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**Newfoundland and Labrador Region**

**An Assessment of Witch Flounder (*Glyptocephalus cynoglossus*) in NAFO  
Subdivision 3Ps from Catch and Survey Information**

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## Foreword

This series documents the scientific basis for the evaluation of aquatic resources and ecosystems in Canada. As such, it addresses the issues of the day in the time frames required and the documents it contains are not intended as definitive statements on the subjects addressed but rather as progress reports on ongoing investigations.

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## ABSTRACT

Information available to evaluate stock status of Witch Flounder (*Glyptocephalus cynoglossus*) in NAFO Subdivision 3Ps consisted of commercial landings data (1974-2017) and information from Canadian RV trawl surveys (1983-2017). The TAC for this stock has been 650 t since 1998. Annual landings from the past 3 years have averaged 472 t, an increase over the previous 3 year period where landings averaged 196 t. Length composition from the fishery has remained stable, with a mode near 40 cm. Witch flounder were found to predominately occupy waters from 100-500 m in depth, in relatively warm waters with bottom temperature of 5-7°C. The availability of thermal habitat within this preferred range in Subdivision 3Ps has fluctuated throughout the time series, but has been consistently higher than average since 2010. Patchy distribution of this species in the spring - associated with pre-spawning aggregations - contributes to large inter-annual variation in survey indices. A large tow in each of the 2016 and 2017 spring RV surveys resulted in indices of biomass and abundance at, or near, time series highs. However, each of these survey indices is associated with a high degree of uncertainty. A proxy for  $B_{MSY}$  in this stock was calculated as the geometric mean of survey biomass indices from 1983-1993. Consequently – and consistent with the DFO decision making policy – an interim Limit Reference Point was adopted at 40%  $B_{MSY}$ . The stock is currently above the LRP, and has been in most years of the time series (1983-2017).

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## COMMERCIAL FISHERY

### DESCRIPTION OF THE FISHERY

The Witch Flounder fishery in NAFO Subdivision 3Ps (Fig. 1) began in the early 1950s, with an inshore Danish seine fishery in Fortune Bay. Declines in catch rates in Fortune Bay by the mid-1950s led to a shift in the fishery, with trawlers targeting the southwest slope of St. Pierre Bank, and bycatch being landed from Burgeo Bank in the Atlantic Cod, Redfish, and American Plaice fisheries (Bowering 1977; Bowering 1981).

Presently, Witch Flounder are landed from both directed effort and as bycatch from other fisheries. The inshore fishery operates primarily with Danish seines in the area around Hermitage Bay. The majority of directed landings come from the offshore, where otter trawls are used to fish shelf slope waters along the southeast portion of St. Pierre Bank; this offshore area has been targeted since the early 1990s (Bowering 1999). The commercial fishery for Witch Flounder typically targets dense aggregations found during the spawning season.

Due to *Privacy Act* provisions, landings are only presented for the stock as a whole, and cannot be presented by fleet, season, or unit area. Bycatch within the directed witch flounder fishery can also not be reported on.

The TAC for 3Ps Witch Flounder has been 650 t since 1998 (Fig. 2), and is shared between Canada (88.7%) and France (11.3%). Total landings fluctuated between 500 and 1,500 t from the early-1970s to the early-1990s, and between 170 and 600 t from the mid-1990s to the present (Table 1). During the past 3 years, annual landings averaged 472 t, an increase over the previous 3 year period where landings were among the lowest in the time series, averaging 196 t.

### LENGTH COMPOSITION

Commercial length frequencies are obtained from a combination of at-sea observers and port sampling, from both the offshore otter trawl fleet (Fig. 3) and inshore Danish seiners (Fig. 4). However, not all sampling types are available for all gears in all years. Commercial sampling has been unavailable from the Danish Seine fishery since 2014, and measurements were limited (2-8 length frequencies annually) in years previous to that. Recent size compositions are therefore based only on measurements taken by observers in the otter trawl fishery. Length composition of the commercial catch changed relatively little from 2014-17, with most of the Witch Flounder catch comprised of fish in the range of 30-50 cm with modes near 40cm. The current fishery covers a similar length range as reported in earlier assessments of this stock (e.g. Bowering 1977; Maddock Parsons and Rideout 2014). These length distributions are largely reflective of gear selectivity, but consistency over time suggests some stability in the availability of fish within this size range. Length distribution of the commercial catch relative to size-at-maturity from annual RV surveys suggests the fishery primarily harvests mature individuals (Figs. 3 and 4).

## RESEARCH VESSEL SURVEYS

### SURVEY BIOMASS AND ABUNDANCE INDICES

Indices of abundance (Tables 2 and 3) and biomass (Tables 4 and 5) are obtained from annual stratified random bottom trawl surveys (RV surveys) completed in the spring in NAFO

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subdivision 3Ps from 1983-2017 (Fig. 5). Details on the calculation of indices from these surveys can be found in Smith and Somerton 1981.

Data from surveys completed from 1972-1982 used a different survey gear type (Yankee 41 Shrimp trawl), and are not considered comparable to more recent surveys as no conversion factors are available. Surveys from 1983-95 used an Engel 145 High Rise otter trawl. The gear was switched to a Campelen 1800 shrimp trawl using rockhopper footgear before the 1996 survey. Full details on various survey trawls used can be found in McCallum and Walsh 1997. Data presented here are based on Engel 145 data converted to Campelen 1800 equivalents for 1983-95 and true Campelen 1800 data for 1996-2017.

The timing of the survey has varied through the time series. Surveys in 3Ps occurred in April and May from 1983-87. This was followed by a sustained period of winter surveys (late-January to February) from 1988-93, and a subsequent shift back to spring (late-March to May) post-1993. The impact of this variation in survey timing on the scale of the survey indices is uncertain. In 1993 both a winter (February) and spring (April) survey were undertaken, with higher abundance and biomass indices in the spring survey, and similar geographic distribution of the catch in both surveys (Fig. 6). However, given only one year with survey coverage in both winter and spring, data are inconclusive with regard to potential impacts of survey timing shifts on stock indices.

Survey coverage was expanded to cover additional strata in the inshore area in 1994 (strata 779-783) and 1997 (strata 293-300). No Witch Flounder were caught in the added inshore strata between 1994-96. Indices from 1983-96 are adjusted based on the geometric mean proportion of biomass and abundance found in inshore strata since the full establishment of the survey in the inshore (1997-2017), in order to account for the potential underestimation of stock size prior to expansion of the survey coverage (Table 6).

The 2006 survey was incomplete and is therefore excluded from analyses.

Indices of biomass and abundance for this stock have varied without trend throughout the time series. In the most recent years (2016, 2017), these indices have increased to levels at or near a time series high (Fig. 7). However, estimates of survey biomass and abundance in these two years are associated with a high degree of uncertainty, with values being driven by a single large tow in each year (Table 7). The large tow observed in each of the 2016 (strata 296, Fortune Bay) and 2017 (strata 319, SE slope of St. Pierre Bank) surveys accounted for 59% and 51% of overall survey catch by weight, respectively, and were comprised of fish primarily in spawning or pre-spawning condition. This suggests these large tows were taken from pre-spawning aggregations typical of this stock in the spring, and was therefore from a highly concentrated portion of the stock.

The large tows and resulting high uncertainty are not uncommon for this stock; similarly high levels of uncertainty in indices resulting from a concentration of the survey catch have been previously observed for this stock (1984, 1990, 1992, and 2007). Witch Flounder form dense aggregations during the pre-spawning and spawning period, which coincides with the current RV survey timing in NAFO Subdivision 3Ps (Templeman 1966; Bowering 1990). The degree of aggregation in the stock at the time of the survey is likely to impact variation in catches within the survey, and uncertainty in resulting biomass and abundance indices.

## **LENGTH COMPOSITION**

Length composition of Witch Flounder caught in the spring RV survey has shown a relatively broad distribution, with the majority of the abundance occurring at lengths of 20-40 cm, and maximum lengths observed exceeding 50 cm in all surveys since 2000 (Fig. 8). There has been

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a general increase in the mode of survey length frequencies since 2011, with a shift from a mode at 24 cm in 2011 to 36 cm by 2017. Length composition of the survey catches in 2016 and 2017 were driven by fish captured in each of the two large sets described above, with modes of the length frequencies from these sets 12cm and 6cm greater than the rest of the survey in 2016 and 2017 respectively (Fig. 9). Overall, length frequencies indicate a broadening length distribution, and a greater number of larger fish in the population in recent years.

As Witch Flounder are a slow-growing, long-lived fish, data do not allow reliable tracking of individual cohorts through length frequencies. Age data have been unavailable for this stock since 1994.

## **DISTRIBUTION**

Cumulative distributions of Witch Flounder from the spring RV survey were computed relative to both bottom temperature (Fig. 10) and set depth (Fig. 11) to identify potential thermal habitat and depth preferences in this stock in the spring. Witch Flounder occurred predominantly in relatively warm waters of approximately 5-7°C (at or near the warmest waters available in the surveyed area), and were generally found between 100-500 m (Table 8). The area of thermal habitat available within this range in 3Ps has fluctuated through the time series, with a low of 1.54% of the surveyed area in 2007, and a high of 42.5% in 1984 (Fig. 12). This area has been increasingly prevalent in recent years, with the mean proportion of area >5°C since 2010 over twice the long term average (2010-17, geomean = 34.5%; 1983-2017, geomean = 15.8%), suggesting a recent expansion of the availability of preferred thermal habitat for this stock.

In Subdivision 3Ps, these depth and temperature ranges are largely associated with the shelf slope waters on the edges of St. Pierre Bank and towards Laurentian Channel (Fig. 1). The geographic distribution of Witch Flounder along these shelf edge waters has been consistent throughout the time series (Figs. 13-15), and coincides with reported spawning areas for this species in the spring (Bowering 1990).

The presence of a disproportionately large abundance of Witch Flounder was observed inshore in Fortune Bay in 2016 at a depth of 370m. Surveys in 2009 and 2011 also showed aggregations in this area, though to a lesser degree than the 2016 survey. Fortune Bay offers waters exceeding 500m in depth, coinciding with depth ranges occupied by Witch Flounder in the offshore shelf edge waters.

## **MATURITY**

Length at 50% mature (L50) was computed from maturity staging of Witch Flounder caught during the spring RV surveys since 1997. L50 has varied without trend throughout this time series, with a long-term mean L50 of 38.3 cm for females, and 27.6 cm for males. L50 for females declined in 2017 to a time series low of 33.1 cm (Fig. 16), however this is suspected to be a tow-effect resulting from the disproportionate influence of the single large tow in the 2017 survey, and may not reflect a population-level change.

As age data have been unavailable since 1994, it cannot be determined if there has been any shift in age-at-maturity in the stock. Changes in growth rates of the stock may lead to either younger (increased growth rate) or older (slower growth) fish maturing at a similar length, which would not be represented in L50 values. Current growth rates are unknown and require updated aging data from this stock.

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## PRE-RECRUIT INDEX

To examine recruitment trends, indices of abundance of pre-recruit fish (16-30 cm, with fish generally recruiting to the fishery at sizes >30 cm) were evaluated from RV survey data (Fig. 17). Following a period of relatively high pre-recruit abundance from 2009 to 2011, this index has been lower than average since 2012, with the exception of 2016 which was approximately 6% above the long term mean. However, the relationship between this pre-recruit size group and future exploitable biomass is unclear, and no stock-recruit relationship has been established for this stock.

## CATCH/BIOMASS RELATIONSHIP

A proxy index of fishing mortality was calculated as the ratio of fishing catch to RV survey biomass index in the same year (Fig. 18). This index has varied without trend throughout the time series, ranging from a high of 0.14 in 1993 to a low 0.017 in 2013. However, the fishery operates in a highly localized area on the southeast slope of St. Pierre Bank, with a relatively large portion of the stock distribution outside of the area targeted by the directed Witch Flounder fishery (i.e. within the Laurentian Channel). Therefore, the use of the catch/biomass index may not be an appropriate representation of fishing mortality in this case.

## LIMIT REFERENCE POINT

Several candidate Limit Reference Points (LRP) were proposed at the 2017 Stock Assessment (DFO 2018) based on assumptions about the potential level of stock biomass that would produce the Maximum Sustainable Yield ( $B_{MSY}$ ). As model-based estimates of  $B_{MSY}$  are not available for this stock, interim proxies were calculated based on the RV survey index of stock biomass. Five options were considered as potential  $B_{MSY}$  candidates based on annual RV survey biomass indices from:

- RV survey time series (1983-2017), pre-1997 converted for reduced inshore survey coverage;
- Spring RV survey series (1993-2017), pre-1997 converted for reduced inshore survey coverage;
- RV series during the time period with full inshore coverage (1997-2017);
- RV series from 1983-1993(winter), adjusted for reduced inshore survey coverage;
- The highest annual biomass estimate ( $B_{MAX}$ ) from the full time series (1983-2017).

The survey period from 1983-93 was chosen as the most appropriate period for the calculation of a  $B_{MSY}$  proxy, as the stock was not observed to decline under the range of harvest levels exerted on it during this time (landings ranged from 387 to 1,331 t), while survey indices varied without trend.  $B_{MSY}$  was therefore calculated as the geometric mean of survey biomass indices from 1983-93. Although two surveys took place in 1993 (winter and spring), the winter survey was used in the calculation of the mean survey biomass in order to be consistent with earlier values in the time series (1983-92). In order to be comparable to current surveys, values within the time series used for  $B_{MSY}$  were adjusted to account for increased survey coverage inshore after 1996 (as described above in “*Survey Biomass and Abundance Indices*”).

Consequently – and consistent with the DFO decision making policy – an interim LRP was accepted at 40%  $B_{MSY}$ . The stock has been at or above this  $B_{lim}$  level throughout the available time series (1983-2017) (Fig. 19).



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## SUMMARY

From 2014/15 to 2016/17, total annual landings averaged 472 t, over twice the average of the previous 3-year period, though remaining below the 650 t total allowable catch (TAC).

Size composition from the fishery has remained stable, primarily composed of fish 30-50 cm, with a peak near 40 cm.

Spring research vessel (RV) survey biomass and abundance indices in 2016 and 2017 are at or among the highest in the time series. However, each of these indices is highly influenced by a single large survey tow resulting in high uncertainty.

Pre-recruit abundance (16-30 cm) from the RV survey has varied without trend since 1996.

An interim Limit Reference Point (LRP) proxy of 40%  $B_{MSY}$  was adopted and is based on the geometric mean of the survey biomass from 1983-93 winter surveys.

The stock is currently above the LRP, and has been in most years of the time series (1983-2017). This stability indicates the stock was able to sustain the range of harvest rates over this time period.

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## TABLES

Table 1. Landings (t) of Witch flounder in subdivision 3Ps 1974-2016/17.

<b>Year</b>	<b>Total Catch</b>
1974	1786
1975	1428
1976	903
1977	4247
1978	1007
1979	854
1980	841
1981	469
1982	489
1983	387
1984	478
1985	597
1986	1329
1987	1273
1988	636
1989	927
1990	1044
1991	1331
1992	1130
1993	973
1994	431
1995	274
1996	256
1997	296
1998	501
1999	561
2000/01	571
2001/02	558
2002/03	546
2003/04	542
2004/05	543
2005/06	201
2006/07	198
2007/08	234
2008/09	589
2009/10	525
2010/11	199
2011/12	179
2012/13	239
2013/14	171
2014/15	484
2015/16	528
2016/17	404

<sup>1</sup> Management year changed from calendar year to April 1-March 31 in 2000.

Table 2. Abundance estimates (000s) of Witch Flounder by stratum for DFO spring RV surveys (Campelen equivalents for 1983-1995; Campelen units 1996-1999) in NAFO subdivision 3Ps.

Depth	Stratum	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993(w)	1993(s)	1994	1995	1996	1997	1998	1999
<=56	314	0	0	0	0	0	0	0	0	0	0	0	19	0	0	0	0	0	0
<=56	320	532	0	0	0	0	0	0	0	0	0	0	318	0	30	0	0	0	0
57-92	293	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0	0	0
57-92	308	0	0	0	0	0	31	0	0	0	0	0	0	0	0	0	0	0	8
57-92	312	0	75	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
57-92	315	284	796	0	265	0	341	179	0	0	0	0	0	0	0	0	0	16	72
57-92	321	0	0	0	0	0	0	0	0	0	0	0	0	0	0	73	0	0	0
57-92	325	0	26	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	16
57-92	326	0	0	-	0	0	0	0	0	0	0	0	0	0	0	0	0	23	0
57-92	783	-	-	-	-	-	-	-	-	-	-	-	-	0	-	-	0	0	0
93-183	294	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0	0	0
93-183	297	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	63	0	660
93-183	307	408	109	290	18	0	0	0	0	0	0	0	54	353	0	41	0	0	223
93-183	311	0	414	55	5945	15	240	58	0	44	0	15	0	33	87	0	0	15	1508
93-183	317	9779	16487	252	544	9	690	0	0	0	119	0	53	0	0	0	0	478	2217
93-183	319	445	338	68	761	587	457	4010		60	0	0	0	0	406	1339	15	1946	846
93-183	322	39	620	0	162	0	36	0	0	0	0	0	0	0	33	150	118	29	32
93-183	323	1548	48	319	19	383	38	41	0	0	0	0	0	0	0	22	24	207	46
93-183	324	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
93-183	781	-	-	-	-	-	-	-	-	-	-	-	-	0	0	0	0	0	0
93-183	782	-	-	-	-	-	-	-	-	-	-	-	-	0	0	-	0	0	13
184-274	295	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	661	1073	14
184-274	298	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	354	502	955
184-274	300	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	371	2421	1030
184-274	306	620	58	317	1114	144	43	134	0	922	115	58	29	86	100	1492	766	188	610
184-274	309	556	183	828	305	122	231	163	244	529	305	27	163	801	556	790	457	706	41
184-274	310	70	105	304	257	316	70	374	117	35	94	58	35	296	164	129	66	373	316
184-274	313	1687	193	340	375	125	863	863	4142	340	1997	329	1975	5062	3007	898	295	1291	363
184-274	316	6357	3874	4368	3952	4766	14975	5607	14403	143	14975		9940	1430	1729	6071	11128	4901	2590
184-274	318	1128	178		3443	178	1870	76		4661	102	288	4941	0	6548	719	311	825	201
184-274	779	-	-	-	-	-	-	-	-	-	-	-	-	0	0	0	0	19	82
184-274	780	-	-	-	-	-	-	-	-	-	-	-	-	0	0	-	0	0	156
275-366	296	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	352	191	102
275-366	299	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1492	2341	1721
275-366	705	957	429	912	1113	590	2106	1194	456	2133	1623	550	724	581	711	891	1019	1085	440

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Depth	Stratum	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993(w)	1993(s)	1994	1995	1996	1997	1998	1999
275-366	706	5998	3372	2488	4273	5147	3536	2063	5959	8299	6626	2728	5029	4240	7350	3318	2447	4551	1855
275-366	707	443	198		403	512	192	294		6141	2309	678	409	0	2698	75	59	148	23
275-366	715	751	163		209	309	327	890	36	0	163	45	413	295	660	471	72	76	44
275-366	716	1112	939	1691	4041	2373	2491	2892	3589	1987	2694	2002	1260	1394	756	5068	1598	2815	968
367-549	708	531	370		628	370	121	853		3275	467	660	225	1421	225	503	14294	193	29
367-549	711	10724	7852	11088	15114	6459	5760	9575	8593	9452	17582	3913	5526	3063	7260	5363	2471	3446	3945
367-549	712	6138	-	14857	10529	7161	6922	7077	7656	13652	18498	4264	3251	3557	14911	8195	4384	5499	3067
367-549	713	3715	-	5472	6848	8200	8252	5668	7150	13068	12742	8870	3485	4313	6087	7036	6621	7682	4433
367-549	714	2252	-	-	9140	5055	10356	8532	8712	12254	8924	4588	4932	2301	7461	7040	7394	6395	3892
550-731	709	20	7	-	-	-	-	647	-	1631	-	508	92	283	5955	718	-	1345	1336
732-914	710	87	42	82	163	-	10	-	-	74	-	87	30	436	-	-	-	-	441

Table 3. Abundance estimates (000s) of Witch Flounder by stratum for DFO spring RV surveys (Campelen units 2000-2017) in NAFO subdivision 3Ps.

Depth	Stratum	2000	2001	2002	2003	2004	2005	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
<=56	314	19	0	17	0	0	0	0	0	22	0	0	0	0	0	0	0	0
<=56	320	0	0	0	0	149	0	0	0	0	0	0	0	0	0	0	0	0
57-92	293	0	0	0	0	0	0	0	0	0	0	0	33	0	0	0	0	0
57-92	308	0	0	0	0	0	0	0	0	0	0	0	0	0	0	15	0	0
57-92	312	0	0	0	19	0	0	0	37	0	19	0	0	0	0	0	0	0
57-92	315	116	0	0	0	173	100	49	440	65	0	228	65	0	38	33	0	0
57-92	321	98	0	0	16	0	0	16	33	0	15	16	114	0	0	0	0	0
57-92	325	0	0	0	0	0	0	0	0	16	16	0	0	0	0	0	0	0
57-92	326	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
57-92	783	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
93-183	294	0	0	9	65	0	0	0	0	0	0	0	0	9	0	19	0	0
93-183	297	385	0	21	0	38	167	0	37	0	103	0	38	10	0	0	52	60
93-183	307	72	0	0	127	72	39	18	235	0	125	36	310	18	82	18	145	18
93-183	311	1875	0	15	0	44	1242	58	1094	291	1563	9938	58	129	0	0	959	189
93-183	317	6252	13	0	0	3664	199	119	1739	5777	84	3692	146	1062	5226	40	3850	4394
93-183	319	2320	2927	1083	118	4126	4822	2656	744	4019	848	4081	5736	10553	3641	5617	8354	35109
93-183	322	2254	1257	66	116	166	497	348	72	38	1874	916	826	405	543	282	294	168
93-183	323	432	32	16	0	16	0	64	368	71	243	0	99	284	2566	2913	38	112
93-183	324	0	0	68	0	0	0	0	51	0	0	0	17	0	0	0	0	0
93-183	781	14	0	0	0	0	0	0	0	0	0	27	0	0	20	410	0	0
93-183	782	0	0	0	0	0	0	0	13	0	11	0	0	0	0	0	0	13
184-274	295	1849	142	43	1508	86	1107	0	1409	396	77	-	307	53	217	14	0	197
184-274	298	223	729	1610	623	153	3481	52	391	1610	815	1576	125	882	951	694	3187	553
184-274	300	410	338	254	876	1642	2284	746	2075	2587	2026	1456	1300	2534	1612	1740	1000	288
184-274	306	1291	350	1572	525	510	1015	1017	413	261	287	200	331	747	458	207	592	83
184-274	309	1112	81	163	640	814	977	253	1323	970	399	2194	561	181	1283	2769	163	785
184-274	310	237	186	175	164	234	177	12	339	363	240	175	316	234	435	257	339	291
184-274	313	1634	1343	4188	4222	1612	1192	976	715	605	780	398	670	744	844	1055	613	863
184-274	316	2093	7683	6851	10439	10758	1638	23568	3107	5650	4437	853	1335	2210	1651	3179	2808	1641
184-274	318	687	2023	1659	1180	754	914	339	568	24	257	437	382	515	494	98	763	3975
184-274	779	58	0	58	0	19	203	65	29	0	606	387	579	0	169	116	135	53
184-274	780	25	18	166	37	0	148	33	234	0	0	131	263	74	72	18	37	61
275-366	296	469	230	932	24	541	348	49	479	1441	301	1393	359	84	205	400	12497	402
275-366	299	3292	2189	3281	5149	3339	1516	768	2605	1959	2779	4895	2787	6172	2615	5199	4404	2616
275-366	705	858	1621	3353	1122	1119	994	505	700	1598	1001	1077	1780	770	492	1583	1797	858
275-366	706	2588	3650	10968	6519	6963	3769	2994	7848	7203	6347	999	1342	2423	1448	1356	2479	2984

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Depth	Stratum	2000	2001	2002	2003	2004	2005	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
275-366	707	229	289	87	453	84	84	87	72	1543	118	204	204	62	143	143	95	167
275-366	715	446	337	2283	458	501	558	1004	85	1030	376	264	299	722	684	161	869	376
275-366	716	6790	2570	1823	5052	1483	2923	4918	1911	1706	3093	3633	1656	1001	1339	3196	6963	3312
367-549	708	160	104	83	69	447	135	84	451	254	2011	608	522	858	-	109	-	508
367-549	711	3707	2625	9609	7735	4410	3839	2320	4291	7073	5685	2572	3624	4100	4629	3638	6404	3237
367-549	712	3455	6184	11329	7352	6400	7642	4914	4623	11635	7432	6768	5972	5179	4726	6776	6487	6352
367-549	713	7336	7631	11336	9419	9185	11889	12402	7590	10650	8494	8339	5586	6561	8487	7411	6985	7360
367-549	714	4485	6446	9300	7548	8520	7053	10657	4762	10683	7650	11994	6240	11004	4821	9265	7092	7332
550-731	709	1375	667	904	162	216	705	1007	229	1246	799	6184	688	810	-	222	3215	985
732-924	710	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Table 4. Biomass estimates (t) of Witch Flounder by stratum for DFO spring RV surveys (Campelen equivalents for 1983-1995; Campelen units 1996-1999) in NAFO subdivision 3Ps.

Depth	Stratum	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993(w)	1993(s)	1994	1995	1996	1997	1998	1999
<=56	314	0	0	0	0	0	0	0	0	0	0	0	14	0	0	0	0	0	0
<=56	320	200	0	0	0	0	0	0	0	0	0	0	64	0	19	0	0	0	0
57-92	293	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0	0	0
57-92	308	0	0	0	0	0	7	0	0	0	0	0	0	0	0	0	0	0	0
57-92	312	0	19	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
57-92	315	134	273	0	68	0	76	44	0	0	0	0	0	0	0	0	0	5	35
57-92	321	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
57-92	325	0	19	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
57-92	326	0	0		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
57-92	783	-	-	-	-	-	-	-	-	-	-	-	-	0	-	-	0	0	0
93-183	294	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0	0	0
93-183	297	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	0	122
93-183	307	51	49	39	13	0	0	0	0	0	0	0	10	64	0	1	0	0	81
93-183	311	0	139	27	1564	6	79	7	0	7	0	5	0	9	15	0	0	2	416
93-183	317	3253	4662	75	144	4	154	0	0	0	42	0	22	0	0	0	0	76	430
93-183	319	171	230	93	319	242	170	1716		21	0	0	0	0	93	618	8	829	265
93-183	322	31	121	0	24	0	10	0	0	0	0	0	0	0	8	1	1	0	0
93-183	323	791	30	285	14	165	30	35	0	0	0	0	0	0	0	10	0	1	24
93-183	324	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
93-183	781	-	-	-	-	-	-	-	-	-	-	-	-	0	0	0	0	0	0
93-183	782	-	-	-	-	-	-	-	-	-	-	-	-	0	0	-	0	0	0
184-274	295	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	109	203	0
184-274	298	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	90	188	305
184-274	300	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	44	268	79
184-274	306	208	16	101	177	61	23	74	0	57	14	16	7	30	27	72	42	35	51
184-274	309	126	79	238	90	12	29	36	46	57	20	15	50	104	87	31	53	52	22
184-274	310	34	65	128	138	51	33	117	77	9	7	29	5	63	22	11	11	40	90
184-274	313	335	62	103	100	32	198	249	747	58	285	59	471	1244	623	158	47	248	78
184-274	316	1598	1139	1275	1198	1260	3595	1343	2829	28	3124		2175	333	209	1512	1802	857	619
184-274	318	286	35		1196	57	551	30		1538	17	85	1533	0	1540	149	119	212	48
184-274	779	-	-	-	-	-	-	-	-	-	-	-	-	0	0	0	0	0	1
184-274	780	-	-	-	-	-	-	-	-	-	-	-	-	0	0	-	0	0	1
275-366	296	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	161	23	35
275-366	299	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	371	674	430
275-366	705	208	124	243	267	211	596	325	137	467	331	89	175	128	161	142	158	215	71
275-366	706	1216	817	621	1067	1461	935	481	1205	2032	1482	764	1387	875	1442	571	491	873	316

Depth	Stratum	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993(w)	1993(s)	1994	1995	1996	1997	1998	1999
275-366	707	117	44	-	152	180	62	116	-	2007	675	186	159	0	666	12	15	36	8
275-366	715	173	48	-	84	112	93	248	28	0	43	14	106	68	143	90	20	12	23
275-366	716	401	355	597	1321	938	920	918	1042	519	708	528	366	304	208	1045	275	460	242
367-549	708	97	80	-	186	148	55	251	-	1741	167	257	67	342	64	92	4988	29	3
367-549	711	1540	1218	1517	2385	1239	1058	1572	1470	1416	3378	846	1119	492	1747	667	328	464	471
367-549	712	940	-	2006	1556	1047	1228	944	1265	1946	3003	891	515	662	2677	860	446	636	321
367-549	713	566	-	786	1073	1769	1240	919	1066	2149	2113	1526	554	690	1008	718	846	625	451
367-549	714	371	-	-	2152	937	2010	1344	1580	2309	1871	816	757	374	1264	747	1130	702	412
550-731	709	3	2	-	-	-	-	137	-	379	-	187	62	42	956	59	-	126	137
732-924	710	15	11	13	28	-	4	-	-	17	-	105	6	57	-	-	-	-	39



Table 5. Biomass estimates (t) of Witch Flounder by stratum for DFO spring RV surveys (Campelen units 2000-2017) in NAFO subdivision 3Ps.

Depth	Stratum	2000	2001	2002	2003	2004	2005	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
<=56	314	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
<=56	320	0	0	0	0	18	0	0	0	0	0	0	0	0	0	0	0	0
57-92	293	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
57-92	308	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
57-92	312	0	0	0	9	0	0	0	10	0	0	0	0	0	0	0	0	0
57-92	315	40	0	0	0	36	24	8	228	32	0	126	19	0	32	26	0	0
57-92	321	1	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
57-92	325	0	0	0	0	0	0	0	0	0	10	0	0	0	0	0	0	0
57-92	326	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
57-92	783	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
93-183	294	0	0	0	6	0	0	0	0	0	0	0	0	0	0	0	0	0
93-183	297	93	0	8	0	5	37	0	4	0	17	0	4	3	0	0	7	22
93-183	307	33	0	0	6	23	9	0	39	0	27	0	72	0	32	0	13	3
93-183	311	377	0	1	0	1	287	7	218	35	350	1527	12	30	0	0	154	47
93-183	317	1301	0	0	0	605	63	18	506	1432	32	549	31	161	1329	12	990	964
93-183	319	548	884	468	2	1431	1813	1348	390	876	218	1556	2097	3552	1064	1560	1961	12703
93-183	322	9	8	1	1	1	11	5	0	0	12	68	14	14	11	18	2	2
93-183	323	2	0	0	0	0	0	1	175	0	2	0	22	7	1077	969	17	10
93-183	324	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
93-183	781	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
93-183	782	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
184-274	295	40	7	3	99	1	181	0	331	12	11	-	56	7	11	1	0	89
184-274	298	90	159	359	97	11	646	8	110	281	162	267	37	151	187	127	880	139
184-274	300	111	53	34	46	188	295	175	149	201	156	140	178	267	212	259	202	24
184-274	306	101	18	86	18	48	66	62	59	56	77	37	45	107	69	40	56	12
184-274	309	82	13	9	19	110	101	87	95	63	42	147	61	12	137	212	32	146
184-274	310	31	34	42	31	23	31	2	73	40	34	30	64	40	73	42	71	58
184-274	313	412	246	602	880	280	270	235	129	78	140	62	169	114	268	211	94	170
184-274	316	359	1464	1061	1654	1978	298	5193	578	980	878	208	243	312	276	788	490	523
184-274	318	108	482	377	267	175	248	75	103	5	66	94	59	77	96	22	214	783
184-274	779	0	0	1	0	0	5	1	0	0	4	4	5	0	5	3	1	1
184-274	780	0	0	2	0	0	1	0	1	0	0	0	1	1	2	0	0	1
275-366	296	40	47	119	3	146	59	8	47	572	43	542	106	21	32	120	5242	72
275-366	299	755	593	760	1121	629	265	234	533	366	302	906	605	1164	556	1080	946	604
275-366	705	141	234	653	194	199	147	123	113	195	157	147	269	189	98	347	365	138
275-366	706	507	570	2009	1285	1117	711	566	1317	922	1419	159	273	452	251	238	396	457

Depth	Stratum	2000	2001	2002	2003	2004	2005	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
275-366	707	43	77	20	125	19	21	26	12	235	36	23	31	15	34	29	17	39
275-366	715	68	75	399	111	95	100	203	17	194	62	46	51	112	104	33	188	79
275-366	716	1128	400	326	580	174	412	872	228	300	338	404	295	354	257	479	1259	705
367-549	708	20	21	23	13	106	33	14	54	42	174	113	58	127	-	17	-	60
367-549	711	418	350	1131	903	606	560	352	549	906	572	256	414	425	537	442	785	414
367-549	712	335	626	928	722	726	742	505	367	975	581	620	552	568	443	677	554	676
367-549	713	535	600	1045	898	917	1013	970	376	710	703	725	512	713	690	800	742	625
367-549	714	476	798	1136	862	695	517	916	330	854	574	827	540	859	488	932	715	591
550-731	709	79	80	168	19	41	61	139	29	121	74	461	42	49	-	27	356	93
732-924	710	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Table 6. Proportion of abundance and biomass found in inshore strata 1997-2017, and adjustment factors (geomean 1997-2017) for years when inshore coverage was less than current (1983-1996; strata 779-783 added in 1994, 293-300 in 1997).

Year	Biomass (kg)				Abundance (#)			
	Inshore	Offshore	Total	Prop. Inshore	Inshore	Offshore	Total	Prop. Inshore
1983	-	12863	12863	-	-	56170	56170	-
1985	-	8147	8147	-	-	43730	43730	-
1986	-	15320	15320	-	-	69662	69662	-
1987	-	9929	9929	-	-	42819	42819	-
1988	-	13155	13155	-	-	59957	59957	-
1989	-	10907	10907	-	-	51189	51189	-
1990	-	11492	11492	-	-	61058	61058	-
1991	-	16568	16568	-	-	77887	77887	-
1992	-	17280	17280	-	-	89336	89336	-
1993(w)	-	6228	6228	-	-	29414	29414	-
1993(s)	-	9539	9539	-	-	42857	42857	-
1994	0	5878	5878	0.000	0	29943	29943	0.000
1995	0	11337	11337	0.000	0	66736	66736	0.000
1996	0	7564	7564	0.000	0	50401	50401	0.000
1997	733	10823	11556	0.063	3294	53537	56831	0.058
1998	1088	6803	7891	0.138	6548	44232	50780	0.129
1999	894	4734	5628	0.159	4733	29562	34295	0.138
2000	1018	7265	8283	0.123	6724	51923	58647	0.115
2001	806	7035	7841	0.103	3647	48020	51667	0.071
2002	1253	10522	11775	0.106	6374	76948	83321	0.076
2003	1326	8647	9973	0.133	8282	63454	71736	0.115
2004	792	9610	10402	0.076	5818	62419	68238	0.085
2005	1193	7835	9028	0.132	9255	52402	61657	0.150
2007	251	11901	12152	0.021	1713	70387	72100	0.024
2008	1025	6145	7170	0.143	7272	43841	51112	0.142
2009	1231	9253	10484	0.117	7993	72792	80785	0.099
2010	540	6734	7274	0.074	6719	54193	60912	0.110
2011	1719	8325	10044	0.171	9865	65808	75673	0.130
2012	814	6122	6936	0.117	5791	38877	44668	0.130
2013	1346	8557	9903	0.136	9818	50571	60389	0.163
2014	794	7576	8370	0.095	5862	44029	49892	0.117
2015	1332	8181	9512	0.140	8611	50344	58955	0.146
2016	7076	9675	16751	0.422	21312	61302	82614	0.258
2017	929	19324	20253	0.046	4242	81099	85341	0.050
Adjustment factor (Geomean 1997-2017)	-	-	-	0.108	-	-	-	0.104

Table 7. Descriptions of large survey sets from 2016 and 2017 spring RV surveys.

-	<b>2016</b>	<b>2017</b>
<b>Trip</b>	157	478
<b>Set</b>	35	94
<b>Strat</b>	296	319
<b>Set Depth Mean (m)</b>	371	154
<b>Bottom Temperature (°C)</b>	2.2	4.7
-	-	-
<b>Number in set</b>	2524	1797
<b>Total number in survey</b>	6797	5644
<b>% number in set</b>	37.1%	31.8%
-	-	-
<b>Weight in set</b>	1065.1	669.4
<b>Total weight in survey</b>	1795.8	1312.7
<b>% weight in set</b>	59.3%	51.0%
-	-	-
<b>Proportion at or near spawning condition<sup>1</sup> in set</b>	83.0%	99.3%
<b>Proportion at or near spawning condition<sup>1</sup> in survey</b>	55.4%	65.7%

<sup>1</sup> Maturity condition recorded as maturing, spawning, or recently spent

Table 8. Estimates of biomass (000t) of Witch flounder from research surveys 1983-2017 by depth zones.

Year	<=56 (m)	57-92 (m)	93-183 (m)	184-274 (m)	275-366 (m)	367-549 (m)	550-731 (m)	732-924 (m)	Total
1983	200	134	4297	2586	2115	3514	3	15	12864
1984	0	311	5232	1397	1389	1298	2	11	9639
1985	0	0	520	1844	1461	4309	-	13	8147
1986	0	68	2077	2898	2890	7353	-	28	15315
1987	0	0	416	1472	2901	5139	-	-	9929
1988	0	84	443	4428	2606	5590	-	4	13155
1989	0	44	1758	1849	2090	5029	137	-	10907
1990	0	0	0	3699	2411	5381	-	-	11492
1991	0	0	28	1746	5024	9562	379	17	16757
1992	0	0	42	3467	3239	10533	-	-	17280
1993(w)	0	0	5	203	1580	4336	187	105	6417
1993(s)	78	0	32	4241	2191	3011	62	6	9622
1994	0	0	73	1774	1374	2559	42	57	5878
1995	19	0	116	2509	2620	6759	956	-	12979
1996	0	0	630	1933	1859	3083	59	-	7564
1997	0	0	11	2316	1491	7738	-	-	11556
1998	0	5	908	2104	2292	2456	126	-	7891
1999	0	35	1339	1295	1124	1658	137	39	5628
2000	0	41	2362	1335	2683	1784	79	-	8283
2001	0	0	892	2476	1997	2395	80	-	7841
2002	0	0	478	2578	4287	4264	168	-	11775
2003	0	10	16	3111	3419	3399	19	-	9973
2004	18	36	2065	2812	2379	3050	41	-	10402
2005	0	24	2221	2143	1715	2865	61	-	9028
2006	-	-	-	-	-	-	-	-	-
2007	0	8	1379	5838	2032	2756	139	-	12152
2008	0	239	1333	1628	2266	1675	29	-	7170
2009	0	32	2343	1716	2784	3486	121	-	10484
2010	0	10	659	1569	2357	2604	74	-	7274
2011	0	126	3700	989	2226	2541	461	-	10044
2012	0	19	2252	918	1629	2076	42	-	6936
2013	0	0	3767	1088	2307	2693	49	-	9903
2014	0	31	3513	1336	1332	2158	-	-	8370
2015	0	26	2560	1705	2326	2869	27	-	9512
2016	0	0	3144	2041	8414	2796	356	-	16751
2017	0	0	13752	1947	2095	2366	93	-	20253

Note: 2006 survey was incomplete.

FIGURES

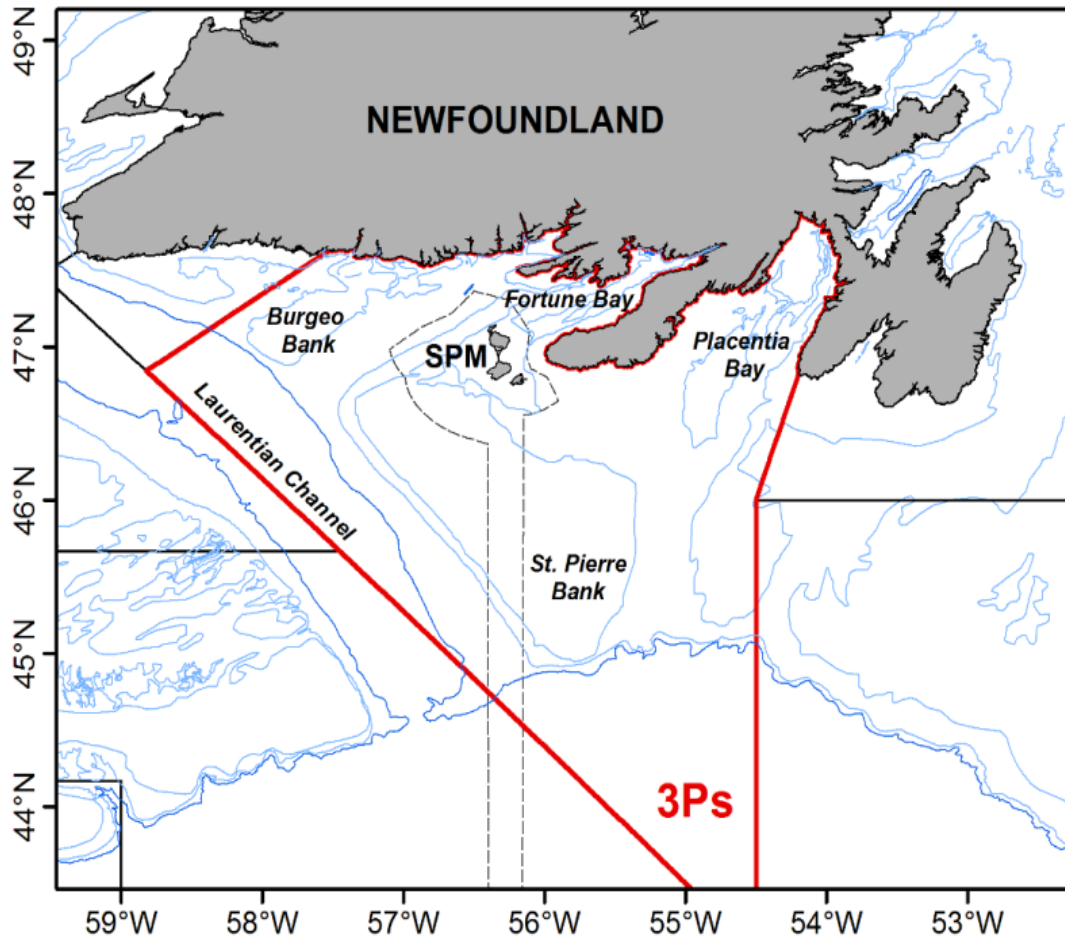


Figure 1. NAFO Subdivision 3Ps (red line) with economic zone around the French islands is St. Pierre and Miquelon (SPM; dashed line).

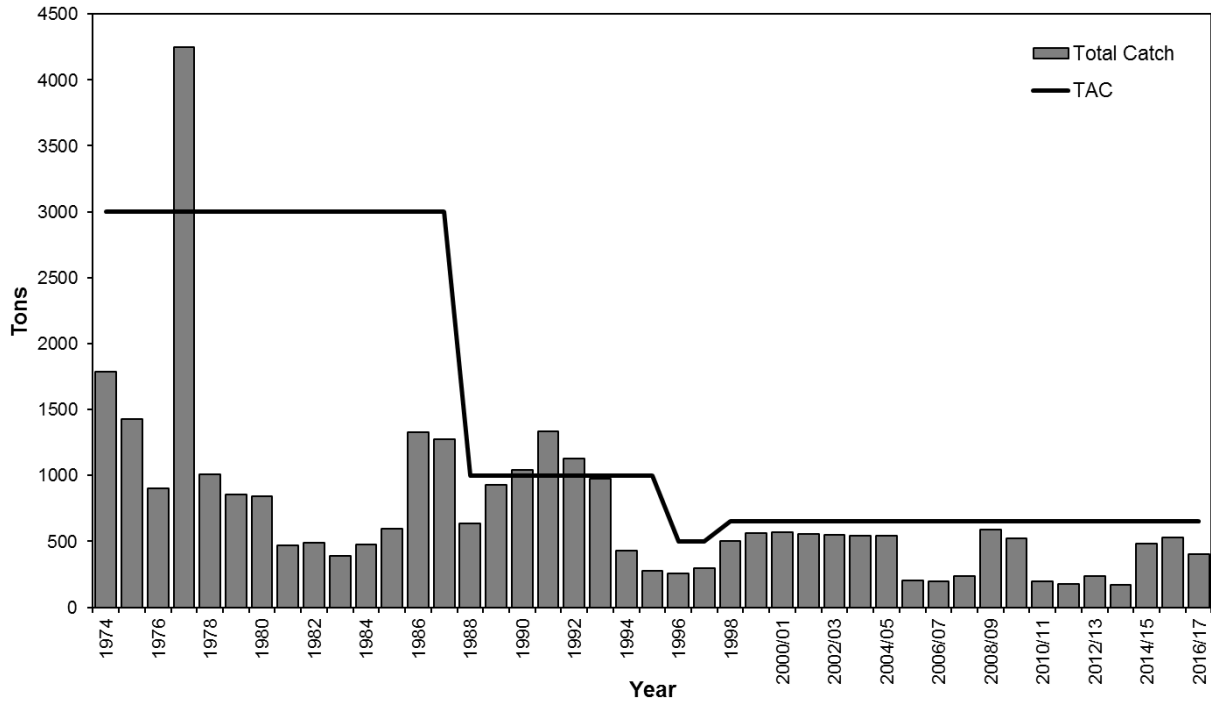


Figure 2. Landings and TACs during 1974-2016/2017. Management changed from calendar year to quota year (April 1- March 31) in 2000.

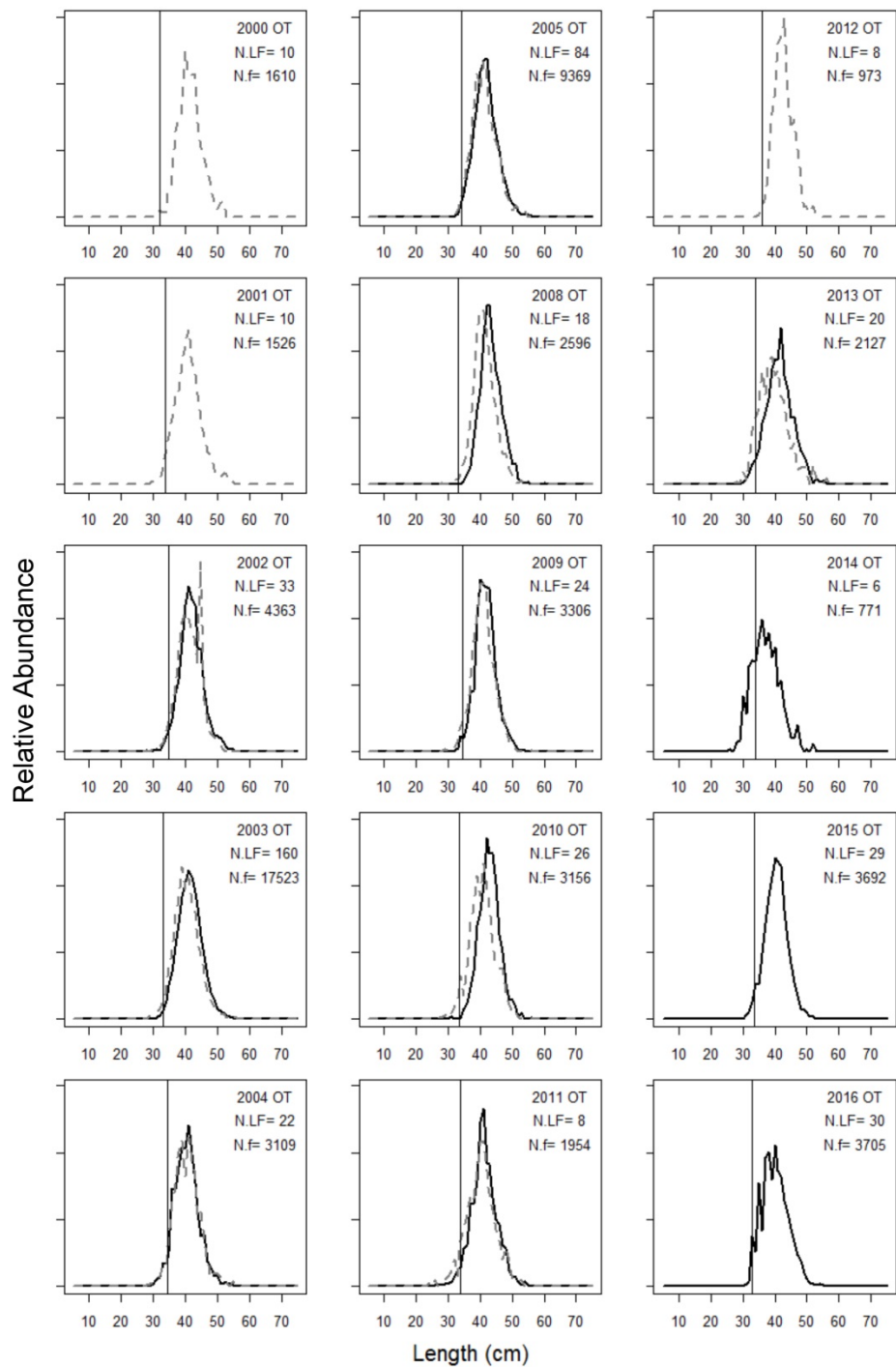


Figure 3. Relative abundance of Witch Flounder caught at length (cm) from the Canada (NL) otter trawl commercial fishery in NAFO Subdivision 3Ps from 2000/2001 – 2016/17. Observer sampling = black lines; Port sampling = dashed lines. Vertical lines indicate length at 50% mature (L50) for fish caught in that year's spring RV survey.



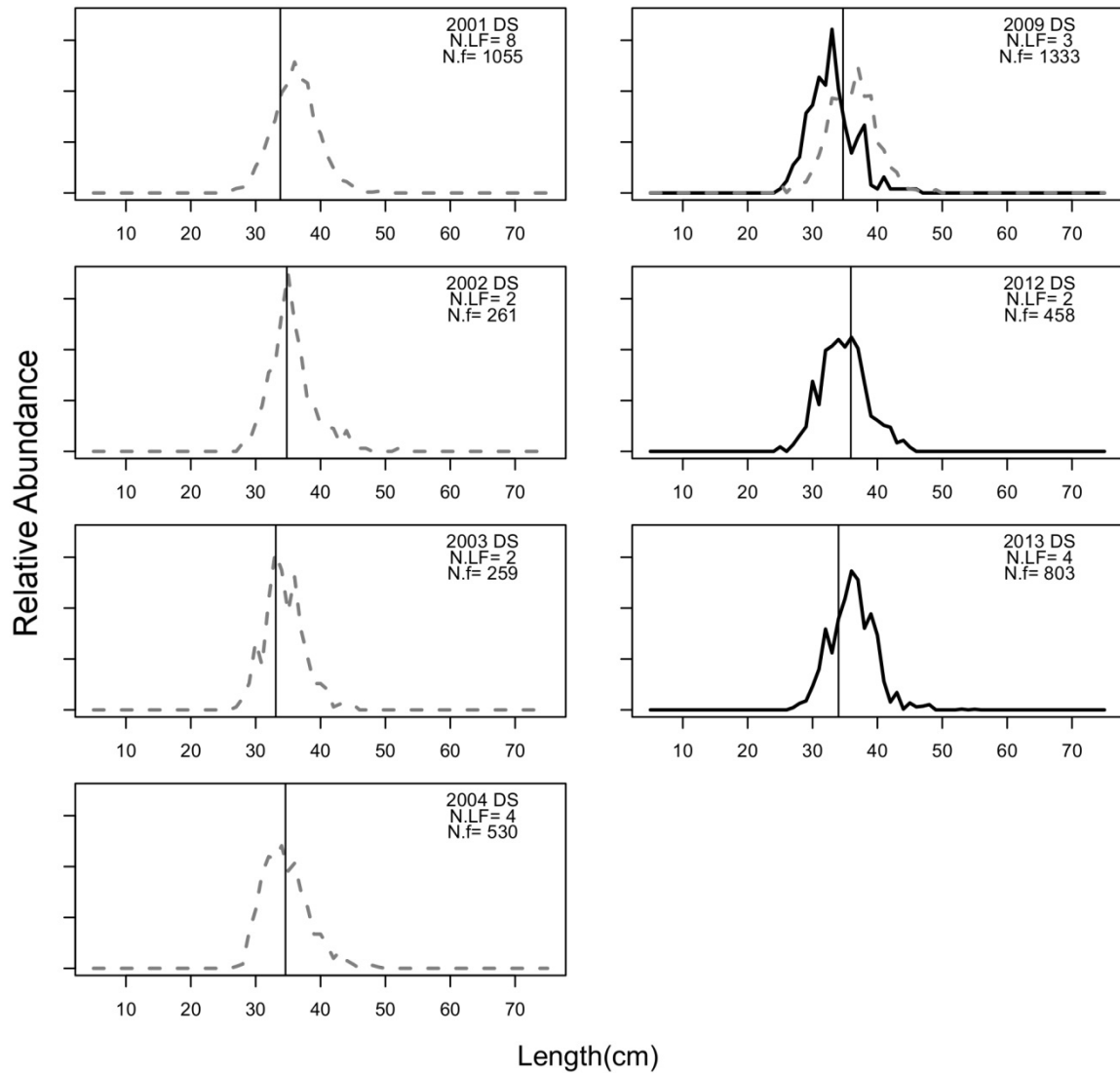


Figure 4. Relative abundance of Witch Flounder caught at length (cm) from the Canada (NL) Danish seine commercial fishery in NAFO Subdivision 3Ps from 2000/2001 – 2016/17. Observer sampling = black lines; Port sampling = dashed lines. No commercial sampling has been available from the Danish seine fishery since 2013/14. Vertical lines indicate length at 50% mature (L50) for fish caught in that year's spring RV survey.

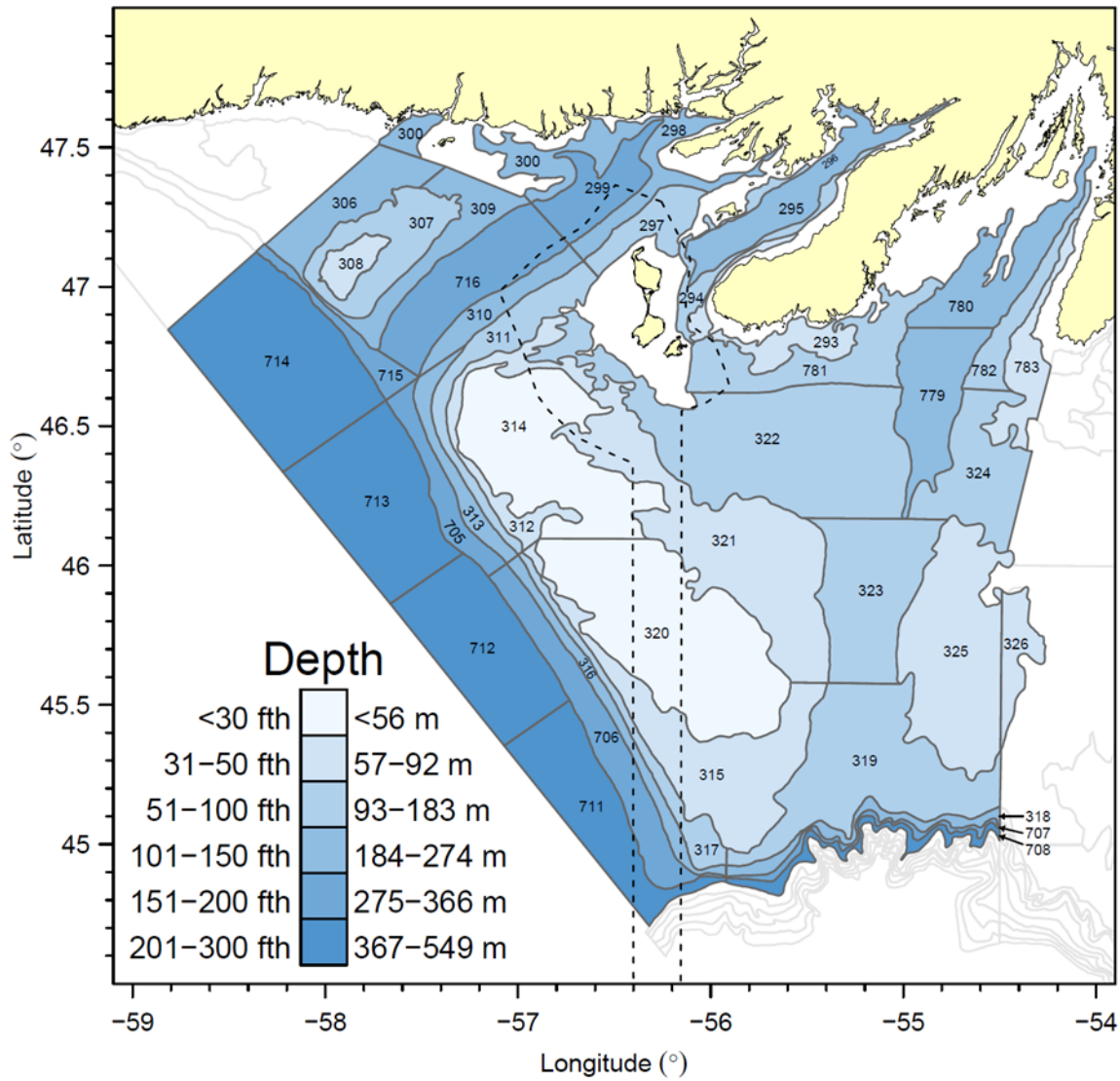


Figure 5. The survey areas in NAFO Subdivision 3Ps showing strata boundaries currently used in the spring DFO RV bottom trawl survey.

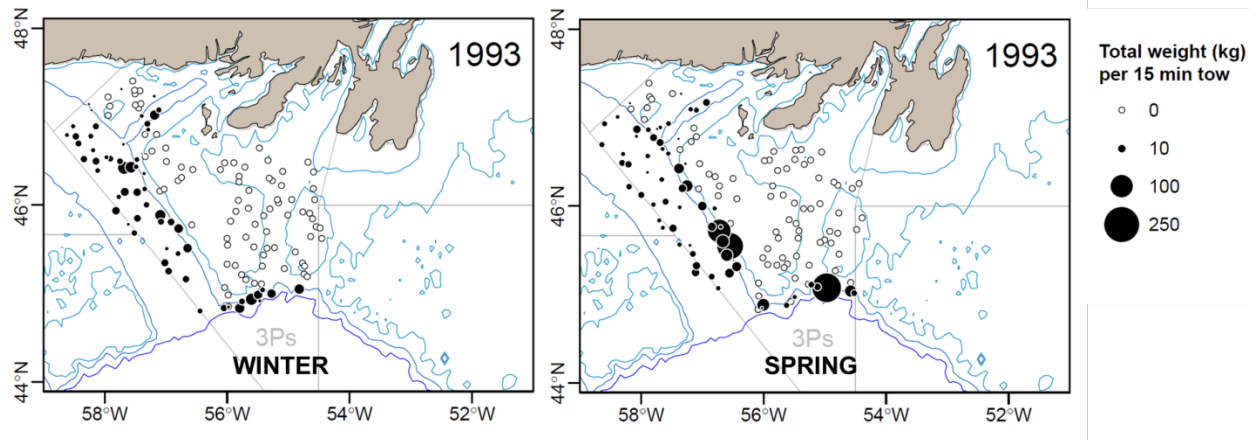


Figure 6. Survey biomass by set in 1993 winter (left) and spring (right) surveys.

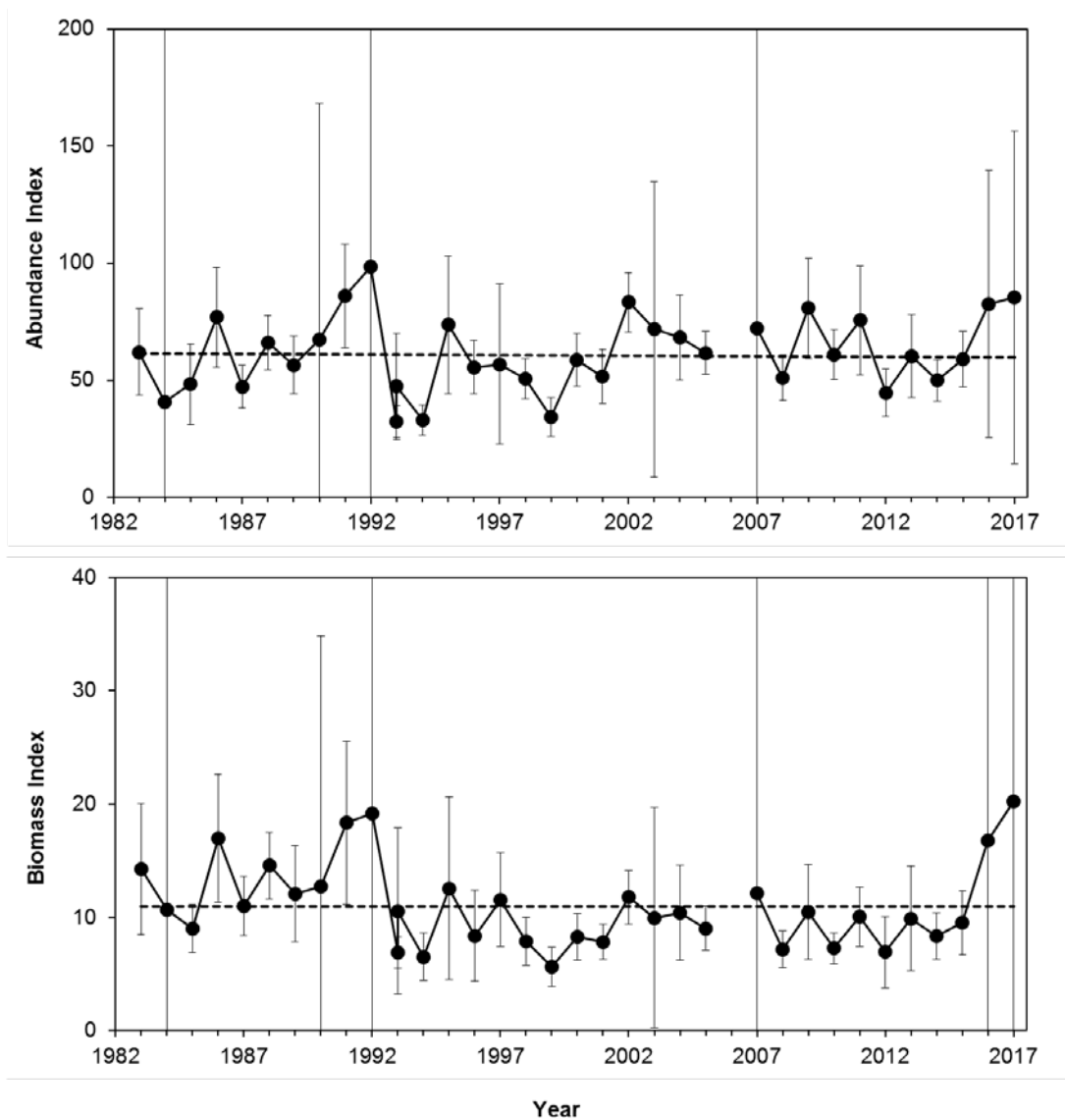


Figure 7. DFO spring RV survey biomass index (top) and abundance index (bottom) for Witch Flounder in NAFO subdivision 3Ps. Pre-1997 values are adjusted for increased inshore survey coverage in more recent years. Dashed line is the time series mean. 2006 survey was incomplete. The two values in 1993 represent the completion of both a winter survey (lower value) and a spring survey (higher value) in that year.

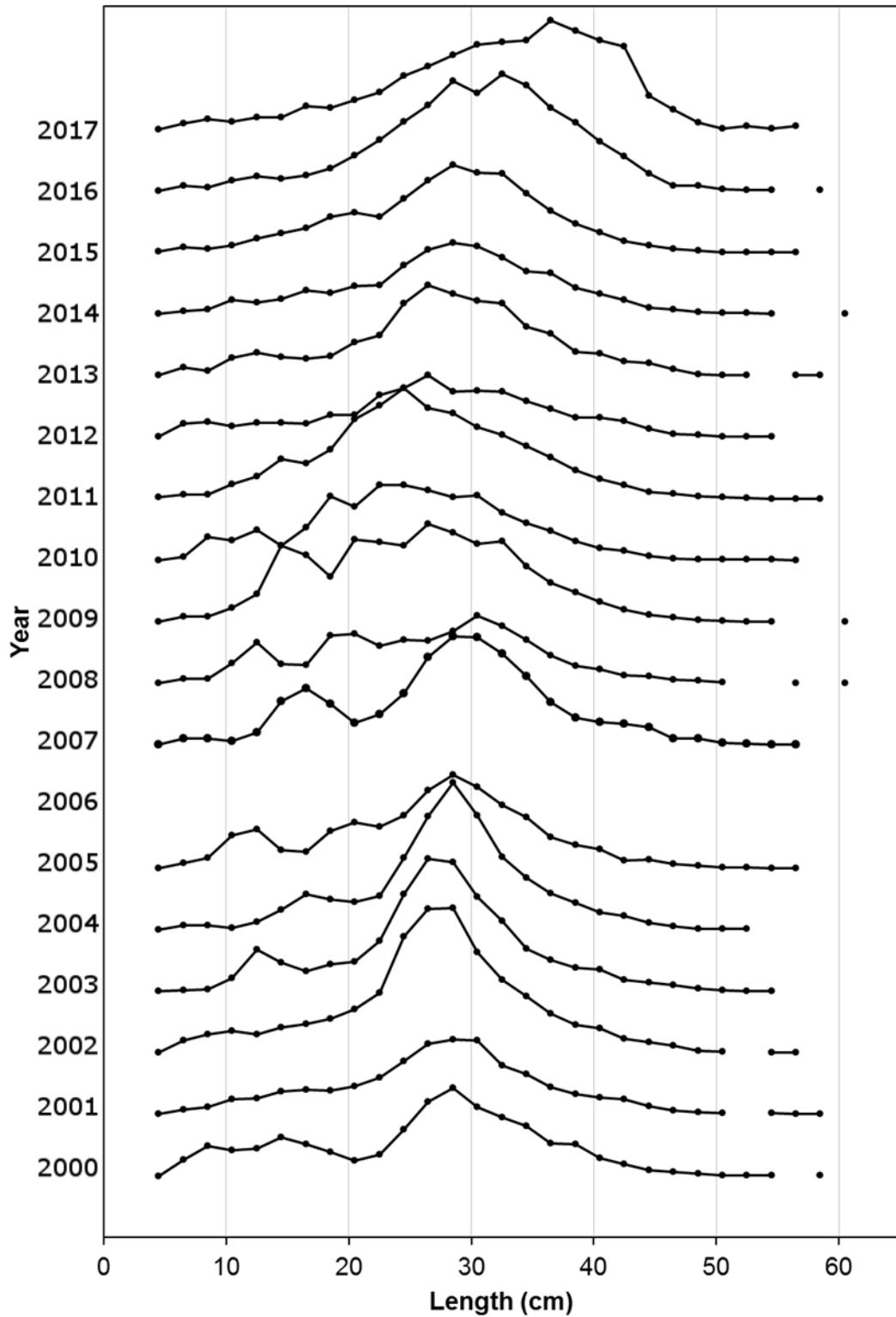


Figure 8. Abundance at length of Witch Flounder from DFO RV Spring surveys in NAFO Subdivision 3Ps 1997-2017. Survey coverage in 2006 was incomplete.

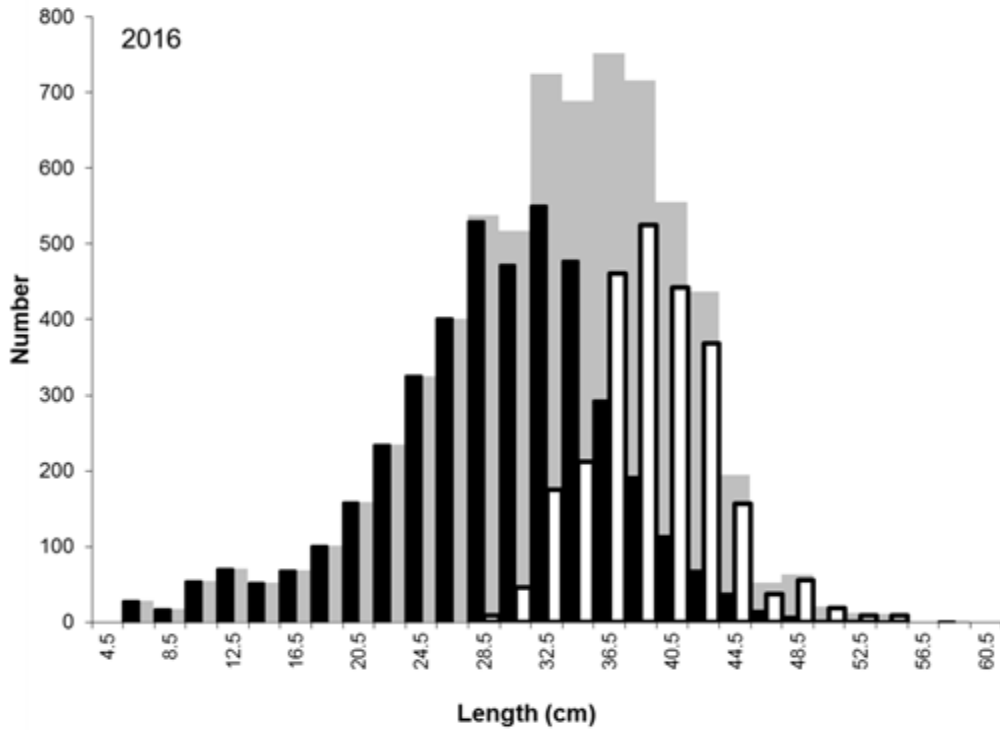
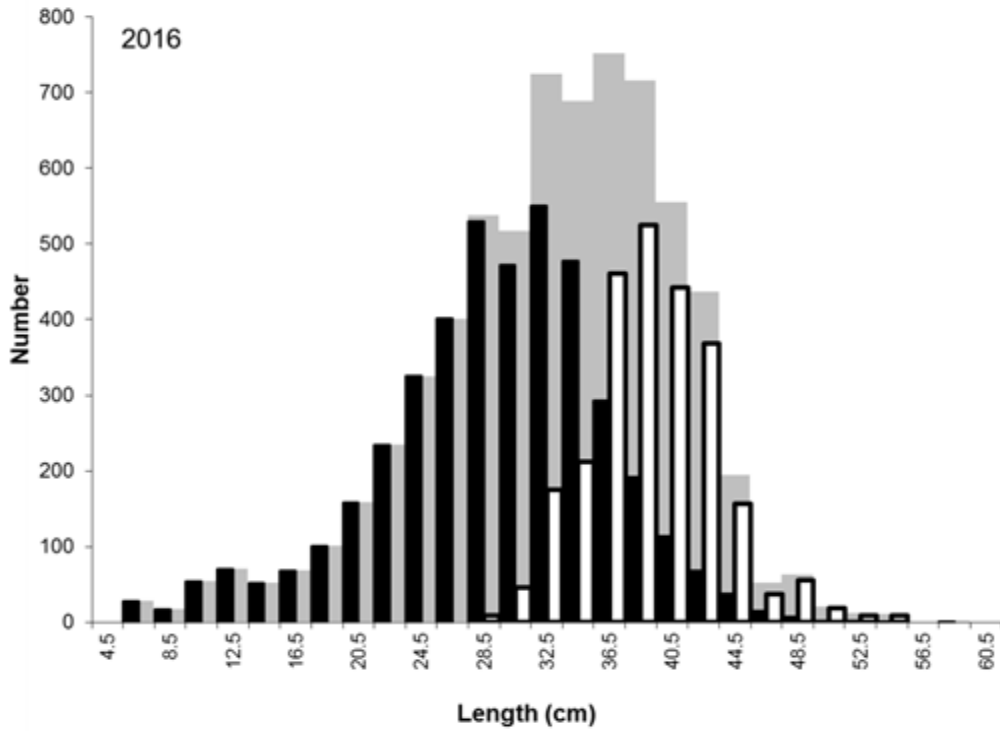


Figure 9. Witch Flounder length distributions from 2016 (top) and 2017 (bottom) spring RV surveys in NAFO Subdivision 3Ps showing: overall survey distribution (grey), large set identified from each survey (white; trip 157, set 35 in 2016; trip 478, set 94 in 2017), and all remaining sets (black).

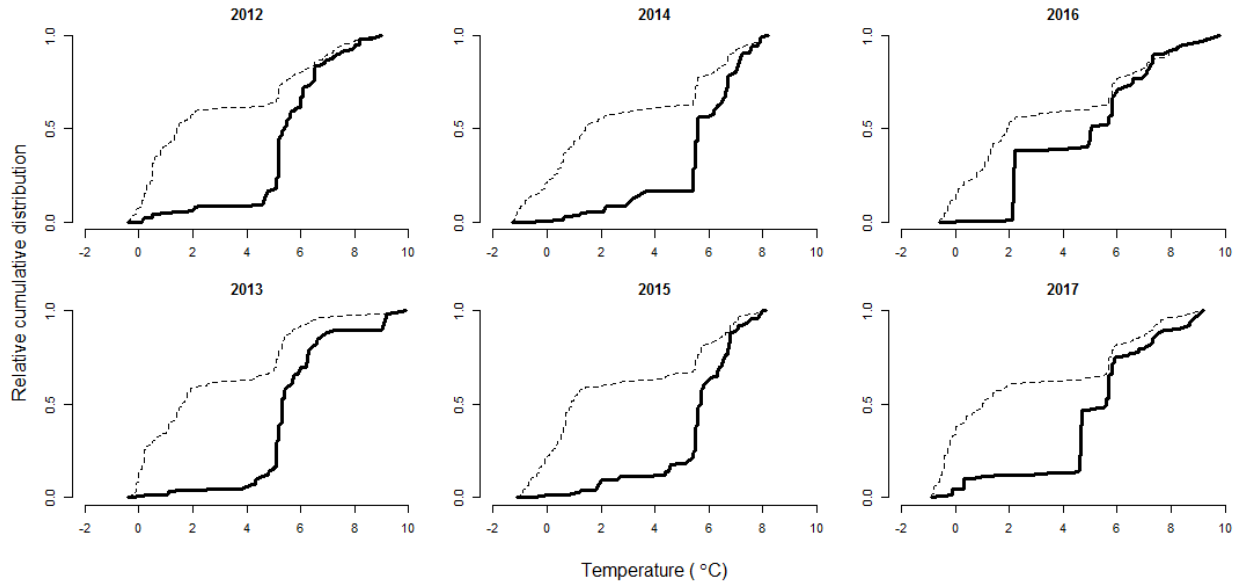


Figure 10. Relative cumulative catch of Witch Flounder (solid lines) by bottom temperature from DFO spring RV surveys from 2012-2017. Dashed lines = cumulative proportion of survey sets by temperature.

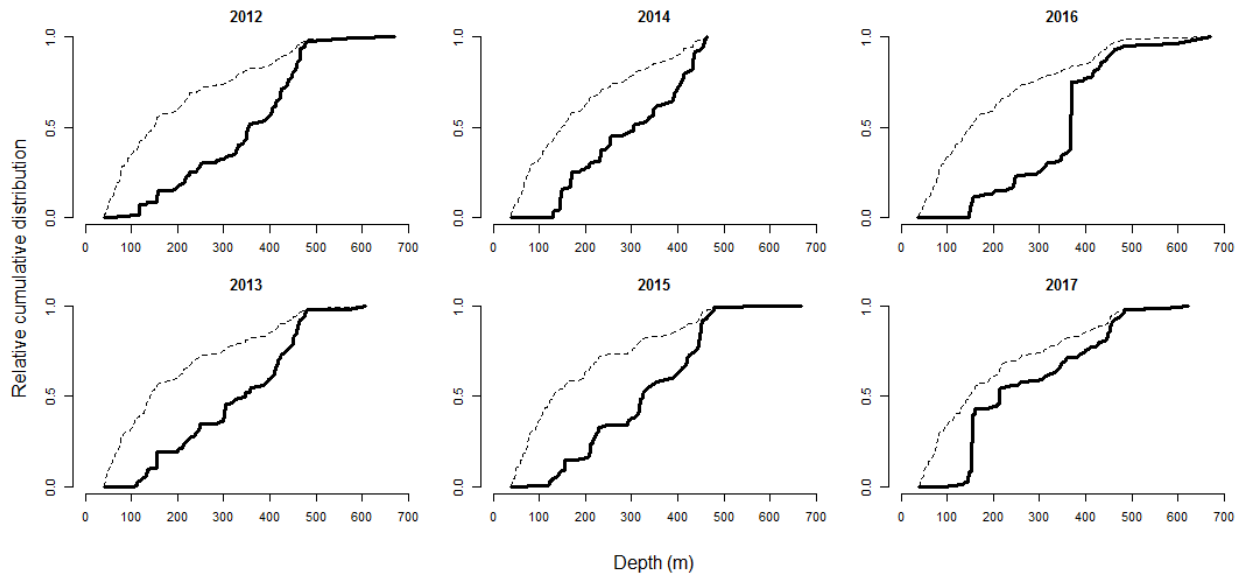


Figure 11. Relative cumulative catch of Witch Flounder (solid lines) by depth from DFO spring RV surveys from 2012-2017. Dashed lines = cumulative proportion of survey sets by depth.

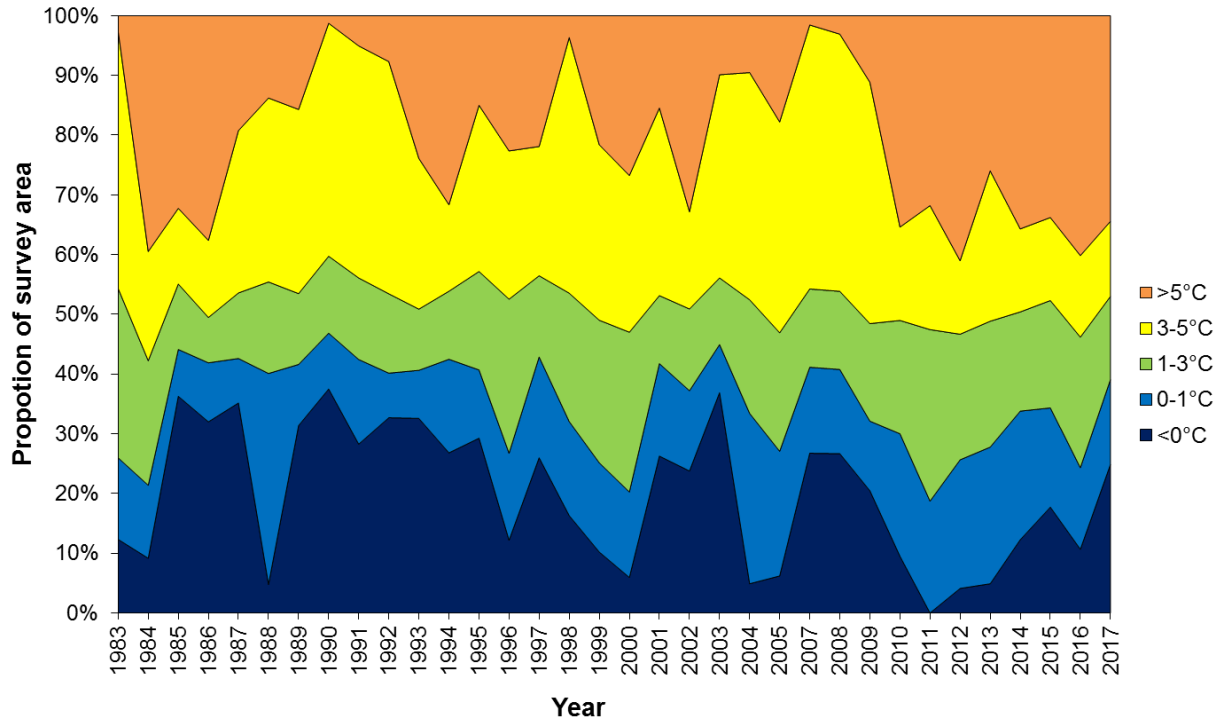


Figure 12. Proportion of spring survey area by bottom temperature. Witch Flounder preferred thermal habitat is represented by the >5°C portion, which is primarily composed of waters in the 5-7°C range as few records exist from these waters >7°C.



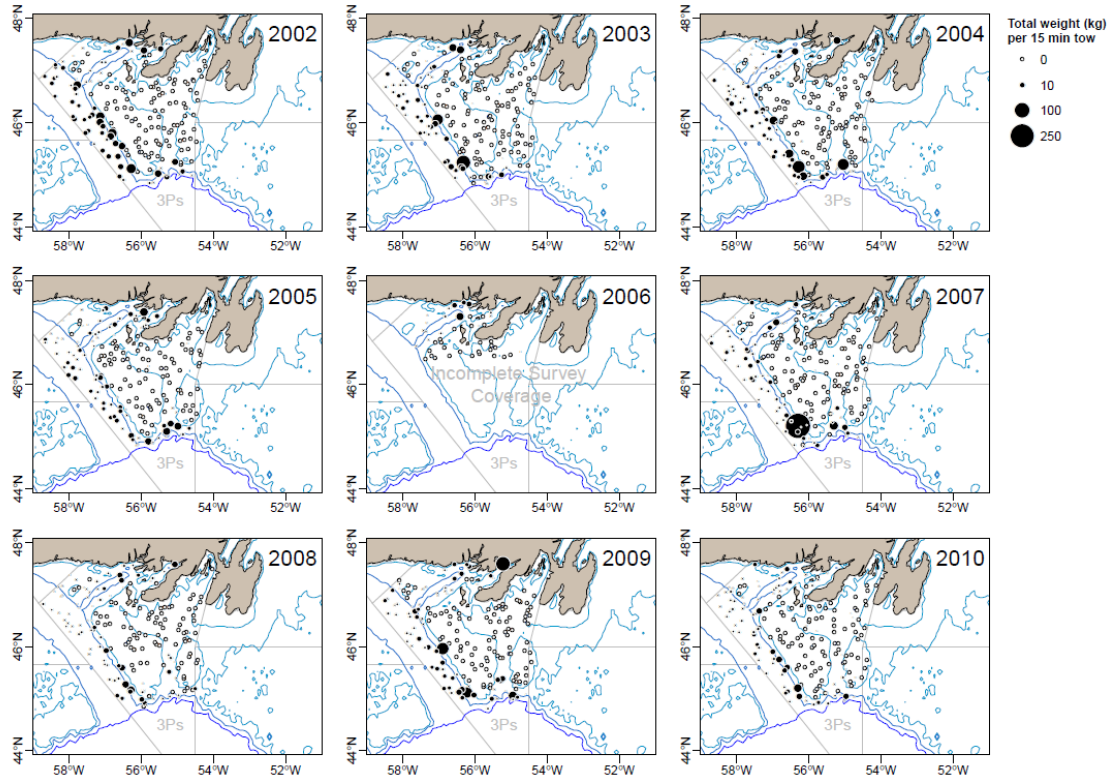


Figure 13. Distribution of Witch Flounder catch (weight per tow) from DFO spring RV surveys from 2002-2010.

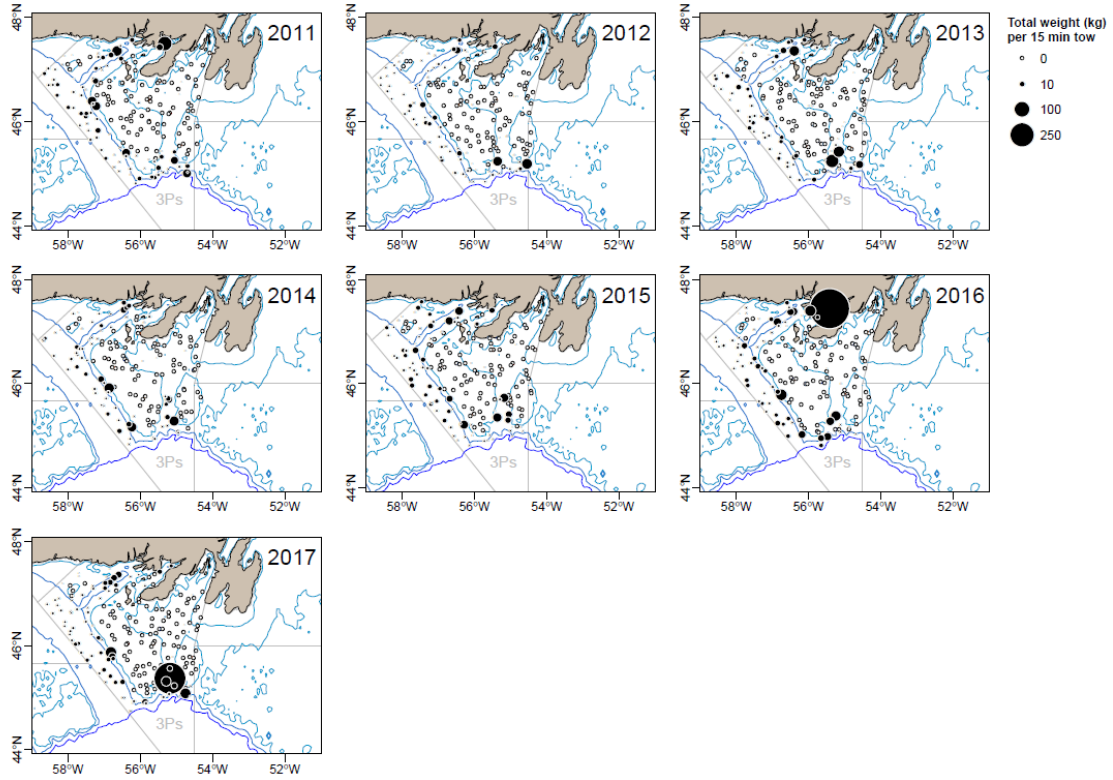


Figure 14. Distribution of Witch Flounder catch (weight per tow) from DFO spring RV surveys from 2011-2017.

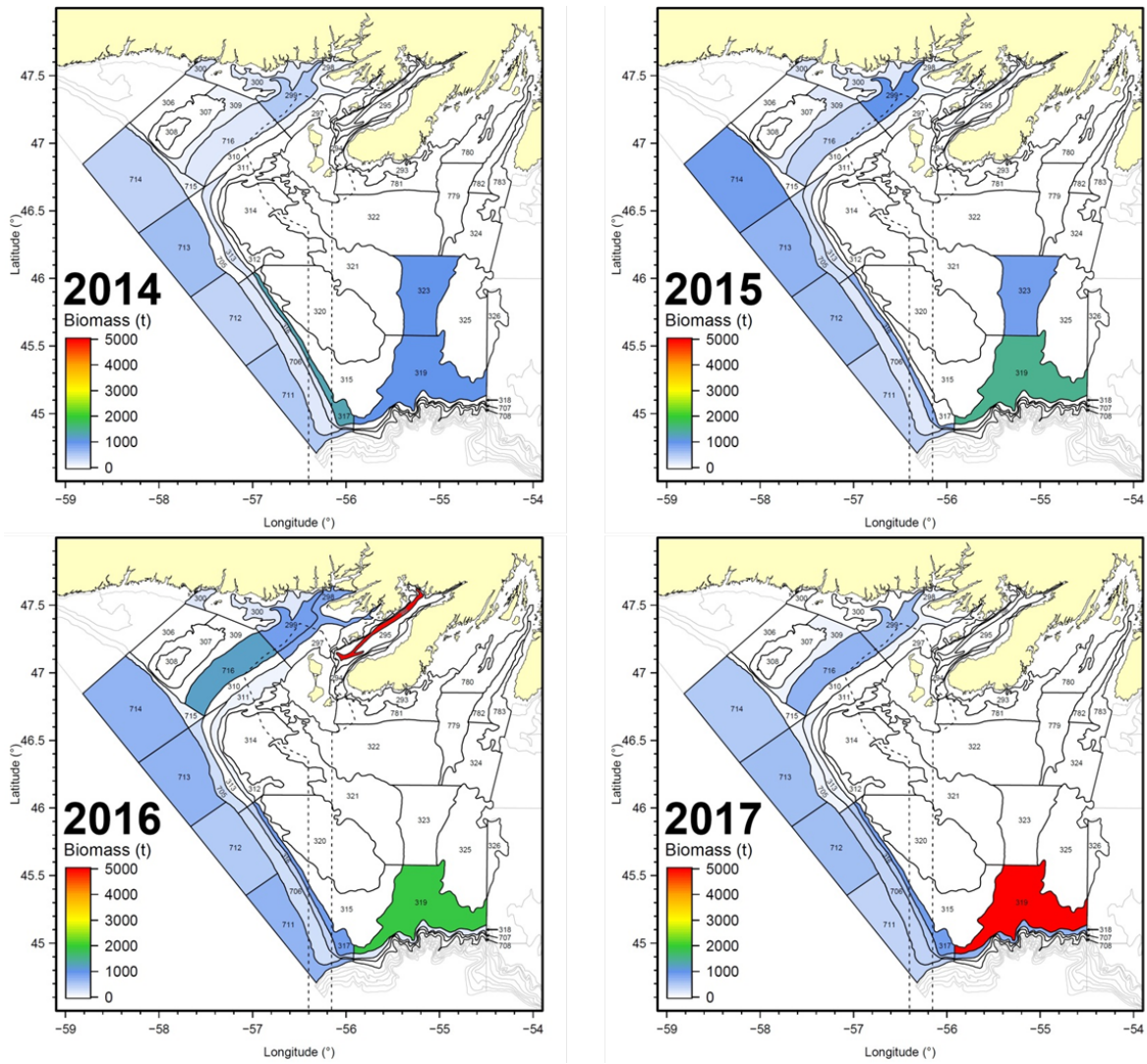


Figure 15. Distribution of Witch Flounder biomass by strata from DFO spring RV surveys from 2014-2017.

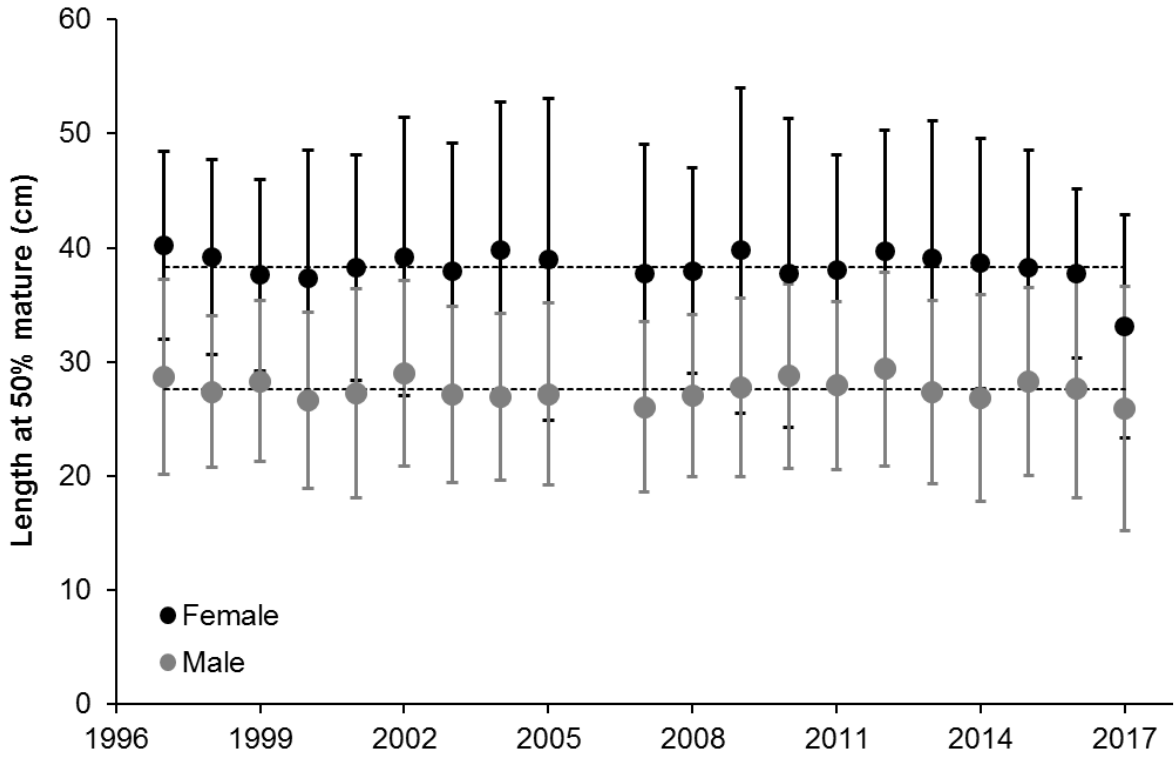


Figure 16. Length at 50% mature for Witch Flounder in NAFO Subdivision 3Ps from DFO spring RV surveys from 1997-2017.

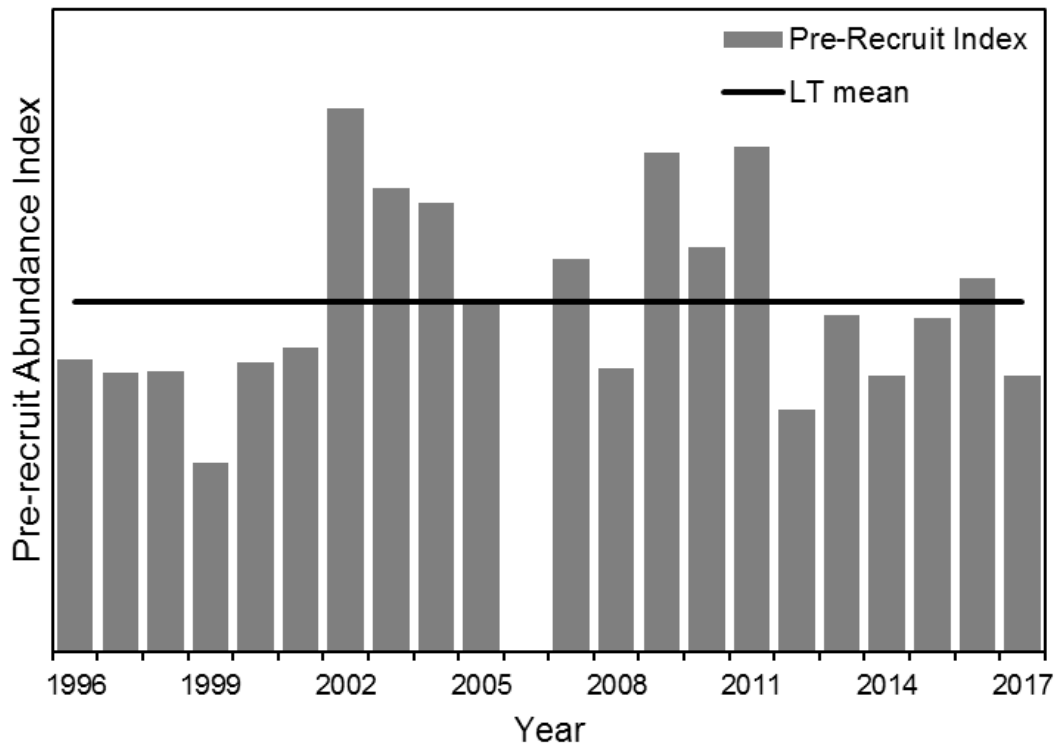


Figure 17. Pre-recruit (16-30cm) abundance index of Witch Flounder from spring surveys in NAFO subdivision 3Ps for 1997-2017. Horizontal line is time series average. 2006 survey was incomplete.

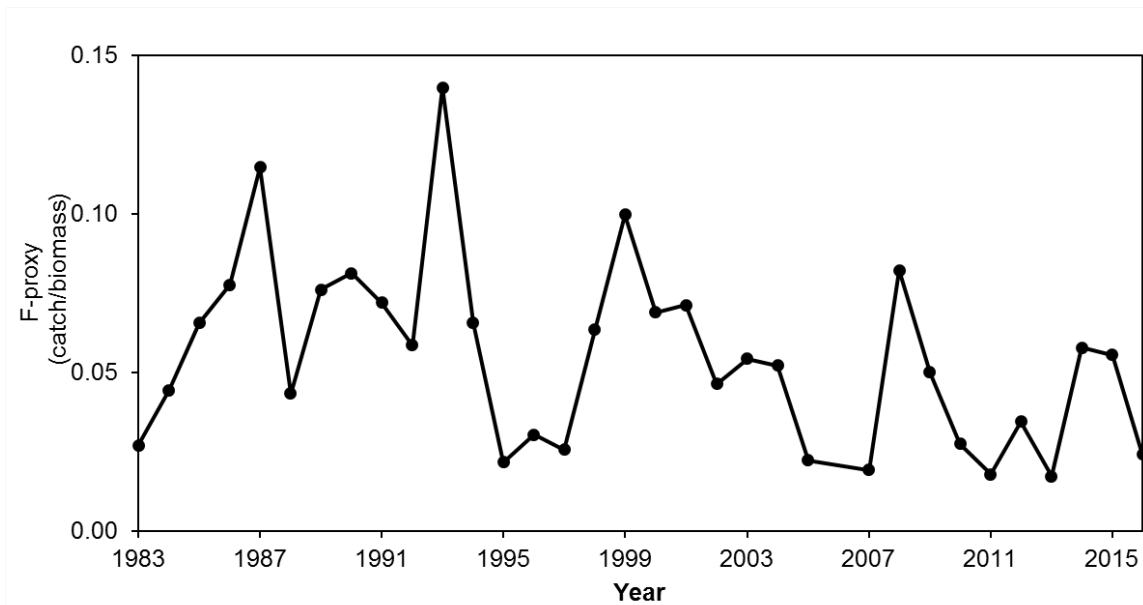


Figure 18. Fishing mortality proxy (ratio of Witch Flounder catch to DFO spring RV survey biomass index) in NAFO Subdivision 3Ps 1983-2017.

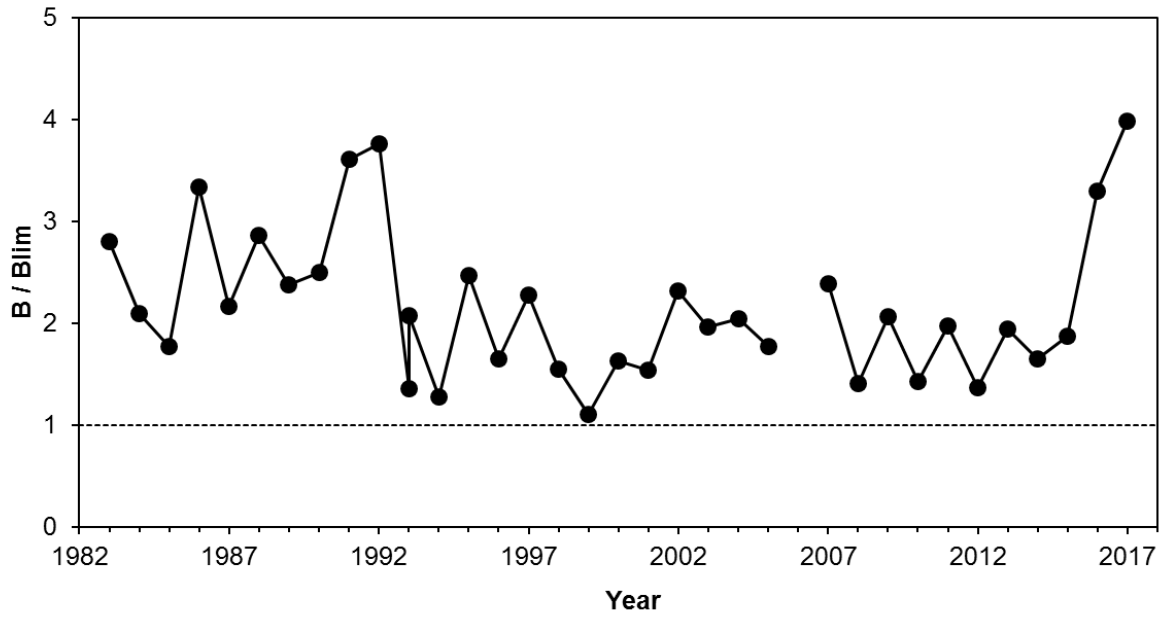


Figure 19. Survey biomass index relative to interim limit reference point ( $B_{lim}$ ) at 40%  $B_{MSY}$ . A proxy for  $B_{MSY}$  was adopted at the geometric mean of survey biomass from 1983 to 1993(winter).