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**Examining the impact that excluding RV surveys from coral and sponge protection areas in Divisions 3LNO would have on Canadian RV survey trends for NAFO-managed fish stocks**

by

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**Abstract**

Several areas within the NAFO Convention Area are currently closed to bottom fishing activities, primarily as a measure to protect high concentrations of corals and sponges. These areas are still subject to occasional trawling from Research Vessel surveys and hence, Fisheries Commission has requested that Scientific Council consider the impact that excluding RV surveys from these protected areas would have on stock assessments. Here, we examine Canadian RV survey indices for fish stocks located all or partially in NAFO Divisions 3LNO, remove any survey sets that occurred within the closed areas in those Divisions, and recalculate the indices. Only the Campelen trawl time series were examined. A total of 220 autumn survey sets and 39 spring survey sets were identified as being located within the closed areas. In general, however, the closed areas are deeper than the main distribution areas for Atlantic cod, American plaice, yellowtail flounder, witch flounder, redfish, thorny skate and white hake and removing the fishing sets located in these areas had little impact on survey indices. The results for Greenland halibut and roughhead grenadier, both generally considered deepwater species, differed from one and other. Excluding survey sets from the closed areas did not influence survey indices for Greenland halibut, whereas autumn survey indices for roughhead grenadier declined slightly in some years) when sets in closed areas were excluded from the analyses. However, these differences were generally small (mean diff=2%, range 0-9%) and did not influence the overall patterns in the index. Because some deep strata are located almost entirely (85% or more) within the closed areas we also examined if the loss of these strata from the Canadian survey design would influence the size composition of Greenland halibut and roughhead grenadier. No discernable impact was observed.

**Introduction**

Coldwater corals and sponges are sessile, habitat forming animals that contribute to the development of complex habit in deep coldwater oceans and these habitats are functionally linked to essential life processes for numerous commercially important fish species and invertebrates. The slow growing and long-lived nature of corals and sponges make them highly vulnerable to human activities, particularly bottom contact fisheries. In recognition of the importance and vulnerability of these vulnerable marine ecosystems, NAFO Fisheries Commission has closed certain areas to commercial bottom fishing that have been identified as having high concentrations of corals and/or sponges.

On the Grand Bank (NAFO Divisions 3LNO) there are currently three such closed areas, the 30 coral closure area, a closure on the tail of the bank, and a closure that extends from the Flemish Pass into the Eastern Canyon region (Fig. 1). There is also a closed area in the Sackville Spur region that is located primarily within



NAFO Division 3M but extends slightly into Division 3L. Canada conducts both a spring and autumn stratified random multi-species RV trawl survey in Divisions 3LNO. These surveys provide crucial data for the assessment of resources in the area. The survey design was established long before the establishment of closed areas and the random position of fishing sets within the survey stratification scheme means that some sets are likely to occur within the closed areas. The extent and impact of structural damage caused to these VMEs by RV trawl gear is difficult to quantify but the presence of these VME species in RV trawl catches is indicative of at least some disruption. NAFO SC has been asked to expedite risk assessment of scientific trawl surveys impact on VME in closed areas to determine how much damage RV trawls might be causing. In addition SC has been asked to consider the effect on stock assessments of excluding surveys from these areas.

González Troncoso et al. (2016) examined data from the EU Flemish Cap (NAFO Division 3M) survey and determined that removing past fishing sets from the database that were located within coral and sponge closed areas had very little impact on the RV survey time series for NAFO-managed fish stocks on the Flemish Cap. This could suggest that removing the closed areas from future survey designs would be unlikely to influence assessments on those fish stocks. Here we essentially repeat the same exercise for fish stocks on the Grand Bank by removing RV fishing sets that have occurred in the previously mentioned closed areas.

## Methods

The four NAFO closed areas located all or partially within NAFO Divisions 3LNO were overlaid with the sampling stratification scheme use in Canadian surveys and the strata which intersected with the closed areas were identified (Table 1) using the ArcGIS 'Select By Location' function. Additionally, the ArcGIS 'Clip' overlay of the NAFO closure polygons (<https://www.nafo.int/Data/GIS>) and the sampling strata was performed to extract the areas of intersection between the two layers (Fig. 3). The amount of affected area (stratum area inside a closed area) was calculated and compared to the total stratum area (Table 1). It is important to note that the GIS-based estimates of stratum areas could vary slightly from those that have historically been used to produce survey estimates for stock assessment purposes and hence there may be slight differences in the indices presented here versus those in the official stock assessments.

Only data from the portion of the Canadian autumn and spring RV surveys that utilized the Campelen shrimp trawl were examined here (i.e. 1995-2016 for the autumn survey, and 1996-2016 for the spring survey). Any survey set that started and/or ended within one of the closed areas (i.e. was all or partially within the closed area) was included as being in the closed area. The overlap of survey sets with the closed areas was determined using the `over()` function in R's `sp` library.

Survey estimates of total biomass were recalculated for NAFO-managed fish stocks located all or partially in Divisions 3LNO (3NO cod, 3LNO American plaice, 3LN redfish, 3O redfish, 2+3 roughhead grenadier, 3LNOPs thorny skate, 2+3 Greenland halibut, 3NOPs white hake, 3NO witch flounder, 3LNO yellowtail flounder) based on dropping any sets that occurred within one of the closed areas and using revised estimates of stratum area (i.e. GIS estimates of stratum area minus the portion of the stratum that overlapped with any of the closed areas). In instances where dropping a set that was located in one of the closed areas resulted in only a single remaining set in that stratum, that single set was used to estimate biomass for that stratum (whereas the minimum number of successful sets required per stratum is normally two). This 'revised' biomass time series was compared with the actual biomass time series in order to explore the potential impact of excluding RV surveys from the NAFO closed areas.

Because some strata were located almost exclusively within NAFO closed areas we explored if completely removing these strata from the survey scheme would influence estimates of abundance at length. To do this, strata that were 85% or more within the closures (Table 1: 755,769-771,773-775) were removed from the analyses and compared with estimates based on all strata.

## Results & Discussion

The stratification scheme for the Canadian RV surveys contains 29 strata that intersect with the closed areas in NAFO Divisions 3LNO. The amount of overlap ranges from less than a square nautical mile to 328 square nautical miles, and from less than 1% of the stratum area to >99% of the stratum area (Table 1).

For the autumn survey, the annual number of survey sets within any of the closed areas ranged from as low as 1 in 2013 and 2014 to as high as 30 in 2007 (Table 2, Fig. 2). The total number of autumn survey sets in the closed areas over the entire time series (1985-2016) was relatively even for the 30 coral closure (n=111) and the Flemish Pass/Eastern Canyon closure (n=106). The number of survey sets in the much smaller Tail of the Bank closure and the small portion of the Sackville Spur closure that extends into Div. 3L was extremely low (n=1 and n=2 respectively).

The Canadian spring survey of Divs. 3LNO does not fish as deep as the autumn survey and hence there are fewer sets (n=39) that occur within the closed areas (Table 3). The annual number of spring survey sets within the closed areas ranged from 0 in 2010 to a maximum of 4 in 2013. Over the entire time series (1996-2016) there were 16 sets in the 30 coral closure, 23 sets in the Flemish Pass/Eastern Canyon closure, and no sets in the other closed areas.

The assessment for 3NO cod is based on index strata <300 fathoms. None of the closed areas overlap with such shallow strata and so eliminating survey sets from the closed areas will not influence survey indices (or the assessment) for 3NO cod. Also, the closed areas are deeper than the main distribution areas for American plaice (Fig. 3), yellowtail flounder (Fig. 11), witch flounder (Fig. 10), redfish (Fig. 4 & 5), thorny skate (Fig. 7) and white hake (Fig. 9) and removing the fishing sets located in these areas had little impact on survey indices.

The results for Greenland halibut and roughhead grenadier, both generally considered deepwater species, differed from one and other. Excluding survey sets from the closed areas did not influence survey indices for Greenland halibut (Fig. 12), whereas autumn survey indices for roughhead grenadier declined slightly in some years when sets in closed areas were excluded from the analyses (Fig. 13). However, these differences were generally small (the maximum difference in any year was 9%) and did not influence the overall patterns in the index.

Completely eliminating strata that were almost entirely (85% or more) within the closed areas did not result in any perceivable change in the estimates of abundance at length for Greenland halibut (Fig. 12) or roughhead grenadier (Fig. 13).

## References

- González Troncoso, D., Nogueira, A., and Alpoim, R. 2016. Effect in mean catch and biomass index of removing stations in the closed Coral, Sponge and Seapen Protection Areas in the design of the EU Flemish Cap survey. NAFO SCR 16/40.

Table 1. Overlap of Divs. 3LNO stratification scheme with areas closed for the protections of corals and sponges.

Div	Stratum	Closed Area that Stratum Overlaps	Area overlapping with closure (sq. n. mi.)	% of stratum area overlapping closure
3L	729	Flemish Pass/Eastern Canyon	4.40	2.38
3L	730	Flemish Pass/Eastern Canyon	77.44	42.14
3L	743	Sackville Spur	0.27	0.13
3L	744	Sackville Spur	8.39	2.96
3L	747	Flemish Pass/Eastern Canyon	101.31	13.83
3L	748	Flemish Pass/Eastern Canyon	115.82	62.10
3L	749	Flemish Pass/Eastern Canyon	79.45	55.90
3L	750	Flemish Pass/Eastern Canyon	259.59	45.20
3L	751	Flemish Pass/Eastern Canyon	80.29	34.86
3N	752	Flemish Pass/Eastern Canyon	0.17	0.14
3N	753	Flemish Pass/Eastern Canyon	11.43	8.11
3N	754	Flemish Pass/Eastern Canyon	116.86	58.34
3N	755	Flemish Pass/Eastern Canyon	328.33	85.50
3N	758	Flemish Pass/Eastern Canyon	1.57	1.37
3N	759	Flemish Pass/Eastern Canyon & Tail of the Bank	44.89	33.40
3O	718	3O Coral Closure	17.07	13.15
3O	720	3O Coral Closure	18.94	17.01
3O	764	3O Coral Closure	1.04	0.95
3O	765	3O Coral Closure	2.73	2.04
3O	766	3O Coral Closure	6.08	3.94
3O	767	3O Coral Closure	67.02	40.37
3O	768	3O Coral Closure	57.82	70.72
3O	769	3O Coral Closure	131.19	96.53
3O	770	3O Coral Closure	125.83	99.68
3O	771	3O Coral Closure	184.73	99.72
3O	772	3O Coral Closure	86.87	63.08
3O	773	3O Coral Closure	103.05	84.60
3O	774	3O Coral Closure	129.66	94.44
3O	775	3O Coral Closure	149.34	99.04

Table 2. Total number of Autumn RV survey sets within the closed areas in NAFO Divisions 3LNO.

Year	30 Coral Closure	Flemish Pass / Eastern Canyon	Sackville Spur	Tail of the Bank	Total
1995	1	1			2
1996		5			5
1997	1	5			6
1998	7	10			17
1999	1	3			4
2000	13	9		1	23
2001	14	12	1		27
2002	3	10			13
2003	10				10
2004		7			7
2005	17	1			18
2006	1	4			5
2007	18	12			30
2008	1	2			3
2009	19	7	1		27
2010	1	6			7
2011	1	1			2
2012	1	1			2
2013		1			1
2014		1			1
2015		8			8
2016	2				2
Total	111	106	2	1	220

Table 3. Total number of Spring RV survey sets within the closed areas in NAFO Divisions 3LNO.

Year	30 Coral Closure	Flemish Pass / Eastern Canyon	Total
1996	1	1	2
1997		2	2
1998		2	2
1999	1	1	2
2000	1	1	2
2001		1	1
2002	1		1
2003		2	2
2004	1	1	2
2005	1	2	3
2006			0
2007	2	1	3
2008	1	2	3
2009	1	1	2
2010			0
2011	1		1
2012		2	2
2013	3	1	4
2014		2	2
2015	1		1
2016	1	1	2
Total	16	23	39

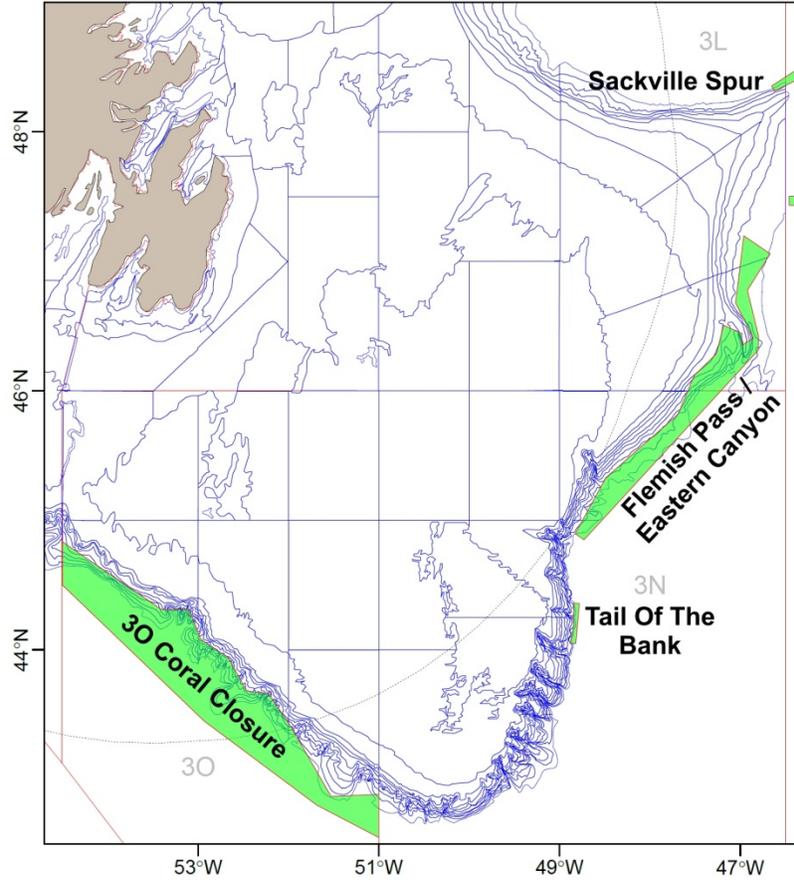


Fig. 1. Closed areas within NAFO Divisions 3LNO.

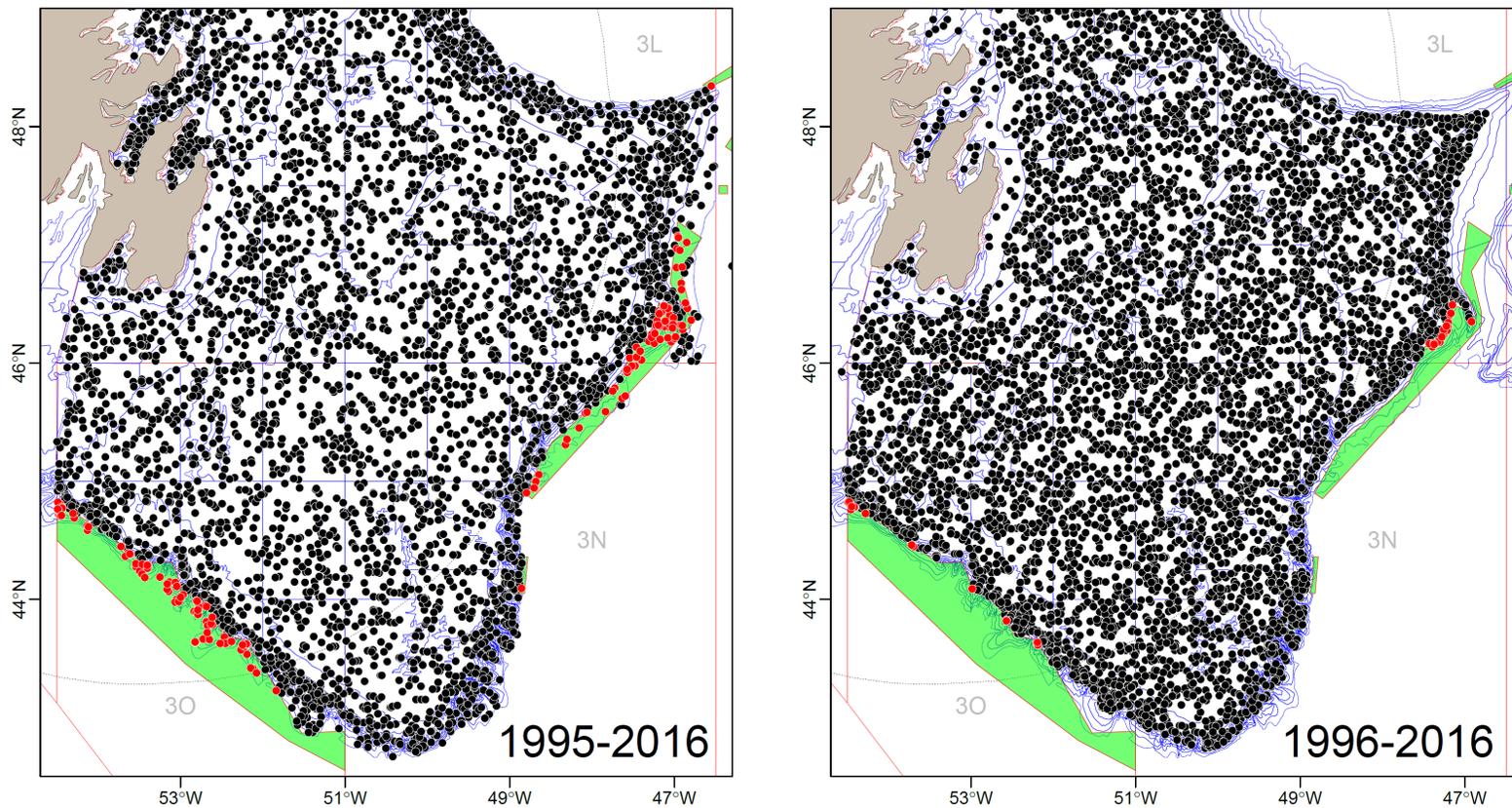


Fig. 2. Fishing set locations for the Canadian Autumn (left) and Spring (right) RV surveys. Symbols represent the midpoint of a survey trawl set. Areas closed to commercial fishing due to high concentrations of corals and/or sponges are highlighted in green. Red symbols represent survey sets that overlapped with these closed areas.

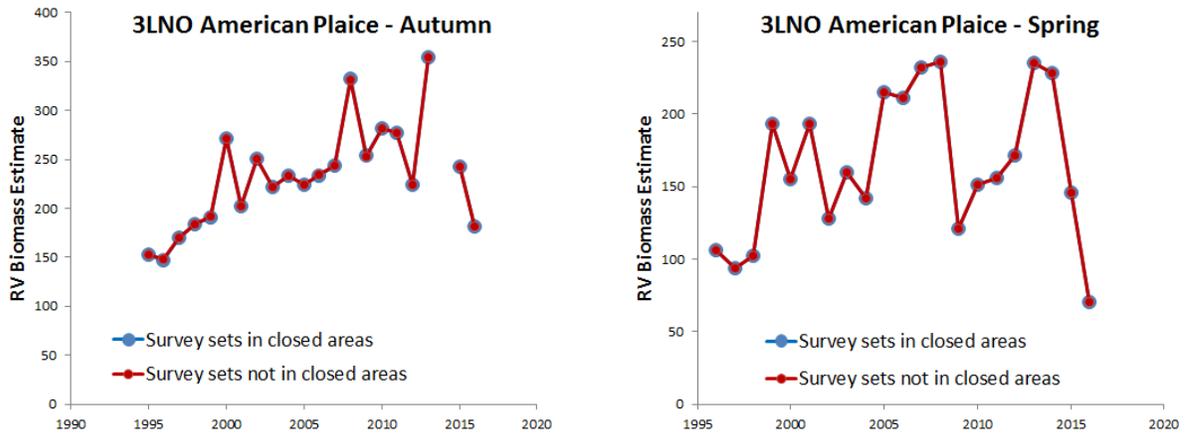


Fig. 3. Comparison of Canadian RV biomass indices for 3LNO American plaice when sets within closed areas are included (blue) and not included (red) in the indices.

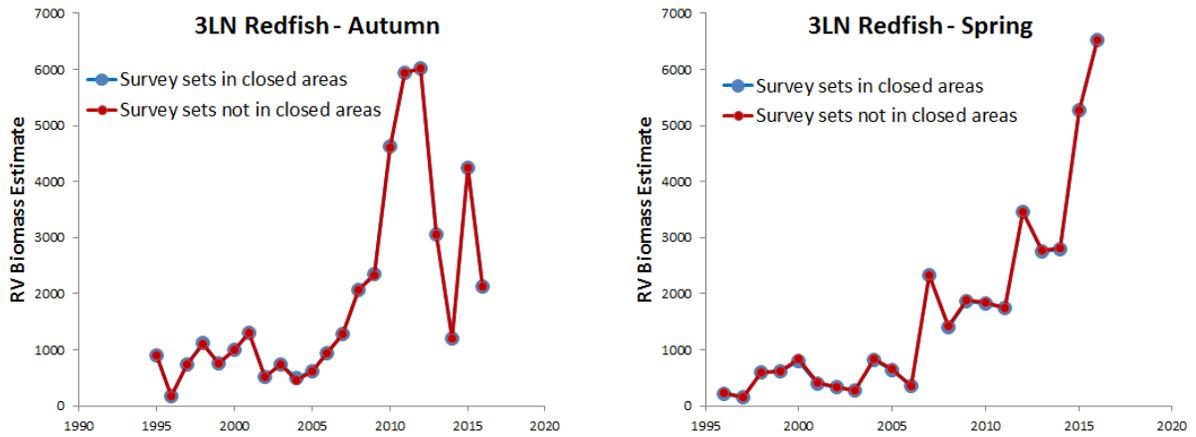


Fig. 4. Comparison of Canadian RV biomass indices for 3LN redfish when sets within closed areas are included (blue) and not included (red) in the indices.

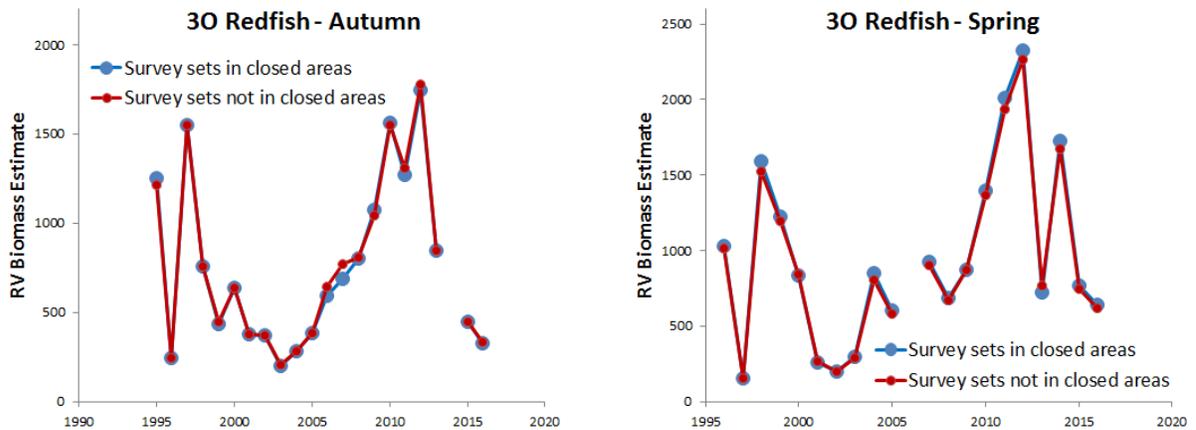


Fig. 5. Comparison of Canadian RV biomass indices for 3O redfish when sets within closed areas are included (blue) and not included (red) in the indices.

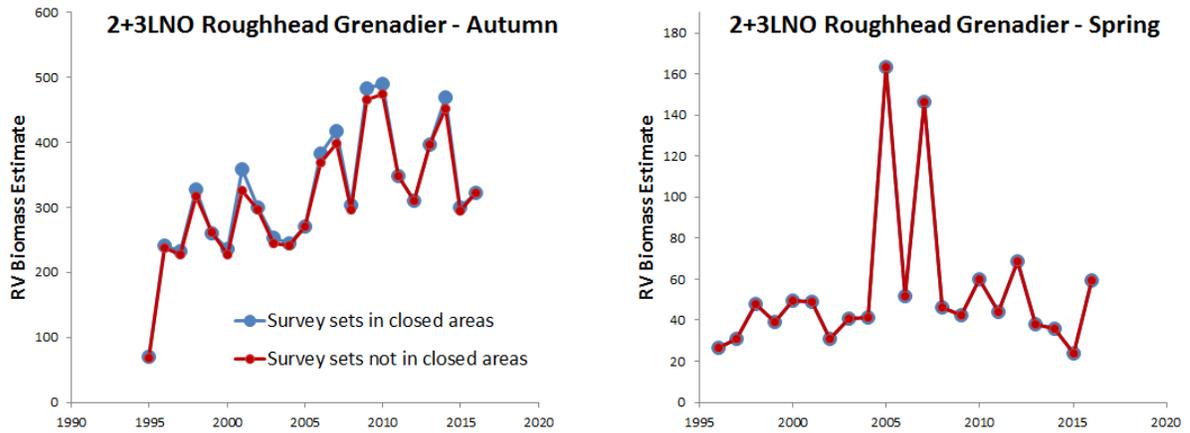


Fig. 6. Comparison of Canadian RV biomass indices for 2+3LNO roughhead grenadier when sets within closed areas are included (blue) and not included (red) in the indices.

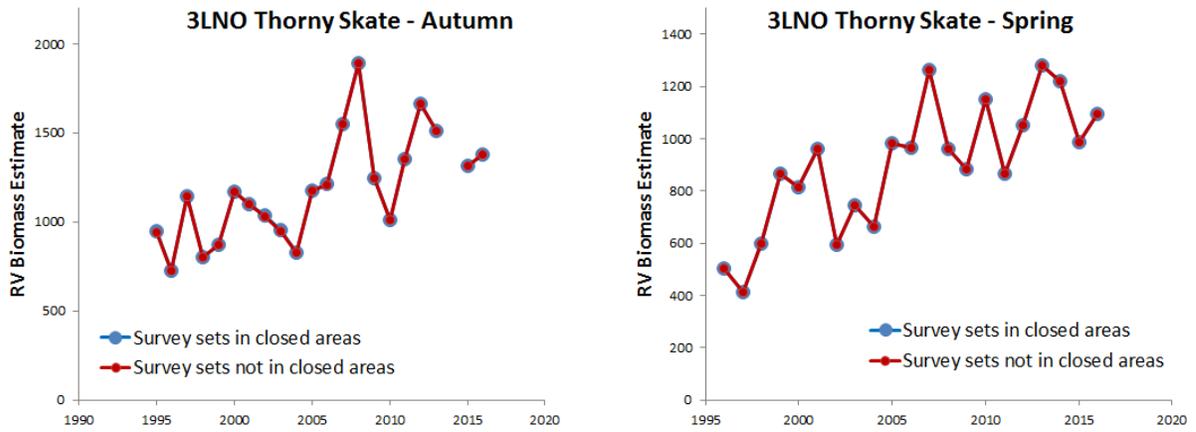


Fig. 7. Comparison of Canadian RV biomass indices for 3LNO Thorny skate when sets within closed areas are included (blue) and not included (red) in the indices.

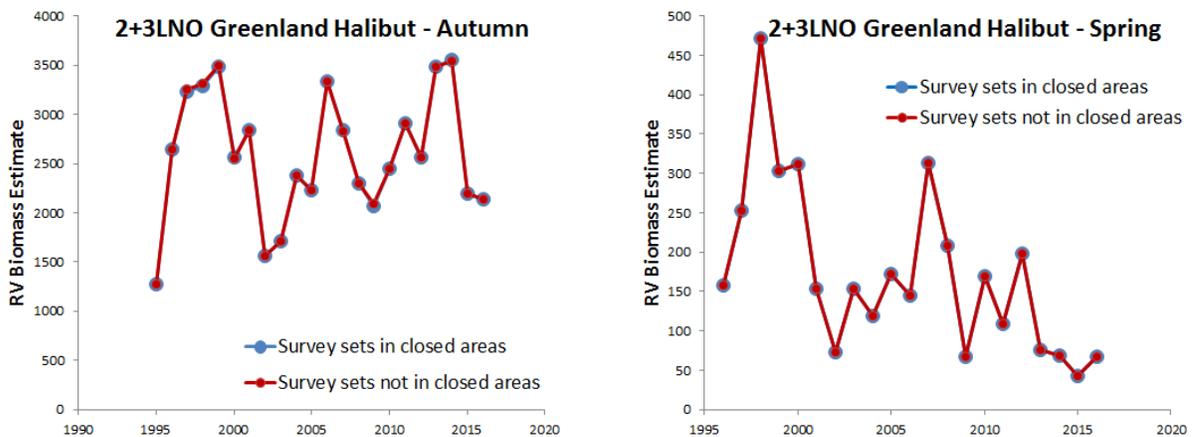


Fig. 8. Comparison of Canadian RV biomass indices for 2+3LNO Greenland halibut when sets within closed areas are included (blue) and not included (red) in the indices.

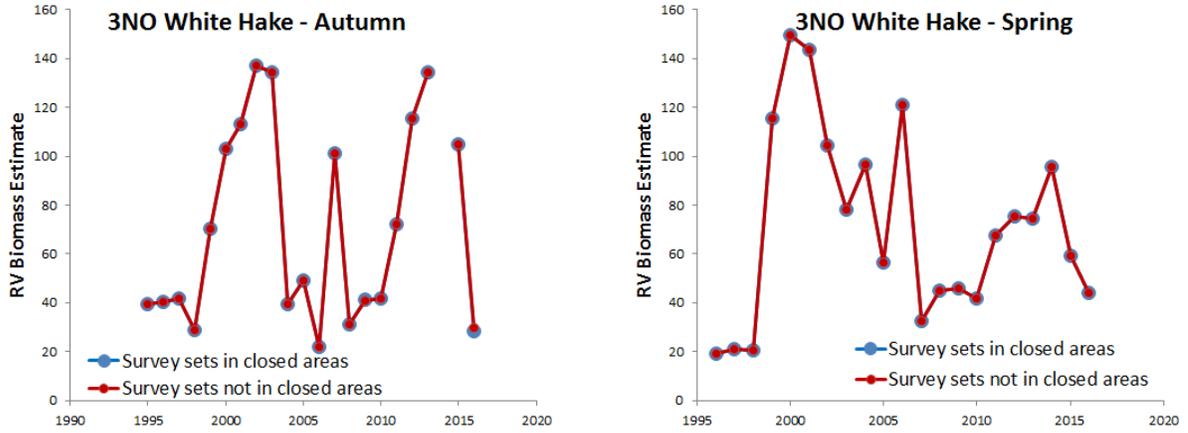


Fig. 9. Comparison of Canadian RV biomass indices for 3NO white hake when sets within closed areas are included (blue) and not included (red) in the indices.

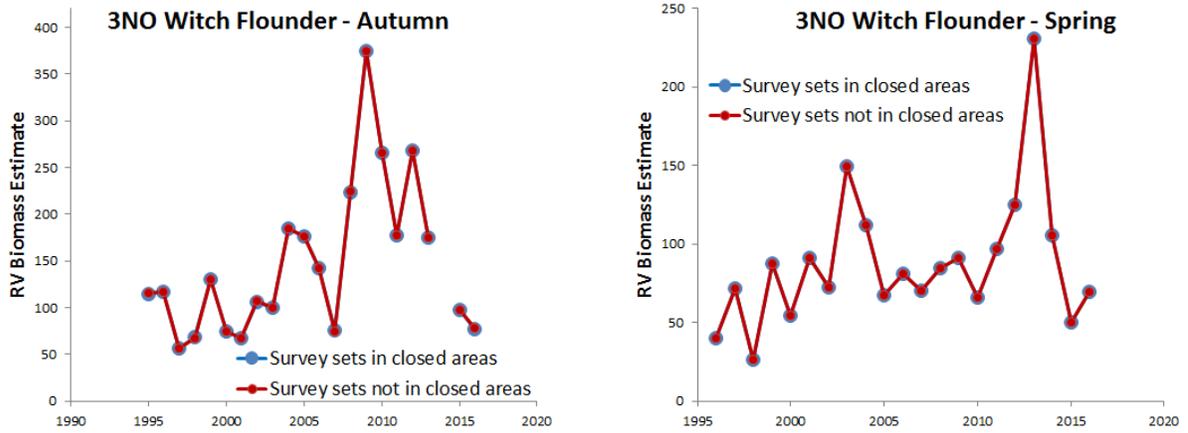


Fig. 10. Comparison of Canadian RV biomass indices for 3NO witch flounder when sets within closed areas are included (blue) and not included (red) in the indices.

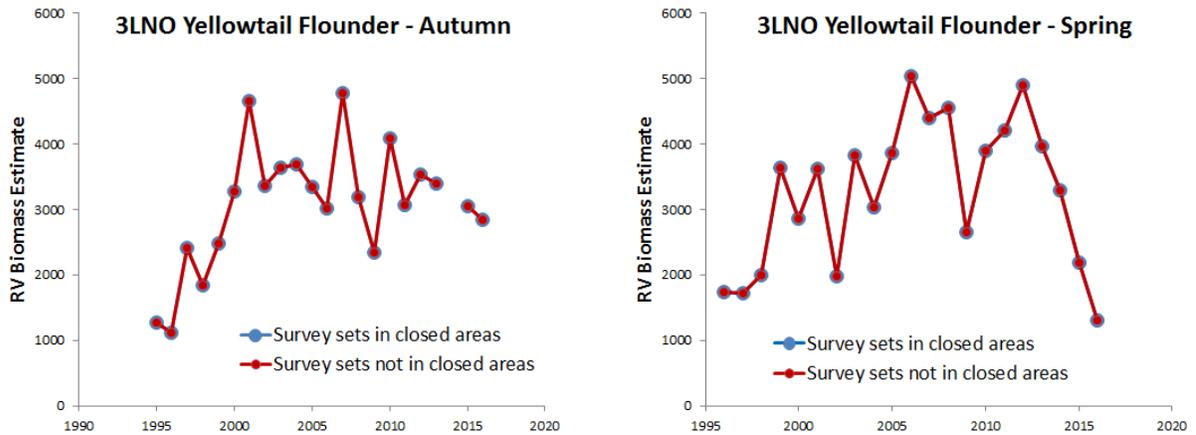


Fig. 11. Comparison of Canadian RV biomass indices for 3LNO yellowtail flounder when sets within closed areas are included (blue) and not included (red) in the indices.

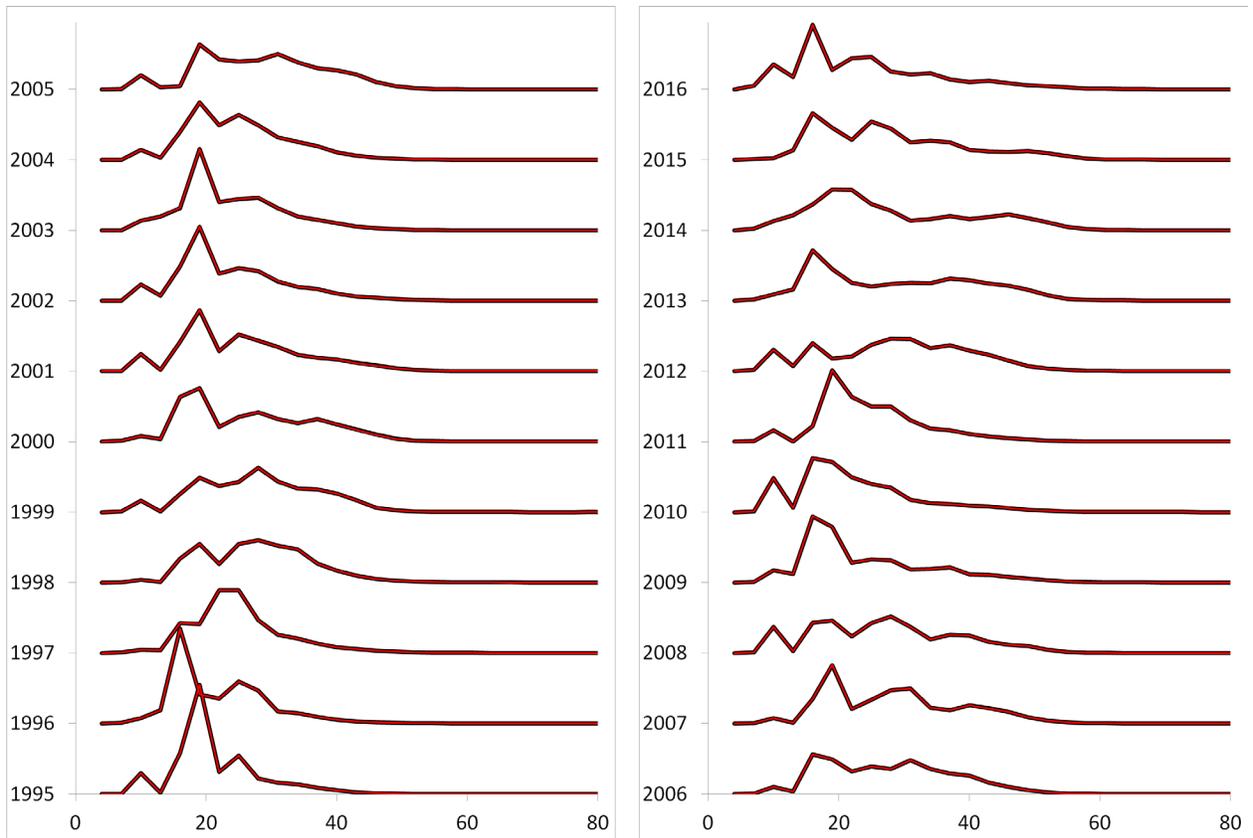


Fig. 12. Comparison of estimates of numbers at length (% of total) for Greenland halibut from Canadian Autumn RV surveys when sets within closed areas are included (black) and not included (red) in the estimates.

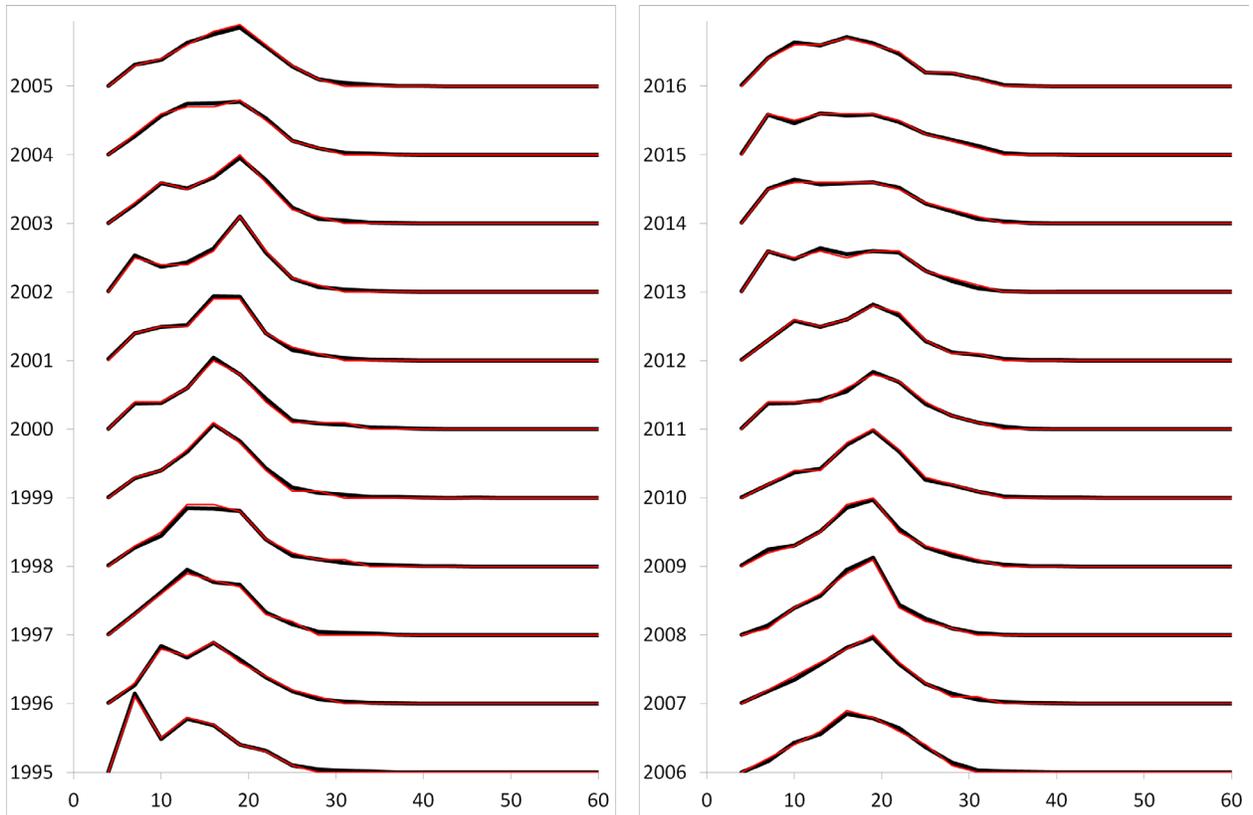


Fig. 13. Comparison of estimates of numbers at length (% of total) for roughhead grenadier from Canadian Autumn RV surveys when sets within closed areas are included (black) and not included (red) in the estimates.