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Assessment update of White Hake (*Urophycis tenuis*, Mitchill 1815 in NAFO Division 3P

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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

White Hakes in NAFO Subdivision 3Ps and Divisions 3NO constitute one biological stock that inhabits the southern Grand Bank and St. Pierre Bank of Newfoundland and Labrador. White Hake is subject to ongoing mortality in directed and bycatch fisheries conducted by Canada and other countries. Annual NAFO-reported landings from Subdiv. 3Ps for Canada averaged 603 tons in 1994-2002, increased to an average of 1,364 t in 2003-07 (following recruitment of a large Div. 3NOPs 1999 year-class to the fishery), then decreased to a 306 t average since 2009. The DFO-NL spring research survey abundance index for Subdiv. 3Ps White Hake ranged from 4.0 million (in 2008) to 15.1 million (in 2002) over 1996-2016, and averaged 7.6 million. In this period, biomass estimates ranged from 2,582 t (in 2009) to 10,294 t (in 2000), averaging 5,737 t. In 2017, the abundance index was 7.1 million, and the biomass index was 4,848 t. Although large episodic recruitment of Div. 3NOPs White Hake was observed in 2000, annual recruitment has remained at much lower levels since 2001. Since 2010, the relative fishing mortality index for Subdiv. 3Ps has remained below its 1996-2016 average. White Hake biomass and abundance indices for Subdiv. 3Ps increased over the past two years, and recent Canadian landings (averaging less than 400 t in this Subdivision since 2009) did not seem to negatively impact the Div. 3P portion of the stock.

Ecosystem signals observed in Subdiv. 3Ps in recent years indicated that structural changes are occurring, and overall ecosystem productivity may be low. Although the direct impacts of these changes on White Hake life stages (i.e., pelagic eggs and larvae, bottom-dwelling juveniles and adults) are unknown, they imply that at least some aspects of White Hake productivity may be affected.

Investigations of Limit Reference Points for this species were previously conducted using several models on the Div. 3NOPs White Hake stock. During its June 2015 Meeting (and reiterated in June 2017), NAFO Scientific Council concluded that none of these assessment models were capable of adequately capturing the episodic nature of White Hake recruitment in Div. 3NOPs and, therefore, proposed limit reference points were rejected. It was thus inappropriate to establish them for Subdiv. 3Ps (or for any subcomponent of this stock).

INTRODUCTION

White Hake (*Urophycis tenuis*, Mitchill 1815) is a highly fecund gadoid species distributed in the Northwest Atlantic from Cape Hatteras to southern Labrador. Current knowledge of its biology for the Grand Banks and southern Newfoundland waters has been summarized in previous assessments (Kulka et al. 2004; Kulka et al. 2005*a*; Kulka et al. 2005*b*; Han and Kulka 2007; Kulka and Miri 2007; Simpson et al. 2012; Simpson et al. 2016*a*; Simpson and Miri 2017).

White Hakes in the Northwest Atlantic Fisheries Organization (NAFO) Subdivision 3Ps and Divisions 3NO constitute one biological stock, which has been assessed by the NAFO Scientific Council every two years since 2005. To satisfy the Fisheries and Oceans Canada (DFO) Fisheries and Aquaculture Management Branch's (Newfoundland and Labrador [NL] Region) requests for advice, White Hake in Subdiv. 3Ps is assessed separately by DFO-NL Science Branch. However, several issues are inherent to this Subdivision-based assessment approach for White Hake: Subdiv. 3Ps abundance and biomass indices are not population indicators for this species, since the majority of recruitment for this stock originates in Div. 3NO, with pelagic larvae settling on the southern part of the Grand Bank, then dispersing into all stock areas (including Div. 3P); the drastic decline in White Hake abundance and biomass following its large recruitment event of 1999-2000 was due to fishing in Div. 3NO (mainly outside Canada's Exclusive Economic Zone (EEZ)); and establishment of Limit Reference Points (LRPs) is precluded by any analytical investigations that exclude Div. 3NO data.

This paper updates the previous assessment of White Hake in Subdiv. 3Ps (Fig. 1; Simpson et al. 2016), using commercial fisheries and DFO-NL research survey data, with additional information from Subdiv. 3Pn.

OCEANOGRAPHY AND ECOSYSTEM OVERVIEW

Oceanographic conditions in Subdiv. 3Ps are influenced by several factors: local atmospheric climate conditions, advection by the Labrador Current from the east and warmer and saltier Gulf Stream waters from the south, and complex bottom topography in the region. The extent of bottom areas where water temperatures exceed 4°C (White Hake are "temperature keepers", mainly found in 4-10°C) has been increasing over the past two decades, and warm slope water intrusions have elevated temperatures to near 10°C in some offshore areas in recent years.

Compared to the standard reference period (1999-2010), the spring phytoplankton bloom was observed later, of a shorter duration, and reduced in magnitude during 2015-17, while zooplankton biomass was at its lowest level in this time-series (Pepin et al., in prep.).

In recent years, ecosystem signals observed in Subdiv. 3Ps indicated that structural changes are occurring, and overall ecosystem productivity may be low. Although the direct impacts of these changes on White Hake life stages (i.e., pelagic eggs and larvae, bottom-dwelling juveniles and adults) are unknown, they imply that at least some aspects of White Hake productivity may be affected.

COMMERCIAL FISHERIES REMOVALS

Commercial fisheries removals of White Hake in Div. 3P were examined using three data sources: NAFO STATLANT-21A landings (1960-2016), as reported by NAFO-member countries; DFO-NL Zonal Interchange File Format (ZIFF) landings (1985-2016), as recorded in logbooks by Canadian fishers operating in Canada's EEZ; and Canadian at-sea fisheries observers' (ASOs) reported catch and discards (1978-2016). It must be noted that Canadian ASOs constitute the sole source of data on total catch (= landings + discards) by species at sea.

In Subdiv. 3Ps, the White Hake-directed fishery is currently open to both the <65-foot, and the 65'-100' fleets, each of which is authorized to use longlines and gillnets. In Subdiv. 3Pn, this fishery is only open to the <65' fleet, which can fish from July 15-September 30, using only longlines, with a maximum of 4,000 hooks. Fishing is also restricted to water depths <125 fathoms.

NAFO-reported landings of White Hake in Div. 3P were mainly from Subdiv. 3Ps, and largely attributed to fishing by Canadian fleets (Table 1; Fig. 2). Since 1989, France (St. Pierre and Miquelon) accounted for all international landings from Subdiv. 3Ps. During the 1960s, total annual landings in Subdiv. 3Ps averaged 266 tons, then increased significantly in 1971 and averaged 1,608 t over 1971-78. Landings were variable throughout 1979-93, but remained relatively high, averaging 1,044 t. During 1994-2002, landings from Canadian fisheries in Subdiv. 3Ps declined to an average of 603 t, then increased to 1,364 t, on average, over 2003-07 (following recruitment of a large Div. 3NOPs 1999 year-class to the fishery). Since 2009, Canadian landings averaged 307 t. In Subdiv. 3Pn, NAFO-reported Canadian landings of White Hake averaged 173 t during the 1970s, with a maximum of 295 t in 1972. Throughout the 1980s and 90s, annual landings averaged 88 t. Canadian landings averaged 79 t over 2000-07, 25 t over 2008-15, and increased to 148 t in 2016.

DFO-NL ZIFF-reported Canadian annual landings of White Hake in Div. 3P also showed a majority from Subdiv. 3Ps (Table 2; Fig. 3). However, most of the reported landings during the mid-1980s to early 90s should be interpreted with caution, as a portion of landings of Atlantic Cod (*Gadus morhua*) from Canadian longline fisheries during this period were misreported as White Hake. Canadian landings of White Hake from Subdiv. 3Ps averaged 952 t in 2000-08, and 243 t in 2009-14. Landings were 149 t in 2015 and 267 t in 2016. In Subdiv. 3Pn, ZIFF-reported Canadian landings of White Hake averaged 76 t annually in 2000-08, and 24 t over 2009-14. Landings from Subdiv. 3Pn were 12 t in 2015, and increased to 149 t in 2016.

From 2000-16, White Hake in Subdiv. 3Ps over 2000-16 were landed primarily from gillnets, secondarily from longlines; a small proportion were taken using otter trawls and other gears (ZIFF; Fig. 4). Landings were predominantly from Subdiv. 3Ps White Hake-directed fisheries, although bycatch in some years accounted for more than 50% of the total landings (Fig. 5). Bycatch of White Hake in Subdiv. 3Ps during this period was landed mainly from fisheries targeting Atlantic Cod and redfish (*Sebastes* spp.). Since 2014, the Atlantic Cod fishery has accounted for greater than 80% of White Hake bycatch in Subdiv. 3Ps (Fig. 6). In White Hake-directed fisheries, bycatch of other commercially important species occurred: Atlantic Cod, Atlantic Halibut (*Hippoglossus hippoglossus*), American Plaice (*Hippoglossoides platessoides*), Haddock (*Melanogrammus aeglefinus*), and Monkfish (*Lophius americanus*).

In Subdiv. 3Pn, Canadian White Hake landings were almost exclusively reported from longlines, secondarily from gillnets, and few other gears (Fig. 4). Canadian landings from Subdiv. 3Pn were almost all reported as bycatch (Fig. 5), although the White Hake-directed fishery accounted for most landings in 2016. Bycatch of White Hake during 2007-09 occurred mainly in the Atlantic Cod fishery; since 2012, bycatch has been reported mainly from the Atlantic Halibut fishery (Fig. 6).

Due to the lack of adequate Canadian ASO coverage of Subdiv. 3Ps groundfish fisheries (29 and 17 observed sets in 2015 and 2016, respectively), analyses of ASO catch and discard data for White Hake could not be updated since the last assessment for Div. 3P (Simpson et al. 2016*b*).

Observers' length distributions of White Hake taken in Canadian directed fisheries in Subdiv. 3Ps indicated that longlines captured a range of 52-102 cm (68 cm mode) in 2013. The Atlantic Cod longline fishery caught a contracted range of 45-73 cm fish in 2012 (55 cm mode; Fig. 7). The Atlantic Halibut longline fishery captured 48-105 cm (63 and 69 cm modes) White Hakes in 2014, while the Cod otter trawl fishery caught a contracted range of 54-75 cm fish (69 cm mode). The Witch Flounder otter trawl fishery (152-155 mm mesh) caught 49-87 cm White Hakes (65, 68, and

75 cm modes) in 2015. Canadian ASO-recorded length frequencies for White Hake catch from Subdiv. 3Ps were not available in 2016.

SPRING RESEARCH SURVEY

DFO-NL spring bottom trawl research surveys have been conducted annually over April-May in Subdiv. 3Ps (1972-present), and Subdiv. 3Pn (1986-2013), using a stratified-random design. Details of these spring surveys, including changes in gear type and spatial coverage over time, are discussed in Doubleday 1981, Bishop 1994, McCallum and Walsh 1996, Walsh and McCallum 1996, Brodie and Stansbury 2007, Healey and Brodie 2009, and Simpson and Miri 2013. It must be noted that, due to different trawls being deployed (Yankee 41.5 in 1972-82; Engel 145 in 1983-95; Campelen 1800 in 1996-present), combined with a lack of size-based conversion factors to account for differences in White Hake catchability resulting from gear changes, the three survey time-series are not directly comparable. In addition, due to mechanical difficulties with research vessels, most of Subdiv. 3Ps was not surveyed in 2006, and Subdiv. 3Pn could not be sampled in 2008 and 2014-17.

SURVEY ABUNDANCE AND BIOMASS INDICES

Abundance and biomass indices indicated that the majority of Div. 3P White Hakes was consistently found in Subdiv. 3Ps (Table 3). Temporal trends in these estimates were similar in both 3Ps and 3Pn, despite a difference in magnitude (Fig. 8). Abundance and biomass increased through the first half of the Yankee and Engel time-series. In Subdiv. 3Ps, abundance and biomass peaked in 1981 (4.7 million fish; 7,500 t; respectively) and 1988 (5.5 million fish; 13,000 t), then declined to the end of both time-series. In the Campelen time-series, abundance estimates ranged from 4.0 (in 2008) to 15.1 million (in 2002) White Hakes over 1996-2016, and averaged 7.6 million (Fig. 8, left panels). In this period, biomass estimates ranged from 2,582 t (in 2009) to 10,294 t (in 2000), averaging 5,737 t. In 2017, the abundance index was 7.1 million, and the biomass index was 4,848 t. In Subdiv. 3Pn, abundance and biomass indices increased from a low of 0.3 million fish and 180 t (respectively) in 2003, and remained stable around 1.6 million White Hakes and 720 t in 2009-13 (Fig. 8, right panels). It must be noted that Div. 3P estimates in isolation do not represent any changes or trends in indices for the entire stock, which extends into Div. 3NO.

Catch rates in DFO-NL spring Campelen surveys of Subdiv. 3Ps peaked in 2002 (5.6 fish/tow and 3.7 kg/tow; Fig. 9). In 2003-15, catch rate estimates ranged from 1.5-2.6 fish/tow and 0.9-2.6 kg/tow. In 2016 and 2017, mean number per tow was 3.2 fish and 2.6 fish, while mean weight per tow was 1.9 kg and 1.8 kg. In Subdiv. 3Pn, mean number and mean weight per tow over 1996-2013 ranged from 2.3-8.4 fish/tow and 1.1-3.9 kg/tow (respectively; Fig. 10). In 2013, mean number per tow (7.6 fish/tow) was higher than the 2010-12 average (6.18 fish /tow), but below the 2009 estimate. Mean weight per tow (3.0 kg/tow) in 2013 was comparable to the 2010-12 average (3.1 kg/tow).

DISTRIBUTION

Geo-referenced mean number per tow from DFO-NL Campelen spring surveys was used to assess the spatial distribution of White Hakes in Div. 3P. Distributions were plotted for 2008-17 (Fig. 11; Fig. 12). Previous distribution maps are available in earlier assessments of this species (Simpson and Miri 2013; Simpson et al. 2016*a*; Simpson et al. 2016*b*; Simpson and Miri 2017). Distributions of White Hake in Div. 3P over 2008-17 were consistent with historic data (Simpson et al. 2016*a*), in that they were found mostly in the Laurentian, Hermitage, and Halibut Channels.

ABUNDANCE AT LENGTH

An abundance index at length for White Hake in Subdiv. 3Ps indicated that few Age 1 fish were found in 2016 and 2017 (Fig. 13). In 2016, two peaks of males (34-37 cm, 39-41 cm) dominated the immatures, while females comprised the majority of the few adults seen. In 2017, a small peak of 45-52 cm females (16% of all immatures) and a larger peak of 37-41 cm males were observed (35%), while females comprised 70% of the mature White Hakes caught.

RECRUITMENT

In DFO-NL spring surveys of Div. 3NOPs, the number of White Hakes ≤26 cm in length is assumed to be an index of recruitment at Age 1. Originating in Div. 3NO, abundance of Age 1 White Hakes in 2000 was large, with pelagic larvae settling on the southern part of the Grand Bank, then dispersing into all stock areas (including Div. 3P), 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 2016, the index was low, but increased in 2017 to a level similar to those in 2013 and 2005; albeit still very small in comparison with Age 1 fish in 2000.

INDEX OF FISHING MORTALITY

Estimates of relative fishing mortality (Relative F = NAFO-reported landings/DFO-NL spring survey biomass index) were calculated for White Hake in Subdiv. 3Ps. The Relative F index increased to a peak in 2003-05, due to the large Div. 3NOPs 1999 year-class (Fig. 15). Since 2010, this index has remained below its 1996-2016 average of 0.12.

ASSESSMENT RESULTS

Limit reference points (LRPs) for White Hake in Div. 3P have not been defined. Previous investigations of LRPs for the 3NOPs stock were conducted using a Bayesian surplus production model, Catch-resilience models (Martell and Froese 2013), and empirical methods based on DFO-NL survey biomass indices (Simpson et al. 2015*b,* 2016a). During its June 2015 meeting (and reiterated in June 2017), NAFO Scientific Council concluded that none of these approaches were capable of adequately capturing the episodic nature of this stock's recruitment. Consequently, the proposed LRPs were rejected (Simpson et al. 2015*b*). Since LRPs have not yet been accepted for the Div. 3NOPs stock, it is inappropriate to establish them for Subdiv. 3Ps (or any subcomponent of the population).

PERSPECTIVE ON SUBDIV. 3PS WHITE HAKE

In Subdiv. 3Ps, White Hake biomass peaked in 2000 at 10,294 t, but has since declined. The biomass index was stable, but low, over 2008-15, increased in 2016, and was similar in 2017. Of equal importance is the fact that recruitment remained low for White Hake in Subdiv. 3Ps and Div. 3NO. However, the Div. 3NOPs recruitment index in 2017 was double the average index for 2012-16 (but half of the 2011 estimate).

Biomass and abundance indices for White Hake in Subdiv. 3Ps increased over the past two years, and recent Canadian landings (averaging less than 400 t in this Subdivision over 2009-16) did not seem to negatively impact the Div. 3P portion of the Div. 3NOPs stock. It must be noted that, without a recruitment event such as that seen for Div. 3NOPs White Hake in 1999-2000 (thereby supporting high landings over 2003-07), higher catches are not sustainable. Moreover, if increased landings result from greater commercial interest in harvesting White Hake due to declining stocks of other groundfish and shellfish species in this area, inhibitive pressures on White Hake in Div. 3P may be further exacerbated.

ASSESSMENT REVIEW AND GUIDANCE

The status of White Hake in Subdiv. 3Ps was first assessed in 1996 (as part of an assessment of the entire Div. 3LNOP stock distribution; DFO 1996), then in 1998 (DFO 1998), 2002 (DFO 2002), and 2015 (DFO 2016). Following an assessment of White Hake in Div. 3LNO and Subdiv. 3Ps for NAFO Scientific Council (Kulka et al. 2004), White Hake in Div. 3NO came under NAFO's quota regulation in September 2004. NAFO Fisheries Commission decided that a Total Allowable Catch (TAC) of 8,500 t be established for Div. 3NO for 2005-07. No quota was implemented for Div. 3L, nor did Canada implement a TAC for Subdiv. 3Ps within its EEZ. The TAC for Div. 3NO was maintained at 8,500 t for 2008-09. In September 2009, NAFO Fisheries Commission reduced the TAC for White Hake in Div. 3NO from 8,500 t to 6,000 t for 2010-11. It was further reduced to 5,000 t for 2012 and to 1,000 t for 2013 with a caveat that the TAC for 2013 could be increased in-season to 5,000 t, based on evidence of an "exceptional" increase in the availability of White Hake. For 2016-17, the TAC remains at 1,000 t (with the possibility of a 1000 t increase under exceptional circumstances, for a total TAC of 2,000 t).

Following implementation of a TAC in Div. 3NO, plus the ongoing assessment of White Hake on a two-year schedule at NAFO Scientific Council, White Hake was not assessed domestically until 2015 (Simpson et al. 2016*a*). NAFO assessments of White Hake (with interim monitoring reports in non-assessment years) include data on Subdiv. 3Ps White Hake, due to the accepted view that Div. 3NO and Subdiv. 3Ps White Hakes constitute a single biological stock (Simpson et al. 2015*a*).

Given the NAFO Scientific Council assessment framework described above, a six-year assessment schedule is recommended for Subdiv. 3Ps White Hake. Based on guidance from TESA (Technical Expertise in Stock Assessment; DFO 2015), if the DFO-NL spring survey Div. 3NOPs biomass index (a major population indicator for this species) statistically changes by more than two standard deviations (as reviewed by NAFO Scientific Council), a full assessment and revised advice will be required. Furthermore, interim-year assessments should also be triggered by an increase in reported Canadian landings relative to their 2009-16 average for Subdiv. 3Ps - without a significant, concomitant positive change in the DFO-NL Div. 3P biomass index.

SOURCES OF UNCERTAINTY

- Discarding at sea of White Hake bycatch remains underreported in Canadian and other fisheries. Canadian at-sea fisheries observers constitute the sole source of data on total catch (= landings + discards) by species at sea. However, there is very low to non-existent at-sea observer coverage of most Canadian Atlantic fisheries; thereby grossly underestimating fishery impacts on this stock, and preventing at-sea collections of important biological data and samples from White Hake (i.e., length, weight, sex, maturity, and otoliths).
- White Hake age data are not available from DFO-NL research surveys. In addition, data on length, weight, and maturity of White Hakes in DFO-NL survey catches are incomplete.
- Originating in Div. 3NO, recruitment of Div. 3NOPs White Hake remains unpredictable, and has been extremely low since the episode generated by its large 1999 year-class.
- Ecosystem signals observed in Subdiv. 3Ps in recent years indicated that structural changes are occurring, and overall ecosystem productivity may be low. Although the direct impacts of these changes on White Hake life stages (i.e., pelagic eggs and larvae, bottom-dwelling juveniles and adults) are unknown, they imply that at least some aspects of White Hake productivity may be affected.

- Impacts of anthropogenic activities (e.g., marine plastics pollution, seismic surveys, oil and gas drilling, oil pollution) and climate change (i.e., increasing ocean temperatures, decreasing salinities, decreasing marine dissolved oxygen) on White Hake life stages (i.e., pelagic eggs and larvae, bottom-dwelling juveniles and adults) and their habitats remain unknown.

CONCLUSION

White Hake biomass and abundance indices for Subdiv. 3Ps increased over the past two years, and recent Canadian landings (averaging below 400 t in this Subdivision over 2009-16) did not seem to negatively impact this species in Div. 3P. It must be noted that, without a recruitment event such as that seen for Divs. 3NOPs White Hake in 1999-2000 (thereby supporting high landings over 2003-07), higher catches are not sustainable. In addition, if increased landings result from the increasing commercial interest in harvesting White Hake due to declining stocks of other groundfish and shellfish in this area, inhibitive pressures on White Hake in Div. 3P may be further exacerbated.

Age-structured assessment of the Divs. 3NOPs stock is currently not feasible. However, population abundance-at-length estimates from DFO-NL spring surveys suggest that no large recruitment has occurred for Divs. 3NOPs White Hake over the past sixteen years.

Given that good recruitment has rarely occurred and remains unpredictable for the Divs. 3NOPs White Hake stock, commercial fishing pressure should be regulated in Div. 3P by a TAC set at a level that will allow survival and growth to maturity of larger year-classes. This strategy (coupled with enforcement) is crucial to rebuilding this species in Div. 3P; especially given that the drastic declines in Divs. 3NOPs White Hake abundance and biomass following its large recruitment event of 1999-2000 was due to fishing in Divs. 3NO (mainly outside Canada’s EEZ; Kulka and Miri 2007).

In the absence of a TAC, regulations that limit the amount of White Hake bycatch for other directed fisheries in Canada’s EEZ could also be implemented; in view of DFO’s new Policy for Managing Bycatch (DFO 2013).

Given that Canadian at-sea fisheries observers constitute the sole source of data on total catch (= landings + discards) by species at sea, annual observer coverage of Canadian White Hake-directed and bycatch fisheries should be increased to significantly improve the reliability and representativeness of estimates of total removals of this species due to fishing, and allow at-sea collections of important biological data on White Hake (length, weight, sex, maturity, otoliths).

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Table 1. NAFO-reported landings (tonnes; STATLANT-21A) of White Hake in Div. 3P, 1960-2016.

-	Subdiv. 3Pn			Subdiv. 3Ps			Div. 3P
Year	non-Canadian	Canada	Total	non-Canadian	Canada	Total	Total
1960	-	-	-	500	232	732	732
1961	4	4	8	32	100	132	140
1962	-	21	21	1	74	75	96
1963	-	4	4	8	103	111	115
1964	-	18	18	-	124	124	142
1965	-	22	22	60	71	131	153
1966	-	-	-	45	39	84	84
1967	72	8	80	43	67	110	190
1968	-	133	133	20	403	423	556
1969	-	202	202	6	375	381	583
1970	30	153	183	227	397	624	807
1971	-	177	177	221	1443	1664	1841
1972	-	295	295	115	2062	2177	2472
1973	-	203	203	84	1330	1414	1617
1974	-	169	169	18	1305	1323	1492
1975	-	59	59	765	1432	2197	2256
1976	-	109	109	10	1344	1354	1463
1977	-	122	122	-	1683	1683	1805
1978	-	176	176	-	1051	1051	1227
1979	-	235	235	-	660	660	895
1980	-	144	144	-	546	546	690
1981	-	130	130	-	1030	1030	1160
1982	-	123	123	-	773	773	896
1983	-	83	83	-	425	425	508
1984	-	122	122	-	683	683	805
1985	-	63	63	-	1156	1156	1219
1986	-	57	57	14	1228	1242	1299
1987	-	92	92	-	1318	1318	1410
1988	-	66	66	12	683	695	761
1989	-	22	22	3	706	709	731
1990	-	13	13	35	1441	1476	1454
1991	-	44	44	36	1445	1481	1524
1992	-	80	80	-	1208	1208	1324
1993	-	244	244	-	741	741	985
1994	-	294	294	-	382	382	676
1995	-	59	59	-	420	420	479
1996	-	80	80	-	362	362	442
1997	-	9	9	-	315	315	324
1998	-	8	8	1	561	562	570
1999	-	34	34	-	575	575	609
2000	-	60	60	134	976	1110	1170
2001	-	141	141	10	920	930	1071
2002	-	52	52	3	915	918	970

-	Subdiv. 3Pn			Subdiv. 3Ps			Div. 3P
Year	non-Canadian	Canada	Total	non-Canadian	Canada	Total	Total
2003	-	210	210	3	1105	1108	1318
2004	-	77	77	22	1361	1383	1460
2005	-	45	45	23	1615	1638	1683
2006	-	15	15	1	1484	1485	1500
2007	-	35	35	2	1253	1255	1290
2008	-	45	45	6	659	665	710
2009	-	26	26	-	362	362	388
2010	-	19	19	-	378	378	397
2011	-	41	41	-	200	200	241
2012	-	18	18	-	208	208	226
2013	-	25	25	-	191	191	216
2014	-	11	11	-	383	383	394
2015	-	12	12	1	330	331	343
2016	-	148	148	3	397	400	548

Table 2. DFO-NL ZIFF reported Canadian landings of White Hake in Div. 3P, 1985-2016.

Year	Subdiv. 3Pn	Subdiv. 3Ps	Div. 3P Total
1985	39	1,138	1,177
1986	60	876	936
1987	93	1,314	1,407
1988	68	687	755
1989	22	680	702
1990	13	1,441	1,453
1991	43	1,401	1,444
1992	80	1,163	1,242
1993	243	732	975
1994	293	383	676
1995	58	396	454
1996	74	565	639
1997	9	407	416
1998	7	498	505
1999	34	570	604
2000	60	715	775
2001	142	754	895
2002	52	760	812
2003	207	878	1085
2004	75	1,096	1172
2005	45	1,405	1450
2006	16	1,221	1237
2007	37	1,134	1171
2008	47	601	648
2009	27	282	310
2010	21	307	328
2011	40	161	201
2012	19	183	201
2013	25	170	195
2014	12	356	368
2015	12	149	162
2016	149	267	416

Table 3. Abundance and biomass estimates of White Hake in Div. 3P from DFO-NL spring research surveys, 1972-2017. Surveys were conducted with a Yankee trawl (1972-1982), Engel trawl (1983-1995), and Campelen trawl (1996-2017). Note that Yankee, Engel, and Campelen time series are not standardized.

-	Abundance (000s)		Biomass (tonnes)	
Year	Subdiv. 3Ps	Subdiv. 3Pn	Subdiv. 3Ps	Subdiv. 3Pn
-	-	Yankee	-	-
1972	1556	-	2725	-
1973	247	-	465	-
1974	2055	-	5224	-
1975	2646	-	4491	-
1976	3856	-	4778	-
1977	3935	-	7168	-
1978	4058	-	6774	-
1979	3077	-	6310	-
1980	2053	-	3970	-
1981	4743	-	7448	-
1982	1340	-	4283	-
-	-	Engel	-	-
1983	1508	-	2539	-
1984	1179	-	2558	-
1985	3045	-	5303	-
1986	4186	299	11105	234
1987	4438	662	9866	1395
1988	5533	1136	13005	2870
1989	4130	756	6884	1745
1990	2941	312	3988	563
1991	3800	189	4591	392
1992	2699	193	3008	170
1993	2670	236	2929	282
1994	2274	226	2433	198
1995	2104	208	2334	305
-	-	Campelen	-	-
1996	8089	318	6282	230
1997	12432	617	8507	260
1998	4765	315	4007	367
1999	8654	949	8236	599
2000	11743	1504	10294	967
2001	13792	1569	8092	940
2002	15098	806	10118	654
2003	6904	262	5762	180
2004	6977	538	6622	262
2005	5506	970	5249	490
2006	-	722	-	472
2007	6061	862	6940	676
2008	3991	-	3633	-
2009	4547	1957	2582	690
2010	5285	1851	3739	701
2011	6745	1032	4727	589
2012	4657	1468	3686	917
2013	5581	1791	3987	703
2014	5834	-	3630	-
2015	6032	-	3596	-
2016	8537	-	5050	-
2017	7092	-	4848	-

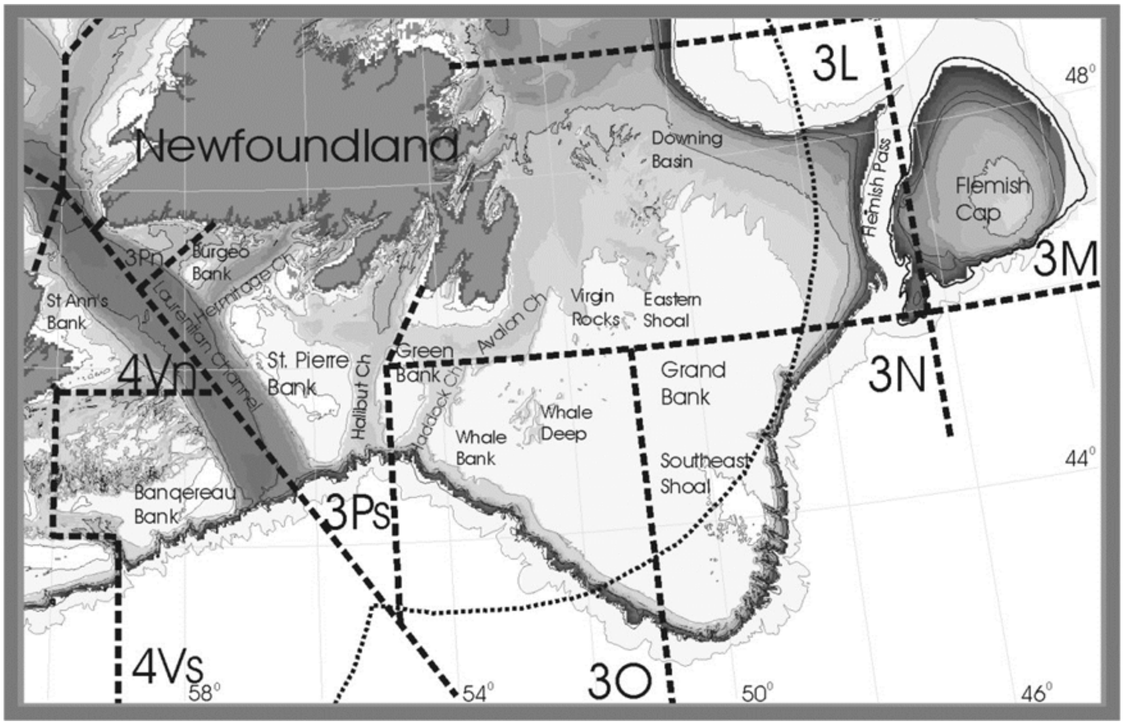

Figure 1. Map of the Grand Bank and southern Newfoundland, showing various banks, basins, and NAFO Divisions. Thick black dashed lines delineate NAFO Divisions. The thin black dotted curved line depicts the boundary between Canada's Exclusive Economic Zone (EEZ) and the NAFO Regulatory Area (NRA).

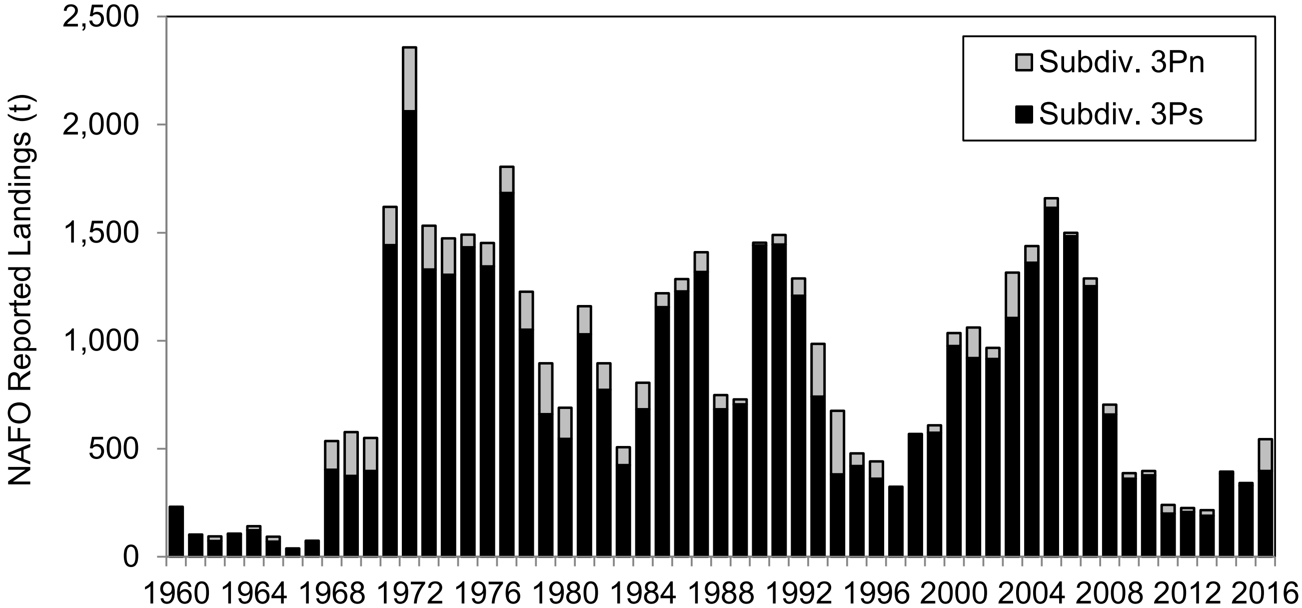

Figure 2. NAFO-reported landings (tonnes) of White Hake by Canada in Subdiv. 3Ps and 3Pn, 1960-2016 (STATLANT-21A).

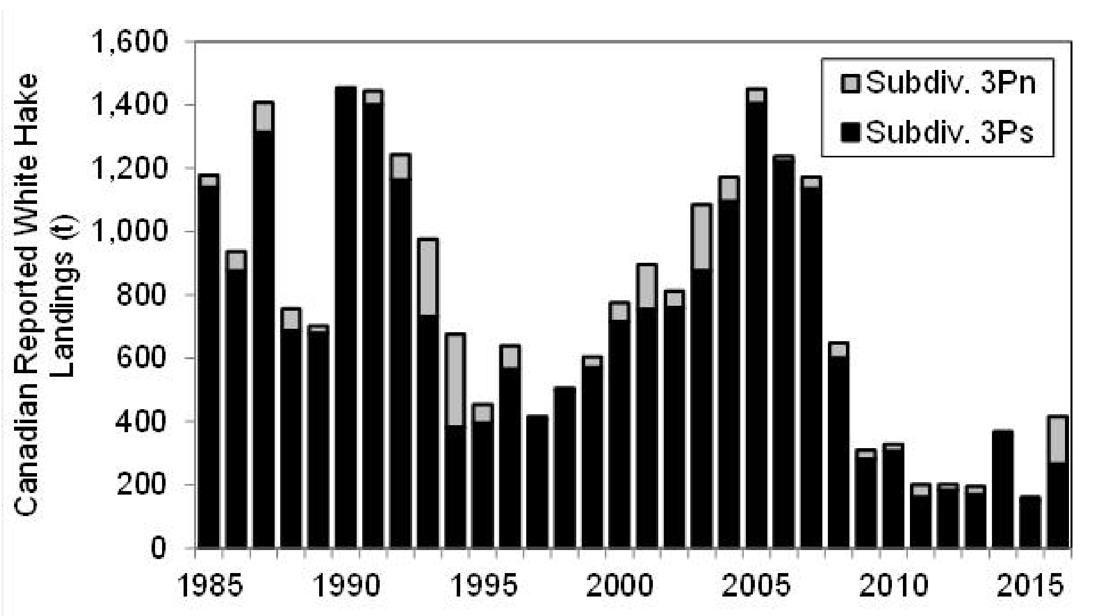

Figure 3. DFO-NL ZIFF-reported Canadian landings (tonnes) of White Hake in Subdiv. 3Ps and 3Pn, 1985-2016.

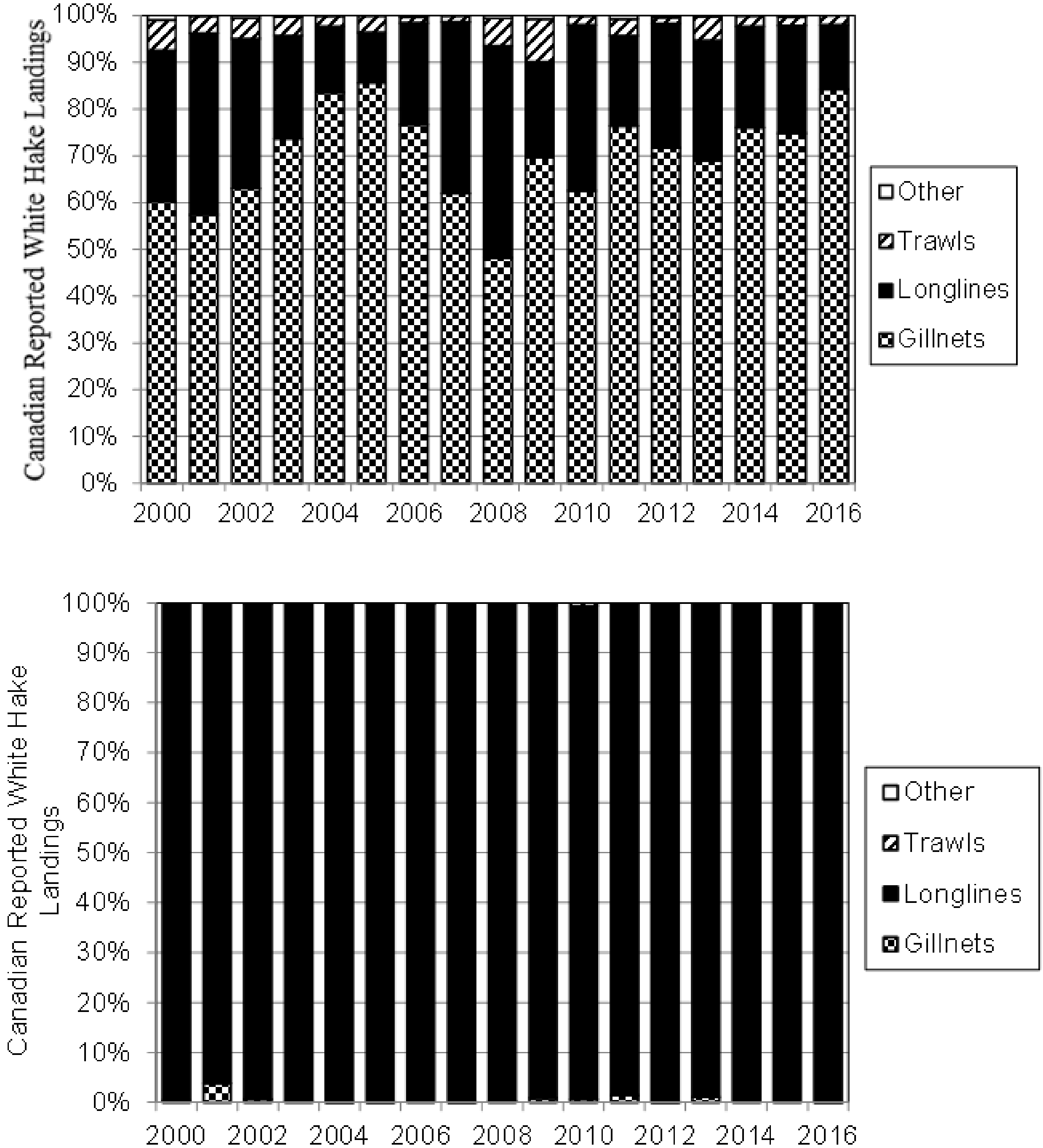

Figure 4. DFO-NL ZIFF-reported landings of White Hake by gear in Subdiv. 3Ps (top panel) and 3Pn (bottom panel), 2000-16.

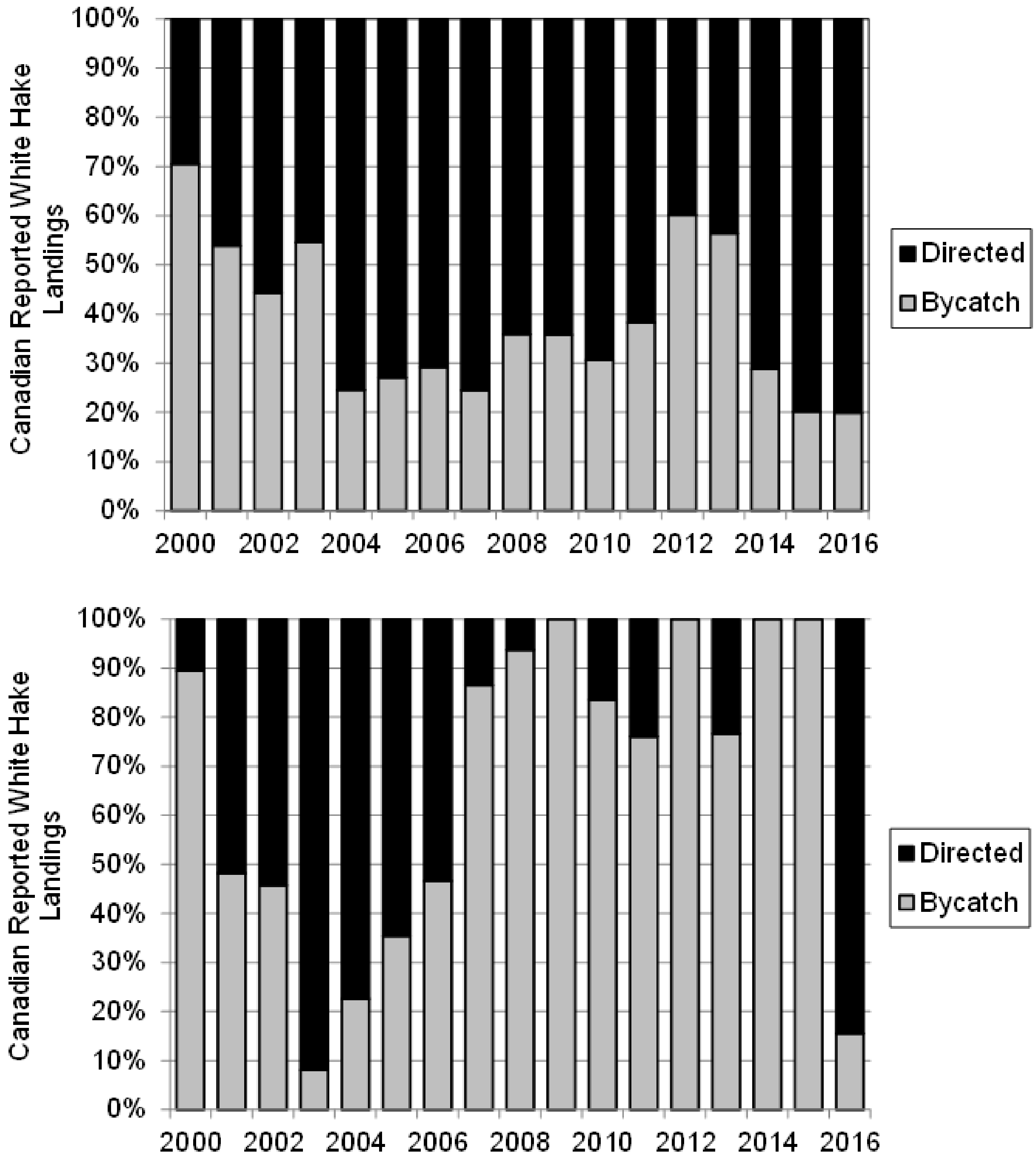

Figure 5. DFO-NL ZIFF-reported directed and bycatch landings of White Hake in Subdiv. 3Ps (top panel) and 3Pn (bottom panel), 2000-16.

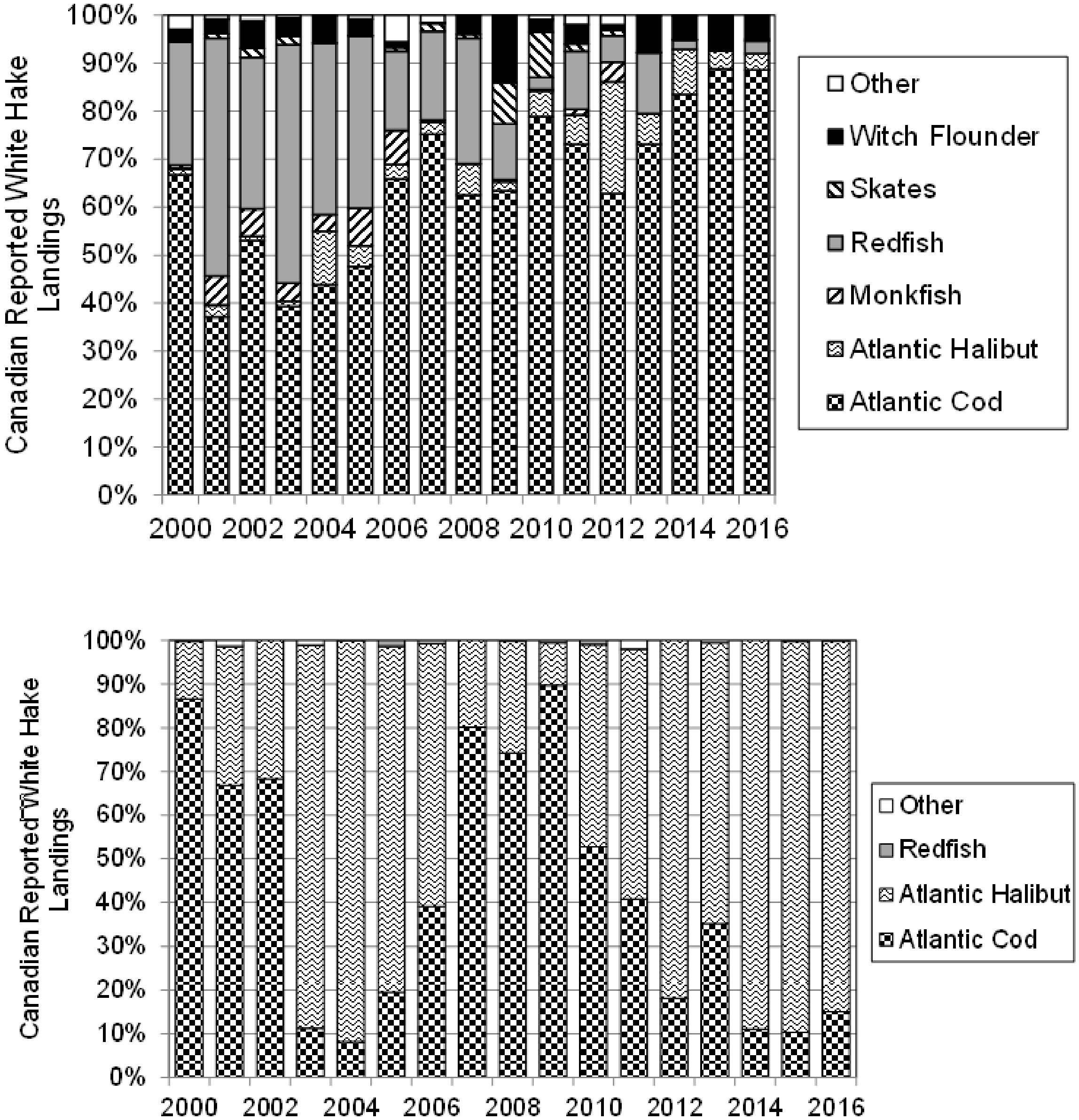

Figure 6. DFO-NL ZIFF-reported landings of White Hake bycatch by directed species in Subdiv. 3Ps (top panel) and 3Pn (bottom panel), 2000-16.

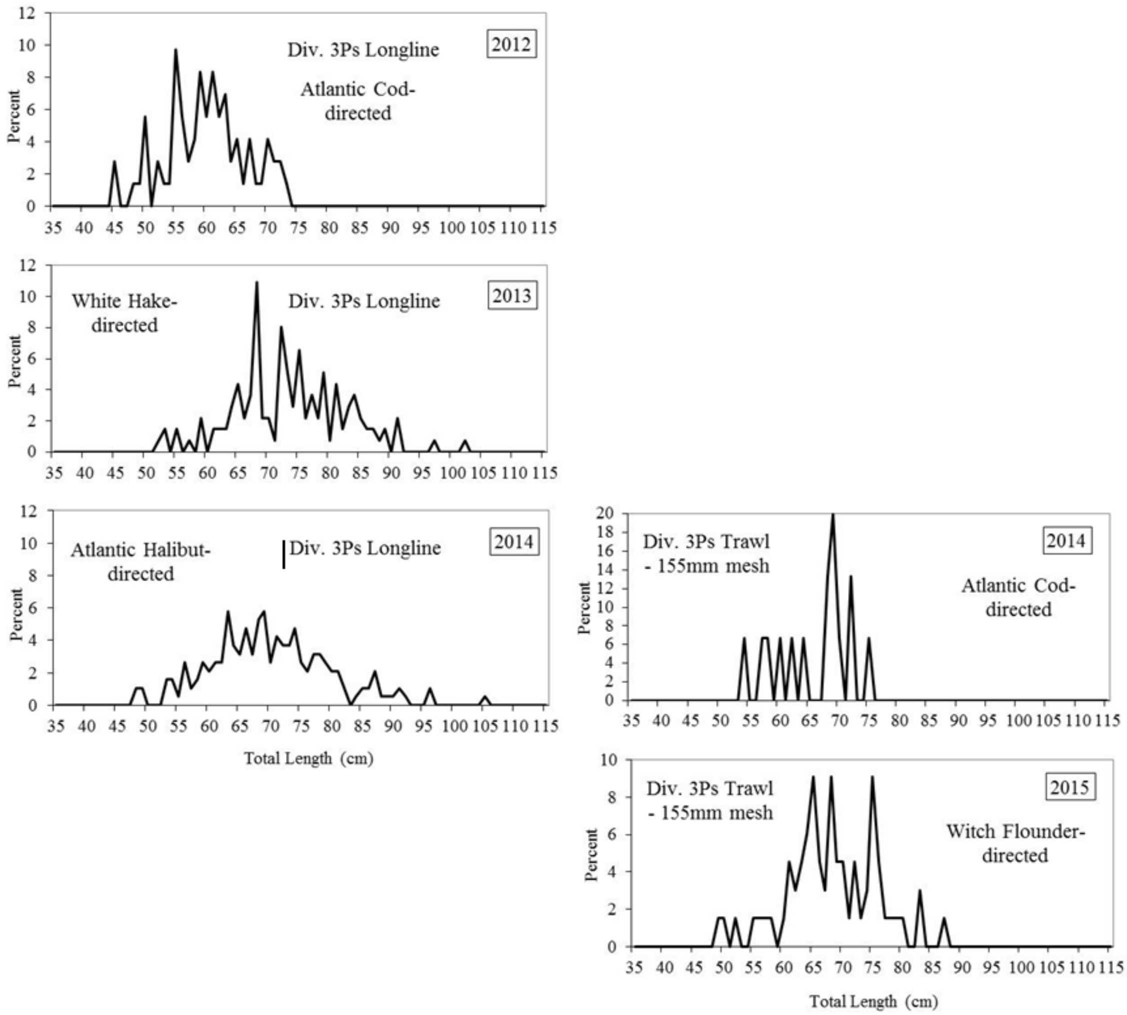

Figure 7. Length frequencies (in cm) of White Hake in Subdiv. 3Ps from Canadian commercial fisheries, 2012-2015. Note that different gears are represented in separate graphs. Data are from Canadian At-Sea Fisheries Observers, and were not collected in 2016.

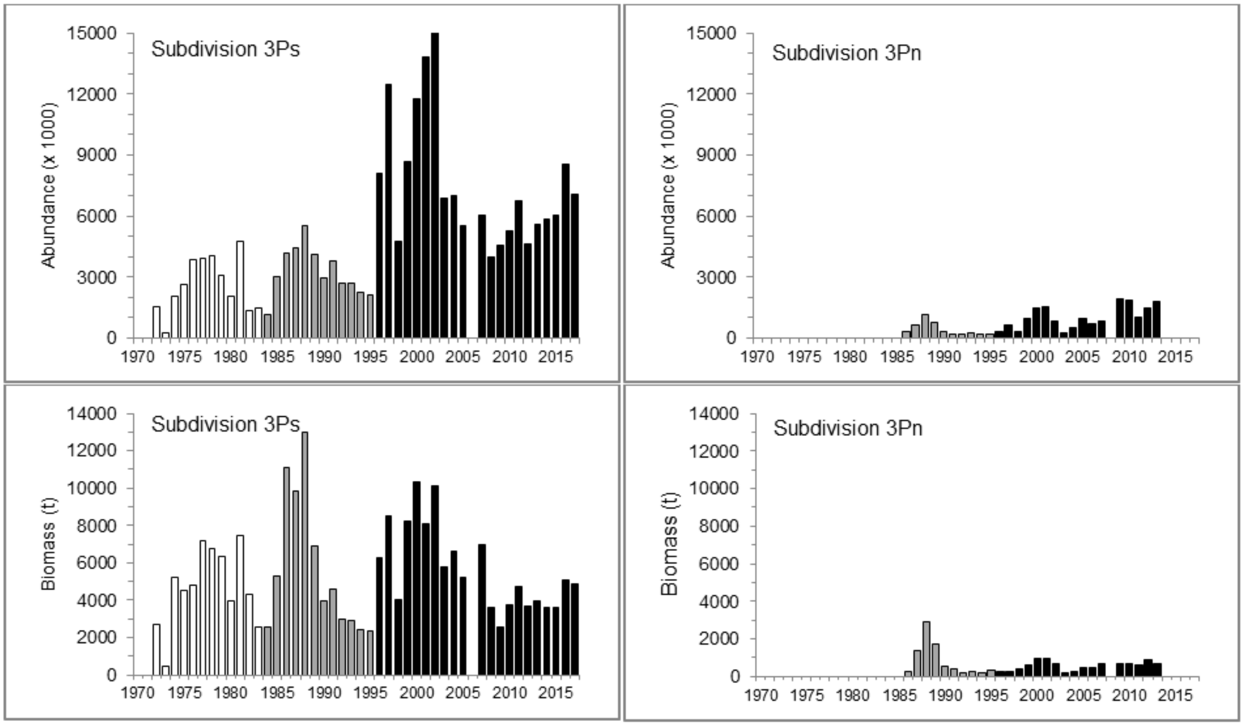

Figure 8. Annual estimates of abundance and biomass for White Hake from DFO-NL spring research surveys in Subdiv. 3Ps (left column) and Subdiv. 3Pn (right column), 1972-2017. Note that there is no conversion factor between Yankee (open columns), Engel (gray columns), and Campelen (black columns) time-series.

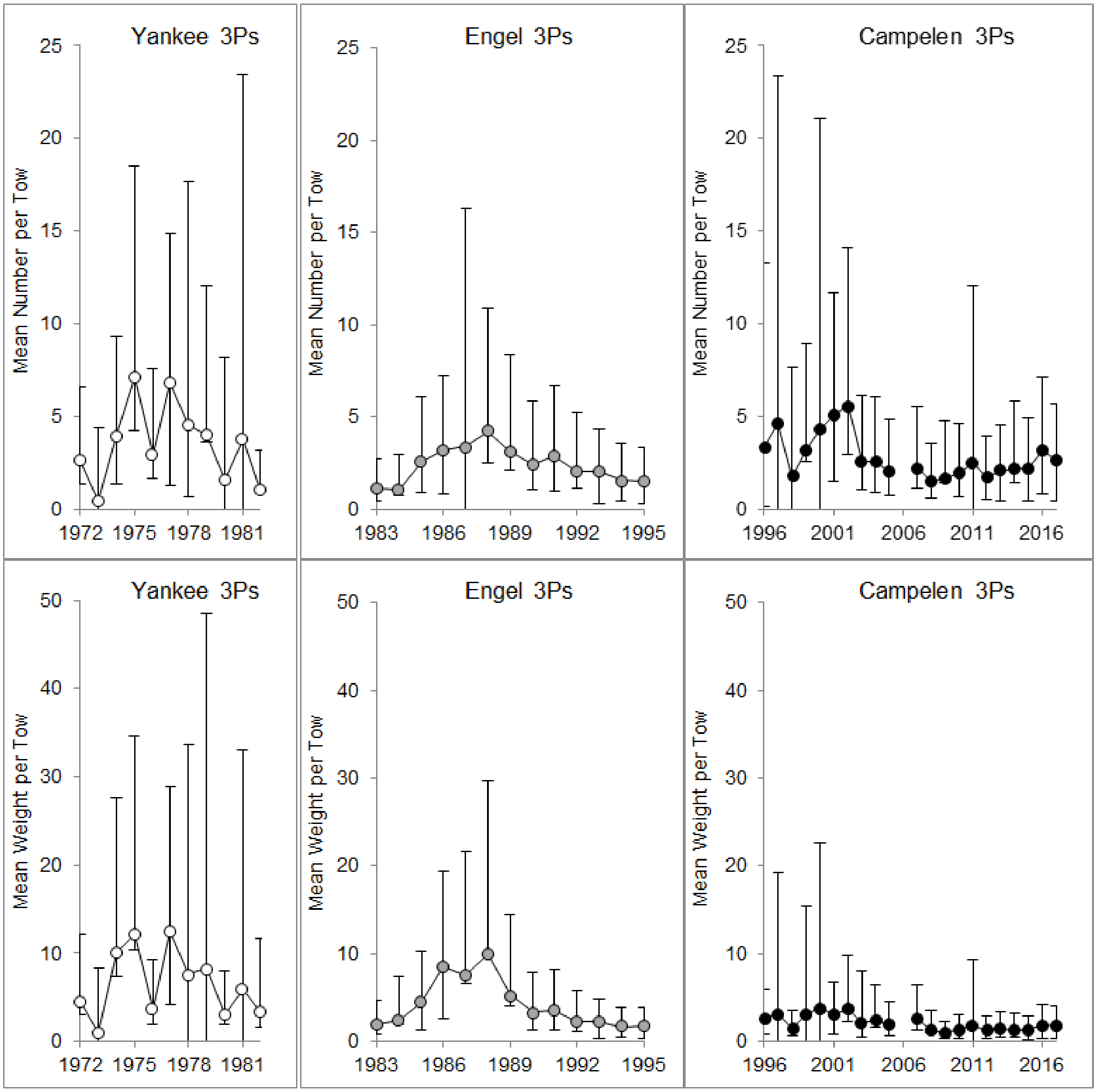

Figure 9. White Hake mean numbers (top panels) and mean weights (kg; bottom panels) per tow (+/-95% CI) from DFO-NL spring surveys in Subdiv. 3Ps, 1972-2017. Yankee, Engel, and Campelen time-series are not standardized, and thus are presented on separate panels.

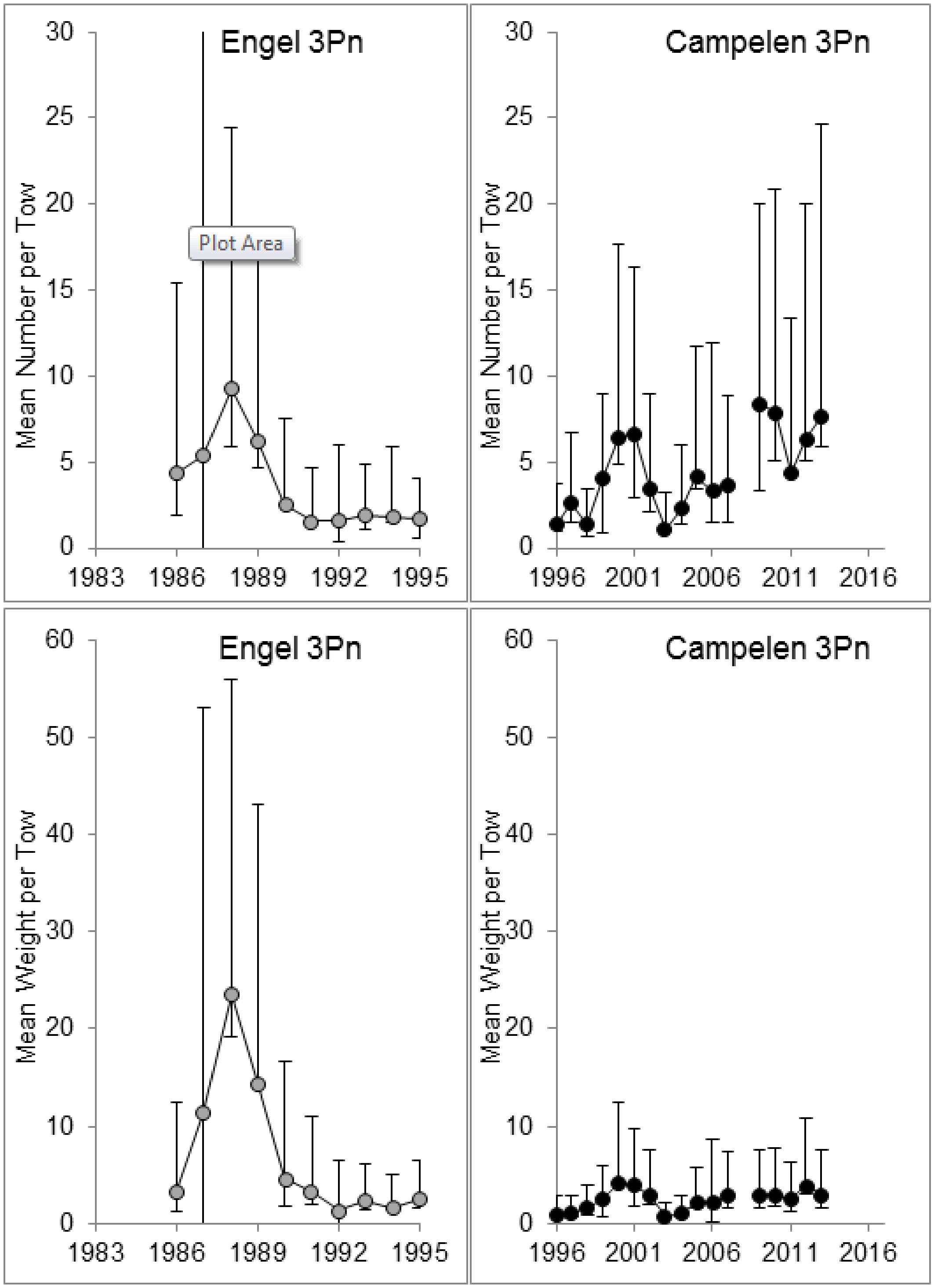

Figure 10. White Hake mean numbers (top panels) and mean weights (kg; bottom panels) per tow (+/-95% CI) from DFO-NL spring surveys in Subdiv. 3Pn, 1986-2013. Engel and Campelen time-series are not standardized, and thus are presented on separate panels.

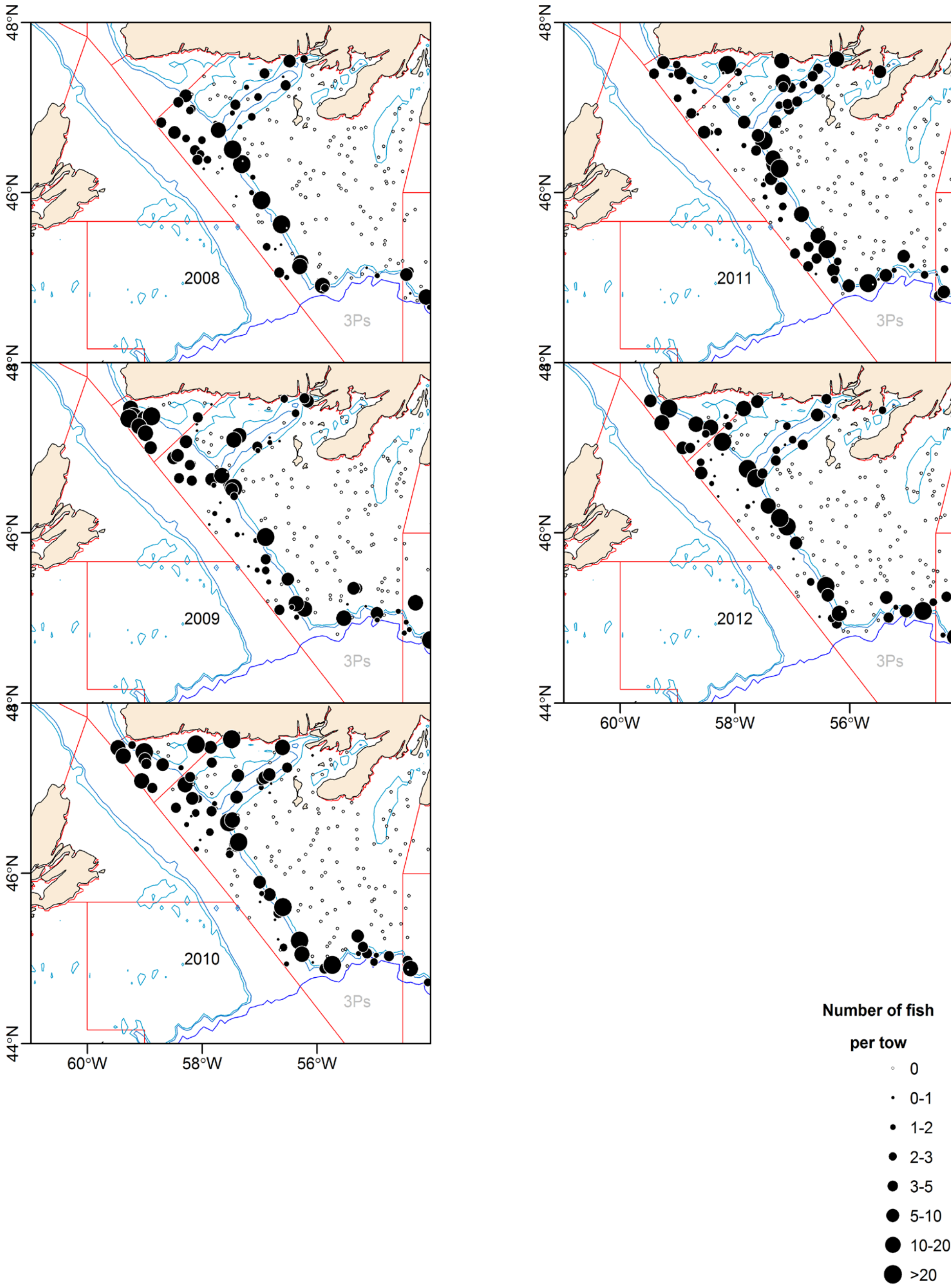

Figure 11. Distribution of White Hake mean numbers per tow in Div. 3P, based on DFO-NL spring surveys in 2008-12. Note that Subdiv. 3Pn was not surveyed in 2008.

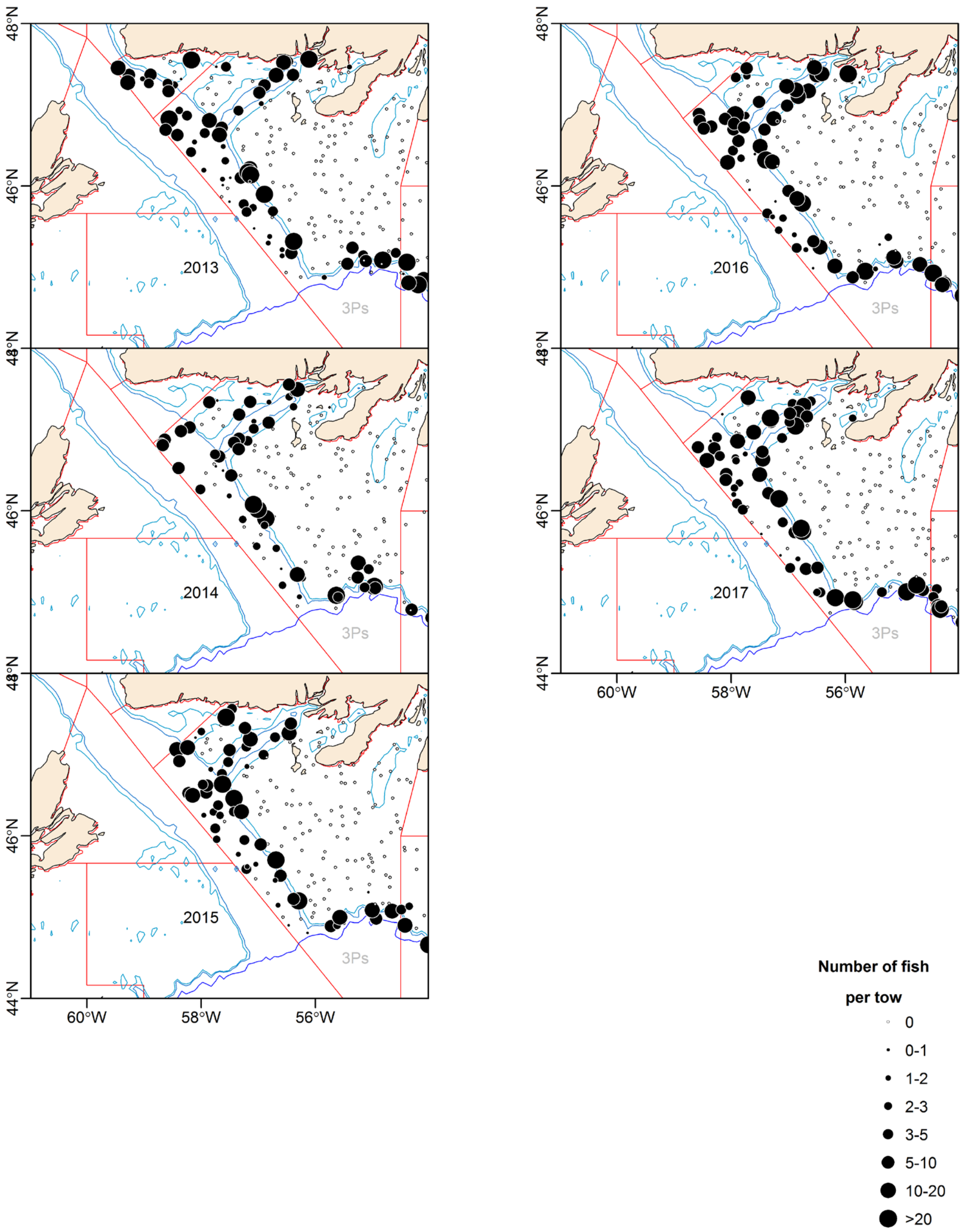

Figure 12. Distribution of White Hake mean numbers per tow in Div. 3P, based on DFO-NL spring surveys in 2013-17. Note that Subdiv. 3Pn was not surveyed in 2014-17.

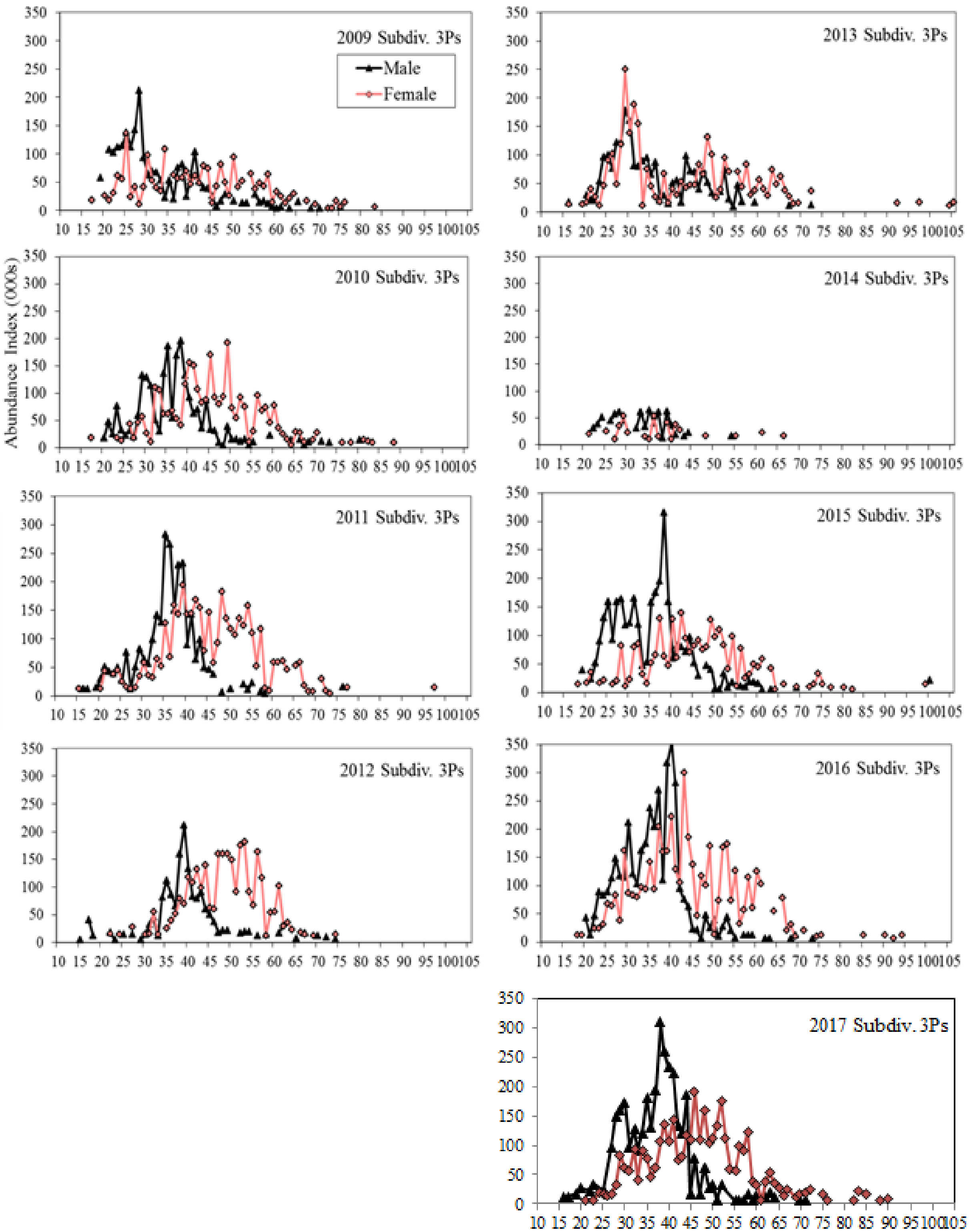

Figure 13. Abundance index at length of male and female White Hakes from DFO-NL spring surveys in Subdiv. 3Ps, 2009-17.

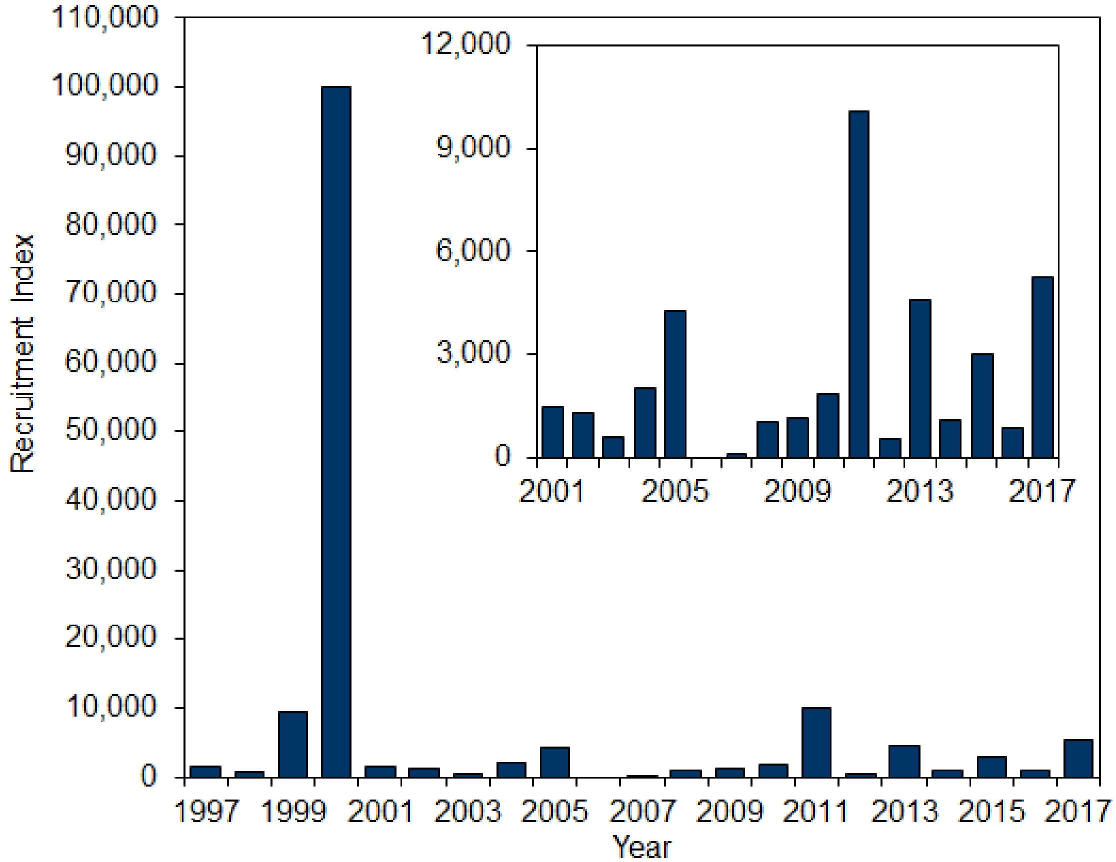

Figure 14. White Hake recruitment index for Age 1 males and females (combined) from DFO-NL Campelen spring surveys in Div. 3NO and Subdiv. 3Ps, 1997-2017. Inset plot depicts 2001-17 on a smaller scale. Estimates from 2006 are not shown, since survey coverage in that year was incomplete.

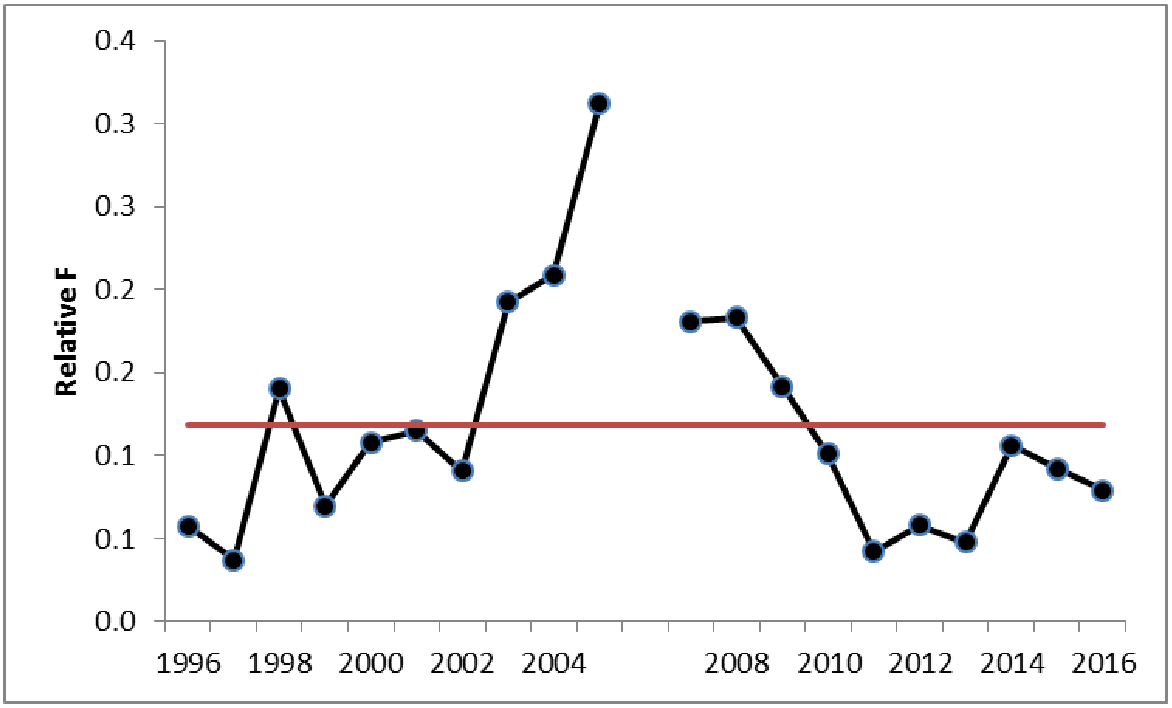

Figure 15. Relative F index (=NAFO-reported commercial landings/ DFO-NL Campelen spring survey biomass) for White Hake in Subdiv. 3Ps, 1996-2016. Thick horizontal line depicts the average over these years.