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Assessment of Thorny Skate (*Amblyraja radiata* Donovan, 1808) in NAFO Divisions 3LNO and Subdivision 3Ps

by

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Abstract

Available information on the fishery, management, biology, and assessment of Thorny Skate in NAFO Divisions 3LNO and Subdivision 3Ps was reviewed to determine the status of this stock. Based on the continuous distribution of this species, and lack of physical barriers between Divs. 3LNO and Subdiv. 3Ps, Thorny Skate in Divs. 3LNOPs is considered to constitute a single stock. Over the period 2018-2023, an average of 3 285 t of Thorny Skate from Divs. 3LNO was commercially landed. STACFIS-agreed total landings from Divs. 3LNO were 2 100 t in 2023. Reported landings in Subdiv. 3Ps averaged 600 t in 2018-2023, and totaled 16 t in 2023. Due to the CoVid-19 global pandemic and research vessel difficulties, no complete Canadian spring research surveys occurred in Divs. 3LNO over 2020-2021. Beginning in 2022 new vessels conducted the Canadian surveys, however, 3L was not completely covered in spring 2022. Subdiv. 3Ps was surveyed in 2021 spring with comparative fishing occurring in 2022 however the survey with the new vessels did not occur in 2023. In addition, no Canadian fall research survey was conducted in Divs. 3LNO in 2021-2022 due to ongoing comparative fishing; the survey did occur in 2023. The comparative fishing indicated that no conversion factors could be estimated to convert the new vessels with the primary vessels. It was also discovered that one of the vessels used in the original series was not comparable to the other two vessels. No new information for the entire stock area of thorny skate can be shown since the 2022 and 2023 surveys missed some portion of the stock area. EU-3NO surveys were available every year with the exception of 2020, while the EU-3L survey was not available from 2020-2022. After a drastic decline in Thorny Skate biomass and abundance over 1985-1995, Canadian spring survey indices indicated that the Thorny Skate stock in Divs. 3LNOPs was relatively stable at low levels. Thorny Skate distribution in Divs. 3LNOPs over 2010-2023 continued to be concentrated on the southwestern Grand Banks, in Subdiv. 3Ps, and northward along the edge of the Bank.

Introduction

Thorny Skates (*Amblyraja radiata* Donovan, 1808) are widely distributed in temperate and Arctic waters of the North Atlantic. In the western Atlantic, Thorny Skate are distributed from Greenland to South Carolina, with the centre of distribution on the Grand Banks (Fig. 1) in NAFO Divisions 3LNO. Commercial catches of skates consist mainly of Thorny Skate, with about 95% in Canadian commercial skate catches (Kulka and Miri 2007); which is similar to the 97-99% of Thorny Skates observed in the Canadian spring survey (Simpson and Miri 2020). In the EU-Spain research survey in Divs. 3NO over 2014-2016, Thorny Skate comprised approximately 90% of the skate taken in the survey (González-Costas et al. 2022). Thus, the skate fishery on the Grand Banks can be considered a directed fishery for Thorny Skate.

Fishery and Management

TAC Regulation

Thorny Skate came under quota regulation in 1995, after a directed skate fishery was established in 1994 by Canada in its Exclusive Economic Zone (EEZ). A Total Allowable Catch (TAC) of 5 000 t for Divisions 3LNO and 1 000 t for Subdivision 3Ps were adopted by Canada in 1995. In 1996, the TAC was raised to 6 000 t for Divs. 3LNO and 2 000 t for Subdiv. 3Ps. In 1997, the TAC was reduced to 1 950 t for Divs. 3LNO, and 1 050 t for Subdiv. 3Ps. Outside Canada's EEZ, catch was unregulated until September 2004, when the Northwest Atlantic Fisheries Organization (NAFO) Fisheries Commission set a TAC of 13 500 t for 2005-2009 in the NAFO Regulatory Area (NRA) of Divs. 3LNO (Fig. 2). This TAC was lowered to 12 000 t for 2010-2011, and to 8 500 t for 2012. The TAC was further reduced to 7 000 t for 2013-2024. The TAC for Subdiv. 3Ps has been maintained at 1 050 t

Landings Trends

On the Grand Banks, Kulka and Mowbray (1998) reported that significant bycatch of skates have been taken since commencement of offshore fishing in the late 1940s, initially by non-Canadian fleets and later by Canadian vessels. The bycatch was derived primarily from the Greenland Halibut fishery and from the Canadian mixed fishery for Thorny Skate, White Hake (*Urophycis tenuis*), and Monkfish (*Lophius americanus*). Kulka and Mowbray (1998) estimated that approximately 5 000 t, on average, were discarded annually by Canadian fleets during the 1980s and early 1990s; although only a few hundred tons were recorded in Canada's annual landings statistics in that period. Catches for Divs. 3LNO (Table 1; Fig. 2) increased in the mid-to-late 1980s with the commencement of a directed fishery for Thorny Skate. In 1985, Spain began targeting skate in a non-regulated fishery in the NRA (Junquera and Paz 1998; del Río and Junquera 2001). During 1985-1991, landings averaged 17 058 t, and peaked at approximately 28 400 t in 1991 (STATLANT-21A). This fishery was mainly conducted by Spain, Portugal, USSR, and the Republic of Korea. Non-Canadian landings declined significantly to 5 059 t in 1992 (Table 1). In 2000, Russia joined the directed fishery for Thorny Skate. Due to a new Canadian-directed fishery that began in 1994, Canadian landings increased during 1994-1999, to an average of 1 590 t (Simpson and Miri 2012). Since 2000, total reported landings of skate by all countries in Divs. 3LNO declined (Fig. 2). In 2018- 2023, an average of 3 285 t of Thorny Skate was landed from Divs. 3LNO. STACFIS-agreed landings for 2023 totaled 2 100 t. In Subdiv. 3Ps, STATLANT-21A data indicated that Canadian fleets reported the majority of Thorny Skate landings, while St. Pierre and Miquelon (EU-France) annually reported smaller amounts of landings (Table 2; Fig. 2). Total reported landings in Subdiv. 3Ps averaged 600 t over 2018-2023. In Subdiv. 3Ps, reported Canadian landings totaled 16 t in 2021.

Commercial Size

Sampling of Canadian commercial catches by Canadian At-Sea Fisheries Observers indicated that Thorny Skates trawled in the Div. 3LN redfish (*Sebastes* sp.) fishery varied between 42-88 cm TL in 2019 (Fig. 3; see Simpson and Miri 2020 for previous years). Skates caught by Canadian trawlers in the Divs. 3LNO Yellowtail Flounder (*Limanda ferruginea*) fishery in 2019-2022 were 23-96 cm TL. Canadian skate bycatch in 3LNO was not sampled in 2023.

From skate-directed trawl fisheries (280 mm mesh) in the NRA of Divs. 3LNO over 2019-2023, EU-Spain reported a range of 13-99 cm TL skates, with a small number of young-of-the-year (≤21 cm TL) caught in 2021-2022 (Fig. 4; see Simpson and Miri 2020 for previous years). In other directed trawl fisheries (130 mm mesh) of Div. 3NO (NRA) over 2019-2023, EU-Portugal reported skate bycatch ranging from 26-90 cm TL; except for 14-100 cm TL in 2021 (Fig. 5; see Simpson and Miri 2020 for previous years). EU-Portugal did not sample Divs. 3LNO skate bycatch in 2020, while EU-Spain have not done so since 2009. Russia sampled Thorny Skates as bycatch in Divs. 3LNO in 2019-2023, ranging from 15-95 cm TL skates in 2019-2020, 53-84 cm TL skates in 2021-2022 (1-3 skates and not plotted), and 31-85 cm TL skates in 2023 (Fig. 5; see Simpson and Miri 2020 for previous years).

Research Survey Data

New vessel time series – Modified Campelen series

Beginning in 2022, new survey vessels have been used to conduct the Canadian multi-species surveys. For Thorny Skate in NAFO Divs 3LNO and Subdivision 3Ps, data from comparative fishing experiments were insufficient to provide conversion factors for past primary research vessels CCGS Wilfred Templeman and CCGS Alfred Needler. As a result, the spring Canadian Campelen series (1984-2019) and the autumn Canadian Campelen series (1990-2020) have ended.

Throughout the survey series the CCGS Teleost was used to compliment or replace the primary vessels, with the assumption that catches from the Teleost were directly comparable to those vessels. However, during the comparative fishing trials with the new vessels it was determined that the Teleost was not directly comparable to the Wilfred Templeman and Alfred Needler for some species. For the spring series, conversion factors allow the CCGS Teleost sets in Div. 3LNO to be converted to the new survey vessels using a length-based conversion, however data are insufficient to convert indices in Subdivision 3Ps. Sensitivity analyses showed most years were not impacted by use of the Teleost (Wheeland et al. 2024), however spring surveys with complete/near-complete coverage by the Teleost (2014, 2016, 2018) have been removed from the 1984-2019 Campelen series.

Canadian Spring Surveys

Stratified-random surveys have been conducted by Canadian research vessels in the spring (April-June) from 1971 to 2023. A summary of the stratified-random survey design adopted by the DFO-NL Region can be found in Doubleday (1981). While survey design has remained constant, additional strata have been included, and some of the original strata have been modified (Bishop 1994). A significant change in the surveys was the addition of shallower and deeper strata after 1993. Additional causes of variation in spring survey coverage are discussed in detail most recently by Rideout et al. (2022). The spring survey can be split into four time series, based on the trawl/vessel used in each period: 1971-1982 (Yankee 41.5), 1983-1995 (Engel 145), and 1996-2021 (Campelen 1800; McCallum and Walsh 1996), and 2024 onward the Modified Campelen (Wheeland et al. 2024).

Conversion factors exist for the Engel to Campelen gear change (Simpson and Kulka 2005), but not for the Yankee to Engel gear change. It should be noted that Cadigan and Simpson (2023) conducted a re-analysis of the previous comparative fishing conversion factors and found that the estimates provided by Simpson and Kulka (2005) were significantly smaller than the current estimates would indicate. Cadigan and Simpson (2023) also found evidence of significant differences among NAFO Divisions and that potential size selective catchabilities existed.

In 2006, most of Subdiv. 3Ps was not surveyed, and only shallow strata in Divs. 3NO were surveyed, due to Canadian research vessels' mechanical difficulties. Therefore, survey estimates for that year are not comparable to others in the Campelen time series. In 2015 and 2017 and 2022, Div. 3L was not completely surveyed, thus impacting biomass and abundance estimates of Thorny Skate. Due to the CoVid-19 global pandemic and research vessel difficulties, no complete Canadian spring research surveys occurred in Divs. 3LNO over 2020-2021. Subdiv. 3Ps was surveyed in 2021 spring with the CCGS Teleost so it is not comparable to the earlier time series, however the survey with the new vessels did not occur in 2023. Therefore there has not been a complete survey since 2019 and a new series will begin in 2024.

Historical abundance and biomass indices from Canadian spring surveys in Divs. 3LNOPs are provided in Tables 3 and 4 and Fig. 6. Since the mid-1990s, spring biomass indices for Thorny Skate in Divs. 3LNOPs were generally increasing, following a declining trend over 1985-1995. The biomass index in Div. 3N had increased since 2015 but declined in 2019 to 19 019 t. The biomass index in 2019 was 72 605 t in Div. 3O, slightly above the 2013-2017 average of 67 052 t. The 2019 biomass estimate of 11 860 t in Div. 3L was similar to the 2013 biomass of 11 713 t. In Subdiv. 3Ps, the biomass index was 48 339 t and 37 211 t in 2018 and 2019, respectively. In 2019, this index declined below the 2014-2018 average of 41 806 t.

Abundance of Thorny Skate in the spring 2023 was 14.9 million, 27 million and 36.7 million in Div. 3L, 3N and 3O, respectively (Table 5). In the case of both NAFO Divs. 3L and 3O these estimates are an increase from the 2022 values of 11.3 and 18.7 million Thorny Skates, respectively. There was no change in abundance of NAFO Div. 3N

between 2022 and 2023.In 2023, the biomass of Thorny Skate in Div. 3L, 3N and 3O respectively were 23 460 t, 60 307 t and 78 686 t using the new Modified Campelen gear (Table 6). In the case of 3L and 3O these estimates are slightly higher than those in 2022, whereas in NAFO Div. there is a slight decrease in biomass.

Canadian Fall Surveys

Stratified-random fall surveys have been conducted by Canada in Div. 3L from 1981 to 2023. In 1990- 2020, fall surveys also extended onto the southern Grand Banks in Divs. 3NO. Due to research vessel difficulties, no Canadian fall survey occurred in 2021 in Divs. 3LNO. Fall surveys do not cover the entire stock area, and thus are not considered spatially complete. For this reason, Canadian spring surveys are used as the primary source of biomass and abundance estimates for Thorny Skate. However, fall indices are still considered in assessments of this stock, because this survey is conducted when a greater proportion of Thorny Skate is available to survey trawls. During fall, Thorny Skates are concentrated on the shelf; in spring, part of this population has moved to the shelf edge, and a proportion apparently moves outside of the survey area (Kulka et al. 2004). When using spring estimates of biomass and abundance to examine trends in this stock, it is assumed that the proportion of skate that moves outside of the surveyed area remains consistent between years. Additional causes of variation in fall survey coverage are discussed in detail most recently by Rideout et al. (2022).

Historical abundance and biomass indices from Canadian fall surveys in Divs. 3LNO are provided in Tables 7 and 8 and Figure 7. Fall abundance indices of Thorny Skate remained stable at very low levels since 1995. Divs. 3NO were not surveyed in fall 2014, as well as deep-water strata (>732 m) of Div. 3L in 2015, 2017-2018; thereby impacting abundance and biomass estimates of this species. Overall, Thorny Skate indices in Divs. 3LNO have been slowly increasing in the fall survey. In 2020, biomass estimates in Div. 3L, 3N, and 3O were 31 671 t, 109 452 t, and 61 540 t, respectively. The biomass index of 202 663 t in Divs. 3LNO (combined) is well above the 5-year average of 154 394 t over 2015-2019, due to above-average biomass levels in Divs. 3LN. However, the biomass estimate of 61 540 t in 2020 was slightly below the 5-year average of 66 630 t in Div. 3O; while that of 31 671 t in Div. 3L appeared to be above the (incomplete) 5-year average of 23 715 t. In Div. 3N, the 2020 biomass index of 109 452 t was significantly higher than the previous 5-year average of 64 050 t. Lack of Canadian fall survey estimates for 2021-2022 and comparable estimates for 2023 prevents verification of this apparently increasing trend.

There was no Divs. 3LNO fall survey in 2022 due to the directed comparative fishing program. Abundance estimates of Thorny Skate in the fall of 2023 were 24.8 million, 71.7 million and 42.6 million in Div. 3L, 3N and 3O, respectively (Table 9). In 2023, the minimum trawlable biomass estimate of Thorny Skate in Div. 3L, 3N and 3O, respectively were 42 468 t, 144 365 t and 94 280 t using the new Modified Campelen gear (Table 10).

EU-Spain 3NO Survey

Spain initiated a stratified-random survey in the NRA of Divs. 3NO in 1995. Initially, this survey was carried out in spring with the C/V Playa de Menduiña using a Pedreira bottom trawl. Since 2001, the R/V Vizconde de Eza replaced that research vessel, and a Campelen trawl replaced Pedreira gear (Garrido et al. 2022). Abundance and biomass of Thorny Skate were estimated from EU-Spain surveys in the NRA of Divs. 3NO from 1997-2019 and 2021-2023. Due to CoVid-19, there was no Spanish survey in 2020 in Divs. 3NO. Although the EU-Spain biomass index indicated an increase in 2012, it declined from a mean weight per tow of 55.81 kg/tow in 2006 to its lowest estimate of 2.76 kg/tow in 2019 (Fig. 8). The estimate of 30.37 kg/tow for 2021 was well above the average for this time-series and was followed by a series low of 2.64 kg/tow in 2022 and a slight increase in 2023 to a below average biomass index estimate of 14.17 kg/tow.

A comparison of the Canadian Campelen spring 3NO biomass indices to those of the Spanish Divs. 3NO surveys in 1997-2019 indicated that the trends have diverged since 2007: the EU-Spain index declined until 2011, while the Canadian index increased and then remained relatively constant since 2007 (Fig. 8). It should be noted that the Canadian spring survey covers the entire area of Divs. 3NO, whereas the Spanish survey is limited to the NRA of Divs. 3NO.

EU-Spain 3L Survey

Spain initiated a stratified-random summer bottom trawl survey in the NRA of Div. 3L in 2003. This survey was conducted with the R/V Vizconde de Eza using a Campelen trawl. Due to the vessel's mechanical difficulties, the survey was not conducted in 2005, and some strata were missed in 2003-2004 (Román-Marcote et al. 2020). Abundance and biomass estimates of Thorny Skate were available from EU-Spain surveys in the NRA of Div. 3L from 2003-2019 (excluding 2005). Due to CoVid-19, there were no Spanish surveys in Div. 3L over 2020-2022 however the survey resumed in 2023. A comparison of the Spanish Div. 3L biomass and Canadian spring Div. 3L indices in 2003-2019 indicated generally similar patterns until 2014 when they diverged: the EU-Spain index followed an increasing trend to 2015 (Fig. 9). The EU-Spain index has since declined from 18.75 to its lowest values in 2018 (7.48 kg/tow) and 2019 (7.82 kg/tow). In 2023 this index increased to 18.94 kg/tow which is above the long term average of 14.5 kg/tow.

The Canadian Campelen Div. 3L fall biomass indices reflected a pattern similar to that from the Spanish survey until 2016, when they diverged: the EU-Spain index followed the declining trend, while Canadian biomass estimates continued along a gradually increasing trend from 3 660 t to 5 302 t. It should be noted that the Canadian surveys cover the entire area of Div. 3L, whereas the Spanish survey is limited to the NRA of Div. 3L.

Index of Fishing Mortality

A relative Fishing Mortality Index (Relative F=STACFIS-agreed commercial landings/Canadian spring survey biomass) was calculated for Thorny Skate in Divs. 3LNO and Subdiv. 3Ps for 1996-2019. Relative F for Divs. 3LNO increased from the late 1980s to a peak of 32% in 1997, then decreased and remained stable at approximately 17% during 1998-2004 (Fig. 10). In 2005-2011, this Divs. 3LNO index averaged 6%, then remained around 4% since 2012. From 2010-2019, relative fishing mortality in Subdiv. 3Ps was ≤2%. Due to the lack of conversion factors that can be applied to the entire stock area, a new time series of relative fishing mortality is required to reflect the new biomass estimates for the Modified Campelen trawl series.

Recruitment

A standardized index of Thorny Skate recruitment, based on the number of skates ≤21 cm TL, is illustrated in Figure 11. Due to a lack of Canadian spring surveys in Divs. 3LNO and subdivision 3Ps in various years during 2020-2023 this index could not be updated. The recruitment index declined from 1.5 in 1996 to below the 1996-2019 average, with its lowest value in 1999 and 2004. Although this index remained above 1.0 over 2010-2013, it was followed by a steep decline in 2015. The recruitment index increased in 2017and in 2019 was at a level comparable to its long-term average. The 2006 index is not presented, because Canadian survey coverage was incomplete over that spring; the Div. 3L survey was incomplete in 2015 and 2017; the survey was conducted on the CCGS Teleost in 2014, 2016, and 2018 which was not comparable. Due to the lack of conversion factors that can be applied to the entire stock area, a new recruitment time series is required.

Distribution

In Divs. 3LNO and Subdiv. 3Ps, the distribution of Thorny Skate has changed significantly since the 1980s. In the early 1980s, Thorny Skates were widely distributed over the entire Grand Banks in moderate to high concentrations (Kulka and Miri 2007). By the late 1990s, much of the biomass was concentrated in the southwest. In 2001-2005, the area of high concentration expanded northward and along the Bank edge. It is important to note that part of this population moves to the shelf edge in spring, thereby moving outside of the Canadian spring survey area; they are concentrated on the shelf during the fall (Kulka et al. 2004). In 2012- 2021, Thorny Skate distribution in Divs. 3LNOPs continued to be concentrated on the southwestern Grand Banks, in Subdiv. 3Ps, and northward along the edge of the Bank in the spring survey (Fig. 12). In the Canadian fall survey over 2011-2020, Thorny Skate continued

to be concentrated along the shelf edge; although higher densities were also apparent in shallower locations on the Grand Banks (Fig. 13).

Summary

Thorny Skate underwent an overall decline in Divs. 3LNO over the late 1980s, to 1996, then stabilized at a low level and, more recently, has generally been increasing. Thorny Skate distribution in Divs. 3LNOPs for 2010- 2019 and 2021 continued to be concentrated on the southwestern Grand Banks, in Subdiv. 3Ps, and northward along the edge of the Bank. An Index of Fishing Mortality for Divs. 3LNO increased from the late 1980s to a peak of 32% in 1997, then stabilized at approximately 17% during 1998-2004. In 2005-2011, this Index averaged 6%, and remained around 4% since 2012. From a peak of 18 277 t in 2000, total reported landings of skate by all countries in Divs. 3LNO declined to an average of 3 470 t in 2018-2020. In 2021, STACFIS-agreed landings totaled 3 677 t. The 2022 TAC of 7 000 t for skates in the NRA of Divs. 3LNO continues to exceed the average commercial catch during a period of very slow stock growth.

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Table 1. NAFO-reported landings (t) of skates in Divs. 3LNO, 1960-2023 (STATLANT-21A).

Year	Canada	Other	Total
1962	0	99	99
1963	0	65	65
1964	0	145	145
1965	17	199	216
1966	75	347	422
1967	212	188	400
1968	128	31	159
1969	68	1,123	1,191
1970	99	539	638
1971	125	77	202
1972	64	487	551
1973	10	413	423
1974	638	1,690	2,328
1975	180	2,535	2,715
1976	260	1,006	1,266
1977	551	1,266	1,817
1978	816	1,015	1,831
1979	382	657	1,039
1980	351	1,027	1,378
1981	244	1,467	1,711
1982	52	756	808
1983	4	1,277	1,281
1984	0	2,013	2,013
1985	9	10,390	10,399
1986	52	14,277	14,329
1987	195	18,301	18,496
1988	91	18,675	18,766
1989	15	14,222	14,237
1990	44	14,726	14,770
1991	18	28,390	28,408
1992	78	5,059	5,137
1995	2,412	4,912	7,324
1996	1,314	4,804	6,118
1997	2,165	9,903	12,068
1998	1,013	8,501	9,514
1999	1,081	10,864	11,945
2000	498	17,779	18,277
2001	354	14,507	14,861
2002	1,107	10,648	11,755
2003	671	13,592	14,263
2004	352	11,476	11,828
2005	685	2,853	3,538
2006	249	5,255	5,504
2007	101	6,110	6,211
2008	243	6,867	7,110
2009	435	5,286	5,721
2010	50	5,314	5,364
2011	69	5,479	5,548
2012	185	4,144	4,329
2013	21	4,323	4,344
2014	2	4,472	4,474
2015	4	3,322	3,326
2016	1	3,480	3,481
2017	5	4,157	4,162
2018	2	127	129
2019	7	3267	3274
2020	4	4036	4040
2021	7		3333
2022	1	2657	2658
2023	16	1842	1858

Table 2. NAFO-reported landings (t) of Thorny Skate in Subdiv. 3Ps, 1960-2023 (STATLANT-21A).

Year	Canada	Other	Total	Year	Canada	Other	Total
1960	0	11	11	1993	22	11	33
1961	0	17	17	1994	1,566	3	1,569
1962	0	11	11	1995	1,866	4	1,870
1963	0	58	58	1996	603	2	605
1964	0	145	145	1997	829	3	832
1965	0	85	85	1998	1,251	6	1,257
1966	0	126	126	1999	1,102	4	1,106
1967	0	162	162	2000	935	21	956
1968	86	67	153	2001	1,769	39	1,808
1969	0	353	353	2002	1,413	238	1,651
1970	35	229	264	2003	1,705	82	1,787
1971	303	213	516	2004	1,190	87	1,277
1972	8	184	192	2005	967	15	982
1973	7	231	238	2006	910	78	988
1974	122	641	763	2007	1,347	491	1,838
1975	9	490	499	2008	763	632	1,395
1976	91	230	321	2009	645	354	999
1977	521	360	881	2010	342	529	871
1978	454	256	710	2011	513	228	741
1979	545	121	666	2012	354	224	578
1980	554	609	1,163	2013	286	271	557
1981	558	520	1,078	2014	201	145	346
1982	117	395	512	2015	168	75	243
1983	0	516	516	2016	404	250	654
1984	21	602	623	2017	413	192	605
1985	21	944	965	2018	944	115	1,059
1986	7	1,576	1,583	2019	890	79	969
1987	52	787	839	2020	486	276	762
1988	2	781	783	2021	536	166	702
1989	0	1,685	1,685	2022	219	14	233
1990	5	549	554	2023	16	1	17
1991	1	639	640				
1992	13	46	59				

Table 3. Abundance (000s) of Thorny Skate from Canadian spring research surveys in Divs. 3LNOPs, 1984-2019. Surveys were conducted with an Engel trawl (1984-spring 1995; converted to Campelen-equivalents), and a Campelen trawl (spring 1996-2019). The surveys in 2014, 2016, 2018 were completed in part by the CCGS Teleost which has been found to not be comparable to the CCGS Wilfred Templeman and the CCGS Alfred Needler and are not included except for 3Ps in 2018. The surveys in 3L were incomplete in 2015 and 2017.

Year	3L	3N	3O	3Ps	3LNOPs
Engel series - Campelen Equivalents					
1984	7,574	25,226	24,615	9,417	66,832
1985	63,081	45,278	50,123	55,214	213,697
1986	51,231	53,394	21,134	36,153	161,911
1987	39,151	33,538	34,041	28,113	134,844
1988	35,030	26,474	42,991	19,043	123,538
1989	40,350	30,030	17,678	25,863	113,921
1990	43,938	71,656	40,118	21,344	177,055
1991	34,779	44,549	35,195	50,254	164,777
1992	37,475	20,645	35,567	21,510	115,198
1993	27,765	17,068	15,025	21,580	81,437
1994	15,999	17,565	19,105	19,221	71,891
1995	9,320	7,017	26,781	19,493	62,611
Campelen Series					
1996	10,418	10,636	22,731	25,591	69,376
1997	6,804	13,554	25,635	18,379	64,372
1998	7,764	10,140	34,130	22,781	74,815
1999	8,263	15,967	36,042	20,212	80,484
2000	12,512	16,027	28,525	18,574	75,638
2001	8,521	16,276	33,321	17,606	75,724
2002	5,920	8,469	32,902	17,560	64,851
2003	6,737	9,645	34,734	24,615	75,732
2004	4,762	8,925	21,153	24,256	59,095
2005	11,011	15,986	26,621	26,399	80,016
2006	8,450	23,618	17,778		49,846
2007	11,357	24,065	23,317	11,440	70,180
2008	10,572	14,477	22,738	31,239	79,027
2009	5,810	15,560	18,132	19,128	58,629
2010	10,964	20,714	32,747	26,447	90,872
2011	7,226	12,731	31,576	23,409	74,942
2012	13,342	15,866	24,268	21,848	75,324
2013	10,681	20,682	35,416	35,067	101,846
2014					
2015	5,265	10,500	23,590	21,535	60,889
2016					
2017	85	25,020	23,173	40,199	88,476
2018				25,431	
2019	11,649	12,979	37,315	19,740	81,684

Table 4. Biomass (t) of Thorny Skate from Canadian spring research surveys in Divs. 3LNOPs, 1984-2019. Surveys were conducted with an Engel trawl (1984-1995; converted to Campelen-equivalents), and a Campelen trawl (1996-2019). The surveys in 2014, 2016, 2018 were completed in part by the CCGS Teleost which has been found to not be comparable to the CCGS Wilfred Templeman and the CCGS Alfred Needler and are not included except for 3Ps in 2018. The surveys in 3L were incomplete in 2015 and 2017.

Year	3L	3N	3O	3Ps	3LNOPs
Engel series - Campelen Equivalents					
1984	17,269	57,720	61,026	20,318	156,333
1985	102,351	86,438	110,322	36,954	336,065
1986	69,864	110,325	46,634	47,728	274,551
1987	82,037	60,535	51,007	40,697	234,276
1988	70,143	49,686	87,375	29,993	237,197
1989	73,291	49,142	40,172	44,271	206,875
1990	45,312	47,479	61,946	24,264	179,002
1991	22,197	28,925	99,003	61,534	211,659
1992	11,945	23,047	57,929	38,693	131,615
1993	8,546	18,550	35,113	16,256	78,465
1994	3,920	10,193	28,874	16,539	59,526
1995	2,798	2,824	32,323	24,924	62,869
Campelen Series					
1996	4,993	11,010	35,529	21,851	73,382
1997	3,969	9,703	28,293	20,705	62,669
1998	5,807	13,186	42,351	28,629	89,972
1999	7,266	26,254	54,045	32,062	119,626
2000	14,011	27,861	40,917	22,528	105,317
2001	10,383	29,197	59,078	24,566	123,223
2002	8,580	13,986	38,025	22,127	82,718
2003	8,411	18,216	49,707	37,072	113,406
2004	7,806	20,425	39,740	38,354	106,325
2005	19,266	33,757	46,515	32,702	132,240
2006	16,193	56,698	25,252		98,143
2007	25,044	54,188	48,369	21,080	148,682
2008	23,344	32,196	42,220	38,509	136,270
2009	7,765	29,478	52,619	27,788	117,651
2010	14,944	34,303	68,435	39,968	157,650
2011	10,046	21,239	57,020	44,310	132,615
2012	14,828	38,621	53,443	33,699	140,592
2013	11,713	43,547	76,358	34,455	166,072
2014					
2015	7,178	23,031	69,703	34,788	134,701
2016					
2017	277	36,484	55,096	46,290	138,146
2018				48,339	
2019	11,860	19,019	72,605	37,211	140,695

Table 5. Abundance (000s) of Thorny Skate from Canadian spring research surveys in Divs. 3LNOPs (2022-2023). The survey in 3L was incomplete in 2022.

Year	3L	3N	3O	3Ps	3LNOPs
2022	11,259	27,025	18,700	29,106	86,090
2023	14,930	27,079	36,695		

Table 6. Biomass (t) of Thorny Skate from Canadian spring research surveys in Divs. 3LNOPs (2022-2023). The survey in 3L was incomplete in 2022.

Year	3L	3N	3O	3Ps	3LNOPs
2022	19,775	63,511	63,649	79,956	226,891
2023	23,460	60,307	78,686		

Table 7. Abundance (000s) of Thorny Skate from Canadian fall research surveys in Divs. 3LNO, 1995-2020. Surveys were conducted with a Campelen trawl. Divs. 3NO were not surveyed in 2014; as well as deep-water strata (>732 m) of Div. 3L in 2015, 2017-2018.

Year	Div. 3L	Div. 3N	Div. 3O	3LNO
Campelen Series				
1995	23,299	37,322	30,582	91,203
1996	23,483	22,694	45,145	91,321
1997	13,448	30,540	50,047	94,035
1998	8,917	21,132	29,785	59,834
1999	10,448	25,116	31,847	67,411
2000	12,536	31,419	39,918	83,873
2001	12,655	21,352	42,095	76,103
2002	7,541	30,925	24,488	62,954
2003	9,363	19,203	34,556	63,121
2004	6,369	21,068	32,343	59,780
2005	11,346	20,027	30,553	61,927
2006	8,888	23,211	27,688	59,787
2007	13,372	36,453	29,768	79,594
2008	15,856	48,011	40,944	104,811
2009	17,145	28,813	42,965	88,922
2010	18,429	30,859	28,137	77,426
2011	16,841	26,907	36,711	80,459
2012	21,202	30,226	51,813	103,240
2013	15,693	25,196	35,785	76,674
2014	24,555			24,555
2015	12,555	30,530	20,287	63,372
2016	17,646	33,054	26,358	77,058
2017	20,499	34,883	31,239	86,621
2018	19,432	44,457	31,515	95,403
2019	18,322	29,031	44,760	92,113
2020	22,220	62,204	25,172	109,596

Table 8. Biomass (t) of Thorny Skate from Canadian fall research surveys in Divs. 3LNO, 1995-2020. Surveys were conducted with a Campelen trawl. Divs. 3NO were not surveyed in 2014; as well as deep-water strata (>732 m) of Div. 3L in 2015, 2017-2018.

Year	Div. 3L	Div. 3N	Div. 3O	3LNO
Campelen Series				
1995	11,306	40,775	44,653	96,734
1996	14,459	28,629	36,969	80,057
1997	7,534	43,075	58,160	108,770
1998	9,205	34,279	39,280	82,764
1999	13,614	32,609	42,608	88,831
2000	17,722	61,202	40,861	119,786
2001	16,420	34,311	62,156	112,886
2002	11,068	52,855	40,593	104,517
2003	14,463	36,829	46,123	97,416
2004	11,327	45,678	26,361	83,366
2005	20,107	37,442	61,595	119,143
2006	18,610	54,372	50,605	123,587
2007	30,089	70,198	56,976	157,263
2008	27,182	83,861	75,892	186,935
2009	22,848	40,801	63,200	126,849
2010	21,051	27,270	54,857	103,178
2011	16,150	51,955	69,053	137,158
2012	19,124	43,739	107,777	170,640
2013	20,752	44,160	92,042	156,954
2014	20,283			20,283
2015	19,540	66,638	48,720	134,898
2016	22,921	61,263	55,231	139,415
2017	23,568	65,010	65,422	154,000
2018	28,142	71,267	72,500	171,909
2019	24,403	56,070	91,278	171,750
2020	31,671	109,452	61,540	202,663

Table 9. Abundance (000s) of Thorny Skate from Canadian fall research surveys in Divs. 3LNO, 2023.

Year	Div. 3L	Div. 3N	Div. 3O	3LNO
Modified Campelen Series				
2023	24,847	71,742	42.6	139.19

Table 10. Biomass (t) of Thorny Skate from Canadian fall research surveys in Divs. 3LNO, 2023.

Year	Div. 3L	Div. 3N	Div. 3O	3LNO
Modified Campelen Series				
2023	42,468	144,365	94,280	281,113

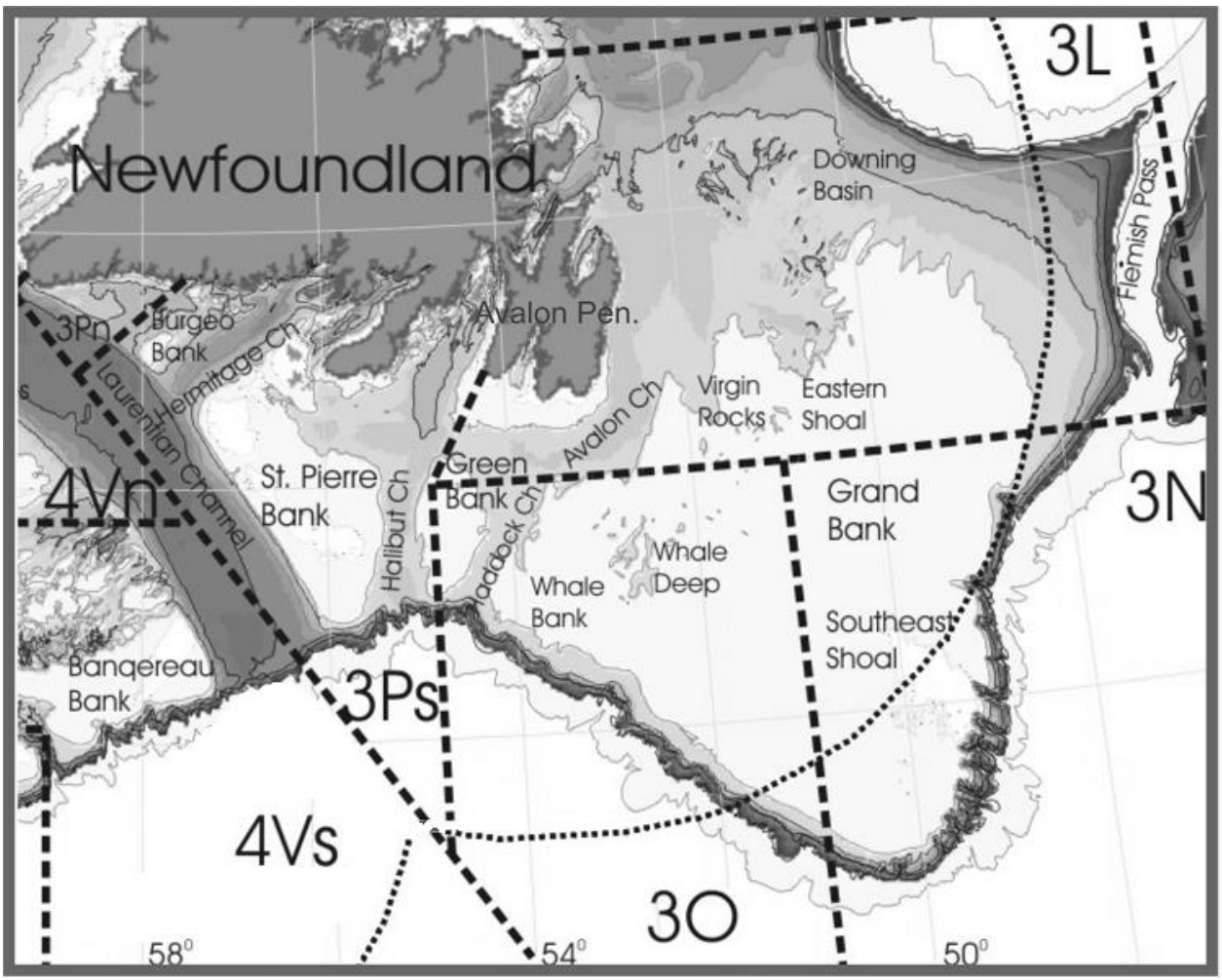

Figure 1. Map of NAFO Divisions 3LNO and Subdivision 3Ps (thick black dashed lines) in relation to Canada's Exclusive Economic Zone (thin black dotted curve).

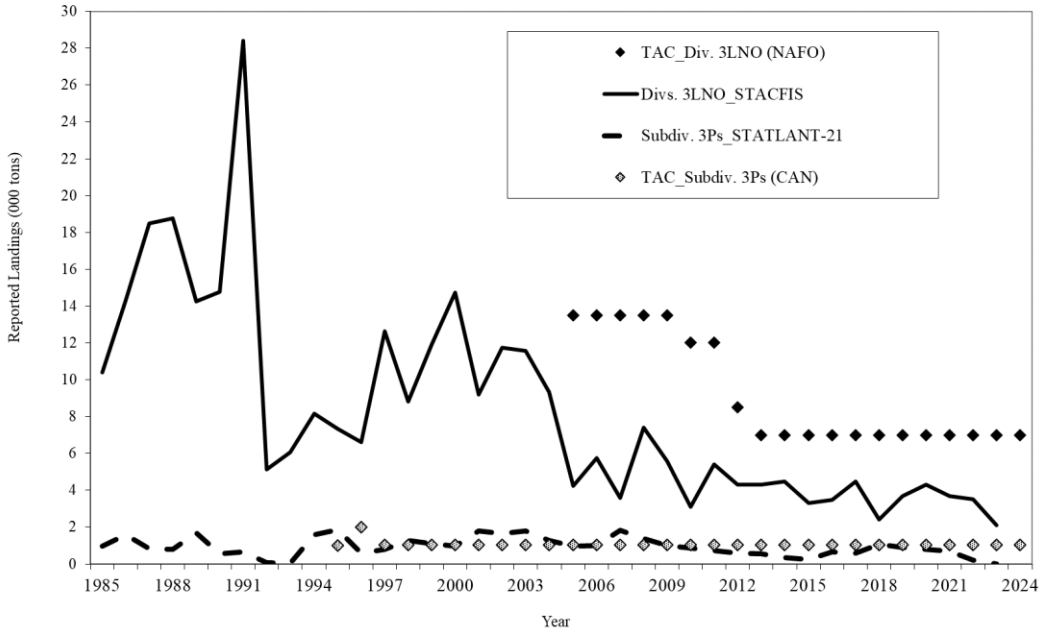

Figure 2. Total reported landings and Total Allowable Catch (TAC) of Thorny Skate in Divs. 3LNO (STACFIS) and Subdiv. 3Ps (STATLANT-21A), 1985-2024.

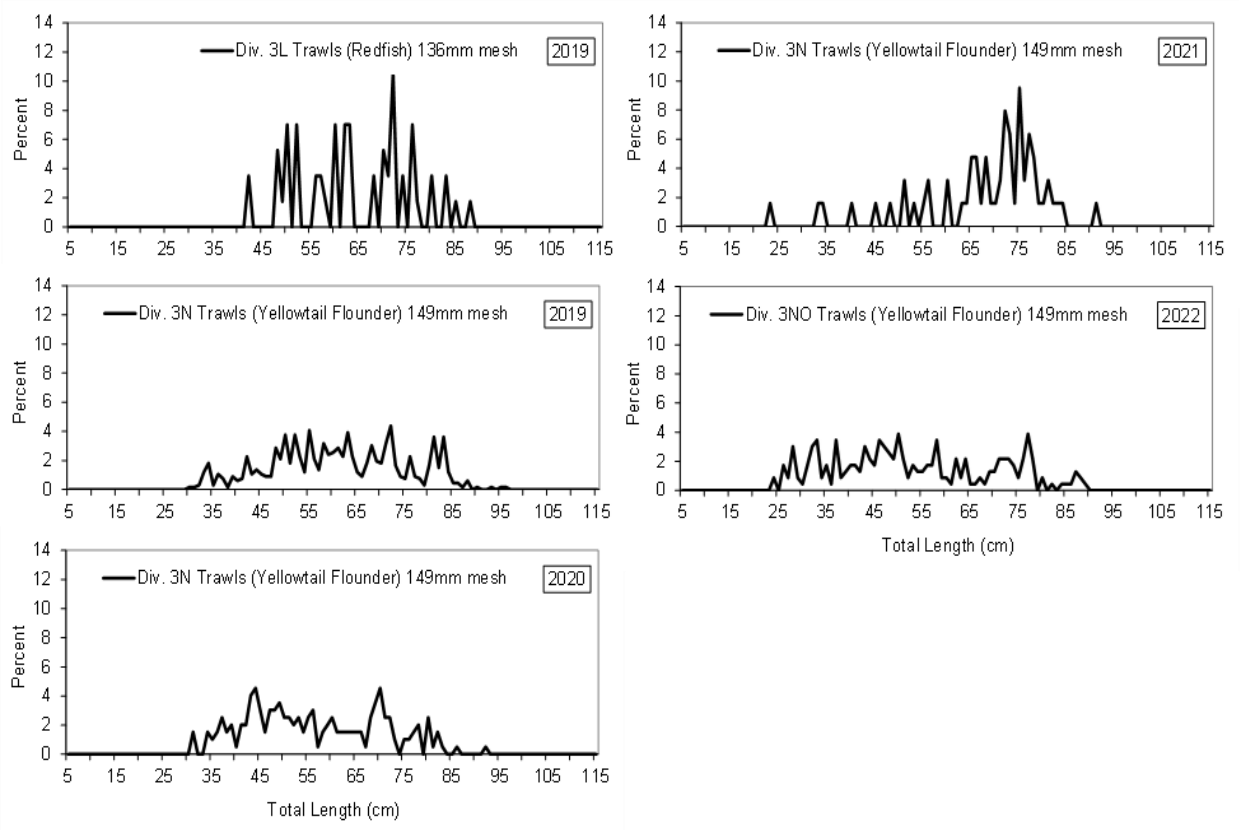

Figure 3. Length distributions of Canadian commercial catches (sexes combined) in NAFO Divs. 3LNO from skate bycatch fisheries, 2019-2022. Data are from Canadian At-Sea Fisheries Observers, and include discards.

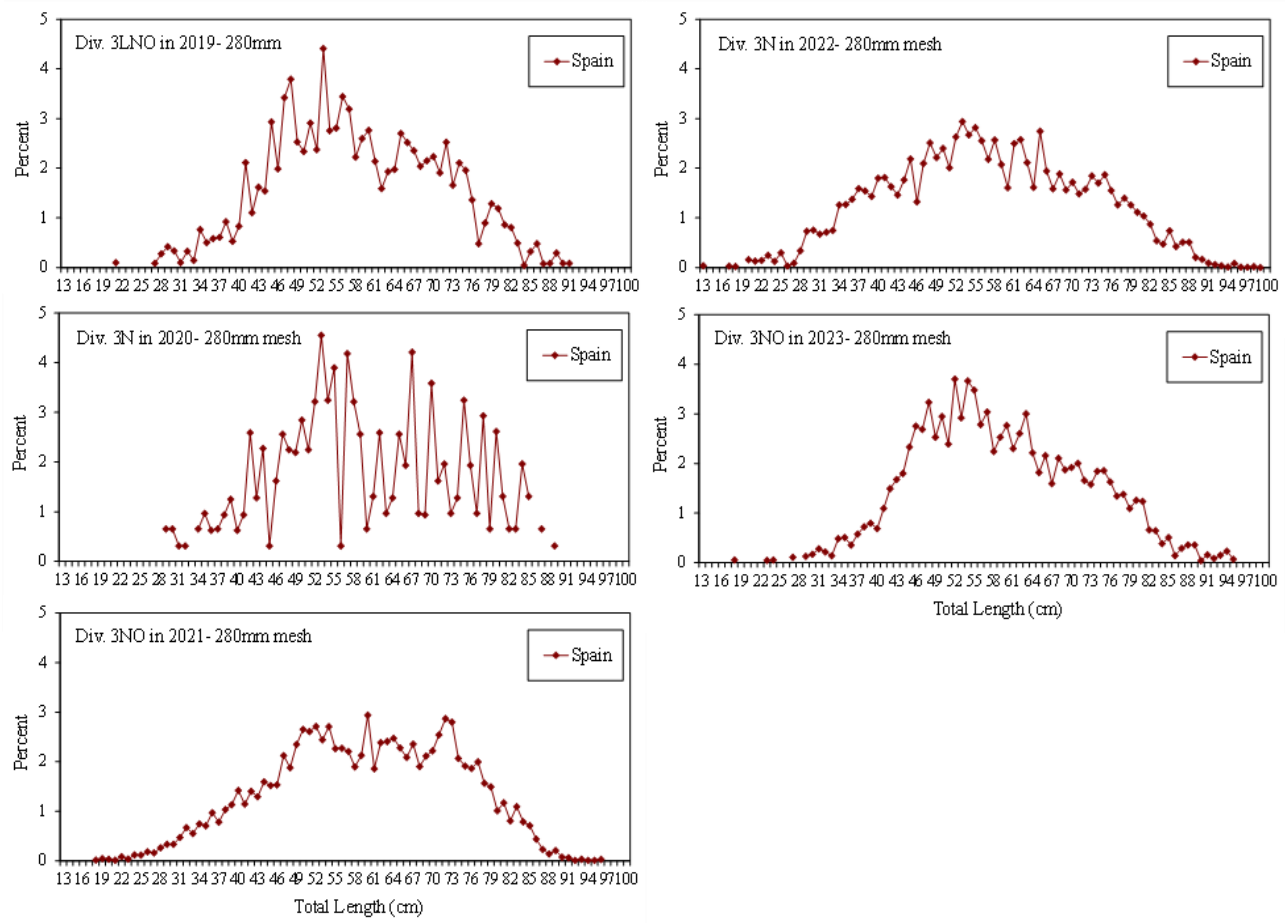

Figure 4. Length distributions of commercial catches (sexes combined) in Divs. 3LNO by country for the skate-directed (280 mm) trawl fishery, 2019-2023.

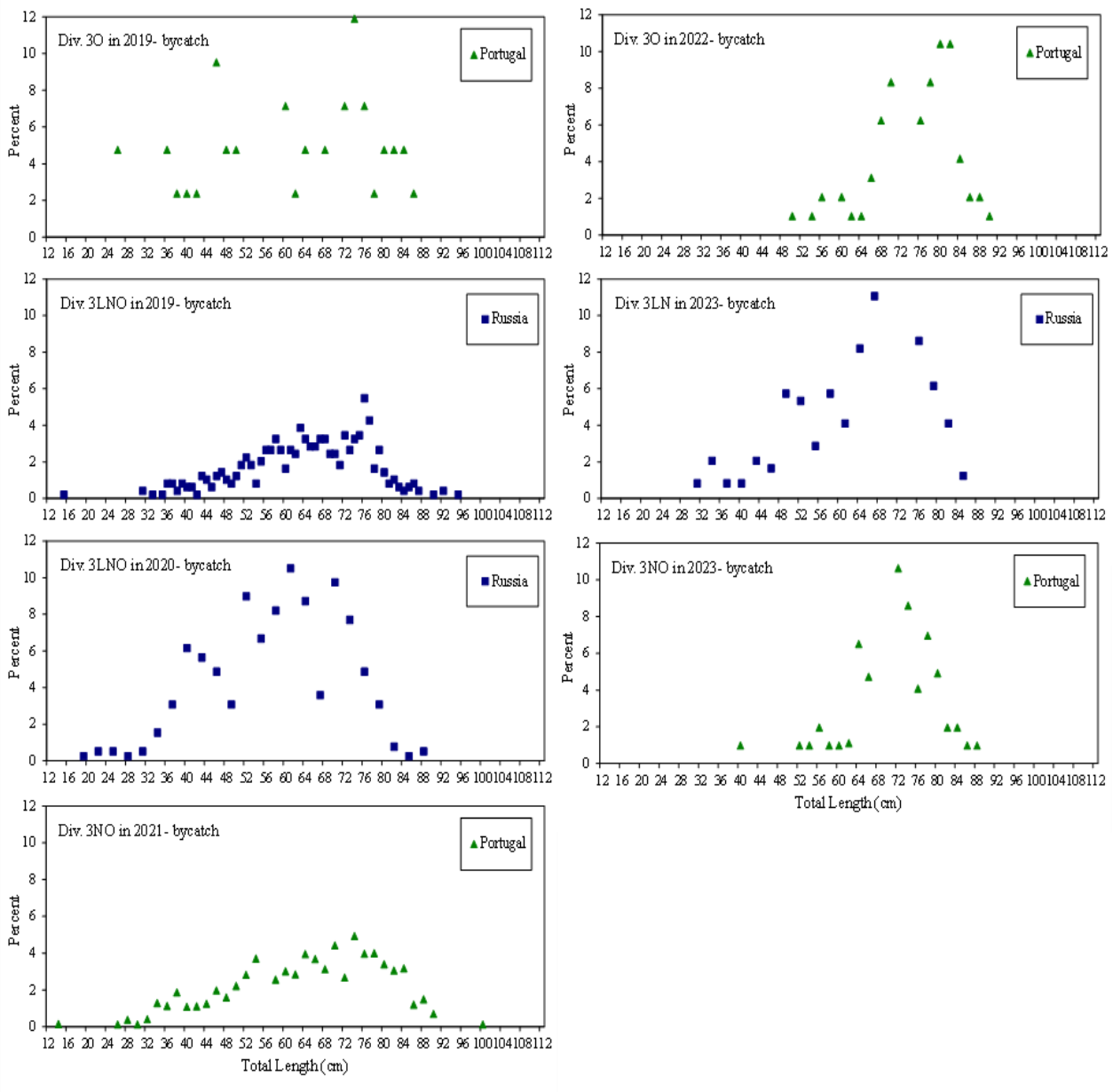

Figure 5. Length distributions of commercial catches (sexes combined) in Divs. 3LNO by country for skate bycatch (130 mm) trawl fisheries in 2019-2023.

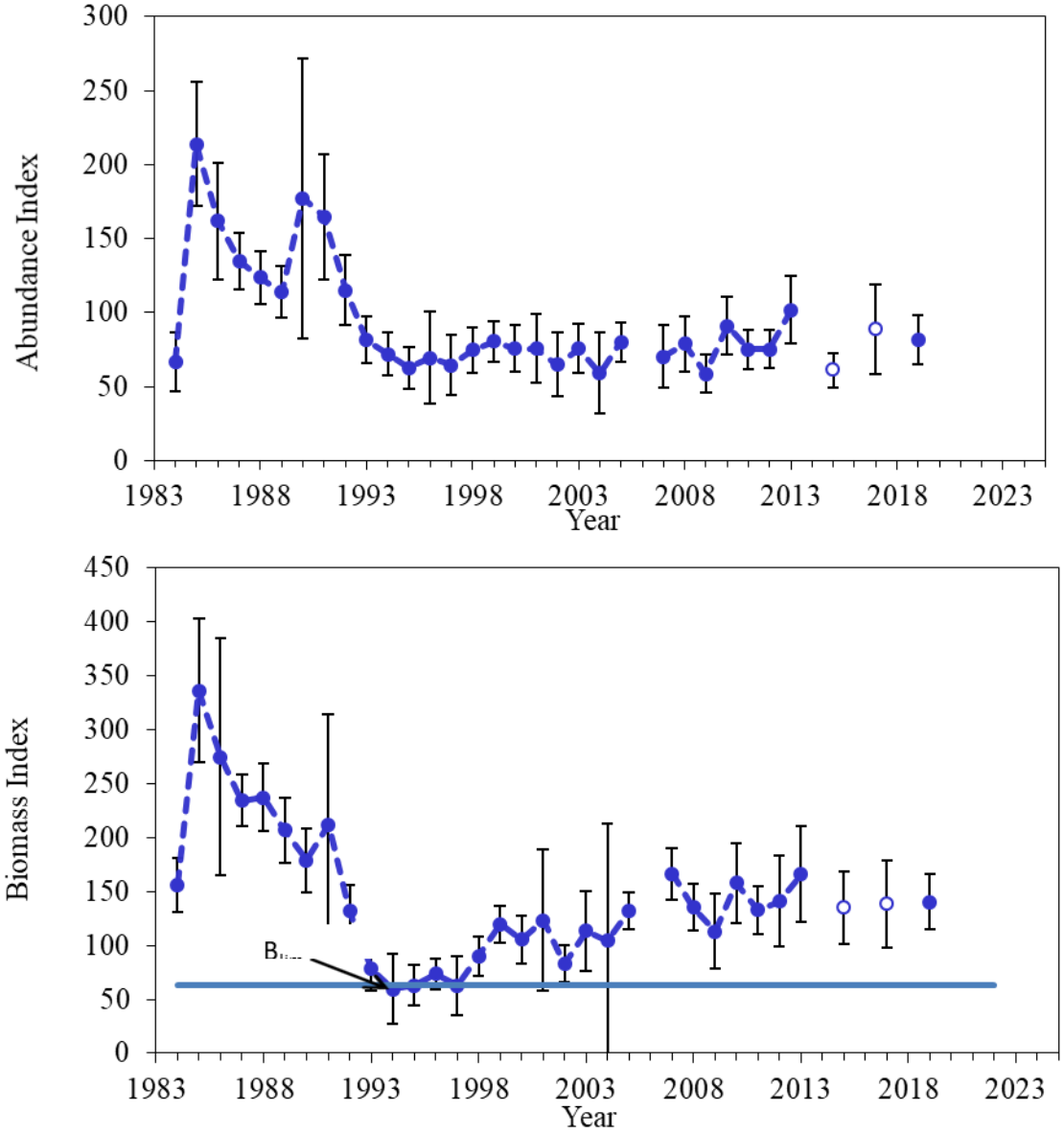

Figure 6. Relative biomass and abundance indices for Thorny Skate from Canadian spring research surveys in NAFO Divs. 3LNOPs, 1983-2019. Divs. 3LNO were not surveyed in 1983; the deeper (>103 m) portion of Divs. 3NO, as well as Subdiv. 3Ps, were not surveyed in 2006; and Div. 3L was not completely surveyed in 2015 and 2017. The survey in 2014, 2016, and 2018 were completed largely on the CCGS Teleost, which is not comparable to the other vessels.

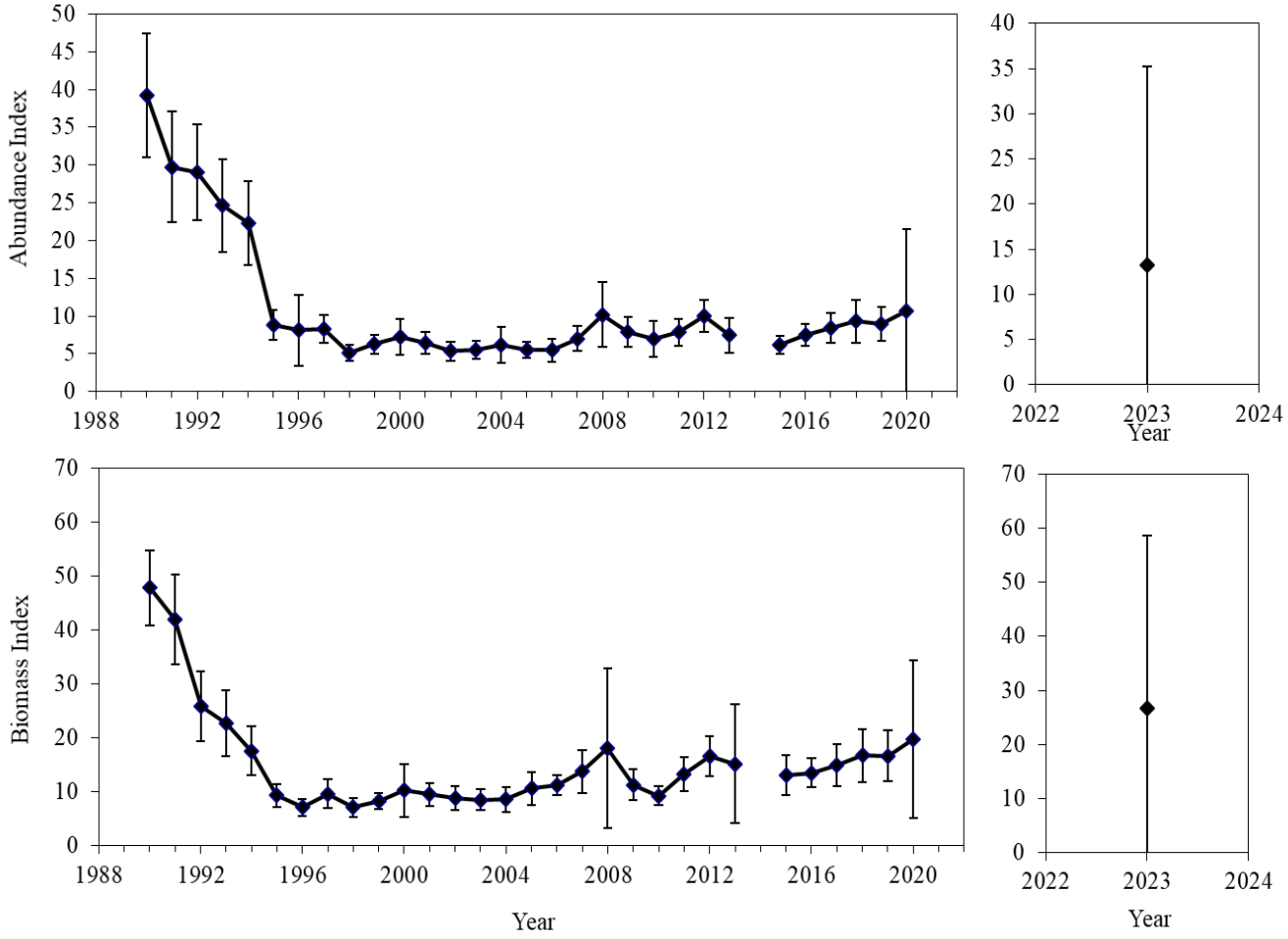

Figure 7. Canadian fall research survey biomass and abundance indices for Thorny Skate in NAFO Divs. 3LNO, 1990-2019. Deep strata of Divs. 3NO were not surveyed in 2003, 2004, 2006, 2008; both Divisions were not surveyed in 2014; as well as deep strata of Div. 3L in 2015, 2017-2018.

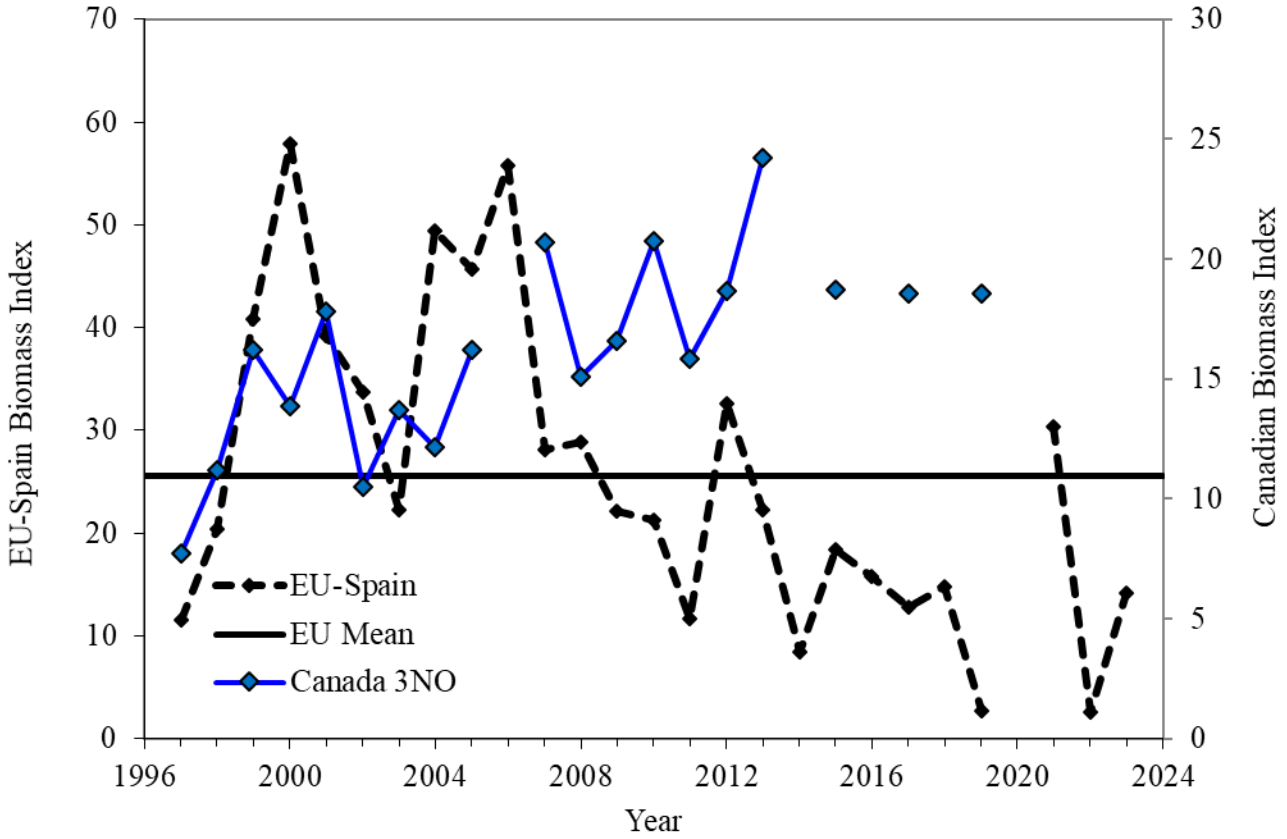

Figure 8. Comparison of Thorny Skate biomass indices from the Canadian Campelen spring survey and the Spanish spring survey in Divs. 3NO, 1997-2023. Note that Divs. 3NO were not surveyed by Canada in 2014, and Spanish surveys occur only in the NAFO Regulatory Area (NRA) of Divs. 3NO. The survey in 2014, 2016, and 2018 were completed largely on the CCGS Teleost, which is not comparable to the other vessels.

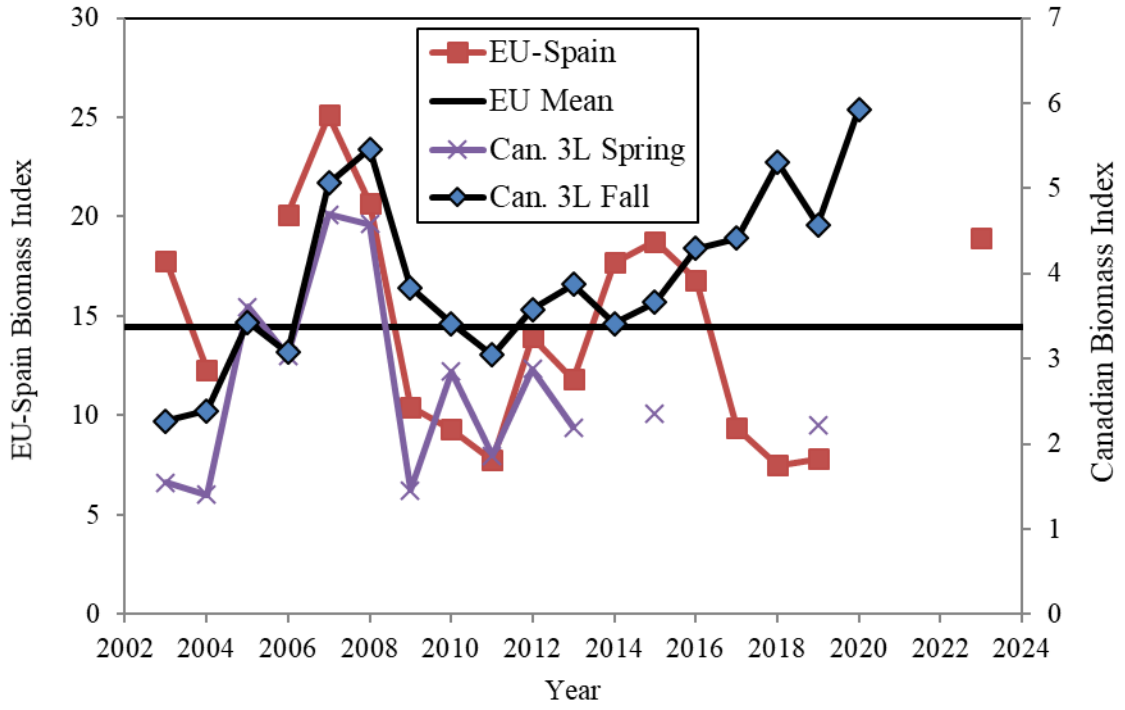

Figure 9. Comparison of Thorny Skate biomass indices from Canadian Campelen surveys and the Spanish summer survey in Div. 3L, 2003-2023. The Canadian spring survey was incomplete in 2015 and 2017; as well as Canada's fall survey of Div. 3L (deep-water) in 2015, 2017-2018; and Spanish surveys occur only in the NAFO Regulatory Area (NRA) of Div. 3L. Spring surveys in 2014, 2016, and 2018 were completed largely on the CCGS Teleost, which is not comparable to the other vessels.

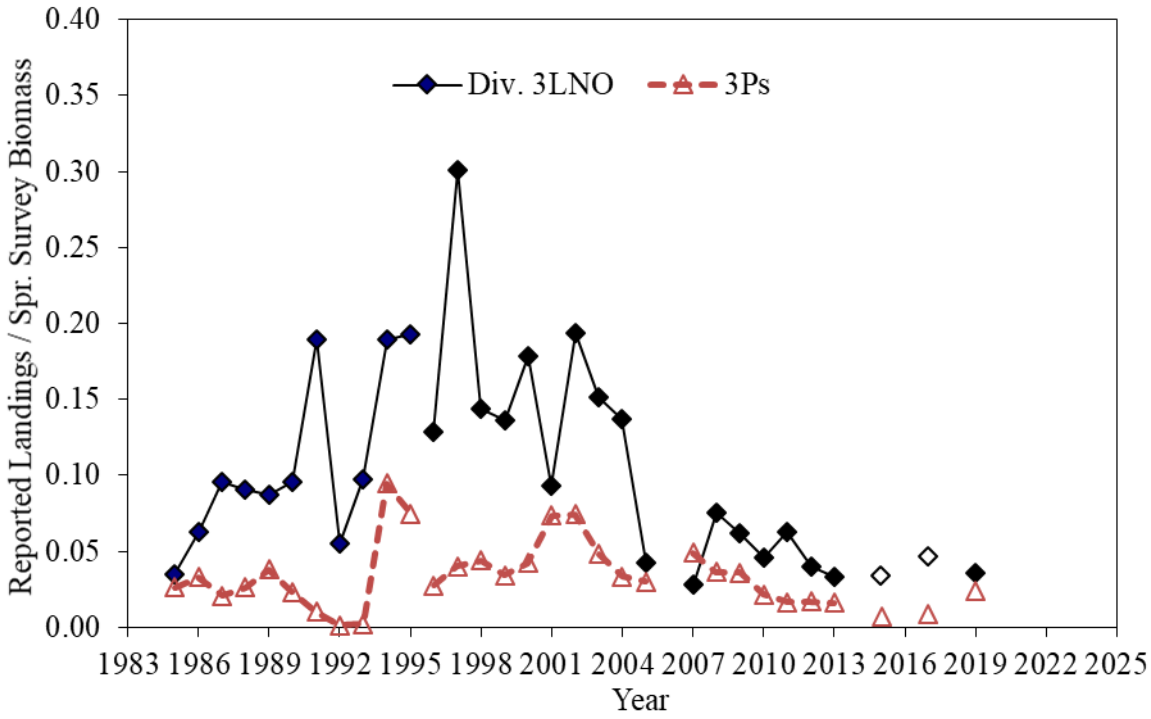

Figure 10. Fishing Mortality Index (reported landings/spring survey biomass) for Divs. 3LNO and Subdiv. 3Ps, 1985-2019. Commercial landings are STACFIS-agreed; biomass indices are from Canadian spring research surveys. The deeper (>103 m) portion of Divs. 3NO, as well as Subdiv. 3Ps, were not surveyed in 2006. The Div. 3L survey was incomplete in 2015 and 2017. The survey in 2014, 2016, and 2018 were completed largely on the CCGS Teleost, which is not comparable to the other vessels.

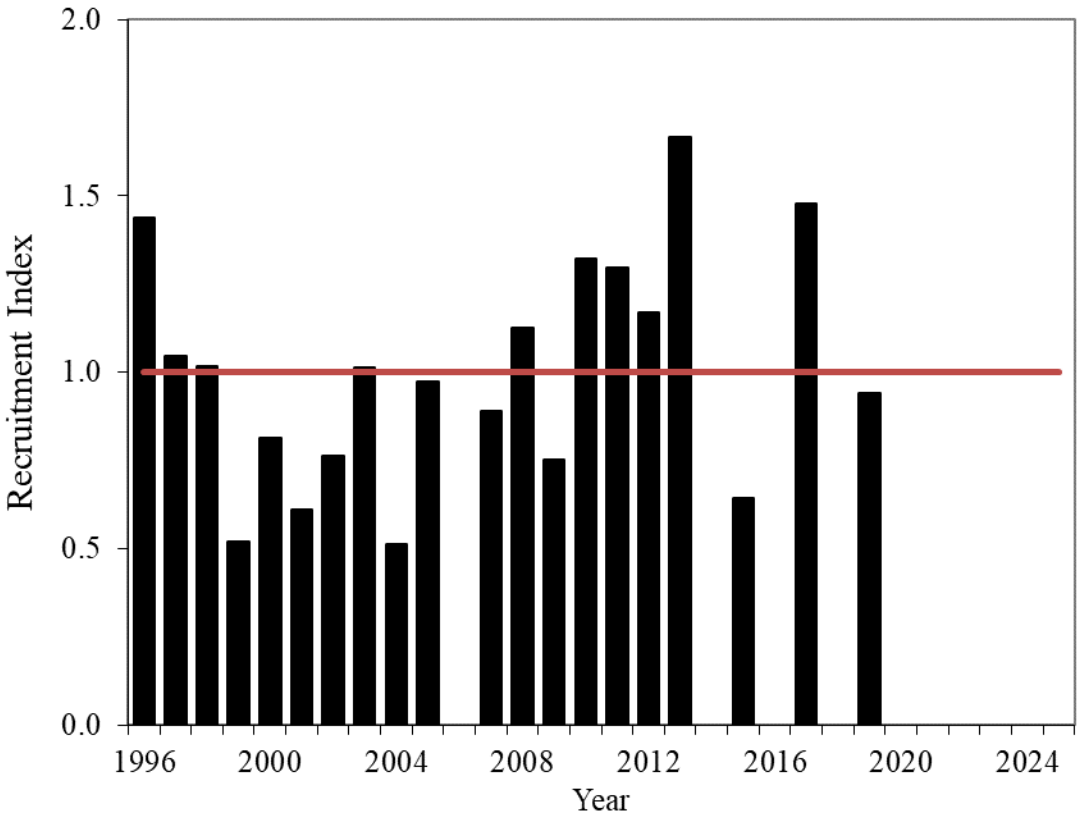

Figure 11. Standardized recruitment index (Thorny Skate ≤21 cm) from Canadian spring surveys in Divs. 3LNOPs, 1996-2019. The deeper portion (>103 m) of Divs. 3NO, as well as Subdiv. 3Ps, were not surveyed in 2006. The Div. 3L survey was incomplete in 2015 and 2017. The surveys in 2014, 2016, and 2018 were conducted mainly on the CCGS Teleost which is not comparable to the other vessels. The red, horizontal line depicts the standardized average recruitment for 1996-2019. The survey in 2014, 2016, and 2018 were completed largely on the CCGS Teleost, which is not comparable to the other vessels.

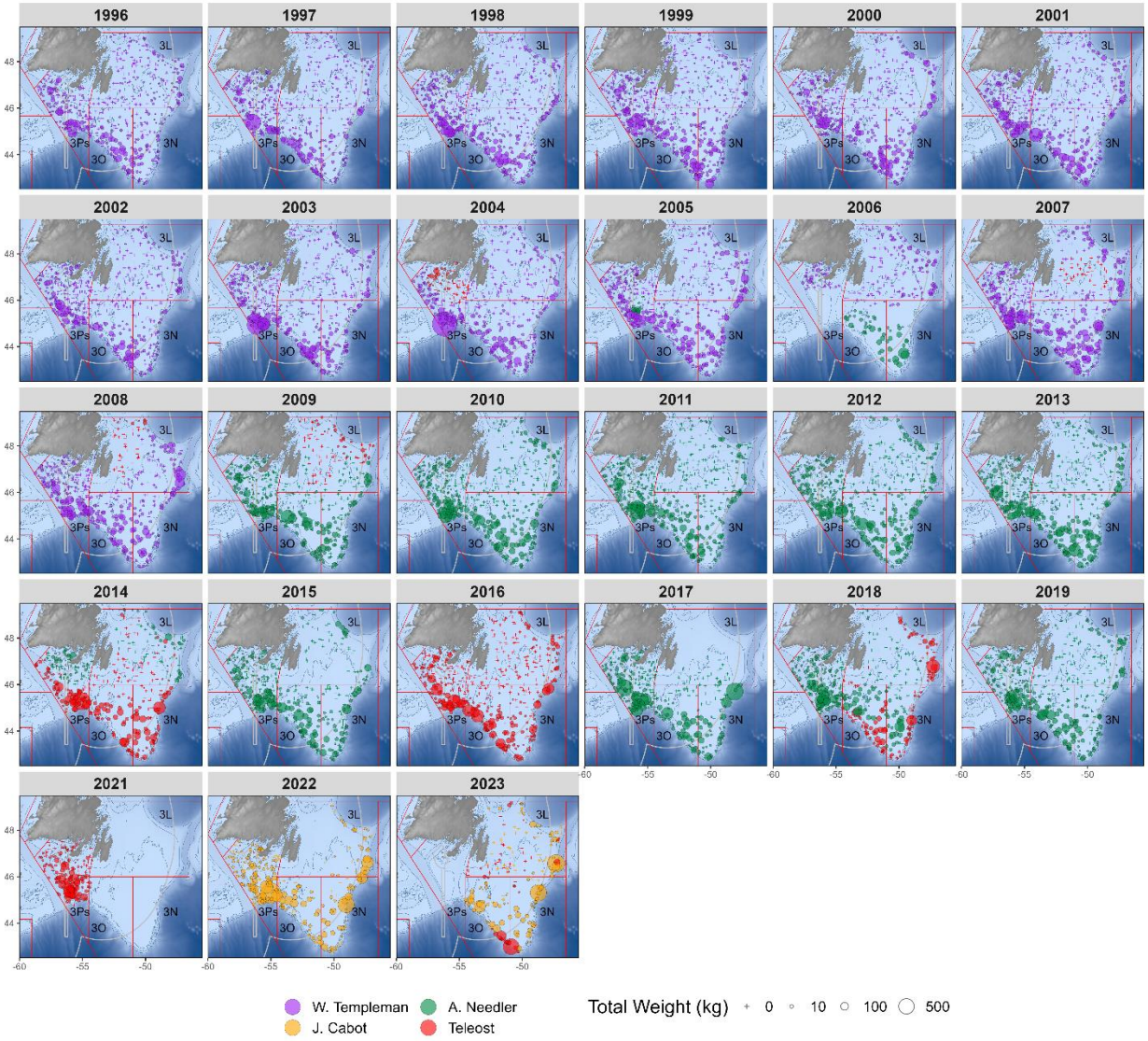

Figure 12. Distribution (weight (kg) per tow) of Thorny Skate on the Grand Banks (Divs. 3LNO) during Canadian spring surveys, 1996-2023. The magnitude of the catches is only comparable between the green and the purple.

Figure 13. Distribution (weight (kg) per tow) of Thorny Skate on the Grand Banks (Divs. 3LNO) during Canadian fall surveys, 1995-2023. The magnitude of the catches is only comparable between the green and the purple and the yellow and the brown.