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Data selection for 3LN redfish in preparation for an updated management strategy evaluation

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This document details the proposed data products for use in the development of Operating Models (OMs) for the update of the Management Strategy Evaluation (MSE) for the NAFO division 3LN redfish stock. The proposed data allow exploration of OMs that fit to the available length composition data, both aggregated and disaggregated by division, in addition to data more standard in surplus production models. Using a subset of strata to derive stratified estimates is considered for the Canadian surveys, although the impacts on stratified biomass estimates are negligible. We also propose two approaches to estimating commercial catch at length data, estimated back to 1975, and discuss the choice of weight at length data. These data inputs will provide a useful starting point to explore a range of OMs for 3LN redfish, including depth- and divisional-based models.

Background

The Commission has requested a review and update of the Management Strategy Evaluation (MSE) for the NAFO division 3LN redfish stock (**SCS, 2021**). As part of addressing the request, the ASPIC based MSE (**Dauphin et al., 2014**) was updated with data up to 2021 (**Varkey et al., 2022**). The scoping exercise noted that differences between treatment of data (choice of survey time-series and elimination of outliers) between Operating Models (OMs) had a large influence on the outputs derived from the OMs (**SCS, 2021**; **Varkey et al., 2022**). A full data review was recommended, and it was suggested that the new MSE could provide an opportunity to explore other model structures (**Varkey et al., 2022**).

To date, a thorough data review has been conducted (**Perreault et al., 2022**), and the next step is to finalize the data that will inform the MSE process. The most recent stock assessment model for 3LN redfish was rejected at the assessment in 2022 due to lack of fit suggested by model diagnostics, hypothesized to be driven by sporadic recruitment and temporal changes in the length composition of the stock (**Rogers et al., 2022**). Additionally, the data review found evidence that size at length from the commercial and survey data in 3L differed than the size at length from the commercial and survey data in 3N (**Perreault et al., 2022**). As such, it was considered of importance to consider OM formulations that include length composition data, both aggregated and dis-aggregated by division, in addition to standard surplus production models. We review the steps taken to select the final data for use in the MSE process below for both the available fishery dependent and independent data.

Fishery independent data

The data review identified six sources of fishery independent (FI) data for 3LN redfish (Table 1), however not all sources were considered for use in the MSE. The Canadian summer and winter research vessel (RV) surveys were discarded, since the sampling across both survey areas was inconsistent and covered a short time period (e.g., three years for the winter survey). Additionally, length composition data were not available for these older Canadian surveys. The Russian surveys were also not considered for use in the MSE due to a lack of availability of length composition data. Therefore, RV survey data from the Canadian fall and spring surveys, and the EU-Spain surveys in divisions 3L and 3N were included.

We consider two aspects when reviewing the RV data. First, we revisit the index strata used to calculate 3LN redfish stratified estimates, and second we consider how to include survey RV data that extend beyond the available converted data.

Survey index strata

Previous stock assessment models for 3LN redfish were fit to Canadian fall and spring survey estimates that only used a subset of the strata sampled in divisions 3L and 3N. It appears as though the motivation for using a subset of strata has not been recorded (and/or has been lost to time), however McKone (**1980**) noted that "length frequencies from Div. 3N cannot be interpreted as clearly because sampling in 1978 was disproportionately greater in the deeper depths (where longer redfish are expected) than in 1979", and Power and Baird (**1992**) stated that "stratified-random surveys conducted by Canada in div 3N have been of little value because they have traditionally only covered strata less than 367m", which indicates that the available strata were an important consideration for the 3LN redfish estimates even in the early years of the surveys.

Survey coverage remains an important consideration when sub-setting strata, since trends from strata that are poorly sampled over time may reflect changes due to missed strata and not changes in stock size. As such, we consider survey coverage when proposing new index strata (see **Perreault et al., 2022**, for details on survey coverage).

We note that the EU-Spain surveys have always included all strata when calculating stratified estimates and survey coverage has not been a major issue. Therefore, we do not suggest new strata for the EU-Spain surveys. For the Canadian fall and spring surveys, we consider using

1. *All*: all strata
2. *Used*: previously used index strata
3. *New*: new index strata (detailed below).

For the Canadian 3L and 3N fall and spring surveys, *Used* strata coincide with depths where redfish were regularly caught over time (middle panels Figs. 1-4; depths ~ 184-731m). Our proposed index strata (*New*) remove fewer strata, however in 3N and 3L we suggest removing the deep water strata that were poorly sampled (right panels; greater than 731m). Additionally in 3L we propose dropping a handful of stratum in the shallower waters since coverage was spotty over time (784-800).

Differences in mean weight per tow (mwpt) are apparent when comparing *New* and *Used* index strata (Fig. 5), noticeably in the earliest and most recent years of the surveys, although overall trends are similar. Changes in the scale of mwpt are not unexpected since stratum weights, i.e. N_h/N, (where N_h is area of stratum h divided by the area covered by a standard trawl, and N is the sum of all N_h) will be larger for a subset of strata, since the denominator N will be smaller but N_h will remain the same. However, when scaled up to biomass totals, the differences in stratified biomass estimates based on the three strata formulations are negligible (Fig. 6). This is unsurprising since the catch in the strata that were excluded were essentially zero (for each division and survey, the mean catch in strata <91m in all years represented less than 0.001% of the total mean catch in all years), and therefore had little impact when scaled up to population totals. Similarly, there were negligible differences in abundance at length estimates for all surveys and divisions, no matter the subset of index strata used (Figs. 7 & 8).

Data aggregations

Consistent converted survey data are available from 1991-2021 for the Canadian surveys and 1995-2021 for the EU-Spain surveys. Note that the converted data for the Canadian surveys do not span back to 1985 since the deeper waters were not covered prior to 1991 (e.g. Fig. 2). Redfish are slow-growing and long-lived, and an OM that only includes this converted data may not adequately capture population processes and subsequent responses to harvest rates. As such, we consider various approaches to incorporating older survey data. We consider three ways to aggregate the data (see Fig. 9 & Table 4 for detailed years covered):

1. *Historic*: using consistent converted data for recent years (i.e. 1991-2021 for Canadian surveys and 1995-2021 for EU-Spain surveys), and unconverted data to cover historic period.

2. *Depth*: same as the historic approach, but the data are split by depth (greater than or less than 550m). This depth was selected as it was considered a reasonable deep and shallow distinction for redfish (**Benestan et al., 2021**; **Power and Baird, 1992**), and stratified abundance at length estimates indicate some differences in the length compositions based on depth (Fig 10). Additionally, splitting by depth allows for a longer converted time series in the spring surveys, since the deep water coverage only began in 1991.

3. *Unconverted*: issues with the conversion factors at the largest and smallest sizes have been noted for redfish (**González-Troncoso et al., 2010**; **Warren, 1996**), so we also consider fitting OMs to the unconverted survey data.

An example plot of how the data are aggregated is given in figure Fig. 11 for the Canadian 3N spring survey. The panels show the time periods covered by the three suggested data aggregations, where each panel represent one of the three data aggregation scenarios and the color represents a separate survey index. Overall, splitting the data by depth (*Depth*) allows for the longest converted time series (Fig 9), although all data aggregations suggested incorporate data as far back as 1975 for the spring surveys and the mid-80's for the fall. Trends in stratified biomass estimates for the converted and unconverted data are similar (Fig 12), while the estimates for the depth aggregations are noisier, although less so for 3N than 3L.

Fishery dependent data

Commercial catch at length in each year and division are estimated from the commercial length frequencies (in 000's; Fig 13), commercial landings statistics (Fig 15) scaled up to the estimates (e.g., STATLANT, CESAG), and weight-length relationship estimates from the Portuguese commercial fishery (middle panel Fig 16). Detailed tables of all commercial data are found in Perreault et al. (**2022**). For each year, division, and country, commercial weights at length are calculated as the product of the Portuguese average weight at length and the commercial length frequencies. The total catch weight is the sum of the commercial weights at length. The catch multiplier that scales the length frequency samples up to the total catch are the total catch (for a country in year y and division d), divided by the total weight of the catch (for that country in year y and division d). In some cases, length frequencies are not available for a country, so we consider two approaches:

1. *Portuguese*: this approach is similar to the approach that was used historically (e.g. **Ávila de Melo et al., 2020**). When length frequencies are not available for a country, then the Portuguese length frequencies are applied.

2. *All*: when length frequencies are not available for a country, the length frequencies from all available countries are applied (i.e. the length frequencies from all available countries are summed and scaled to 000's, and the combined length frequencies are used to derive the catch weights, total catch and catch multiplier).

In some cases (e.g. year 2000) extra CESAG catches are not divided by division. We allocated the extra catches to each division in a year by using the proportion of the STATLANT catch in a division to the total STATLANT catch in divs 3LN in that year (i.e. 3L STATLANT catch / 3LN STATLANT catch). The code to estimate catch at length for both methods is freely available upon request.

Overall, the differences between the two approaches (*Portuguese* & *All*) are similar in 3L and in 3N (Fig 17), with some differences noted in the late 1980's. This is unsurprising since the Canadian and Portuguese length frequencies differed in these years (Fig 13) and the international proportion of the total catch was large (Fig 15).The differences between the two approaches are also provided for 3LN combined (Fig 18).

To compare to the approach previously used to estimate catch at length for 3LN redfish, we provide a comparison plot of the old approach (old, e.g., **Ávila de Melo et al., 2020**) and our Portuguese approach (Fig 19). Differences between the two approaches are quite substantial in the most recent years, however this is not surprising since our new approach (*New*) includes Canadian length frequencies from the commercial observer program that were not used in prior calculations of catch at length. In 3L in recent years, the Canadian catches contributed approximately 50% of the total catch, and therefore the addition of the Canadian length frequencies had a large impact of the shape of the commercial catch at length distribution. Using the length frequencies from the Canadian commercial fleets better represents the length composition of the Canadian catches.

Biological considerations

Weights at length

Estimates of average weight at length are available from the commercial Portuguese sampling for years 1990-2019, and the EU-Spain surveys from 2003-2019 in 3L and 1997-2021 in 3N (Fig 16), with the EU-Spain data also available disaggregated by sex. Differences across the data sources, whether commercial or from RV surveys, are negligible, and we expect little differences in OM output if one or the other is used.

Maturity data

Maturity at length data are available from two data sources: 1) collected for years 1972-1995 during the Canadian RV surveys in 3N and 3L when otolith samples were taken for age determination (AG data), and 2) collected for years 1996-2020 from set-by-set Canadian RV samples taken for length, sex and maturity during the fall and spring surveys in 3N and 3L (LSM data, see **Power, 2001** for details).

Previously, a logistic model with a logit link function and binomial error was fit to each data source, with data aggregated by year (**Power, 2001**). Initial data investigations have noted some strange patterns in the proportions of mature females which cannot be explained. It is currently unclear whether the unusually low proportions of mature fish at larger sizes in some years is related to errors in maturity classification, differences in maturation schedule between the two redfish species or some other, as of yet unknown, aspect of their reproductive biology. There has thus far been insufficient time to investigate the issue in detail, and there is no guarantee that the issue could be resolved without a future dedicated research project on redfish maturation. Therefore, due to the large uncertainties associated with the data, we do not yet finalize our choice of maturity inputs for the MSE. Future directions will be discussed and finalized as the MSE progresses.

Summary

In summary, we consider for divisions 3L and 3N (see Table 4 for detailed survey years covered):

- Landings (Kt; 1959-2022)
- Abundance at length and stratified biomass for *New* index strata
  - *Historic* Canadian Fall, Spring and EU-Spain
  - *Depth* Canadian Fall, Spring and EU-Spain (deep and shallow)
  - *Unconverted* Canadian Fall, Spring and EU-Spain
- Commercial catch at length
  - *All* (1975-2021)
- Weight at length
  - Portuguese commercial sampling (3LN; 1990-2019), EU-Spain RV 3L (pre-1997 =mean(1997-2021), 1997-2021) and 3N (pre-2003=mean(2003-2021), 2003-2019)

These data inputs will provide a useful starting point to explore a range of OMs for 3LN redfish, including depth- and divisional-based models.

Figures

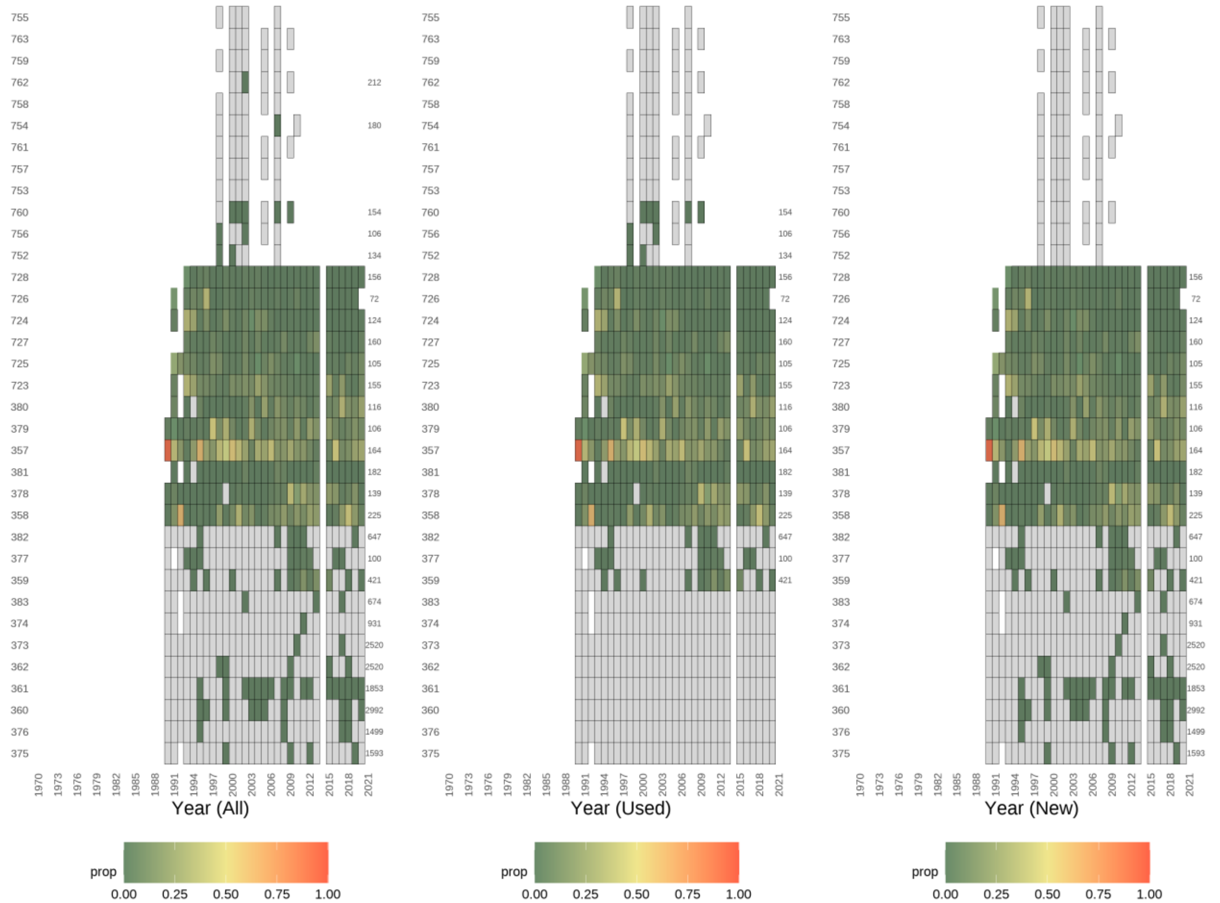

Figure 1. Proportion of the total mean catch (kg) in a year in a stratum with zeros filtered out for the Canadian fall 3N survey. Strata are organized by depth (from shallow at bottom to deep at top). The numbers on the right side of the panels are the area of the stratum (nm^2). If the number is present, that stratum is used in calculating the index strata. The left panel gives all strata (All), the middle panel is the historical index strata used ($Used$), and the right panel is the new suggested strata (New). The darker the green, the closer to zero the proportion. Grey boxes indicate that the strata/year was successfully sampled, and white means that the survey was not completed.

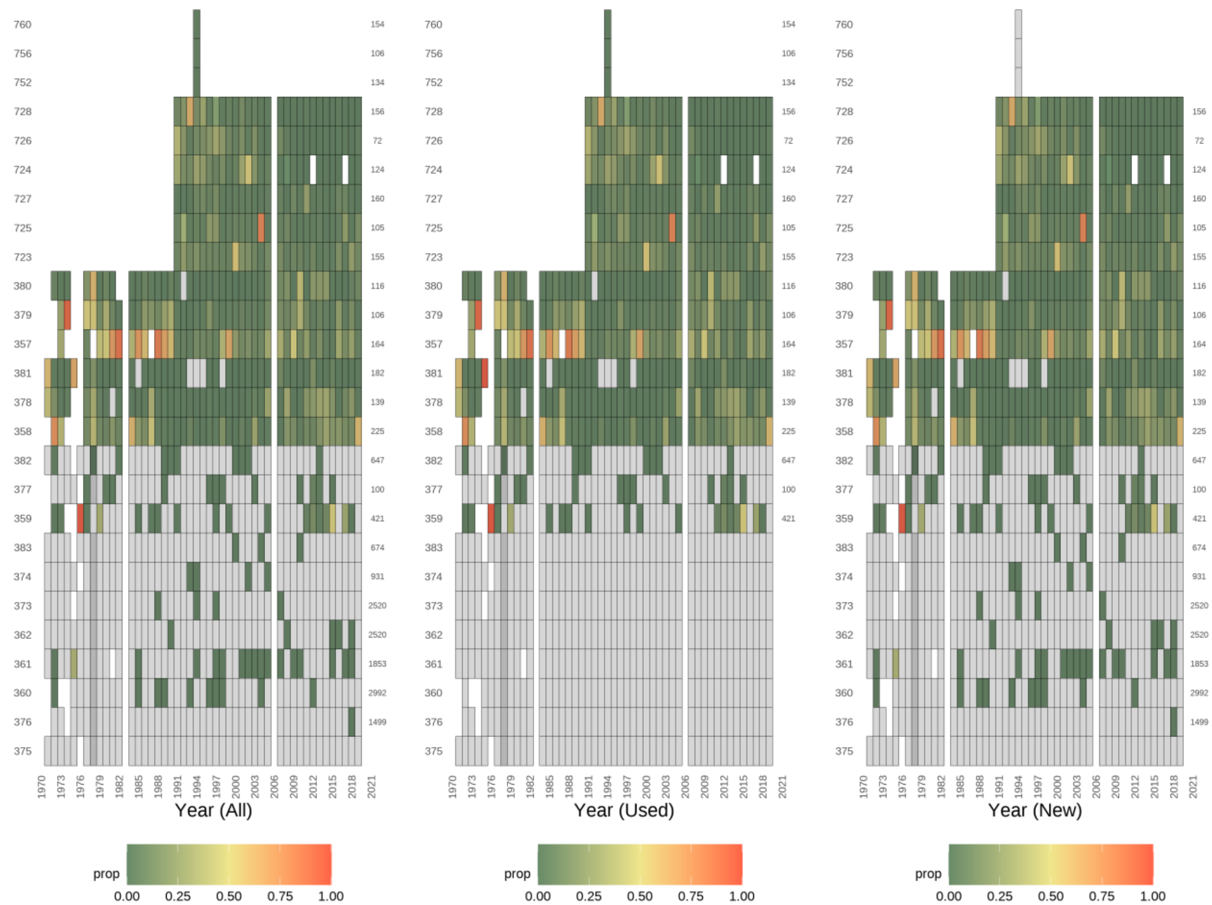

Figure 2. Proportion of the total mean catch (kg) in a year in a stratum with zeros filtered out for the Canadian spring 3N survey. Strata are organized by depth (from shallow at bottom to deep at top). The numbers on the right side of the panels are the area of the stratum (nm^2). If the number is present, that stratum is used in calculating the index strata. The left panel gives all strata (All), the middle panel is the historical index strata used ($Used$), and the right panel is the new suggested strata (New). The darker the green, the closer to zero the proportion. Grey boxes indicate that the strata/year was successfully sampled, and white means that the survey was not completed.

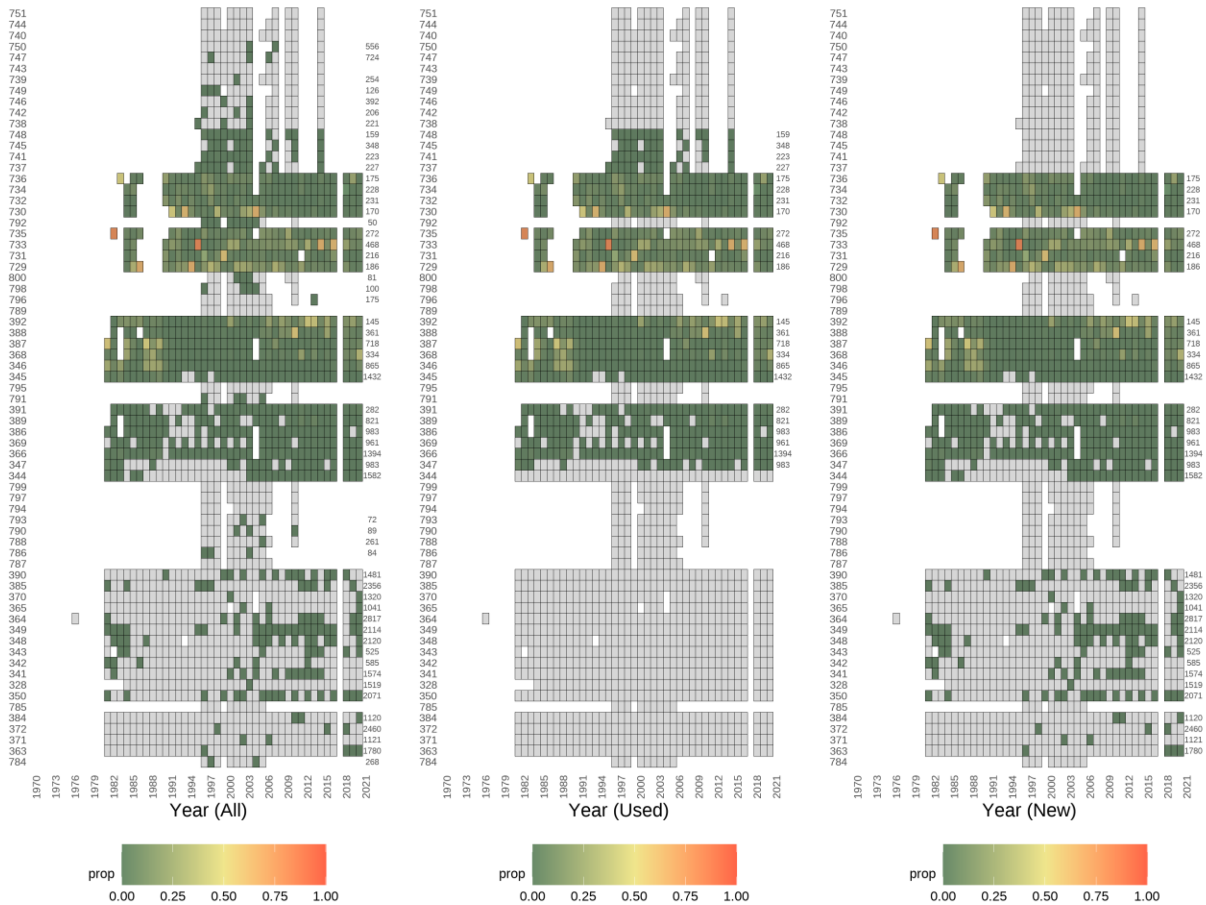

Figure 3. Proportion of the total mean catch (kg) in a year in a stratum with zeros filtered out for the Canadian fall 3L survey. Strata are organized by depth (from shallow at bottom to deep at top). The numbers on the right side of the panels are the area of the stratum (nm^2). If the number is present, that stratum is used in calculating the index strata. The left panel gives all strata (All), the middle panel is the historical index strata used ($Used$), and the right panel is the new suggested strata (New). The darker the green, the closer to zero the proportion. Grey boxes indicate that the strata/year was successfully sampled, and white means that the survey was not completed.

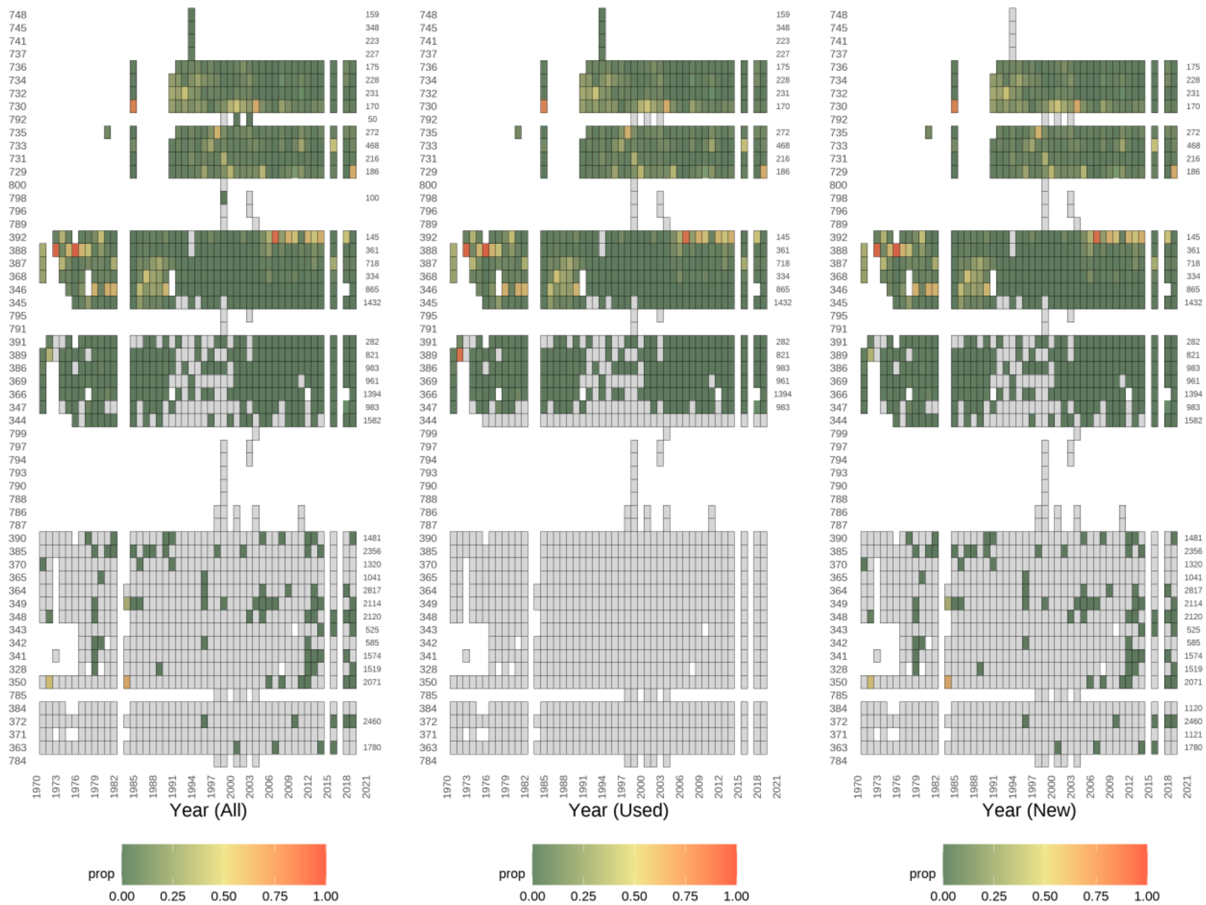

Figure 4. Proportion of the total mean catch (kg) in a year in a stratum with zeros filtered out for the Canadian spring 3L survey. Strata are organized by depth (from shallow at bottom to deep at top). The numbers on the right side of the panels are the area of the stratum (nm^2). If the number is present, that stratum is used in calculating the index strata. The left panel gives all strata (All), the middle panel is the historical index strata used ($Used$), and the right panel is the new suggested strata (New). The darker the green, the closer to zero the proportion. Grey boxes indicate that the strata/year was successfully sampled, and white means that the survey was not completed.

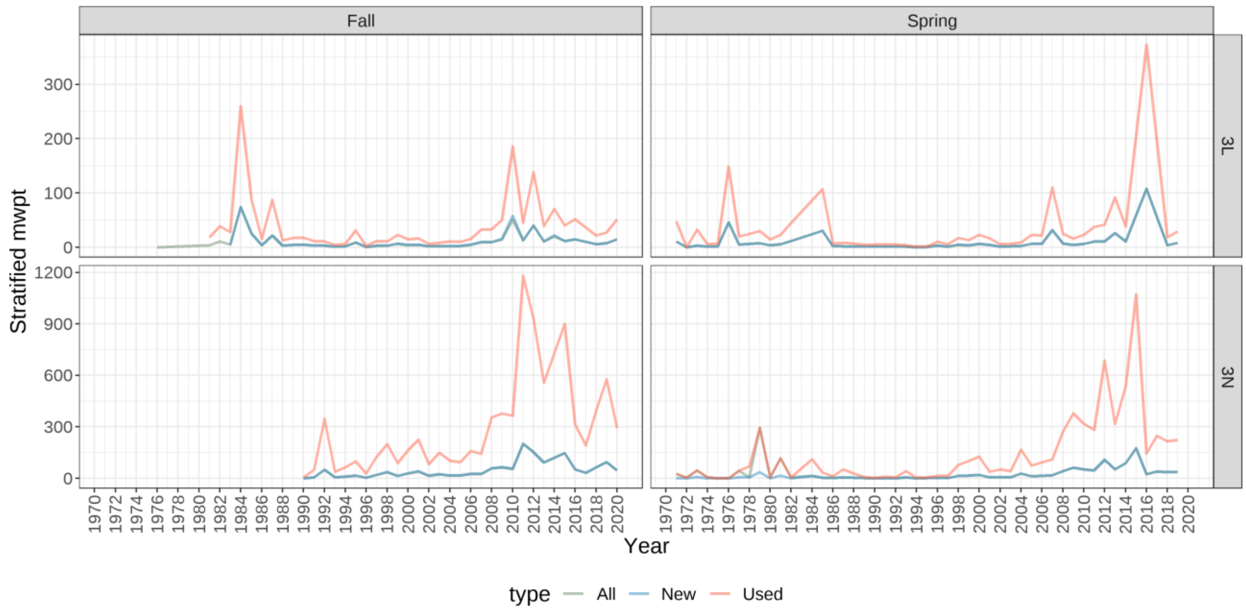

Figure 5. Stratified mwpt estimates for redfish using *All* (green), *Used* (red) and *New* (blue) index strata for 3L and 3N for the fall and spring RV surveys. Data are unconverted and plotted as a single time series to better compare trends, but should not be used to interpret trends over time

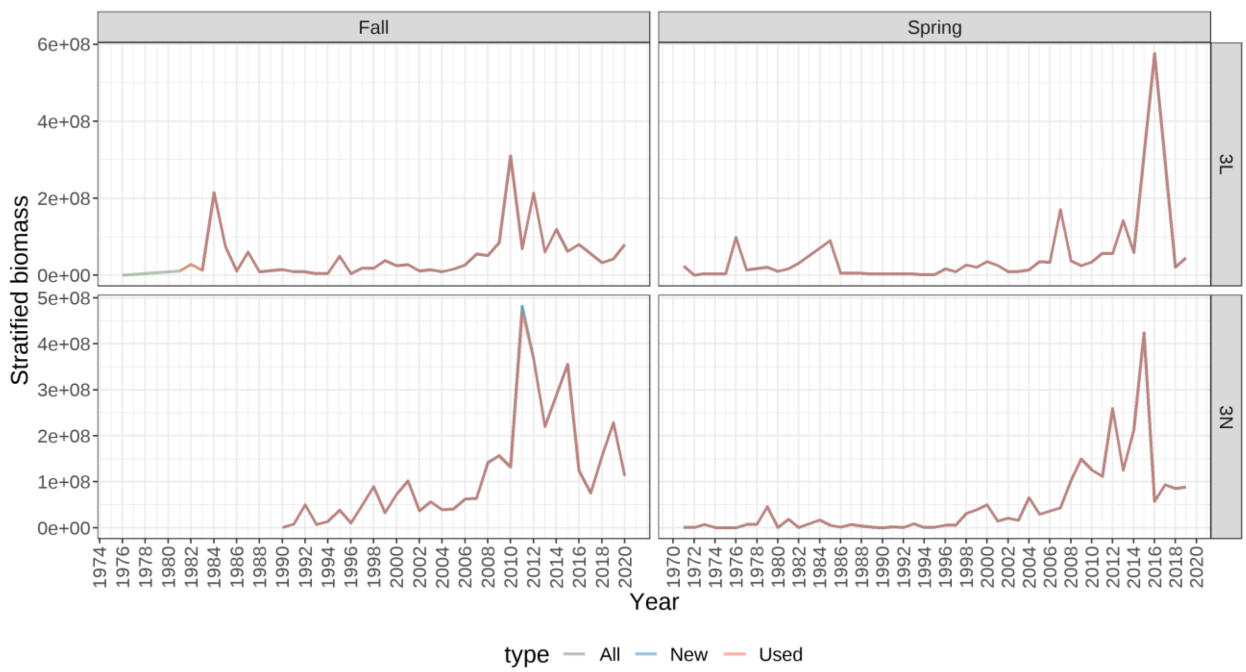

Figure 6. Stratified biomass estimates for redfish using *All* (green), *Used* (red) and *New* (blue) index strata for 3L and 3N for the fall and spring RV surveys. Data are unconverted and plotted as a single time series to better compare trends, but should not be used to interpret trends over time.

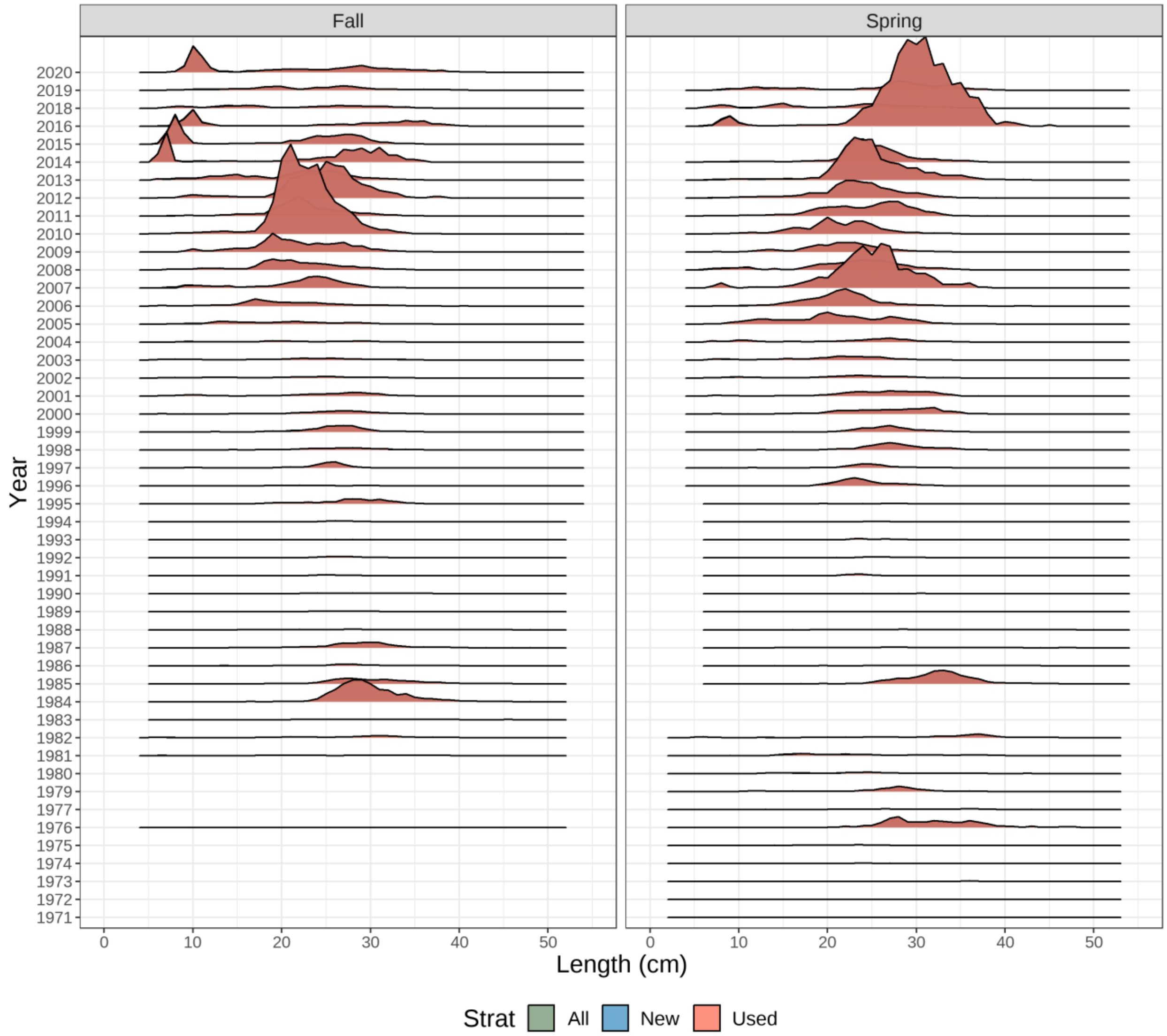

Figure 7. Stratified abundance at length estimates for redfish in div 3L for *All* (green), *Used* (red) and *New* (blue) index strata for 3L and 3N for the fall and spring RV surveys. Data are unconverted and plotted as a single time series to better compare trends, but should not be used to interpret trends over time.

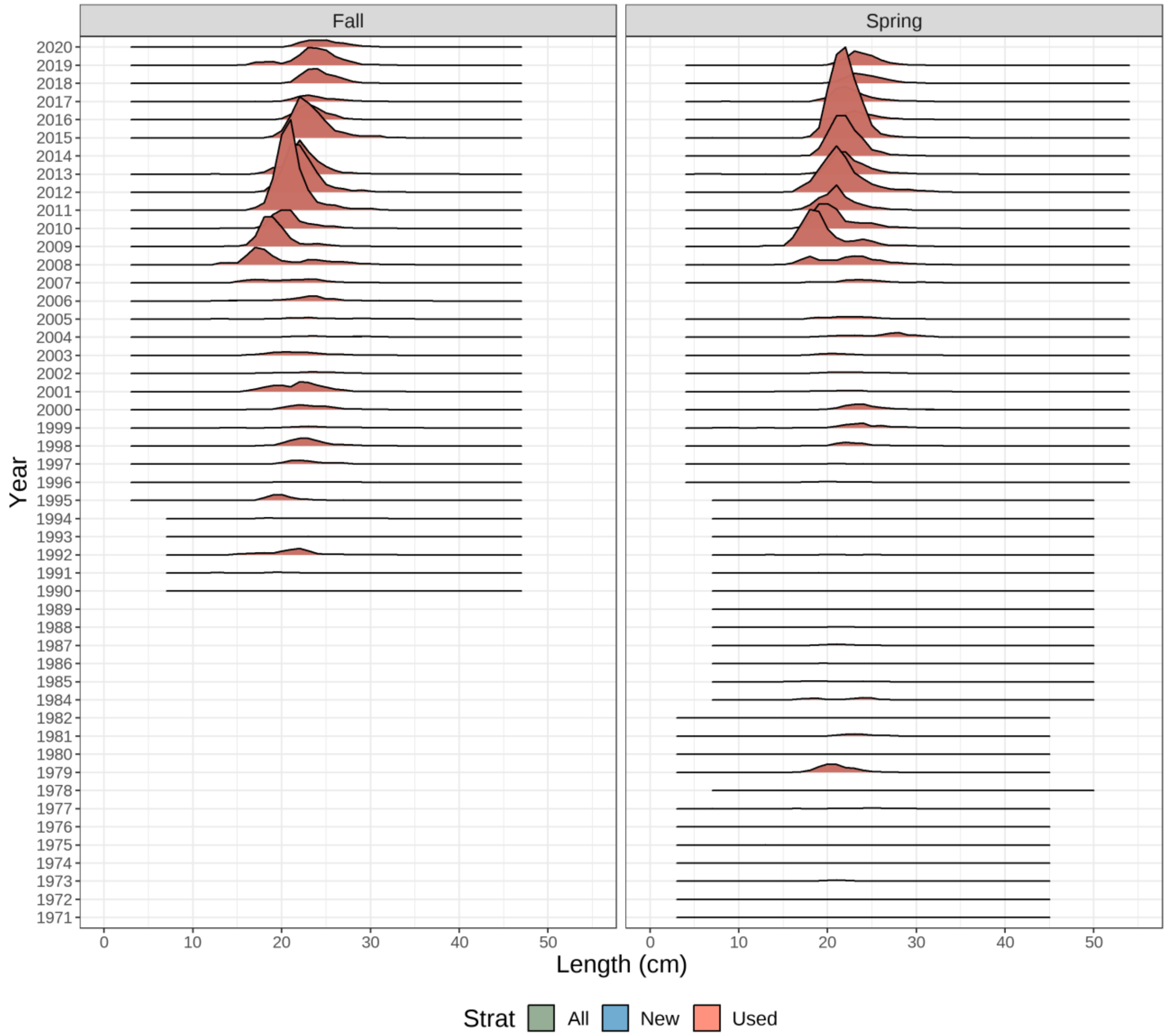

Figure 8. Stratified abundance at length estimates for redfish in div 3N for *All* (green), *Used* (red) and *New* (blue) index strata for 3L and 3N for the fall and spring RV surveys. Data are unconverted and plotted as a single time series to better compare trends, but should not be used to interpret trends over time.

Figure 9. Data aggregations considered for the 3LN redfish MSE. The color of the line represents a separate gear type and will be considered a separate index for modeling purposes.

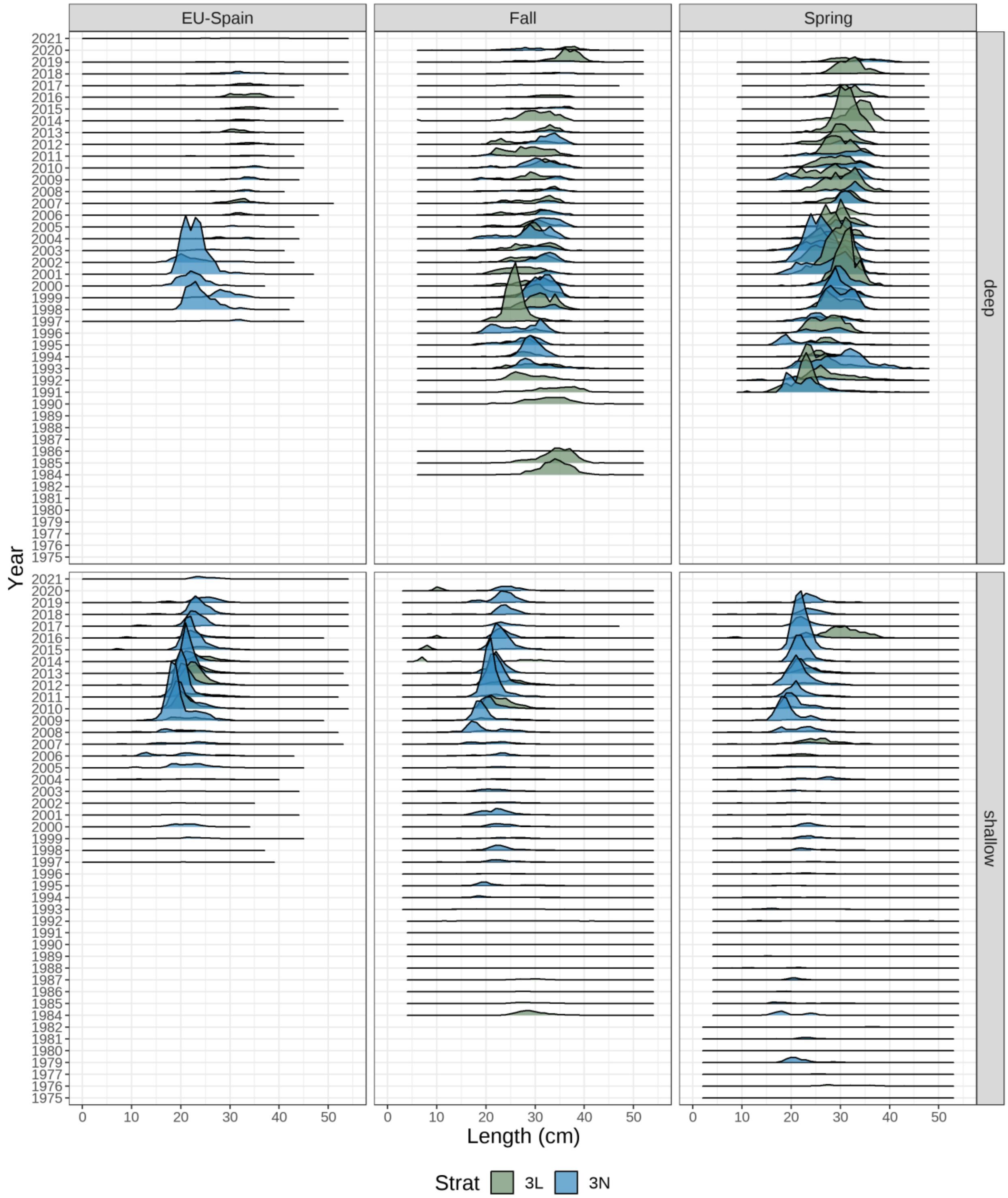

Figure 10. Stratified abundance at length estimates for redfish by depth for deep (≥550m; top) and shallow (<550m; bottom) for 3L (green) and 3N (blue) for the fall, spring and EU-Spain RV surveys. Data are unconverted and plotted as a single time series to better compare trends in strata used, but should not be used to interpret trends over time.

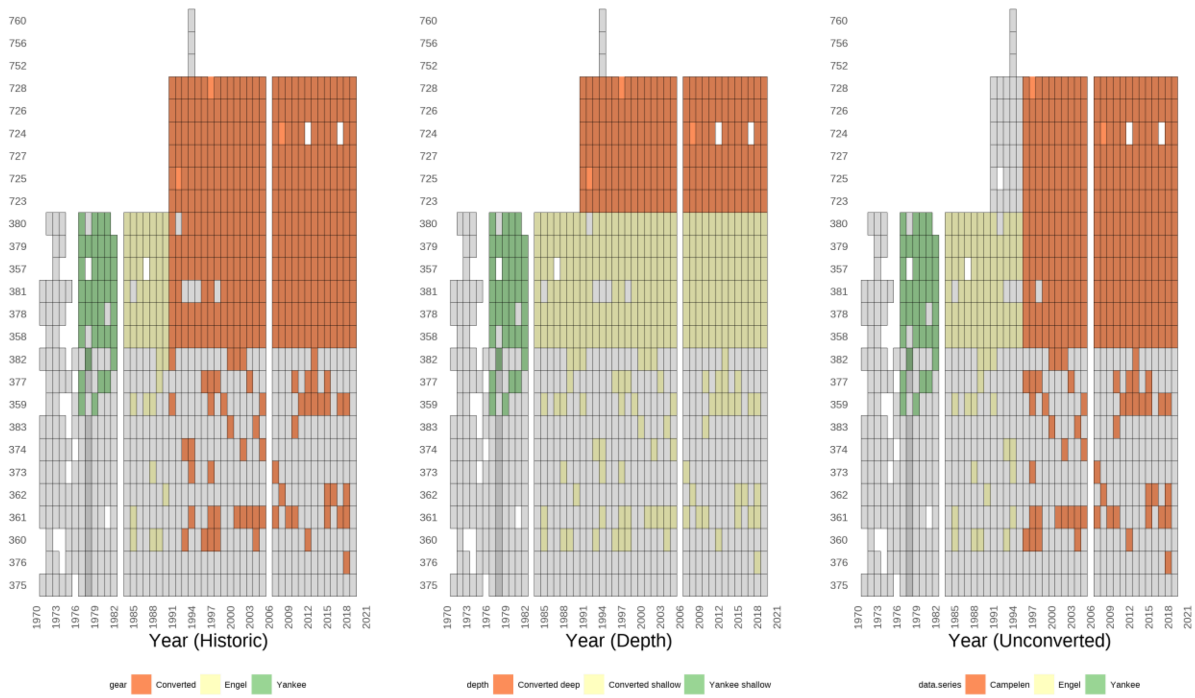

Figure 11. Example of data aggregations considered for the 3LN redfish MSE. The color of the boxes represents a separate time series for the *Historic* (left), *Depth* (middle) and *Unconverted* (right) data aggregations.

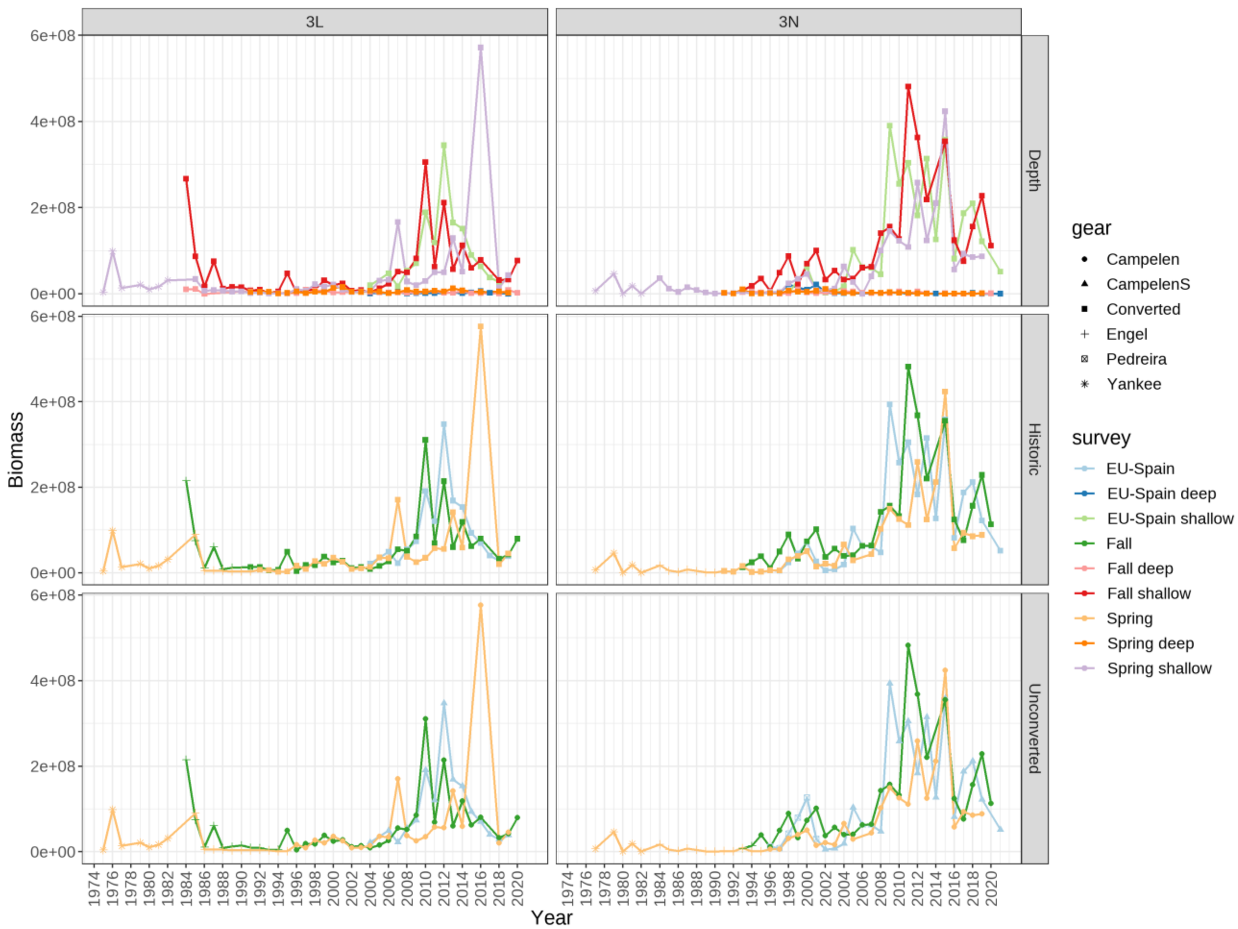

Figure 12. Stratified biomass estimates for 3LN redfish for the various data aggregations. Data are unconverted and plotted as a single time series to better compare trends in strata used, but should not be used to interpret trends over time.

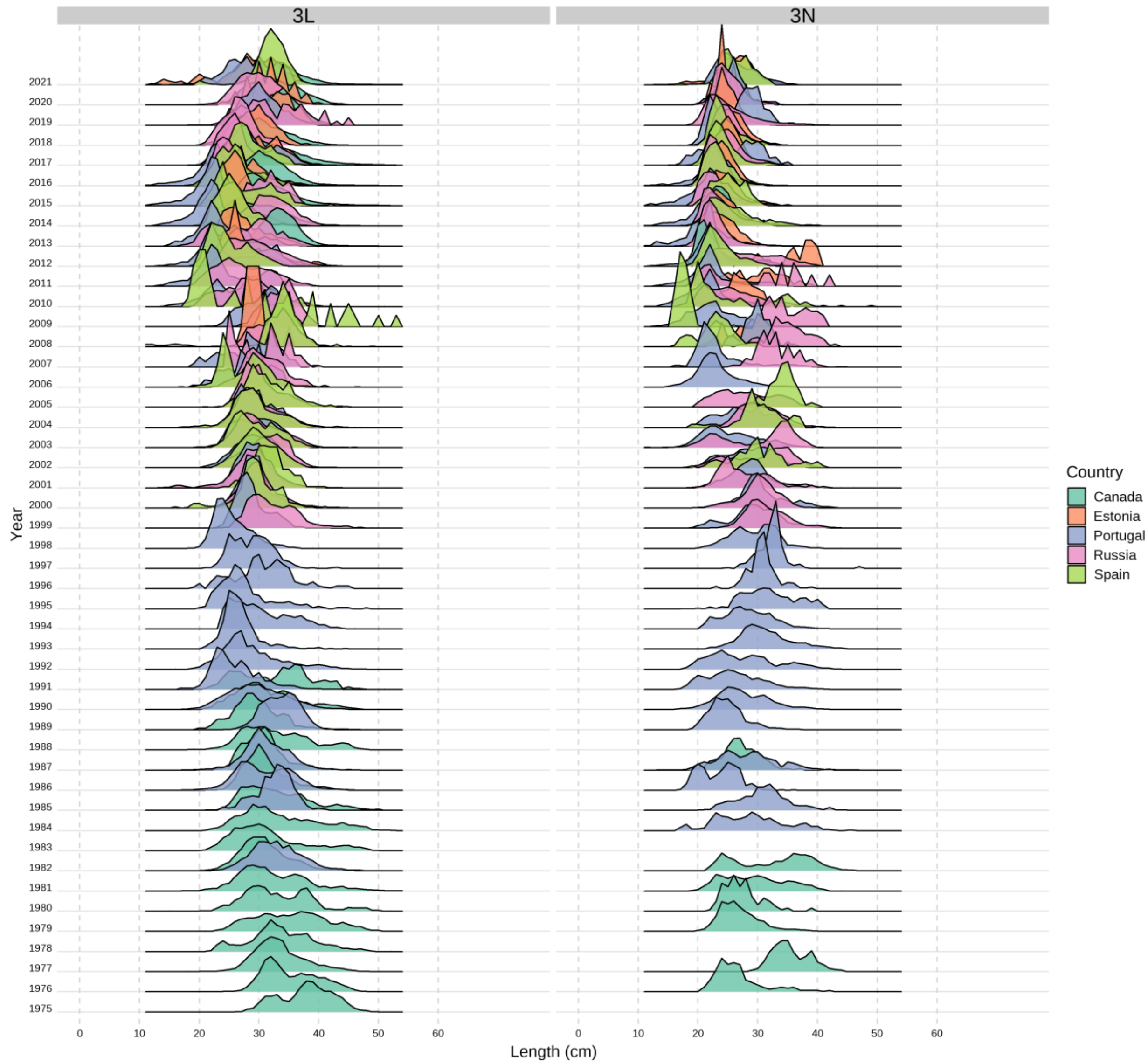

Figure 13. Length frequencies (000's) for redfish from the commercial sampling for div 3L and 3N (10cm<length<55cm) for available countries.

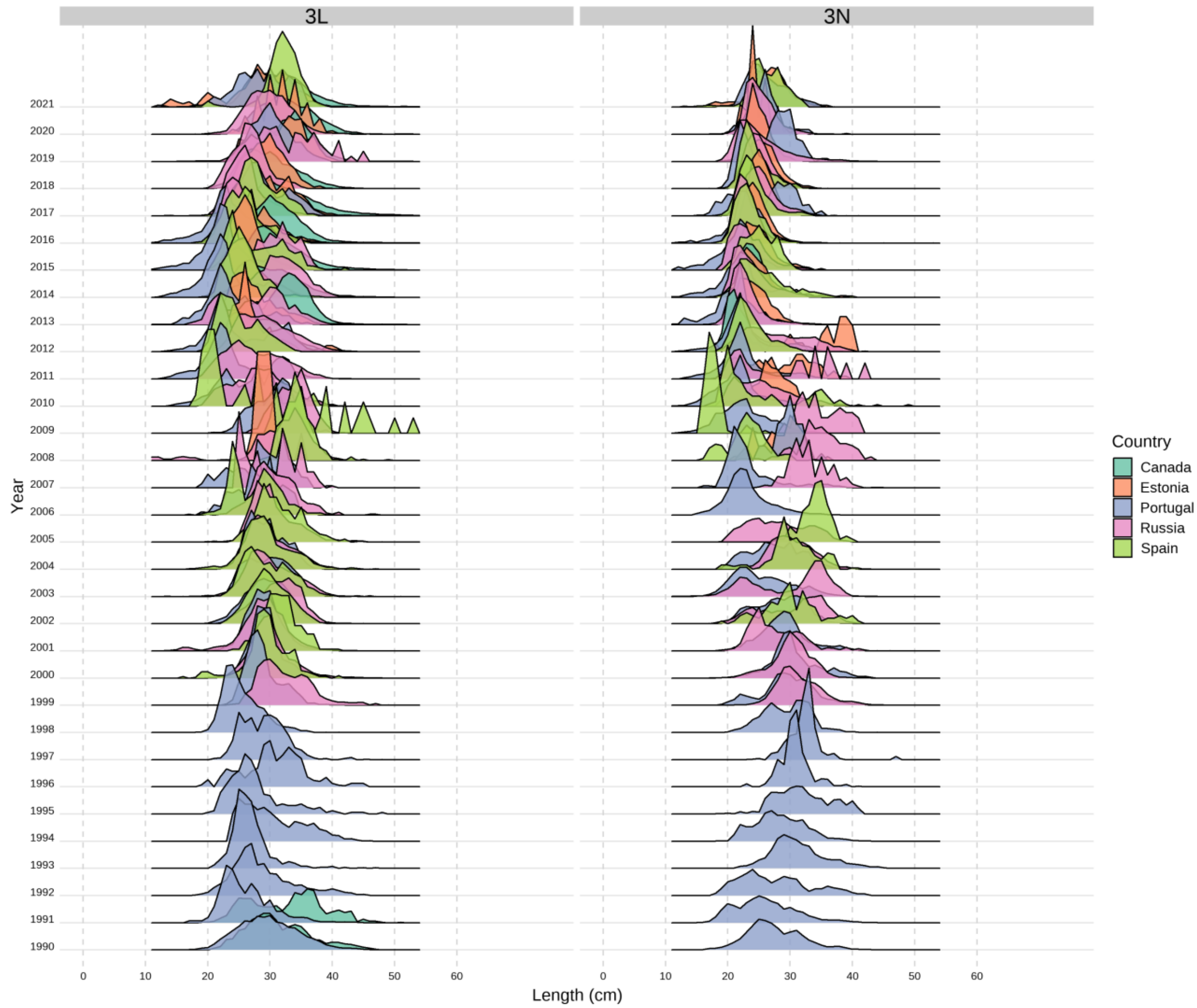

Figure 14. Length frequencies (000's) for redfish from the commercial sampling for div 3L and 3N (10cm<length<55cm) for available countries for years 1990-2021.

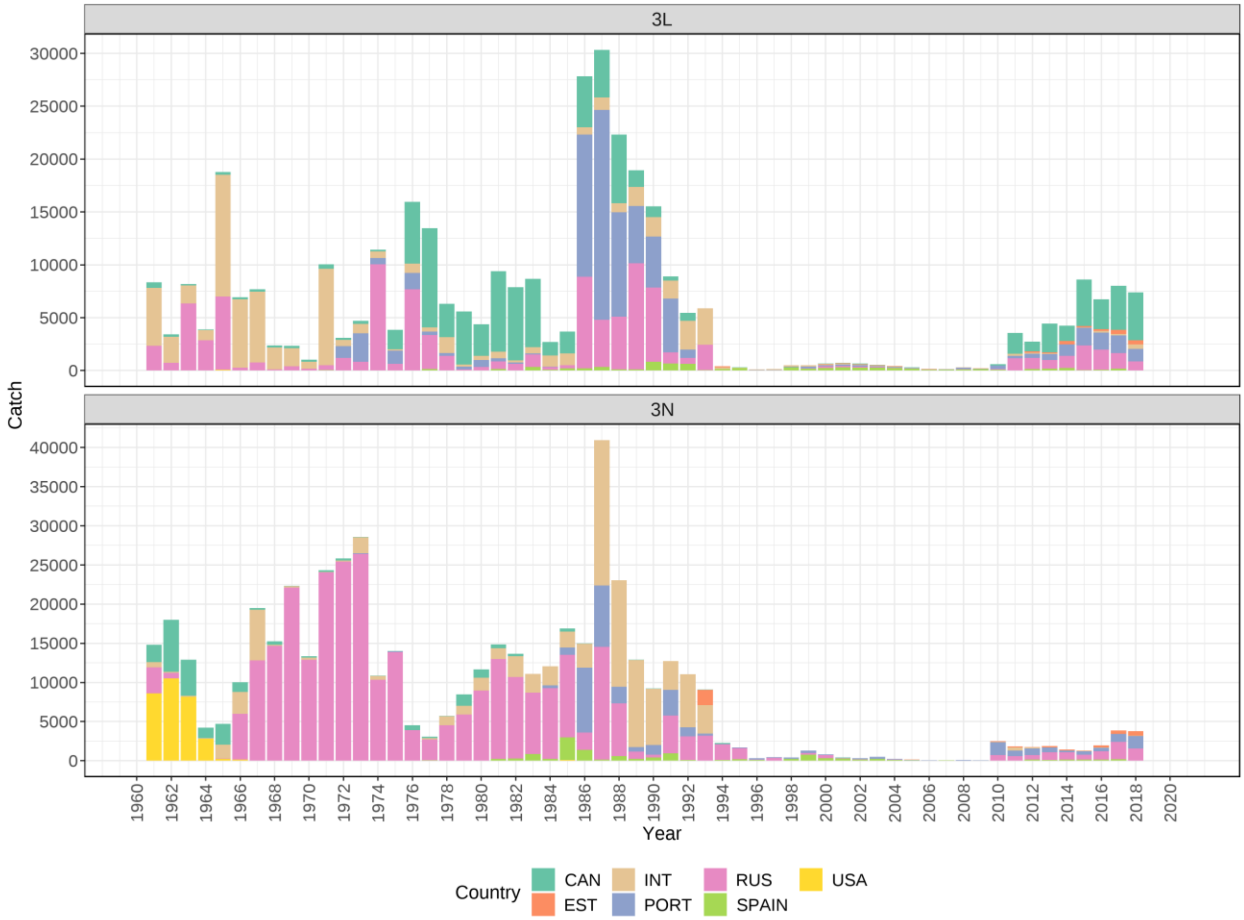

Figure 15. STATLANT commercial catches by country (with available length sampling) for 3L and 3N.

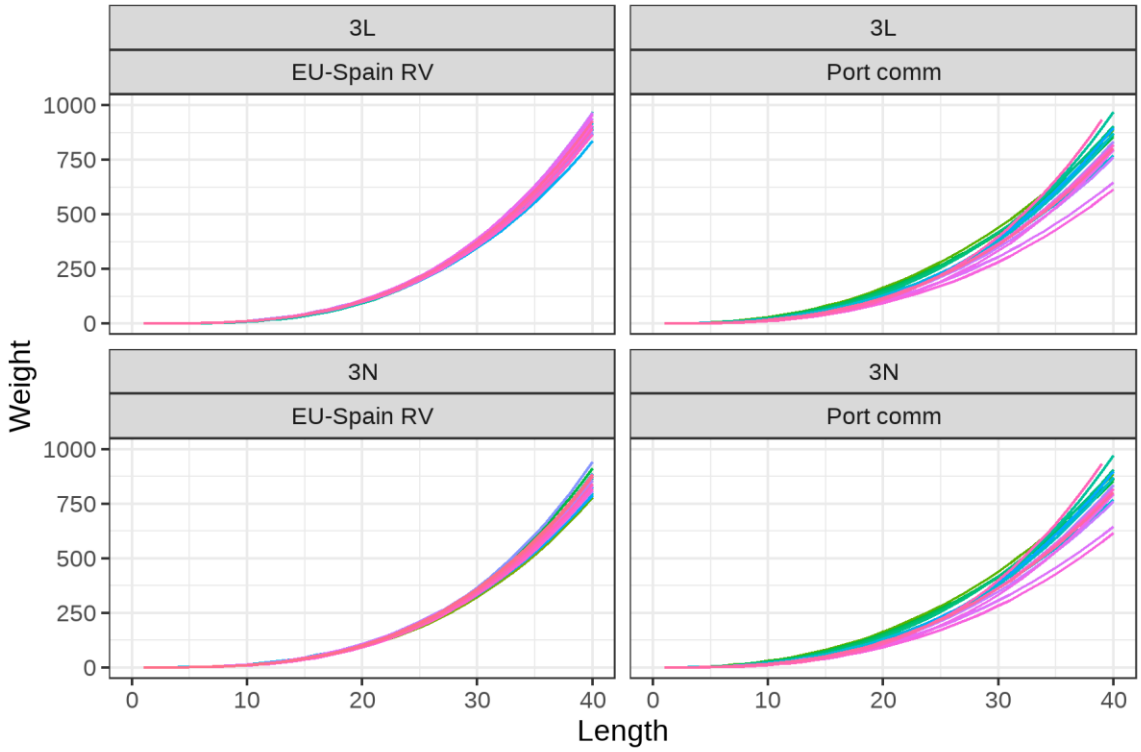

Figure 16. Average weight at length estimates from the EU-Spain RV surveys (left) and the Portuguese (right) commercial sampling.

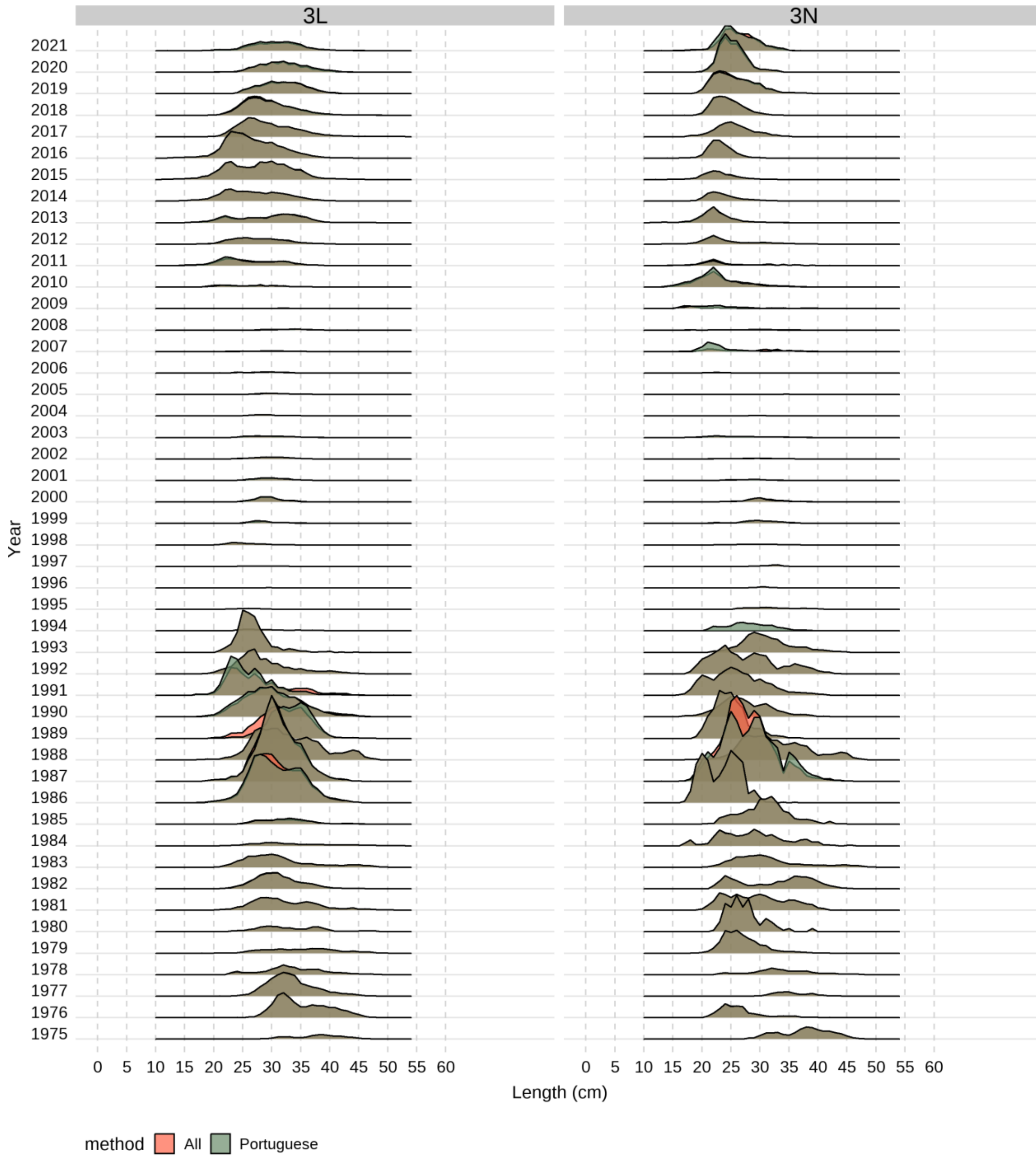

Figure17. Catch at length estimates for 3L and 3N for the *Portuguese* (green) and *All* (pink) approaches.

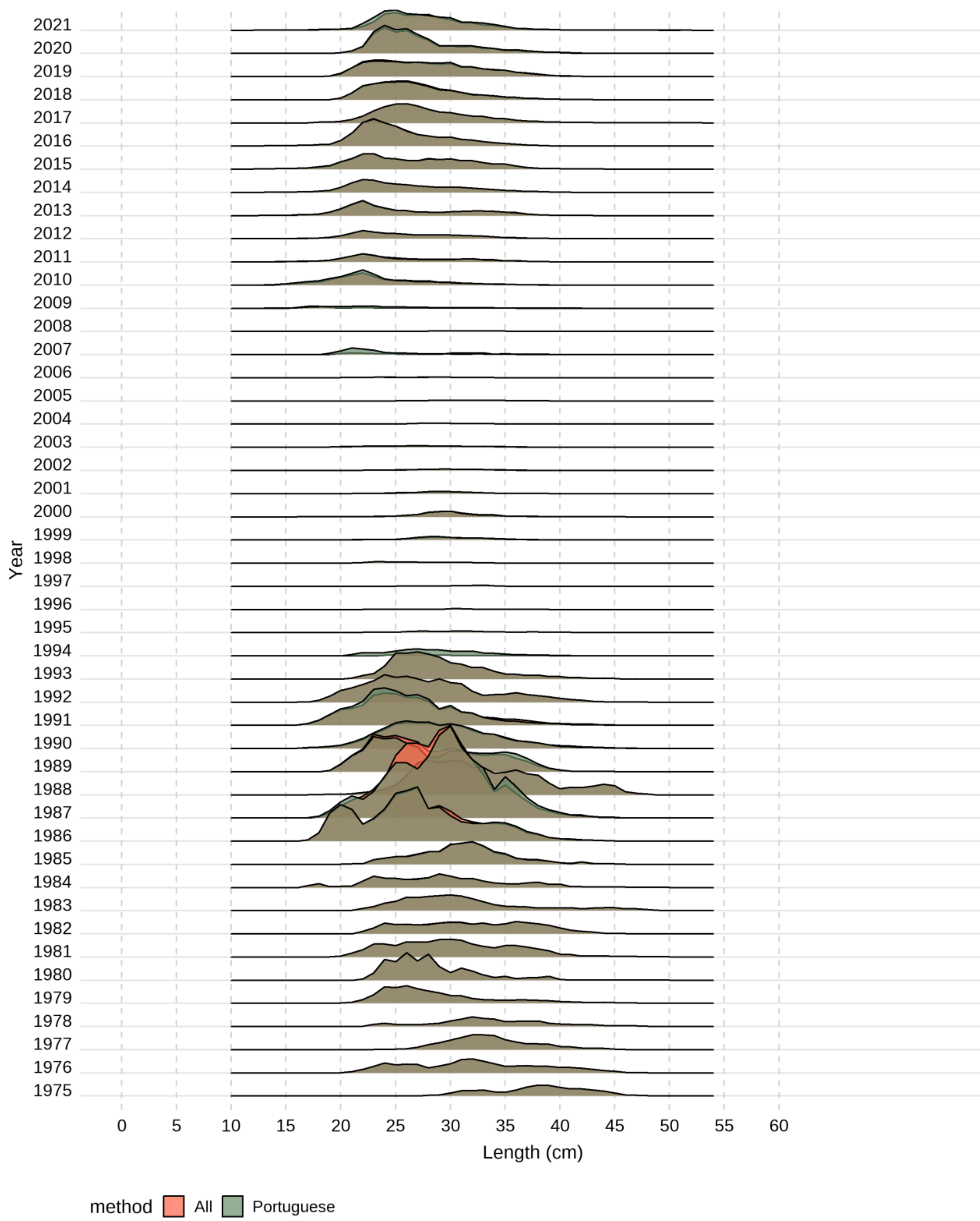

Figure 18. Catch at length estimates for div 3LN for the *Portuguese* (green) and *All* (pink) approaches

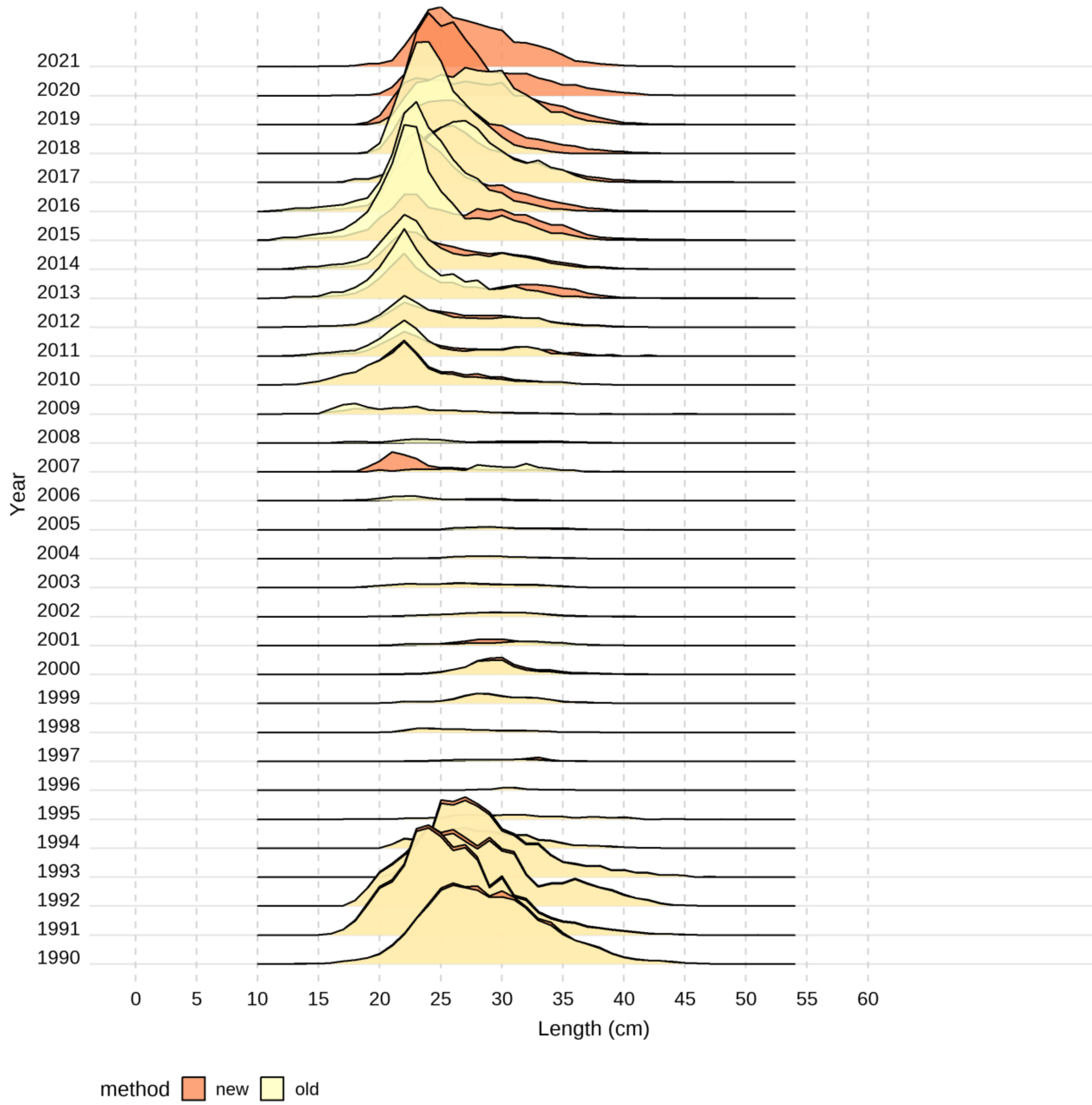

Figure 19. Comparison of catch at length estimates for 3LN from the historic (yellow) and Portuguese (pink) approaches. The old approach was not applied to 2020-2021 data.

TABLES

Table 1. Overview of available fishery independent (FI) data for 3LN redfish

Data	Type	Name	Years	Summary
FI	RV survey	EU-Spain Groundfish	1995-2021	Yearly stratified random survey targeting groundfish outside the 200nm limit. Fairly consistent spatial sampling after 2005. One major gear change in 3N.
FI	RV survey	Canadian Fall Groundfish	1976-2021	Yearly stratified random survey targeting groundfish. Two major gear changes. One strata sampled in 1976. Except for deep strata and inshore strata, fairly consistent spatial sampling after 1985 in 3L and 1993 in 3N.
FI	RV survey	Canadian Spring Groundfish	1971-2021	Yearly stratified random survey targeting groundfish. Two major gear changes. Fairly consistent spatial sampling after 1985 in 3L and 1991 in 3N, although some issues in recent years in 3L.
FI	RV survey	Canadian Summer	1978-1979, 1981, 1984-1985, 1990-1991, 1993	Sporadic stratified random survey. Within-stratum coverage inconsistent. Engel 164 trawl in 1978, Engel 145 all other years.
FI	RV survey	Canadian Winter	1985-1986, 1990	Sporadic stratified random survey. Within-stratum coverage inconsistent. Only three years sampled.
FI	RV survey	Russian Groundfish	1972-1982	Fixed station surveys. Spatial coverage spotty over time. No notes on whether a change in area covered occurred after the establishment of the 200nm limit.
FI	RV survey	Russian Groundfish	1984-1994	Yearly stratified random survey. Targeting 3 sets per stratum, regardless of stratum area. In 1985, 1991-1994, a smaller vessel was used. Coverage issues from 1991 onward.

Table 2. Estimates of mean weight per tow (mwpt) for 3L and 3N redfish from the Canadian fall and spring survey using All, Used, and New index strata

Year	3L Fall Used	3L Fall New	3L Fall All	3L Spring Used	3L Spring New	3L Spring All	3N Fall Used	3N Fall New	3N Fall All	3N Spring Used	3N Spring New	3N Spring All
1971				48.1	11.2	11.2				25.7	2.2	25.7
1972				0.4	0.1	0.1				4.5	0.5	4.5
1973				32.6	3.6	3.6				45.8	7.0	45.8
1974				6.0	1.4	1.4				5.1	0.6	5.1
1975				7.1	2.0	2.0				0.0	0.0	0.0
1976			0.0	148.4	46.2	46.2				0.2	0.0	0.2
1977				19.6	4.9	4.9				45.2	5.7	45.2
1978										70.5	6.6	6.6
1979				30.2	7.7	7.7				294.4	37.0	294.4
1980				15.0	4.0	4.0				5.3	0.7	5.3
1981	18.5		4.3	23.2	6.2	6.2				117.2	16.6	117.2
1982	39.3		10.8	44.8	11.4	11.4				5.9	0.7	5.9
1983	28.4	5.5	5.5									
1984	259.3	74.3	74.3							111.6	14.1	14.1
1985	88.8	25.7	25.7	107.0	31.0	31.0				33.9	4.3	4.3
1986	15.4	4.0	4.0	7.2	1.8	1.8				12.6	1.6	1.6
1987	87.2	22.0	22.0	8.3	2.1	2.1				52.2	6.1	6.1
1988	13.0	3.3	3.3	6.9	1.7	1.7				27.7	3.5	3.5
1989	17.6	4.4	4.4	4.9	1.2	1.2				8.8	1.1	1.1
1990	18.3	5.2	5.2	5.4	1.4	1.4	5.0	0.6	0.6	1.5	0.2	0.2
1991	11.4	3.3	3.3	5.5	1.3	1.3	49.5	6.4	6.4	9.6	1.6	1.6
1992	10.7	3.1	3.1	5.4	1.6	1.6	347.9	49.9	49.9	5.2	0.8	0.8
1993	4.9	1.5	1.5	3.8	1.1	1.1	37.9	6.0	6.0	41.5	6.8	6.8
1994	6.5	1.9	1.9	1.4	0.4	0.4	64.5	10.6	10.6	3.5	0.6	0.7
1995	31.6	9.3	9.3	2.1	0.6	0.6	98.1	16.1	16.1	5.8	0.9	0.9
1996	2.7	0.8	0.7	10.6	3.1	3.1	27.5	4.5	4.5	14.8	2.4	2.4
1997	11.3	3.5	3.0	5.8	1.7	1.7	125.8	20.7	20.7	14.9	2.4	2.4
1998	10.9	3.4	2.9	17.6	5.1	4.9	199.5	37.3	34.2	79.4	13.1	13.1
1999	22.8	7.1	6.5	13.4	3.9	3.6	88.2	13.8	13.8	100.3	16.5	16.5
2000	14.7	4.8	4.0	23.1	6.7	6.7	163.4	30.6	27.3	127.6	21.0	21.0
2001	16.8	5.2	4.4	16.6	4.8	4.6	226.7	42.4	37.9	37.6	6.2	6.2
2002	6.8	2.1	1.8	5.7	1.7	1.6	82.9	15.5	13.9	52.8	8.8	8.8
2003	8.7	2.6	2.3	6.5	1.9	1.9	149.7	23.8	23.8	41.7	6.9	6.9
2004	10.7	2.1	1.9	8.8	2.5	2.4	103.5	16.6	16.6	167.4	27.6	27.6
2005	10.2	3.0	2.7	23.3	6.7	6.7	94.8	17.0	15.9	74.7	12.3	12.3
2006	15.7	4.9	4.4	21.9	6.3	6.3	159.1	26.2	26.2			
2007	32.8	10.3	9.3	110.5	31.9	31.9	142.5	26.7	23.9	110.5	18.2	18.2
2008	33.6	9.7	9.7	24.8	7.4	7.4	354.6	59.4	59.4	271.8	43.1	43.1
2009	50.8	15.9	14.3	16.3	4.7	4.7	377.7	65.5	62.7	378.6	62.3	62.3
2010	185.4	58.2	50.4	23.1	6.7	6.7	366.0	55.9	55.3	318.4	52.4	52.4
2011	45.6	13.1	13.1	38.0	10.8	10.6	1,181.9	200.8	200.8	282.4	46.5	46.5
2012	138.7	40.1	40.1	41.4	10.9	10.9	930.5	153.4	153.4	685.5	108.7	108.7
2013	38.9	11.3	11.2	91.9	26.6	26.6	557.0	91.8	91.8	315.9	52.0	52.0
2014	71.0	22.3	20.0	38.2	11.1	11.1				536.8	88.3	88.3
2015	40.4	11.7	11.7				899.7	148.1	148.1	1,072.7	176.5	176.5
2016	51.9	15.0	15.0	373.1	107.9	107.9	315.1	51.8	51.8	145.4	23.9	23.9
2017							192.4	31.7	31.7	247.5	39.2	39.2
2018	21.5	6.2	6.2	18.6	4.2	4.2	396.5	65.3	65.3	216.1	35.6	35.6
2019	27.5	8.0	8.0	29.4	8.5	8.5	578.3	95.3	95.3	224.1	36.9	36.9
2020	51.5	14.9	14.9				293.5	47.3	47.3			

Table 3. Estimates of stratified biomass (000'S) for 3L and 3N redfish from the Canadian fall and spring survey using All, Used, and New index strata.

Year	3L Fall Used	3L Fall New	3L Fall All	3L Spring Used	3L Spring New	3L Spring All	3N Fall Used	3N Fall New	3N Fall All	3N Spring Used	3N Spring New	3N Spring All
1971				23666	23756	23756				1869	1869	1869
1972				37	168	168				621	640	621
1973				3940	3940	3940				7215	7215	7215
1974				3124	3124	3124				495	495	495
1975				4175	4175	4175				1	4	1
1976			0	98603	98623	98623				14	14	14
1977				13644	13644	13644				7125	7125	7125
1978										7990	7990	7990
1979				21052	21313	21313				46400	46400	46400
1980				10426	10540	10540				833	833	833
1981	10630		10790	16665	16841	16841				18479	18479	18479
1982	28156		28306	31218	31423	31423				877	877	877
1983	13310	13319	13319									
1984	215115	215135	215135							17595	17595	17595
1985	74828	74832	74832	90176	90186	90186				5348	5427	5427
1986	11045	11054	11054	4990	5015	5015				1985	1985	1985
1987	60705	60706	60706	5794	5826	5826				7592	7592	7592
1988	9033	9033	9033	4785	4787	4787				4366	4384	4384
1989	12245	12245	12245	3428	3445	3445				1386	1389	1389
1990	14788	14830	14830	3744	3745	3745	677	677	677	240	247	247
1991	9574	9574	9574	3366	3391	3391	8068	8068	8068	2080	2080	2080
1992	9037	9037	9037	4528	4528	4528	49807	49807	49807	1071	1071	1071
1993	4095	4095	4095	3241	3241	3241	7735	7735	7735	8935	8970	8970
1994	5462	5462	5462	1304	1245	1304	13907	13907	13907	864	849	890
1995	49861	49472	49885	1756	1756	1756	38741	38752	38752	1241	1241	1241
1996	4458	4231	4486	16450	16465	16465	10878	10906	10906	5830	5834	5834
1997	19018	18715	19059	8996	9004	9004	49692	49692	49692	5559	5614	5614
1998	18218	17894	18227	27234	27237	27237	89631	89613	89631	31384	31397	31397
1999	38191	38091	38299	20703	20704	20709	32871	32889	32889	39628	39628	39628
2000	24663	24660	24683	35605	35606	35606	73419	73409	73419	50417	50476	50476
2001	28075	28002	28091	25656	25657	25660	101840	101813	101840	14857	14909	14909
2002	11329	11242	11356	8844	8871	8871	37228	37222	37257	20857	21226	21226
2003	14620	13649	14737	10110	10112	10118	56588	56643	56643	16483	16485	16485
2004	9060	9084	9090	13622	13628	13628	39411	39596	39596	66149	66220	66220
2005	15986	15986	16013	35922	35949	35949	40823	40842	40842	29490	29505	29505
2006	26352	26348	26383	33856	33889	33889	62839	62852	62852			
2007	54982	55054	55068	170590	170594	170594	64034	64007	64042	43654	43741	43741
2008	51840	51858	51858	37517	37529	37529	140109	142570	142570	102738	102740	102740
2009	85074	85097	85106	25106	25107	25107	157225	157330	157332	149563	149568	149568
2010	310697	310599	310719	35013	35034	35034	132315	132375	132375	125797	125870	125870
2011	69075	69272	69272	57525	57537	57537	466951	482066	482066	111568	111568	111568
2012	214172	214183	214183	55950	55963	55963	367611	368240	368240	259128	259148	259148
2013	60047	60118	60124	141881	141929	141929	220078	220301	220301	124815	124815	124815
2014	119021	118943	119084	58997	59044	59044				212080	212080	212080
2015	62376	62408	62408				355454	355478	355478	423783	423809	423809
2016	80142	80259	80259	576119	576166	576166	124477	124478	124478	57464	57465	57465
2017							76005	76103	76103	93552	93553	93553
2018	32579	32625	32625	20483	20491	20491	156659	156693	156693	85378	85415	85415
2019	42437	42541	42541	45366	45386	45386	228482	228886	228886	88533	88533	88533
2020	79493	79626	79626				113057	113060	113060			

Table 4. Summary of years covered for suggested data aggregations (Historic, Depth and Unconverted) for redfish in 3L and 3N for the Canadian fall, spring and EU-Spain surveys.

Survey index	Gear	Historic 3L	Unconverted 3L	Historic 3N	Unconverted 3N	Survey index	Gear	Shallow 3L	Shallow 3N	Deep 3L	Deep 3N
EU-Spain	Pedreira				1996-2001	EU-Spain deep	CampelenS			2004-2019	1996-2021
EU-Spain	CampelenS	2004-2019	2004-2019	1996-2021	2002-2021	EU-Spain deep	Pedreira				2001-2001
Fall	Engel	1984-1989	1984-1994		1993-1994	EU-Spain shallow	CampelenS	2004-2019	1996-2021		
Fall	Converted	1990-2016,2018-2020		1993-2013,2015-2020		EU-Spain shallow	Pedreira		2001-2001		
Fall	Campelen		1995-2016,2018-2020		1995-2013, 2015-2020	Fall deep	Converted			1984-2016,2018-2020	1993-2013,2015-2020
Spring	Yankee	1975-1982	1975-1982	1977-1982	1977-1982	Fall shallow	Converted	1984-2016,2018-2020	1993-2013,2015-2020		
Spring	Engel	1985-1991	1985-1995	1984-1990	1984-1995	Spring deep	Converted			1991-2014,2016,2018--2019	1991-2013, 2015-2019
Spring	Converted	1992-2014,2016,2018-2019		1991-2005,2007-2019		Spring shallow	Yankee	1975-1982	1977-1982		
Spring	Campelen		1996-2014,2016,2018-2019		1996-2005,2007-2019	Spring shallow	Converted	1985-2014,2016,2018-2019	1984-2019		

Table 5. Estimates of stratified biomass (000'S) for 3L and 3N redfish from the Canadian fall, spring and EU-Spain surveys for the Unconverted and Historic approaches.

Year	3L EU-Spain Historic	3L EU-Spain Unconverted	3N EU-Spain Historic	3N EU-Spain Unconverted	3L Fall Historic	3L Fall Unconverted	3N Fall Historic	3N Fall Unconverted	3L Spring Historic	3L Spring Unconverted	3N Spring Historic	3N Spring Unconverted
1975									4175	4175		
1976									98623	98623		
1977									13644	13644	7125	7125
1979									21313	21313	46400	46400
1980									10540	10540	833	833
1981									16841	16841	18479	18479
1982									31423	31423	877	877
1984					215135	215135					17595	17595
1985					74832	74832			90186	90186	5427	5427
1986					11054	11054			5015	5015	1985	1985
1987					60706	60706			5826	5826	7592	7592
1988					9033	9033			4787	4787	4384	4384
1989					12245	12245			3445	3445	1389	1389
1990						14830			3745	3745	247	247
1991					13665	9574			3391	3391	4375	2080
1992					13424	9037			7404	4528	2662	1071
1993					6011	4095	13222	7735	6461	3241	16213	8970
1994					7173	5462	24584	13907	2302	1245	1835	849
1995					49472	49472	38752	38752	3284	1756	2572	1241
1996			6518	11406	4231	4231	10906	10906	16465	16465	5834	5834
1997			4752	8315	18715	18715	49692	49692	9004	9004	5614	5614
1998			24258	42447	17894	17894	89613	89613	27237	27237	31397	31397
1999			45463	79551	38091	38091	32889	32889	20704	20704	39628	39628
2000			72290	126494	24660	24660	73409	73409	35606	35606	50476	50476
2001			26489	29930	28002	28002	101813	101813	25657	25657	14909	14909
2002			5478	5478	11242	11242	37222	37222	8871	8871	21226	21226
2003			7772	7772	13649	13649	56643	56643	10112	10112	16485	16485
2004	21746	21746	19233	19233	9084	9084	39596	39596	13628	13628	66220	66220
2005			103678	103678	15986	15986	40842	40842	35949	35949	29505	29505
2006	49485	49485	62336	62336	26348	26348	62852	62852	33889	33889		
2007	22388	22388	62278	62278	55054	55054	64007	64007	170594	170594	43741	43741
2008	54960	54960	47468	47468	51858	51858	142570	142570	37529	37529	102740	102740
2009	73339	73339	393561	393561	85097	85097	157330	157330	25107	25107	149568	149568
2010	191045	191045	257853	257853	310599	310599	132375	132375	35034	35034	125870	125870
2011	120684	120684	304907	304907	69272	69272	482066	482066	57537	57537	111568	111568
2012	347368	347368	183326	183326	214183	214183	368240	368240	55963	55963	259148	259148

Year	3L EU-Spain Historic	3L EU-Spain Unconverted	3N EU-Spain Historic	3N EU-Spain Unconverted	3L Fall Historic	3L Fall Unconverted	3N Fall Historic	3N Fall Unconverted	3L Spring Historic	3L Spring Unconverted	3N Spring Historic	3N Spring Unconverted
2013	168821	168821	314906	314906	60118	60118	220301	220301	141929	141929	124815	124815
2014	153584	153584	127024	127024	118943	118943			59044	59044	212080	212080
2015	93434	93434	358473	358473	62408	62408	355478	355478			423809	423809
2016	69851	69851	81871	81871	80259	80259	124478	124478	576166	576166	57465	57465
2017	40457	40457	187758	187758			76103	76103			93553	93553
2018	28867	28867	211983	211983	32625	32625	156693	156693	20491	20491	85415	85415
2019	38672	38672	122321	122321	42541	42541	228886	228886	45386	45386	88533	88533
2020					79626	79626	113060	113060				
2021			51763	51763								

Table 6. Estimates of stratified biomass (000'S) for divs 3L and 3N from the Canadian fall, spring and EU-Spain surveys for the Depth approach.

Year	3L_EU-Spain deep	3L_EU-Spain shallow	3L_Fall deep	3L_Fall shallow	3L_Spring deep	3L_Spring shallow	3N_EU-Spain deep	3N_EU-Spain shallow	3N_Fall deep	3N_Fall shallow	3N_Spring deep	3N_Spring shallow
1975						4175						
1976						98623						
1977						13644						7125
1979						21313						46400
1980						10540						833
1981						16841						18479
1982						31423						877
1984			10316	267431								36302
1985			11153	87109		34228						12073
1986			292	16914		7017						4402
1987				75474		8902						15062
1988				12314		7791						8690
1989				15921		5300						3063
1990			5842	14959		5859						905
1991			5352	8313	4209	2115					2695	1680
1992			3676	9748	4502	2901					977	1685
1993			3700	2311	5111	1351			4025	9196	10412	5801
1994			1491	5681	1110	1191			5948	18636	611	1224
1995			1964	47508	2142	1142			3145	35606	1350	1222
1996			1768	2463	5399	11067	3616	2903	4761	6145	1578	4256
1997			9519	9196	1804	7200	3046	1707	324	49368	1582	4033
1998			7349	10545	5092	22145	21694	2564	2014	87600	7368	24029
1999			6901	31189	3775	16929	14297	31166	10468	22421	4788	34840
2000			3543	21116	13957	21648	9568	62723	3150	70259	4613	45863
2001			4146	23856	15767	9889	21799	4690	1432	100381	6831	8078

Year	3L_EU-Spain deep	3L_EU-Spain shallow	3L_Fall deep	3L_Fall shallow	3L_Spring deep	3L_Spring shallow	3N_EU-Spain deep	3N_EU-Spain shallow	3N_Fall deep	3N_Fall shallow	3N_Spring deep	3N_Spring shallow
2002			4129	7113	4924	3947	3080	2398	4171	33051	11038	10188
2003			4815	8834	4402	5710	1710	6062	2440	54203	4485	12000
2004	1340	20406	4838	4245	7354	6274	1405	17828	6469	33127	2504	63717
2005			3031	12954	5160	30789	1574	102104	5162	35680	2014	27491
2006	1893	47592	2743	23605	1893	31996	757	61579	2033	60819		13
2007	4398	17990	3630	51424	3999	166595	2019	60259	1362	62646	3031	40710
2008	779	54182	2211	49647	8983	28547	1992	45476	1611	140959	2121	100619
2009	2140	71198	3120	81976	5155	19953	2993	390568	1656	155674	3656	145913
2010	1907	189138	4761	305838	5299	29735	2309	255544	5450	126925	2725	123145
2011	1419	119265	6480	62792	7168	50369	926	303981	672	481394	2627	108941
2012	2510	344858	2632	211551	5805	50159	951	182375	5352	362887	1218	257930
2013	3354	165466	2815	57303	12660	129269	1160	313746	1440	218860	951	123864
2014	1992	151592	6273	112670	7679	51365	558	126466				210464
2015	3385	90048	1778	60630			782	357692	1131	354348	134	423675
2016	6310	63541	1731	78529	4373	571793	185	81686	119	124359	952	56513
2017	2452	38005					569	187189	504	75599	678	92875
2018	896	27971	819	31806	5658	14834	2162	209821	745	155948	352	85063
2019	441	38232	9071	33470	2361	43025	286	122035	906	227980	1521	87012
2020			2255	77371					1282	111778		
2021							419	51344				

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#>    evaluate       0.18     2022-11-07 [1] CRAN (R 4.2.2)
#>    ezknitr      * 0.6      2016-09-16 [1] CRAN (R 4.2.2)
#>    fansi          1.0.3    2022-03-24 [1] CRAN (R 4.2.2)
#>    farver         2.1.1    2022-07-06 [1] CRAN (R 4.2.2)
#>    fastmap        1.1.0    2021-01-25 [1] CRAN (R 4.2.2)
#>    flextable    * 0.8.3    2022-11-06 [1] CRAN (R 4.2.2)
#>    forcats      * 0.5.2    2022-08-19 [1] CRAN (R 4.2.2)
#>    fs             1.5.2    2021-12-08 [1] CRAN (R 4.2.2)
#>    gargle         1.2.1    2022-09-08 [1] CRAN (R 4.2.2)
#>    gdtools        0.2.4    2022-02-14 [1] CRAN (R 4.2.2)
```

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#>   generics       0.1.3      2022-07-05 [1] CRAN (R 4.2.2)
#>   ggplot2      * 3.4.0      2022-11-04 [1] CRAN (R 4.2.2)
#>   ggridges     * 0.5.4      2022-09-26 [1] CRAN (R 4.2.2)
#>   ggthemes       4.2.4      2021-01-20 [1] CRAN (R 4.2.2)
#>   glue           1.6.2      2022-02-24 [1] CRAN (R 4.2.2)
#>   googledrive    2.0.0      2021-07-08 [1] CRAN (R 4.2.2)
#>   googlesheets4  1.0.1      2022-08-13 [1] CRAN (R 4.2.2)
#>   gridExtra      2.3        2017-09-09 [1] CRAN (R 4.2.2)
#>   gtable         0.3.1      2022-09-01 [1] CRAN (R 4.2.2)
#>   haven          2.5.1      2022-08-22 [1] CRAN (R 4.2.2)
#>   here         * 1.0.1      2020-12-13 [1] CRAN (R 4.2.2)
#>   highr          0.9        2021-04-16 [1] CRAN (R 4.2.2)
#>   hms            1.1.2      2022-08-19 [1] CRAN (R 4.2.2)
#>   htmltools      0.5.4      2022-12-07 [1] CRAN (R 4.2.2)
#>   htmlwidgets    1.6.1      2023-01-07 [1] CRAN (R 4.2.2)
#>   httpuv         1.6.6      2022-09-08 [1] CRAN (R 4.2.2)
#>   httr           1.4.4      2022-08-17 [1] CRAN (R 4.2.2)
#>   jsonlite       1.8.3      2022-10-21 [1] CRAN (R 4.2.2)
#>   knitr          1.41       2022-11-18 [1] CRAN (R 4.2.2)
#>   labeling       0.4.2      2020-10-20 [1] CRAN (R 4.2.0)
#>   later          1.3.0      2021-08-18 [1] CRAN (R 4.2.2)
#>   lifecycle      1.0.3      2022-10-07 [1] CRAN (R 4.2.2)
#>   lubridate    * 1.9.0      2022-11-06 [1] CRAN (R 4.2.2)
#>   magrittr       2.0.3      2022-03-30 [1] CRAN (R 4.2.2)
#>   memoise        2.0.1      2021-11-26 [1] CRAN (R 4.2.2)
#>   mime           0.12       2021-09-28 [1] CRAN (R 4.2.0)
#>   miniUI         0.1.1.1    2018-05-18 [1] CRAN (R 4.2.2)
#>   modelr         0.1.10     2022-11-11 [1] CRAN (R 4.2.2)
#>   munsell        0.5.0      2018-06-12 [1] CRAN (R 4.2.2)
#>   NAFOdown     * 0.0.1.9000 2023-01-13 [1] Github (nafc-assess/NAFOdown@f9eda23)
#>   officer      * 0.5.1      2023-01-06 [1] CRAN (R 4.2.2)
#>   openssl        2.0.4      2022-10-17 [1] CRAN (R 4.2.2)
#>   patchwork    * 1.1.2      2022-08-19 [1] CRAN (R 4.2.2)
#>   pillar         1.8.1      2022-08-19 [1] CRAN (R 4.2.2)
#>   pkgbuild       1.4.0      2022-11-27 [1] CRAN (R 4.2.2)
#>   pkgconfig      2.0.3      2019-09-22 [1] CRAN (R 4.2.2)
#>   pkgload        1.3.2      2022-11-16 [1] CRAN (R 4.2.2)
#>   plyr           1.8.8      2022-11-11 [1] CRAN (R 4.2.2)
#>   prettyunits    1.1.1      2020-01-24 [1] CRAN (R 4.2.2)
#>   processx       3.8.0      2022-10-26 [1] CRAN (R 4.2.2)
#>   profvis        0.3.7      2020-11-02 [1] CRAN (R 4.2.2)
#>   promises       1.2.0.1    2021-02-11 [1] CRAN (R 4.2.2)
#>   ps             1.7.2      2022-10-26 [1] CRAN (R 4.2.2)
#>   purrr        * 0.3.5      2022-10-06 [1] CRAN (R 4.2.2)
#>   R6             2.5.1      2021-08-19 [1] CRAN (R 4.2.2)
#>   ragg           1.2.4      2022-10-24 [1] CRAN (R 4.2.2)
#>   RColorBrewer * 1.1-3      2022-04-03 [1] CRAN (R 4.2.0)
#>   Rcpp           1.0.9      2022-07-08 [1] CRAN (R 4.2.2)
#>   readr        * 2.1.3      2022-10-01 [1] CRAN (R 4.2.2)
#>   readxl       * 1.4.1      2022-08-17 [1] CRAN (R 4.2.2)
#>   remotes        2.4.2      2021-11-30 [1] CRAN (R 4.2.2)
#>   reprex         2.0.2      2022-08-17 [1] CRAN (R 4.2.2)
#>   reshape        0.8.9      2022-04-12 [1] CRAN (R 4.2.2)
#>   reshape2     * 1.4.4      2020-04-09 [1] CRAN (R 4.2.2)
#> D rJava          1.0-6      2021-12-10 [1] CRAN (R 4.2.0)
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#>   rlang         1.0.6     2022-09-24 [1] CRAN (R 4.2.2)
#>   rmarkdown     2.18      2022-11-09 [1] CRAN (R 4.2.2)
#>   rprojroot     2.0.3     2022-04-02 [1] CRAN (R 4.2.2)
#>   Rstrap      * 1.14.1    2022-11-27 [1] local
#>   rstudioapi    0.14      2022-08-22 [1] CRAN (R 4.2.2)
#>   rvest         1.0.3     2022-08-19 [1] CRAN (R 4.2.2)
#>   scales        1.2.1     2022-08-20 [1] CRAN (R 4.2.2)
#>   sessioninfo   1.2.2     2021-12-06 [1] CRAN (R 4.2.2)
#>   shiny         1.7.3     2022-10-25 [1] CRAN (R 4.2.2)
#>   showtext      0.9-5     2022-02-09 [1] CRAN (R 4.2.2)
#>   showtextdb    3.0       2020-06-04 [1] CRAN (R 4.2.2)
#>   stringi       1.7.8     2022-07-11 [1] CRAN (R 4.2.1)
#>   stringr     * 1.4.1     2022-08-20 [1] CRAN (R 4.2.2)
#>   sysfonts      0.8.8     2022-03-13 [1] CRAN (R 4.2.2)
#>   systemfonts   1.0.4     2022-02-11 [1] CRAN (R 4.2.2)
#>   textshaping   0.3.6     2021-10-13 [1] CRAN (R 4.2.2)
#>   tibble      * 3.1.8     2022-07-22 [1] CRAN (R 4.2.2)
#>   tidyr       * 1.2.1     2022-09-08 [1] CRAN (R 4.2.2)
#>   tidyselect    1.2.0     2022-10-10 [1] CRAN (R 4.2.2)
#>   tidyverse   * 1.3.2     2022-07-18 [1] CRAN (R 4.2.2)
#>   timechange  * 0.1.1     2022-11-04 [1] CRAN (R 4.2.2)
#>   tzdb          0.3.0     2022-03-28 [1] CRAN (R 4.2.2)
#>   urlchecker    1.0.1     2021-11-30 [1] CRAN (R 4.2.2)
#>   usethis       2.1.6     2022-05-25 [1] CRAN (R 4.2.2)
#>   utf8          1.2.2     2021-07-24 [1] CRAN (R 4.2.2)
#>   uuid          1.1-0     2022-04-19 [1] CRAN (R 4.2.0)
#>   vctrs         0.5.0     2022-10-22 [1] CRAN (R 4.2.2)
#>   viridis     * 0.6.2     2021-10-13 [1] CRAN (R 4.2.2)
#>   viridisLite * 0.4.1     2022-08-22 [1] CRAN (R 4.2.2)
#>   vroom         1.6.0     2022-09-30 [1] CRAN (R 4.2.2)
#>   withr         2.5.0     2022-03-03 [1] CRAN (R 4.2.2)
#>   xfun          0.35      2022-11-16 [1] CRAN (R 4.2.2)
#>   xlsx        * 0.6.5     2020-11-10 [1] CRAN (R 4.2.2)
#>   xlsxjars      0.6.1     2014-08-22 [1] CRAN (R 4.2.0)
#>   xml2          1.3.3     2021-11-30 [1] CRAN (R 4.2.2)
#>   xtable        1.8-4     2019-04-21 [1] CRAN (R 4.2.2)
#>   yaml          2.3.6     2022-10-18 [1] CRAN (R 4.2.1)
#>   zip           2.2.2     2022-10-26 [1] CRAN (R 4.2.2)
#>
#>  [1] C:/Users/perreaultan/AppData/Local/R/win-library/4.2
#>  [2] C:/Program Files/R/R-4.2/library
#>
#>  D ── DLL MD5 mismatch, broken installation.
#>
#> ──────────────────────────────────────────────────────────────────────────────
```