Northwest Atlantic Fisheries Organization

Serial No. N5404 **SCR Doc. 07/52**

SCIENTIFIC COUNCIL MEETING – JUNE 2007

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

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ABSTRACT

Canada commenced a directed fishery for white hake in 1988 in Div. 3NO and Subdiv. 3Ps. All Canadian landings prior to 1988 were as bycatch in various groundfish fisheries. In Div. 3NO of the NAFO Regulatory Area, EU-Spain and EU-Portugal commenced a directed fishery in 2002, and Russia in 2003; resulting in the 2003-2004 peak. There were no directed fisheries by EU-Spain in 2004, or by EU-Spain, EU-Portugal, or Russia in 2005-2006. In 2003-2004, 14% of the total catches of white hake in Div. 3NO and Subdiv. 3Ps were taken by Canada but increased to 93% in 2006, primarily due to an absence of a white hake-directed fishery by other countries in 2005-2006. From 1970-2006, white hake catches in Div. 3NO fluctuated: averaging approximately 2 000 tons, and exceeding 5 000 tons in three years during that period. Catches peaked in 1985 at approximately 8 100 tons then declined, averaging 2 090 tons from 1988 to 1994. With the restriction of fishing by other countries to areas outside Canada's 200-mile-limit in 1992, non-Canadian landings fell to zero. Average catch was at its lowest in 1995-2001 (455 tons) but increased to 6 752 tons in 2002 and 4 841 tons in 2003; following recruitment of the large 1999 year-class. Catches declined to an average of 1 102 tons in 2004-2006. Data from spring surveys in Div. 3N, 3O, and Subdiv. 3Ps were available from 1975 to 2005. In the 2006 Canadian spring survey, most of Subdiv. 3Ps was not surveyed and only shallow strata in Div. 3NO (to a depth of 77 m in Div. 3N, to 103 m in Div 3O) were surveyed. Data from autumn surveys in Div. 3NO were available from 1990 to 2006. The spring index in Div. 3NOPs, covering the entire stock area, was used as the primary source of information on change in stock size. The spring index for Div. 3NOPs declined in the early 1980s, peaked in the late 1980s and again in 2000. In particular, the very large 1999 year-class resulted in a large peak in the autumn of 1999 and spring of 2000. The indices have since declined to levels similar to 1996-1998. From 2002 to 2005, the population was stable at a low level similar to what was observed in 1996-1998. The EU-Spain surveys in Div. 3NO of the NRA showed a very similar trend from 2001-2006. It was the very large 1999 year-class that resulted in a dominant mode of 15 cm (young-of-the-year) in the 1999 Canadian autumn research survey, and another of 22 cm (1-year-old) fish observed in both the 2000 Canadian and Spanish spring surveys. This mode was tracked through subsequent years in both surveys, and in 2005 constituted 2% of the abundance observed in 2000 (estimated Z=0.7 for 2000-2005). The 1999 year-class comprised a large portion of the catch in the expanded non-Canadian fishery in 2002-2003 in Div. 3NO of the NRA. Since 1999, recruitment has been extremely low; with the largest value in recent years (2004) being 1.6 recruits per spawner as compared to 35 in 1999.

INTRODUCTION

White hake (*Urophycis tenuis*, Mitchill 1815) is a highly fecund, demersal gadoid species distributed solely in the Northwest Atlantic from Cape Hatteras to southern Labrador. It reaches peak abundance on the Grand Banks (northern limit of significant concentrations), Gulf of St. Lawrence, the Scotian Shelf and the Gulf of Maine (Musick 1969, 1974, Bundy *et al*. 2001, Hurlbut and Poirier 2001, Kulka and Simpson 2002, Kulka *et al*. 2005a). Present knowledge of the biology of this species is found in Kulka *et al.* (2005a) in detail for the Grand Banks and is summarized over its remaining range.

Formerly one of the commercially important species in the Gulf of St. Lawrence (NAFO Div. 4T), Scotian Shelf (Div. 4VWX and 5), and Gulf of Maine (Div. 5YZ), white hake stocks have declined there in recent years. Their status as a commercial resource has been assessed by: Beacham and Nepszy (1980), Clay *et al.* (1986), Clay (1986, 1987), Clay and Hurlbut (1988, 1989, 1990), Hurlbut and Chouinard (1992), Chadwick and Robichaud (1993), Hurlbut *et al.* (1994), Morin and Hurlbut (1994), Anon. (1994), Anon. (1995), Hurlbut *et al.* (1995, 1996, 1997), and Hurlbut and Poirier (2001) for the southern Gulf of St. Lawrence stock (4T), and Fowler *et al*. (1996), Fowler (1998), and Bundy *et al*. (2001) for the Scotian Shelf stock. Given that these fisheries have been closed in recent years, assessment updates have only been performed on these stocks since 2002 (see DFO 2002, 2003, 2004, 2005 status reports that are located at http://www.dfo-mpo.gc.ca/csas/csas/Publications/Pub_Index_e.htm). The Georges Bank/Gulf of Maine stock is assessed by the USA (NEFSC 1999, 2001, 2007).

Concentrations of white hake are also found in the waters south and east of Newfoundland in Divisions 3L, 3N, 3O, and Subdivision 3Ps (Fig. 1, Kulka *et al.* 2005a) but prior to the mid1980s, white hake on the Grand Banks were usually taken only as bycatch. Unlike the commercially targeted stocks in the Gulf of St. Lawrence and Scotian Shelf, it was rarely reported as a directed species. Although bycatch records have existed for years from the Grand Banks, it was a relatively minor component of the total commercial landings until this century (described in Kulka and Mowbray 1998).

Records of directed catches of white hake first appeared in 1988 in Div. 3NO and Subdiv. 3Ps. Interest in this species increased in the mid1990s. It was assessed for the first time in 1996 (Kulka and DeBlois 1996). Although not regulated by quota in Canadian waters, fishery closures due to high bycatch of regulated species often restricted Canadian catches, generally <500 tons annually (Kulka and Simpson 2002). However, Kulka *et al.* (2004) reported a >10-fold increase in the catch of white hake in Div. 3NO in 2002; attributable to new directed effort by EU-Spain and EU-Portugal in the NAFO Regulatory Area (NRA). Russia joined this fishery in 2004. Given the large increase in commercial catches, the Fisheries Commission of the Northwest Atlantic Fisheries Organization (NAFO) requested in 2003 specific information on fishing mortality, abundance, distribution, reference points, conservation measures, size of fish, and delineation of fishery areas. With limited information available, the advice provided is summarized in Kulka *et al.* (2004, 2005b).

The Fisheries Commission, by originally specifying advice for Div. 3NO and not Subdiv. 3Ps, implicitly set the white hake stock management unit as Div. 3NO. Previously, it had been assessed as a unit in 3NOPs by Canada. In addition, Kulka *et al.* (2005a) indicated that white hake form a continuous distribution and a single spawning stock within Div. 3N, 3O, and Subdiv. 3Ps. The authors determined that different life stages of white hake (young and older juveniles, and adults) distribute differently over those three Divisions. Spawning adults and young-of-the-year juveniles were found mainly in Div. 3NO; while 1+ juveniles were distributed across the entire area and dominated in Subdiv. 3Ps. Therefore, assessing white hake only from Div. 3NO, while excluding fish in Subdiv. 3Ps, would bias the results because of annual changes in the distribution of life history stages as various year classes mature.

In response to the request for advice on the status of the Grand Banks stock from the Fisheries Commission, this paper presents an assessment of white hake in 3NOPs focusing on: fishery statistics, and research survey information (stage-based biomass and abundance indices). However, incorporation of the most recent 2006 Canadian spring survey data into this assessment has been impaired by the incomplete coverage of Subdiv. 3Ps, and the lack of deepwater sets being done in Div. 3NO. Thus, advice for Subdiv. 3Ps pertains primarily to the period up to 2005; while limited information from Div. 3NO is presented for 2006.

METHODS

Survey Data

The Department of Fisheries and Oceans Canada in the Newfoundland and Labrador (DFO-NL) Region undertakes a number of fishery-independent surveys to collect biological information. For this study, survey data were derived from five sources (first four are Canadian surveys; described below in detail):

1) Standard NL demersal trawl surveys (random stratified using trawl gear, spring and autumn, post-1970 using Yankee-41.5 to 1983, Engel-145 Hi-lift to the spring of 1995, and Campelen-1800 shrimp trawl from the autumn of 1995 to date);
2) Special demersal trawl surveys (same gear and effort protocol as standard survey);
3) Juvenile demersal surveys (Yankee-41 shrimp trawl, August-October, 1985-1994);
4) IYGPT pelagic surveys (pelagic trawl at 36 m below surface, August-September, 1996-2000);
5) EU-Spain demersal survey in the NRA (Campelen-1800 shrimp trawl, 2001-2006)

Canadian standard and special trawl surveys - Data on white hake have routinely been collected during stratified-random trawl surveys around Newfoundland and Labrador for the purpose of estimating biomass and abundance of demersal species. A summary of the stratified-random survey design (standard sets) adopted by the DFO-NL Region after 1970 can be found in Doubleday (1981). While survey design has remained constant, additional strata have been added in recent years along with modifications to some of the original strata. An accounting of these modifications up to 1994 can be found in Bishop (1994). One of the recent significant changes in the surveys is the addition of shallower and deeper strata after 1993 although sets at depths < 50 m were occasionally recorded in earlier years (Table 1). Due primarily to the addition of the new strata, the total surveyed area has changed over the years. From 1996 to date, the area surveyed was ~295,000 km^2, in 1994-95 it was 283,000 km^2 and from 1986-1993 was 255,000 km^2. Table 2 enumerates catches of white hake by year and depth and the potential affect of additional shallow and deep strata, introduced since 1996 are discussed.

The most significant alteration in NL survey design was a change in gear in the autumn of 1995, from Engel-145 High-Lift Otter Trawl (demersal) to Campelen-1800 Shrimp Trawl. McCallum and Walsh (1996) and Walsh and McCallum (1996) described the geometry and specifications of the two gears. In addition to gear dimensions, the mesh size was different – 160 mm in the bellies and codend for Engel and 40 mm for Campelen. Visual analyses verify that the two gears capture different size ranges and composition of white hake (Kulka *et al.* 2005b). While size based conversion factors for amounts of fish caught in the two survey gears were derived from comparative surveys for the major commercial species, this exercise was not done for "minor" species, including white hake. Thus, the catch rate data and resulting biomass and abundance indices must be considered as separate indices, differently scaled. The change in gear occurred in the autumn of 1995. The change in scale is delineated on the various tables by spatial separations and on the figures. Table 1 enumerates the Engel and Campelen survey sets by NAFO Div., survey season and depth.

In addition to the proportional allocation of the random-stratified sets used for Stratified Random (STRAP) estimates of relative biomass and abundance, extra sets using the same gear and effort (tow time) were done on occasion. These extra sets were done primarily to survey redfish, mainly in the vicinity of the Laurentian Channel and for diurnal studies at other locations on the Grand Bank. Those extra sets are particularly useful for delineating autumn distribution of white hake along the southern St. Pierre Banks and Laurentian Channel (Subdiv. 3Ps), an area not covered by the standard survey in the autumn. Table 1b and 1d show the total sets, standard plus special used for mapping white hake and Table 2 enumerates sets containing white hake catches. These extra sets were not used in the estimation of biomass and abundance.

In the 2006 Canadian spring survey, most of Subdiv. 3Ps was not surveyed and only shallow strata in Div. 3NO (to a depth of 77 m in Div. 3N, to 103 m in Div 3O) were surveyed due to technical problems with the vessel and thus the survey estimates in the most recent year are not included in this analysis.

Canadian juvenile surveys: The Grand Bank, within Div. 3LNO, was surveyed in August to October 1985-1993, using a Yankee-41 shrimp trawl with 38 mm mesh in the bellies and codend (i.e., more efficient at capturing small fish than the Engel gear used for standard Canadian surveys). Only a limited number of white hake were measured during this survey, 73 length frequencies from 1989-1992, and is used as an extra source of information on summer/autumn distribution of juvenile fish. Table 3 enumerates the juvenile survey sets, all of which occurred on the bank at depths of 39-260 m (average 91 m).

IYGPT (Pelagic) surveys: The IYGPT (International Young Gadoids Pelagic Trawl) survey took place on the Grand Banks in 1996-2000. The survey has since been discontinued, but contains some valuable information on the pelagic (young-of-the-year or YOY) stage of white hake. This survey series, taking place ~30 m below the surface in August-September on the Grand Banks, covered Div. 3LNO, but not Subdiv. 3Ps (Dalley and Anderson 1997, 2000). It was used as a source of information on recruitment (YOY) and is compared to newly settled fish observed in the autumn Campelen survey. Table 4 enumerates the sampling effort. White hake captured were measured for total length.

EU-Spanish Survey: Data from the EU-Spanish survey undertaken in June, using the Campelen-1800 gear and covering the NRA portion of Div. 3NO was compared to the Canadian spring survey results for 2001-2005.

Analyses

STRAP (described in Smith and Somerton 1981) was used to estimate relative biomass and abundance by areal expansion within each of a series of pre-defined strata added over the survey area. Standard sets from the seasonal surveys, spring and autumn (see Table 1a and c) are used to estimate index of abundance and biomass using STRAP2**,** while a combination of the standard and special sets (described above) are used to map the distribution. Eighty-two percent of sets containing white hake were sampled for length by sex in both trawl surveys in Div. 3N, 3O (spring and autumn), and Subdiv. 3Ps (spring only), and those samples were used to estimate numbers at length using STRAP1. Estimates based on sets from strata that have been surveyed throughout the years compared to estimates that include deep water and inshore strata (which have been added in recent years) yield very similar results for white hake (refer to Kulka and Mowbray 1998)**,** and thus no adjustments for these changes are necessary. Therefore, data from the new strata are included in the estimates of recent years.

Stage-based analyses, including examination of a stock recruitment relationship and stage-based distribution**,** integrate information on length and maturity collected for each sex during standard research trawl surveys. The focus of this analysis is on years when a Campelen trawl was used (1996-2006) since it captures a wider range of sizes**,** including juveniles in their first year. Maturities, recorded for ~ 97% of survey sets were used to calculate maturity ogives and length at 50% maturity (L_{50} =length at which 50% of the fish were sexually mature) by sex for each Campelen year in the combined Divisions of 3NO, 3NOPs, and Subdiv. 3Ps alone. In addition, for historical interest, white hake maturities available for Engel trawl years (1988-1992) are included although a paucity of early data only allowed ogives to be calculated for 1989 and applied to other Engel years.

The von Bertalanffy growth function was used to model a preliminary estimate of growth using modal mean estimates since age samples were not available:

$$L\,t = L\infty\,[1 - \exp(-k(t - t0))]$$

where Lt = length at age Lt, L∞ = asymptotic or maximum length, k = growth coefficient, and t_0 = theoretical age when length equals zero. The input comprised average size at age for the 1999 year class by sex. Average size of that age class was estimated in subsequent years as the mean of the 1999 year class frequency mode in subsequent years. This approach was possible because that year class dominated in the length frequencies because of poor recruitment in years prior to and following 1999.

A GIS (SPANS, Anon 2000) was used to investigate the spatial distribution of trawl, longline and gillnet fisheries on the Grand Banks and comparing that to catch locations of white hake.

Fishery data

Canadian landings from white hake-directed fishing and bycatch from other fisheries were compiled using statistical records in the Zonal Interchange Format database (ZIF); available since 1985. However, the primary source of catch information is a Table of catch estimates reported by all countries per NAFO Division and agreed to by STACFIS of NAFO.

Captures of white hake along the southwest slope of the Grand Banks (Div. 3NO and Subdiv. 3Ps) were the result of a mixed fishery for monkfish (American angler, *Lophius americanus*), thorny skate (*Amblyraja radiata*), and Atlantic halibut (*Hippoglossus hippoglossus*); in addition to white hake. Discards from Canadian fisheries were calculated by applying the proportion of white hake catch to groundfish landings (kept fish, all species) in the Canadian Fisheries Observer database (see below) to the reported groundfish landings in Canadian ZIF files. These total removals were very similar to those reported by Canada in NAFO catch tables (STATLANT-21A). Catches outside Canada's 200-mile-limit by other countries were compiled from NAFO STATLANT-21A statistics. Both sources represent NAFO Scientific Council "agreed values". In recent years, the largest portion of white hake landings was recorded as directed, but bycatch data in other fisheries are included.

Since the start of the Canadian white hake fishery in 1988 in Div. 3NO and Subdiv. 3Ps, Canadian Fisheries Observers have observed approximately 8 % of Canadian efforts targeting white hake. Observers collect set-by-set information on catches, employing methods described in Kulka and Firth (1987). Information from this program was used to examine distribution of lengths of white hake in the Canadian fisheries. Research reports of various countries were used to examine sizes of fish taken in the non-Canadian fishery. Length measurements of white hake from the various fisheries were staged using a maturity ogive (combined by sex), in order to determine the proportion of commercial catches that was mature. Commercial length frequencies were recorded in 1-cm length groups for all countries except Russia (3-cm length intervals).

RESULTS AND DISCUSSION

Survey Coverage

Spatial coverage for Canadian spring and autumn trawl surveys was compared to the range of white hake records of occurrence to verify that the surveys adequately covered the distribution on the Grand Banks. Standard Canadian trawl survey sets used as input to STRAP are enumerated in Tables 1a and 1c. Non-standard sets plus standard sets within that area are listed in Tables 2b and 2d. The latter dataset was used for the purpose of mapping species distribution, because it increases the sampling density.

Canadian spring surveys cover all NAFO Divisions where white hake were encountered on the Grand Banks; whereas standard autumn surveys do not cover Subdiv. 3Ps. However, the addition of non-standard sets during 1972-1996 extends the coverage into Subdiv. 3Ps in the Laurentian Channel and outer fringe of St. Pierre Bank, where white hake are observed in significant numbers during the spring survey. Limited sets on the top of St. Pierre Bank in the autumn did not capture white hake. Thus, these non-standard Subdiv. 3Ps autumn sets (from 1972-1996) confirmed that white hake in autumn were distributed similarly to the spring period.

In terms of depth, new deep strata (>700 m) added to autumn surveys after 1996 had little impact on the enumeration or distribution results for white hake, because this species was rarely recorded at depths >700 m: 2 sets in spring, 2 sets in autumn over a period of 11 years (Tables 2a and 2b). Catch rate at those depths was very low: <2% of the average catch rate at the usual depths of 51-700 m (Table 2b).

However, white hake were occasionally captured in new shallow coastal strata, which were introduced in 1995. While these added shallow strata revealed the presence of white hake in St. Mary's Bay on the south coast, and Trinity and Notre Dame Bays on the northeast coast (but not in Conception Bay or along the Avalon Peninsula), such captures were sporadic and at densities (numbers per tow) far less than at >50 m along the southern Grand Banks (Table 2b). Thus, addition of shallow strata had little effect on the enumeration of the species as a whole, except to show the presence of small numbers in some of the bays.

With the change from the Engel-145 Hi-lift trawl (codend mesh size of 160 mm) to the Campelen-1800 shrimp trawl (40 mm codend mesh) in the autumn of 1995, sampling efficiency by size changed significantly as shown by the knife-edge increase in proportion of small fish captured in autumn 1995 with the Campelen trawl. Size-based conversion experiments between Engel and Campelen gear were not carried out for white hake. Thus, the stage-based analyses in this paper that compare first year fish to juveniles and mature adults were conducted only for the period when Campelen gear was used (since autumn 1995). The earlier Engel and Yankee data were used only to examine historical abundance and biomass indices for all sizes captured, but as independent time series which are not directly comparable for white hake.

Survey Estimates

Canadian survey estimates of relative biomass, abundance, and mean fish weight (biomass/abundance) derived using STRAP2 are presented separately for spring and autumn in Div. 3NOPs and Div. 3NO (Table 5, Fig. 2a). Mean numbers per tow with confidence intervals are presented in Figure 2b. Note the missing estimate for 3NOPs and 3NO in spring 2006, due to insufficient coverage by the Canadian spring survey in that year. Given that it was previously determined that white hake in 3NOPs constitute a single entity, and that the different life stages of white hake distribute differentially between Div. 3NO and Subdiv. 3Ps (refer to Kulka *et al*. 2005a for details), the spring index which includes data from Subdiv. 3Ps (except in 2006), in addition to Div. 3NO, is used as the main indicator of changes in relative abundance of the stock. As well, the information from Yankee (1975-1983), Engel (1984-spring 1995), and Campelen trawls (autumn 1995 to date) are presented separately; given that there are no conversion factors available to standardize inherent differences in catchability. The three time series represent changes in biomass and abundance, but at difference scales and with a different mix of fish sizes/life stages. Spanish surveys were also conducted with Campelen gear (identical to that used in Canadian surveys) in the spring to a depth of 1 400 m. Spanish biomass indices were highest in 2001, then declined to 2003, and have been relatively stable since. The trend is very similar to the Canadian spring survey index (Fig. 2d).

The biomass of white hake was observed to peak approximately every ten years during the period when Canadian stratified survey data were available: 1972-2005. During the period when the Yankee trawl was used, the biomass index in Div. 3NOPs peaked at about 9 900 tons in 1975-1978, and at about 15 000 tons with the Engel trawl in 1986-1988, undergoing a significant decline after each peak (Table 5, Fig. 2a). The second period of decline in the late 1980s to early 1990s temporally corresponds to declines that were observed for a substantial number of other species on the Grand Banks (Atkinson *et al*. 1994). Declines in other white hake populations were observed in the Gulf of St. Lawrence and Scotian Shelf during the late 1980s and early 1990s (Hurlbut *et al.* 1997, Hurlbut and Poirier 2001, Fowler *et al.* 1996, Fowler 1998, Bundy *et al*. 2001). Declines were also reported for white hake in the Gulf of Maine (NEFSC 1999, 2001, 2007).

Following the decline of the early 1990s, relative biomass of white hake on the Grand Banks increased rapidly in 1999-2000 to about 26 000 t on the Campelen scale, but has steeply declined since and is presently at the lowest level observed in the Campelen years. The sharp increase early in the century was due to a moderate year class produced in 1998 plus a very large year class in 1999; both of these year classes were much larger than any other observed after 1995 (described by Kulka *et al.* 2005b). The knife-edge difference observed in autumn 1995 and in spring 1996 is the result of a different Canadian survey trawl being used. Given this change in gear types, biomass indices since 1995 (autumn) and 1996 (spring) cannot be directly compared with the preceding years. However, if one applies a conversion factor derived by averaging the last three years when an Engel-145 trawl was used, divided by an average of the first three years when a Campelen-1800 trawl was deployed, one can speculate on the relativity between both time series. Calculating such a factor (average biomass index) for 1999-2001 resulted in an index almost 3 times higher than that for 1996-1998. The difference between these two time periods was even more apparent in terms of abundance: approximately 6 times higher in the latter series; thereby suggesting that small white hake had a higher catchability in Campelen trawls (refer to discussion below on fish sizes). Applying the conversion factor described above, the 1999-2001 biomass index (converted) is comparable to the 1975-1978 peak. However, this comparison is only speculative; given that this conversion scales the values, but does not account for differences in the sizes of fish caught by the different trawls. An examination of Canadian research survey frequencies indicates differences in white hake catchability at size between both trawl types.

Autumn biomass and abundance estimates (1990-2006) were restricted to Div. 3NO (no autumn research surveys in Subdiv. 3Ps), and thus is missing a large portion of mainly 1+ juveniles. These trends show a similar large increase in Divs. 3NO between 1998 and 1999 (Table 5, Fig. 2a); 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 observed previously (refer to discussion of distribution of this biomass in Div. 3O below). The biomass index has drastically 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 YOY that were spawned the previous spring (Kulka *et al.* 2005b). About 25 weeks later, the next spring survey picks up the previous year's cohort as 1-years-olds. This pattern was most apparent when larger year classes were produced, such as in 1999. After 2000, biomass and abundance indices declined to low levels similar to those observed in 1996-1998.

Trends in mean weight (biomass/abundance) summed over Div. 3NO and Subdiv. 3Ps tended to fluctuate without pattern until the late 1980s, then declined in the early 1990s (Fig. 2a). An average fish weight of 2 kg in Div. 3NOPs in the 1970s and 1980s, dropped to about 1 kg in the mid1990s for Engel trawl surveys. For Div. 3NO in spring, average weight also fluctuated: peaking in the 1970s and the late 1980s. After Canadian surveys changed to Campelen gear in autumn 1995, average weights reached their lowest levels in 1999-2000 with the introduction of two substantial year classes to a small population of adults (Fig. 2a). The subsequent increase in average size related to growth of the 1998 and 1999 year-classes.

Relative abundance by life history stage more clearly describes the 1998 and 1999 year-classes: lengths <26 cm correspond to white hake in their first year, 27-57 cm represents age 2+ juveniles, and 58+ cm fish are primarily mature adults (see Kulka *et al.* 2005 for a detailed description of length at maturity). The 1999 year-class peaked in 2000; a subsequent increase and decline in the abundance of older juveniles then occurred, and finally an increase in adults was observed (particularly in Div. 3NO; Fig. 3). There was also a difference in the percent of different size classes in different areas, which were related to movement of life stages among areas (Fig. 3).Kulka *et al.* (2005a) fully describes the manner in which these three life stages migrate and distribute differently on the Grand Banks.

Figure 4 shows the trend in mean number per tow in the Canadian juvenile survey series, 1985-1994 (Table 3). However, this series is not spatially consistent and is therefore not considered to be a reliable index.

Available information on white hake numbers at length from Canadian Engel surveys are presented for 1988-1995 in Figure 5a, and relative abundance at length for 1997-2005 in Figure 5b-d. Modes averaging about 45 cm in 1988 and 1990, corresponding to 3-year-old fish (based on a preliminary sample of aged white hake, and similar to observations in the Gulf of St Lawrence by Hurlbut and Poirier 2001), suggest that significant recruitment occurred in 1985 and 1987. However, the strength of those year classes is unknown; except that they were larger than in surrounding years. There is no evidence of significant recruitment in subsequent years until 1998, when a 25-cm mode was observed in 1999 in the Campelen data (Fig. 5b-d).

The largest year class of white hake was produced in 1999, and was first detected by the IYGPT young-of-the-year survey in the summer of 1999 in Div. 3NO (Table 4). An estimated growth rate of about 2.5 cm per month (see Kulka *et al.* 2005a) corresponds to the dominant 25-cm mode of white hake seen in the following year's Canadian spring survey (Fig. 5e). Surveys by both countries tracked progression of this large 1999 year-class through 2001-2005. The EU-Spanish Div. 3NO survey also observed the remnants of this distinctive year-class in 2006; but the Canadian 2006 spring survey was inadequate to do so (as described previously). Average length of the majority of fish in both surveys increased through time: 34 cm in 2001, 43 cm in 2002, 48 cm in 2003, 54 cm in 2004, 58 cm in 2005, and 61 cm in 2006. In 2004, there was also a small peak of 15-26 cm white hake in Div. 3NO in both surveys.

Figure 6 tracks the average modal size (cm) of the 1999 year-class. Starting in September 1999, the pelagic young-of-the-year averaged 5 cm, growing rapidly to 36 cm by the spring of 2001, then growing at a slower rate thereafter. Tracking the mode of the 1999 year-class through time allowed for the first estimate of growth for white hake on the Grand Banks. A von Bertalanffy growth model was applied to the 1999 year-class by sex. Observed size at age was derived from mean length of the mode of the 1999 year-class in subsequent years. The observed points at less than one year of age are illustrated, but not included in the model. The results must be considered as preliminary, because the ages were not derived from otolith rings, but rather from the mean size of the 1999 mode through time. Values added in later years as the year-class ages could make a significant difference to the parameter estimates, in particular L_{inf}. It is expected that L_{inf} will increase in value as estimates of length at age of the 1999 year-class are added to the model in future years. Nonetheless, L_{inf} of 67 cm (males) and 86 cm (females) are lower than what was reported in other locations (Clay and Clay in the Gulf of St. Lawrence, Bundy on the Scotian Shelf, Sosebee on Georges Bank).

Following the growth of the distinctive 1999 year-class and as compared to growth estimates of Bundy *et al.* (2001), Grand Banks white hake appeared to be approximately the same size as those on the Scotian Shelf by age 5. However, Grand Banks hake seems to have a faster growth rate than Georges Bank hake between ages 1-3 (albeit achieving sizes similar to the latter hakes by age 4). Furthermore, Grand Bank females between ages 2-4 seem to grow faster than both sexes obtained from the commercial fishery in the southern Gulf of St. Lawrence, but showing similar sizes per sex by age 5 (using data from Clay and Clay, 1991). A caveat for this comparative discussion is that the Grand Banks estimates of size at age are based on a single (1999) year-class using modal progression; rather than age from otoliths. It is possible that growth rates may have varied in earlier years. Earlier survey data containing larger fish may suggest that either growth rate was higher in earlier years, or older age classes were present.

Recruits per spawner varied between 0.4 and 35 fish for each adult female in 1997-2004 (Fig. 7). Two significant values were observed in this time series: 13.5 fish in 1998, and 35 in 1999. The largest value in recent years is 1.6 in 2004. The dominant year class is also reflected in the stage-based analysis of abundance (Fig. 8). Until 2000, immature fish older than one year was the dominant component in the population. From 2001 to 2005, immature hake declined as a proportion of the total population, while adults increased to where the two components were almost equal; a result of the 1999 year-class fish reaching maturity.

In 2005, only 2% of the abundance of the dominant 1999 year-class estimated in 2000 remains (Fig. 9). An estimate of Z (total mortality) for the 1999 year-class is 0.7 for the period 2000-2005 (Fig. 10). It is expected that a similar estimate done over the entire population would be insignificantly different; given dominance of the 1999 year-class in the population from 2000 onwards. Thus, the current population is only a small fraction of its size as compared to 2000. Factors contributing to this drastic decline are high fishing mortality, particularly in 2002-2004, and very low recruitment since 1999.

The Fishery

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 7, Fig. 11). With the restriction of fishing by other countries to areas outside Canada's 200-mile-limit (Div. 3NO in the 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 (464 tons) but increased to 6 752 tons in 2002 and 4 841 tons in 2003; following recruitment of the large 1999 year-class. Catches declined to an average of 1 102 tons in 2004-2006.

Catches in Subdiv. 3Ps were less variable: 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 1 338 tons in 2004-2006.

Canada commenced a directed fishery for white hake in 1988 in Div. 3NO and Subdiv. 3Ps. All Canadian landings prior to 1988 were as bycatch in various groundfish fisheries. However, caution should be exercised with Canadian reported catches for hook and line gear from the mid1980s to the early 1990s, because the majority of these data may have represented Atlantic cod (*Gadus morhua*) reported as white hake. If so, the statistics for white hake during that period may be over-reported.

In Div. 3NO of the NAFO Regulatory Area, EU-Spain and EU-Portugal commenced a directed fishery in 2002, and Russia in 2003; resulting in the 2003-2004 peak. There were no directed fisheries by EU-Spain in 2004, or by EU-Spain, EU-Portugal, or Russia in 2005-2006. (Fig 11: lower panel, Fig. 12). In 2003-2004, 86% of the total reported catches of white hake in Div. 3NO and Subdiv. 3Ps were taken by other countries in the NRA. However, the majority of catches were usually taken by Canada within its 200-mile-limit prior to that period, and has increased to 93% in 2006; primarily due to an absence of a white hake-directed fishery by other countries in 2005-2006.

All non-Canadian reported catches are attributed to a directed fishery prosecuted with otter trawls. The Canadian fishery is more complex. Since 1989, the reported directed fishery employing otter trawls, longlines, and gillnets has contributed about 50% of the annual reported total Canadian catch: ranging from 30–70% (Fig. 13). Most white hake were taken in a mixed fishery directing for monkfish, skate, and hake (reported as "unspecified" fisheries), but were also taken as bycatch with Greenland halibut, Atlantic cod, and other commercial groundfish. In most years prior to 2004, the majority of Canadian catches of white hake were taken with longlines (Fig. 14). However, gillnet catches have increased since 2005. Trawls have rarely contributed a significant proportion to the total Canadian catch.

Non-Canadian catches of white hake in the NRA are reported throughout the year; while the Canadian fishery in Div. 3NOPs is seasonal (Fig.15). The majority of Canadian landings occur mainly in the latter half of each year; due to seasonal restrictions resulting from Atlantic cod bycatch problems, as opposed to white hake and monkfish availabilities. Gillnet catches usually peaked in August-September; whereas peaks in longline catches were more variable in timing among years, along with use being spread out over each year.

The non-Canadian (trawl) fishery for white hake occurred mainly at a very small location in the NRA, adjacent to Canada's 200-mile-limit along the western slope of the Grand Banks (González and del Río 2004), which corresponds to the highest concentration of white hake outside the 200-mile-limit. A comparison of the Canadian southwest slope mixed fishery grounds (2002-2006) with the distribution of white hake shows that fishing sets primarily occurred where the Canadian survey distribution predicted the highest concentrations to be (Fig. 16). Commercial logbook and Canadian Fisheries Observer data indicated that longlines are fished more frequently on the shelf edge in Div. 3O; whereas gillnet grounds straddled the border of Div. 3O and Subdiv. 3Ps after 1997. Kulka and Mowbray (1998) reported a similar pattern in earlier years.

Limited data on sizes of white hake taken in the commercial directed fisheries from 2001-2006 indicated that Canadian gillnets captured the smallest proportion of juveniles: usually <5% of the catch (Fig. 17a). Canadian longlines captured a greater proportion of juveniles: varying between 7 and 39 %, and usually <20% depending on location and year (Fig. 17b). The sample size for Canadian otter trawls was low, and the proportion of catch consisting of juveniles was highly variable: between 1 and 43% depending on location and period (Fig. 17c). Longline and otter trawl catches generally contained a larger range of sizes than did catches from gillnets (Fig. 17a-c). Non-Canadian (EU-Spain) otter trawl catches in the NRA showed a very different pattern: varying between 35 and 75% immature fish depending on year (Fig. 17d). This may be due to different trawl mesh sizes used, because locations fished by Canada and EU-Spain contain a similar mix of adults and juveniles.

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) fluctuated in the 1980s, then declined in the 1990s (Fig. 18). The index increased in 2002-2003, declined in 2004 then increased again in 2005. Canadian survey data were not available for 2006. Relative F was higher in Div. 3NO compared to Subdiv. 3Ps, particularly during 2002-2003. This was due primarily to new directed fisheries for white hake by EU-Spain, EU-Portugal, and Russia; coupled with very low recruitment after 1999.

CONCLUSIONS

Abundance and biomass of white hake in Div. 3NOPs have undergone wide fluctuations since the beginning of the Canadian stratified random surveys. Cyclic changes in the abundance of the population over time are the result of occasional large year classes (documented for the 1999 year-class), interspersed by years of very low recruitment. White hake are amongst the most fecund of marine fish, and are capable of producing very large year classes from very small SSB. For this highly fecund species, it appears that production and survival of large year classes are sporadic, and probably affected by environmental conditions; thereby leading to natural cycles of increase and decline in the population. Thus, environmental conditions appropriate to survival of early life stages may constitute the key to production of a good year class and eventual recovery of this stock.

One possible mechanism leading to good survival is near-surface ocean currents where eggs, larvae, and young-of-the-year exist for several months. These currents can concentrate the majority of those early life stages at a location where there could be high survival when the pelagic stage settles onto the bottom. The large 1998 and very large 1999 year-classes settled onto the shallow part of the Grand Banks, where bottom temperatures were warmest; similar concentrations at this location were not observed in years of low recruitment. When such conditions might recur is unknown; although Han and Kulka (2007) suggested that variation in ocean current strength and direction, location of release of white hake eggs, and depth of the particles (eggs, larvae, and young juveniles) in the water column can affect location where the young fish settle. In years when a larger proportion of juveniles settle onto the shallow part of the Grand Banks (nursery area), rather than being carried out beyond the shelf edge, leads to greater survival of young fish. In particular, interannual variability in strength of the Labrador Current may have profound impacts on the destination of the eggs, larvae, and pelagic juveniles. Reduced flow of the Labrador current in 1999 may have led to the observed settlement of large numbers of juveniles onto the shallow Grand Banks, and the subsequent large year-class.

From 2002 to 2005, the Div. 3NOPs population was stable at a low level; similar to what was observed in 1996-1998. There has been very low recruitment since 1999. In 2005, abundance was ~ 2% of that in 2000. It takes several years before a good year class reaches maturity and replenishes the adult component of a population; although white hake reach commercially harvestable sizes in less than three years. The very large 1999 year-class resulted in a sharp rise in abundance, with good survival through 2001. However, heavy fishing pressure in the NRA during 2002-2003 (unsustainable catches averaging 5 771 t), combined with very low recruitment, resulted in a drastic decline in this stock. Although a TAC for white hake in the NRA had been adopted by NAFO for the first time in 2004, it could only regulate fishing as of 2005 (i.e., after the 1999 year-class was already drastically reduced). **The quota set at 8 500 tons is far too large to be effective in recovering or sustaining this stock; particularly given the lack of significant recruitment over the past 8 years.** This quota exceeds the largest annual reported catch (8 129 t in 1985) in the time series. At best, once (if) good recruitment occurs, at least several years will be required before there are enough white hake on the Grand Banks to support more than a minor bycatch fishery.

Sources of Uncertainty

1) Stock structure of white hake is only now being examined and structure remains uncertain. Spatial analyses by Kulka *et al*. (2005a) suggest that the species in Div. 3LNOPs and possibly 3Pn and 4R form a single reproductive unit; with life stages moving among these areas as they mature. The differences in population trends among the Grand Banks and other areas in the northwestern Atlantic (Gulf of St. Lawrence, Scotian Shelf, Bay of Fundy, and Georges Banks) suggest different spawning units. Genetic research on the population structure of this species in Canadian Atlantic waters is ongoing, and preliminary results by late 2007 should help determine whether Div. 3NOPs white hakes comprise a single breeding population.

2) Catch rates and biological characteristics (i.e., length, sex, maturities since 1988) were recorded for only a portion of Canadian research surveys, and are reported only sporadically for any commercial fisheries. Sampling of the commercial fishery remains sparse, with only a small sample of length frequencies from recent years.

3) Fishery bycatch statistics from earlier years may be incomplete and inaccurate, particularly in early years. Given that white hake were often of less value than directed species, discarding could have resulted in biased landing statistics in early years. The issue of misreporting more valuable species as white hake in the 1980s remains unresolved. The majority of Canadian landings of white hake reported for hook and line gear from the mid1980s to the early 1990s may have actually represented valuable Atlantic cod. In addition, current catch records may not be adequate for separating landings of white hake originating from bycatch and those from a directed mixed fishery (skate, monkfish, hake). Furthermore, reported catches of white hake by non-Canadian fleets may not be accurate. It is possible that some fish caught in the NRA and reported as red hake were actually white hake.

4) A valuable source of information on recruitment, the annual Canadian IYGPT survey, has been eliminated since the year 2000.

5) There are still no age-based historical data. Research focusing on Grand Banks white hake, including the collection and synthesis of data required to conduct an age-based assessment, has commenced; but funding to determine ages of white hake otoliths collected during annual Canadian surveys in 1972-2006 is not yet forthcoming.

6) Canadian spring survey coverage was poor or unsampled in some areas in some years: particularly poor coverage occurred in 1971 – 3N, 3O, 3Ps; in 1972 and 1974 – 3O; in 1983 – 3N, 3O; and in 2006 – 3Ps, deepwater 3NO. In addition, biomass and abundance levels for 1996-2005 cannot be compared to those prior to autumn 1995; due to a change in survey gear from Engel to Campelen trawls, with no comparative length-based information available for

this species. As well, the Engel trawl used prior to autumn 1995 poorly sampled the smallest sizes of white hake; leaving unresolvable questions regarding recruitment and proportion of adults in this population over the long term.

Outlook

A sharp increase in white hake biomass and abundance in 2000, due to the moderate 1998 year-class and large 1999 year-class from small SSB, suggests that this highly fecund species is capable of producing large year classes from very small SSB when environmental conditions are optimal. However, recruitment has been very low since 1999 and the 1999 year-class, dominating the total population since 2000, now comprises only ~2% of the stock in 2005.

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 of larger year classes to maturity. The current TAC of 8 500 tons far exceeds that level. A quota for 2008-2010 of ~1000 t for Div. 3NOPs, which equals the average catch taken in 1995-2001 when the exploitable portion of this population was at low levels, may be necessary until good recruitment recurs and begins to rebuild this stock over the subsequent three years.

Acknowledgements

We would like to acknowledge the efforts of scientific and technical staff of the Department of Fisheries and Oceans Canada – Newfoundland & Labrador Region in the collection of numbers, weights, lengths, maturities, and otoliths of white hake over many years during various Canadian research surveys. We would also like to thank many Canadian Fisheries Observers who have estimated catches and measured white hake under difficult conditions aboard numerous commercial vessels. Lastly, we are very grateful to Fernando González and his colleagues at the Instituto Español de Oceanografía in Vigo (Spain) for providing us with data from their Spanish research surveys of Divisions 3NO in the NAFO Regulatory Area.

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Table 1a. Count of sets in the Engel and Campelen spring time series by year, depth interval and NAFO Division. Only standard sets used for STRAP are included.

	3L					3N					3O					3Ps					
Year	0-50	51-700	701-800	801+	Total	0-50	51-700	701-800	801+	Total	0-50	51-700	701-800	801+	Total	0-50	51-700	701-800	801+	Total	Total
1971		60			60		25			25											85
1972		38			38	1	44			45		1			1	1	43			44	128
1973		33			33	3	46			49		47			47	1	54			55	184
1974		74			74	1	36			37							81			81	192
1975		55			55	1	22			23		35			35		62			62	175
1976		64			64	2	30			32		46			46	3	114			117	259
1977		102			102	3	45			48		40			40	2	100			102	292
1978		95			95	7	79			86		89			89	1	105			106	376
1979		141			141	5	85			90		90			90	1	80			81	402
1980		115			115	4	77			81		59			59	4	77			81	336
1981		81			81	3	52			55		22			22	3	68			71	229
1982		103			103	4	57			61		77			77	5	87			92	333
1983																8	163			171	171
1984		37			37	3	58			61		57			57	8	87			95	250
1985		220	1		221	5	80			85		93			93	6	106			112	511
1986		211			211	9	92			101		102			102	7	138			145	559
1987		181			181	5	86			91		100			100	8	127			135	507
1988		160			160	5	72			77		84			84	11	141			152	473
1989		205			205	8	87			95		101			101	9	148			157	558
1990		156			156	7	80			87		93			93	4	105			109	445
1991		143			143	5	88			93		116			116	7	157			164	516
1992		177	1		178	4	121			125		91			91	9	138			147	541
1993		181			181	3	82			85		81			81	16	263			279	626
1994		152	2	6	160	5	65		5	77		77		2	81	8	162			172	490
1995		151			151	6	83			89		85			85	15	149			164	489
1996		188			188	8	74			82		88			88	7	141			148	506
1997		158			158	4	67			71		82			82	12	146			158	469
1998		162	1		163	5	83			88		93			93	14	163			177	521
1999	2	175			177	8	73		1	82		86			86	13	160		2	175	520
2000		134			134	5	84			89		83			83	14	157			171	477
2001	2	152			154	7	76			83		79			79	10	163			173	489
2002	2	143	1		146	6	80			86		79			79	15	162			177	488
2003		156			156	8	76			84		78			79	17	159			176	495
2004	2	148	1		151	8	71			79		79			79	18	159			177	486
2005		133			133	9	69			78	78	1		79	158	161			178	339	708
Total	8	4484	7	6	4505	167	2345	0	6	2520	78	2334	0	81	2496	418	4165	0	180	4765	14286

Table 1b. Count of sets in the Engel and Campelen spring time series by year, depth interval, and NAFO Division. The data used for species mapping, both standard and special sets, are included.

	3L					3N					3O					3Ps					
Year	0-50	51-700	701-800	801+	Total	0-50	51-700	701-800	801+	Total	0-50	51-700	701-800	801+	Total	0-50	51-700	701-800	801+	Total	Total
1971		63			63		42			42		8			8					0	113
1972		38			38	1	44			45		1			1	1	43			44	128
1973		33			33	3	46			49		47			47	1	54			55	184
1974		73			73	1	42			43					0		170			170	286
1975		55			55	1	22			23		35			35		62			62	175
1976		64			64	2	30			32		46			46	3	114			117	259
1977		102			102	3	45			48		40			40	2	100			102	292
1978		324	1		325	16	183			199		182			182	1	110			111	817
1979		278			278	5	85			90		122			122	1	80			81	571
1980		185		3	188	4	113			117		91			91	6	105			111	507
1981		142			142	3	53			56		68			68	3	103			106	372
1982		121		1	122	4	69			73		194		2	196	5	118			123	514
1983		225			225	1	18		1	20		83			83	8	187			195	523
1984		439	10	3	452	4	70	2		76		57			57	8	87			95	680
1985		442	1		443	6	113			119		110			110	6	106			112	784
1986		220			220	24	137			161		125			125	7	179			186	692
1987		407	1		408	6	89			95		155			155	8	127			135	793
1988		227			227	7	72			79		84			84	11	141			152	542
1989		237			237	11	88			99		101			101	9	148			157	594
1990		312	3		315	7	114			121		132			132	4	105			109	677
1991		236			236	5	129			134		132			132	7	157			164	666
1992		192	4	10	206	20	121			141		91			91	9	138			147	585
1993		255	10	16	281	3	129	1	1	134		109		1	110	16	263	2		281	806
1994		152	2	6	160	5	65	2	5	77	4	127	3	5	139	8	222	2	2	234	610
1995		160			160	6	83			89		95		2	97	15	352	1	1	369	715
1996		196			196	8	122			130		216		1	217	7	195	1	1	204	747
1997		161			161	4	67			71		90			90	12	200			212	534
1998		162	1		163	5	83			88		93			93	14	182			196	540
1999	2	199			201	8	73		1	82		86			86	13	160		2	175	544
2000		160			160	5	84			89		84			84	16	235			251	584
2001	5	202			207	7	76			83		85			85	10	164			174	549
2002	3	177	1		181	6	86			92		80			80	15	243			258	611
2003	3	189			192	8	76			84		78	1		79	17	159			176	531
2004	2	148	1		151	8	71			79		79			79	18	159			177	486
2005		133			133	9	69			78	78	1		79	158	161			178	339	708
Total	15	6709	35	39	6798	216	2809	5	8	3038	82	3127	4	90	3303	422	4968	6	184	5580	18719

Table 1c. Count of sets in the Engel and Campelen autumn time series by year, depth interval, and NAFO Division. Only standard sets used for STRAP are included.

	3L					3N					3O					3Ps					
Year	0-50	51-700	701-800	801+	Total	0-50	51-700	701-800	801+	Total	0-50	51-700	701-800	801+	Total	0-50	51-700	701-800	801+	Total	All
1971					0					0					0					0	0
1972					0					0					0					0	0
1973					0					0					0					0	0
1974					0					0					0					0	0
1975					0					0					0					0	0
1976					0					0					0					0	0
1977					0					0					0					0	0
1978		44			44		7			7					0					0	0
1979					0					0					0					0	51
1980					0					0					0					0	0
1981		99			99	2	71			73					0					0	0
1982		121			121					0					0					0	172
1983		126			126					0					0					0	121
1984		209			209					0					0					0	126
1985		231	1		232					0					0					0	209
1986		141	1		142					0					0					0	232
1987		165			165					0					0					0	142
1988		189			189					0					0					0	165
1989		174			174					0					0					0	189
1990		161			161	3	77			80		91			91					0	174
1991		219			219	3	64			67		83	1		84					0	332
1992		215			215	2	32			34		54			54					0	370
1993		153			153	5	65			70		75			75					0	303
1994		199	1		200	3	72			75		75			75					0	298
1995		177	1	4	182	9	87			96		80	1		81					0	350
1996		180		31	211	13	70		1	84		61			61					0	359
1997	2	172	3	28	205	9	90	1		100		81			81					0	356
1998	2	171	4	27	204	11	90		21	122		84	2	10	96					0	386
1999		142	3	25	170	6	62			68		75			75					0	422
2000	2	144		30	176	6	64	2	22	94		76	2	22	100					0	313
2001	2	172	2	29	205	7	63	1	23	94		74	1	22	97					0	370
2002	2	174	1	29	206	6	64		24	94		75	3	21	99					0	396
2003	2	172	4	27	205	5	64	1		70		75	2	6	83					0	399
2004	1	142			143	6	61			67					0					0	358
2005		125		7	132	10	73	1	16	100	75	2	22	99	198					0	210
Total	13	4217	21	237	4488	106	1176	6	107	1395	75	1061	34	180	1350	0	0	0	0	0	6803

Table 1d. Count of sets in the Engel and Campelen autumn time series by year, depth interval, and NAFO Division. The data used for species mapping, both standard and special sets, are included.

Year	3L					3N					3O					3Ps					All
	0-50	51-700	701-800	801+	Total	0-50	51-700	701-800	801+	Total	0-50	51-700	701-800	801+	Total	0-50	51-700	701-800	801+	Total	
1971		36			36	2	8			10		6			6					0	0
1972		12			12	6	30			36		2			2		2			2	52
1973		9			9					0					0		32			32	52
1974					0					0					0		29			29	41
1975		4			4					0					0					0	29
1976		55			55		3			3					0		10			10	4
1977		48			48		11			11		25			25		64			64	68
1978		44			44		7			7					0	1	119			120	148
1979	2	114	1		117		12			12		3			3	2	89			91	171
1980		41			41					0					0					0	223
1981	1	183	1		185	2	114			116		25			25					0	41
1982		135			135					0		4			4		2			2	326
1983		145			145					0					0					0	141
1984		209			209					0					0					0	145
1985		464	1		465		70			70					0					0	209
1986		355	3	3	361					0					0					0	535
1987		165			165					0					0	1	47			48	361
1988		206			206	12	8			20					0	11	141			152	213
1989		214			214		24			24		56			56	9	148			157	378
1990		248			248	3	93			96		91			91	4	105			109	451
1991		284			284	3	64			67		83	1		84	7	157			164	544
1992		295			295	2	33			35		54			54	9	138			147	599
1993		199	1	1	201	5	65			70		75			75	8	133	1		142	531
1994		293	1		294	3	72			75		85			85					0	488
1995		371	22	33	426	9	95			104		152	1		153		28			28	454
1996		201	1	36	238	13	124		1	138		91			91		100			100	711
1997	2	172	3	28	205	9	90	1		100		81			81					0	567
1998	2	171	4	28	205	11	90		21	122		84	2	10	96					0	386
1999		142	3	25	170	6	62			68		75			75					0	423
2000	2	144		30	176	6	64	2	22	94		76	2	22	100					0	313
2001	2	172	2	29	205	7	63	1	23	94		74	1	22	97					0	370
2002	2	174	1	29	206	6	64		24	94		75	3	21	99					0	396
2003	2	172	4	27	205	5	64	1		70		75	2	6	83					0	399
2004	1	142			143	6	61			67					0					0	358
Total	16	5619	48	269	5952	116	1391	5	91	1603	0	1292	12	81	1385	52	1344	1	0	1397	10127

Table 2a. Count of sets containing white hake by seasonal research vessel survey. Data include non-standard sets used for species mapping.

Spring	0-50	51-700	701-800	801+	Total
1971		2			2
1972		23			23
1973		22			22
1974		114			114
1975		40			40
1976		81			81
1977		84			84
1978		146			146
1979		68			68
1980		78			78
1981		95			95
1982		95			95
1983		112			112
1984		43			43
1985		70			70
1986		98			98
1987		78			78
1988		51			51
1989		20			20
1990		16			16
1991		34			34
1992	2	23			25
1993		81			81
1994		119	1		120
1995		171			171
1996		131			131
1997		113			113
1998		73			73
1999		85			85
2000		143			143
2001		102			102
2002		152			152
2003		86	1		87
2004		91			91
Total	2	2740	2		2744

Autumn	0-50	51-700	701-800	801+	Total
1971		6			6
1972					
1973		23			23
1974					
1975					
1976					
1977		50			50
1978		54			54
1979		29			29
1980					
1981	1	19			20
1982		2			2
1983					
1984					
1985					
1986					
1987		12			12
1988		61			61
1989		79			79
1990		53			53
1991		66			66
1992		64			64
1993		72			72
1994		22			22
1995	1	78			79
1996	1	67			68
1997	1	22			23
1998	1	28		1	30
1999		54			54
2000	2	49			51
2001	1	51			52
2002	1	44			45
2003	2	43	1		46
2004					
Total	11	1048	1	1	1061

Table 2b. Proportion of total sets with white hake and average catch rate of white hake by depth.

Depth (m)	Sets with White hake	Total sets	Percent with White hake	# White hake per tow	Season
< 51	11	184	6.21%	0.342	autumn
< 51	2	487	0.46%	0.004	spring
51-700	1048	9646	11.24%	1.530	autumn
51-700	2740	17457	16.51%	2.345	spring
>700	1	507	1.77%	0.002	autumn
>700	2	110	0.39%	0.045	spring

Table 3. Count of sets in the Canadian juvenile survey series by month and NAFO Division. Avg. num refers to Average number of white hake captured per standard tow.

	3L						3N						3O													
	August		September		October		August		September		October		August		September		October		3L		3N		3O		All areas	
Year	Set Count	Avg num	Set Count	Avg num	Set Count	Avg num	Set Count	Avg num	Set Count	Avg num	Set Count	Avg num	Set Count	Avg num	Set Count	Avg num	Set Coun	Avg num	Set Count	Avg num	Set Count	Avg num	Set Count	Avg num	Set Count	Avg num
1985	9	0.00	18	0.00					47	0.02					4	0.00			27	0.00	47	0.02	4	0.00	78	0.01
1986	19	0.00					23	0.00	42	0.02			7	0.00	24	1.83			19	0.00	65	0.02	31	1.42	115	0.39
1987											47	0.06					2	0.00			47	0.06	2	0.00	49	0.06
1988	21	0.00	9	0.00			20	0.00	53	0.04			5	0.00	36	0.28			30	0.00	73	0.03	41	0.24	144	0.08
1989	5	0.00	79	0.00			62	0.03	27	0.30			16	0.00	44	7.80			84	0.00	89	0.11	60	5.72	233	1.52
1990			51	0.02			71	0.03	19	0.00			9	0.00	52	1.02			51	0.02	90	0.02	61	0.87	202	0.28
1991			71	0.00			49	0.00	29	1.45			3	0.00	68	4.72			71	0.00	78	0.54	71	4.52	220	1.65
1992			125	0.00			55	1.09	15	0.00			22	0.09	42	4.10			125	0.00	70	0.86	64	2.72	259	0.90
1993			127	0.00					77	0.00			57	5.26	8	1.38			127	0.00	77	0.00	65	4.78	269	1.16
1994			18	0.00	78	0.00			63	0.22					47	4.30			96	0.00	63	0.22	47	4.30	206	1.05
	54	0.00	498	0.00	78	0.00	280	0.23	372	0.18	47	0.06	119	2.54	325	3.56	2	0.00	630	0.00	699	0.19	446	3.27	1775	0.90

Table 4. Number of sets, average number of young-of-the-year white hake per set, and average weight of fish per set taken in IYGPT trawls, 1996-2000. Average trawl depth was 30 m below the surface.

Year	# of Sets	Average Number per set	Average Weight (kg)
1996	125	0	0.000
	7	1	0.010
	4	2	0.010
	1	3	0.010
	2	5	0.010
	1	11	0.010
	1	12	0.010
	1	18	0.010
	1	23	0.010
Total	**143**	**0.64**	**0.001**
1997	133	0	0.000
	2	1	0.010
	1	2	0.030
Total	**136**	**0.03**	**0.000**
1998	107	0	0.000
	5	1	0.014
	2	2	0.025
	1	3	0.010
Total	**115**	**0.10**	**0.001**
1999	95	0	0.000
	6	1	0.010
	2	2	0.005
	3	3	0.010
	1	5	0.010
	1	14	0.030
	1	16	0.030
	1	17	0.030
	1	21	0.020
	1	54	0.140
	1	91	0.230
	1	277	0.610
	1	465	0.790
Total	**115**	**8.51**	**0.017**
2000	24	0	0.000

Table 5. Biomass, abundance and mean weight of white hake from Spring research vessel surveys, 1971-2006. Surveys were conducted with an Engel trawl (1971-Autumn 1995) and Campelen trawl (Spring 1996-2006). Spring surveys: NAFO Subdiv. 3Ps was not surveyed in 1971, 2006; NAFO Div. 3O was not surveyed in 1972, 1974, 1983; and NAFO Div. 3N was not surveyed in 1983.

Canadian research vessel Spring surveys															
	Biomass (tonnes)					Abundance (thousands)					Mean weight (kg)				
Year	3N	3O	3Ps	3NO	3NOPs	3N	3O	3Ps	3NO	3NOPs	3N	3O	3Ps	3NO	3NOPs
Engel series															
1971	0	0		0		0	0		0						
1972	354		2,707	354	3,061	61		1,556	61	1,617	5.80		1.74	5.80	1.89
1973	36	1,532	465	1,568	2,033	11	327	247	338	585	3.25	4.69	1.88	4.64	3.47
1974	0		5,051	0	5,051	0		2,055	0	2,055			2.46		2.46
1975	0	3,173	4,499	3,173	7,672	0	1,080	2,646	1,080	3,726		2.94	1.70	2.94	2.06
1976	110	5,623	4,783	5,733	10,516	32	1,413	3,856	1,445	5,301	3.43	3.98	1.24	3.97	1.98
1977	50	1,339	7,084	1,389	8,473	43	466	3,935	509	4,444	1.17	2.87	1.80	2.73	1.91
1978	0	6,188	6,754	6,188	12,942	0	4,362	4,058	4,362	8,420		1.42	1.66	1.42	1.54
1979	165	1,978	6,310	2,143	8,114	34	1,065	3,078	1,099	4,177	4.85	1.86	2.05	1.95	1.94
1980	0	1,385	3,968	1,385	5,353	0	1,015	2,053	1,015	3,068		1.36	1.93	1.36	1.74
1981	139	96	7,448	234	7,682	29	93	4,743	122	4,865	4.78	1.03	1.57	1.92	1.58
1982	0	1,058	4,356	1,058	5,415	0	400	1,340	400	1,740		2.65	3.25	2.65	3.11
1983			2,545		2,545			1,508		1,508			1.69		1.69
1984	258	3,531	2,559	3,789	6,349	57	1,085	1,179	1,142	2,321	4.53	3.25	2.17	3.32	2.74
1985	46	2,878	5,303	2,924	8,227	9	1,315	3,045	1,324	4,369	5.16	2.19	1.74	2.21	1.88
1986	356	2,438	11,105	2,794	13,899	70	574	4,186	644	4,830	5.09	4.25	2.65	4.34	2.88
1987	44	2,752	9,866	2,796	12,662	95	1,114	4,438	1,209	5,647	0.46	2.47	2.22	2.31	2.24
1988	32	5,432	13,005	5,464	18,469	63	690	5,533	753	6,286	0.51	7.87	2.35	7.26	2.94
1989	0	925	6,884	925	7,809	0	251	4,130	251	4,381		3.69	1.67	3.69	1.78
1990	0	754	3,988	754	4,742	0	236	2,941	236	3,177		3.19	1.36	3.19	1.49
1991	0	1,039	4,591	1,039	5,630	0	1,118	3,800	1,118	4,918		0.93	1.21	0.93	1.14
1992	0	606	3,008	606	3,614	0	574	2,699	574	3,273		1.06	1.11	1.06	1.10
1993	0	522	2,731	522	3,253	0	301	2,559	301	2,860		1.73	1.07	1.73	1.14
1994	0	1,079	2,433	1,079	3,512	0	886	2,274	886	3,160		1.22	1.07	1.22	1.11
1995	0	334	2,334	334	2,668	0	189	2,104	189	2,293		1.77	1.11	1.77	1.16
Campelen series															
1996	4	2,020	6,282	2,024	8,306	75	2,982	8,089	3,057	11,146	0.05	0.68	0.78	0.66	0.75
1997	4	2,221	8,507	2,225	10,732	91	2,987	12,432	3,078	15,510	0.04	0.74	0.68	0.72	0.69
1998	7	2,205	4,007	2,212	6,219	79	2,249	4,765	2,328	7,093	0.09	0.98	0.84	0.95	0.88
1999	20	12,194	8,236	12,214	20,450	29	26,010	8,654	26,039	34,693	0.69	0.47	0.95	0.47	0.59
2000	30	15,900	10,294	15,930	26,164	716	104,360	11,743	105,076	116,819	0.04	0.15	0.88	0.15	0.22
2001	269	14,908	8,092	15,177	23,269	517	39,384	13,792	39,901	53,693	0.52	0.38	0.59	0.38	0.43
2002	96	10,808	10,118	10,904	21,022	105	11,334	15,098	11,439	26,537	0.91	0.95	0.67	0.95	0.79
2003	234	7,981	5,762	8,215	13,977	176	7,250	6,904	7,426	14,330	1.33	1.10	0.83	1.11	0.98
2004	33	10,369	6,622	10,402	17,024	53	8,477	6,977	8,530	15,507	0.62	1.22	0.95	1.22	1.10
2005	20	5,932	213	5,952	6,165	36	9,725	541	9,761	10,302	0.56	0.61	0.39	0.61	0.60
2006	247	12,267		12,514		69	10,370		10,438		3.60	1.18		1.20	

Table 6. Comparison of von Bertalanffy growth parameters among four areas in Canadian waters.

Sex	Source	L_{inf}	k	t_o	Size at age 5
male	southern Gulf, research – based on 1980-89 September surveys (Clay and Clay, 1991).	120.8	0.08	-1.64	51.6
female	southern Gulf, research – based on 1980-89 September surveys (Clay and Clay, 1991).	454.36	0.02	-1.55	55.8
male	southern Gulf, commercial – based on 1986-89 mean length at age (ages 3-10 years; Clay and Clay, 1991).	84.02	0.22	0.13	55.0
female	southern Gulf, commercial – based on 1986-89 mean length at age (ages 2-16 years; Clay and Clay, 1991).	136.63	0.11	-0.28	58.5
combined sexes	eastern Scotian Shelf, commercial – based on pooled data from 1998-2000; only used fish $\geq$49 cm (ages 4^+ years; Bundy *et al.* 2001).	142.4	0.09	-1.50	61.0
combined sexes	western Scotian Shelf, commercial – based on pooled data from 1998-2000; only used fish $\geq$49 cm (ages 4^+ years; Bundy *et al.* 2001).	169.6	0.06	-1.50	55.5
male	Grand Banks, survey – based on the 1999 year class average length in 2000 to 2004 (ages 1 to 5; this study)	67.1	0.32	-0.38	54.1
female	Grand Banks, survey – based on the 1999 year class average length in 2000 to 2004 ages 1 to 5; (this study)	85.7	0.25	-0.34	61.6

Table 7. Reported catches of white hake by NAFO Division and country (Canada versus other countries), 1985-2006.

	3N			3O			3NO		3Ps	3NOPs
Year	Can	non-Can	All	Can	non-Can	All	STATLANT-21A All	STACFIS All	STATLANT-21A Can	STACFIS Can + non Can
1985	101	1,542	1,643	3,301	3,185	6,486	8,129	8,129	1,156	9,408
1986	297	21	318	1,980	1,252	3,232	3,550	3,550	1,242	4,954
1987	1,314	4,019	5,333	1,740	990	2,730	8,064	8,064	1,318	9,392
1988	828	867	1,695	1,115	111	1,226	2,921	2,921	695	3,678
1989	878	5	883	1,169	23	1,192	2,075	2,075	709	2,859
1990	830	228	1,058	1,226	7	1,233	2,291	2,291	1,441	3,898
1991	19	1,507	1,526	1,087	0	1,087	2,613	2,613	1,480	4,231
1992	18	0	18	1,640	0	1,640	1,658	1,658	1,244	2,924
1993	19	0	19	1,035	0	1,035	1,054	1,054	741	1,802
1994	16	20	36	1,977	4	1,981	2,017	2,017	382	4,118
1995	0	5	5	216	1	217	222	222	420	652
1996	0	28	28	490	1	491	519	519	362	883
1997	0	92	92	489	6	495	587	587	315	905
1998	0	81	81	133	8	141	222	222	562	790
1999	44	51	95	314	13	327	422	422	575	1,004
2000	21	124	145	404	29	433	567	578	1,110	1,700
2001	16	52	68	516	49	565	633	633	930	1,585
2002	0	1,220	1,220	1,013	3,133	4,146	4,788	6,718	918	7,670
2003	0	2,688	2,688	433	3,053	3,486	6,158	4,823	1,108	5,949
2004	0	170	170	341	148	489	1,869	1,267	1,094	2,524
2005	0	3	3	710	177	887	931	878	1,395	2,421
2006	0	4	4	830	160	990	1,205	1,066	1,244	2,377

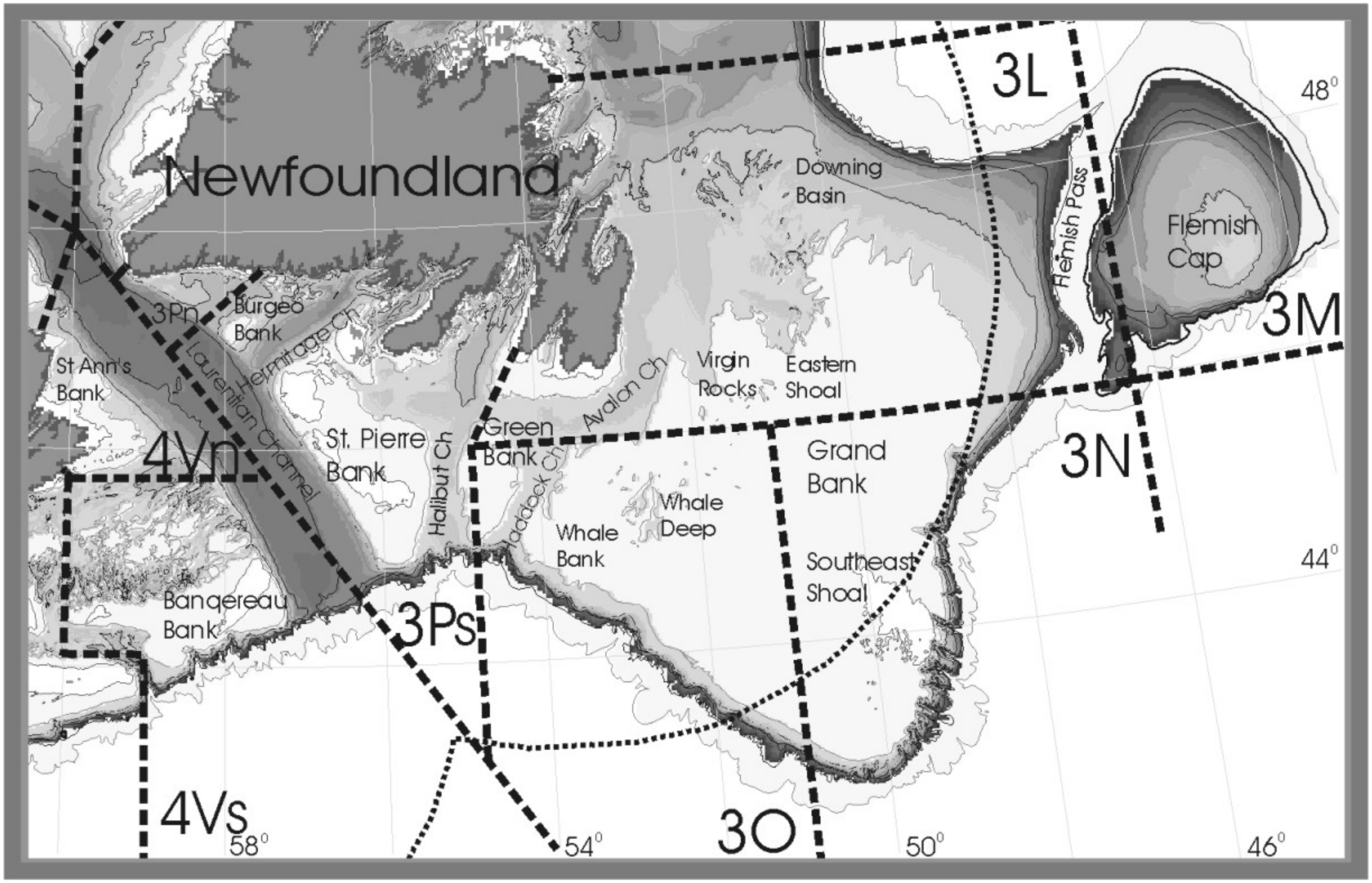


Figure 1. Map of the Grand Banks showing various banks, basins, and NAFO Divisions. Thick dotted lines delineate NAFO Divisions. The thin dotted curved line shows Canada's 200-mile-limit: delineating Canadian territory from the NAFO Regulatory Area.

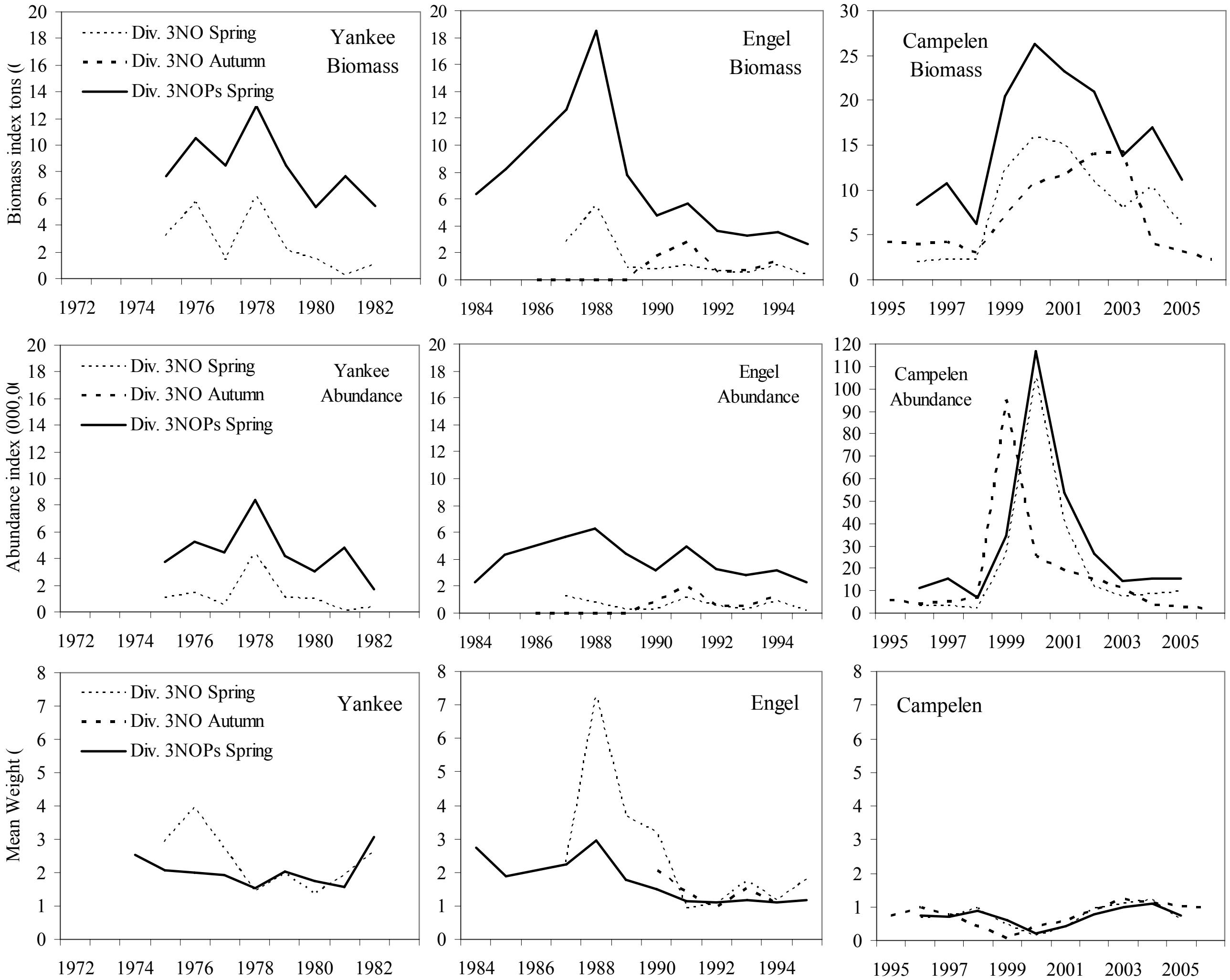


Figure 2a. Canadian spring and autumn research survey biomass and abundance indices, and average weights for white hake in NAFO Divisions 3N, 3O, and Subdivision 3Ps, 1972-2006. Both time series are unstandardized. See Table 1 for an inventory of areas not surveyed.

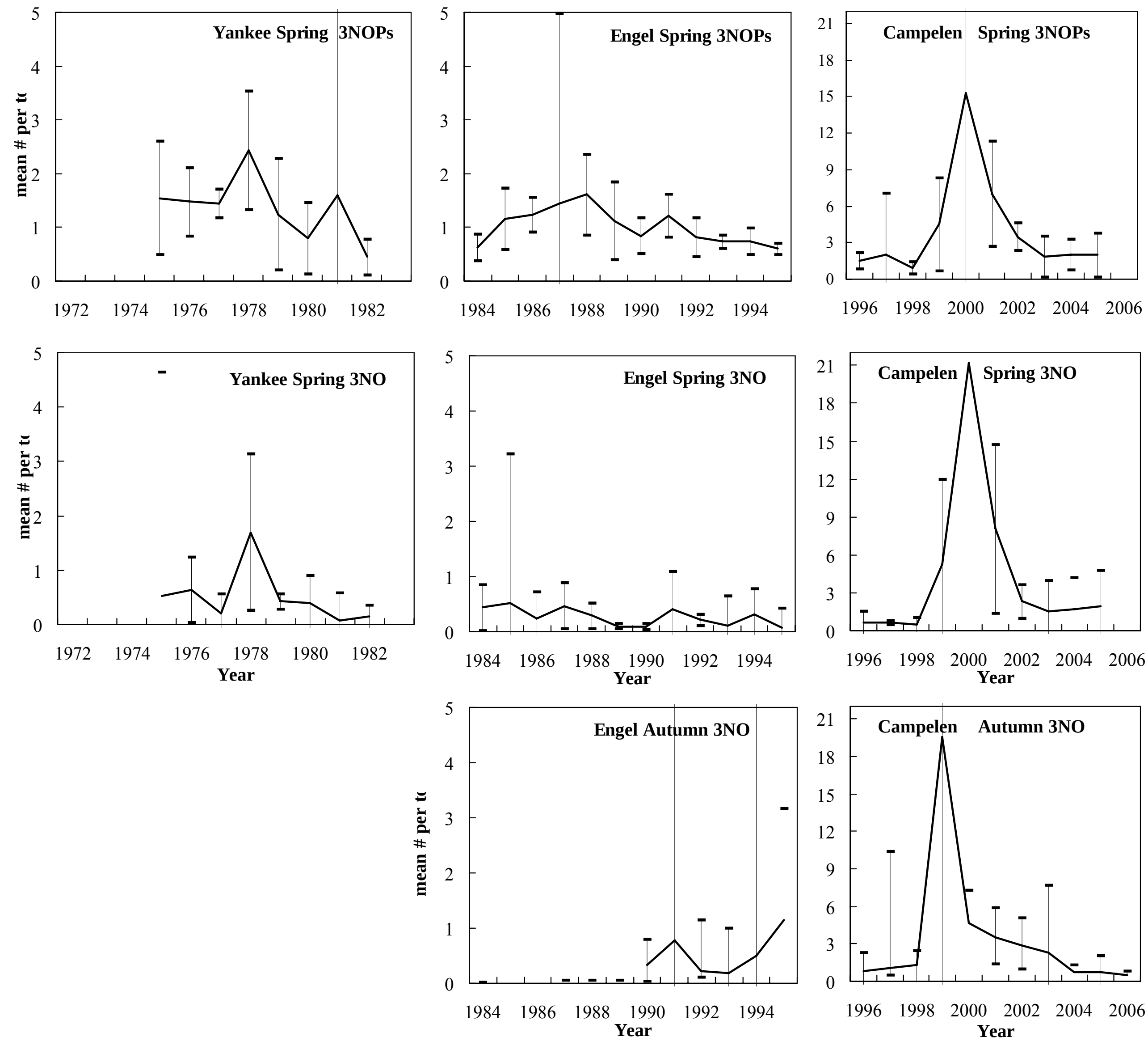


Figure 2b. Mean numbers per tow of white hake from Canadian spring and autumn research surveys in NAFO Divisions 3N, 3O, and Subdivision 3Ps (except in autumn), 1972-2006. Both time series are unstandardized. See Table 1 for an inventory of areas not surveyed.

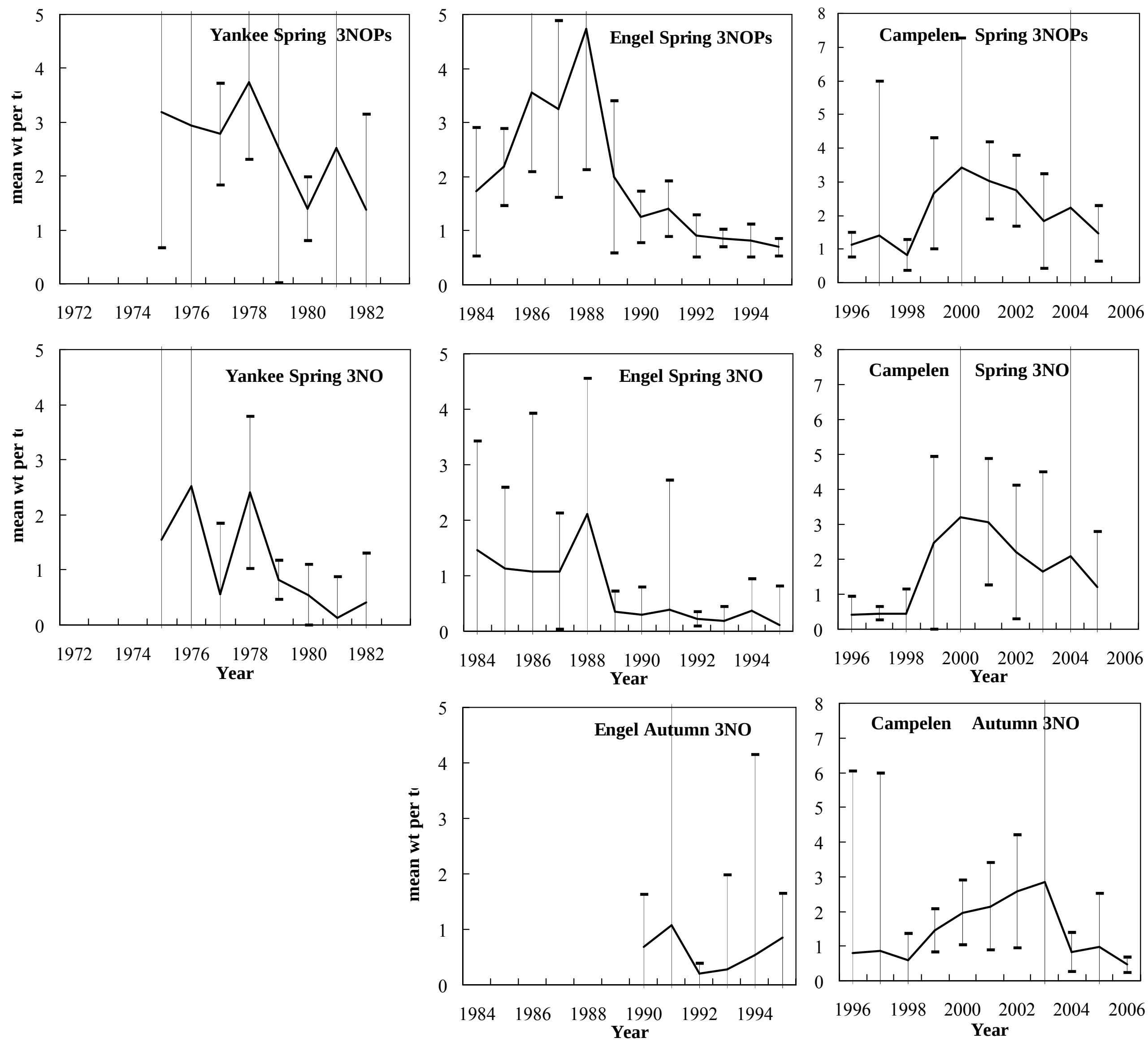


Figure 2c. Mean weight per tow of white hake from Canadian spring and autumn research surveys in NAFO Divisions 3N, 3O, and Subdivision 3Ps (except in autumn), 1972-2006. Both time series are unstandardized. See Table 1 for an inventory of areas not surveyed.

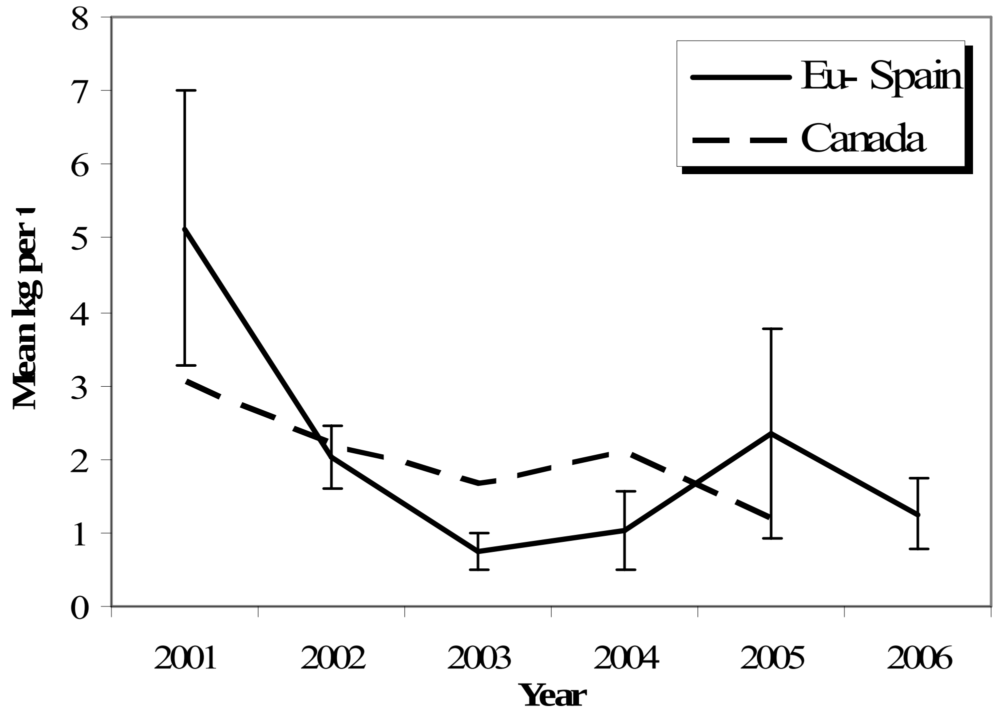


Figure 2d. White hake biomass indices in Div. 3NO: Mean weights per tow from Spanish Campelen surveys in June of 2001-2006 in the NRA of Div. 3NO; compared to Canadian spring survey indices in all of Div. 3NO. Error bars represent ± S.D.

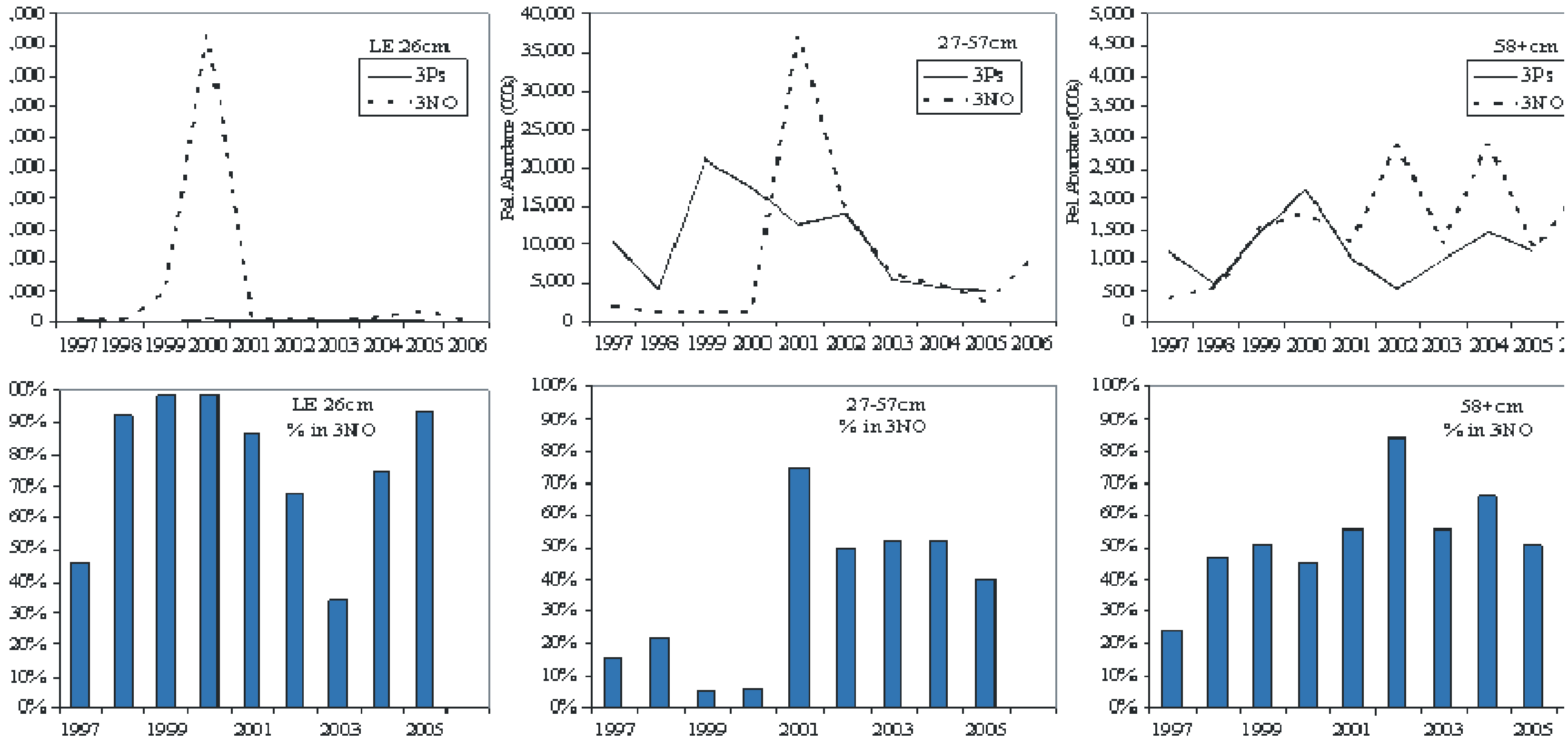


Figure 3. Relative abundance of white hake by life stage, 1997-2006: Less than or Equal to 26 cm is mainly year class-1; 27-57 cm contains mainly juveniles; and 58+ cm is mainly mature fish. Upper panel: Relative abundance (000s). Lower panel: Percent overall abundance in NAFO Divisions 3NO.

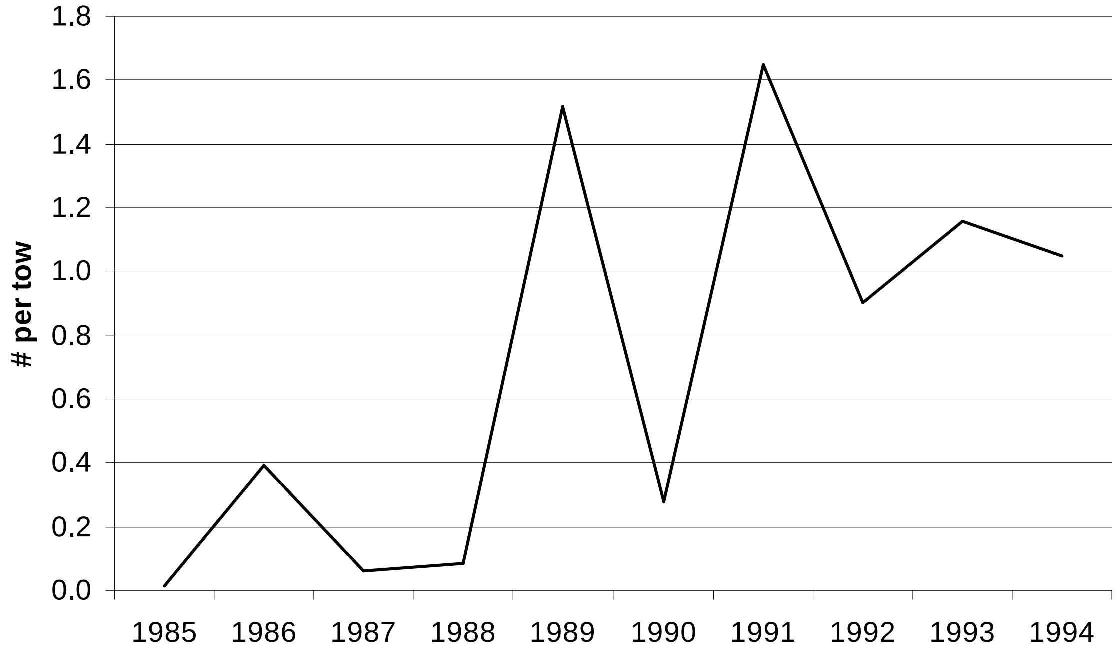


Figure 4. Canadian juvenile research survey in 1985-1994: numbers per tow. This survey series was not spatially consistent.

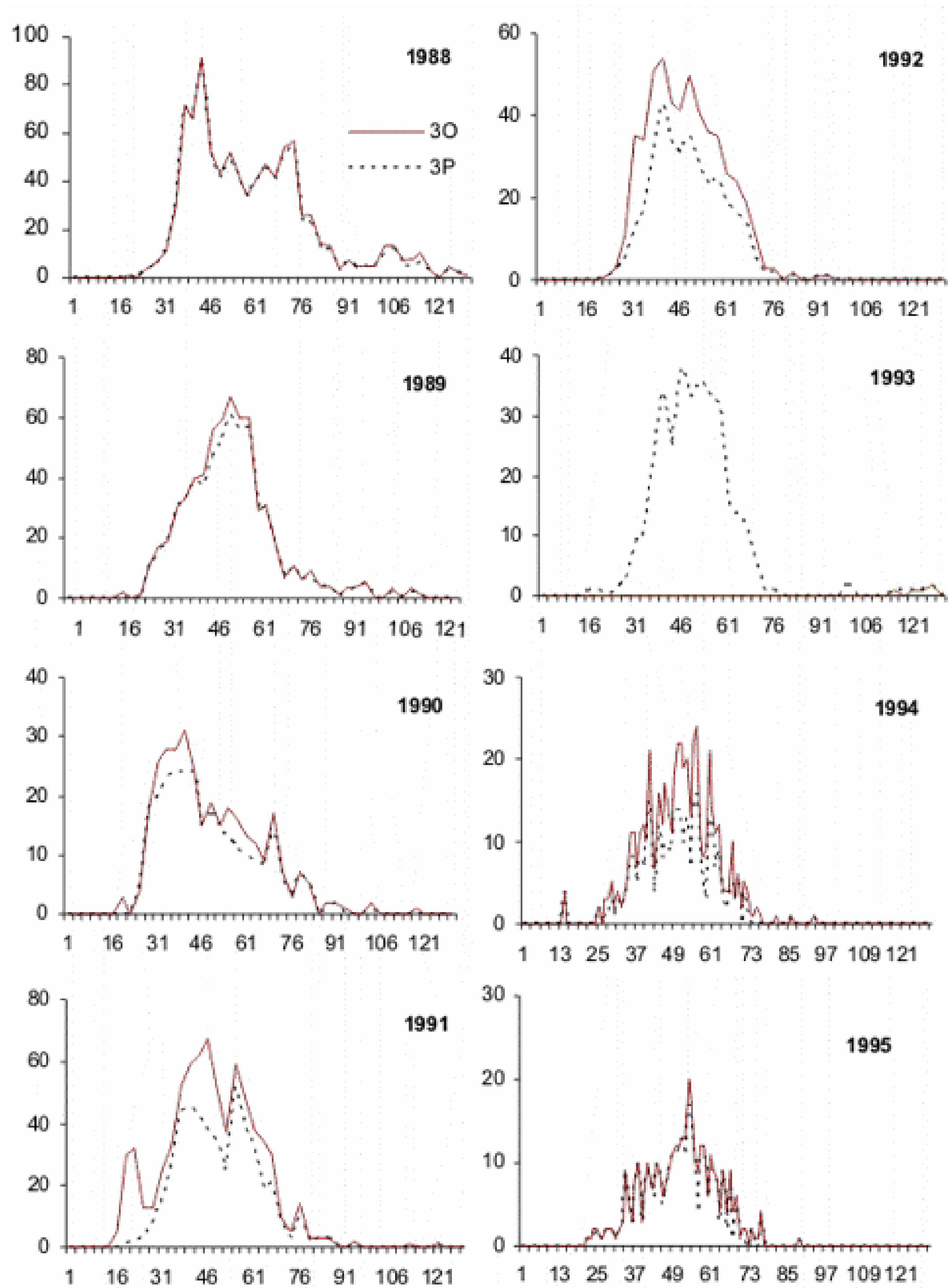


Figure 5a. Number of white hake at length (in cm on X-axis) from Canadian spring research surveys in NAFO Div. 3O and Subdiv. 3Ps, 1988-1995.

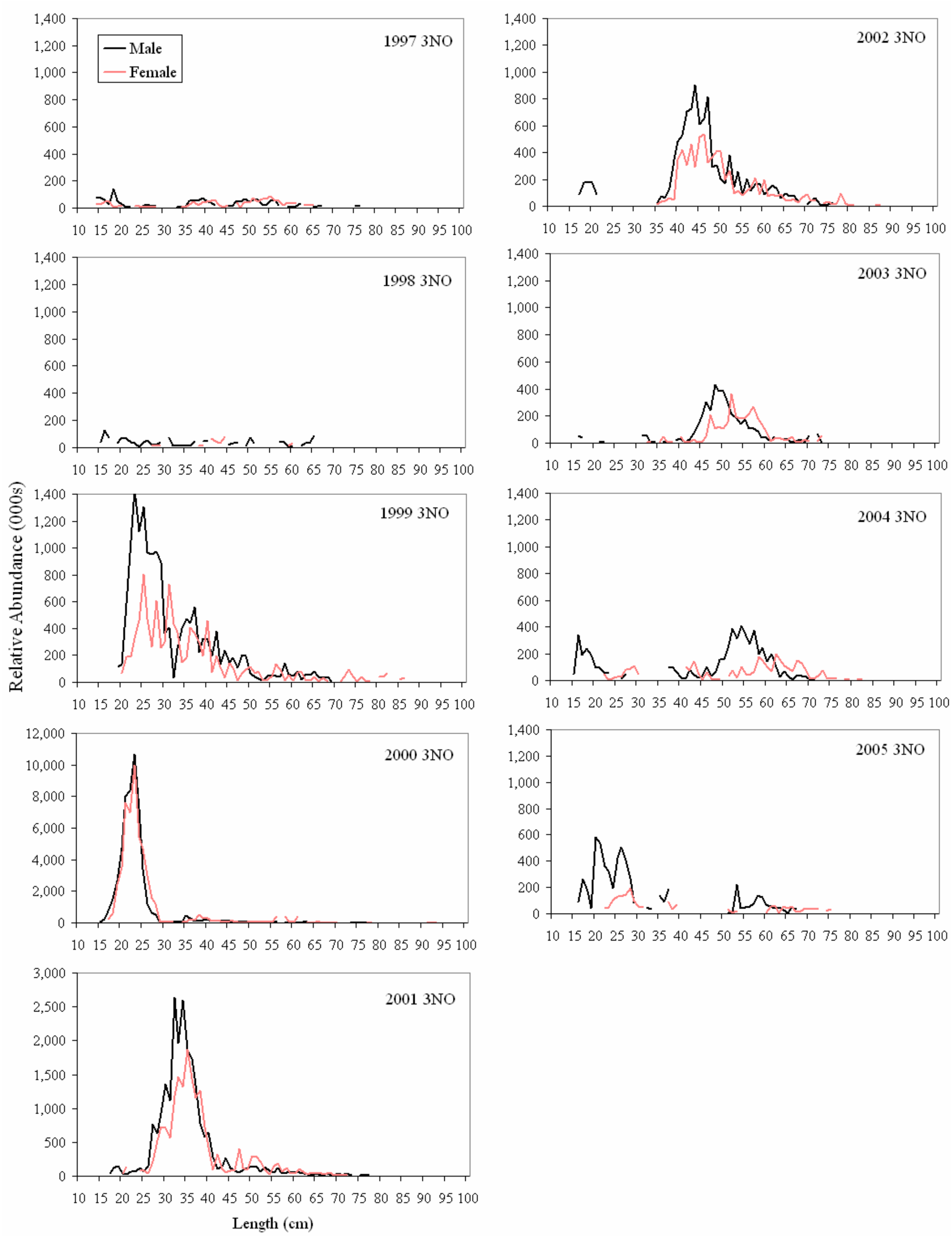


Figure 5b. Relative abundance at length of male and female white hake from Canadian spring research surveys in NAFO Div. 3NO, 1997-2006.

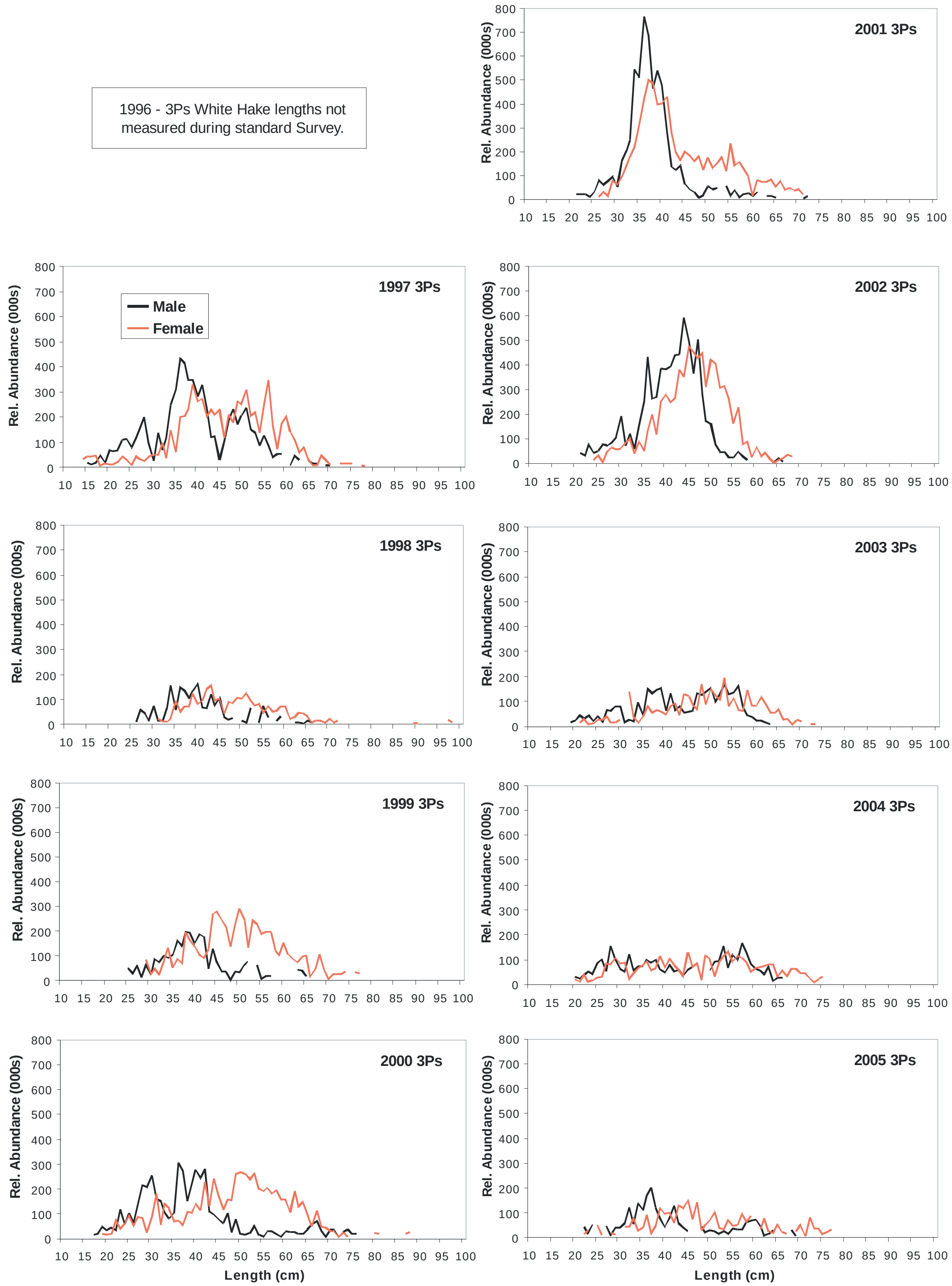


Figure 5c. Relative abundance at length of male and female white hake from Canadian spring research surveys in NAFO Subdivision 3Ps, 1997-2005. Note that Subdiv. 3Ps was not surveyed in 2006; due to Canadian research vessels' mechanical difficulties.

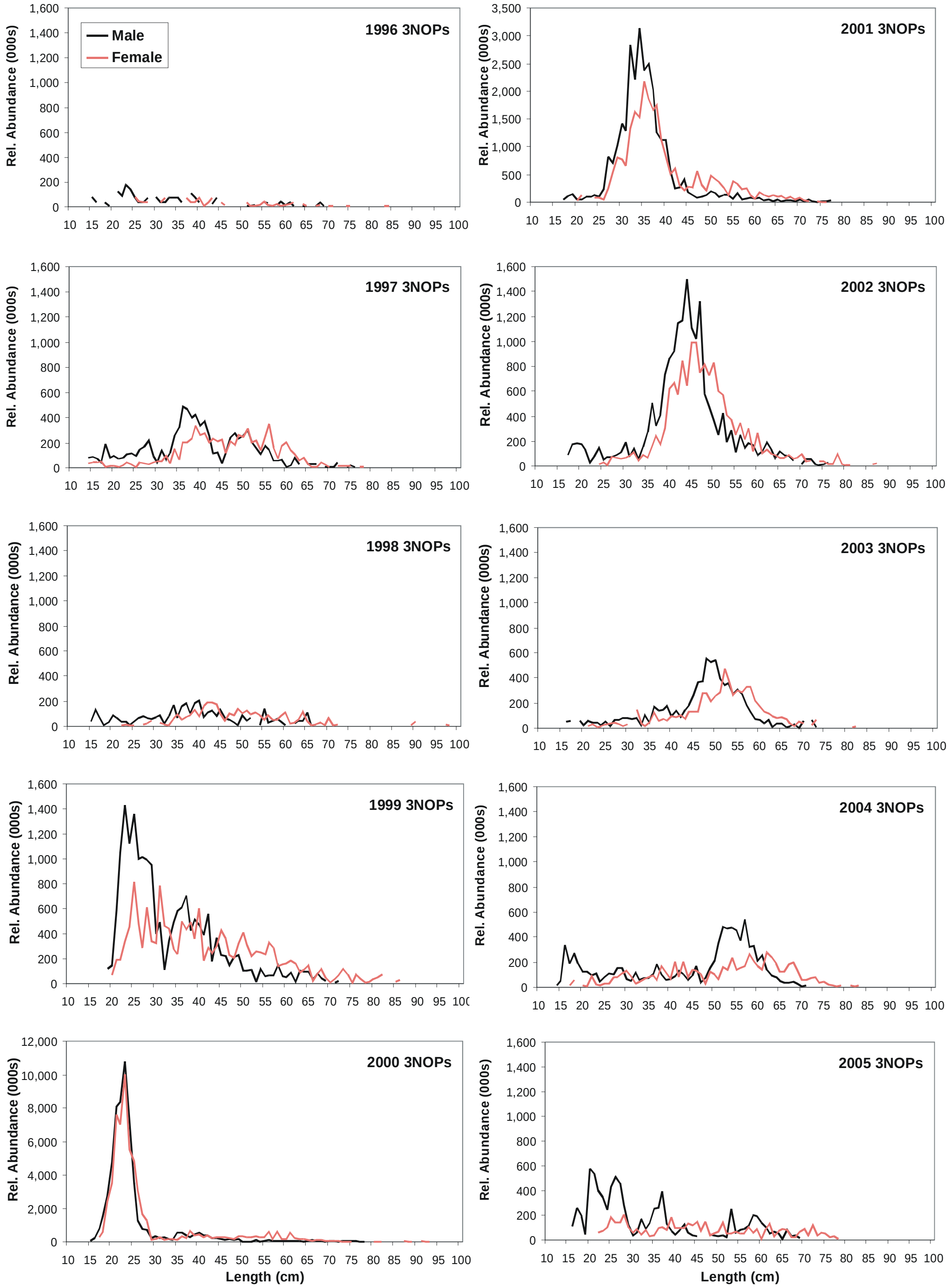


Figure 5d. Relative abundance at length of male and female white hake from Canadian spring research surveys in NAFO Div. 3NO and Subdivision 3Ps, 1996-2005. Note that Subdiv. 3Ps was not surveyed in 2006; due to Canadian research vessels' mechanical difficulties.

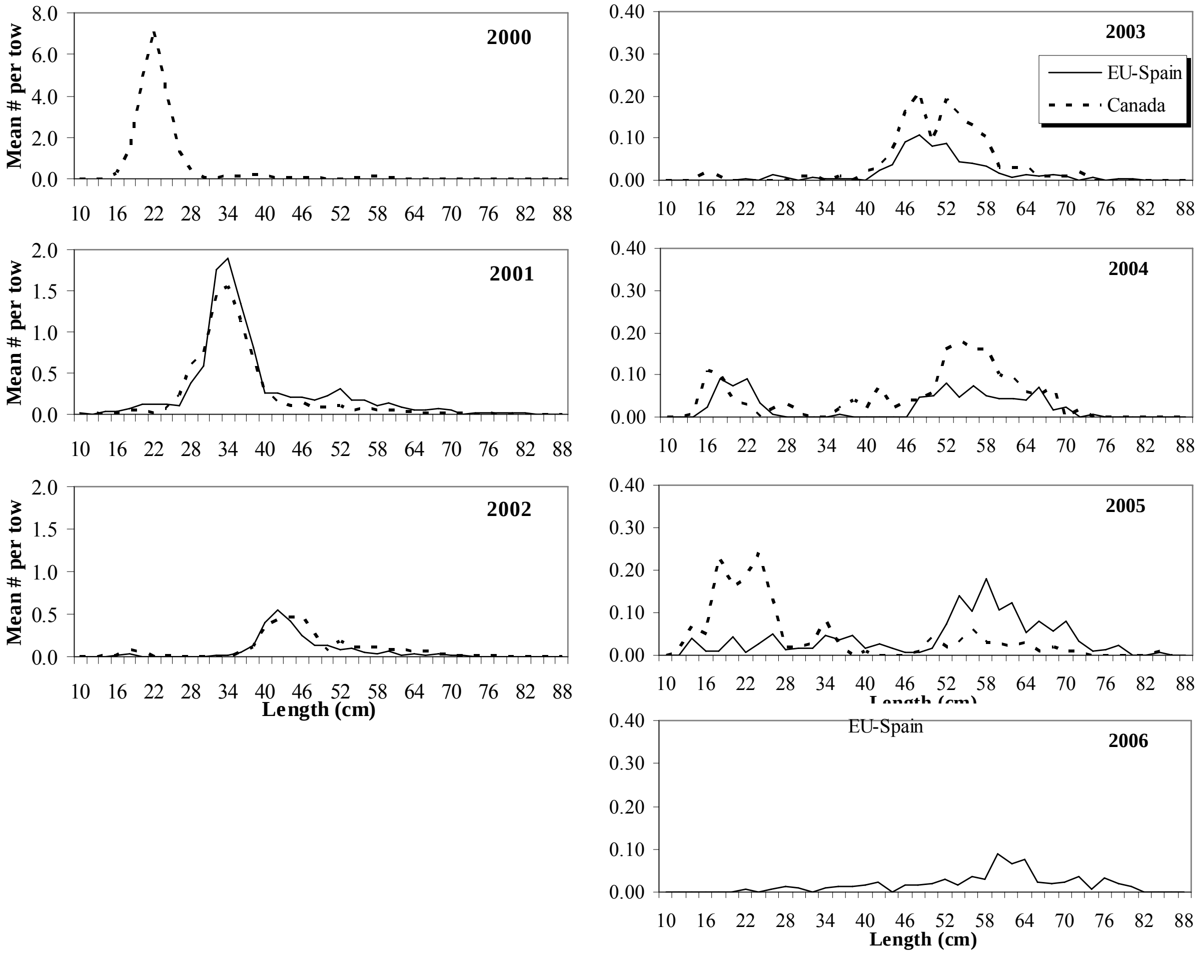


Figure 5e. Abundance at length from Canadian Campelen and Spanish Campelen spring research surveys in NAFO Div. 3NO (outside Canada's 200-mile-limit for Spanish surveys), 2000-2006. Number per tow was calculated using mean catches.

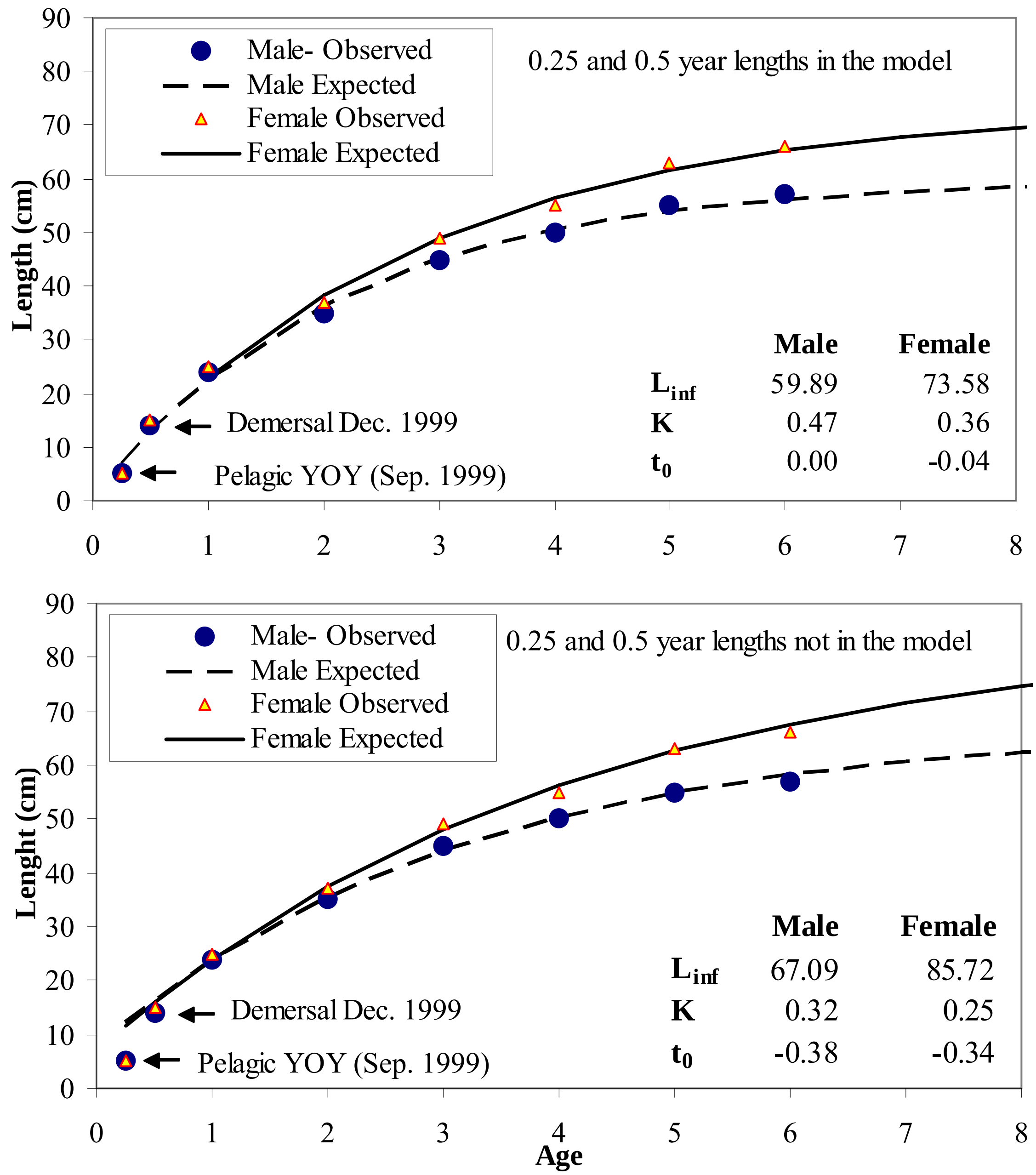


Figure 6. Preliminary von Bertalanffy growth curves by sex for the 1999 year class. Observed size at age was derived from mean length of the mode of the 1999 year class in subsequent years. Annual values of length were taken from spring (Apr.-Jun.) surveys. The observed points at less than one year of age are illustrated but not included in the model.

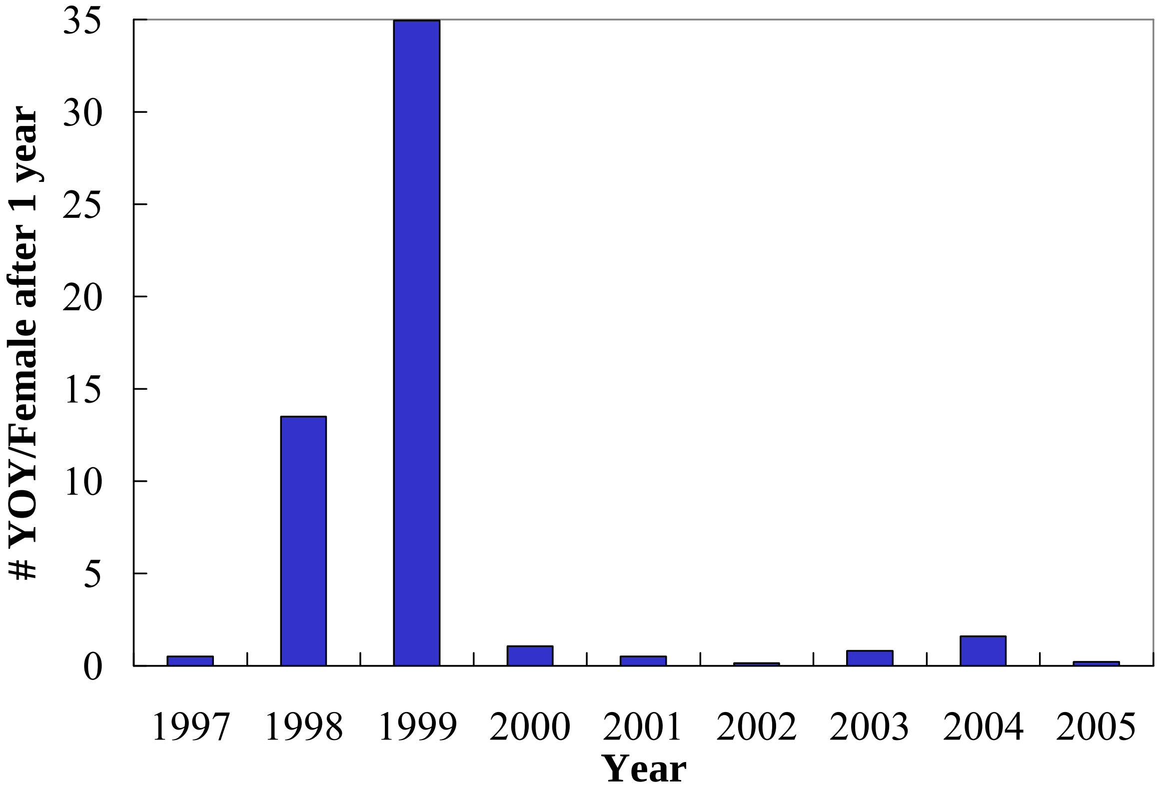


Figure 7. Recruit per spawner expressed as number of young-of-the-year males and females (1 year olds produced per female in year -1) from Canadian Campelen spring surveys in NAFO Div. 3NO and Subdiv. 3Ps, 1997-2005. For the 2005 point, one year olds in 2006 are only from the shallow (< 103 m) portion of Div. 3NO rather than the entire stock area because of incomplete sampling in that year.

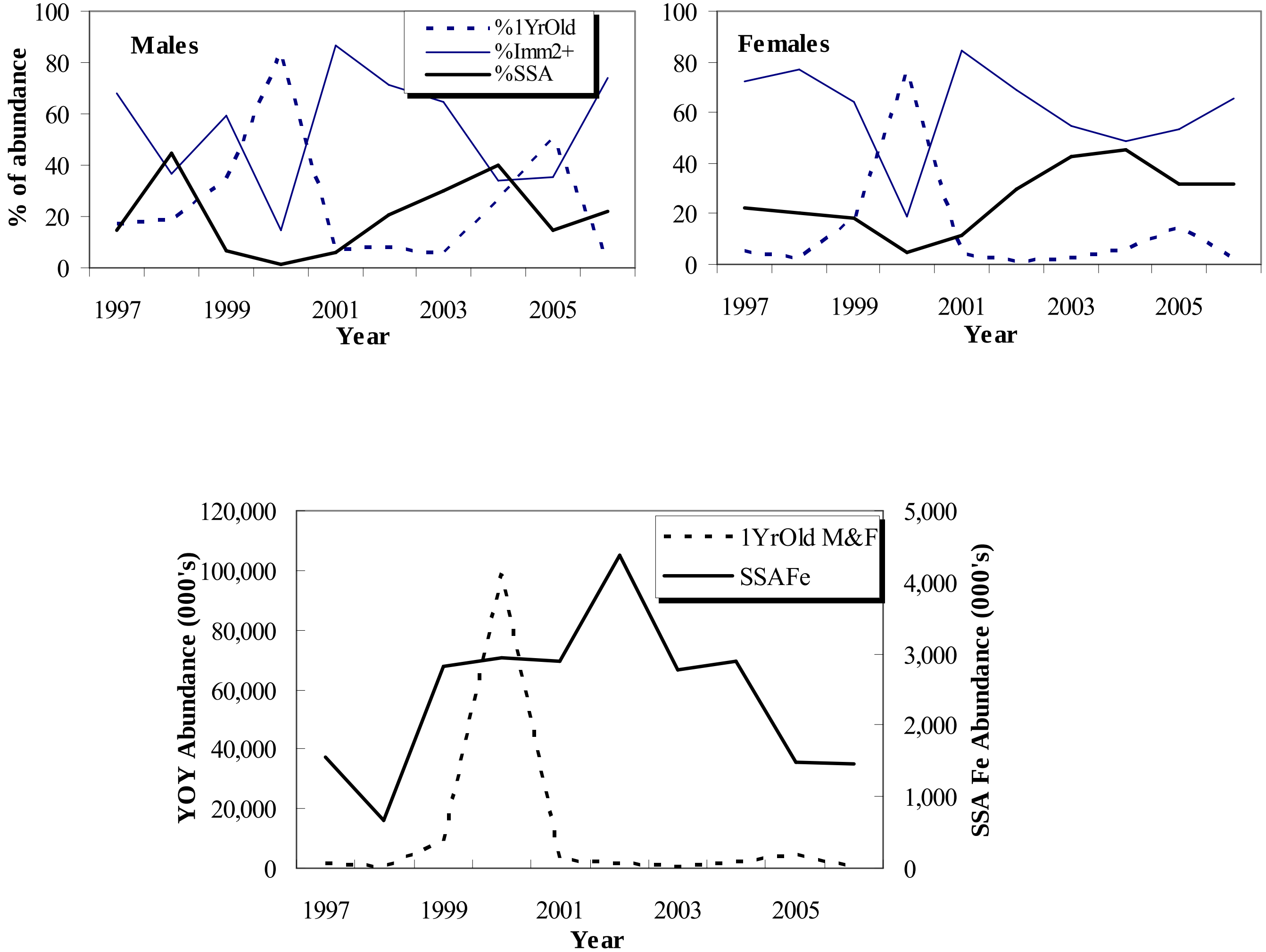


Figure 8. Staged trends in relative abundance of young-of-the-year (YOY) and female spawning biomass (SSAFe) from Canadian Campelen spring surveys in NAFO Div. 3NO and Subdiv. 3Ps, 1997-2006.

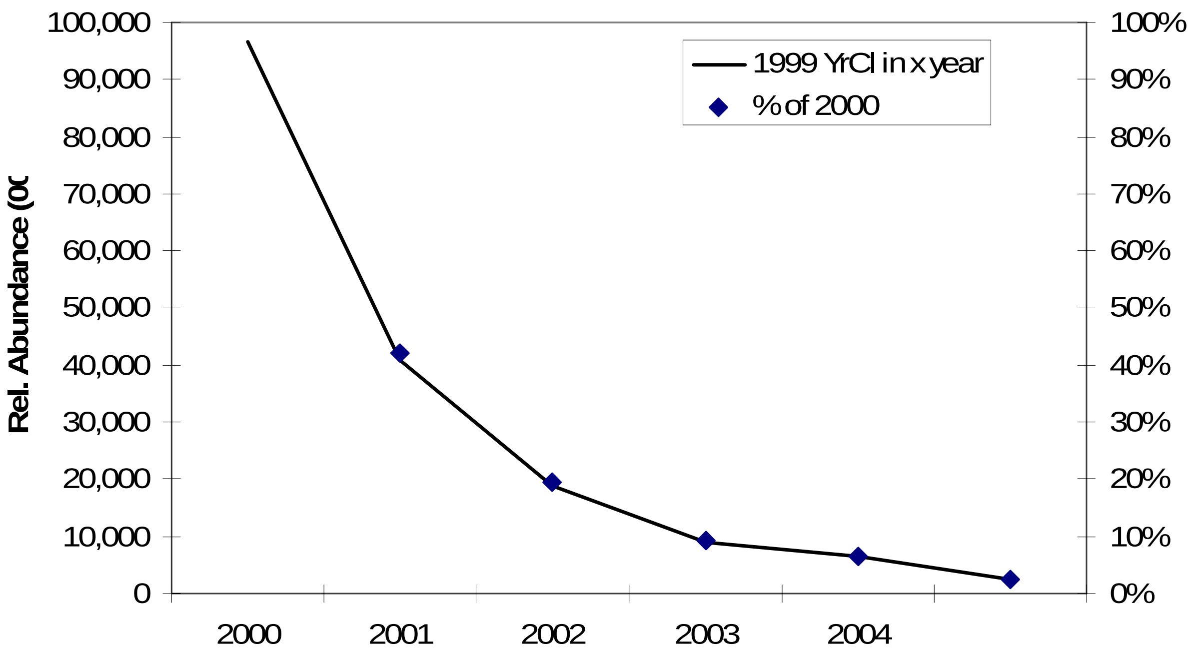


Figure 9. Change in the relative abundance of the 1999 year-class, estimated by modal analysis, 2000-2005.

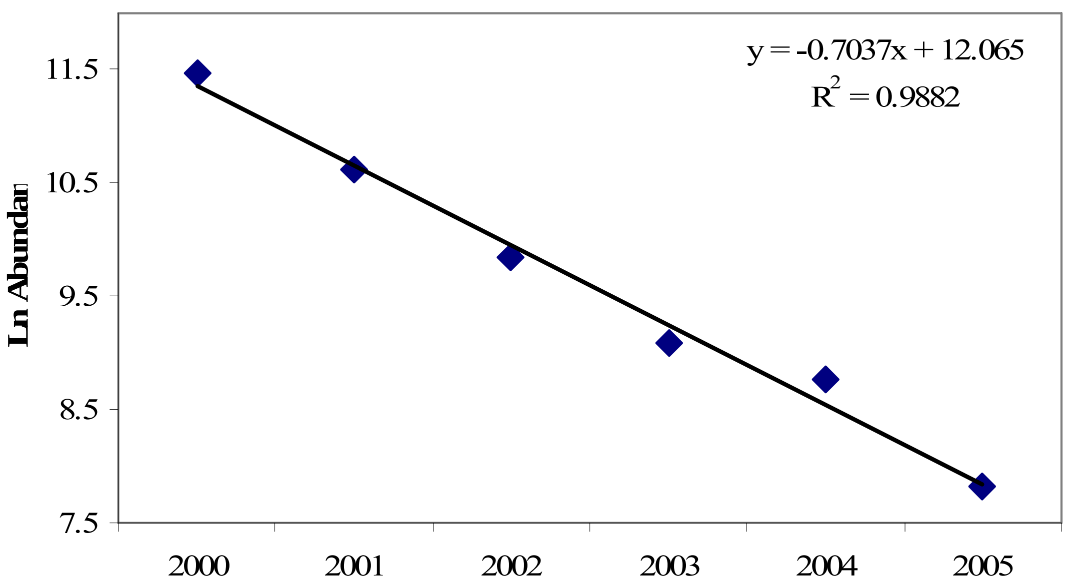


Figure 10. Ln Abundance of the 1999 year class, 2000-2005. Slope is Z for 2000-2005.

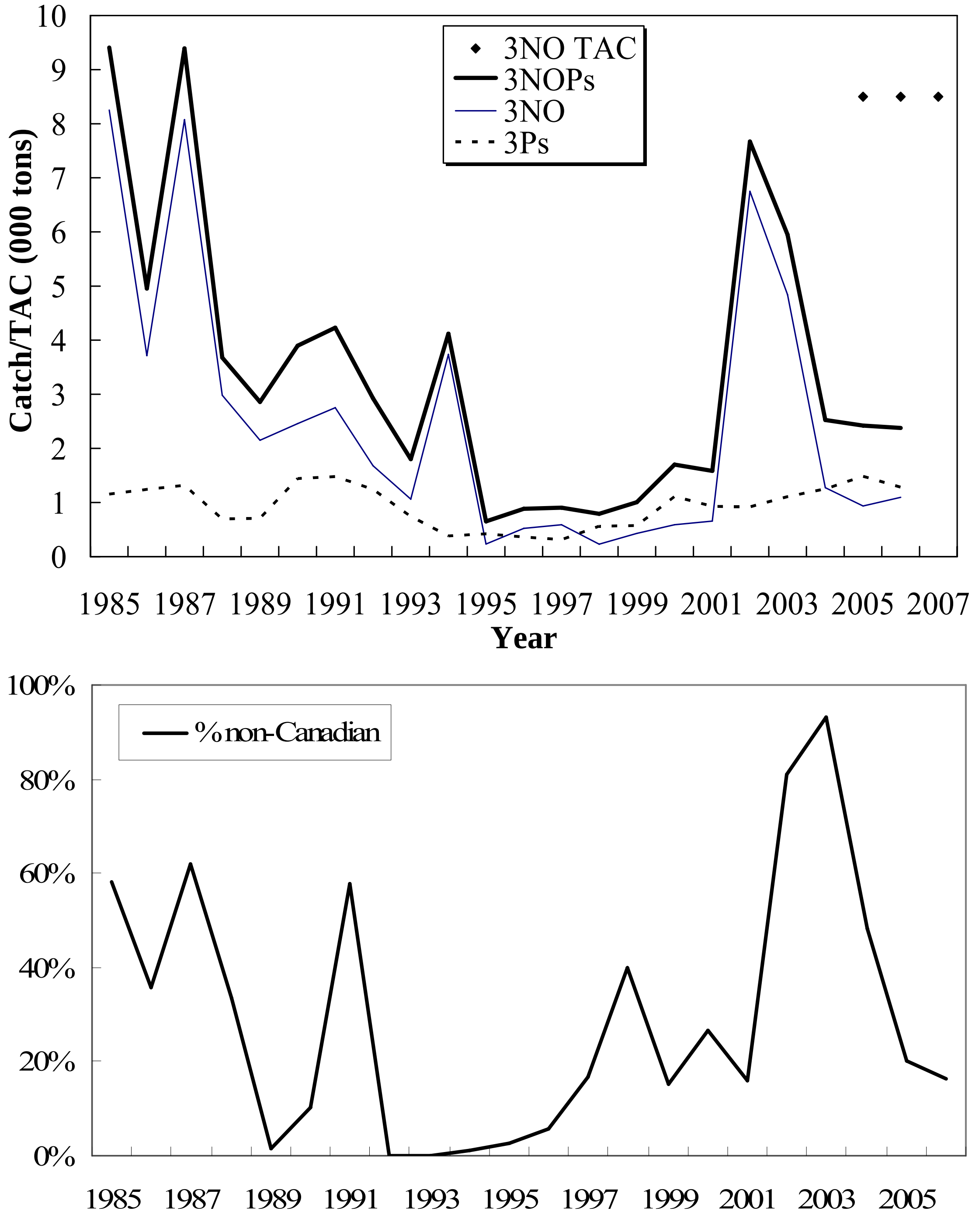


Figure 11. Upper panel: Total reported catch of white hake and TAC in NAFO Div. 3NO and Subdivision 3Ps, 1985-2006. Lower panel: Percent of white hake taken by non-Canadian fleets in the NAFO Regulatory Area (Div. 3NO in the NRA), 1985-2006.

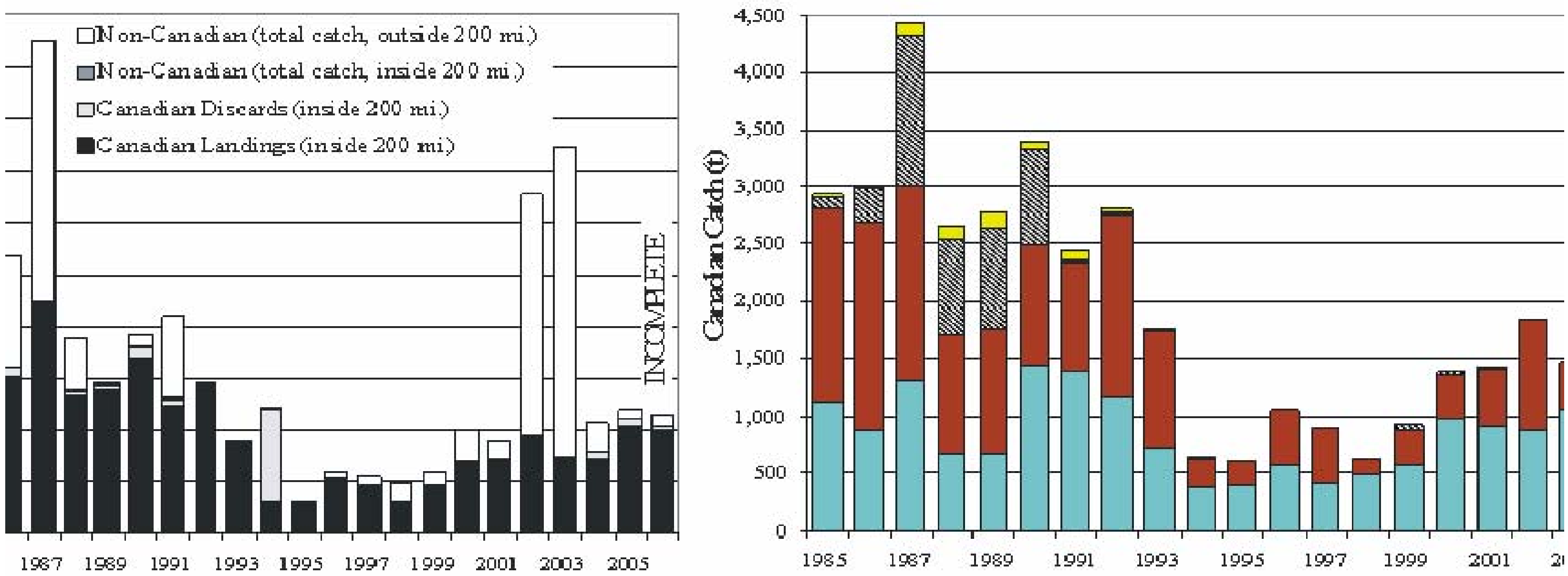
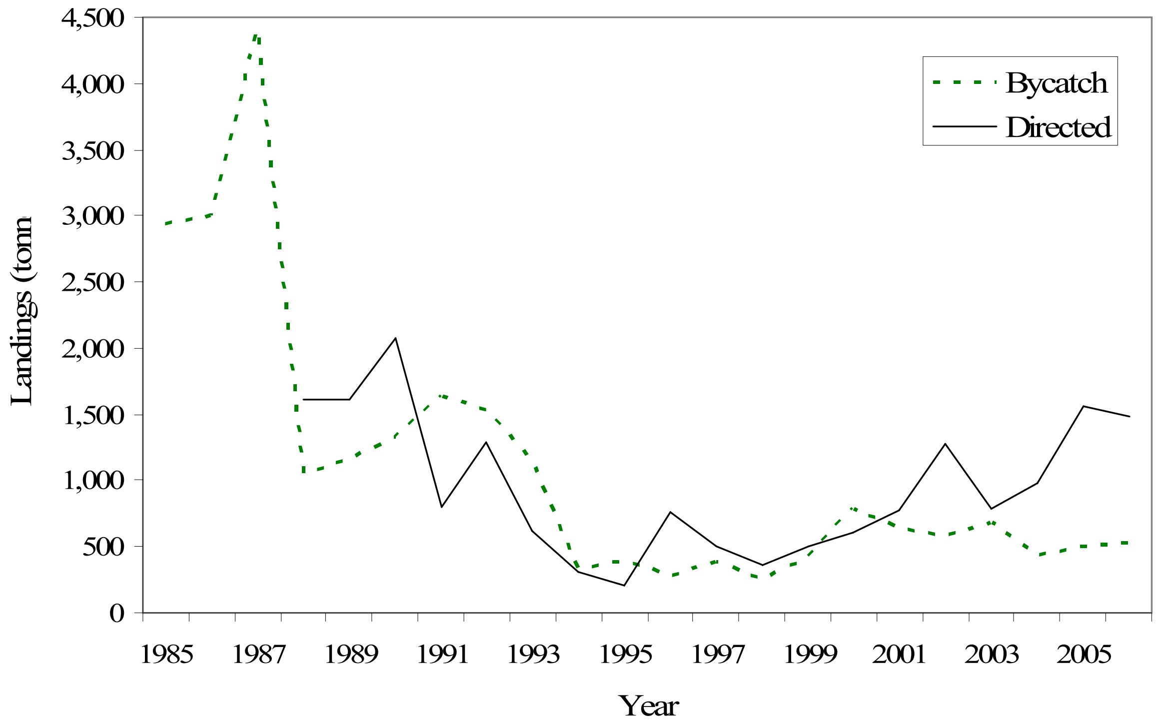
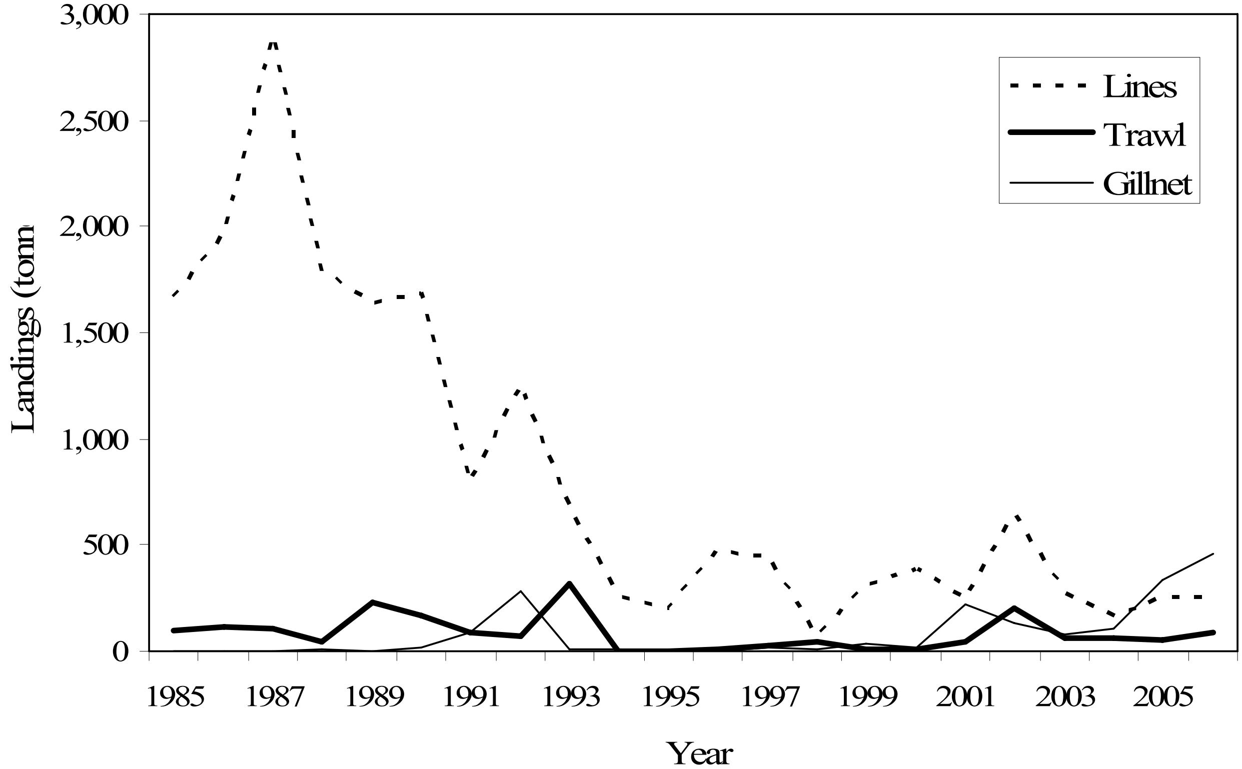


Fig. 12. Landings of white hake in NAFO Divisions 3LNO and Subdivision 3Ps, 1985-2006. Canadian landings were tabulated from ZIF; non-Canadian landings were collated from NAFO statistics for years prior to 2002, and from STACFIS since. The 2006 statistics are preliminary. Data from Div. 3L are presented for information purposes only.



Year	3L		3N		3O		3Ps		All Divisions		
	Bycatch	Directed	Bycatch	Directed	Bycatch	Directed	Bycatch	Directed	Total	Bycatch	Directed
1985	32	0	101	0	1,665	0	1,138	0	2,936	2,936	
1986	17	0	297	0	1,818	0	876	0	3,007	3,007	
1987	80	0	1,314	0	1,705	0	1,314	0	4,413	4,413	
1988	105	16	183	644	365	672	405	282	2,672	1,058	1,614
1989	80	45	235	642	416	671	432	248	2,770	1,164	1,606
1990	36	38	190	640	383	670	714	727	3,398	1,322	2,076
1991	70	0	16	3	362	585	1,194	207	2,438	1,643	796
1992	42	0	7	12	466	1,132	1,016	147	2,821	1,531	1,290
1993	3	0	17	1	545	464	580	152	1,763	1,146	617
1994	0	0	16	0	76	181	249	134	657	341	315
1995	2	0	0	0	153	52	244	151	603	400	203
1996	1	0	0	0	134	354	154	411	1,054	289	765
1997	0	0	0	0	173	313	217	189	893	391	502
1998	1	0	0	0	76	51	187	311	626	264	362
1999	0	0	23	20	76	230	321	249	920	420	500
2000	1	0	21	0	83	309	678	297	1,390	783	607
2001	0	0	5	11	150	344	495	424	1,430	651	779
2002	1	0	0	0	205	774	368	500	1,847	574	1,273
2003	0	0	0	0	144	271	537	517	1,469	681	788
2004			0		176	159	269	828	1,431	445	986
2005	3	2	0		121	530	381	1,025	2,062	505	1,557
2006					173	626	352	855	2,006	525	1,481

Figure 13. Directed and non-directed Canadian white hake landings in NAFO Divisions 3NOPs, 1985-2006. Data do not include discards at sea. Data from Div. 3L are presented for information purposes only.



	Gillnet		Lines		Trawl			Bycatch and Directed		
Year	Bycatch	Directed	Bycatch	Directed	Bycatch	Directed	Total	Gillnet	Lines	Trawl
1985	0	0	1,666	0	100	0	1,766	0	1,666	100
1986	0	0	1,971	0	116	0	2,087	0	1,971	116
1987	0	0	2,904	0	107	0	3,011	0	2,904	107
1988	13	0	487	1,306	32	10	1,847	13	1,793	42
1989	1	0	490	1,149	117	114	1,872	1	1,640	231
1990	1	20	479	1,205	81	86	1,871	21	1,684	167
1991	17	67	288	509	72	12	965	84	796	84
1992	172	108	215	1,035	67	0	1,597	280	1,250	67
1993	9	0	233	446	297	18	1,002	9	678	315
1994	6	0	87	181	0	0	274	6	268	0
1995	0	1	153	51	0	0	206	2	204	0
1996	2	0	126	354	6	0	488	2	480	6
1997	9	6	137	306	27	0	486	15	443	27
1998	9	0	22	51	46	0	127	9	73	46
1999	32	0	56	250	11	0	350	33	306	11
2000	17	1	77	309	11	0	414	18	385	11
2001	50	171	60	183	45	0	511	221	244	46
2002	47	85	72	568	86	121	979	132	640	207
2003	49	30	30	242	66	0	415	79	271	66
2004	70	39	46	120	60	0	334	109	166	60
2005	32	305	34	225	55		651	337	259	55
2006	66	391	19	234	88	1	800	458	253	89

Figure 14. Canadian white hake landings in NAFO Divisions 3NOPs by gear type and mode (directed or bycatch), 1985-2006. Data do not include discards at sea. Data from Div. 3L are presented for information purposes only.

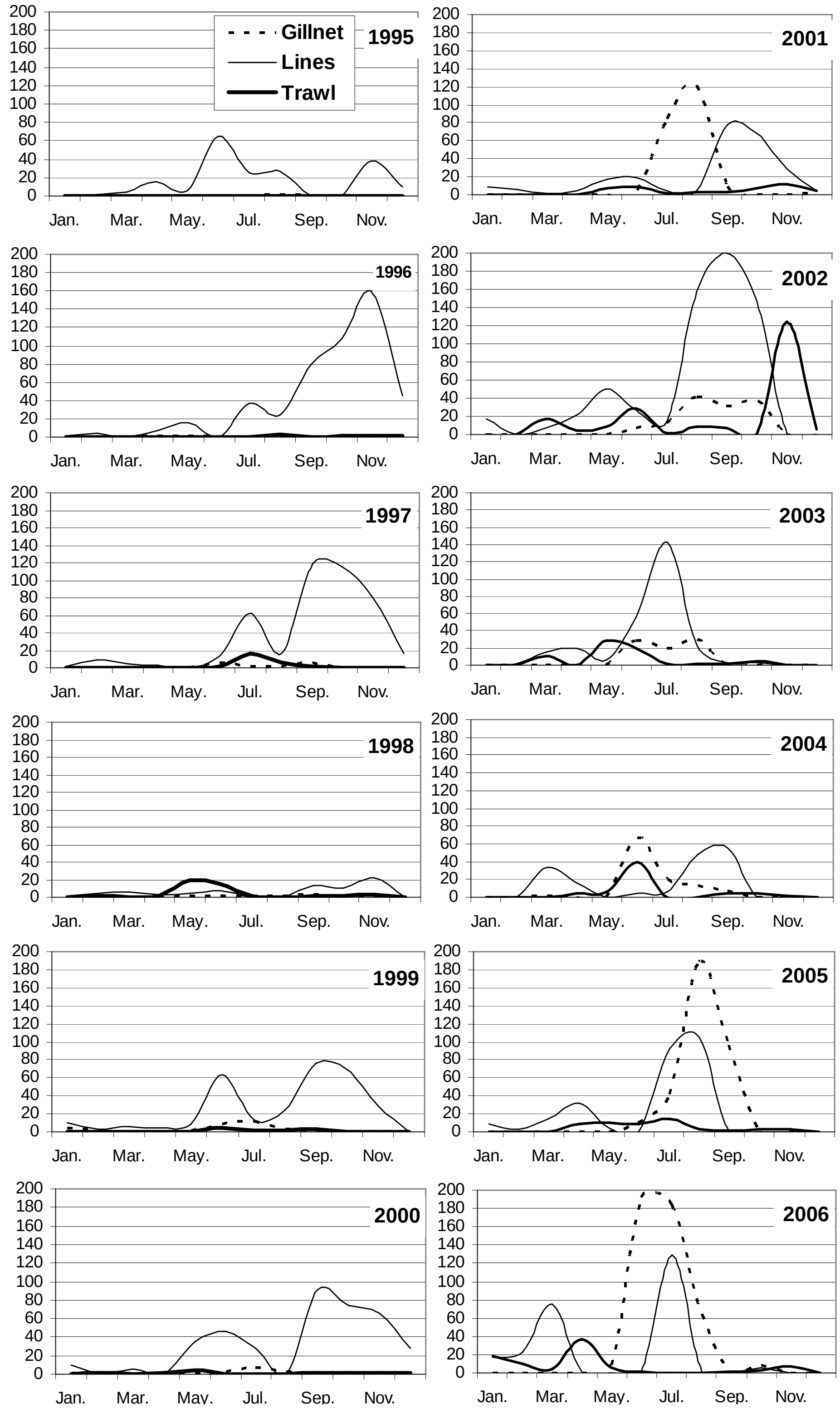


Figure 15. Canadian landings of white hake in NAFO Divisions 3NO and Subdivision 3Ps by month and gear type, 1995-2006.

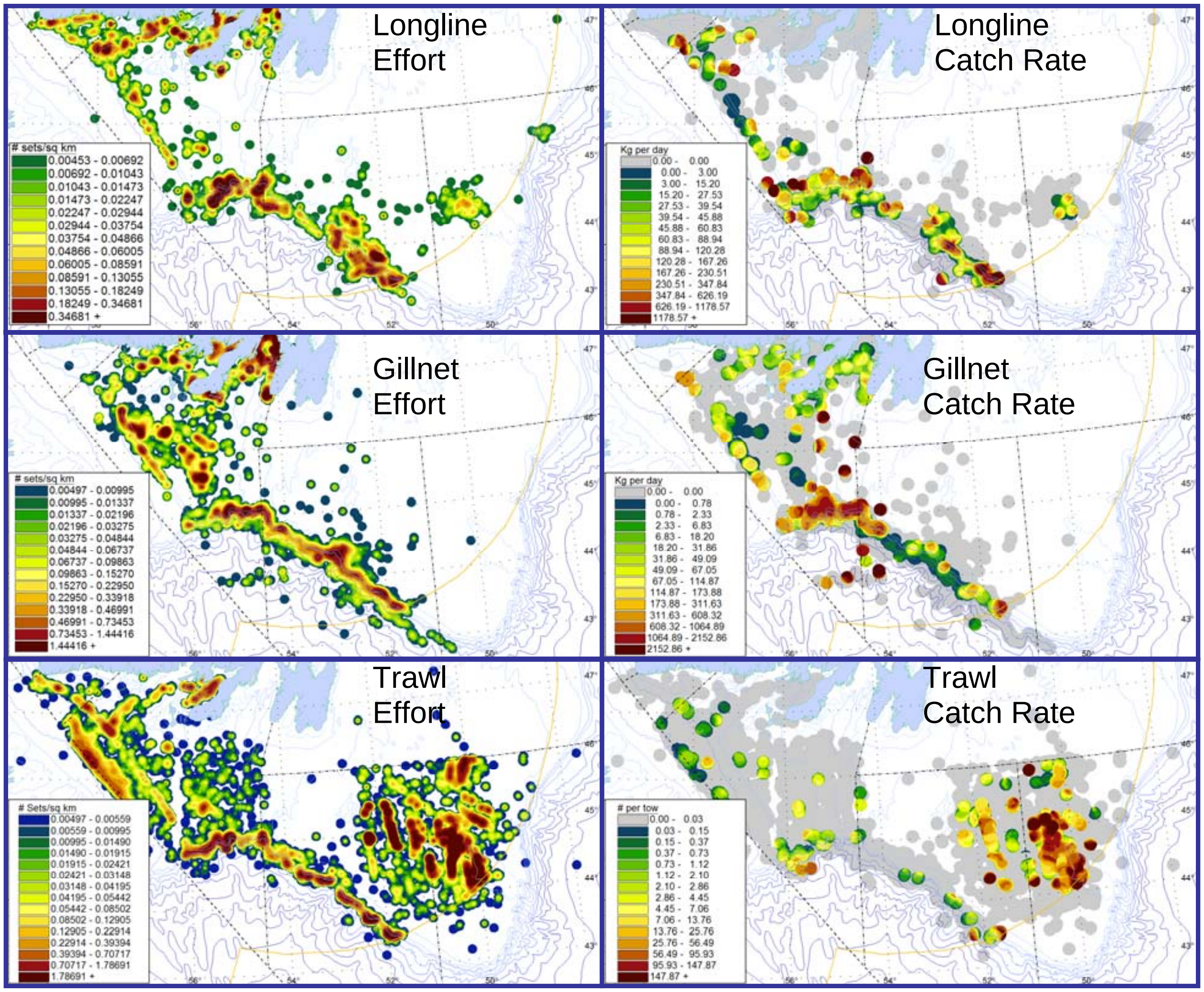


Figure 16. Distribution of Canadian fishing effort and white hake catches based on log records, 2002-2006. Left column depicts effort distribution expressed as # sets/sq km. Right column depicts catch rate of white hake. Note that the gray colour represents fished locations; but with no catches of white hake.

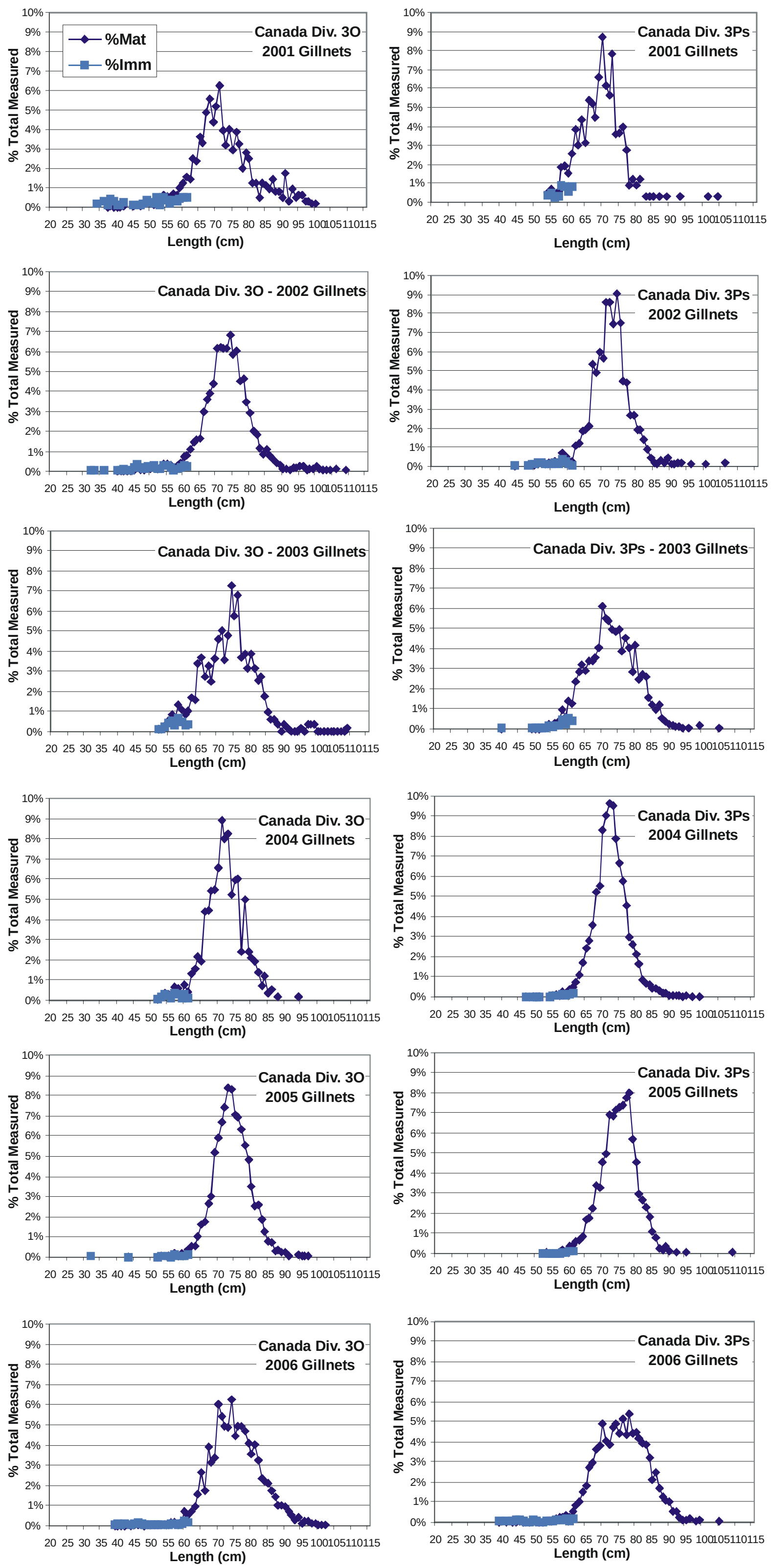


Figure 17a. Size of fish caught in the various Canadian commercial gillnets, 2001-2006. Data are from Canadian Fisheries Observers.

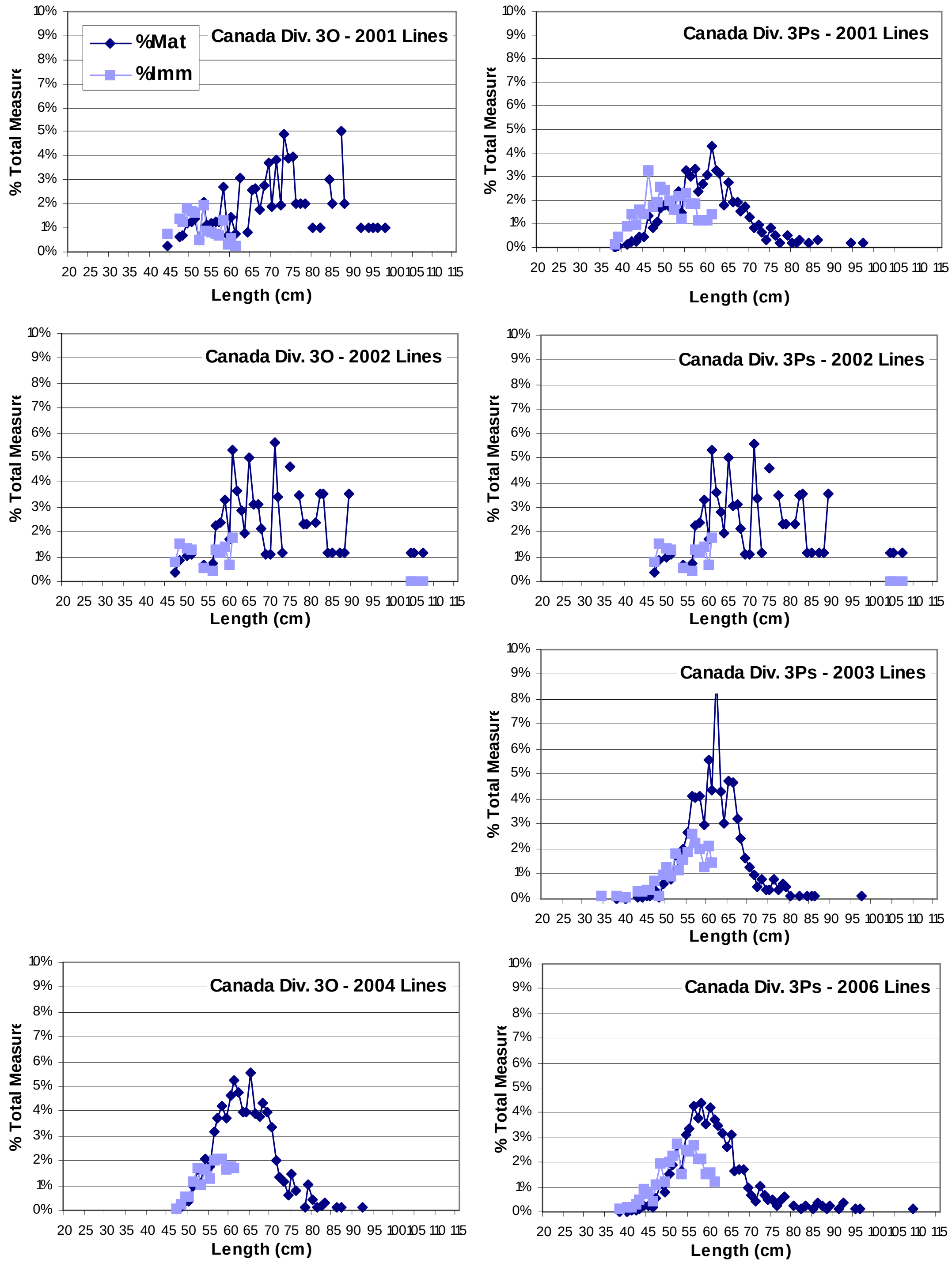


Figure 17b. Size of fish caught in the various Canadian commercial longlines, 2001-2006. Data are from Canadian Fisheries Observers.

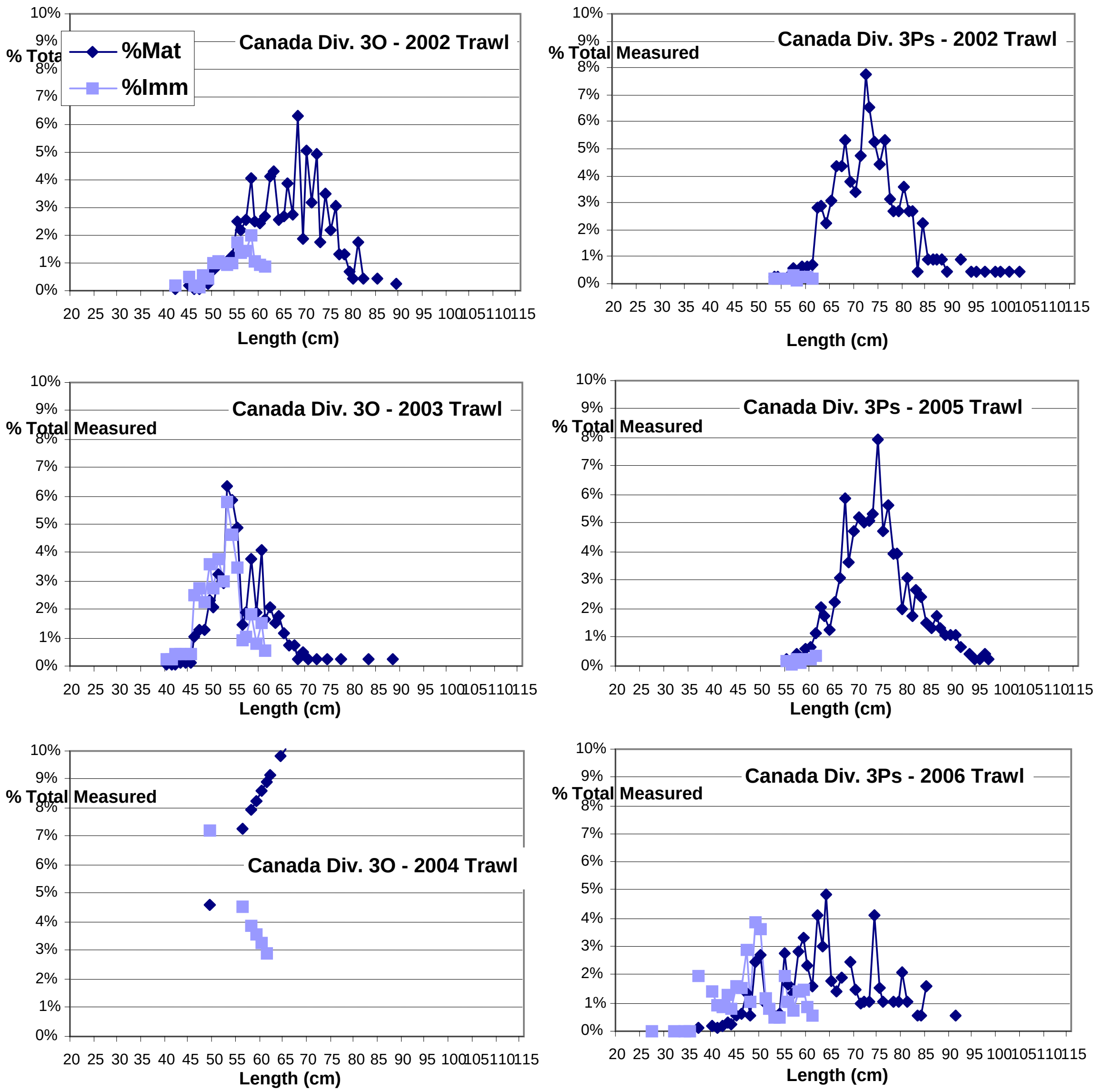


Figure 17c. Size of white hake caught in the various Canadian otter trawls, 2002-2006. Data are from Canadian Fisheries Observers.

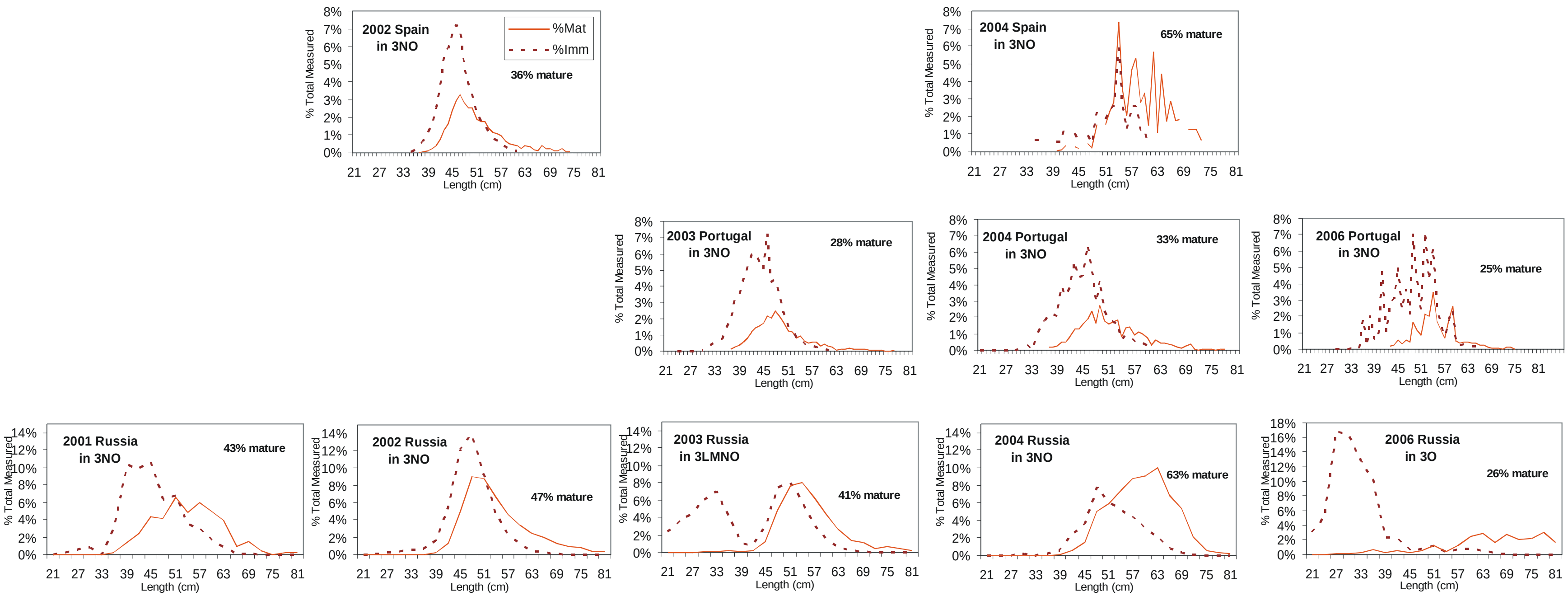


Figure 17d. Available size frequency data for white hake caught in the non-Canadian commercial trawl fishery in the NRA, 2001-2006. The frequencies are partitioned into immature and mature fish using an ogive averaged over sexes and years (2001-2004).

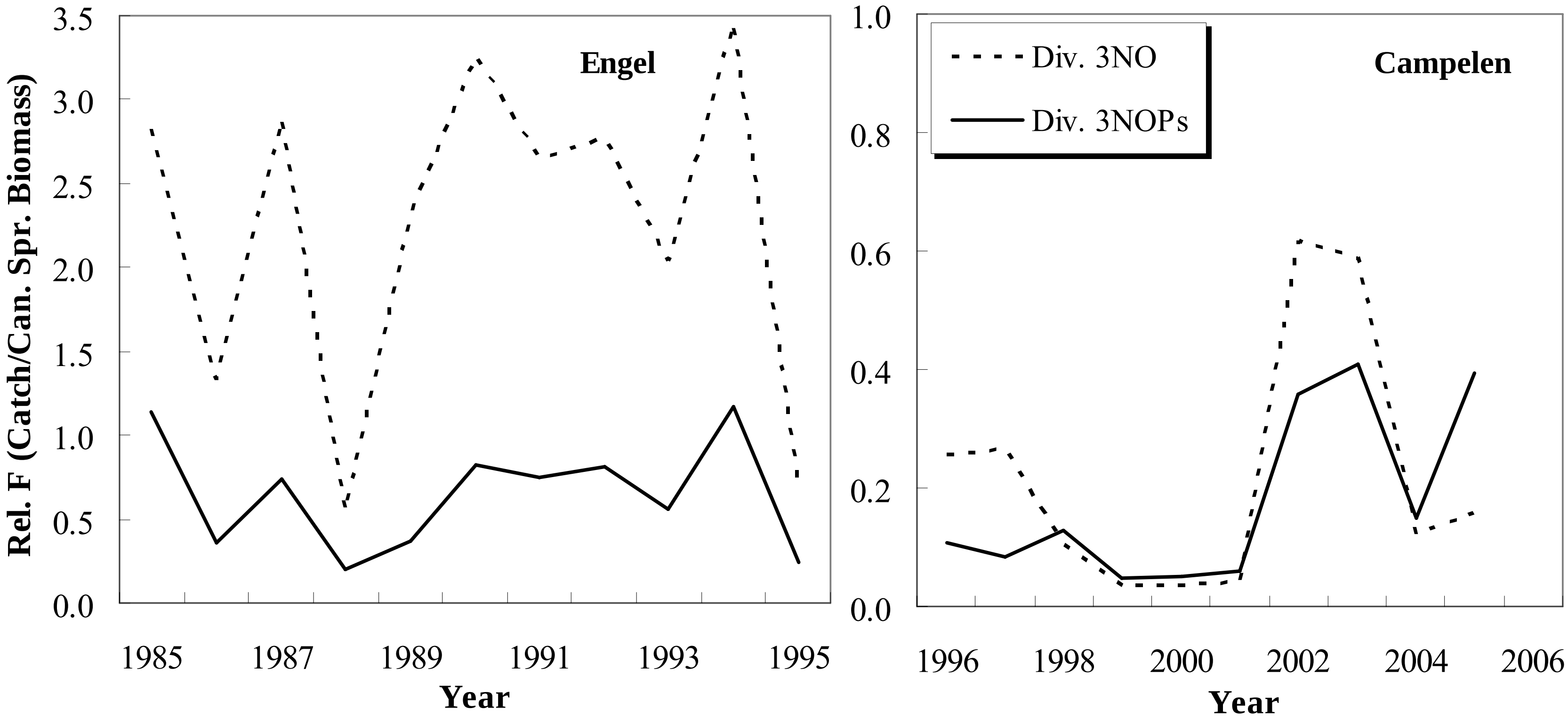


Figure 18. Relative F index (= STACFIS agreed commercial catch/Canadian Campelen spring survey biomass) for white hake in NAFO Div. 3NO and 3NOPs, 1985-2005. Both time series are unstandardized. Note that Subdivision 3Ps was not surveyed in 2006; due to Canadian research vessels' mechanical difficulties.