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**An Assessment of White Hake (*Urophycis tenuis*, Mitchell 1815) in
NAFO Divisions 3N, 3O, and Subdivision 3Ps**

M.R. Simpson, C.M. Miri, and R.K. Collins

Department of Fisheries and Oceans Canada
P.O. Box 5667
St. John's, NL, Canada A1C 5X1

ABSTRACT

White Hake in NAFO Divisions 3NO and Subdivision 3Ps inhabit the southern Grand Bank and St. Pierre Bank of Newfoundland and Labrador. The spring survey index for Div. 3NOPs peaked in 2000, due to a very large 1999 year-class. Annual landings, which were at low levels in 1995-2001 (422-t average), increased to 6 718 tons in 2002 and 4 823 tons in 2003, following recruitment of the very large 1999 year-class. Since 2004, the stock has remained at a level of abundance similar to that observed in the mid-1990s. In 2002-2014, the population has exhibited little recruitment; as indicated by staged abundance analysis. Increases in White Hake spawner biomass in Div. 3NOPs will require a number of large year-classes that survive to maturity.

INTRODUCTION

White Hake (*Urophycis tenuis*, Mitchell 1815) is a highly fecund gadoid species distributed in the Northwest Atlantic from Cape Hatteras to southern Labrador. Present knowledge of its biology for the Grand Banks has been summarized in previous assessments of this species (Han and Kulka 2007, Simpson *et al.* 2012, Simpson and Miri 2013).

Formerly one of the commercially important species in the Southern Gulf of St. Lawrence (NAFO Division 4T) and the Scotian Shelf (Div. 4VWX and 5), White Hake stocks have declined in those regions in recent years. Their status as a commercial resource has been assessed most recently by Fisheries and Oceans Canada for Div. 4T in 2012 and 2015 (Swain *et al.* 2012), and for Div. 4VWX/5 in 2012 and 2015 (Simon and Cook 2013).

Stock structure of White Hake has been investigated using morphological and parasite loads (Hurlburt and Clay 1998, Melendy *et al.* 2005), tagging work (Kohler 1971), and allozyme data (Clay *et al.* 1992). More recently, polymorphic micro-satellite loci have been applied to investigate stock structure in White Hake (Seibert and Ruzzante 2006, Zinck 2007, Roy *et al.* 2012). Three genetically distinct populations were identified, which straddle several NAFO Divisions and overlap in their distribution (Roy *et al.* 2012). One such population of White Hake includes Div. 3OPs.

This paper presents an updated assessment of White Hake in Div. 3NO and Subdiv. 3Ps (Fig. 1); focusing on the available research survey information and fisheries data.

Fisheries and Management

A. TAC Regulation

White Hake in Div. 3NO came under quota regulation in September 2004, when the Fisheries Commission decided that a TAC of 8 500 t be established for 2005-2007. This allocation was between Canada at 2 500 t, the EU at 5 000 t, Russia at 500 t, and remaining NAFO member countries at 500 t. This TAC was maintained

at 8 500 t for 2008-2009. In September 2009, Fisheries Commission reduced the Total Allowable Catch of White Hake in Div. 3NO from 8 500 t to 6 000 t for 2010 and 2011. The TAC was further reduced to 5 000 t for 2012, and to 1 000 t for 2013-2015 with a caveat. The TAC in 2013-2015 and for subsequent years can be increased in-season to 5 000 t, based on evidence of an “exceptional” increase in the availability of White Hake (see Table 2 footnote).

B. Catch Trends

Reported landings of White Hake in Div. 3NO (all countries combined; STATLANT-21A) peaked in 1985 and 1987 at approximately 8 100 tons, with about half of that reported by non-Canadian sources as bycatch, then declined to an average of 2 090 t from 1988 to 1994 (Table 1; Fig. 2). With the restriction of fishing by other countries to areas outside Canada’s 200-mile limit (Div. 3NO in the NAFO Regulatory Area, or NRA) in 1992, reported non-Canadian landings fell to zero. Average landings were lowest in 1994-2001 (406 t), then increased to 6 718 t in 2002 and 4 823 t in 2003; following recruitment of the very large 1999 year-class. Reported landings decreased to an average of 386 t in 2008-2012. Div. 3NO landings declined to 205 t and 273 t in 2013 and 2014, respectively. (Table 2).

Commercial landings of White Hake in Subdiv. 3Ps were less variable (Tables 1, 2; Fig. 2): averaging 1 114 tons in 1985-93, then decreasing to an average of 619 t in 1994-2002. Subsequently, reported landings increased to an average of 1 374 t in 2003-2007, then decreased to a 368-t average in 2008-2012. Subdiv. 3Ps landings declined further to 167 t in 2013, and increased to 354 t in 2014.

Fisheries Interactions

White Hakes are captured in directed fisheries in Div. 3NOPs, and as bycatch primarily in those targeting Atlantic Cod (*Gadus morhua*), Atlantic Halibut (*Hippoglossus hippoglossus*), Monkfish (*Lophius americanus*), and Redfish (*Sebastes* spp.; Table 3; Fig. 3). White Hakes are also caught mainly by gillnets, longlines, and otter trawls (Table 4; Fig. 4). In White Hake-directed fisheries, bycatch of other commercially important species occurs, including Atlantic Cod, Haddock (*Melanogrammus aeglefinus*), American Plaice (*Hippoglossoides platessoides*), Atlantic Halibut, and Monkfish.

Size

Commercial catch of White Hake by Portuguese trawlers (130 mm mesh) in the NRA of Div. 3NO in 2009 and 2012 contained 25-68 cm fish (Fig. 5a). However, a larger length range of 24-83 cm was reported from Div. 3O by EU-Portugal in 2010-2011, and 24-76 cm in 2013. EU-Portugal reported 24-67 cm White Hakes in 2014. Russian trawl fisheries in the NRA of Div. 3NO in 2006-2007 captured very similar White Hakes: 21-90 cm fish with a mean length of 53 cm (Fig. 5b). Russia reported 39-75 cm White Hakes in 2013, and 35-45 cm fish from a small sample in 2014. Spanish trawlers using 130-135 mm mesh in the NRA of Div. 3NO in 2012 caught 27-52 cm White Hakes (37 cm mode), and 21-80 cm fish (30-33 cm mode) in 2014 (Fig. 5c). Using 280 mm mesh gear in Div. 3NO, EU-Spain also captured a range of 44-78 cm fish (49-50 cm mode) in 2012, and 20-95 cm fish (33-34 cm mode) in 2014.

C. Research Surveys

Canadian Research Surveys -Spring

Stratified-random demersal surveys have been conducted by Canadian research vessels in the spring (April-June) of each year from 1971 to the present. The most significant alterations in Canadian standardized survey design are changes in survey gear. The spring survey can be separated into three time periods, based on the trawl used in each period: 1971-1983 (Yankee 41.5), 1984-spring 1995 (Engel 145), and spring 1996 to the present (Campelen 1800). McCallum and Walsh (1996) and Walsh and McCallum (1996) described the geometry and specifications of the Engel and Campelen trawls. While survey design remained constant, additional strata were included, along with modifications to some of the original strata (Bishop 1994). A significant change in the surveys is the addition of shallower and deeper strata after 1993. Additional causes of variation in spring survey coverage are discussed in detail by Brodie and Stansbury (2007), and Healey and Brodie (2009). No size-based conversion factors for the two gears were derived from comparative surveys for White Hake; therefore, catch rate data and resulting biomass and abundance indices cannot be directly compared between trawl types. Similarly, no conversion factor exists for White Hake between Yankee and Engel trawls.

In the 2006 Canadian spring survey, most of Subdiv. 3Ps was not surveyed, and only shallow strata in Div. 3NO (to 77 m in Div. 3N; to 103 m in Div. 3O) were surveyed; due to Canadian research vessels' mechanical difficulties. Thus, survey estimates for that year are not comparable to others in the Campelen time series.

Spring Survey Biomass and Abundance Indices

Spring survey estimates of biomass and abundance are presented in Table 5a for Div. 3NO and Subdiv. 3Ps. Mean weights and mean numbers per tow with 95% confidence intervals are presented in Figure 6a.

The spring biomass index for White Hake on the Grand Banks in Div. 3NOPs increased rapidly in 1999-2000 to approximately 26 000 tons, but then steeply declined and is presently at low levels comparable to earlier estimates in the Campelen time series. During the Canadian spring survey of 2000, the estimated abundance of about 117 000 000 fish was 10-times greater than that observed in either the first years of the Campelen series or during recent years, due to the very large 1999 year-class. In 2011, the abundance index increased from low levels to about 27 000 000 fish (3 times the 2007-2009 average), primarily due to a moderate 2010 year-class. Average spring abundance estimates were 16 000 000 White Hakes in 2012-2014.

Canadian Research Surveys -Autumn

Stratified-random autumn surveys have been conducted by Canada in Div. 3NO from 1990 to the present. Beginning in autumn 1995, Canadian survey gear was changed from the Engel 145 otter trawl to the Campelen 1800 shrimp trawl. Additional causes of variation in autumn survey coverage are discussed in detail by Brodie and Stansbury (2007), and Healey and Brodie (2009). In addition, Canada does not survey Subdiv. 3Ps in autumn. Furthermore, autumn surveys reach deeper maximum depths (~1 400 m) than those in spring (~750 m). Therefore, autumn survey data are not directly comparable to spring survey data. Because the autumn series is not spatially complete over the designated stock area, Canadian spring surveys are used as the primary estimator of biomass and abundance trends for White Hake. It must also be noted that Canadian research vessels' mechanical difficulties prevented the surveying of: deep strata in Div. 3NO in 2003, 2004, and 2006; strata deeper than 730 m in 2008; and Div. 3NO in autumn 2014.

Autumn Survey Biomass and Abundance Indices

Autumn biomass and abundance estimates (1990-present) are restricted to Div. 3NO. These indices show a large increase in Div. 3NO White Hake between 1998 and 1999 (Table 5b; Fig. 6b), primarily due to the presence of large numbers of Young-of-the-Year (YOY). Of particular interest is the large increase in abundance in Div. 3N to levels never previously observed (~83 000 000 fish). The pattern of Campelen autumn indices is offset by one year (earlier) as compared to that from spring surveys, because autumn surveys catch newly settled YOY that were spawned in the previous spring (Kulka *et al.* 2005b). About twenty-five weeks later, the next spring survey samples the previous year's cohort as 1-year-old White Hakes. This pattern was most apparent when a very large year-class was produced, such as in 1999. After 2003, autumn abundance indices drastically declined to low levels (5 000 000-average annually in 2004-2010); comparable to those of 1995-1998. In 2011-2013, the autumn abundance index for Div. 3NO increased to 2001-2002 levels at approximately 16 000 000 fish.

EU-Spain Div. 3NO Spring Surveys

Spain initiated a survey in the NRA of Div. 3NO in 1995. Initially, the survey was carried out in spring with the C/V *Playa de Mendiña* using a Pedreira bottom trawl. Since 2001, the R/V *Vizconde de Eza* replaced the C/V *Playa de Mendiña*, and a Campelen 1800 trawl replaced the Pedreira (González-Troncoso and Paz 2014). Results of this survey are available for White Hake from 2001 onwards.

EU-Spain biomass indices were highest in 2001, declined to 2003, increased to a small peak in 2005, then declined to its lowest level in 2008 (Fig. 7). In 2009-2013, the EU-Spain index indicated a gradually increasing trend relative to 2008. In 2014, this trend reversed with a decline in biomass. The generally increasing trend over 2008-2013 is similar to that depicted by Canadian spring surveys, which cover all of Div. 3NO (Fig. 7). The Canadian index continued to increase in 2014. Both trends are also reflected in abundance at length data from EU-Spain and Canadian spring surveys (Fig. 8). In 2011, Canada observed a moderate peak of 21-26 cm fish (Age 1); representing the 2010 year-class. In 2012, EU-Spain observed a small peak of 36-45 cm fish with a mode of 44 cm, while a similar peak of 37-45 cm White Hakes (mode of 42 cm) was found in the Canadian spring survey. The majority of these Age-2+ juveniles represent the 2010 cohort. In 2013, both EU-Spain and

Canada observed a small peak of 13-26 cm fish with modes of 22 and 25 cm (representing the 2012 year-class), and another small peak of 40-56 cm fish with modes of 52 and 54 cm (majority representing the 2010 year-class). Few Age 1 White Hakes were found in 2014 by Canada, and none by EU-Spain.

Landings/ Biomass Ratios

Using STACFIS-reported landings and the Canadian spring survey biomass index, estimates of Relative F were calculated for White Hake in Div. 3NO and Div. 3NOPs. Relative fishing mortality (Rel. F = NAFO-reported landings/Can. spring biomass) declined to low levels in 1999-2001, increased to a high peak in 2002-2003 supported by the very large 1999 year-class, then declined to its lowest levels in 2011-2014 (Fig. 9). Relative F was higher in Div. 3NO than in Subdiv. 3Ps during 2002-2003, because of new directed fisheries for White Hake by EU-Spain, EU-Portugal, and Russia; coupled with very low recruitment after 1999.

D. Biological Studies

Stage-based Analysis

Maturity analysis from data collected by Canadian Campelen spring surveys in 1996-2014 indicated that length at 50% maturity is different between sexes; but very similar for each sex among years and between areas (Div. 3NO *versus* Subdiv. 3Ps; Fig. 10). Females reach 50% maturity at 54 cm, and males do so at 38 cm.

Information on White Hake abundance by life stage from Canadian spring surveys is presented for 2004-2014 in Figure 11. White Hakes in their first year correspond to lengths ≤ 26 cm, while 27-57 cm represents Age 2+ juveniles, and 58+ cm fish are primarily mature adults (Kulka *et al.* 2005a). A 2010 cohort was seen as a moderate peak of 1-year-olds in 2011, as a small peak of 2+ juveniles in 2012, and as a small peak of larger immatures in 2013. Note that almost all of the Age 1 White Hakes were found in Div. 3NO, whereas 2+ juveniles were observed almost equally in Div. 3NO and in Subdiv. 3Ps. For mature White Hakes (58+ cm), percent abundance was higher in Div. 3NO relative to Subdiv. 3Ps, and almost all adults surveyed in 2014 were found in Div. 3NO.

Partitioned by sex, relative numbers at length data from Canadian spring surveys of Div. 3NO in 2007-2014 indicated that a small number of 1-year-olds was observed in 2008 (16% female), with a small peak of 28-cm males (Fig. 12a). No Age 1 fish were found in 2007 and 2009, while the latter (44% female) showed a small peak of 58-61 cm males. The very small 2010 peak of 1-year-olds noted previously was 38% female. A larger peak of 1-year-olds (2010 year-class) observed in 2011 was 31% female. In 2012, a moderate peak of 35-47 cm White Hakes was observed; primarily representing the 2010 year-class, and 30% of all immatures were female. In 2013, a small peak of 1-year-olds (2012 year-class) was 23% female, and another small peak of 40-56 cm fish was also seen (43% of all immatures being female; some fish representing the 2010 cohort). Few Age 1 White Hakes were found in 2014, while a small peak of 2+ juveniles (31-43 cm fish; mostly representing the 2012 year-class) and another small peak of 48-56 cm immatures (39% of all juveniles being female) were observed in Div. 3NO.

In Subdiv. 3Ps, relative abundance from Canadian spring surveys indicated two peaks of females in 2007: one at 44 cm in length, and another at 52-62 cm (Fig. 12b). Males comprised 37% of the 2007 survey results, with mainly 46-51 cm and 62-67 cm fish. Peaks of females were again observed in 2008: a small one at 30-32 cm in length, one at 37-45 cm, and a predominant one at 51-60 cm. Males constituted 41% of the 2008 results, with primarily 36-49 cm fish. In 2009, a small peak of Age 1 White Hakes was observed (33% female). This 2008 cohort was also found as juveniles in 2010; with 23% of all immatures comprised of 32-42 cm females, and 30% being 29-39 cm males. In 2011, 35-57 cm females dominated the immatures (52%), and a peak of 32-41 cm males (31%) was also observed. Results were similar for immature females (54%) and males (27%) in 2012. In 2013, a small peak of 1-year-olds (46% female; 2012 year-class), and other small peaks of 28-32 cm females (20% of all immatures), 46-49 cm females (9%), 27-30 cm males (14%), and 43-48 cm males (10%) were seen. In 2014, almost no Age 1 or mature White Hakes were found in Subdiv. 3Ps, and 71% of 2+ juveniles were observed in a 28-39 cm range (34% female).

Stage-based analysis of abundance from Canadian spring surveys in Div. 3NOPs for 2001-2014 indicated that immature White Hakes (sexes combined) older than one year dominated the population (Fig. 13); similar to what was observed for this stock prior to 2000 (Kulka *et al.* 2005b). A small peak of 1-year-old fish (13% female) was observed in 2005; depicting the 2004 year-class. Although spawning stock abundance was low in

2010-2013, small peaks of Age 1 fish were observed in 2011 (31% female; representing the 2010 cohort) and 2013 (27% female; representing the 2012 year-class). There are currently no indications of increased abundance of mature White Hakes.

In Canadian spring research surveys, the number of White Hakes ≤ 26 cm in length is assumed to be an index of recruitment at Age 1. Abundance of Age 1 White Hakes in 2000 was very large, but no large year-classes were observed since 1999 (Fig. 14). The index of recruitment (sexes combined) for 2011 was comparable to that seen in 1999, and a smaller peak in 2013 was similar to one in 2005. In 2014, the index was low.

E. Stock Distribution

White Hake in Div. 3NO and Subdiv. 3Ps are confined largely to an area associated with the warmest bottom temperatures (4-8°C) along the southwest fringe of the Grand Banks, edge of the Laurentian Channel, and the south-west coast of Newfoundland (Kulka *et al.* 2005a).

Distributions of White Hake from Canadian spring surveys in Div. 3NOPs during 2005-2014 are shown in Figures 15a,b. As in previous years, this stock continues to occupy the southwest shelf edge areas of Div. 3NO. In Subdiv. 3Ps, White Hake are distributed along the shelf edge, and in the Laurentian and Hermitage Channels.

F. Assessment Results

Precautionary Reference Points

Work in progress.

Resource Status

Recent spring survey indices indicate that the White Hake stock size in Div. 3NOPs remains at levels comparable to those observed during the Canadian Campelen spring surveys of 1996-1999.

Age-structured assessment of this stock is currently not feasible. However, population abundance at length estimates from Canadian spring surveys suggest that no significant recruitment has occurred for White Hake in Div. 3NO. In fact, there has been extremely low recruitment since that generated by the very large 1999 year-class.

Given that good recruitment rarely occurs and remains unpredictable for this White Hake population, commercial fishing pressure should be regulated in the NRA of Div. 3NO by a TAC set at a level that will allow survival and growth to maturity of larger year-classes: a strategy crucial to rebuilding this stock.

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Table 1. NAFO STATLANT-21A reported landings of White Hake (tonnes) by NAFO Division in 1960-2014.

Year	3N			3O			3Ps			3NO	3NOPs
	non-Can	Canada	Total	non-Can	Canada	Total	non-Can	Canada	Total	Total	Total
1960	164	37	201	210	181	391	500	232	732	592	1324
1961	9	17	26	25	152	177	32	100	132	203	335
1962	1	2	3	1384	406	1790	1	74	75	1793	1868
1963		12	12	5	129	134	8	103	111	146	257
1964		14	14		113	113		124	124	127	251
1965	125	5	130	18	28	46	60	71	131	176	307
1966	4	9	13	102	51	153	45	39	84	166	250
1967	549	24	573	967	34	1001	43	67	110	1574	1684
1968		5	5	22	64	86	20	403	423	91	514
1969	9	1	10	7	49	56	6	375	381	66	447
1970	21	48	54	44	107	151	227	397	624	205	829
1971	366	132	498	4110	2584	6694	221	1443	1664	7192	8856
1972	259	34	293	1594	1998	3592	115	2062	2177	3885	6062
1973	33	59	92	307	2508	2815	84	1330	1414	2907	4321
1974	214	31	245	358	2476	2834	18	1305	1323	3079	4402
1975	1186	43	1227	2430	1926	4356	765	1432	2197	5583	7780
1976	663	237	900	1272	1225	2497	10	1344	1354	3397	4751
1977	1005	22	1027	976	1095	2071		1683	1683	3098	4781
1978	670	42	712	1199	682	1881		1051	1051	2593	3644
1979	246	44	290	919	360	1279		660	660	1569	2229
1980	209	242	451	1856	311	2167		546	546	2618	3164
1981	809	22	831	564	310	874		1030	1030	1705	2735
1982	687	5	692	913	336	1249		773	773	1941	2714
1983	271	30	301	1912	683	2595		425	425	2896	3321
1984	400	108	508	3182	645	3827		683	683	4335	5018
1985	1542	110	1652	2835	1672	4507		1156	1156	6159	7315
1986	473	394	867	1569	2169	3738	14	1228	1242	4605	5847
1987	4019	1321	5340	990	1731	2721		1318	1318	8061	9379
1988	866	830	1696	111	954	1065	12	683	695	2761	3456
1989	5	878	883	23	1103	1126	3	706	709	2009	2718
1990	228	832	1060	7	1053	1060	35	1441	1476	2120	3596
1991	1507	20	1527		960	960	36	1445	1481	2487	3968
1992		19	19		1647	1647		1208	1208	1666	2874
1993		18	18		1004	1004		741	741	1022	1763

Table 1. continued-

	3N			3O			3Ps			3NO	3NOPs
Year	non-Can	Canada	Total	non-Can	Canada	Total	non-Can	Canada	Total	Total	Total
1994	20	16	36	4	253	257		382	382	293	675
1995	5		5	1	276	277		420	420	282	702
1996	28		28	1	311	312		362	362	340	702
1997	92		92	6	329	335		315	315	427	742
1998	81		81	8	188	196	1	561	562	277	839
1999	51	43	94	13	322	335		575	575	429	1004
2000	124	21	145	29	393	422	134	976	1110	567	1677
2001	73	18	91	49	493	542	10	920	930	633	1563
2002	1221		1221	3132	1014	4146	3	915	918	5367	6285
2003	2688		2688	3053	417	3470	3	1105	1108	6158	7266
2004	170	6	176	1364	375	1739	22	1361	1383	1915	3298
2005	21	0	21	258	685	943	23	1615	1638	964	2602
2006	73	2	75	178	950	1128	1	1484	1485	1203	2688
2007	12	10	22	74	627	701	2	1253	1255	723	1978
2008	26	6	32	60	778	838	6	659	665	870	1535
2009	19	3	22	70	389	459		362	362	481	843
2010	20	13	33	65	174	239		378	378	272	650
2011	3	0	3	94	66	160		200	200	163	363
2012	3	3	9	83	48	131	-	207	207	140	347
2013	10	-	10	112	83	195	-	167	167	205	372
2014	26	4	30	215	26	243		354	354	273	627

Table 2. White Hake STACFIS estimates, STATLANT-21A reported landings, and Total Allowable Catch quotas (000s of tonnes) for NAFO Divisions 3NO and Subdivision 3Ps.

	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Div. 3NO:										
TAC	8.5	8.5	8.5	8.5	6	6	5	1 ¹	1 ¹	1 ¹
STATLANT-21A ¹	1.2	0.7	0.9	0.5	0.3	0.2	0.1	0.2	0.3	
STACFIS	1.1	0.6	0.9	0.4	0.2	0.3	0.1	0.2	0.3	
Subdiv. 3Ps:										
STATLANT-21A	1.5	1.3	0.7	0.4	0.4	0.2	0.2	0.2	0.4	

¹Should a Contracting Party experience higher than normal catches per unit of effort (CPUE) and conclude that a shift to high availability levels of White Hake during the fishing season - such as what apparently was the case in 2002 and 2003 - is taking place, then that Contracting Party shall notify the Executive Secretary. Upon this notification, the TAC is increased to 5 000 metric tons. The Executive Secretary shall notify all Contracting Parties of the increased TAC. Within one month that Contracting Party shall submit a summary of evidence for its conclusion (higher than normal CPUE and any other additional relevant information). On this basis, a mail vote will be submitted to the Fisheries Commission as to whether an exceptional increase in the availability of fish occurs. In case of a positive vote, the TAC is confirmed to be 5 000 metric tons. In case of a negative vote, the TAC is 1 000 metric tons and catches between the notification of high availability and the notification to Contracting Parties of the result of the vote will not be accounted for the catch limitation provided in Article 5 of the NCEM.

Table 3. Canadian reported White Hake landings (t) from fisheries targeting other species in Div. 3NOPS, 2000-2014.

	Atlantic Cod	Atlantic Halibut	Monkfish	Redfish	Skates	Witch Flounder	White Hake
Year	Bycatch	Bycatch	Bycatch	Bycatch	Bycatch	Bycatch	Directed
2000	449.1	126.1	5.6	151.6	13.0	13.0	606.9
2001	216.0	82.3	63.8	250.5	13.4	12.3	778.8
2002	197.9	50.9	60.2	183.7	46.4	19.4	1,273.3
2003	212.7	29.8	69.6	308.7	28.1	18.5	787.9
2004	117.7	72.0	76.4	155.6	5.2	15.3	986.2
2005	186.0	27.0	60.5	190.9	13.9	13.2	1,554.9
2006	234.6	23.1	67.8	146.9	9.6	4.2	1,519.9
2007	208.9	8.2	10.8	59.4	53.5	0.6	1,296.4
2008	134.9	54.7	1.1	61.6	1.8	8.7	1,076.7
2009	63.2	12.4	1.4	13.2	48.5	14.3	516.0
2010	75.1	15.4	5.7	2.4	8.9	2.4	370.6
2011	45.2	3.9	14.2	7.5	0.9	2.6	148.2
2012	69.0	26.1	6.6	6.1	3.1	1.4	115.8
2013	70.2	6.9	0.9	12.2	0.0	7.4	154.3
2014	85.5	14.5		9.0	0.6	5.0	273.6

Table 4. Canadian reported White Hake landings (t) from directed and bycatch fisheries using gillnets, longlines, and otter trawls in Div. 3NOPs, 2000-2014.

Year	Gillnets		Longlines		Otter Trawls	
	Bycatch	Directed	Bycatch	Directed	Bycatch	Directed
2000	307.5	142.5	397.8	463.5	70.4	0.9
2001	348.8	304.3	218.1	473.9	83.2	0.6
2002	251.2	335.0	193.0	813.8	125.1	124.5
2003	471.0	376.7	104.4	411.2	108.0	
2004	241.2	783.3	118.2	202.9	84.0	
2005	296.6	1,243.4	99.2	311.5	105.5	
2006	191.7	1,206.7	207.0	311.7	103.8	1.4
2007	133.6	820.9	187.9	475.5	24.0	
2008	77.6	336.3	140.7	740.4	40.7	
2009	30.7	218.0	93.5	298.0	26.5	
2010	44.7	239.3	58.9	131.3	7.7	
2011	56.7	106.8	13.1	41.4	5.7	
2012	72.0	105.7	38.8	10.1	2.3	
2013	73.5	106.2	14.8	48.1	8.6	
2014	18.8	272.7	80.5	0.9	16.1	

Table 5a. Biomass and abundance of White Hake from Canadian spring research vessel surveys, 1971-2014. Surveys were conducted with a Yankee bottom trawl (1971-1983), an Engel trawl (1984-spring 1995), and a Campelen trawl (spring 1996-2014). NAFO Subdiv. 3Ps was not surveyed in 1971, 2006; Div. 30 was not surveyed in 1971, 1972, 1974, 1983; and Div. 3N was not surveyed in 1983. Note that deep strata in Div. 3NO were not surveyed in spring 2006.

Year	Biomass (tonnes)				Abundance (000s)			
	3N	3O	3Ps	3NOPs	3N	3O	3Ps	3NOPs
Yankee series								
1971	0	0		0	0	0		0
1972	354		2,725	3,079	61		1,556	1,618
1973	36	1,532	465	2,033	11	327	247	585
1974	0		5,224	5,224	0		2,055	2,055
1975	0	3,173	4,491	7,664	0	1,080	2,646	3,726
1976	110	5,623	4,778	10,511	32	1,413	3,856	5,301
1977	50	1,339	7,168	8,557	43	466	3,935	4,444
1978	0	6,188	6,774	12,962	0	4,361	4,058	8,420
1979	165	1,978	6,310	8,453	34	1,065	3,077	4,176
1980	0	1,385	3,970	5,356	0	1,015	2,053	3,068
1981	139	96	7,448	7,682	28	93	4,743	4,865
1982	0	1,058	4,283	5,342	0	399	1,340	1,739
1983			0	0			0	0
Engel series								
1984	258	3,531	2,558	6,348	57	1,085	1,179	2,321
1985	46	2,878	5,303	8,227	8	1,315	3,045	4,368
1986	356	2,438	11,105	13,899	70	574	4,186	4,830
1987	43	2,752	9,866	12,661	95	1,114	4,438	5,647
1988	32	5,431	13,005	18,469	63	690	5,533	6,286
1989	0	925	6,884	7,809	0	251	4,130	4,382
1990	0	754	3,988	4,742	0	236	2,941	3,177
1991	0	1,039	4,591	5,630	0	1,118	3,800	4,918
1992	0	606	3,008	3,614	0	574	2,699	3,274
1993	0	522	2,929	3,451	0	301	2,670	2,970
1994	0	1,079	2,433	3,512	0	885	2,274	3,159
1995	0	334	2,334	2,668	0	189	2,104	2,294
Campelen series								
1996	4	2,020	6,282	8,306	75	2,982	8,089	11,145
1997	4	2,221	8,507	10,733	91	2,987	12,432	15,510
1998	7	2,205	4,007	6,219	79	2,249	4,765	7,093
1999	20	12,194	8,236	20,450	29	26,010	8,654	34,693
2000	30	15,900	10,294	26,224	716	104,360	11,743	116,819
2001	269	14,908	8,092	23,269	517	39,384	13,792	53,692
2002	96	10,808	10,118	21,022	105	11,334	15,098	26,537
2003	234	7,981	5,762	13,977	176	7,250	6,904	14,330
2004	33	10,369	6,622	17,024	53	8,477	6,977	15,506
2005	20	5,932	5,249	11,205	35	9,725	5,506	15,306
2006	247	12,267		12,517	69	10,370		10,463
2007	2	3,510	6,940	10,452	7	2,734	6,061	8,802
2008	108	4,660	3,633	8,400	23	5,689	3,991	9,703
2009	183	4,656	2,582	7,435	152	2,804	4,547	7,548

Table 5a. continued-

	Biomass (tonnes)				Abundance (000s)			
Year	3N	3O	3Ps	3NOPs	3N	3O	3Ps	3NOPs
Campelen series								
2010	52	4,283	3,739	8,074	30	5,085	5,285	10,400
2011	571	6,423	4,727	11,722	2,175	17,834	6,745	26,754
2012	1,548	6,215	3,686	11,449	2,933	7,383	4,657	14,972
2013	49	7,755	3,987	11,792	178	11,807	5,581	17,566
2014	482	9,494	3,631	13,607	529	8,342	5,834	14,705

Table 5b. Biomass and abundance of White Hake from Canadian autumn research vessel surveys in Div. 3NO, 1990-2014. Surveys were conducted with an Engel trawl (1990-autumn 1994), and a Campelen trawl (autumn 1995-2014). Note that Canadian research vessels' mechanical difficulties prevented the surveying of: deep strata in Div. 3NO in autumn of 2003, 2004, and 2006; strata deeper than 730 m in autumn 2008; and Div. 3NO in autumn 2014.

Year	Biomass (tonnes)			Abundance (000s)		
	3N	3O	3NO	3N	3O	3NO
Engel series						
1990	0	1,784	1,784	0	863	863
1991	0	2,805	2,805	0	2,047	2,047
1992	22	471	493	63	448	511
1993	0	748	748	0	490	490
1994	0	1,445	1,445	0	1,341	1,341
Campelen series						
1995	94	4,099	4,193	306	5,409	5,715
1996	6	3,960	3,966	143	3,850	3,993
1997	72	4,192	4,264	64	5,361	5,425
1998	171	2,896	3,067	2,036	5,079	7,115
1999	3,028	4,043	7,071	83,220	11,583	94,803
2000	1,165	9,551	10,716	2,875	22,750	25,625
2001	946	10,740	11,686	1,077	18,207	19,284
2002	2,753	11,384	14,137	2,126	13,434	15,561
2003	906	13,374	14,280	748	10,628	11,376
2004	1,847	2,237	4,083	2,084	1,492	3,576
2005	539	4,739	5,277	109	4,001	4,110
2006	212	2,088	2,299	98	2,288	2,386
2007	276	10,337	10,613	543	7,859	8,402
2008	620	2,557	3,177	415	2,426	2,841
2009	132	4,189	4,321	73	4,123	4,195
2010	630	3,695	4,325	2,508	3,465	5,973
2011	270	7,293	7,563	947	13,410	14,357
2012	8,842	2,902	11,745	12,307	5,768	18,075
2013	857	13,201	14,058	993	15,721	16,714
2014	ns	ns	ns	ns	ns	ns

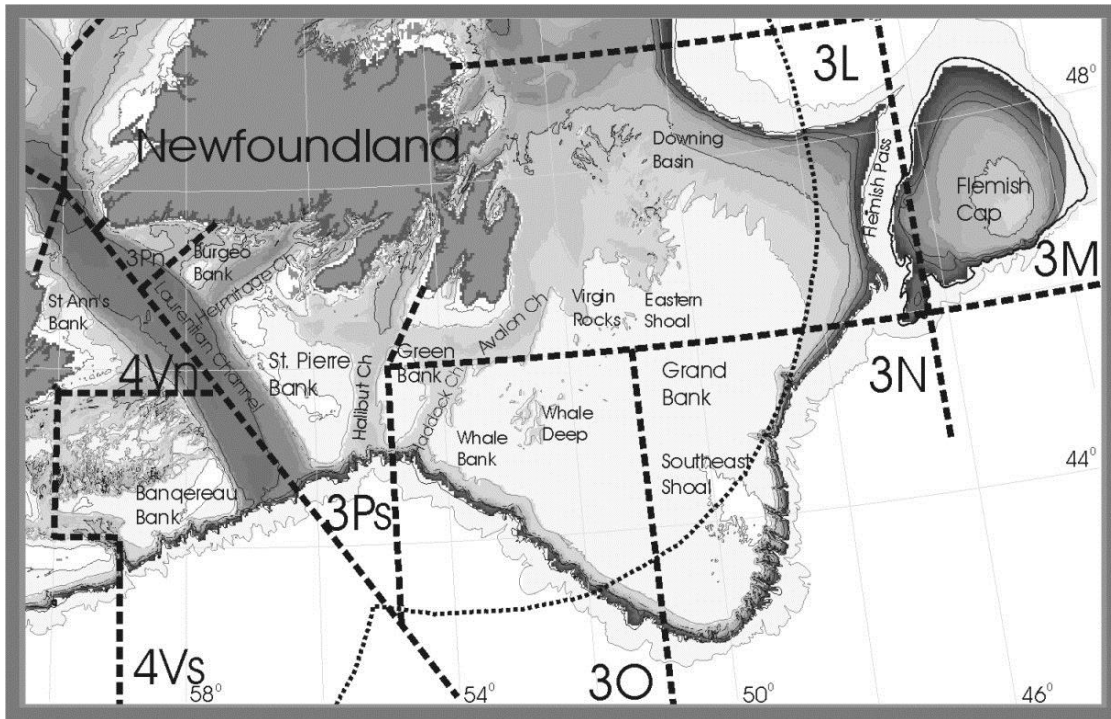


Figure 1. Map of the Grand Banks showing various banks, basins, and NAFO Divisions. Thick dotted lines delineate NAFO Divisions. The thin dotted curved line shows Canada's 200-mile limit: delineating Canadian territory from the NAFO Regulatory Area (NRA).

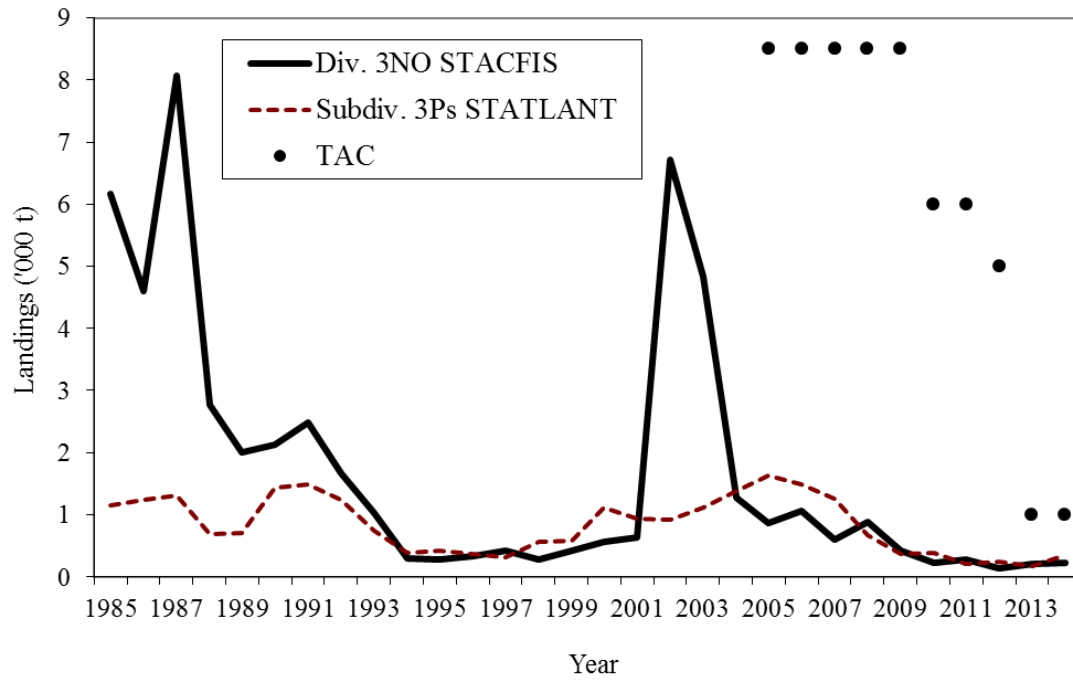


Figure 2. Total reported landings of White Hake and TAC in Div. 3NO and Subdiv. 3Ps, 1985-2014.

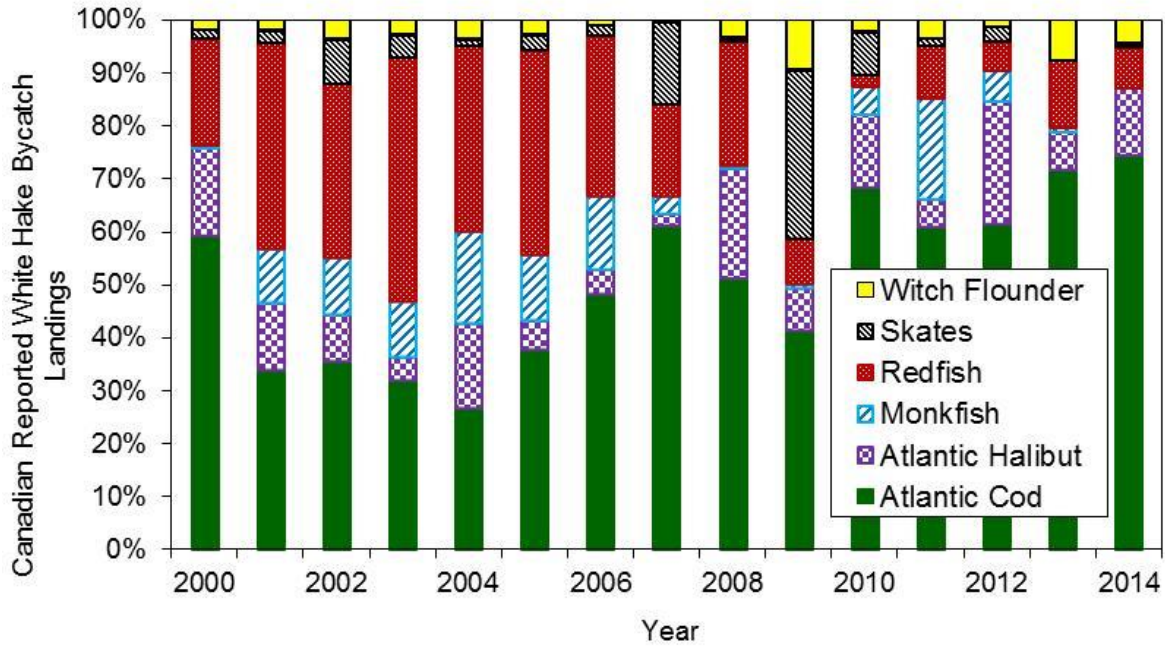


Figure 3. Canadian reported landings of White Hake bycatch from various fisheries in Div. 3NOPs, 2000-2014.

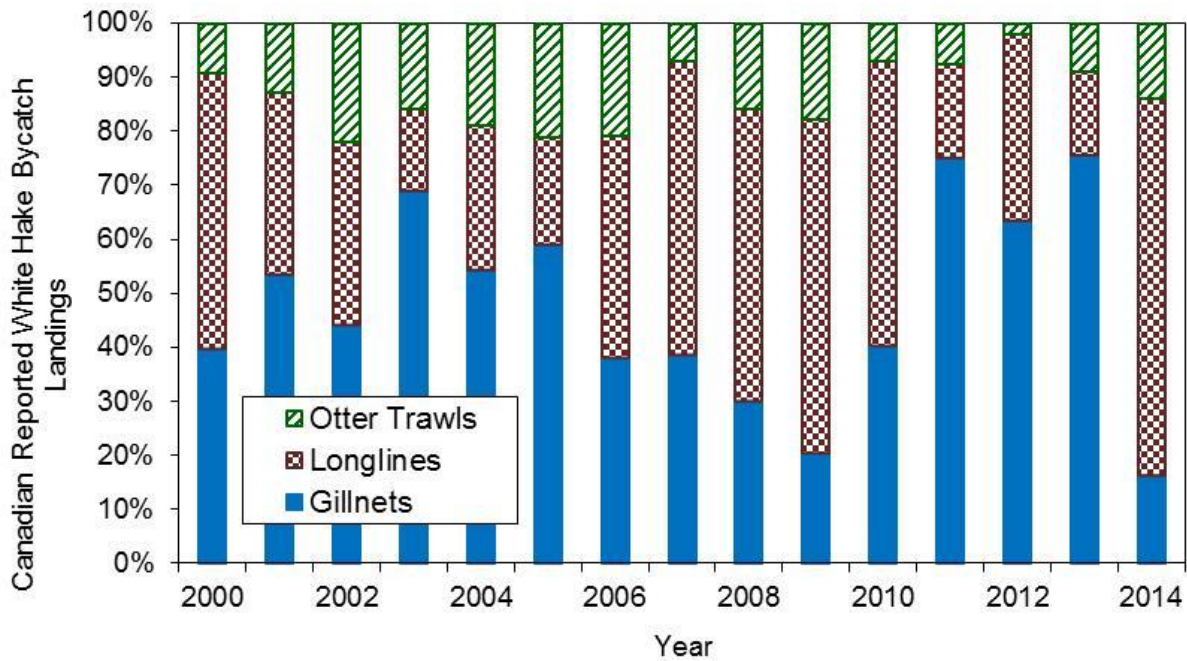


Figure 4. Canadian reported landings of White Hake bycatch by gear in Div. 3NOPs, 2000-2014.

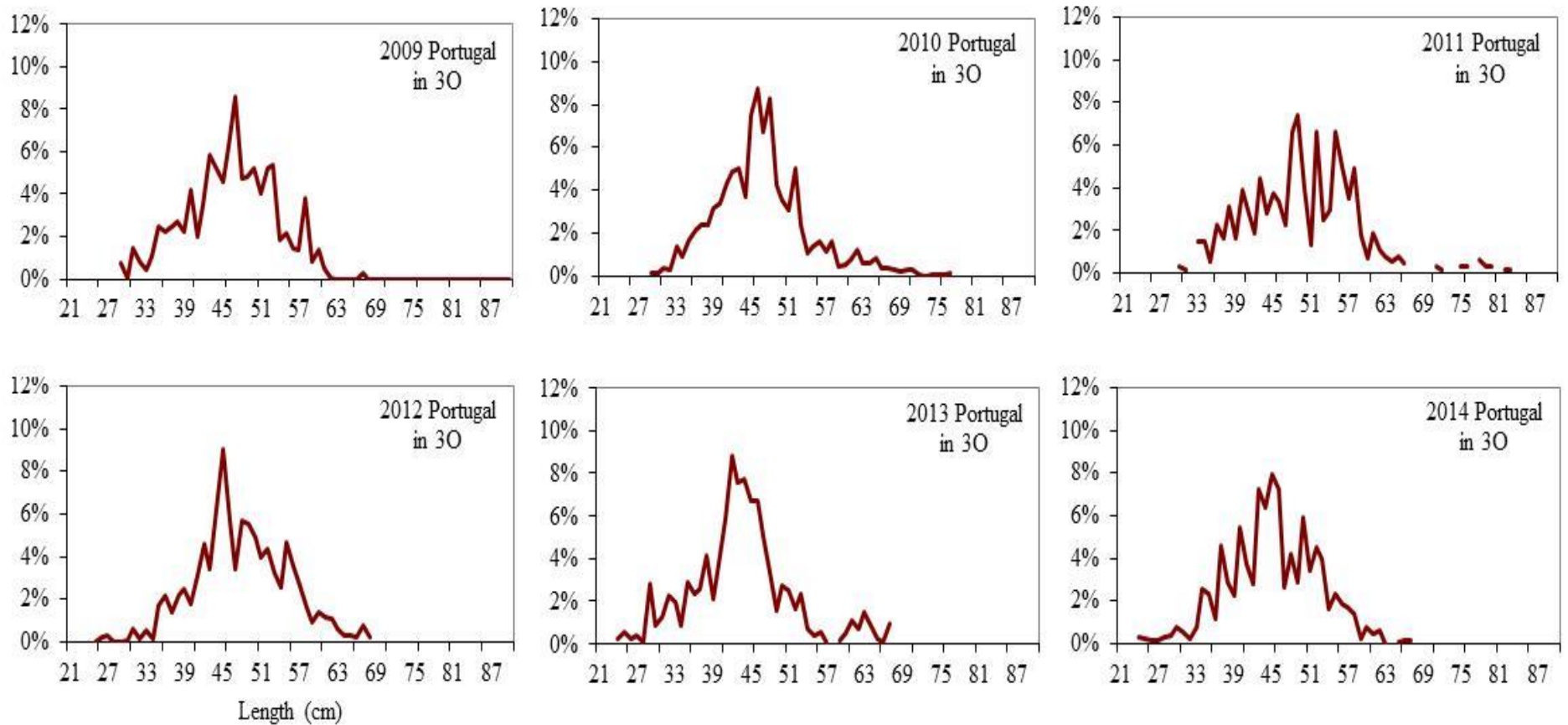


Figure 5a. Available size frequency data for White Hake bycatch in EU-Portugal commercial trawl fisheries in the NAFO Regulatory Area in 2007-2013 (excluding 2008 due to small sample size).

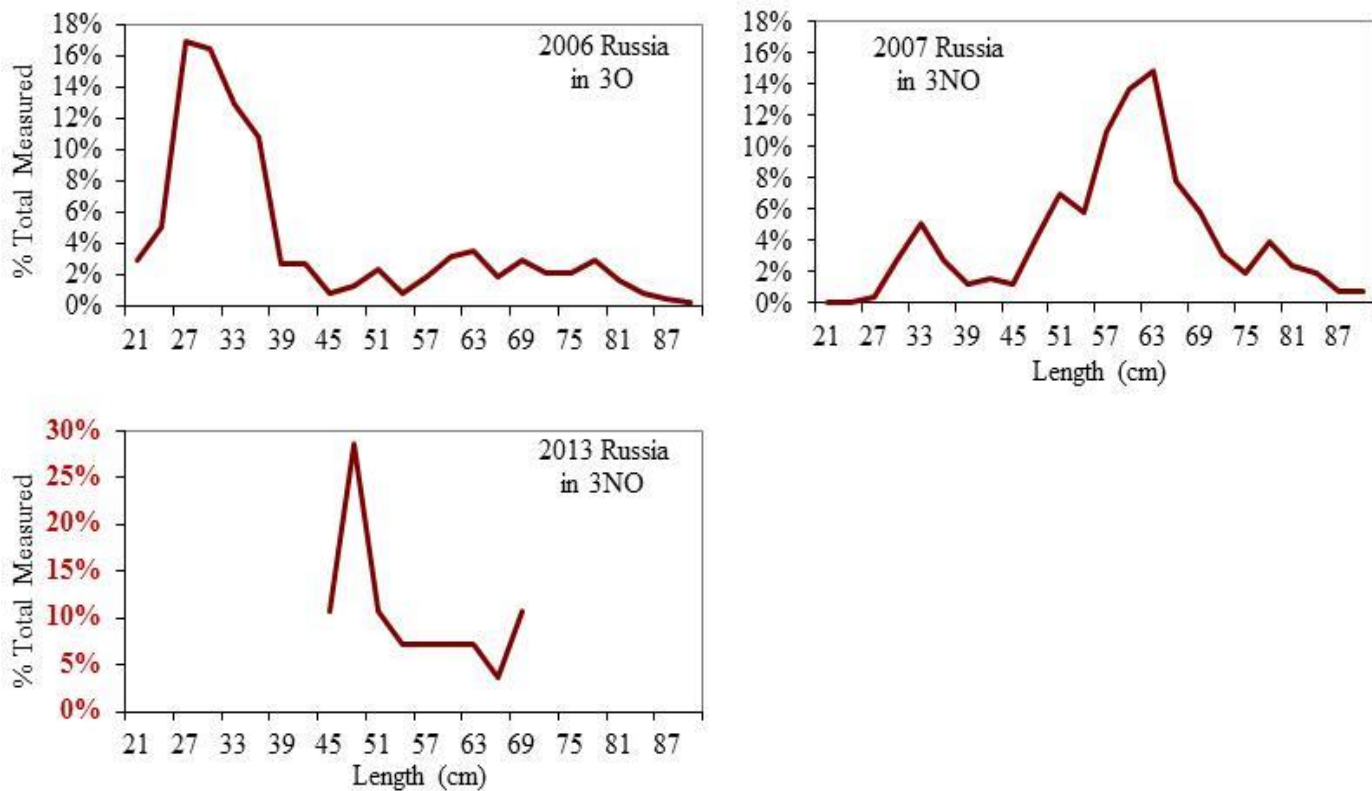


Figure 5b. Available size frequency data for White Hake bycatch in Russian commercial trawl fisheries in the NAFO Regulatory Area in 2006-2007, 2013. Note that the Y-axis scale for 2013 is larger than those for 2006-2007. Russia did not sample commercial White Hakes in 2008-2012, and the sample in 2014 was very small.

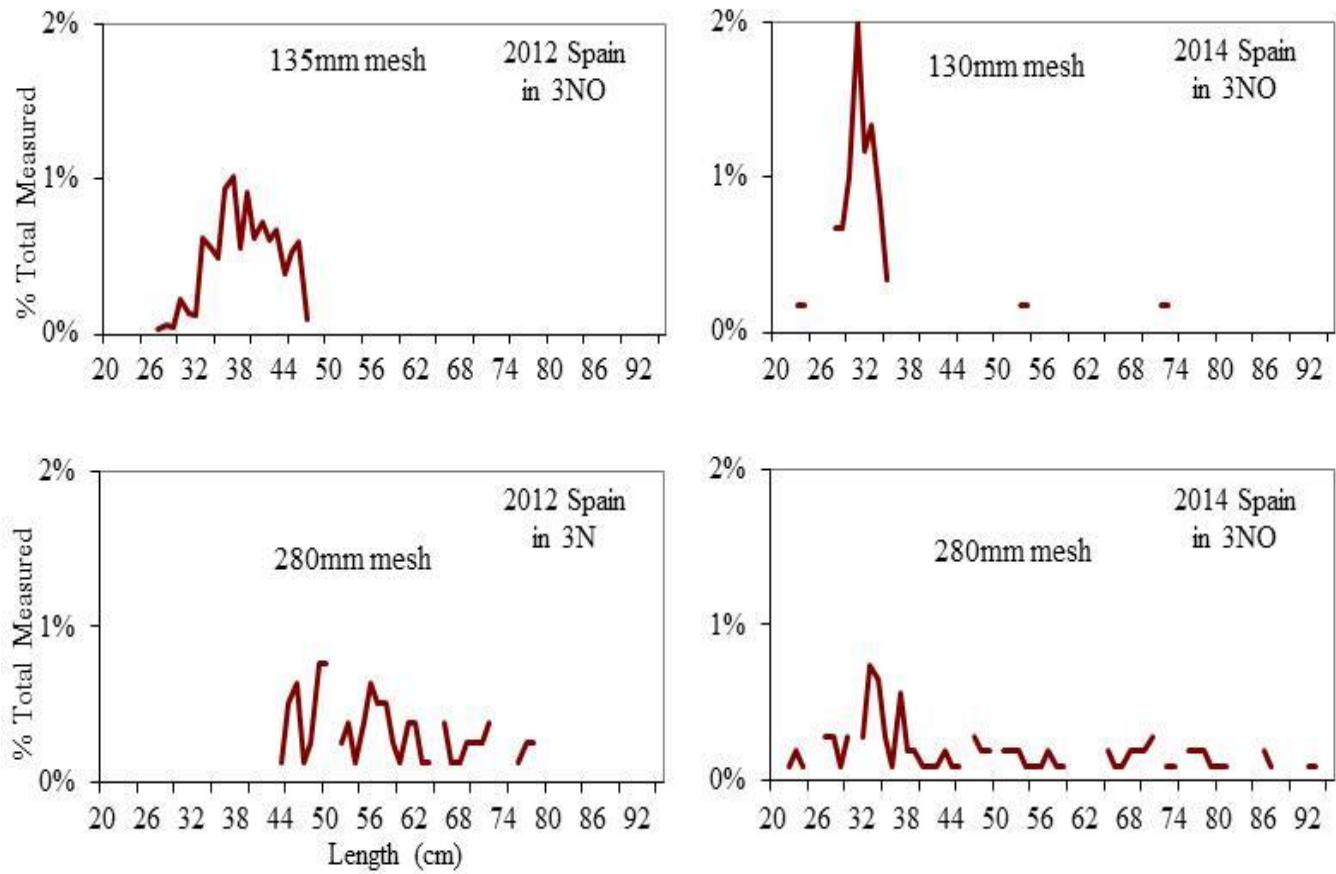


Figure 5c. Available size frequency data for White Hake bycatch in Spanish commercial trawl fisheries in the NAFO Regulatory Area in 2012, 2014. EU-Spain did not sample commercial White Hakes in 2013.

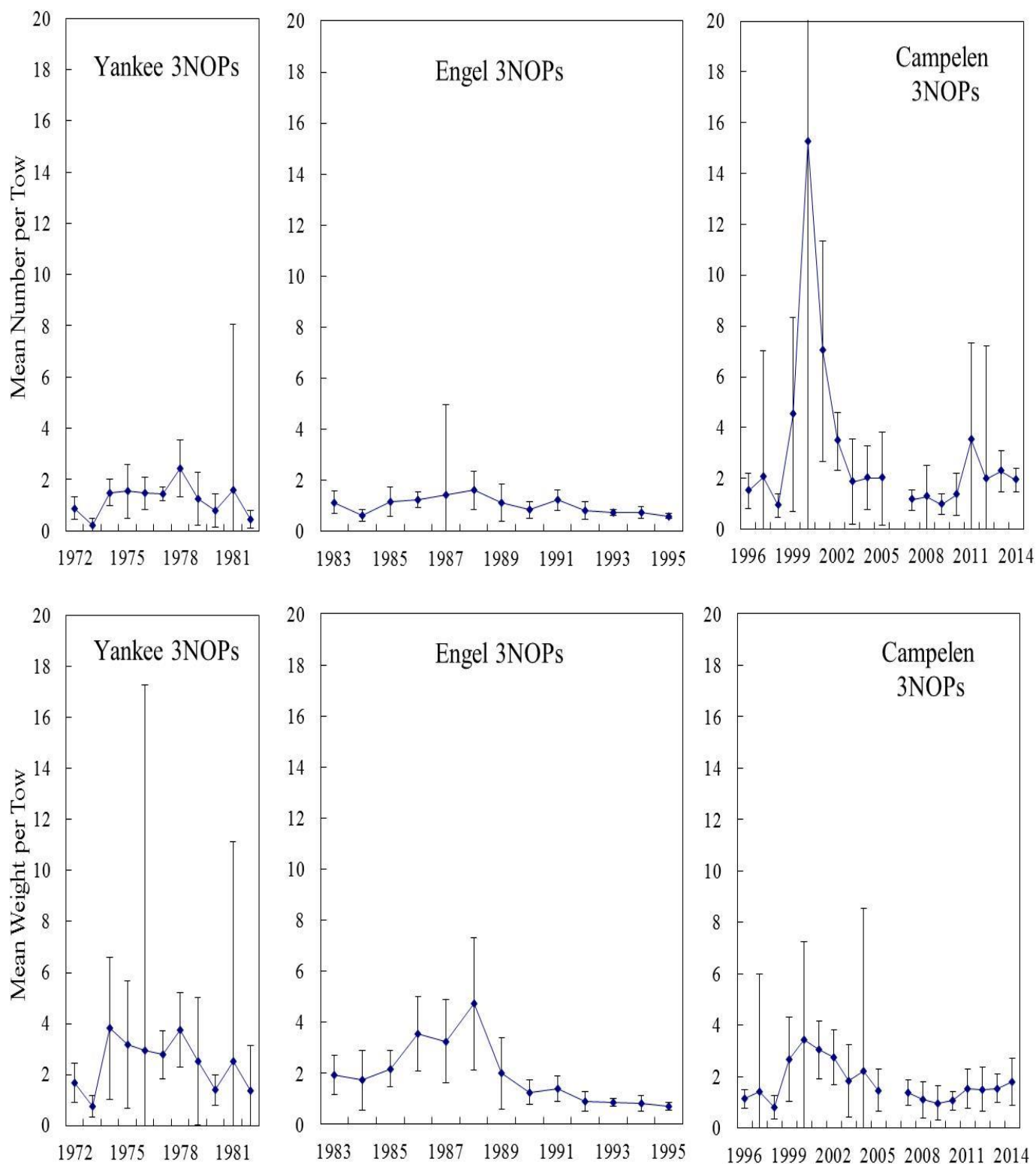


Figure 6a. White Hake mean numbers (top panels) and mean weights (kg; bottom panels) per tow (+95% CI) from Canadian spring research surveys in Div. 3NO and Subdiv. 3Ps, 1972-2014. Yankee, Engel, and Campelen time series are not standardized, and thus are presented on separate panels. Note that deep strata in Div. 3NO and all of Subdiv. 3Ps were not surveyed in spring 2006, due to Canadian research vessels' mechanical difficulties.

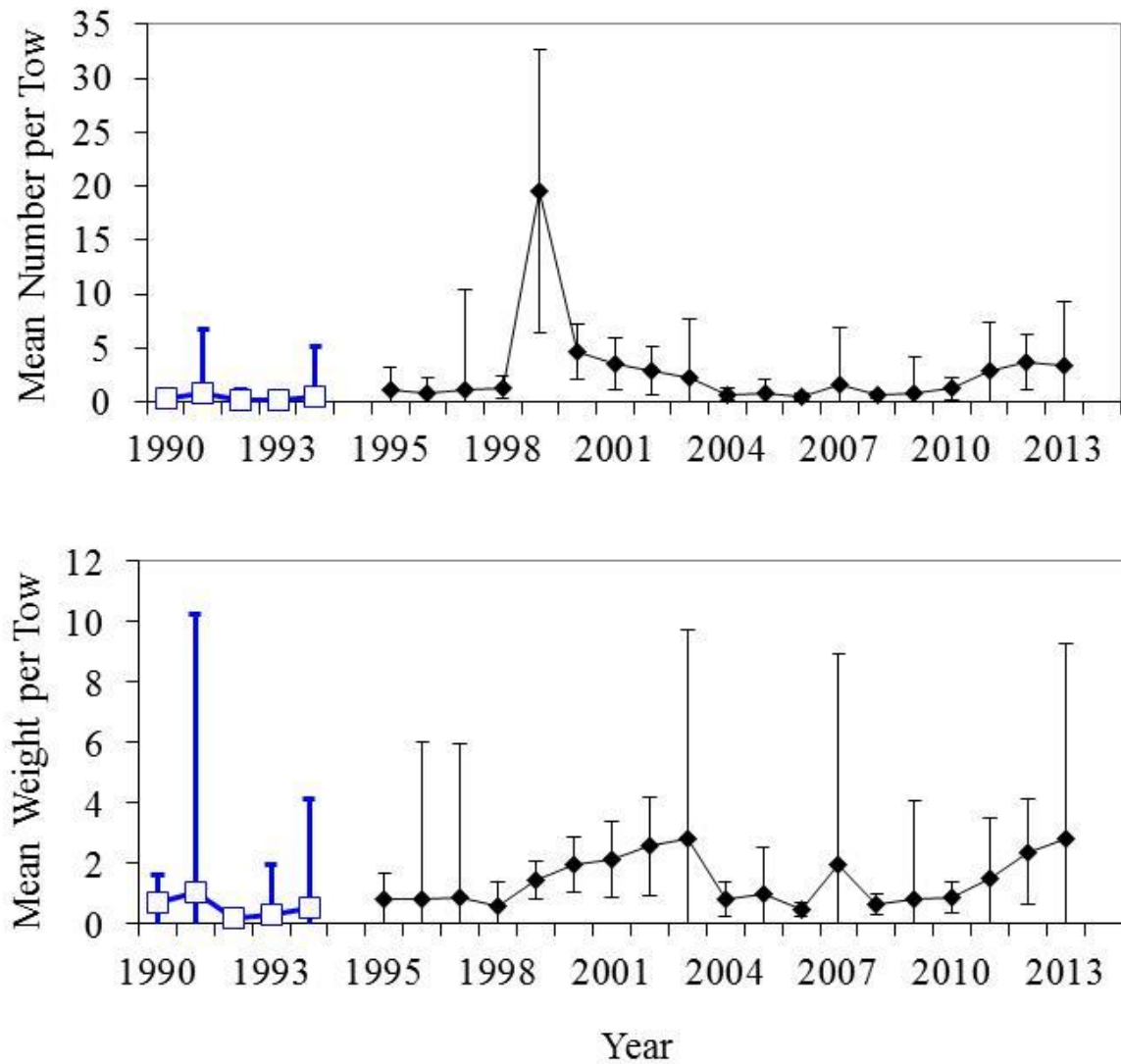


Figure 6b. White Hake mean numbers (top panel) and mean weights (kg; bottom panel) per tow (+95% CI) from Canadian autumn research surveys in Div. 3NO, 1990-2013. Engel (\square , 1990-1994) and Campelen (\blacklozenge , 1995-2013) time series are not standardized. Note that Canadian research vessels' mechanical difficulties prevented the surveying of: deep strata in Div. 3NO in autumn of 2003, 2004, and 2006; strata deeper than 730 m in autumn 2008; and Div. 3NO in autumn 2014.

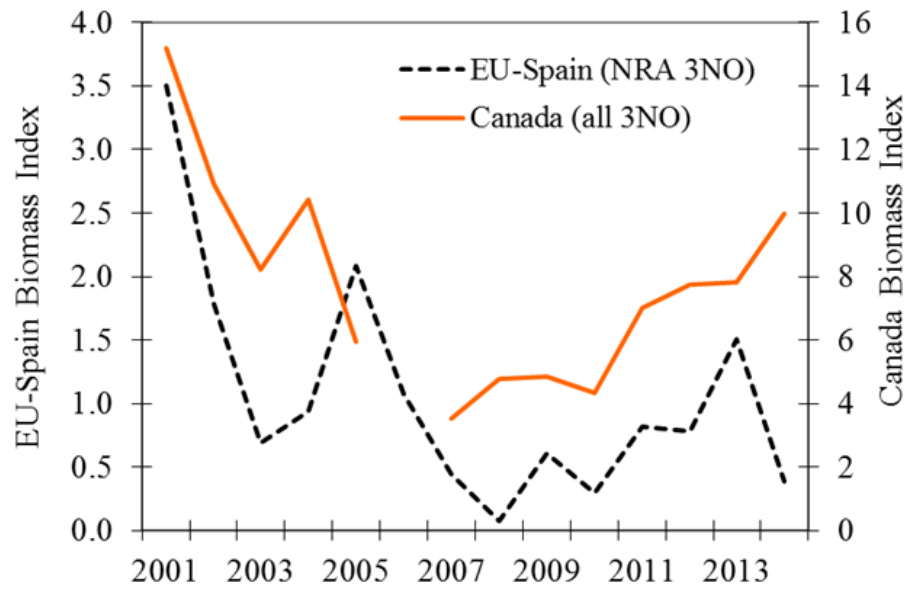


Figure 7. White Hake biomass indices (000s tonnes) in Div. 3NO: EU-Spain spring surveys in the NRA of Div. 3NO compared to Canadian spring surveys in all of Div. 3NO, 2001-2014. Note that deep strata in Div. 3NO were not surveyed by Canada in spring 2006, due to research vessels' mechanical difficulties.

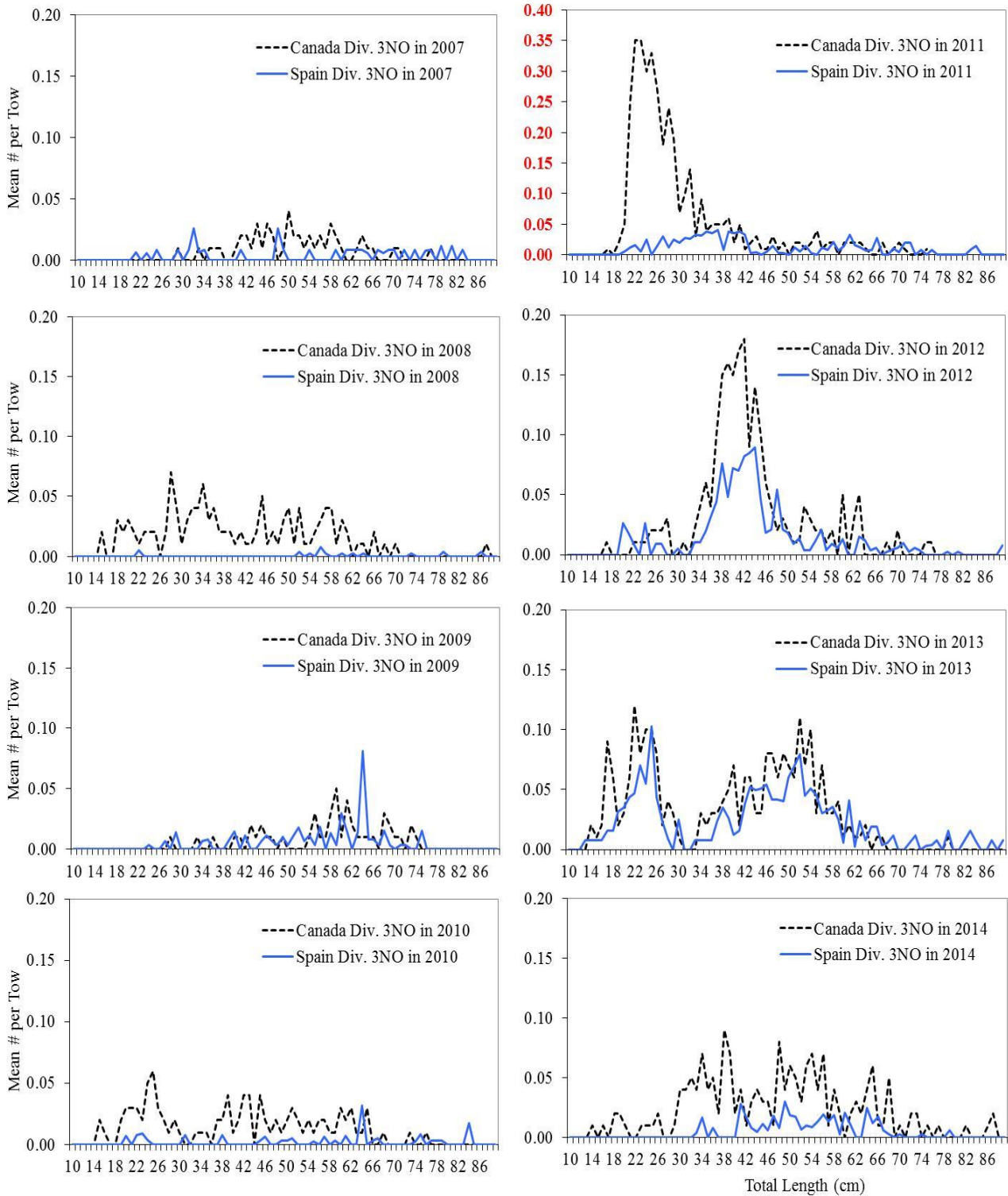


Figure 8. Abundance at length from Canadian Campelen and EU-Spain Campelen spring research surveys in Div. 3NO (EU-Spain surveys limited to NRA), 2007-2014. Note that Y-axis values for 2011 are double those for 2007-2010 and 2012-2014. Deep strata in Div. 3NO were not surveyed in 2006, due to Canadian research vessels' mechanical difficulties.

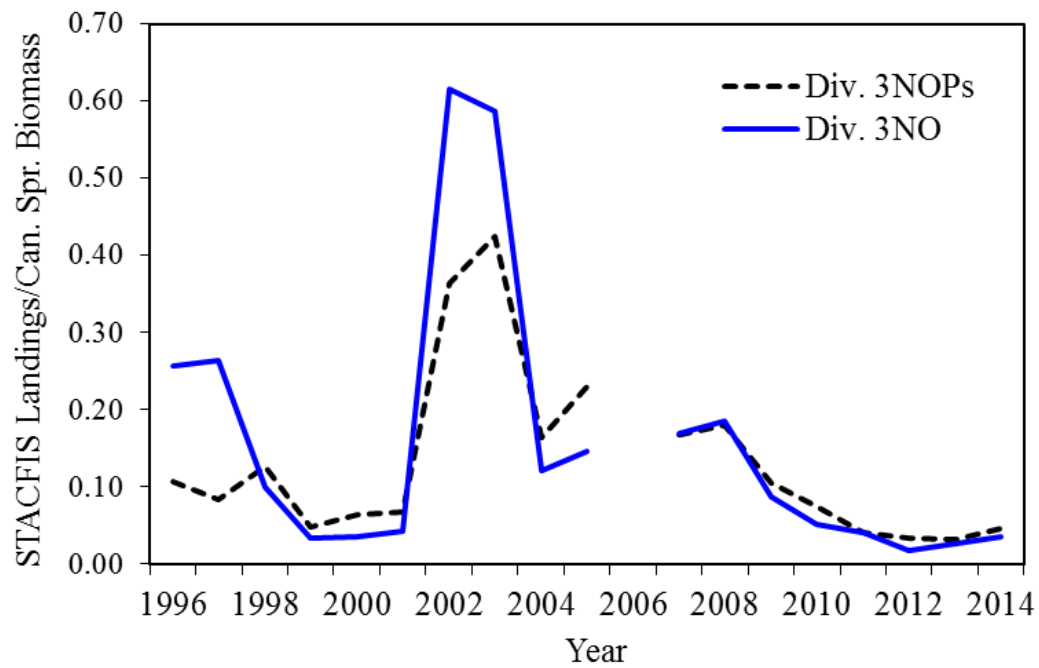


Figure 9. Relative F index (= STACFIS commercial landings/Canadian Campelen spring survey biomass) for White Hake in Div. 3NO and Div. 3NOPs, 1996-2014. Note that deep strata in Div. 3NO and all of Subdiv. 3Ps were not surveyed in 2006, due to Canadian research vessels' mechanical difficulties.

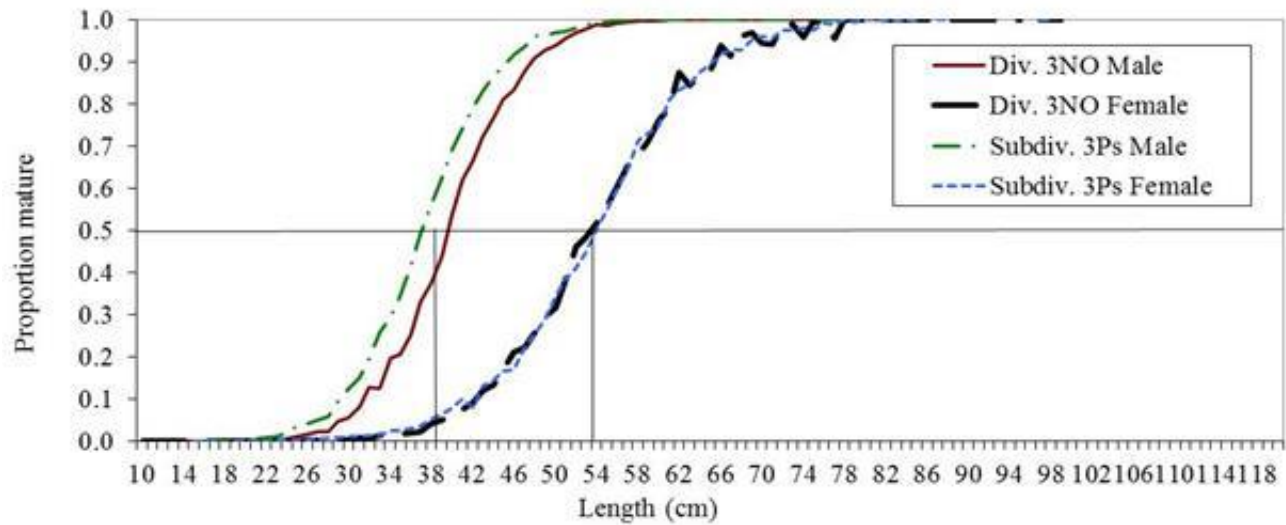


Figure 10. White Hake in Div. 3NO and Subdiv. 3Ps: Maturity ogives calculated for each sex from Canadian Campelen spring surveys, and averaged over 1996-2014 (excluding 2006). Note that deep strata in Div. 3NO and all of Subdiv. 3Ps were not surveyed in 2006, due to Canadian research vessels' mechanical difficulties.

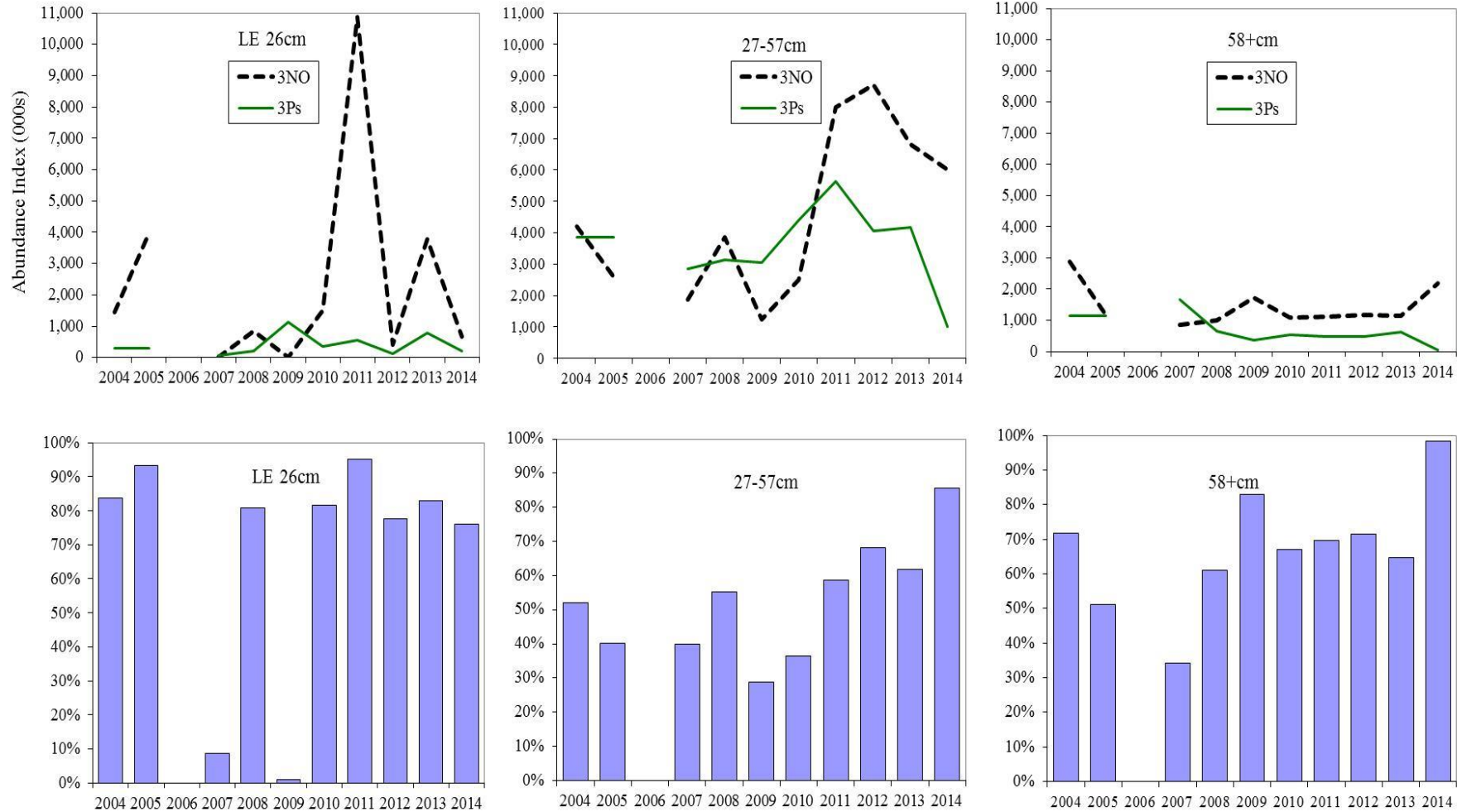


Figure 11. Abundance Index of White Hake by life stage, 2004-2014: Less than or Equal to 26 cm is mainly year-class 1; 27-57 cm contains mainly juveniles; and 58+ cm is mainly mature fish. Upper panel: Abundance Index (000s). Lower panel: Percent abundance in Div. 3NO as compared to the entire area of Div. 3NOs. Note that deep strata in Div. 3NO and all of Subdiv. 3Ps were not surveyed in spring 2006, due to Canadian research vessels' mechanical difficulties.

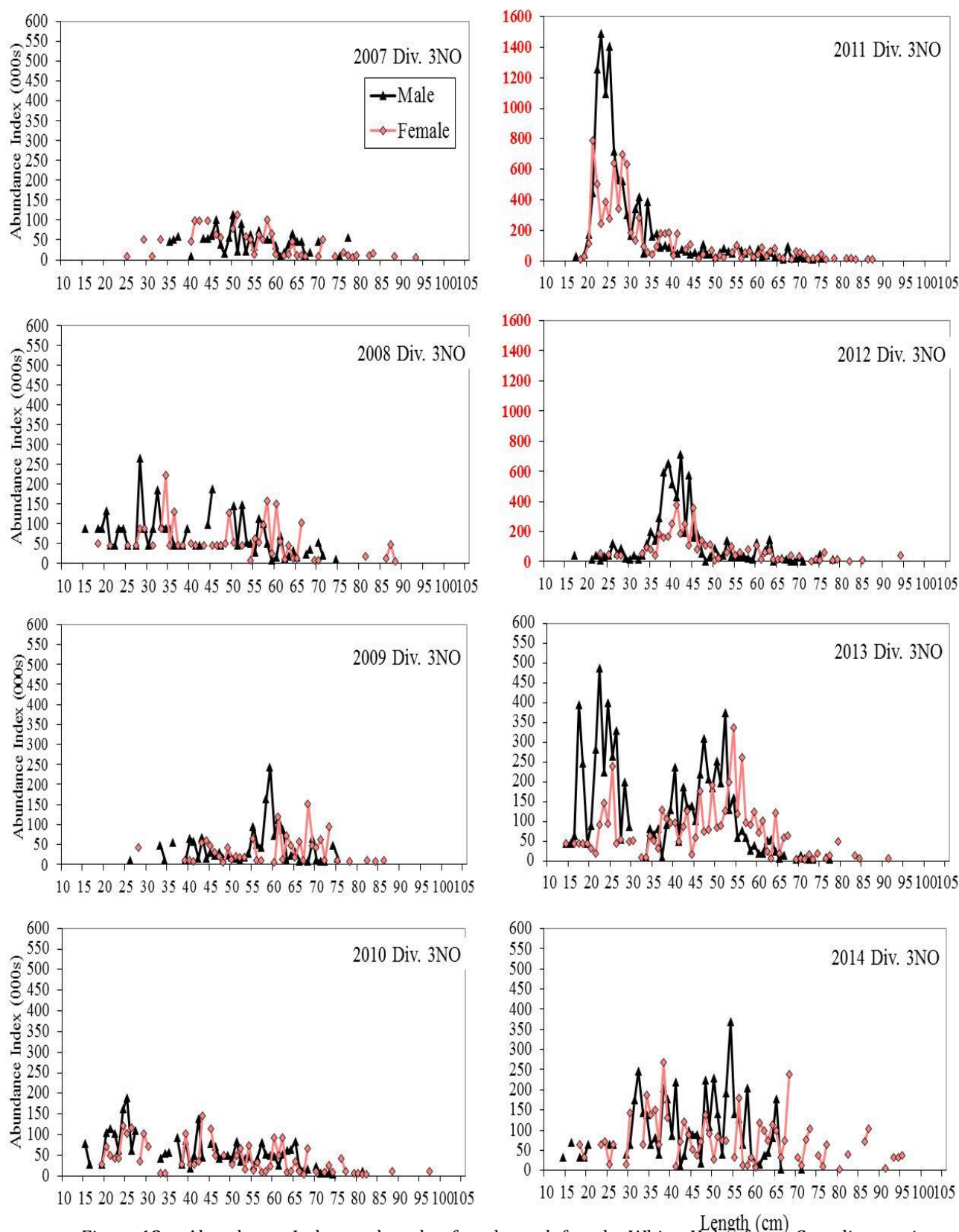


Figure 12a. Abundance Index at length of male and female White Hake from Canadian spring research surveys in Div. 3NO, 2007-2014. Deep strata in Div. 3NO were not surveyed in spring 2006, due to Canadian research vessels' mechanical difficulties. Note that Y-axis values for 2011 and 2012 are larger than those for 2007-2010 and 2013-2014.

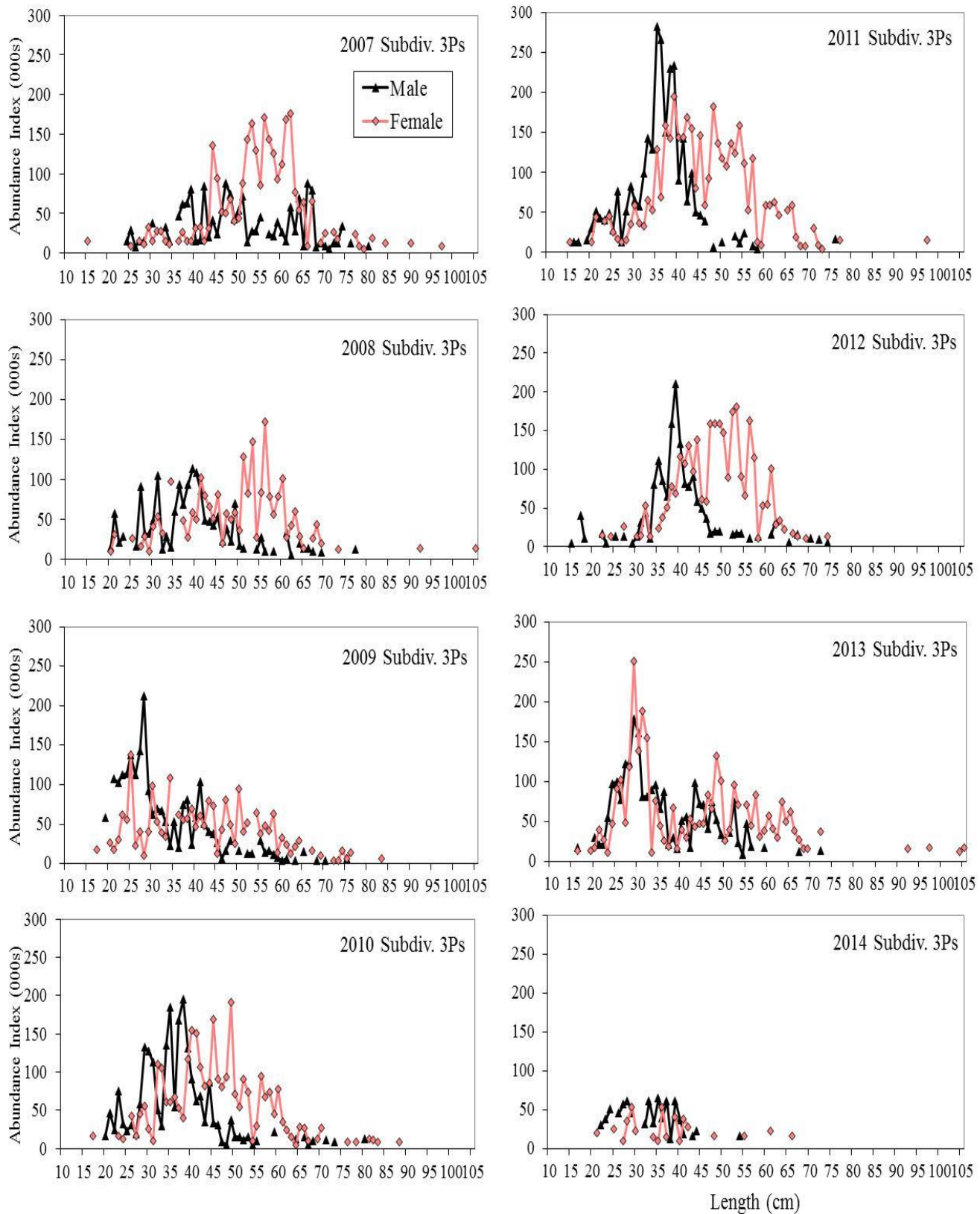


Figure 12b. Abundance Index at length of male and female White Hake from Canadian spring research surveys in Subdiv. 3Ps, 2007-2014. Note that Subdiv. 3Ps was not surveyed in 2006, due to Canadian research vessels' mechanical difficulties.

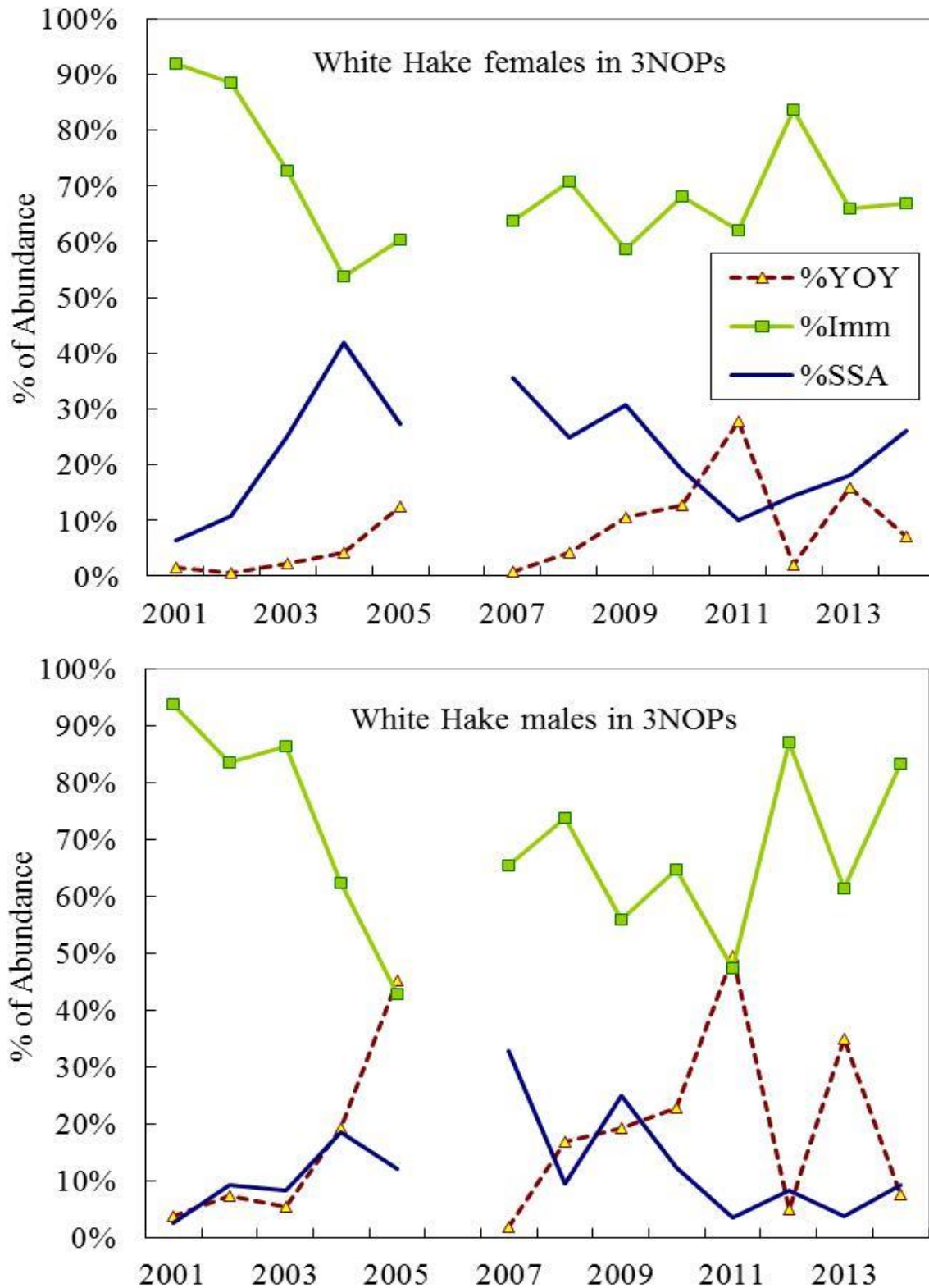


Figure 13. Staged trends in relative abundance of 1-year-olds, immature, and mature female (upper panel), and male (lower panel) White Hake from Canadian Campelen spring surveys in Div. 3NO and Subdiv. 3Ps, 2001-2014. Note that deep strata in Div. 3NO and all of Subdiv. 3Ps were not surveyed in 2006, due to Canadian research vessels' mechanical difficulties.

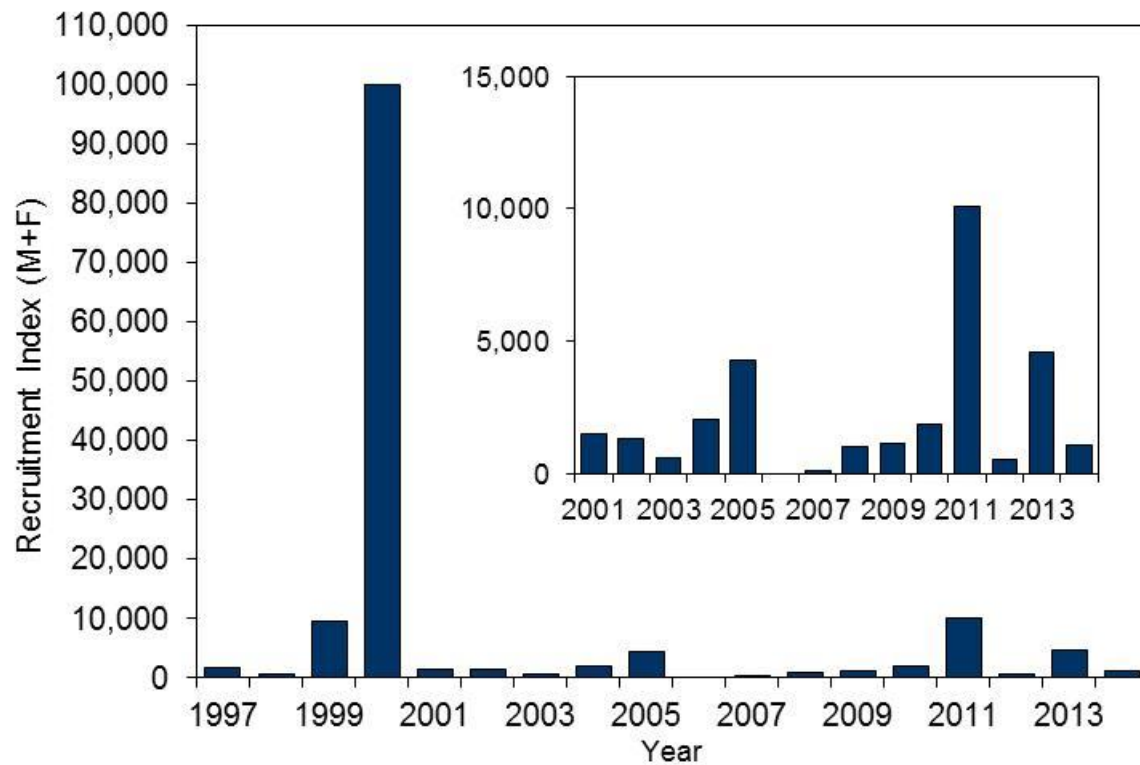


Figure 14. White Hake recruitment index for Age 1 males and females (combined) from Canadian Campelen spring surveys in Div. 3NO and Subdiv. 3Ps, 1997-2014. Inset plot depicts 2001-2014 on a smaller scale. Estimates from 2006 are not shown, since survey coverage in that year was incomplete.

Figure 15a. Distribution of White Hake mean numbers per tow in Div. 3NO and Subdiv. 3Ps, based on Canadian spring research surveys in 2005-2009. Note that deep strata in Div. 3NO and all of Subdiv. 3Ps were not surveyed in 2006, due to Canadian research vessels' mechanical difficulties.

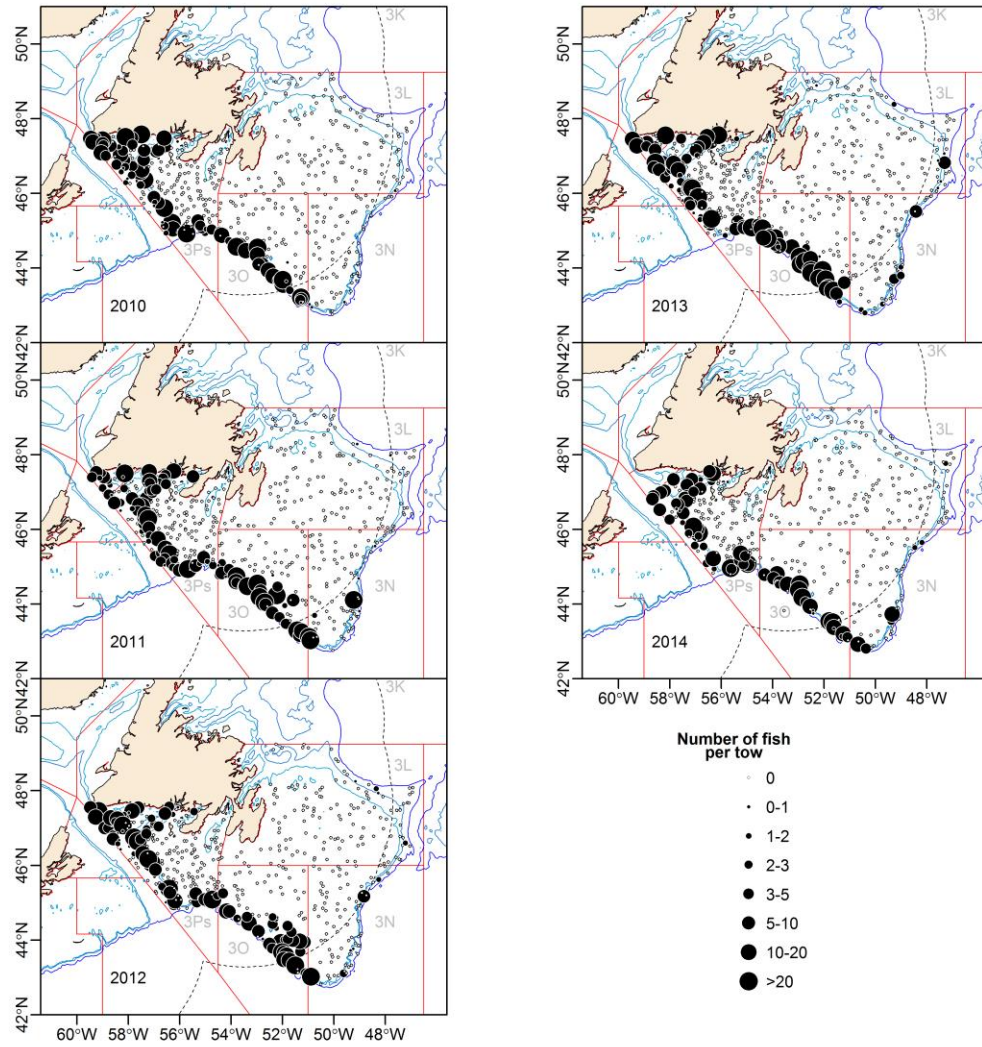


Figure 15b. Distribution of White Hake mean numbers per tow in Div. 3NO and Subdiv. 3Ps, based on Canadian spring research surveys in 2010-2014.