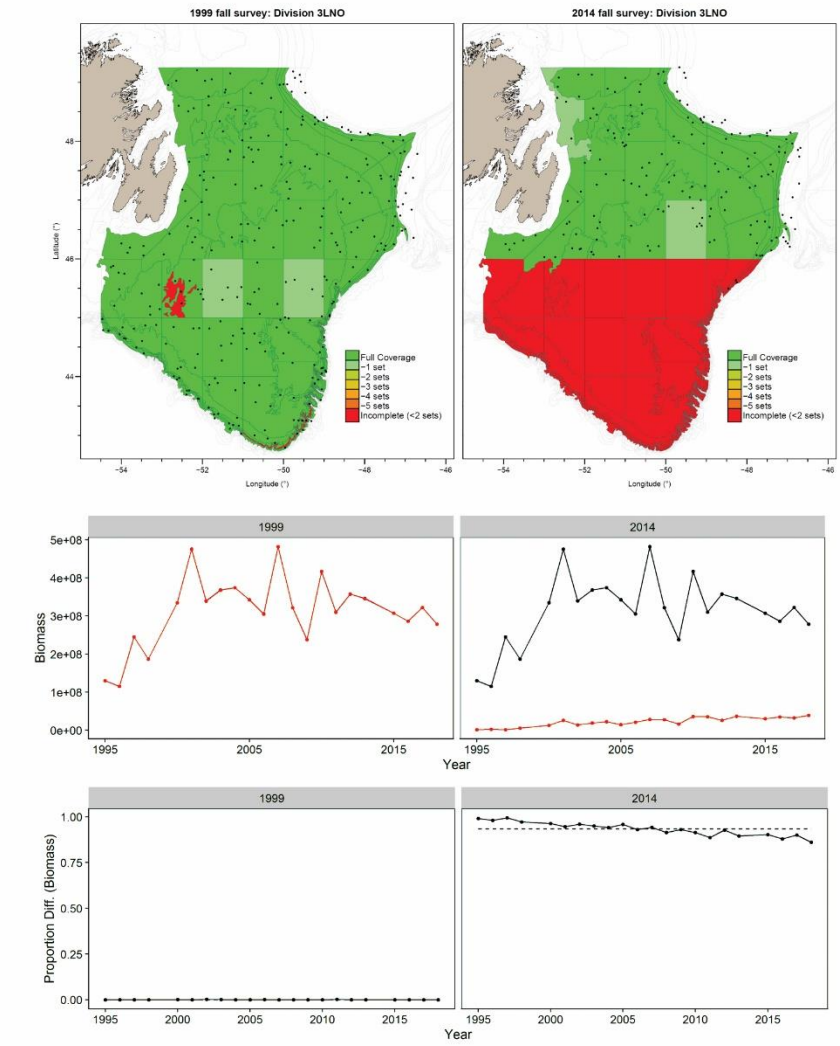

Figure 2. Yellowtail Flounder in Divs. 3LNO autumn. Two years with potential survey coverage issues (red in the top plots indicates incomplete strata) were explored: 1999, 2014. The 2014 data point has been excluded from the assessment. The line plots show the impact that excluding the strata missed in each of these years from all other years has on the estimate of survey biomass (middle plots) and the proportion of the biomass attributed to these strata (as well as the mean proportion) (lower plots).

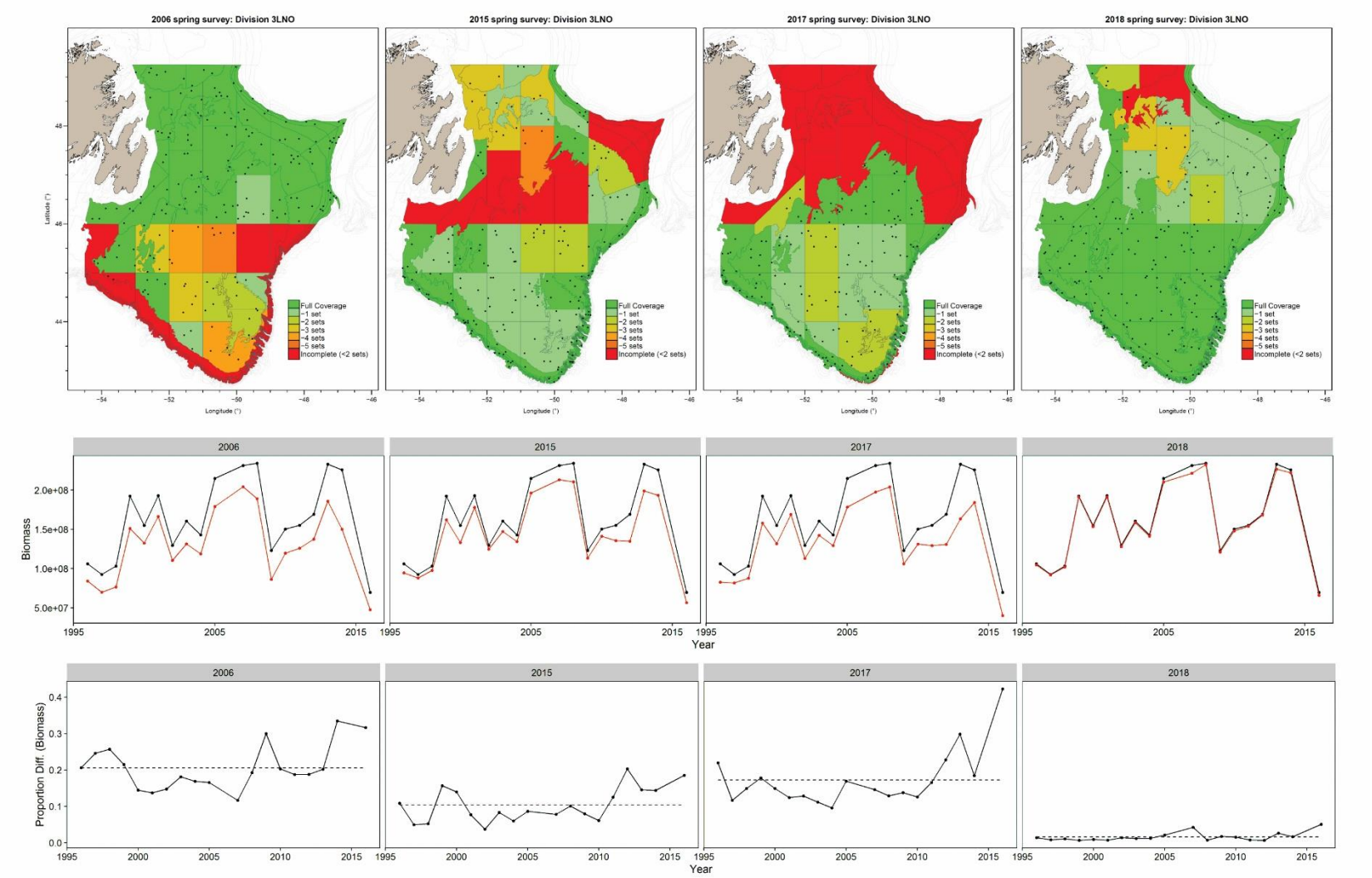

Figure 3. American Plaice in Divs. 3LNO spring. Four years with survey coverage issues (red in the top plots indicates incomplete strata) were explored: 2006, 2015, 2017, 2018. The current assessment excludes 2006, 2015 and 2017. The line plots show the impact that excluding the strata missed in each of these years from all other years has on the estimate of survey biomass (middle plots) and the proportion of the biomass attributed to these strata (as well as the mean proportion) (lower plots).

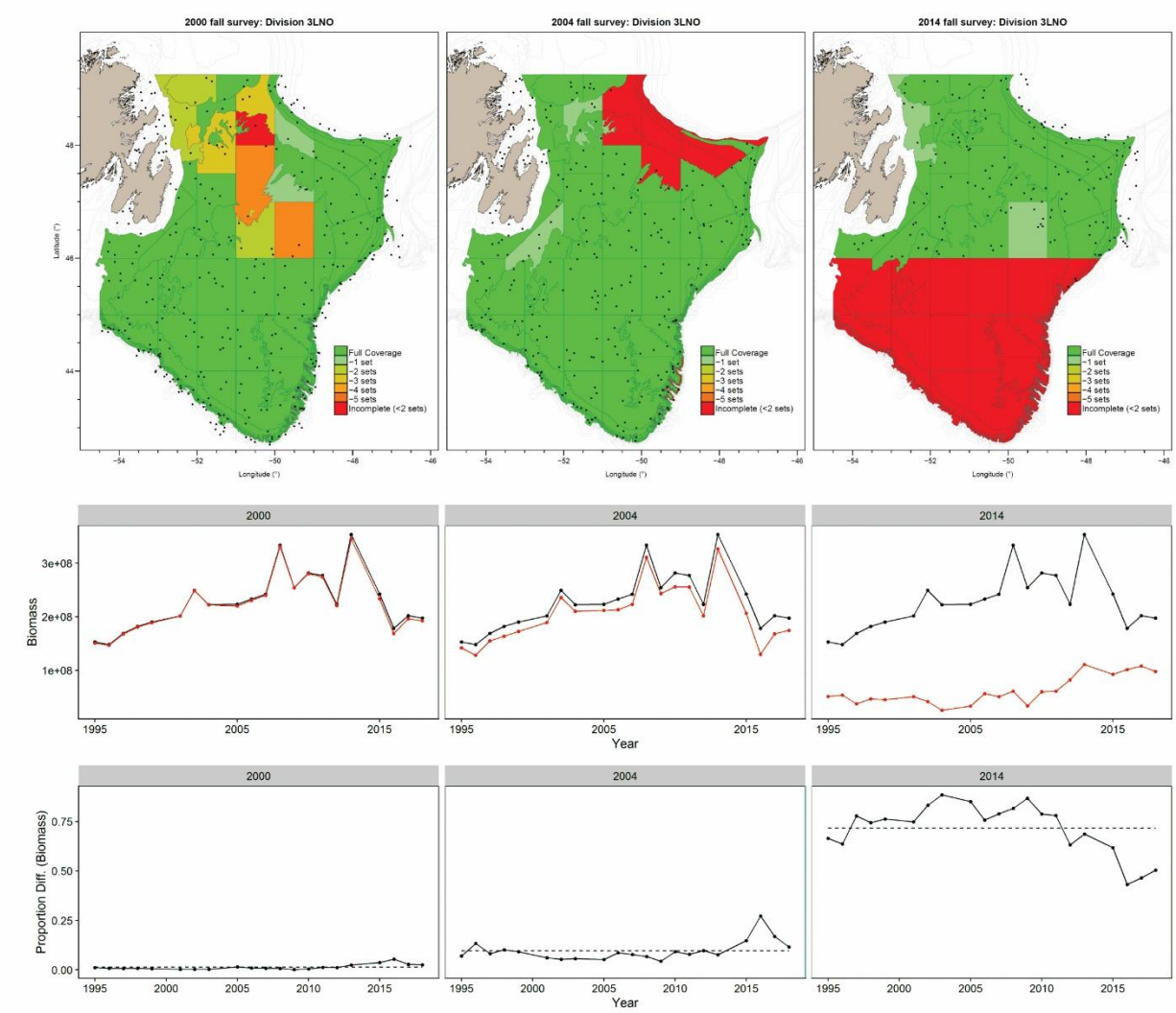

Figure 4. American Plaice in Divs. 3LNO autumn. Three years with potential survey coverage issues (red in the top plots indicates incomplete strata) were explored: 2000, 2004, 2014. The 2004 and 2014 data points have been excluded from the assessment. The line plots show the impact that excluding the strata missed in each of these years from all other years has on the estimate of survey biomass (middle plots) and the proportion of the biomass attributed to these strata (as well as the mean proportion) (lower plots).

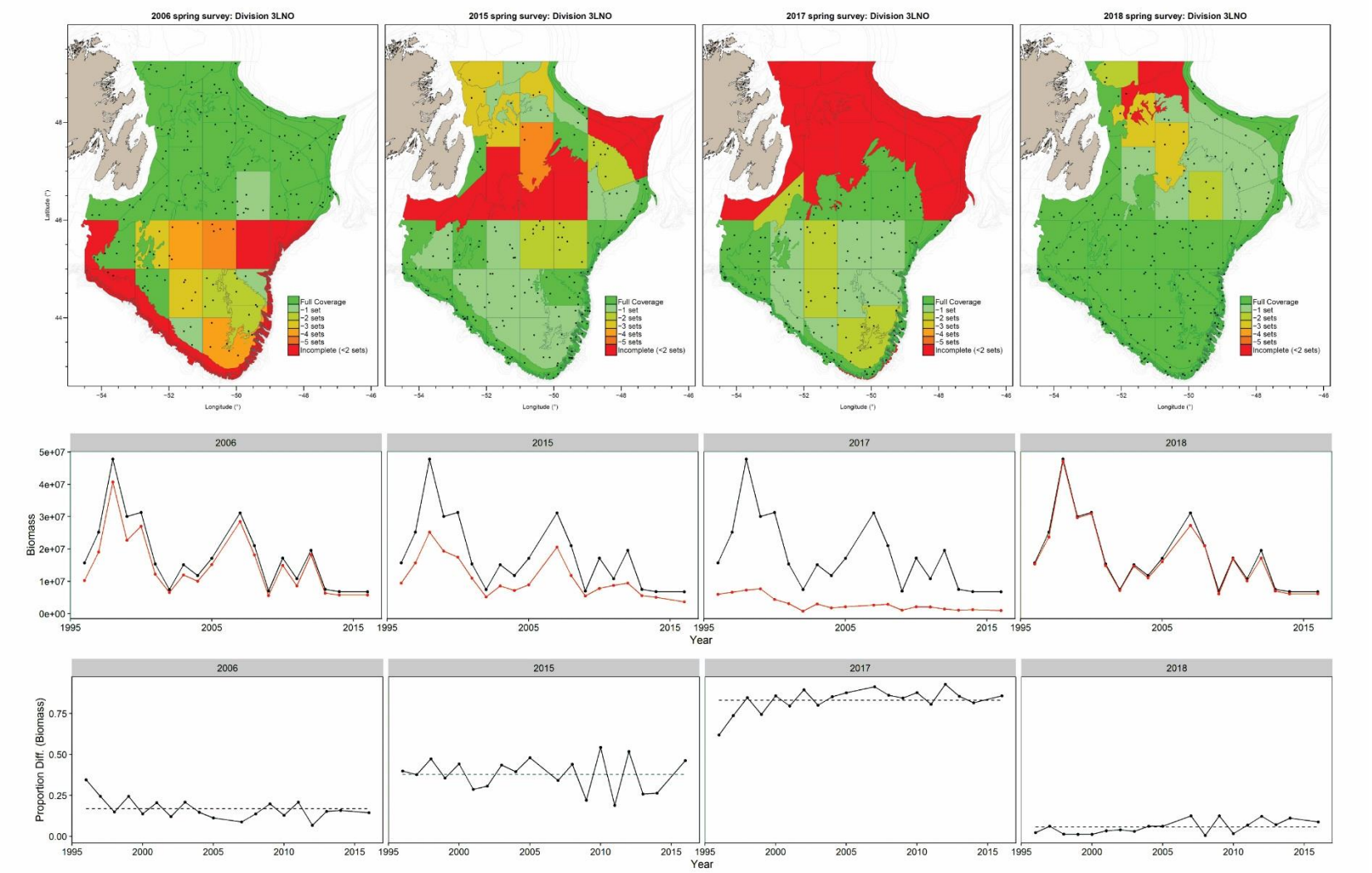

Figure 5. Greenland halibut in Divs. 3LNO spring. Four years with survey coverage issues (red in the top plots indicates incomplete strata) were explored: 2006, 2015, 2017, 2018. The current assessment excludes 2006, 2015 and 2017. The line plots show the impact that excluding the strata missed in each of these years from all other years has on the estimate of survey biomass (middle plots) and the proportion of the biomass attributed to these strata (as well as the mean proportion) (lower plots).

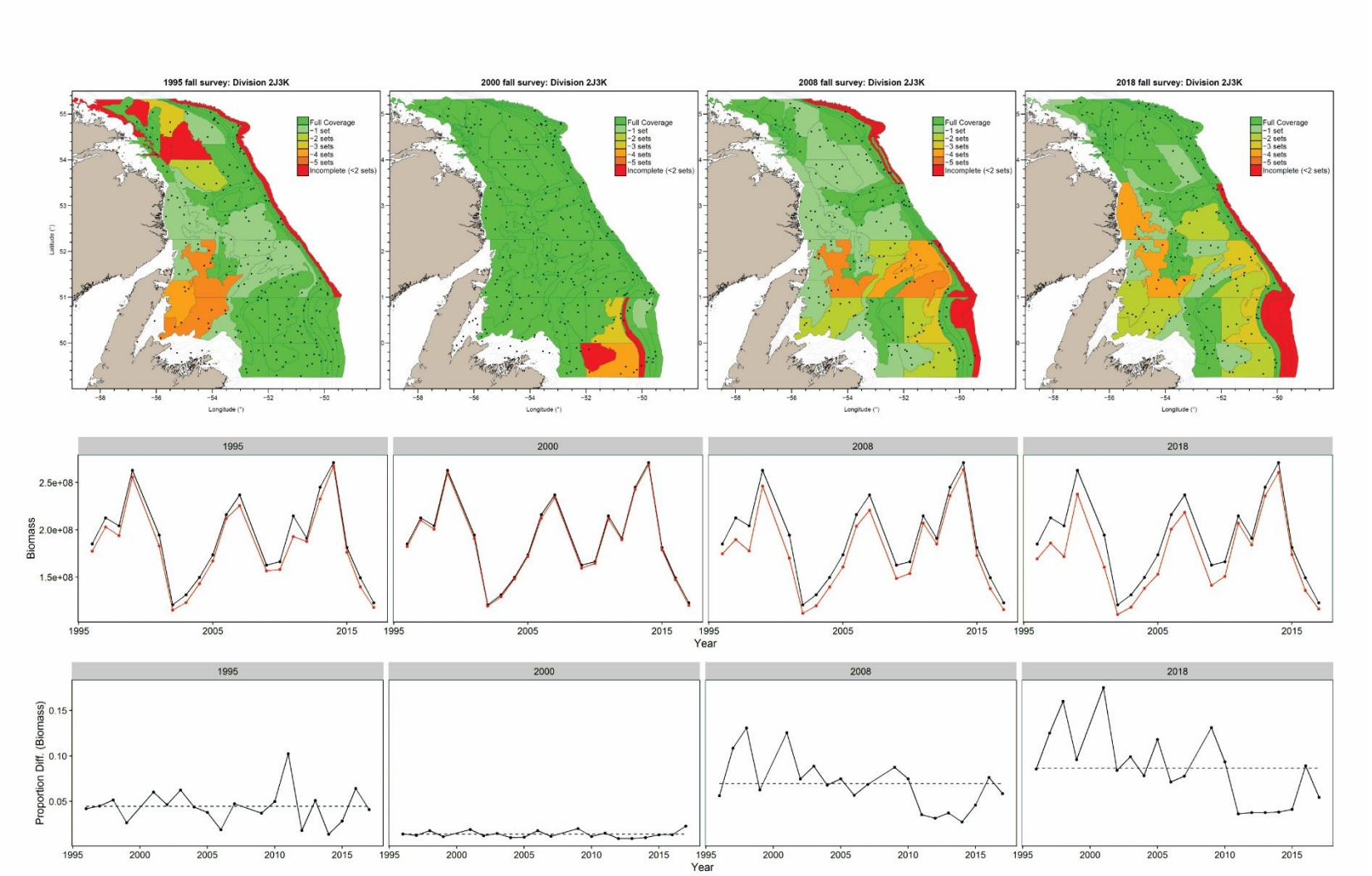

Figure 6. Greenland halibut in Divs. 2J3K autumn. Four years with survey coverage issues (red in the top plots indicates incomplete strata) were explored: 1995, 2000, 2008, 2018. The 2008 data point has been excluded from the assessment. The line plots show the impact that excluding the strata missed in each of these years from all other years has on the estimate of survey biomass (middle plots) and the proportion of the biomass attributed to these strata (as well as the mean proportion) (lower plots).

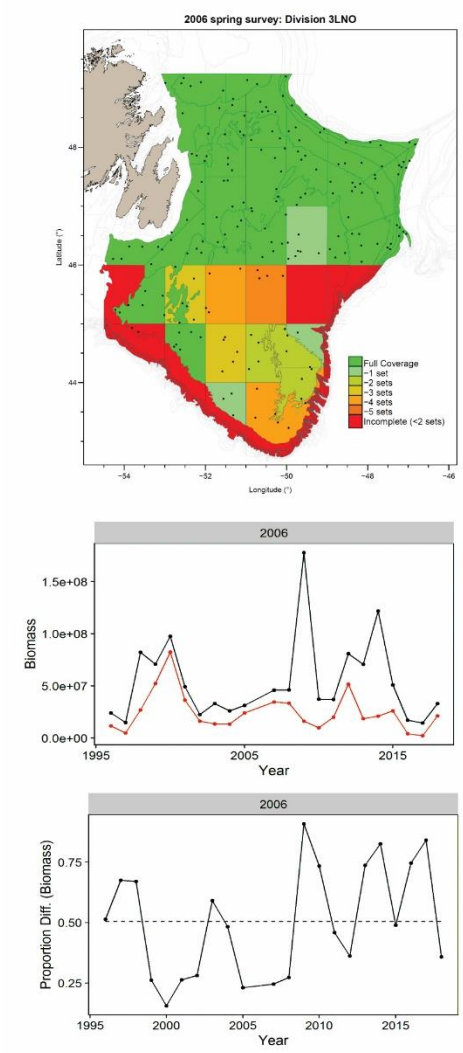

Figure 7. Atlantic Cod in Divs. 3NO spring. One year with survey coverage issues (red in the top plots indicates incomplete strata) was explored: 2006. The current assessment excludes that year. The line plots show the impact that excluding the strata missed in each of these years from all other years has on the estimate of survey biomass (middle plots) and the proportion of the biomass attributed to these strata (as well as the mean proportion) (lower plots).

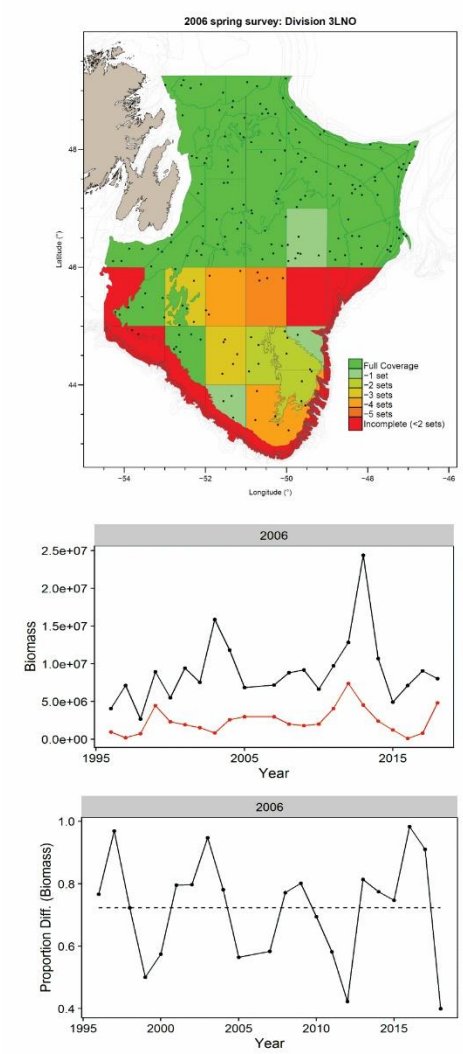

Figure 8. Witch Flounder in Divs. 3NO spring. One year with survey coverage issues (red in the top plots indicates incomplete strata) was explored: 2006. The current assessment excludes that year. The line plots show the impact that excluding the strata missed in each of these years from all other years has on the estimate of survey biomass (middle plots) and the proportion of the biomass attributed to these strata (as well as the mean proportion) (lower plots).

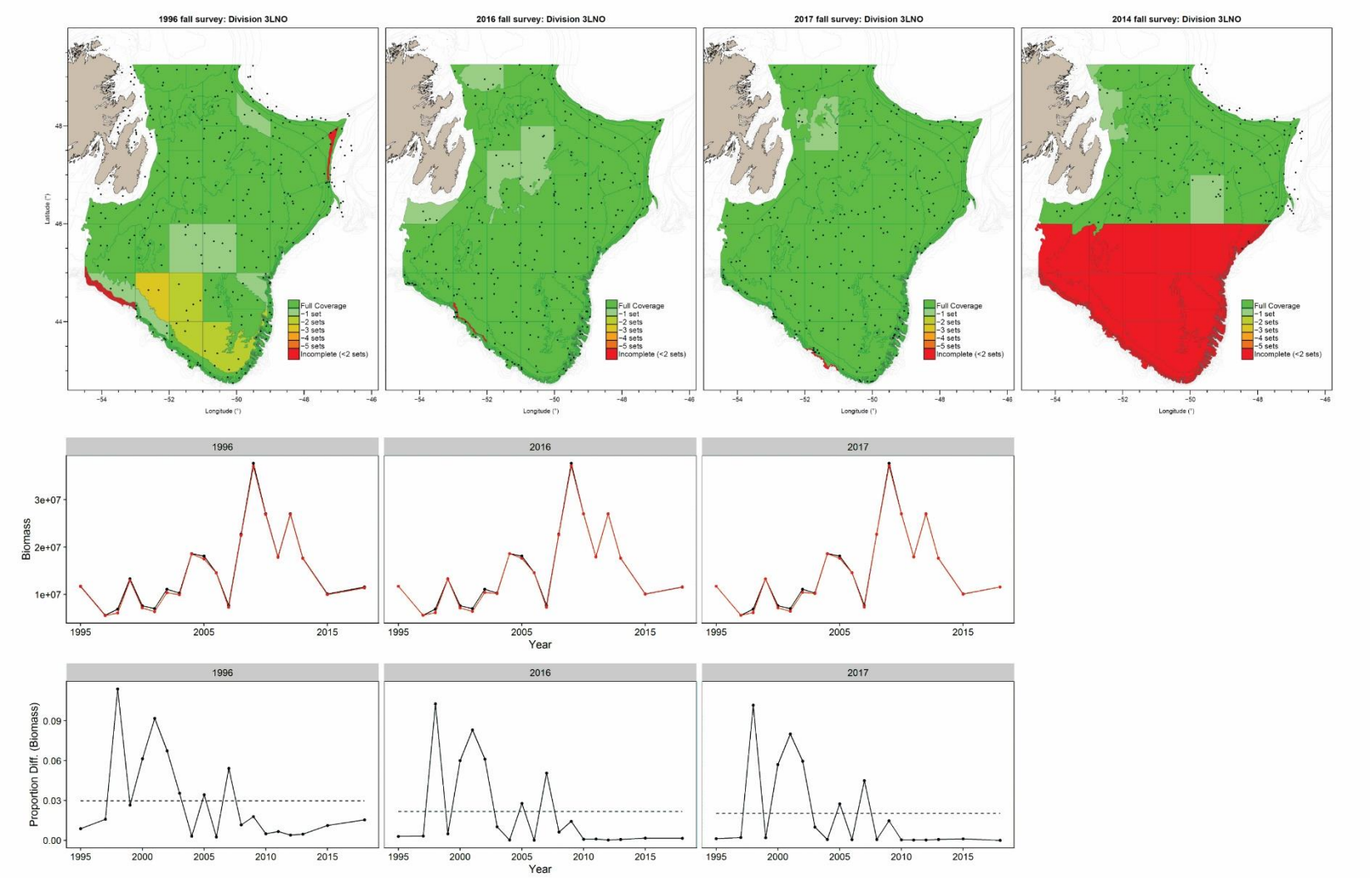

Figure 9. Witch Flounder in Divs. 3NO autumn. Four years with potential survey coverage issues (red in the top plots indicates incomplete strata) were explored: 1996, 2016, 2017. The 2014 data point has been excluded from the assessment due to a complete lack of coverage. The line plots show the impact that excluding the strata missed in each of these years from all other years has on the estimate of survey biomass (middle plots) and the proportion of the biomass attributed to these strata (as well as the mean proportion) (lower plots).

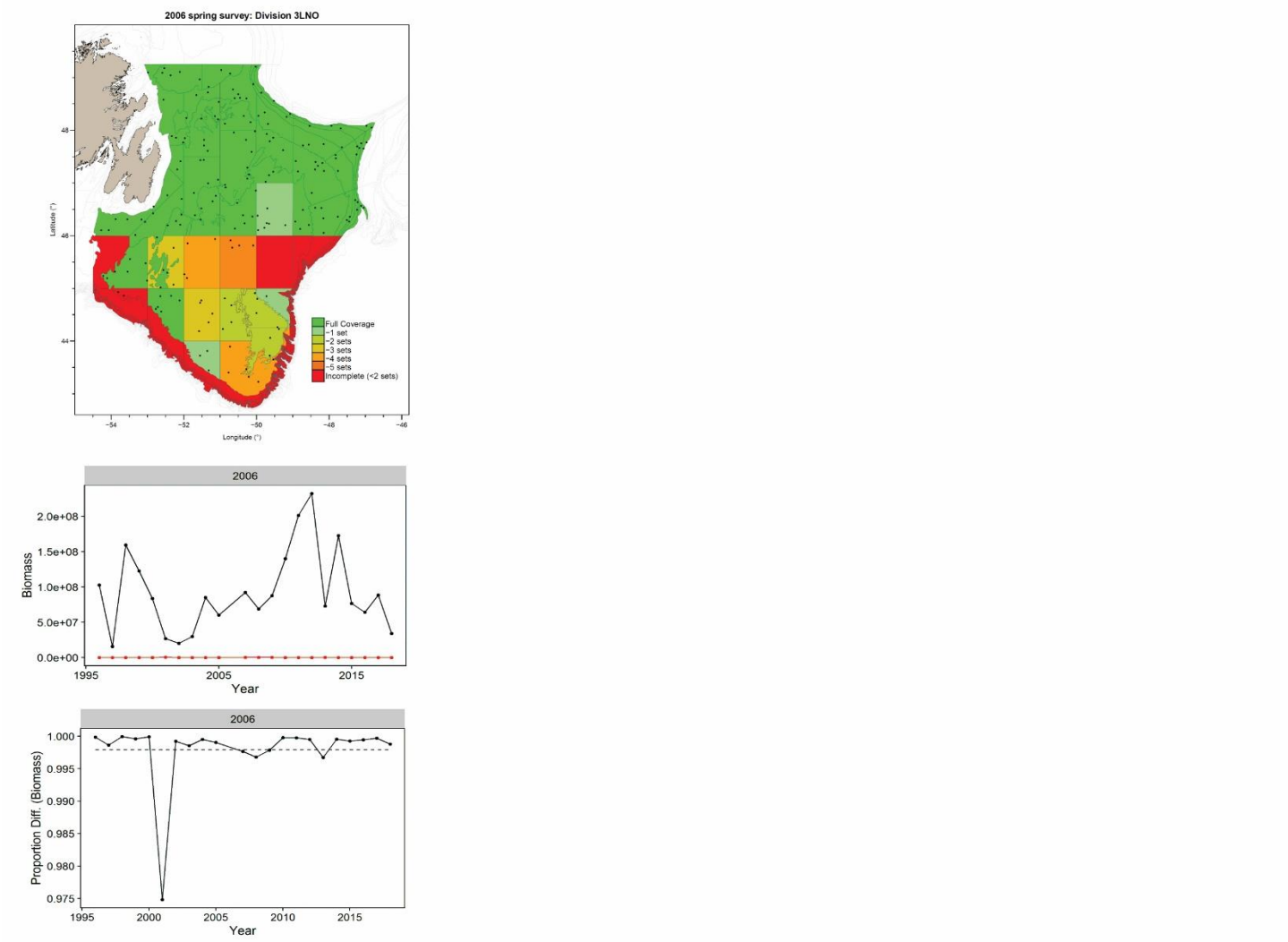

Figure 10. Redfish in Div. 3O spring. One year with survey coverage issues (red in the top plots indicates incomplete strata) was explored: 2006. The current assessment excludes that year. The line plots show the impact that excluding the strata missed in each of these years from all other years has on the estimate of survey biomass (middle plots) and the proportion of the biomass attributed to these strata (as well as the mean proportion) (lower plots).

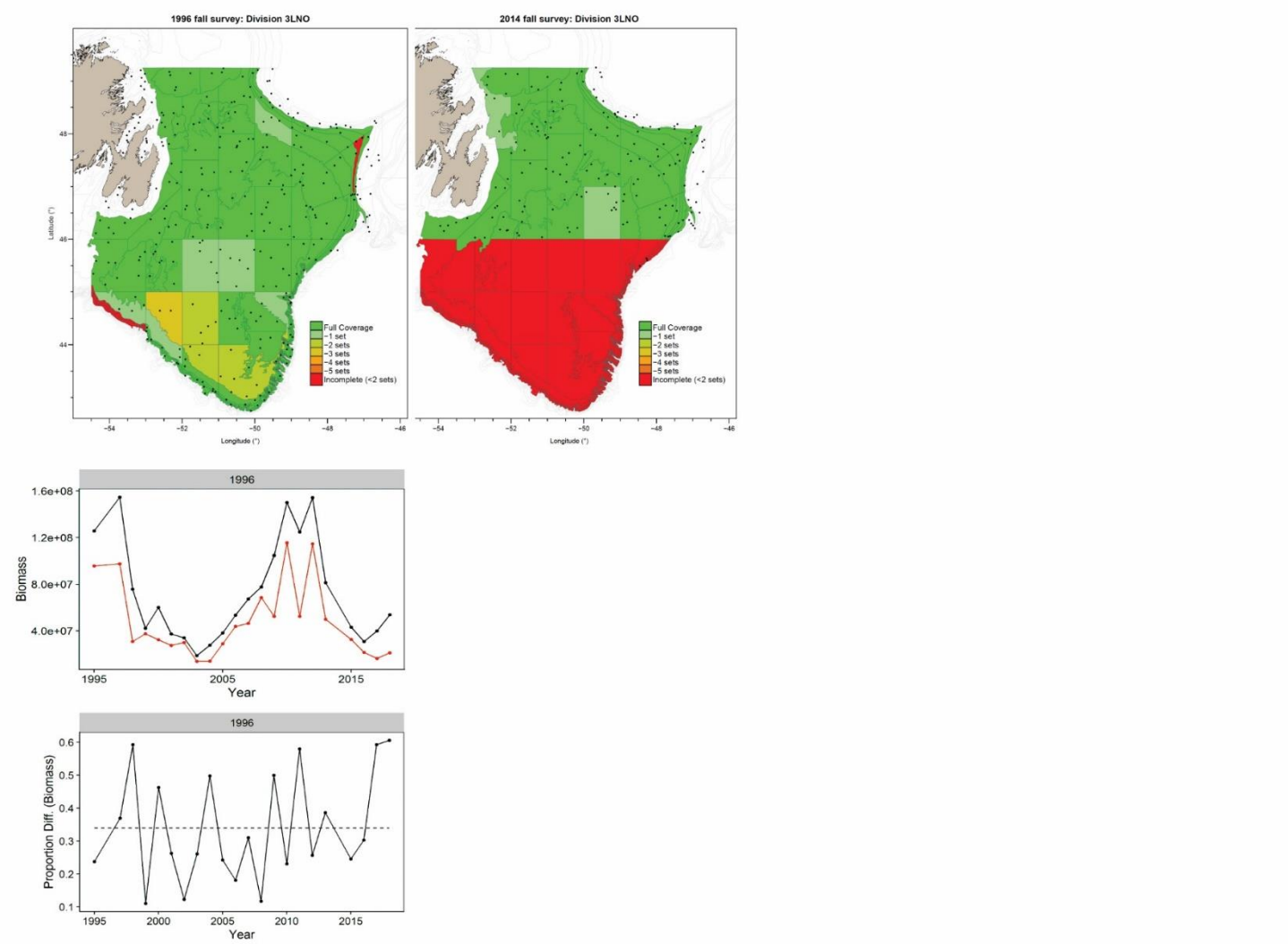

Figure 11. Redfish in Div. 3O autumn. Two years with potential survey coverage issues (red in the top plots indicates incomplete strata) were explored: 1996, 2014. The 2014 data point has been excluded from the assessment due to a complete lack of coverage. The line plots show the impact that excluding the strata missed in each of these years from all other years has on the estimate of survey biomass (middle plots) and the proportion of the biomass attributed to these strata (as well as the mean proportion) (lower plots).

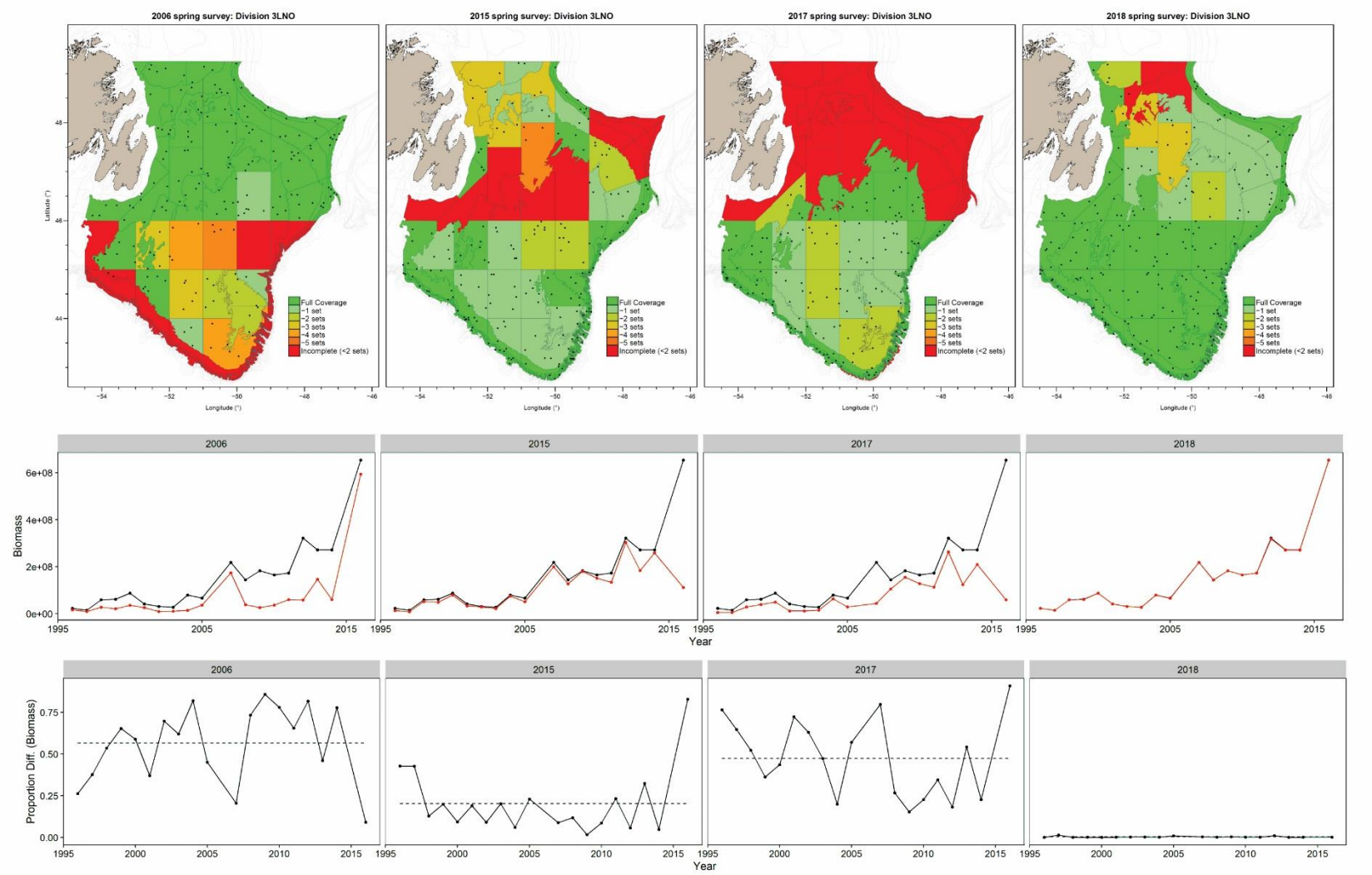

Figure 12. Redfish in Divs. 3LN spring. Four years with survey coverage issues (red in the top plots indicates incomplete strata) were explored: 2006, 2015, 2017, 2018. The most recent assessment excluded the 2006 and 2017 data points. The line plots show the impact that excluding the strata missed in each of these years from all other years has on the estimate of survey biomass (middle plots) and the proportion of the biomass attributed to these strata (as well as the mean proportion) (lower plots).

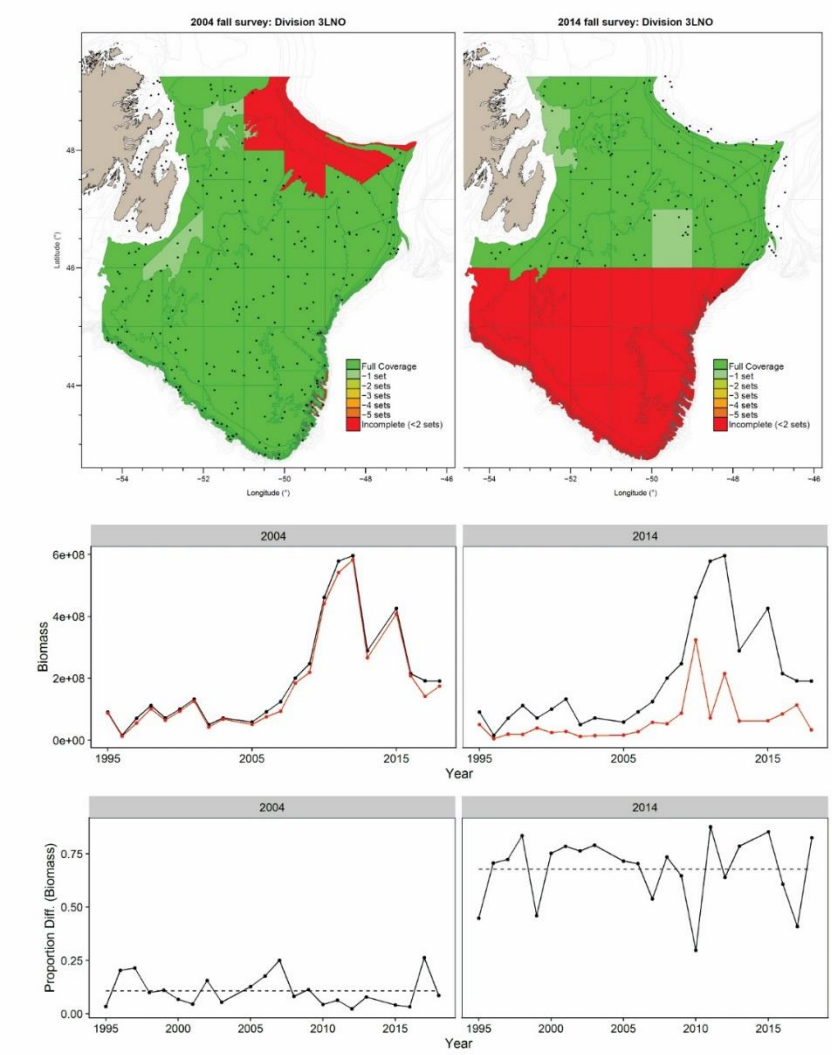

Figure 13. Redfish in Divs. 3LN autumn. One year with potential survey coverage issues (red in the top plots indicates incomplete strata) was explored: 2014. This year was excluded from the most recent assessment. The line plots show the impact that excluding the strata missed in each of these years from all other years has on the estimate of survey biomass (middle plots) and the proportion of the biomass attributed to these strata (as well as the mean proportion) (lower plots).

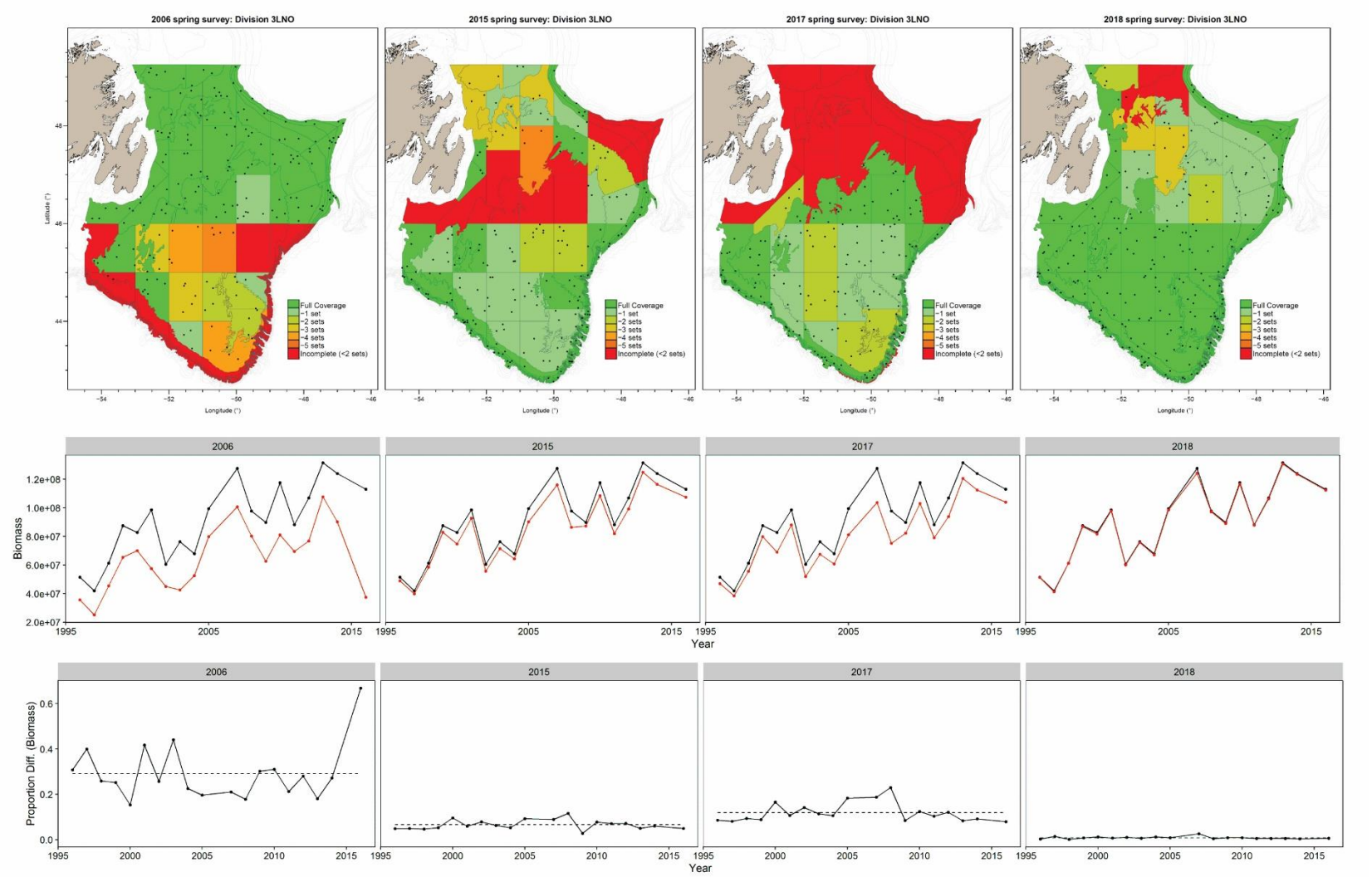

Figure 14. Thorny Skate in Divs. 3LNO spring. Four years with survey coverage issues (red in the top plots indicates incomplete strata) were explored: 2006, 2015, 2017, 2018. The current assessment excludes the 2006 data point. The line plots show the impact that excluding the strata missed in each of these years from all other years has on the estimate of survey biomass (middle plots) and the proportion of the biomass attributed to these strata (as well as the mean proportion) (lower plots).

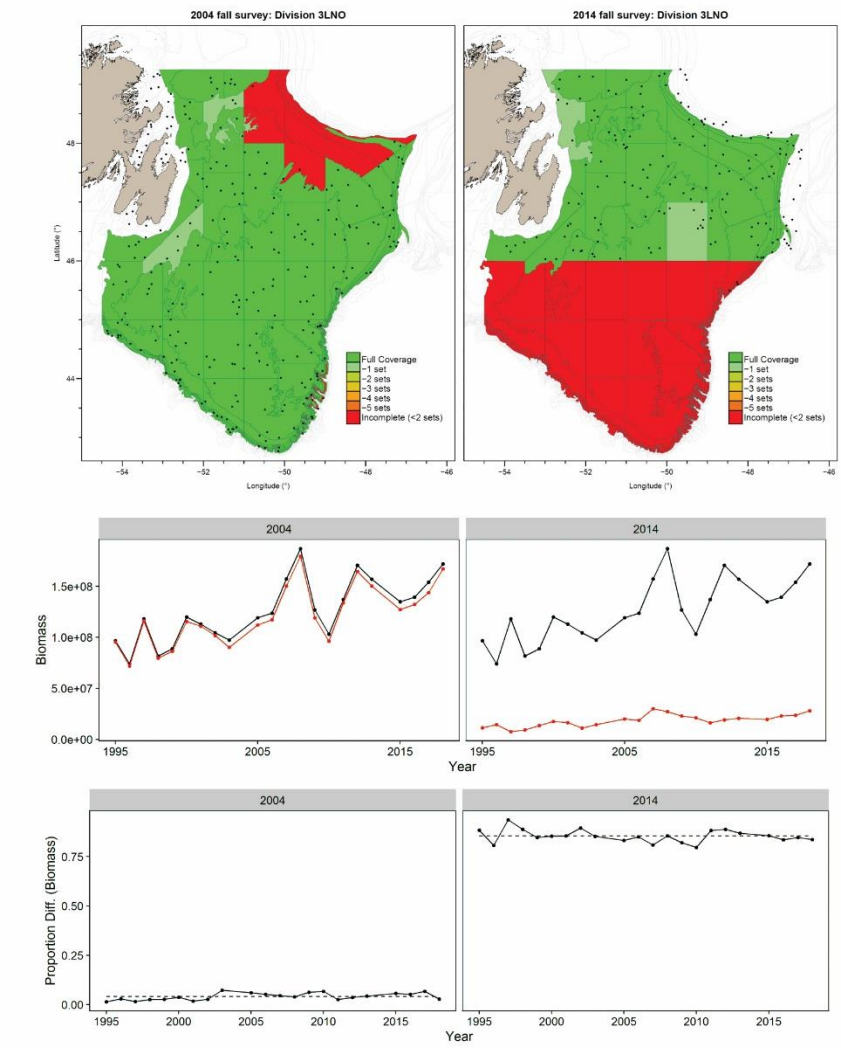

Figure 15. Thorny Skate in Divs. 3LNO autumn. Two years with potential survey coverage issues (red in the top plots indicates incomplete strata) were explored: 2004, 2014. The 2014 data point has been excluded from the assessment. The line plots show the impact that excluding the strata missed in each of these years from all other years has on the estimate of survey biomass (middle plots) and the proportion of the biomass attributed to these strata (as well as the mean proportion) (lower plots).

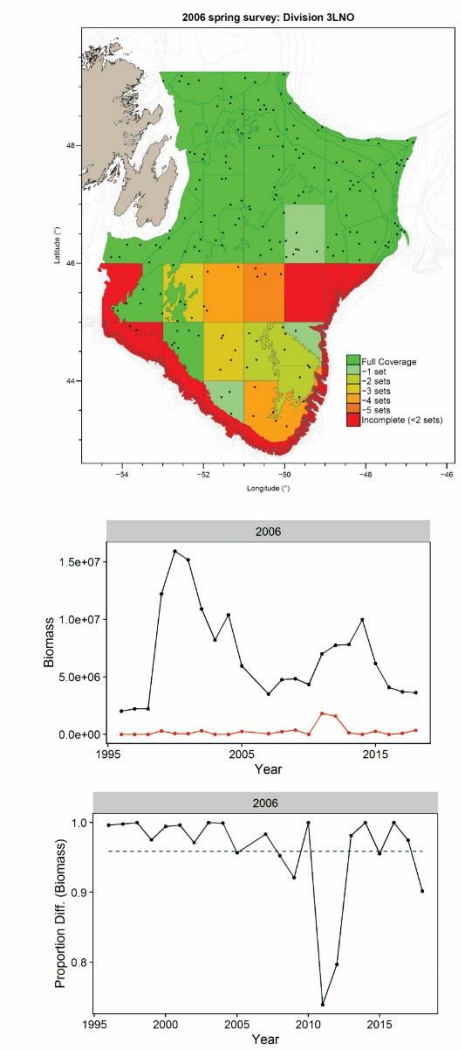

Figure 16. White Hake in Divs. 3NO spring. One year with survey coverage issues (red in the top plots indicates incomplete strata) was explored: 2006. The current assessment excludes that year. The line plots show the impact that excluding the strata missed in each of these years from all other years has on the estimate of survey biomass (middle plots) and the proportion of the biomass attributed to these strata (as well as the mean proportion) (lower plots).

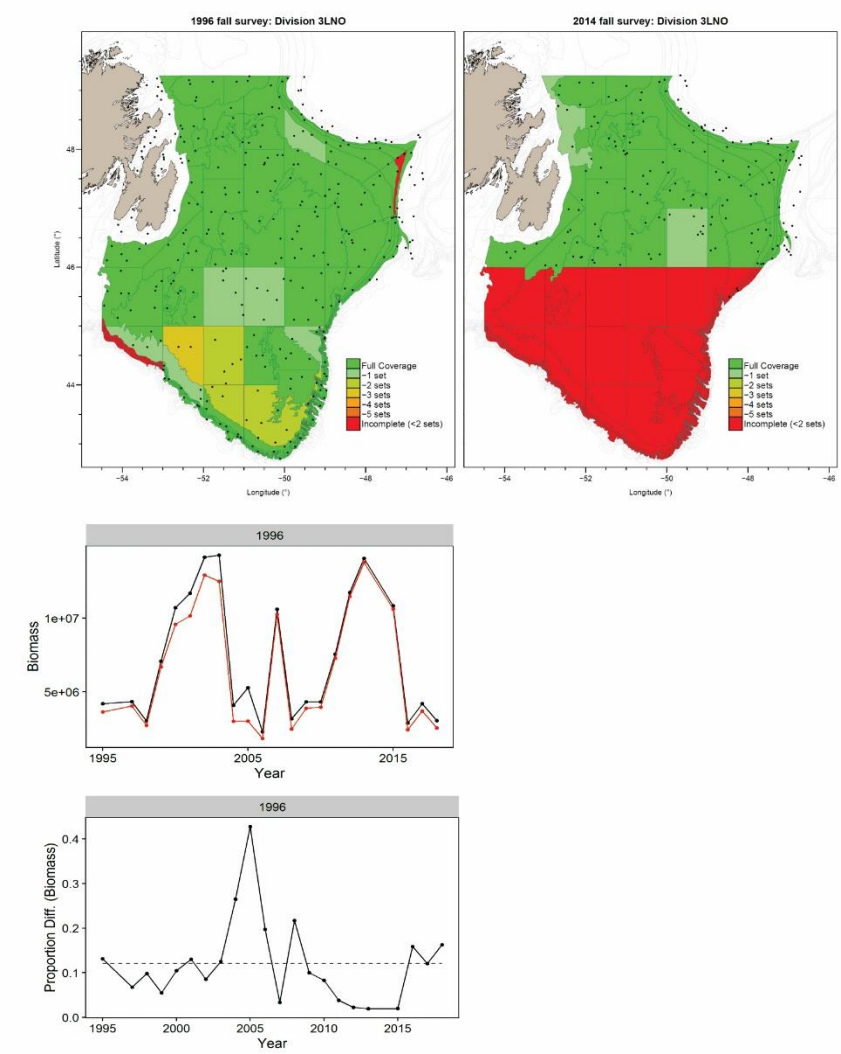

Figure 17. White Hake in Divs. 3NO autumn. Two years with potential survey coverage issues (red in the top plots indicates incomplete strata) were explored: 1996, 2014. The 2014 data point has been excluded from the assessment due to a complete lack of coverage. The line plots show the impact that excluding the strata missed in each of these years from all other years has on the estimate of survey biomass (middle plots) and the proportion of the biomass attributed to these strata (as well as the mean proportion) (lower plots).

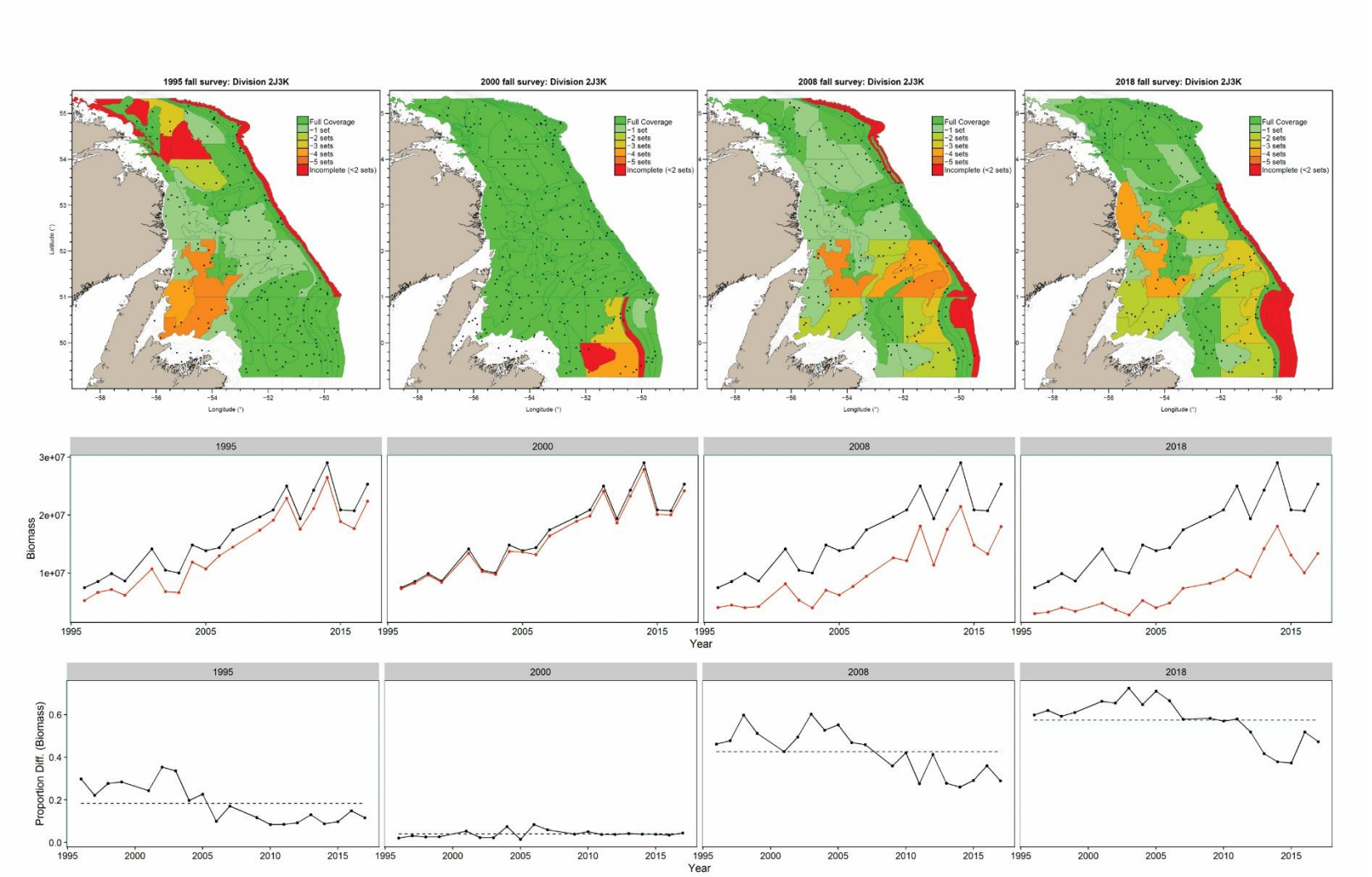

Figure 18. Roughhead grenadier in Divs. 2JK autumn. Four years with survey coverage issues (red in the top plots indicates incomplete strata) were explored: 1995, 2000, 2008, 2018. The 2018 data point has been excluded from the assessment. The line plots show the impact that excluding the strata missed in each of these years from all other years has on the estimate of survey biomass (middle plots) and the proportion of the biomass attributed to these strata (as well as the mean proportion) (lower plots).

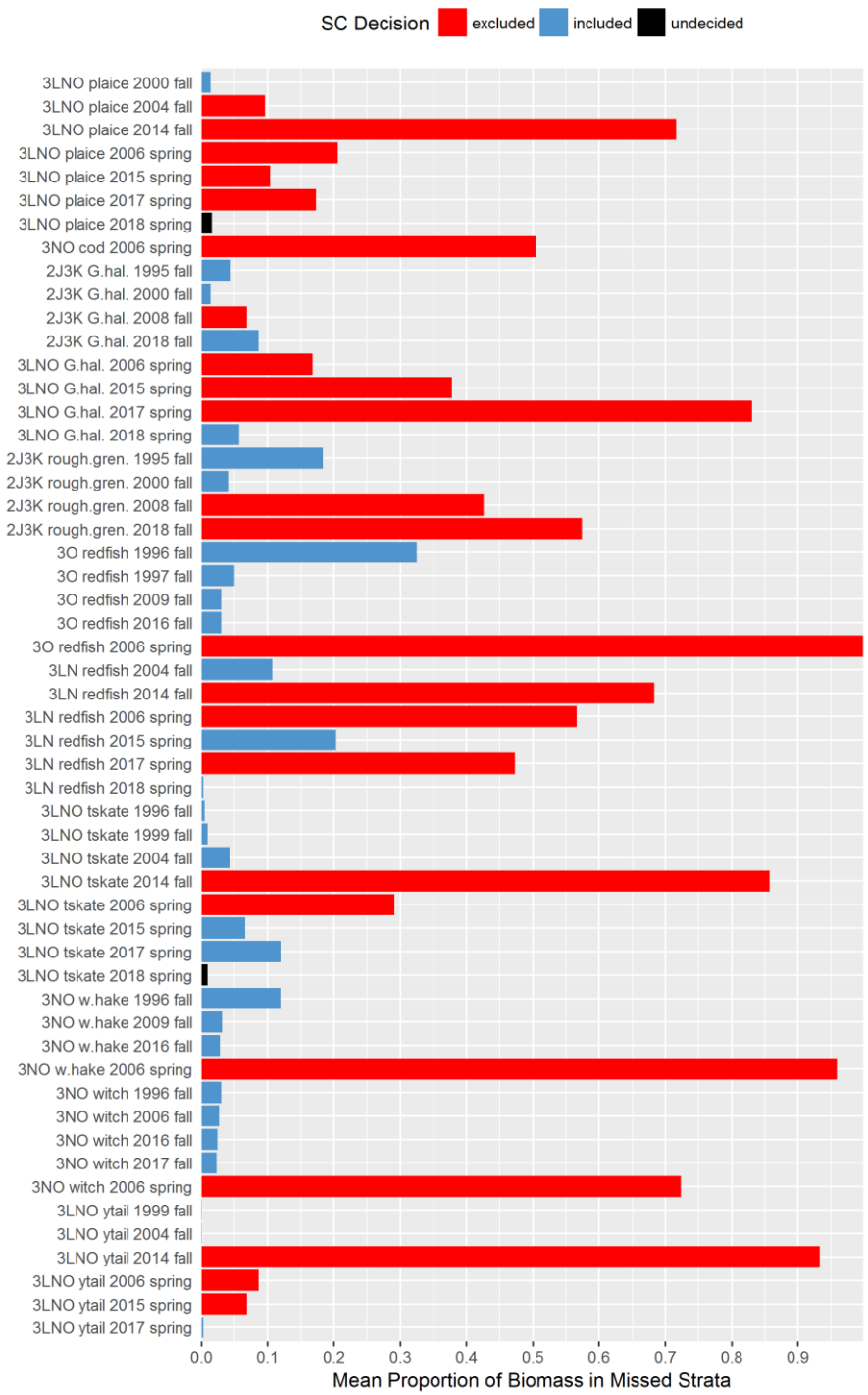

Figure 19. An examination of the consistency in handling survey data points with reduced spatial coverage. Only stock-survey combinations with spatial coverage issues are included. Values are the mean proportion of the total survey biomass found in those missed strata in other survey years. Colours indicate whether that survey point was included (blue) or excluded (red) from the assessment of the given stock. Survey points that are "undecided" have occurred since the last full assessment of that stock.

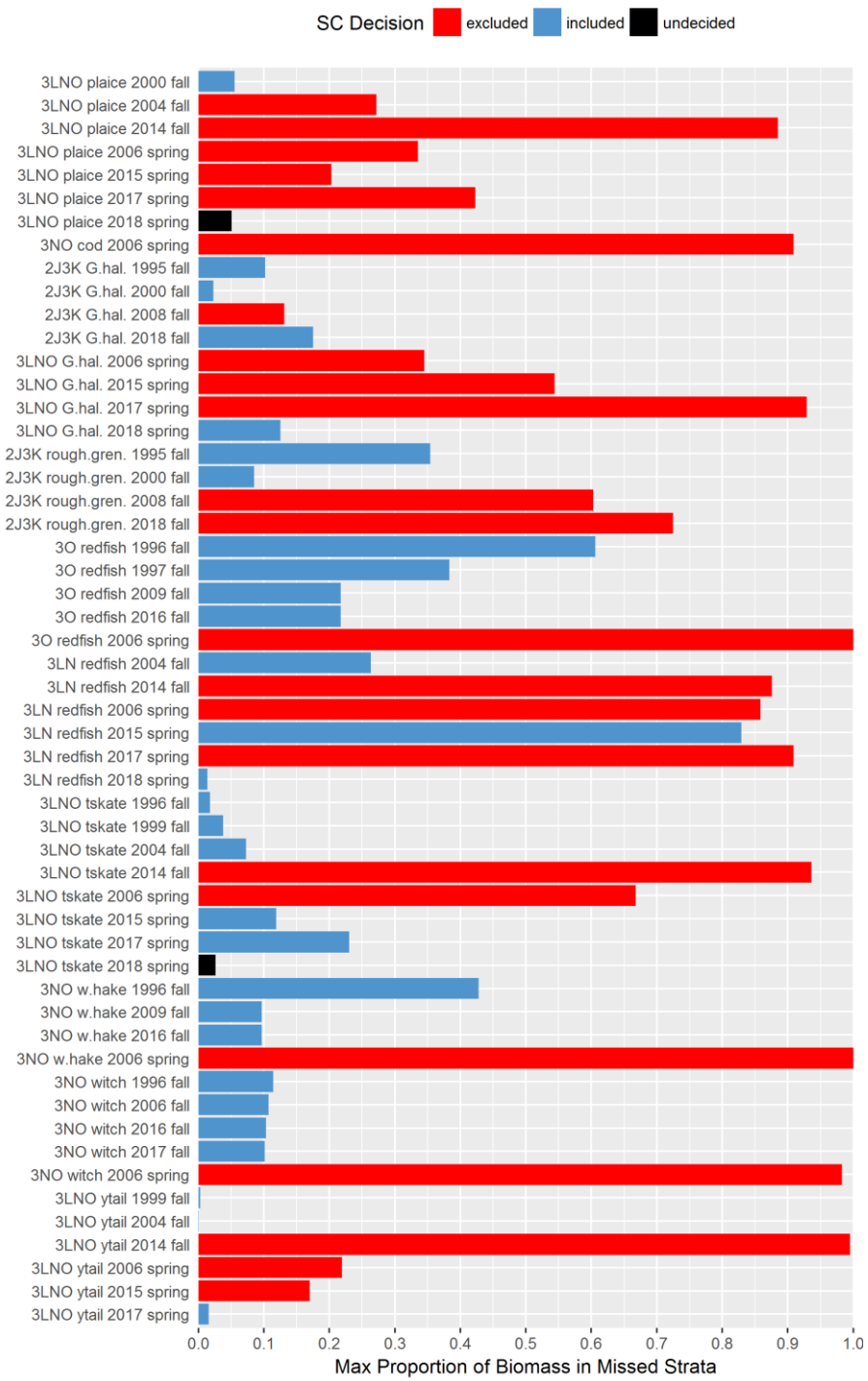

Figure 20. An examination of the consistency in handling survey data points with reduced spatial coverage. Only stock-survey combinations with spatial coverage issues are included. Values are the maximum proportion of the total survey biomass found in those missed strata in other survey years. Colours indicate whether that survey point was included (blue) or excluded (red) from the assessment of the given stock. Survey points that are "undecided" have occurred since the last full assessment of that stock.