Northwest Atlantic Fisheries Organization

Serial No. N5905 **SCR Doc. 11/022**

SCIENTIFIC COUNCIL MEETING – JUNE 2011

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

M.R. Simpson, C.M. Miri, and L. Mello

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 & Labrador. The spring index for Div. 3NOPs peaked in 2000, due to a very large 1999 year-class. Average catch, which was at its lowest levels in 1995-2001 (455 tons), increased to 6 752 tons in 2002 and 4 841 tons in 2003, following recruitment of the large 1999 year-class. Since 2004, the stock has remained at a level of abundance similar to that observed in the mid1990s. From 2002 to 2010, 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 relatively strong year-classes that survive to maturity.

INTRODUCTION

White Hake (*Urophycis tenuis*, Mitchill 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 (Kulka and Miri 2007).

Formerly one of the commercially important species in the 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 the southern Gulf of St. Lawrence (Div. 4T) in 2005 (DFO 2005), and by Bundy and Simon (2005) for Div. 4VWX/5.

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

Fisheries and Management

A. TAC Regulation

White Hake in NAFO Divisions 3NO came under quota regulation in September 2004, when the Fisheries Commission decided that a TAC of 8 500 mt be established for 2005-2007. This allocation was between Canada at 2 500 mt, the EU at 5 000 mt, Russia at 500 mt, and remaining NAFO member countries at 500 mt. This TAC was maintained at 8 500 mt for 2008-2009. In September 2009, Fisheries Commission reduced the Total Allowable Catch of White Hake in Div. 3NO from 8 500 mt to 6 000 mt for 2010 and 2011.

B. Catch Trends

Reported catches of White Hake in Div. 3NO (all countries combined) 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 tons 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 catches fell to zero. Average catch of White Hake in Div. 3NO was at its lowest in 1995-2001 (455 tons), but increased to 6 718 tons in 2002 and 4 823 tons in 2003. STACFIS reported catches declined to an average of 767 tons in 2005-2009 (Table 2), and was 226 tons in 2010. Although 87% of the total reported catches of White Hake in Div. 3NO (NRA) were taken as a target species by other countries in 2002-2003, Canada has taken a majority of catches in 2005-2010 (up to 93% in 2009).

Catches in Subdivision 3Ps were less variable (Tables 1,2; Fig. 2): averaging 1 114 tons in 1985-93, then decreasing to an average of 668 tons in 1994-2003. Subsequently, catches increased to an average of 1 440 tons in 2004-2007, then decreased to a 443-t average in 2008-2010; with the lowest level reported in 2010 (302 t).

Size

Length distributions of White Hake taken in Canadian commercial directed fisheries in Div. 3O from 2005-2008 **i**ndicated that gillnets captured 32-104 cm fish (mode ~74 cm); and a smaller range of 45-99 cm fish (mode at 71-72 cm) were observed in 2009 (Fig. 3a; no samples taken in 2010). Canadian longlines in Div. 3O caught larger White Hake: with a range of 41-111 cm, and mean lengths of 83, 75, and 77 cm in 2007, 2008, and 2009, respectively (Fig. 3b; no samples taken in 2010). In Subdiv. 3Ps, Canadian longlines captured 39-105 cm fish; with mean lengths of 76 cm and 73 cm in 2008 and 2010, respectively (no samples taken in 2009).

Commercial catch of White Hake by Russian trawlers in the NRA of Div. 3NO in 2006-2007 contained 21-90 cm fish with a mean length of 53 cm (Fig. 4). In addition, Russia observed a peak of 24-36 cm White Hakes (mode at 27 cm) in 2006, and a main peak of 51-69 cm (mode at 63 cm) in the following year. Russia did not sample commercial White Hakes in 2008-2010. Portuguese trawl fisheries (130 mm mesh) in the NRA of Div. 3NO in 2006-2007 captured very similar White Hakes: 23-76 cm fish in 2006 (mean of 49 cm); and 26-65 cm fish in the following year (mean of 45 cm; main mode at 40 cm, Fig. 14a). In 2008, EU-Portugal collected only one sample of 31 trawled fish (range: 38-58 cm; mean: 48 cm), which precludes any conclusions to be drawn from it. EU-Portugal captured similar sized fish in 2009 relative to earlier years; with a range of 29-67 cm, and a mode at 47 cm. In 2010, while a mode at 46 cm was similar to previous years catch in Div. 3O, the distribution of lengths was larger ranging from 29 to 77 cm.

C. Research Vessel Surveys

Canadian Research Vessel 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 gears. In addition to gear dimensions, the mesh size is different: 160 mm in the bellies and codend for Engel trawls, and 40 mm for Campelen gear. 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 Subdivision 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 relative biomass and abundance are presented in Table 3a for NAFO Divisions 3NO and Subdiv. 3Ps. Mean weights and numbers per tow with confidence intervals are presented in Figure 5a.

Relative biomass of White Hake on the Grand Banks in NAFO Divisions 3NOPs increased rapidly in 1999-2000 to about 26 000 tons, but then steeply declined and is presently at levels comparable to earlier estimates in the Campelen time series. During the Canadian spring survey of 2000, estimated abundance was 10-times greater than that observed in either the first years of the Campelen series or during recent years.

Canadian Research Vessel Surveys -Autumn

Stratified-random autumn surveys have been conducted by Canada in NAFO Divisions 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. In addition, Canada does not survey Subdivision 3Ps in autumn. 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, due to Canadian research vessels' mechanical difficulties, deep strata in Div. 3NO were not surveyed in 2003, 2004, and 2006, and strata deeper than 730 m in the survey area were not surveyed in 2008.

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 between 1998 and 1999 (Table 3b, Fig. 5b); due mainly to the presence of large numbers of 1-year-old fish. Relative biomass in these areas doubled and abundance increased by 10 times. Of particular interest is the large increase in biomass in Div. 3N to levels never previously observed. The biomass index has declined since 1999. 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 Young-of-the-Year (YOY) that were spawned in the previous spring (Kulka *et al.* 2005b). About twenty-five weeks later, the next spring survey picks up the previous year's cohort as 1-year-olds. This pattern was most apparent when larger year classes were produced; such as in 1999. After 2003, biomass and abundance indices have remained at levels similar to those observed in 1995-1998.

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 Menduiña* using a Pedreira bottom trawl. Since 2001, the R/V *Vizconde de Eza* replaced the C/V *Playa de Menduíña*, and a Campelen 1800 trawl replaced the Pedreira (González-Troncoso and Paz 2008). Results of this survey are available for White Hake from 2001 onward.

Spanish biomass indices were highest in 2001, declined to 2003, increased to a small peak in 2005, then declined to its lowest level in 2008. This trend is similar to that depicted by Canadian spring surveys which cover all of Div. 3NO; although the latter trend appears to include a peak in 2006 (Fig. 6). Both trends are also reflected in abundance at length data from Spanish and Canadian spring surveys (Fig. 7): the 2005 peak observed by Spain consisted primarily of 52-71 cm White Hake with a mode at 58, while a small peak of 14-27 cm fish (1-year-olds; as described by Kulka *et al.* 2005a) appeared with modes of 14, 20, and 26 cm. These Age-1 fish represent the 2004 cohort. The 2006 peak observed by Canada consisted primarily of 36-46 cm White Hakes with a mode of 42 cm; and probably included the 2004 cohort. In 2009, Spain observed a small peak of 59-65 cm fish with a mode of 65 cm, while a similar peak of 54-61 cm White Hakes (mode of 58 cm) was found in the Canadian spring survey. In 2010, Canada observed a small peak of 15-27 cm fish (Age-1); representing the 2009 cohort.

Catch/ Biomass Ratios

Using STACFIS-agreed commercial catch and 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 = commercial catch/Can. spring biomass) declined to its lowest level in 1999-2001, increased to a high peak in 2002-2003, then declined to a level comparable to the mid1990s (Fig. 8). 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 1996-2010 indicated that length at 50% maturity is different between sexes; but similar among years and between areas (Div. 3NO *versus* Subdiv. 3Ps; Fig. 9). Females reach 50% maturity at 52 cm (50-54 cm; 1996-2010), and males do so at 38 cm (37-39 cm; 1996-2010).

Information on White Hake abundance by life stage from Canadian spring surveys is presented for 2004-2010 in Figure 10. White Hake in their first year correspond to lengths $\leq$26 cm, while 27-57 cm represents age 2+ juveniles, and 58+ cm fish are primarily mature adults (Kulka *et al.* 2005a). In the Upper Panel (Fig. 10), a 2004 cohort appeared as a peak of 1-year-olds in 2005, and as a peak of 2+ juveniles in 2006. Note that the almost zero values in Subdiv. 3Ps resulted from the fact that this area was not surveyed in spring 2006; due to Canadian research vessels' mechanical difficulties. In the Lower Panel, almost all of the Year Class-1 White Hakes were found in Div. 3NO. Except for a peak in 2006, 2+ juveniles were observed almost equally in Div. 3NO and in Subdiv. 3Ps for 2004-2010; except for a majority observed in Subdiv. 3Ps in 2009. For mature White Hakes (58+ cm), percent abundance was higher in Div. 3NO relative to the entire area of Div. 3NOPs. These three observations were similar to those reported for 1997-2003 by Kulka *et al.* (*ibid.*).

Partitioned by sex, relative numbers at length data from Canadian spring surveys of Division 3NO in 2005-2010 indicate that the peak of 1-year-olds observed in 2005 (16-28 cm) contained a majority of male White Hakes, with only 16% females (Fig. 11a). In addition, a small peak of 53-59 cm males was observed in 2005 (modes at 53 and 58); with a smaller number of females ranging from 51 to 86 cm in length. The 2006 peak noted previously consisted of 58% males 33-45 cm long, and 42% females 36-47 cm in length. Furthermore, a small number of males ranged between 53 and 78 cm; while females were observed between 50 and 94 cm. In 2007, 51% of the relative abundance was male, while 49% was female (no peaks). A small number of 1-year-olds (15-28 cm) was observed in 2008; containing 84% males and 16% females. In 2009, no Age-1 fish were found; while a small peak of 58-61 cm males (mode of 59 cm) was predominant. The 2010 peak of 1-year-olds noted previously consisted of 62% males and 38% females. In Subdivision 3Ps, 46% of the relative abundance in 2005 was male; with a main peak of 32-38 cm (main mode of 37 cm), and a small one at 55-61 cm (60 cm mode; Fig. 11b). Females in 2005 were observed primarily in a peak at 39-47 cm (45-47 cm mode). Data were not available for 2006 due to mechanical difficulties on Canadian research vessels. In 2007, 2 peaks of females were obvious: one at 44 cm in length, and another at 52-62 cm. 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 peak of Age-1 fish (19-28 cm) was observed; containing 67% males and 33% females. This probable 2008 cohort was also found as juveniles in 2010; with 69% of all immatures representing males at 29-39 cm (main mode at 38 cm), and 42% of all immatures being females at 32-42 cm (main mode at 40 cm). Two other peaks of immature females were also observed that year at 45 and 49 cm.

Stage-based analysis of abundance from Canadian spring surveys in Div. 3NOPs for 1996-2010 indicated that immature White Hakes (sexes combined) older than one year comprised the dominant component of the population (Fig. 12); similar to what was observed for this stock in the years prior to 2000 (Kulka *et al.* 2005b). A peak of 1-year-old fish (sexes combined) was observed in 2005; depicting the 2004 cohort.

Recruits per spawner varied between 0.07 and 1.7 fish for each adult female in 2000-2009 (Fig. 13); with the largest value of that period occurring in 2009. However, the latter appears insignificant when compared to two large values observed over the whole time series: 13.2 recruits per spawner in 1998, and 48.7 in 1999 (see Kulka *et al.* 2005b for details on the latter**)**.

E. Stock Distribution

White Hake in NAFO Div. 3NO and Subdiv. 3Ps are confined largely to an area associated with the warmest bottom temperatures (4-8^{o}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 in Div. 3NOPs for 2007/2008 and 2009/2010 are shown in Figure 14 and 15 respectively. As in previous years, the stock continues to occupy the southwest shelf edge areas of Div. 3NO. In Subdiv. 3Ps, White Hake are distributed along the shelf edge, and the Laurentian and Hermitage Channels.

F. Assessment Results

Precautionary Reference Points

No precautionary reference points have been established for this stock.

Resource Status

Spring survey indices indicate that the White Hake stock size in Div. 3NOPs remains at levels comparable to those observed during the mid1990s.

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

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.

References

Bundy, A., and J. Simon. 2005. Assessment of the Status of 4VWX5 White Hake, 2005. DFO Can. Sci. Advisory Sec. Res. Doc. 2005/081. 46p.

DFO. 2005. White Hake in the Southern Gulf of St. Lawrence (Div. 4T). DFO Can. Sci. Advisory Sec. Sci. Advis. Rep. 2005/009. 6p.

González-Troncoso, D., and X. Paz. 2008. Biomass and length distribution for Roughhead grenadier, Thorny skate and White Hake from the surveys conducted by Spain in NAFO 3NO. NAFO SCR Doc. 08/009. 38p.

Kulka, D.W., C.M. Miri, and M.R. Simpson. 2005a. Distribution and aspects of the life history of White Hake (*Urophycis tenuis*, Mitchill 1815) on the Grand Banks of Newfoundland. NAFO SCR Doc. 05/60. 40p.

Kulka, D.W., C.M. Miri, and M.R. Simpson. 2005b. The status of White Hake (*Urophycis tenuis*, Mitchill 1815) in NAFO Divisions 3L, 3N, 3O and Subdivision 3Ps. NAFO SCR Doc. 05/66. 55p.

Kulka, D.W., and C.M. Miri. 2007. The status of White Hake (*Urophycis tenuis*, Mitchill 1815) in NAFO Divisions 3N, 3O, and Subdivision 3Ps. NAFO SCR Doc. 07/52. 52p.

McCallum, B., and S.J. Walsh. 1996. Groundfish survey trawls used at the Northwest Atlantic Fisheries Centre, 1971-present. NAFO Sci. Coun. Studies 29: 93-103.

Walsh, S.J., and B.R. McCallum. 1996. Performance of the Campelen 1800 Shrimp Trawl during the 1995 Northwest Atlantic Fisheries Centre autumn groundfish survey. NAFO Sci. Coun. Studies 29:105-116.

Table 1. STATLANT-21A reported catches of White Hake in 1960-2010 by NAFO Division .

	3N			3O			3Ps			3NO	3NOPs
Year	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	6	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	1184	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
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	1219		1219	3132	1014	4146	3	915	918	5365	6283
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	37	6	43	63	778	841	6	659	665	884	1549
2009	19	3	22	70	389	459		362	362	481	843
2010	20	13	33	55	180	235		380	380	268	648

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

	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
Div. 3NO:										
TAC	-	-	-	8.5	8.5	8.5	8.5	8.5	6	6
STATLANT-21A[1]	5.4	6.2	1.9	1.0	1.2	0.7	0.9	0.5	0.3	
STACFIS	6.7	4.8	1.3	0.9	1.1	0.6	0.9	0.4	0.2	
Subdiv. 3Ps:										
STATLANT-21A	0.9	1.1	1.2	1.4	1.3	1.2	0.6	0.3	0.4[2]	

[1]Provisional for 2010

[2]Based on ZIF landings (STATLANT 21A not available)

Table 3a. Biomass and abundance of White Hake from Canadian Spring research vessel surveys, 1971-2010. Surveys were conducted with a Yankee bottom trawl (1971-1983), an Engel trawl (1984-Spring 1995), and a Campelen trawl (Spring 1996-2010). NAFO Subdiv. 3Ps was not surveyed in 1971, 2006; NAFO Div. 3O was not surveyed in 1971, 1972, 1974, 1983; and NAFO Div. 3N was not surveyed in 1983. Note that deep strata in Div. 3NO were not surveyed in Spring 2006.

	Biomass(tonnes)				Abundance(000's)			
Year	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
2010	52	4,283	3,739	8,074	30	5,085	5,285	10,400

Table 3b. Biomass and abundance of White Hake from Canadian Autumn research vessel surveys in Div. 3NO, 1990-2010. Surveys were conducted with an Engel trawl (1990-Autumn 1994), and a Campelen trawl (Autumn 1995-2010). Note that deep strata in Div. 3NO were not surveyed in 2003, 2004, 2006, and strata deeper than 730 m in the survey area were not surveyed in 2008.

	Biomass(tons)			Abundance ('000's)		
Year	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

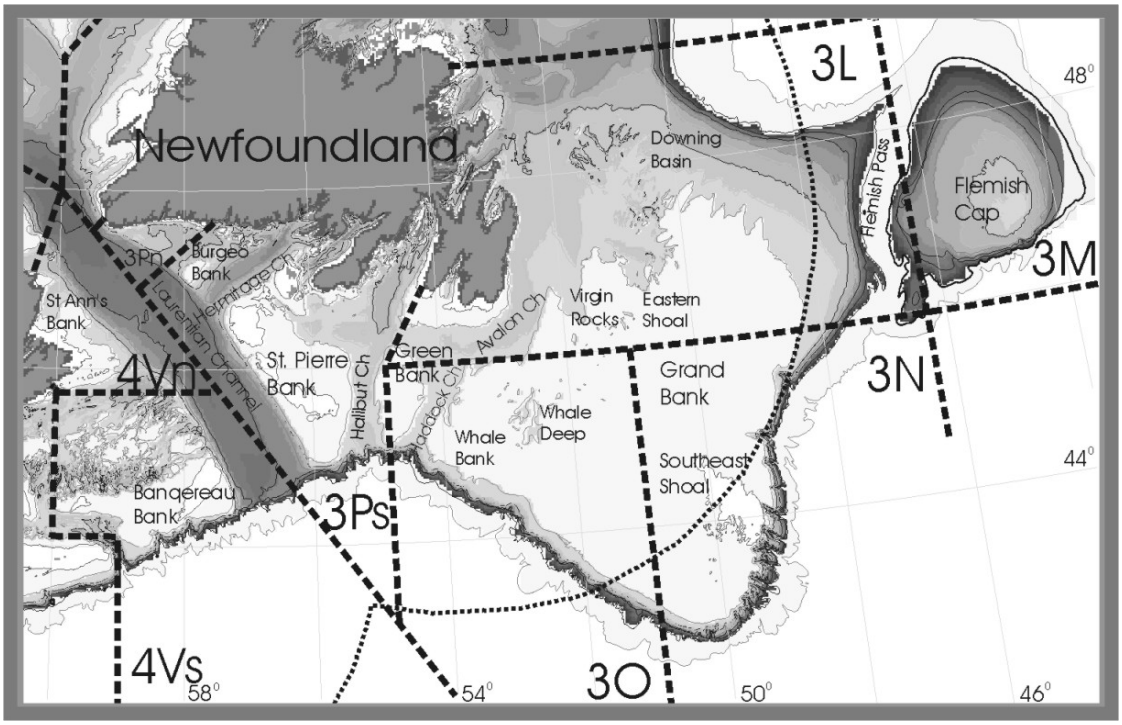

Figure 1. Map of the Grand Banks showing various banks, basins, and NAFO Divisions. Thick dotted lines delineate NAFO Divisions. The thin dotted curved line shows Canada's 200-mile-limit: delineating Canadian territory from the NAFO Regulatory Area.

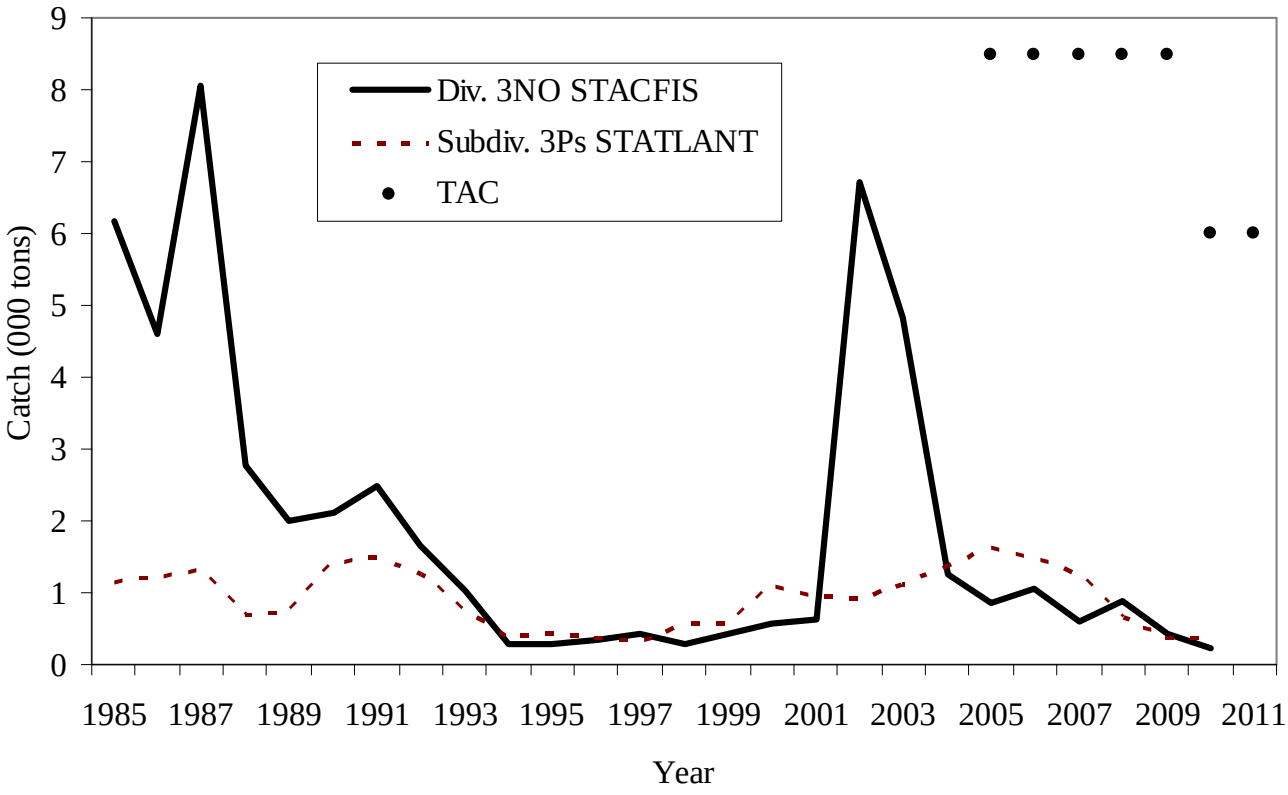

Figure 2. Total reported catch of White Hake and TAC in NAFO Division 3NO and Subdivion 3Ps, 1985-2010.

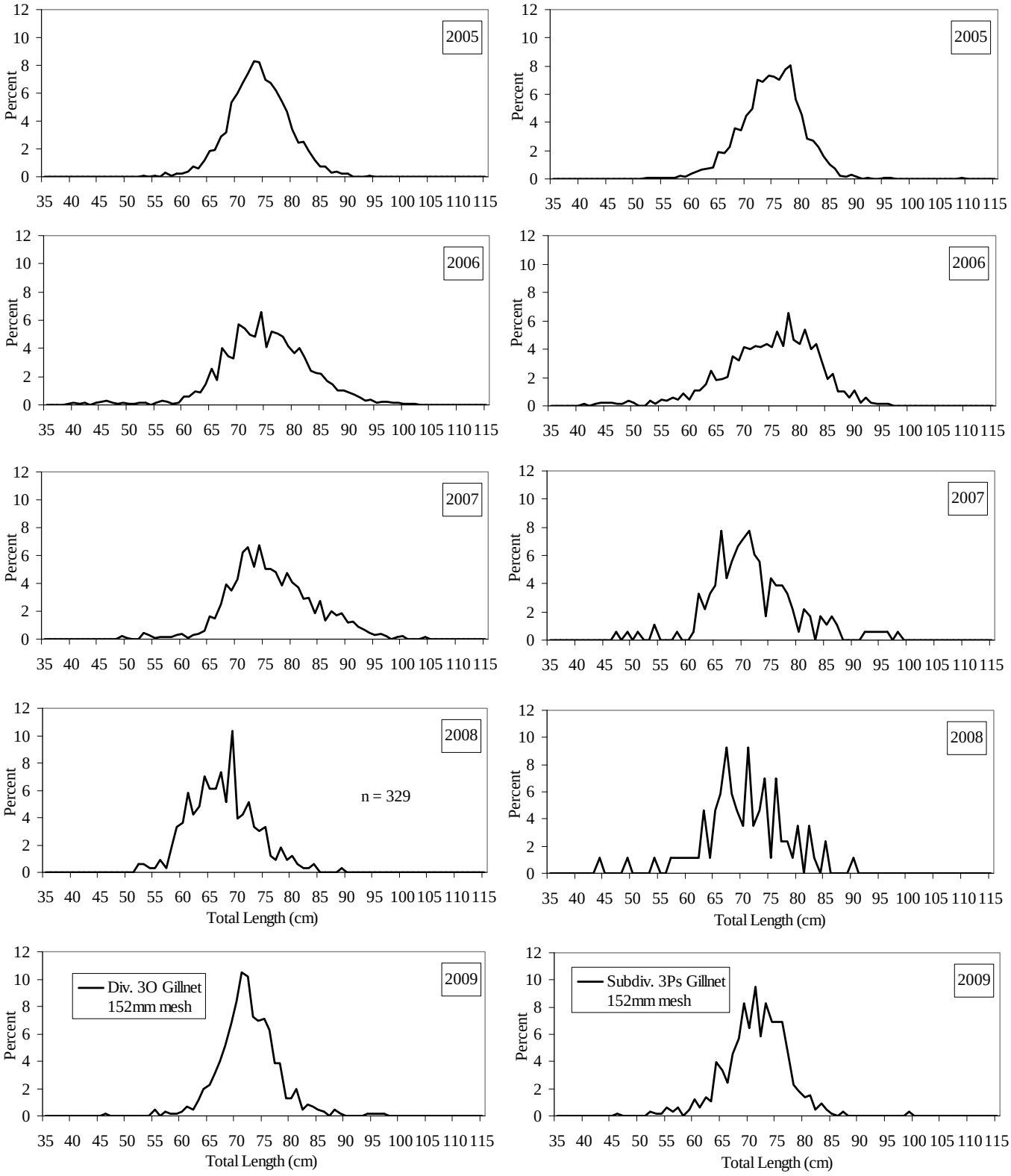

Figure 3a. Size of White Hake caught in NAFO Div. 3O and Subdiv. 3Ps by Canadian commercial gillnets, 2005-2009. Data are from Canadian Fisheries Observers. No Canadian gillnet length frequencies were available for 2010.

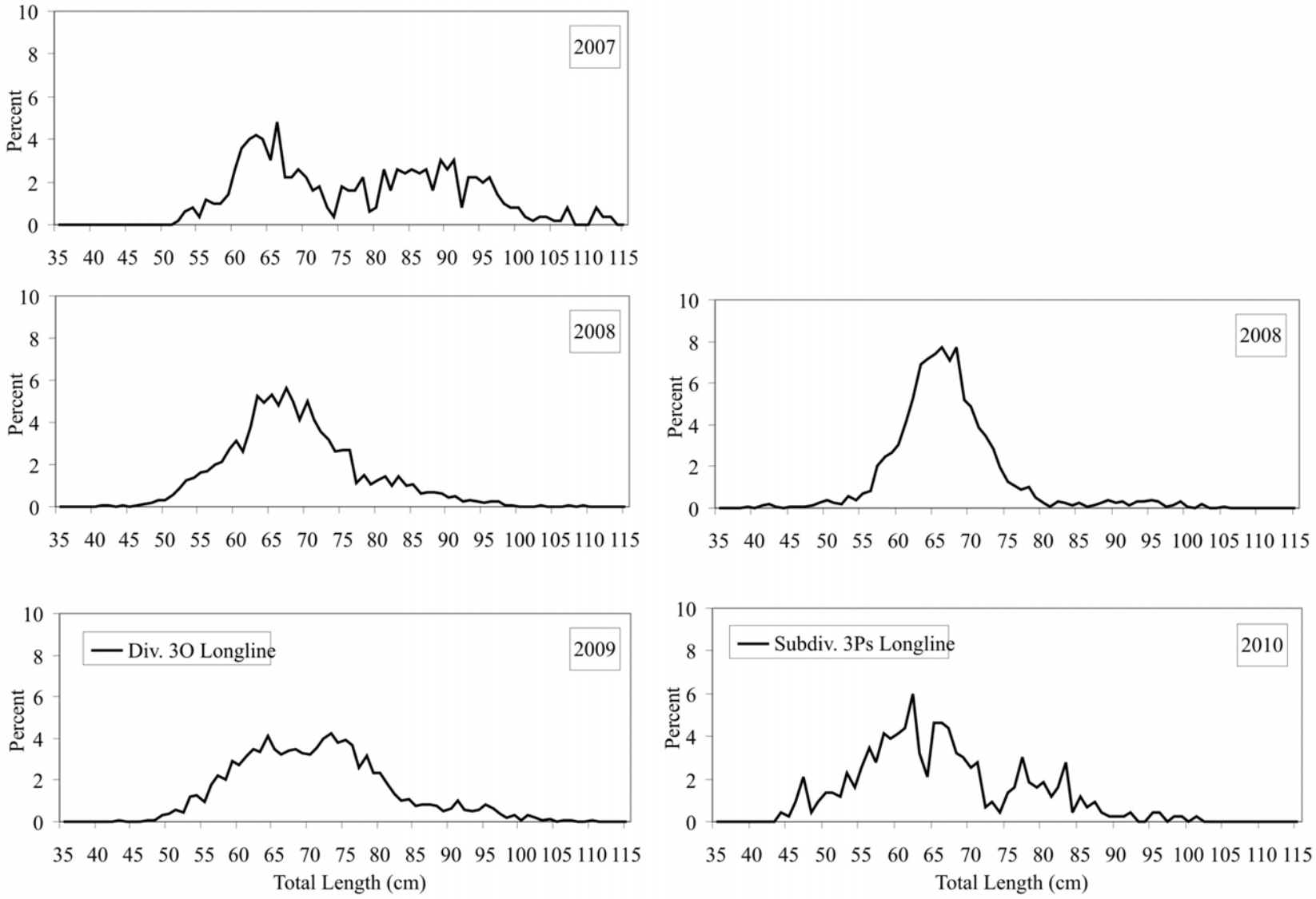

Figure 3b. Size of White Hake caught in NAFO Div. 3O and Subdiv. 3Ps by Canadian commercial longlines, 2007-2010. Data are from Canadian Fisheries Observers.

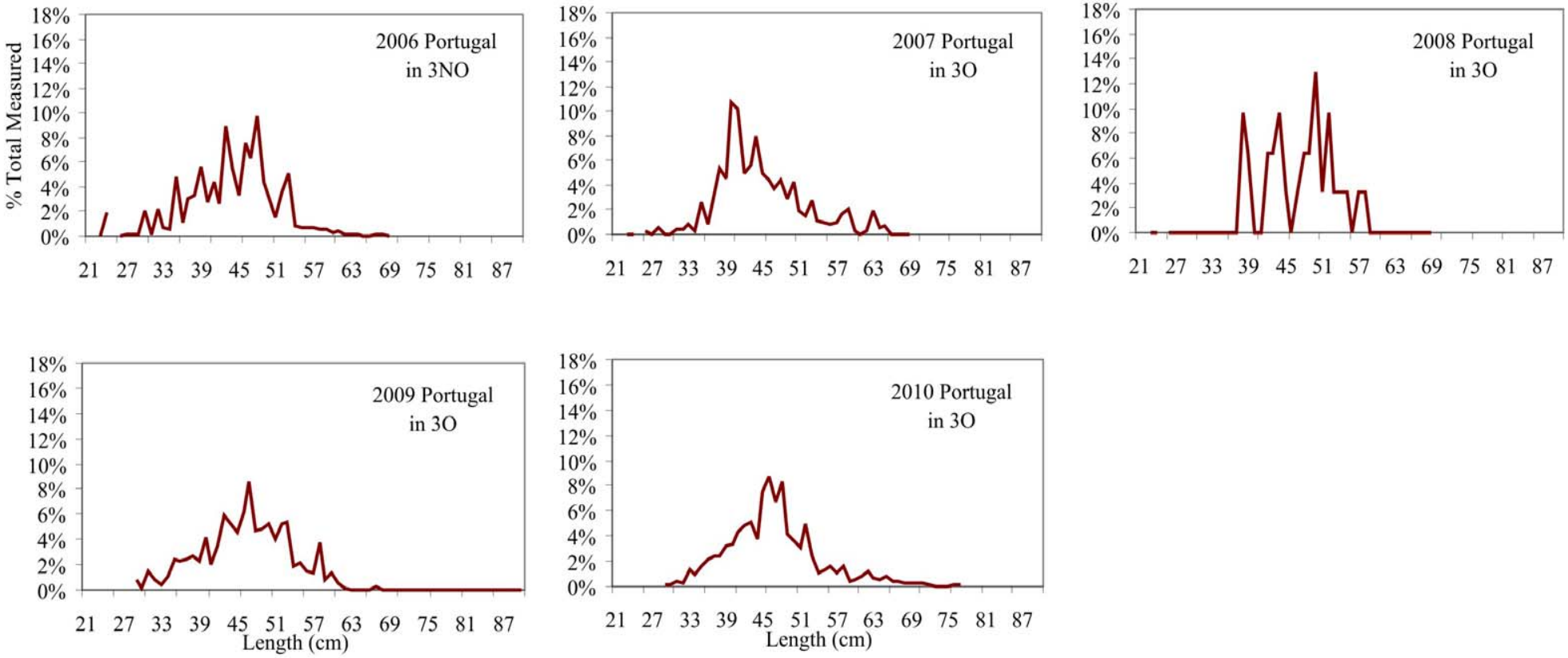

Figure 4a. Available size frequency data for White Hake bycatch in EU-Portugal commercial trawl fisheries in the NAFO Regulatory Area, 2006-2010.

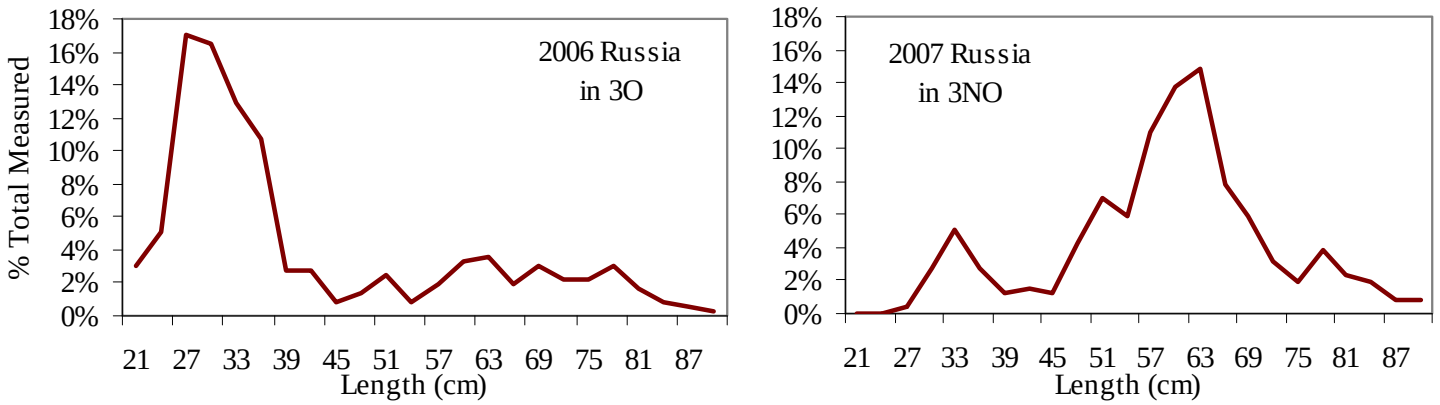

Figure 4b. Available size frequency data for White Hake bycatch in Russian commercial trawl fisheries in the NAFO Regulatory Area, 2006-2010. Russia did not sample commercial White Hake in 2008, 2009, or 2010.

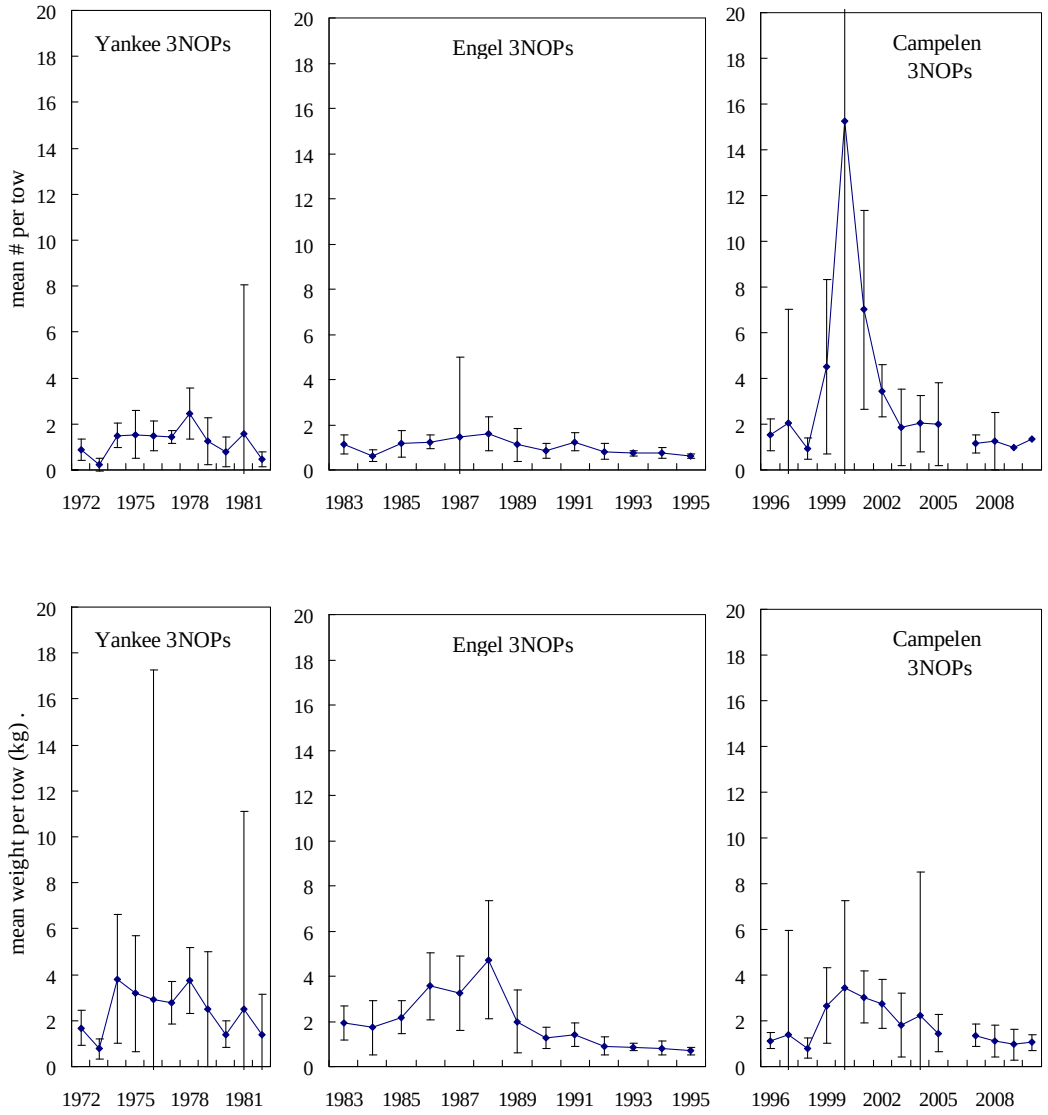

Figure 5a. Mean numbers (Upper Panel) and mean weights (in kg; Lower Panel) per tow of White Hake from Canadian Campelen spring research surveys in NAFO Divisions 3NO and Subdivision 3Ps, 1972-2010. Yankee, Engel, and Campelen time series are not standardized, and thus are presented on separate panels. Note that deep strata in Div. 3NO and all of Subdiv. 3Ps were not surveyed in spring 2006.

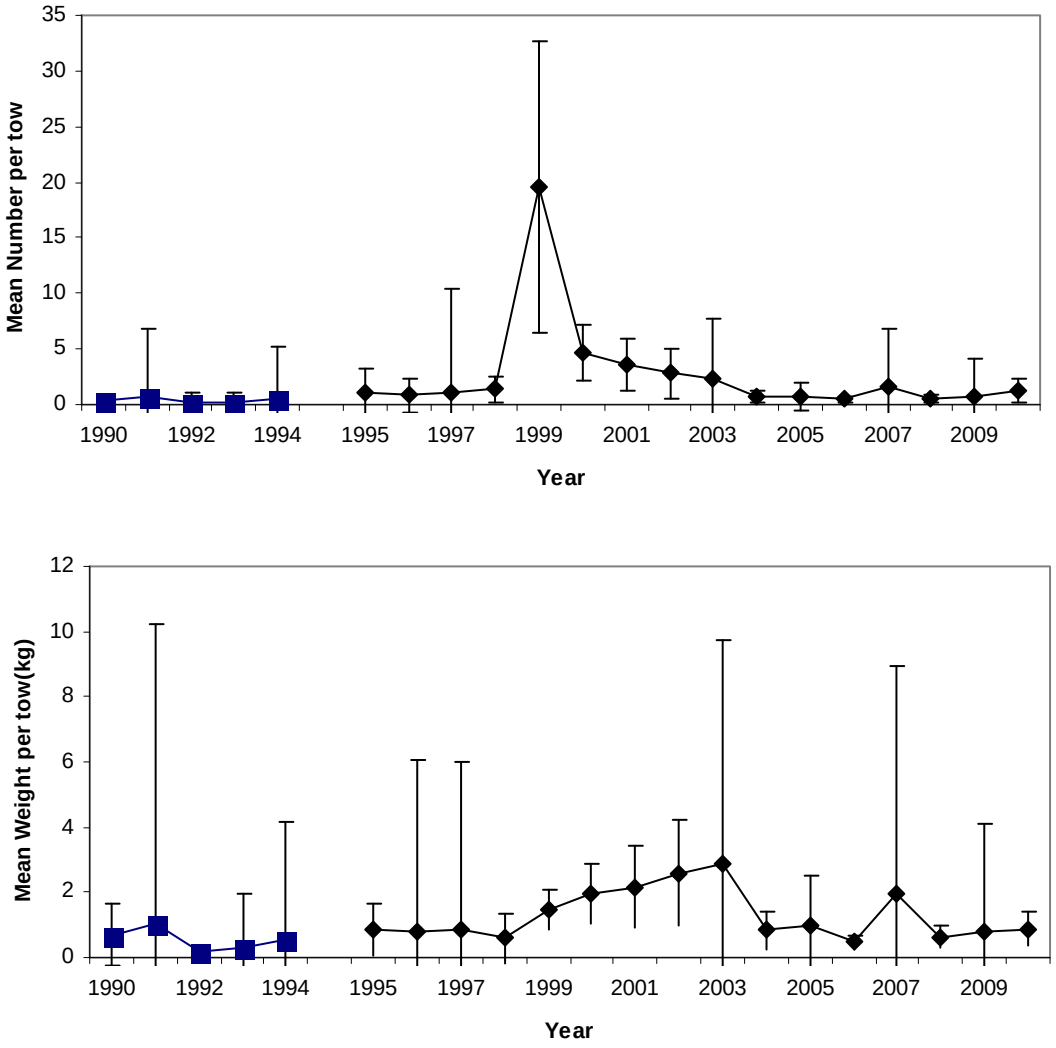

Figure 5b. Mean numbers (Upper Panel) and mean weights (in kg; Lower Panel) per tow of White Hake from Canadian autumn research surveys in NAFO Divisions 3NO. Engel (1990-1994) and Campelen (1995-present) time series are not standardized. Note that deep strata in Div. 3NO were not surveyed in autumn of 2003, 2004, 2006, and strata deeper than 730 m in the survey area were not surveyed in autumn 2008; due to Canadian research vessels' mechanical difficulties

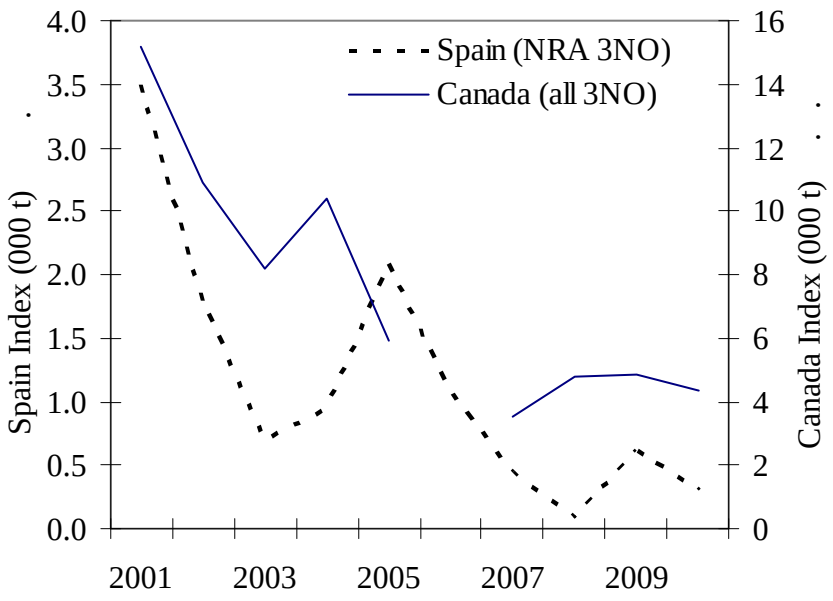

Figure 6. White Hake biomass indices in NAFO Div. 3NO: Spanish spring surveys in the NRA of Div. 3NO compared to Canadian spring surveys in all of Div. 3NO, 2001-2010. Note that deep strata in Div. 3NO were not surveyed by Canada in spring 2006, due to research vessels' mechanical difficulties.

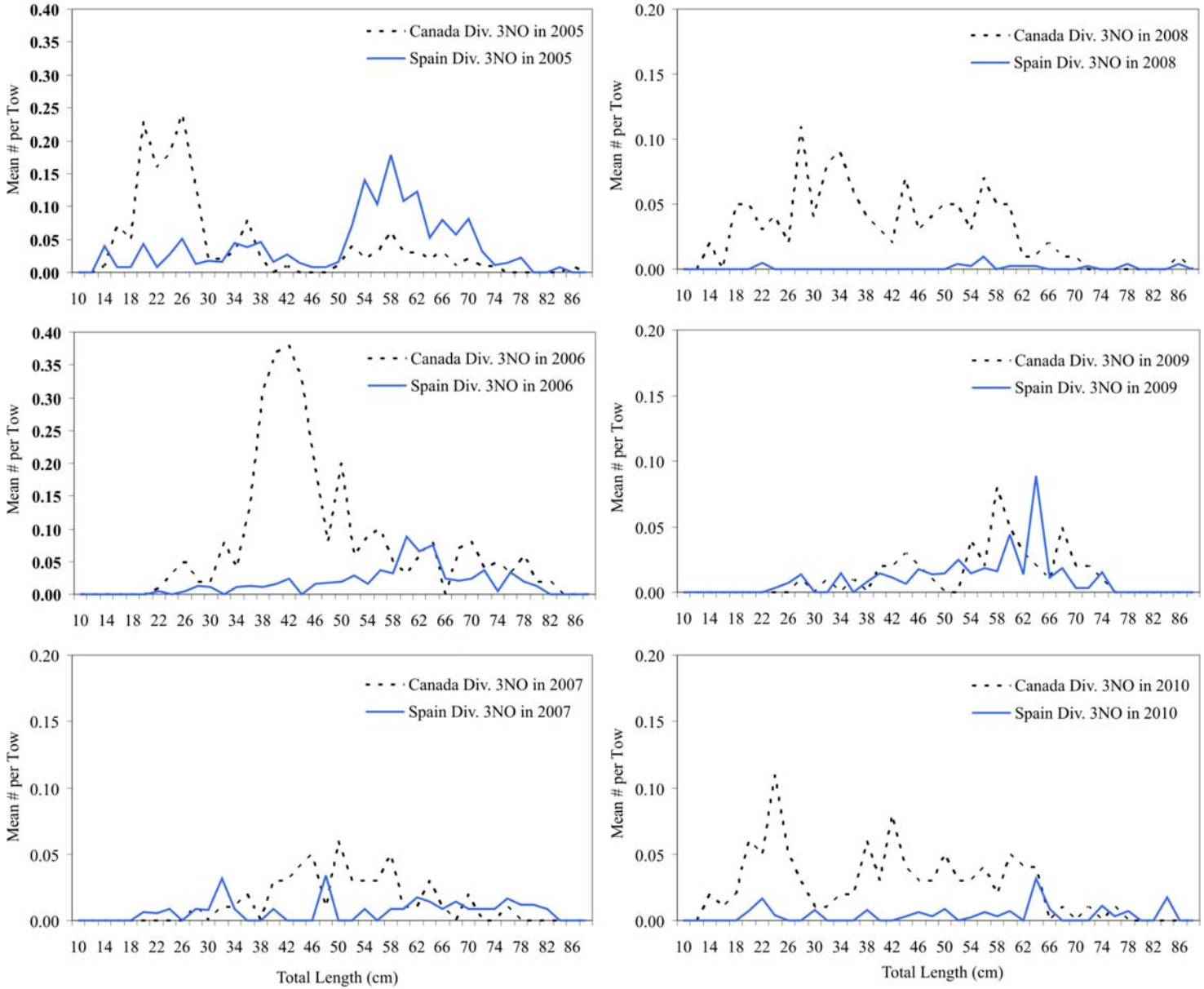

Figure 7. Abundance at length from Canadian Campelen and Spanish Campelen spring research surveys in NAFO Div. 3NO (Spanish surveys limited to NRA), 2005-2010. Number per tow was calculated using mean catches. Note that Y-axes for 2007-2010 are half the value of those for 2005-2006.

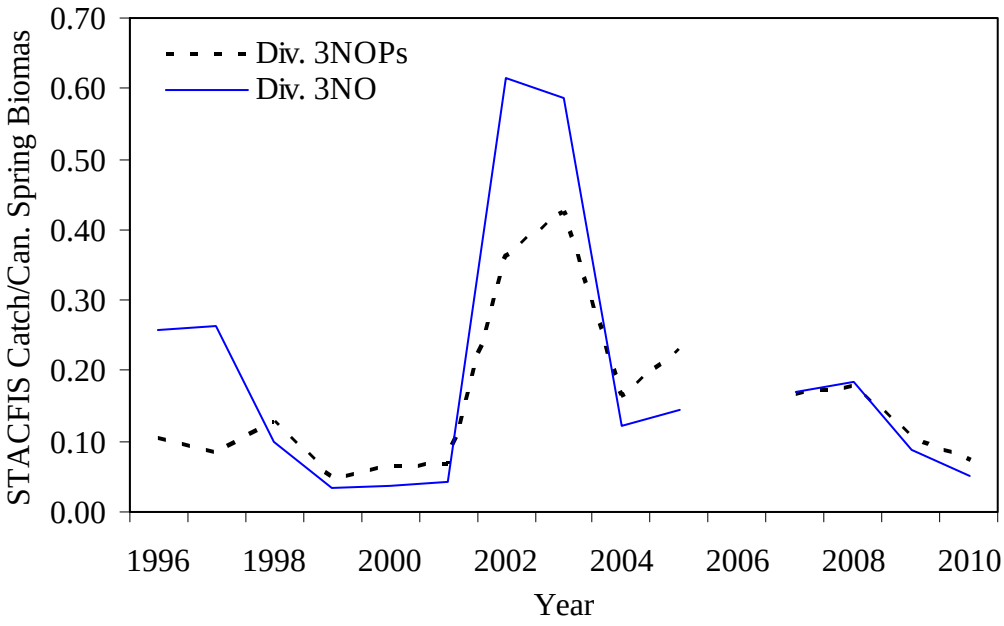

Figure 8. Relative F index (= STACFIS agreed commercial catch/Canadian Campelen spring survey biomass) for White Hake in NAFO Div. 3NO and 3NOPs, 1996-2010. Note that deep strata in Div. 3NO and all of Subdiv. 3Ps were not surveyed in 2006; due to Canadian research vessels' mechanical difficulties.

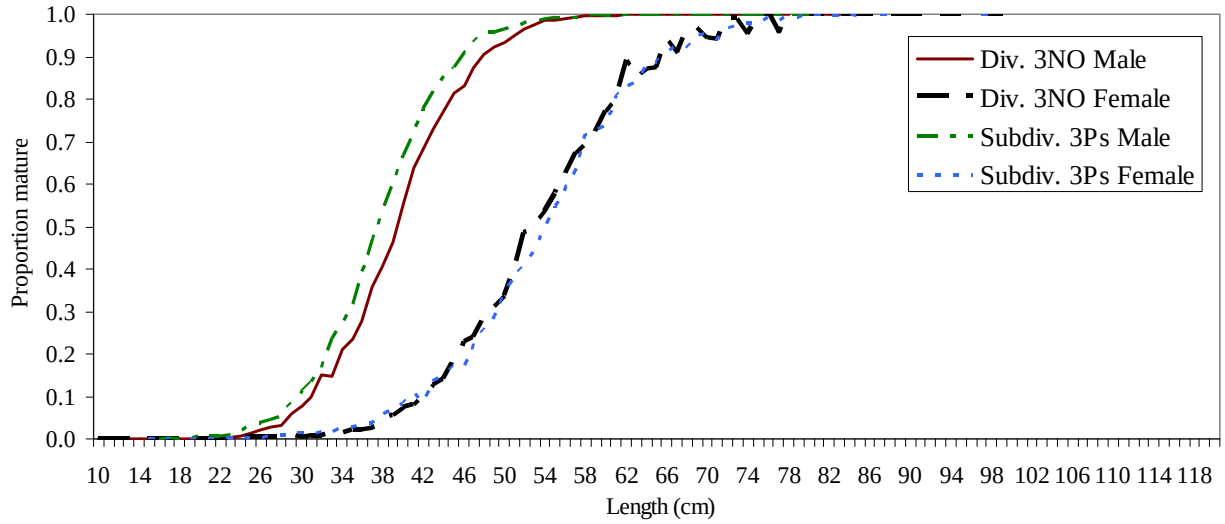

Figure 9. White Hake in Div. 3NO and Subdiv. 3Ps: Maturity ogives calculated for each sex from Canadian Campelen spring surveys and averaged over 1996-2010.

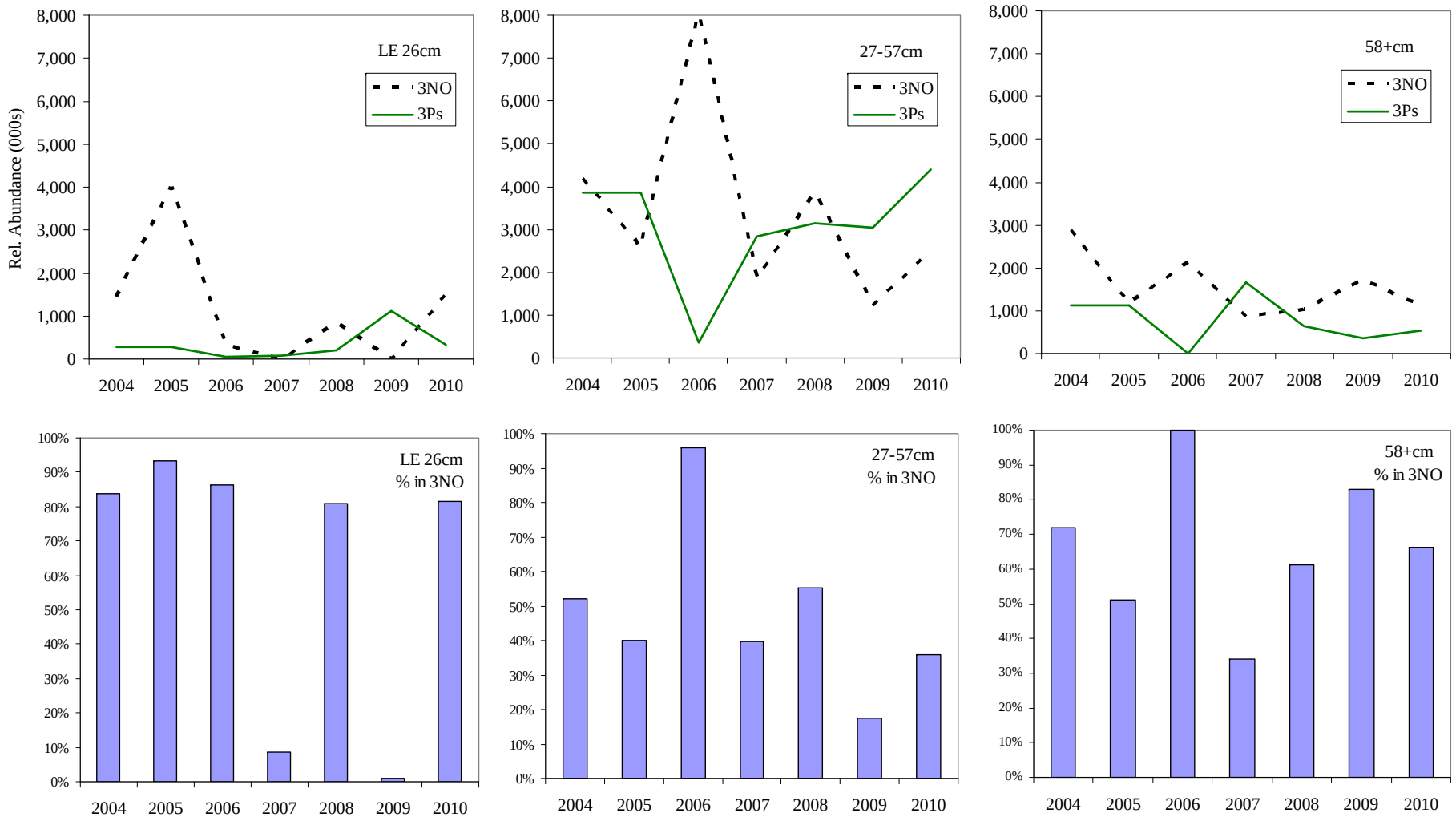

Figure 10. Relative abundance of White Hake by life stage, 2004-2010: Less than or Equal to 26 cm is mainly Year Class-1; 27-57 cm contains mainly juveniles; and 58+ cm is mainly mature fish. Upper Panel: Relative abundance (000s). Lower Panel: Percent abundance in NAFO Divisions 3NO as compared to the entire area of Div. 3NOPs. 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.

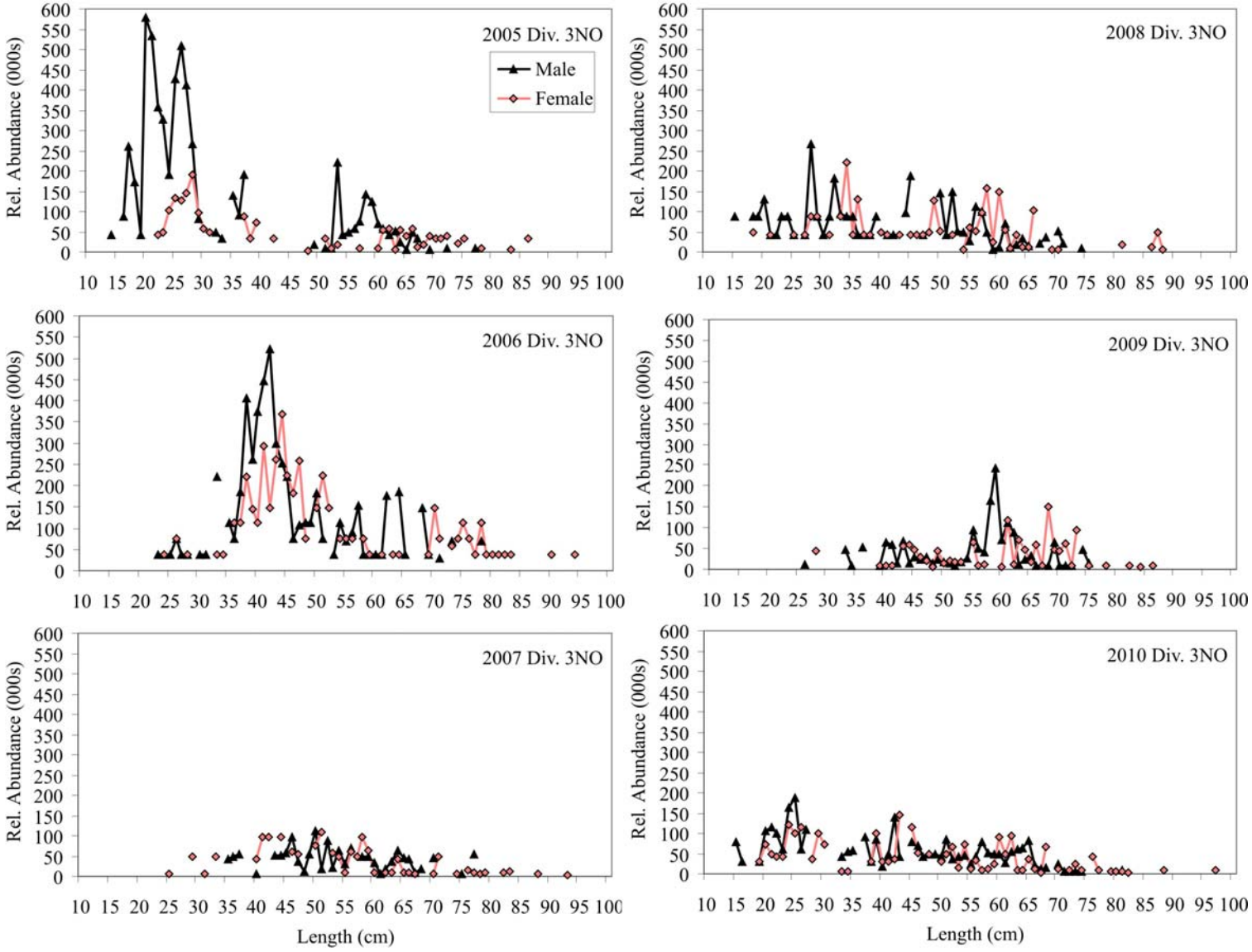

Figure 11a. Relative abundance at length of male and female White Hake from Canadian spring research surveys in NAFO Div. 3NO, 2005-2010. Note that deep strata in Div. 3NO were not surveyed in spring 2006; due to Canadian research vessels' mechanical difficulties.

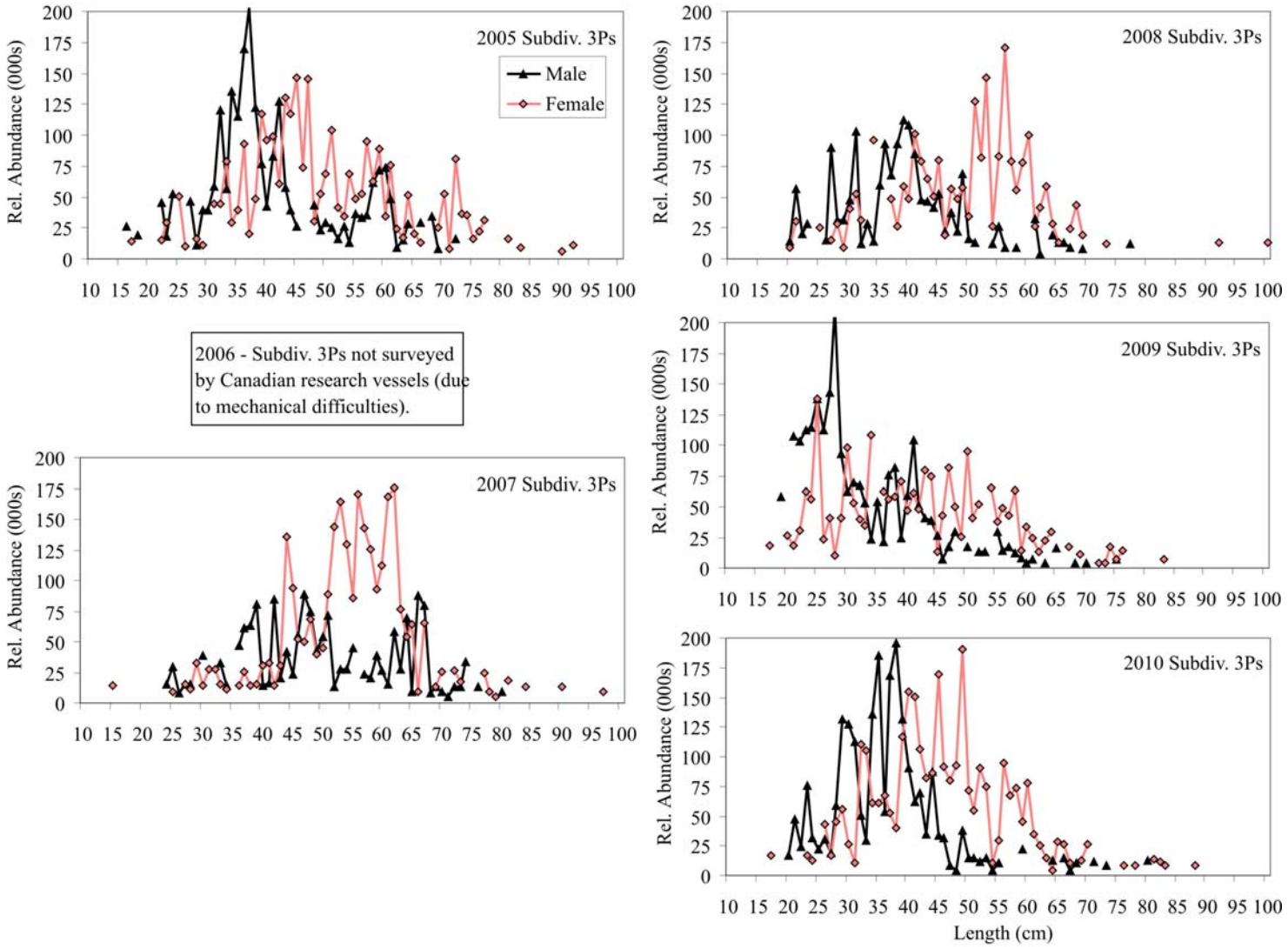

Figure 11b. Relative abundance at length of male and female White Hake from Canadian spring research surveys in NAFO Subdiv. 3Ps, 2005-2010. Note that Subdiv. 3Ps was not surveyed in 2006; due to Canadian research vessels' mechanical difficulties.

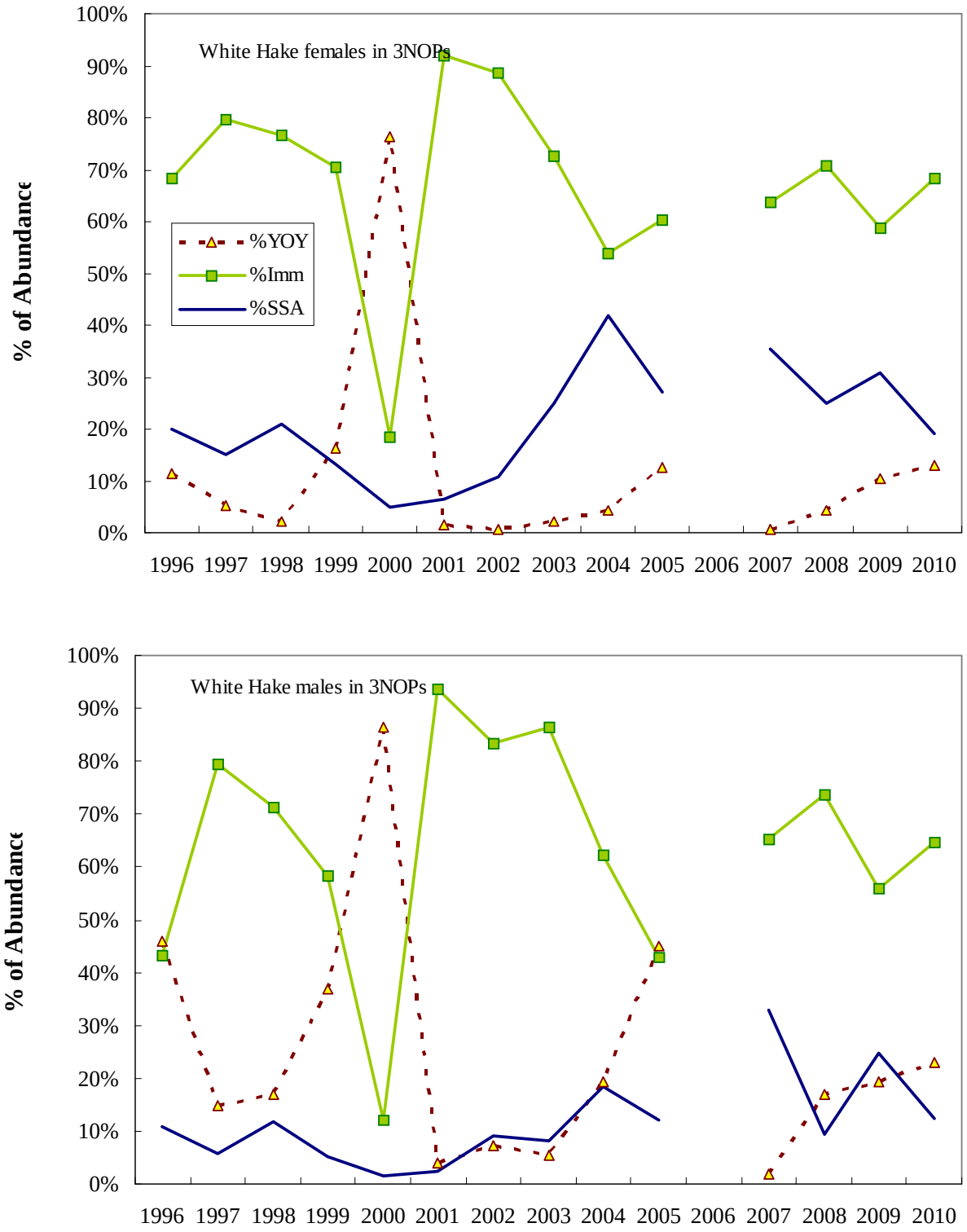

Figure 12. Staged trends in relative abundance of 1-year-olds, immature, and mature female (Upper Panel), and male (Lower Panel) White Hake from Canadian Campelen spring surveys in NAFO Div. 3NO and Subdiv. 3Ps, 1996-2010. Note that deep strata in Div. 3NO and all of Subdiv. 3Ps were not surveyed in 2006; due to Canadian research vessels' mechanical difficulties.

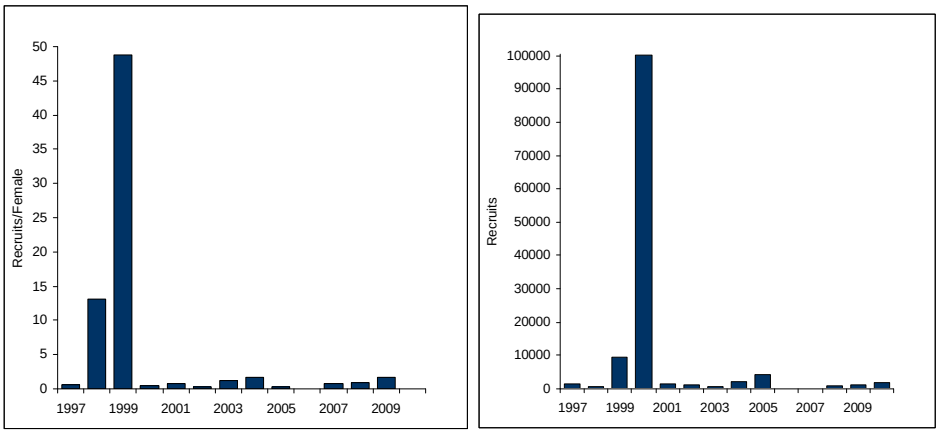

Figure 13. Recruits per spawner expressed as number of Age-1 males and females (1-year-olds produced per adult female in Year-1) from Canadian Campelen spring surveys in NAFO Div. 3NO and Subdiv. 3Ps, 1997-2009 (Left panel). White hake recruits from Canadian Campelen spring surveys in Div. 3NO and Subdiv. 3Ps during 1997-2010 (Right panel). For the 2005 point, one-year-olds in 2006 are only from the shallow (<103 m) portion of Div. 3NO; rather than the entire stock area because of incomplete Canadian survey coverage in that year.

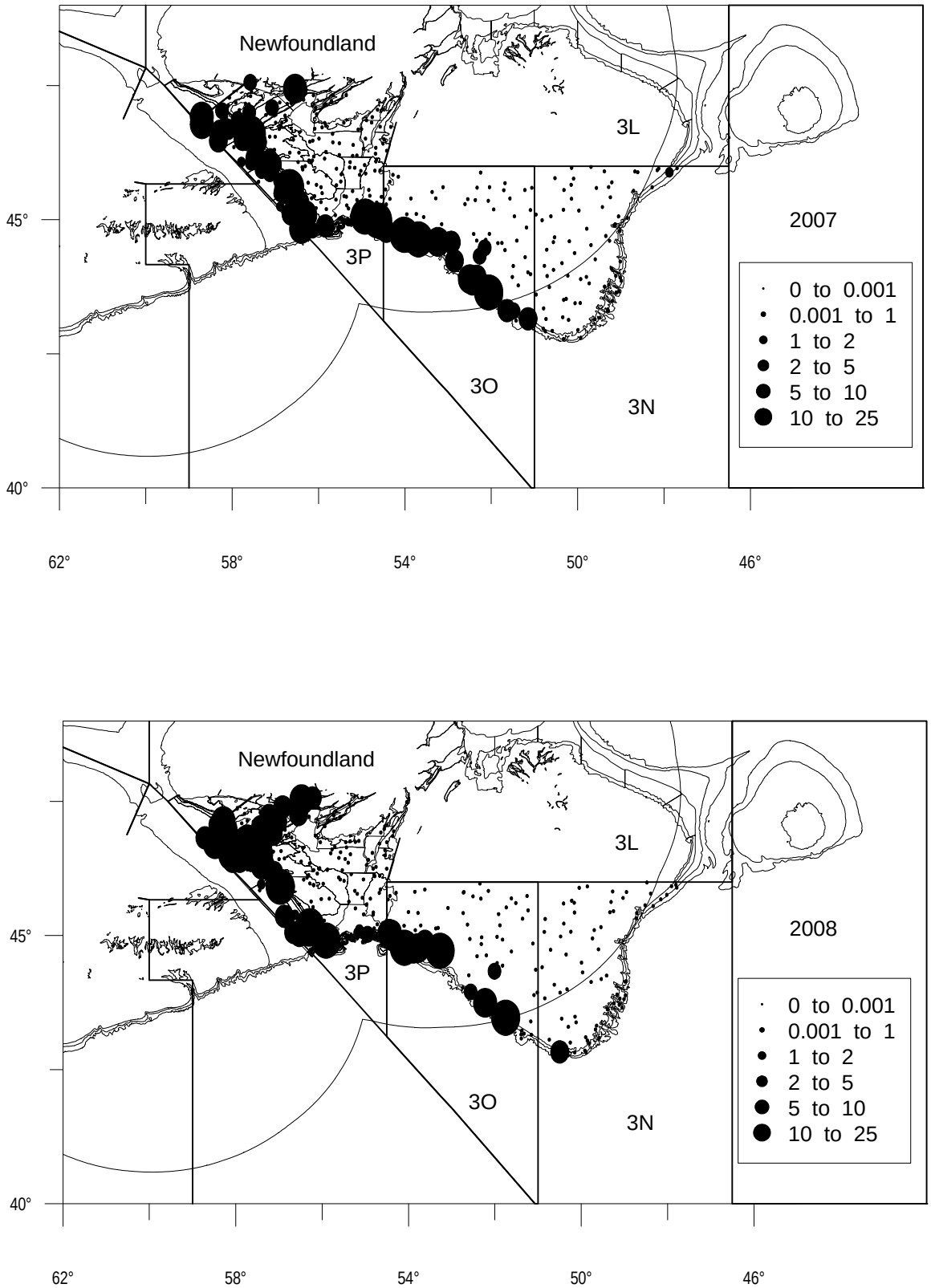

Figure 14a. Distribution of White Hake numbers per tow in NAFO Div. 3NO and Subdiv. 3Ps; based on Canadian spring research surveys in 2007 (Upper Panel) and 2008 (Lower Panel).

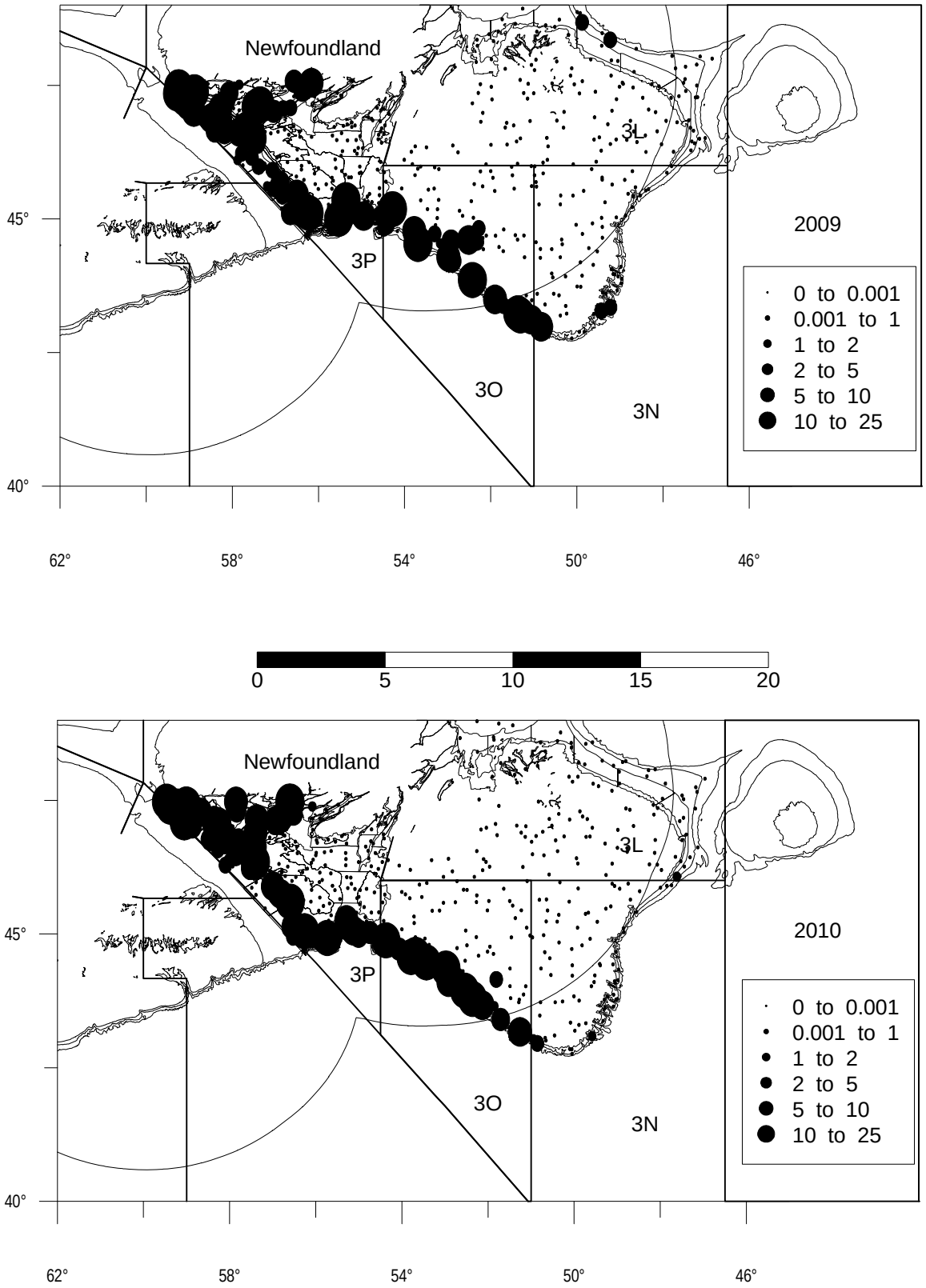

Figure 14b. Distribution of White Hake numbers per tow in NAFO Div. 3NO and Subdiv. 3Ps; based on Canadian spring research surveys in 2009 (Upper Panel) and 2010 (Lower Panel).