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

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Abstract

With the decline in "traditional" groundfish resources in the waters around Newfoundland, Canadian interest in the exploitation of alternate species, including white hake (*Urophycis tenuis*), increased in the mid1990s. A limited directed fishery for white hake commenced on the southern Grand Banks, namely in NAFO Div. 3O and Subdiv. 3Ps; however, it continued to be commonly taken in mixed fisheries with Atlantic cod, monkfish, and thorny skate. In 2001, EU-Spain, EU-Portugal, and Russia commenced a fishery in the NAFO Regulatory Area (Div. 3NO), and catches increased 10-fold. Prior to 2005, there was no quota for the white hake fishery in the NRA; while fishing efforts in the Canadian zone have been regulated by closures due to excessive by-catch of other species. Total reported catches in Div. 3NO averaged 455 tons in 1995-2001, but increased to an average of 5 771 tons in 2002-2003; then decreased to 1 225 tons in 2004. Abundance declined to its lowest historic level in 1995. However, biomass and abundance indices increased dramatically in 2000; due mainly to a very large year-class in 1999. It was this year-class that resulted in a dominant mode of 15 cm in the 1999 Canadian autumn research survey, and another of 25 cm (1-year-old) fish separately in the 2000 Canadian and Spanish spring surveys. This mode was tracked through subsequent years by both countries, and in 2004 was 7% of the size observed in 2000 (estimated $Z = 0.7$, 2000-2004). The 1999 year-class greatly supported the expanded fishery in 2002-2003 in Div. 3NO of the NRA. Since 1999, year-classes have been extremely low by comparison (2% or less). This paper provides: a review of fishery catch, effort, and catch composition; an analysis of abundance, biomass and size composition, and a stage-based analysis of research survey data.

Introduction

White hake (*Urophycis tenuis*, Mitchill 1815) is a highly fecund, bottom-dwelling species distributed in the Northwest Atlantic from Cape Hatteras to southern Labrador; reaching its peak abundance in the Grand Banks, Gulf of St. Lawrence, on the Scotian Shelf, and in the Gulf of Maine (Musick, 1969, 1974; Bundy *et al*., 2001; Hurlbut and Poirier, 2001; Kulka and Simpson, 2002). Present knowledge of the biology of this species is summarized in Kulka *et al.* (2005).

The location of formerly the most important Canadian fisheries is the southern Gulf of St. Lawrence (NAFO Div. 4T), and on the Scotian Shelf and Georges Bank (NAFO Div. 4VWX and 5). These stocks had been the object of directed fishing effort for decades, and their status as a commercial resource have 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 (Div. 4T); and Fowler *et al*. (1996), Fowler (1998), and Bundy *et al*. (2001) for the Scotian Shelf stock. Given that the fisheries have been closed in recent years, assessment updates only have 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). Although white hake in the eastern Gulf of St. Lawrence (Subdiv.

3Pn, 4R) are considered separate from the southern Gulf fish (Div. 4T), they have not been the target of directed fishing, and thus have not been assessed. However, Bourdages *et al*. (2002) and earlier research surveys have briefly reported on the distribution and sizes of white hake there. The Georges Bank/Gulf of Maine stock is assessed by the USA (NEFSC, 1999, 2001).

Formerly one of the most abundant and commercially important fisheries in the Gulf of St. Lawrence, Scotian Shelf, and Gulf of Maine, white hake stocks have declined in recent years. Until a moratorium on fishing in 1995, the NAFO Div. 4T stock was the third most important commercial groundfish resource in the Gulf of St. Lawrence. While recruitment led to an increase in abundance there in the late 1990s, the population remains low in relation to the 1970s-1980s (Hurlbut and Poirier, 2001). On the Scotian Shelf, landings were stable from the 1970s to the late 1990s (Fowler *et al.*, 1996). However, abundance estimates are currently at historic lows, and, consequently, there has been no directed fishery since 1999. Lang *et al.* (1996) reported that landings of white hake in the Gulf of Maine region had increased since the late 1960s. The 2001 assessment for that stock stated that it was overfished, and recommended a level of fishing mortality close to zero (NEFSC, 2001).

Concentrations of white hake are also found in the waters south and east of Newfoundland in NAFO Div. 3L, 3N, 3O, and Subdiv. 3Ps (collectively known as 3LNOPs; Fig. 1). Here, its distribution is confined largely to an area associated with the warmest bottom temperatures along the southwest fringe of the Grand Banks (Kulka and Mowbray, 1998; Kulka *et al.*, 2005). North of this area, white hake occur only sporadically and mainly in autumn. Prior to the mid-1980s, white hake on the Grand Banks were usually taken only as by-catch. Unlike the stocks in the Gulf of St. Lawrence and Scotian Shelf, it was rarely reported as a directed species. Although catch records have existed for years from the Grand Banks, it was a relatively minor component of the total commercial landings (described in Kulka and Mowbray, 1998).

Given increased interest in this stock by Canadian industry, 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 by-catch of regulated species have at times restricted Canadian catches: generally <500 tons annually (Kulka and Simpson, 2002). However in 2002, Kulka *et al.* (2004) reported a >10-fold increase in the catch of white hake in NAFO Div. 3NO; attributable to new directed efforts by EU-Spain and EU-Portugal in the NAFO Regulatory Area (NRA). Russia joined this fishery in 2004. Given large increases in catch, the Fisheries Commission (FC) of the Northwest Atlantic Fisheries Organization (NAFO) requested specific information in 2003 on white hake fishing mortality, abundance, distribution, reference points, conservation measures, size of fish, and delineation of fishery areas. Given the data available, the advice provided is summarized in Kulka *et al.* (2004).

The Fisheries Commission, by specifying advice for NAFO Div. 3NO, implicitly set the white hake stock management unit as Div. 3NO. However, Kulka *et al.* (2005) indicated that white hake appear to form a single spawning component within NAFO 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. Therefore, assessing fish from Div. 3NO, excluding 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 first request for advice on the status of the Grand Banks stock from the Fisheries Commission of NAFO, this paper presents an assessment of white hake in both NAFO Div. 3NO and 3NOPs (given the findings of Kulka *et al.* (2005) with respect to fishery statistics, research survey information (stage based biomass and abundance) and various aspect of biology.

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 four sources:

1) Standard NL demersal trawl surveys (random stratified, Engel and Campelen trawl gear, spring and autumn, post-1970 using Yankee-41.5 to 1983, Engel-145 Hi-lift to 1996, and Campelen-1800 shrimp trawl 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);

as described below in detail.

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 (STRAP). 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 included 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). 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 (demersal) Trawl 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. While size based conversion factors for amounts of fish caught 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 Division, survey season and depth.

In addition to the proportional allocation of the random-stratified sets used for STRAP estimates, extra sets using the same gear and effort (tow time) were done on occasion, apart. These 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 (NAFO Div. 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.

Primarily due to the addition of 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. CTD, BT, or XBT gear was used to record bottom temperatures at all tow locations. These data were used to examine the relationship between hake distribution and bottom temperature.

Juvenile surveys: The Grand Bank, within NAFO 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 (newly-hatched) stage of white hake. This short survey series, taking place ~30 m below the surface in August-September on the Grand Banks, covered NAFO Div. 3LNO, but not Subdiv. 3Ps (Dalley and Anderson, 1997, 2000). This survey was used as source of information on recruitment (pelagic young-of-the-year), and is compared to Campelen results after the fish have settled. Table 4 enumerates the sampling effort. White hake captured were measured for total length.

Analyses

Standard sets from the seasonal surveys, spring and autumn (see Table 1a and c) are used to estimate index of abundance (STRAP2) and biomass**,** while a combination of the standard and special sets are used to map the distribution. Eighty-two percent of sets containing white hake were sampled for length by sex in both spring and autumn trawl surveys in Div. 3L, 3N, 3O, and Subdiv. 3Ps (spring only), and those samples were used to estimate numbers at length using STRAP1 (Smith and Somerton, 1981). STRAP estimates biomass (and numbers of fish) by areal expansion within each of a series of pre-defined strata added over the survey area. 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 (1996-2004), since it captures a wider range of sizes**;** including juveniles in their first year. Maturities, recorded ~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 Subdivision 3Ps. 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.

$$L_t = L\infty\,[1 - \exp(-K\,(t - t_0))]$$

where L_t = length at age L_t, 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 frequency mode. This approach was possible because that year-class dominated in the length frequencies.

A GIS was used to investigate the spatial distribution of white hake with survey data. Potential mapping in SPANS (Anon., 2000) transforms points (kg per tow) to density surfaces (areas of similar kg per tow) by placing a circle around each point and averaging the values of all points that fall within the circle. The circle size selected (12 km diameter) provided complete coverage of the survey area while minimizing gaps in the density surface, and thus maximizing spatial resolution. The study area periphery was isolated using a 'cookie cut' technique (referred to as a basemap cut in SPANS). This resulted in a density surface bounded on all sides by either land or the 1 000 m depth contour. The resulting map was then post-stratified into 15 classes defining density of fish; each density class covering approximately the same amount of area. The method is further described in Kulka (1998).

Fishery data

Canadian landings from white hake directed fishing and by-catch from other fisheries were compiled using statistical records in the Zonal Interchange Format database (ZIF; available since 1985). The fishery along the southwest slope of the Grand Banks (NAFO Div. 3NO and Subdiv. 3Ps) is 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 (i.e., 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 by-catch data in other fisheries are included.

Since the start of the Canadian white hake fishery in 1988 in NAFO Div. 3NO and Subdiv. 3Ps, Canadian Fisheries Observers have been observing approximately 8% of Canadian efforts targeting white hake. Observers collect set-by-set information on catches, employing methods described in Kulka and Firth (1987). This information was used to examine distribution of Canadian fishing effort, catch rates, and amounts discarded. The potential mapping technique described previously was used to create distribution maps of observed fishing activity (catch rate by NAFO Division and gear). The fishing patterns observed were then compared to white hake distributions derived from Canadian research survey data.

Length measurements of white hake from the Canadian (1994-2005 preliminary), EU-Spanish (2002, 2004), EU-Portuguese (2003-2004), and Russian fisheries (2000-2004) 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 in 3-cm 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 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 NAFO Subdiv. 3Ps. However, the addition of non-standard sets during 1972-1996 extends the coverage into NAFO 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 only occasionally recorded at depths >700 m: 2 sets in spring, 2 sets in autumn (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).

With the change from the Engel 145 trawl (codend mesh size of 160 mm) to the Campelen 1800 trawl (40 mm codend mesh) in the autumn of 1995, sampling efficiency by size changed significantly; as shown by an increase in proportion of small fish captured with the Campelen trawl. Size-based conversion experiments for Engel to Campelen 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 done only for the period when the Campelen gear was used (since autumn 1995). The earlier Engel and Yankee data were used only to examine historical abundance and biomass summed over all sizes captured; but as an independent time series.

Survey Estimates

Survey estimates of relative biomass, abundance, and average fish size (biomass/abundance) derived using STRAP2 are presented separately for spring and autumn in NAFO Div. 3NOPs and Div. 3NO (Table 4; Fig. 2a). Survey numbers per tow with confidence intervals are presented in Fig. 2b. NAFO Subdivision 3Ps was not surveyed during autumn. Thus, the spring index is used as the main indicator of changes in relative abundance; given that the stages of white hake distribute differentially between NAFO Div. 3NO and Subdiv. 3Ps (refer to Kulka *et al*., 2005 for details). As well, the information from Engel (1972-spring 1995) and Campelen (autumn 1995 to date) are presented separately; given that there are no conversion factors available to standardize the differences in catchability. The two time series reflect changes in biomass and abundance, but at difference scales and with a different mix of stages.

The biomass of white hake was observed to peak approximately every ten years during the period when Canadian stratified survey data were available: 1972-2004. During the period when the Engel trawl was used, the relative biomass in Div. 3NOPs peaked at about 9 000 tons in 1975-1978, and about 14 000 tons in 1986-1988; and underwent substantial declines after each peak (Table 5, Fig. 2). 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). The average biomass index for 1992-1995 was only 23% of the biomass for 1986-1988. Declines in hake populations were also 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) and in the Gulf of Maine (NEFSC, 1999, 2001).

Following the decline of the early 1990s, biomass of white hake on the Grand Banks increased rapidly in 1999-2000 to about 25 000 tons on the Campelen scale but has steeply declined since. This sharp increase was due to a moderate year-class produced in 1998 plus a very large year-class in 1999 (described by Kulka *et al.*, 2005). The knife edge difference observed in autumn 1995 and in spring 1996 is the result of a different research survey trawl being used. Given the change in gear types, biomass indices since 1995 (autumn) and 1996 (spring) cannot be directly compared with the preceding years. However, if 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 is applied, 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 dramatic in terms of abundance, approximately a 6 times difference in numbers between both time series thereby suggesting that small fish were a large component of the increased numbers (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 purely speculative; given that this conversion scales the values, but does not account for differences in catch-at-length. An examination of Canadian research survey frequencies indicates differences in white hake catchability at size between both trawl types.

Autumn biomass and abundance estimates (1990-2001) were restricted to NAFO Div. 3NO (no autumn research surveys in Subdiv. 3Ps). They show a similar dramatic increase in Div. 3NO between 1998 and 1999 (Table 5, Fig. 2a). 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 before (refer to discussion of distribution of this biomass in Div. 3O below). The biomass index has steeply declined since 1999. The pattern of autumn indices is offset by one year (earlier) as compared to Campelen spring surveys because the autumn survey picks up newly settled young-of-the-year white hake. About 25 weeks later, the spring survey picks up the previous year's cohort (Kulka *et al.*, 2005). This pattern was most pronounced when larger year-classes were produced.

Trends in mean weight (biomass/abundance) summed over NAFO Div. 3NO and Subdiv. 3Ps tended to fluctuate without pattern until the late 1980s; then declined in the early 1990s (Fig. 2). 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 NAFO Div. 3NO in spring, average weight also fluctuated peaking in the 1970s and the late 1980s. Comparing sizes of white hake caught by both survey gears suggests that the Campelen trawl is probably more efficient at capturing smaller fish. After Canadian surveys changed to Campelen gear in autumn 1995, average weights reached their lowest level in 1999-2000, although increasing since then. The large drop in average weight in 1999 (and its subsequent increase since) corresponded to the very large 1999 year-class and its subsequent growth.
Relative abundance by life history stage more clearly describes the 1998 and 1999 years classes, with length <26 cm corresponding to white hake in their first year, 27-57 cm representing age 2+ juveniles, and 58+ cm fish comprising

mainly mature adults (see Kulka *et al*., 2005 for a description of length at maturity). The 1999 year-class produces a peak in 2000, a subsequent increase then decline in abundance of older juveniles and finally an increase in adults (particularly in Div. 3NO; Fig. 2c). Kulka *et al.* (2005) describes the manner in which these three life stages distribute differently on the Grand Banks.

The area occupied by white hake, seasons combined, fluctuated without trend in 1971-2004 although abundance (and biomass) changed significantly over that same period (see upper and lower panels of Fig. 3). On average, white hake occupied 21% (12-24%) of the area surveyed (the Grand Banks in NAFO Div. 3LNO and Subdiv. 3Ps), amounting to 80 000 km^2 (38 000-98 000). Much of the variation between years can be attributed to incomplete coverage by Canadian surveys. Refer to Kulka *et al*. (1995) for further details on the spatial distribution of white hake.

The Grand Bank, within NAFO 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). Figure 4 illustrates annual estimates of number per tow, showing a increase from the mid-1980s to the mid-1990s. However, the survey was not spatially consistent among years and the catch rate series is not considered to reliably reflect relative abundance although the trend is somewhat similar compared to the spring Engel index.

Available information on white hake numbers at length from Canadian Engel surveys are presented for 1988-1995 in Fig. 5a and abundance at length for 1997-2004 in Fig. 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 relative strength of those year-classes is unknown. There is no evidence of significant recruitment in subsequent years until 1998; based on a 25-cm mode observed in 1999 during Canadian Campelen surveys (Fig. 5b-d).

The largest year-class of white hake since 1977 was produced in 1999 and was first detected by the IYGPT young-of-the-year survey (see Table 4), also observed in the Spanish research survey. An estimated growth rate of about 2.5 cm per month corresponds to the dominant 25-cm mode of white hake seen in the following year's Canadian spring research survey. Research surveys by both countries have tracked progression of this large 1999 year-class through 2001-2004 (Fig. 5e). In 2001, a large number of white hake with an average length of 34 cm was observed; this proportion decreased in subsequent years. Average length of the majority of fish in both surveys increased through this time period: 43 cm in 2002; 48 cm in 2003; and 53 cm in 2004. In 2004, there was also a small peak of 15-26 cm white hake in Div. 3NO in both surveys.

The von Bertalanffy growth model was applied to the 1999 year-class by sex at age 0.25 (Sep. 1999), 0.5 (Dec. 1999), and at ages 1 through 5 (spring 2000 to 2004) to provide a preliminary analysis of growth in white hake on the Grand Banks (Fig. 6, upper). Growth was also modeled without the 0.25 and 0.5 points (Fig. 6, lower). The results must be considered as preliminary because a) only 5 years (plus two points at less than 1 year), no older ages was used as model input b) the length at age is derived for a single year-class (1999) and c) size at age was not derived from otoliths, rather from the mean size of 1999 frequency modes through time. The key issue is curvature of the model (K, the growth coefficient). By including the 0.25 and 0.5 lengths, it emphasizes the bend of the curve (larger K) not only on the low end but also on the high end, thereby flattening the curve so that a lower L_∞ results. This problem will be less of an issue in future when future points for the 1999 year-class are added to the model.

This is the first estimate of growth for white hake on the Grand Banks.Values added in future years as the 1999 year-class ages could make a significant difference to the parameter estimates. It is expected that L_∞, will increase in value and K, growth coefficient will decrease (curvature of the model will become straighter) as estimates of length at age of the 1999 year-class are added to the model in future years.

L_∞ of 67 cm (males) and 86 cm (females) for age 1 to 5 (age 0.25 and 0.5 not included) in the model is lower than what has been reported in other locations (see Table 6). Bundy *et al.* (2001) showed that white hake grew faster on Georges Bank than on the Scotian Shelf. Bundy et al. (ibid.) noted that the Georges Bank data were from research vessel surveys and were considered accurate from age 1+ years. However, the Scotian Shelf data were from the commercial fishery and only hake from age 4+ years (larger than 49 cm; sexes combined) were used to fit the von Bertalanffy equations, thereby rendering unreliable the growth estimates for Scotian Shelf hakes of ages 1-3. Using fishery data from 1985, Bundy *et al.* (ibid.) also described white hake on the eastern Scotian Shelf as growing at a similar rate to those in the Gulf of St. Lawrence.

Using the 1999 year-class of white hake on the Grand Banks, preliminary data suggest that females were approximately the same size at age 5 as hake (sexes combined) on the western Scotian Shelf. Males were similar in size to eastern Scotian Shelf hakes by age 5. However, Grand Bank hake appears to have a faster growth rate than Georges Bank hake between ages 1-3 (albeit achieving sizes similar to the latter hake by age 4). Furthermore, Grand Bank females between ages 2-4 appear 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). Caveat for this comparative discussion is that the Grand Banks estimates of size at age are based on a single (1999) year-class. It is quite possible that growth rates may have varied in earlier years. Earlier survey data containing larger fish may suggest that either growth rate may have been higher in earlier years or that older age classes were present. Given that the IYGPT young-of-the-year findings described a predominance of 1-year-old fish in 2000 (Kulka *et al.*, 2005), an observed increase in the biomass index in 1999-2001, and a very large increase in abundance during that period indicate that recruitment was very high in 1999 when each female produced an average of 35 young (males and females surviving to one year, Fig. 7). However, year-classes since 1999, comparatively speaking, have been extremely low, each female producing no more than about one (surviving to age one) young, on average (Fig. 7).

This dominance of the 1999 year-class is reflected in the stage based analysis of abundance illustrated in Fig. 8. Until 2000, immature fish older than one year was the dominant component in the population. From 2001 to 2004, immature hake declined as a proportion of the total population while adults increased to where the two components where almost equal, a result of the 1999 year-class fish reaching maturity.

An estimate of change in the relative abundance of 1999 year-class white hake was done for the period 2000 to 2004 (Fig. 9). Only 7% of the abundance of the 1999 year-class in 2000 remains in 2004. An estimate of Z (total mortality) for the 1999 year-class is 0.7 for the period 2000-2004 (Fig. 10). It is expected that a similar estimate done over the entire population would be very little different given the dominance of the 1999 year-class from 2000 on. Thus, the current population is only a small fraction of its size in compared to 1999. Factors contributing to this decline are high fishing mortality, particularly in 2002-2004 and low recruitment.

The Fishery

Records of directed catches of white hake first appeared in 1988 in NAFO Div. 3NO and Subdiv. 3Ps. All Canadian records prior to 1988 were as by-catch in various groundfish fisheries. However, caution should be exercised with Canadian reported catches for hook and line gear from the mid-1980s to the early 1990s because the majority of these data may have represented Atlantic cod (*Gadus morhua*). If so, the statistics for white hake during that period may be over-reported.

EU-Spain and EU-Portugal commenced a directed fishery for white hake in 2002 in Div. 3NO in the NAFO Regulatory Area (NRA; Fig. 11). Since 2002, 85% of the total reported catch was taken in the NRA whereas the majority of the catches were usually taken within Canada's 200 mile limit prior to that time. There was no directed fishery by EU-Spain in 2004.

Reported catches of white hake in NAFO Div. 3NO, all countries combined peaked in 1987 at approximately 8 000 tons (with about half of that reported by non-Canadian sources as by-catch (Table 9; Fig. 12), then declined from 1988 to 1994, with an average of 2 090 tons. However, as noted above, the accuracy of the reported catches prior to the late 1980s are unclear.

With the restriction of fishing by other countries to areas outside Canada's 200-mile-limit in 1992, non-Canadian reported catches fell to near-zero. Average catch was at its lowest in 1995-2001 (455 tons) then increased to approximately 6 700 tons in 2002 and 4 800 tons in 2003. Total catch decreased to 1 267 tons in 2004, and 500 tons were reportedly caught by July 2005.

Since 1989, the reported directed fishery has contributed, on average, about 50% of the annual Canadian catch, ranging from 30-70%. (Fig. 13). Table 7 shows that, in recent years for the Canadian fishery, the majority of white hake were taken in a mixed fishery with monkfish and skate, and are reported as "unspecified" fisheries. In this hake/skate/monkfish fishery, the main species caught changes from day to day indicating the mixed nature of that fishery. White hake are also taken as by-catch with Greenland halibut, cod, and other commercial groundfish species. In most years prior to 2001, the majority of commercial catches were taken with longlines by Canada. However, gillnet catches have risen since then, while longline catches continue to decline. Trawls have rarely contributed a significant proportion to the total catch (Fig. 14) except in the non-Canadian fishery where otter trawls are exclusively used to fish white hake.

The majority of Canadian landings occurred in the latter half of the year partly due to regulations. Gillnet catches typically peaked in August or September, whereas longline catches were spread out over the year (Fig. 15). Fisheries Observer data indicated that longlines are fished more frequently on the shelf edge in NAFO Div. 3O; whereas gillnet grounds straddle the border of Div. 3O and Subdiv. 3Ps after 1997. Kulka and Mowbray (1998) reported a similar pattern in earlier years. Regularity in the timing of gillnet catch in Subdiv. 3Ps probably reflects seasonal constraints on the fishery due to cod by-catch problems; as opposed to hake and monkfish availability.

A comparison of the observed Canadian fishing grounds (1991-2004) with the distribution of white hake shows that fishing sets primarily occurred where the survey distribution predicted the highest concentrations (Fig. 16). The commercial CPUE and concentration of sets were clustered where numbers per tow from the survey were highest i.e. where highest concentrations of white hake occurred (Fig. 17). The non-Canadian (trawl) fishery largely occurred over a very small location just outside the 200 mile limit along the western slope of the Grand Banks (González and del Río, 2004, refer to Fig. 4) corresponding with the highest concentration of white hake outside the 200 mile limit.

Limited available data on sizes of fish taken in the directed commercial fisheries from 2001-2004 indicated that Canadian gillnets captured the smallest proportion of juvenile fish, usually <5% of the catch (Fig. 18a, Table 10). Canadian longlines captured a greater proportion of juveniles varying between 7 and 39%, usually <20% depending on location and year (Fig. 18b). The sample size for Canadian otter trawls was low and proportion of catch comprising juvenile was highly variable, between 1 and 43% depending on location and period (Fig. 18c). Longline and otter trawl catches generally contained a larger range of sizes than did catches from gillnets (Fig. 18a-c). Non-Canadian (EU-Spain) otter trawl catches in the NRA showed a very different pattern, varying between 35 and 72% immature fish in the catches depending on country and year (Fig. 18d). This may be due to different mesh size used as the locations fished by Canada and EU-Spain contains a similar mix of adults and juveniles.

Figure 19 illustrates the commercial catch rates of white hake, when specified as directed and in all fisheries combined as derived from fishing log data (see also Table 8). By separate vessel classes, the reported catch rates for trawl classes <65ft and >100ft increased during 1999-2001. The results appear to be of limited value as indices of abundance.

Relative F is higher in Div. 3NO compared to Subdiv. 3Ps, particularly in recent years due mainly to catches in the NRA (Fig. 20). The sharp increase in relative F after 2001 is due mainly to a new directed fishery for white hake by EU-Spain and Russia coupled with very low recruitment after 1999.

Conclusions

NAFO Div. 3LNOPs white hake abundance and biomass has undergone wide fluctuations since the beginning of the Canadian stratified random surveys in 1971. Cyclic changes in the abundance of the population over time are primarily the result of occasional production of large year-classes from very low SSB. White hake, amongst the most fecund of marine fish are capable of producing a very large year-classes from very small SSB. For this highly fecund species, it appears that production and early survival of large year-classes is sporadic and affected by environmental conditions. Thus, conditions appropriate to survival of early stages may constitute the key to recovery of this population.

It takes several years before a good year-class reaches maturity to replenish the adult component of the 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, white hake catches averaging 5 771 tons resulted in a sharp decline in this population (2004 abundance was 7% of that in 2000). 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 for 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 sustaining this stock, given the lack of significant recruitment.

Thus, regeneration of this depleted stock is obviously dependant on the recruitment and survival of large year-classes from the presently low SSB. One possible mechanism leading to good survival is favourable near surface currents of the southern Grand Banks that concentrate the majority of eggs and larvae at a location where there will be high survival when the pelagic stage settles on the bottom. The large majority of the large 1998 and 1999 year-classes settled on the shallow part of the Grand Bank where bottom temperatures were warmest. When such favourable conditions might occur again is unknown, and when a good year-class is produced it will then take several years before the fish are large enough to be exploited. Therefore, at best, it will be at least several years before there are enough white hake on the Grand Banks again to support more than a minor by-catch fishery.

Sources of Uncertainty

Stock structure of white hake is only now being examined. Spatial analyses by Kulka *et al.* (2005) suggest that the species in NAFO Div. 3LNOPs and possibly 3Pn and 4R form a single reproductive unit. The differences in population trends among the Grand Banks and other areas in the Atlantic (Gulf of St. Lawrence, Scotian Shelf, Bay of Fundy and Georges Banks) suggest different spawning components between those areas. Genetic research on population structure of white hake in Atlantic Canada is presently underway that will add to our knowledge of the stock structure of this species.

Research focusing on Grand Banks white hake including the collection and synthesis of data required to conduct an age-based assessment of this species has only recently commenced. Catch rates and biological characteristics (i.e., length; sex; maturities since 1988) were recorded for only a portion of Canadian surveys. No ages or fish weights are presently available although an aging program has recently commenced. Data on total length, individual weight, and maturity of white hake caught in the Canadian surveys are incomplete. A valuable source of information on recruitment, the annual Canadian IYGPT survey, was eliminated in 2000. Sampling of the commercial fishery remains sparse, with only a small sample of length frequencies from recent years.

Current biomass and abundance levels cannot be compared to those prior to autumn 1995 due to the change in survey gear with no comparative length based information available for this species. Similarly, comparisons of sizes of white hake caught by Campelen versus Engel trawls is not possible leaving unanswered questions concerning recruitment and proportion of adults in this population over the long term.

Fishery by-catch statistics from earlier years, particularly prior to the 1990s may be incomplete and inaccurate. Given that white hake were often of less value than some other directed species, discarding could have resulted in biased landing statistics in earlier years. The degree 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 mid-1980s to the early 1990s may have actually represented the more valuable Atlantic cod. As well, current catch records may not be adequate for separating landings originating from by-catch and those from any directed fishery. Furthermore, reported catches of white hake by non-Canadian fleets may not be accurate. It is possible that some fish caught in NRA waters, reported as red hake are actually white hake.

Outlook

As noted above, since Campelen biomass indices cannot be compared to those from Engel surveys in years previous to autumn 1995, the current state of the stock in Div. 3LNOPs cannot be properly assessed over the long term. The stock did reach low levels during the 1990s. However, a sharp increase in biomass and abundance due to the 1999 year-class, and subsequent increase in the fishery suggest that this highly fecund species is capable of producing large year-classes from very small SSB when environmental conditions are optimal. However, good recruitment has not been observed since 2000 and the 1999 year-class, comprising the large majority of the total population is now (in 2004) now only 7% of its size (abundance) in 2000.

Given that good recruitment occurs infrequently and unpredictably (and appears to requires favorable environmental conditions for early survival), fishing pressure should be regulated in Div. 3NO of the NRA by a TAC set at a level that will sustain growth and survival of larger year-classes to maturity. The current TAC of 8 400 tons far exceeds this amount. A quota for 2006 and 2007 of ~450 tons, which equals the average catch taken in 1995-2001 when the exploitable portion of this stock was again at low levels, might be more reasonable, until another good year-class occurs.

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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
Total	8	4351	7	6	4372	158	2276		6	2442		2333		2	2338	257	4165		2	4426	13578

Table 1b. Count of sets in the Engel and Campelen **spring** time series by year, depth interval, and NAFO Division. The data used for 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
Total	**15**	**6576**	**35**	**39**	**6665**	**207**	**2740**	**5**	**8**	**2960**	**4**	**3126**		**11**	**3145**	**261**	**4968**		**6**	**5241**	**18011**

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
Total	**13**	**4092**	**21**	**230**	**4356**	**96**	**1103**	**5**	**91**	**1295**	**0**	**1059**	**12**	**81**	**1152**	**0**	**0**	**0**	**0**	**0**	**6593**

Table 1d. Count of sets in the Engel and Campelen **autumn** time series by year, depth interval, and NAFO Division. The data used for 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**	**All**
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 using 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 Juvenile survey 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, 1971-2004. Surveys were conducted with an Engel trawl (1971- autumn 1995) and Campelen trawl (spring 1996- 2004). spring surveys: NAFO Subdiv. 3Ps was not surveyed in 1971; NAFO Div. 3O was not surveyed in 1972, 1974, 1983; and NAFO Div. 3N was not surveyed in 1983.

Canadian RV Surveys

	Biomass (tonnes)								Abundance (thousands)								Mean weight (kg)							
	3N		3O		3Ps	3NO	3NO	3NOPs	3N		3O		3Ps	3NO	3NO	3NOPs	3N		3O		3Ps	3NO	3NO	3NOPs
Year	Spring	Autumn	Spring	Autumn	Spring	Spring	Autumn	Spring	Spring	Autumn	Spring	Autumn	Spring	Spring	Autumn	Spring	Spring	Autumn	Spring	Autumn	Spring	Spring	Autumn	Spring
Engel series																								
1971	0		0			0			0		0			0										
1972	354		0		2,707	354		3,061	61		0		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		0		5,051	0		5,051	0		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		8,453	34		1,065		3,078	1,099		4,177	4.85		1.86		2.05	1.95		2.02
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	0		0		2,545	0		2,545	0		0		1,508	0		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	0	2,438	0	11,105	2,794	0	13,899	70	0	574	0	4,186	644	0	4,830	5.09		4.25		2.65	4.34		2.88
1987	44	0	2,752	0	9,866	2,796	0	12,662	95	0	1,114	0	4,438	1,209	0	5,647	0.46		2.47		2.22	2.31		2.24
1988	32	0	5,432	0	13,005	5,464	0	18,469	63	0	690	0	5,533	753	0	6,286	0.51		7.87		2.35	7.26		2.94
1989	0	0	925	0	6,884	925	0	7,809	0	0	251	0	4,130	251	0	4,381			3.69		1.67	3.69		1.78
1990	0	0	754	1784	3,988	754	1,784	4,742	0	0	236	863	2,941	236	863	3,177			3.19	2.07	1.36	3.19	2.07	1.49
1991	0	0	1,039	2805	4,591	1,039	2,805	5,630	0	0	1,118	2,047	3,800	1,118	2,047	4,918			0.93	1.37	1.21	0.93	1.37	1.14
1992	0	22	606	471	3,008	606	493	3,614	0	63	574	448	2,699	574	511	3,273		0.35	1.06	1.05	1.11	1.06	0.96	1.10
1993	0	0	522	748	2,731	522	748	3,253	0	0	301	490	2,559	301	490	2,860			1.73	1.53	1.07	1.73	1.53	1.14
1994	0	0	1,079	1445	2,433	1,079	1,445	3,512	0	0	886	1,341	2,274	886	1,341	3,160			1.22	1.08	1.07	1.22	1.08	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																								
1995		94		4099			4,193			306		5,409			5,715			0.31		0.76			0.73	
1996	4	6	2,020	3960	6,282	2,024	3,966	8,306	75	143	2,982	3,850	8,089	3,057	3,993	11,146	0.05	0.04	0.68	1.03	0.78	0.66	0.99	0.75
1997	4	72	2,221	4192	8,507	2,225	4,264	10,732	91	64	2,987	5,361	12,432	3,078	5,425	15,510	0.04	1.13	0.74	0.78	0.68	0.72	0.79	0.69
1998	7	171	2,205	2896	4,007	2,212	3,067	6,219	79	2,036	2,249	5,079	4,765	2,328	7,115	7,093	0.09	0.08	0.98	0.57	0.84	0.95	0.43	0.88
1999	20	3,028	12,194	4043	8,236	12,214	7,071	20,450	29	83,220	26,010	11,583	8,654	26,039	94,803	34,693	0.69	0.04	0.47	0.35	0.95	0.47	0.07	0.59
2000	30	1,165	15,900	9551	10,294	15,930	10,716	26,224	716	2,875	104,360	22,750	11,743	105,076	25,625	116,819	0.04	0.41	0.15	0.42	0.88	0.15	0.42	0.22
2001	269	946	14,908	10739	8,092	15,177	11,685	23,269	517	1,077	39,384	18,207	13,792	39,901	19,284	53,693	0.52	0.88	0.38	0.59	0.59	0.38	0.61	0.43
2002	96	2,753	10,808	11384	10,118	10,904	14,137	21,022	105	2,126	11,334	13,434	15,098	11,439	15,560	26,537	0.91	1.29	0.95	0.85	0.67	0.95	0.91	0.79
2003	2	**906**	7,981	**13374**	5,762	7,983	14,280	13,745	35	**748**	7,250	**10,628**	6,904	7,285	11,376	14,189	0.06	**1.21**	1.10	**1.26**	0.83	1.10	**1.26**	0.97
2004	33	**1,847**	10,369	**2237**	6,622	10,402	4,084	17,024	53	**2,084**	8,477	**1,492**	6,977	8,530	3,576	15,507	0.62	**0.89**	1.22	**1.50**	0.95	1.22	**1.14**	1.10

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

Sex	**Source**	**L_∞**	**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. Catch rates of white hake in Canadian gillnet, longline, and trawl fisheries on the Grand Banks. The last 3 columns (highlighted in yellow) show catch rates averaged across all fisheries, in fisheries where white hake was reported as by-catch, and where white hake was reported as the directed species. Blue columns highlight key directed fisheries where white hake was taken as by-catch. Data for gillnets are in tonnes/net; for longlines are in tonnes/hook; and for trawls are in tonnes/hour.

Gillnet	Cod	Flat ns	GF_unsp	Haddock	Halibut	Monkfish	Plaice	Skates	Turbot	Unspec	Witch	Y_Tail	All fisheries	Other	Directed
1991	0.0004	0.0000	0.0013				0.0000		0.0000				0.0137	0.0007	0.0137
1992	0.0009	0.0000	0.0100				0.0017		0.0003				0.0193	0.0037	0.0193
1993	0.0001		0.0003		0.0000	0.0000	0.0000		0.0001					0.0001	
1995			0.0165		0.0000		0.0000	0.0001		0.0000			0.0089		0.0089
1996	0.0001		0.0017		0.0002	0.0004				0.0000			0.0111		0.0111
1997			0.0028	0.0016	0.0000	0.0004	0.0000						0.0054		0.0054
1998					0.0000	0.0008	0.0000			0.0000					
1999					0.0019	0.0008		0.0012	0.0002				0.0116		0.0116
2000					0.0008	0.0009		0.0017		0.0000					
2001					0.0010	0.0018		0.0007		0.0000			0.0241		0.0241
2002					0.0006	0.0005		0.0005	0.0000	0.0000			0.0232		0.0232
2003					0.0001	0.0006	0.0001	0.0005	0.0001	0.0000			0.0231		0.0231
2004	0.0034			0.0000	0.0002	0.0045	0.0000	0.0005	0.0004	0.0000			0.0833	0.0021	0.0833

Longline	Cod		GF_unsp	Haddock	Halibut	Monkfish	Plaice	Skates	Turbot	Unspec	Witch	Y_Tail	All fisheries	Other	Directed
1991	0.0000				0.0692				0.0000						
1992			0.1362		0.0000				0.0000				0.0907	0.1279	0.0907
1993	0.0071		0.0563		0.0026								0.0540	0.0150	0.0540
1995			0.1563	0.0111	0.0000			0.1073		0.0000			0.2330	0.1042	0.2330
1996			0.0387						0.0141						0.0007
1997				0.0000	0.0000			0.0000							0.0001
1998				0.0000	0.0000			0.0001	0.0000				0.0007		
1999					0.0000				0.0000	0.0000			0.0001		0.0002
2000									0.0000						0.0003
2001					0.0032		0.0000		0.0000				0.0002		0.0002
2002					0.0000				0.0000				0.0003		0.0010
2003					0.0000			0.0001	0.0000				0.0002		
2004					0.0004			0.0001	0.0000				0.0010		

Trawl	Cod	Flat ns	GF_unsp	Haddock	Halibut	Monkfish	Plaice	Skates	Turbot	Unspec	Witch	Y_Tail	All fisheries	Other	Directed
1991	0.0014	0.0006	0.0009	0.0004			0.0025		0.0000	0.0000	0.0007	0.0003	0.0846	0.0018	0.0846
1992	0.0010	0.0010	0.0005	0.0001			0.0004		0.0000		0.0025	0.0000		0.0008	
1993	0.0033	0.0049	0.0020				0.0016		0.0000		0.0064	0.0002		0.0032	
1994															
1995			0.0000						0.0000						
1996			0.0000					0.0000	0.0000		0.0019			0.0006	
1997	0.0000								0.0000	0.0000	0.0052				
1998	0.0004			0.0000			0.0017	0.0004	0.0000	0.0091	0.0083	0.0000		0.0010	
1999	0.0073						0.0000	0.0001			0.0755	0.0030		0.0087	
2000	0.0651							0.0000	0.0000		0.0992				
2001	0.0601						0.0087	0.0015	0.0000		0.1292	0.0001	0.0000	0.0098	0.0846
2002	0.0068						0.0000	0.0001	0.0000		0.0690	0.0001		0.0029	0.0000
2003					0.0000		0.0000	0.0000	0.0000		0.0814	0.0000			
2004	0.0335							0.0448	0.0000		0.0301	0.0000		0.0043	

Table 8. Catch rates of white hake in Canadian gillnet, longline, and trawl fisheries on the Grand Banks by fleet: <65 feet fixed gear and mobile gear; 65-100 feet fixed gear and mobile gear; and >100 feet fixed gear and mobile gear. Data for gillnets are in tonnes/net; for longlines are in tonnes/hook; and for trawls are in tonnes/hour.

Gillnet	< 65ft fxd gr	> 100ft fxd gr	65-100ft fxd gr
1991		0.0022	0.0001
1992		0.0080	0.0031
1993		0.0001	0.0001
1995			
1996		0.0001	0.0011
1997		0.0000	
1998		0.0000	0.0000
1999		0.0012	0.0014
2000		0.0005	
2001		0.0007	0.0022
2002		0.0003	
2003		0.0002	0.0002
2004	0.0108	0.0002	0.0004

Longline	< 65ft fxd gr	> 100ft fxd gr	65-100ft fxd gr
1991		0.0643	
1992		0.2217	0.0165
1993			0.0196
1995	0.0947	0.0000	0.1629
1996			
1997			
1998		0.0000	0.0003
1999			
2000		0.0000	
2001		0.0000	
2002		0.0000	0.0002
2003		0.0000	0.0000
2004		0.0000	0.0003

Trawl	< 65ft mbl gr	> 100ft mbl gr	65-100ft mbl gr
1991		0.0020	0.0068
1992		0.0008	
1993		0.0033	
1994			
1995		0.0000	
1996	0.0000	0.0017	
1997		0.0051	0.0000
1998	0.0015	0.0020	0.0000
1999	0.0001	0.0316	0.0000
2000	0.0229	0.0367	
2001	0.0104	0.0320	0.0005
2002	0.0019	0.0105	0.0007
2003	0.0000		0.0000
2004	0.0091	0.0038	0.0754

Table 9. Reported landings of white hake by NAFO Division and country (Canada *versus* other countries), 1985-2004.

	3N			3O			3NO		3Ps	3NOPs
Year	Can	non-Can	All	Can	non-Can	All	STATLANT 21A	STACFIS	Can	Can - non-Can
1985	101	1,542	1,643	3,301	3,185	6,486	8,129	8,129	1,138	9,267
1986	297	21	318	1,980	1,252	3,232	3,550	3,550	890	4,440
1987	1,314	4,019	5,333	1,740	990	2,730	8,064	8,064	1,314	9,378
1988	828	867	1,695	1,115	111	1,226	2,921	2,921	699	3,619
1989	878	5	883	1,169	23	1,192	2,075	2,075	699	2,774
1990	830	228	1,058	1,226	7	1,233	2,291	2,291	1,479	3,771
1991	19	1,507	1,526	1,087	0	1,087	2,613	2,613	1,444	4,058
1992	18	0	18	1,640	0	1,640	1,658	1,658	1,208	2,866
1993	19	0	19	1,035	0	1,035	1,054	1,054	732	1,786
1994	16	20	36	1,977	4	1,981	2,017	2,017	383	2,400
1995	0	5	5	216	1	217	222	222	396	618
1996	0	28	28	490	1	491	519	519	565	1,084
1997	0	92	92	489	6	495	587	587	407	994
1998	0	81	81	133	8	141	222	222	499	722
1999	44	51	95	314	13	327	422	422	570	992
2000	21	124	145	404	29	433	578	578	1,109	1,688
2001	16	52	68	516	49	565	633	633	929	1,562
2002	0	1,220	1,220	1,013	3,133	4,146	5,366	5,401	871	6,237
2003	0	2,688	2,688	433	3,053	3,486	6,174	5,083	1,057	7,231
2004	5	69	74	386	775	1,161	1,225	1,225	1,255	2,489

Table 10. Commercial length frequency statistics for white hake catches, 2000-2004.

	Can 3O-GN				Can 3O-LL			Can 3O-OT			Spain 3NO-OT		Portugal 3NO-OT		Russia 3O-OT		Russia 3NO-OT		
	2001	2002	2003	2004	2001	2002	2004	2002	2003	2004	2002	2004	2003	2004	2000	2001	2002	2003	2004
length	number	number	number	number	number	number	number	number	number	number	number	number	number	number	number	number	number	number	number
15																			
16																			
17																			
18																			
19													1						
20																			
21															3		1	165	
22																			
23																			
24													1		24	1	8	240	
25																			
26														1					
27													1		137	2	33	314	
28														1					
29													3	1					
30													1	1	96	3	50	424	3
31											393		6	1					
32		1										69	7	6					
33		2									297		11	1	26		68	496	
34	1												14	16					
35											165	69	15	26					
36	2	1									393	69	28	35	27	12	91	310	2
37	1										958		41	47					
38	3										1,579		70	48					
39	2										2,677		77	46	76	45	230	84	7
40	1	1							1		4,471	69	101	90					
41	1	2							1		6,812	69	123	77					
42	2	3						1	2		10,179	206	144	93	111	47	850	74	31
43	5	1							2		15,782		151	136					
44	4	2			1				2		17,332	138	141	115					
45	1	6						3	2		21,208	69	138	123	139	58	2,172	288	55
46		12						1	13		23,496		151	133					
47	1	6			2	1	1	1	15		23,249	137	128	148					
48	2	5			2	2	4	4	13		17,941	69	139	92	137	40	2,919	851	139
49	4	9			3		9	3	22	1	14,886	412	111	143					
50	3	7			3	2	9	8	18		13,681		86	84					
51	2	12			3	2	21	9	26		9,358	344	55	71	89	51	2,284	1,072	130
52	6	5	1	1	1		33	9	22		8,067	481	49	69					
53	2	7	1	2	4		21	9	45		7,641	550	31	71					
54	7	15	3	4	2	1	37	10	39		5,647	1,375	33	29	70	32	1,430	951	138
55	6	15	5	3	2		30	19	31		4,357	618	21	46					
56	3	11	7	2	2	1	51	16	9	1	4,110	343	17	46					
57	7	5	4	6	2	3	57	18	11		3,386	756	18	29	33	34	878	648	143
58	6	8	10	5	4	3	62	27	21	1	2,361	824	16	34					
59	9	13	8	2	1	4	53	16	10	1	1,602	412	9	29					
60	11	23	6	6	2	2	63	15	21	1	1,520	481	12	21	23	25	564	402	132
61	13	23	7	3	1	6	69	16	8	1	1,172	206	8	9					
62	12	32	11	10	4	4	61	24	10	1	618	756	6	16					
63	20	40	10	11		3	49	24	7		1,082	138	2	10	18	18	382	223	132
64	18	43	21	15	1	2	47	14	8	1	997	550	3	11					
65	27	42	22	13	3	5	64	14	5	1	406	206	3	9					
66	24	76	16	29	3	3	44	20	3		297	344	4	7	24	4	274	109	83
67	35	89	19	29	2	3	42	14	3		1,081	206	3	4					
68	39	94	14	34	3	2	47	31	1		517	206	3	3					
69	30	104	20	34	4	1	42	9	2		515		2	5	13	6	175	83	62
70	35	145	25	40	2	1	35	24	1		327	137	3	8					
71	42	145	27	54	4	5	21	15			326	137	2	1					
72	26	142	19	48	2	3	14	23	1		515	137	2	1	4	2	123	35	23
73	21	140	25	49	5	1	12	8			109	69	2	1					
74	26	154	38	31	4		6	16	1		82		1	2					
75	19	132	30	35	4	4	15	10				69	1	2	2		103	48	6
76	25	135	35	35	2		8	14						1					
77	21	100	19	14	2	3		6	1				1	1					
78	13	103	20	29	2	2	1	6						1	3	1	51	29	4
79	18	77	16	14		2	10	3											
80	16	65	20	12	1		4	2						1					
81	8	45	16	11	1	2	1	8								1	43	13	2
82	8	40	13	8	1	3	2	2				69							
83	3	26	14	4		3	3		1		218								
84	8	19	9	7	3	1											13	18	
85	7	24	5	2	2	1		2					1	1					
86	6	18	3	3			1												
87	9	14	3		5	1	1						1			2	11	10	
88	5	9	2	1	2	1			1										
89	5	7				3		1											
90	3	3	2														2	6	
91	11	3	1																
92	2	2			1		1												
93	6	4			1												1	2	
94	3	4		1	1														
95	4	6	1		1														
96	4	6			1												5	1	
97	2	2	2																
98	2	3	2		1														
99	1	3	2													1	4	1	
100	1	5																	
101		3																	
102		2																	
103		1																	
104		2				1													
105						1													
106		3																	
107						1													
108																			
109		1	1																
110																			

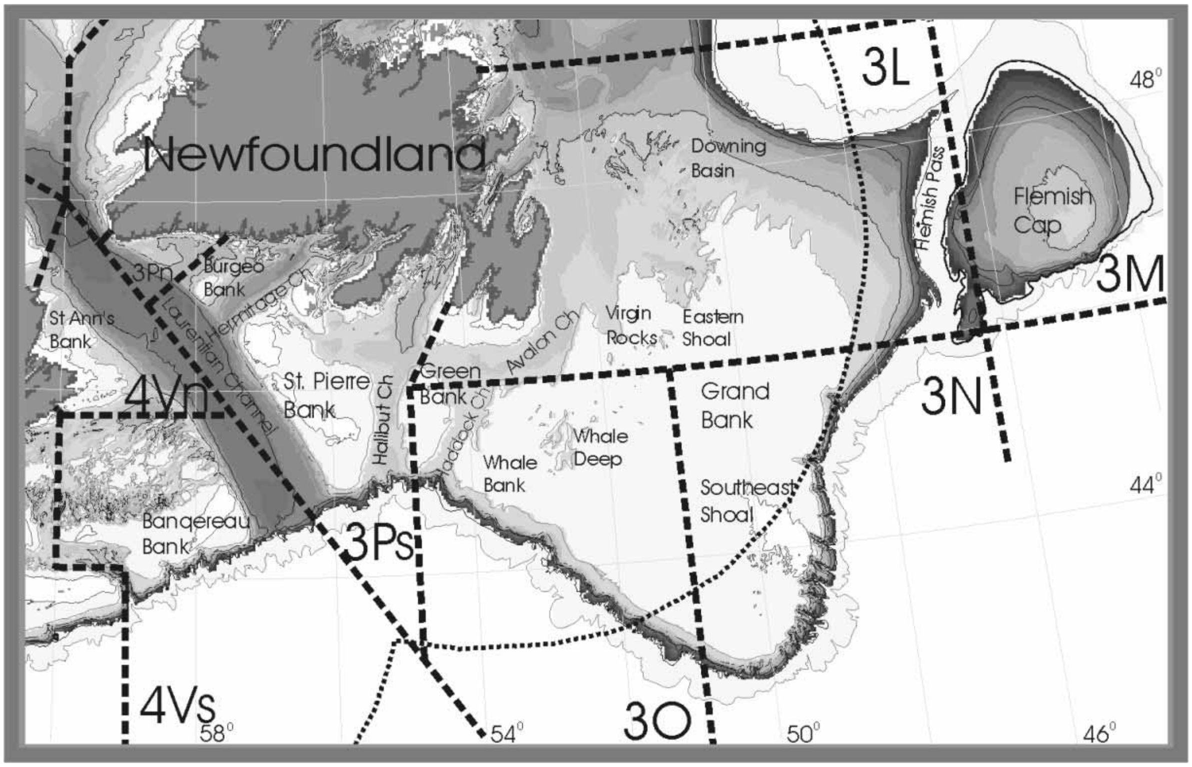


Fig. 1. Map of the Grand Banks showing various banks, basins, and NAFO Divisions. Thick dotted lines delineate NAFO Divisions. The thin dotted curved line shows Canada's 200-mile-limit: delineating Canadian territory from the NAFO Regulatory Area.

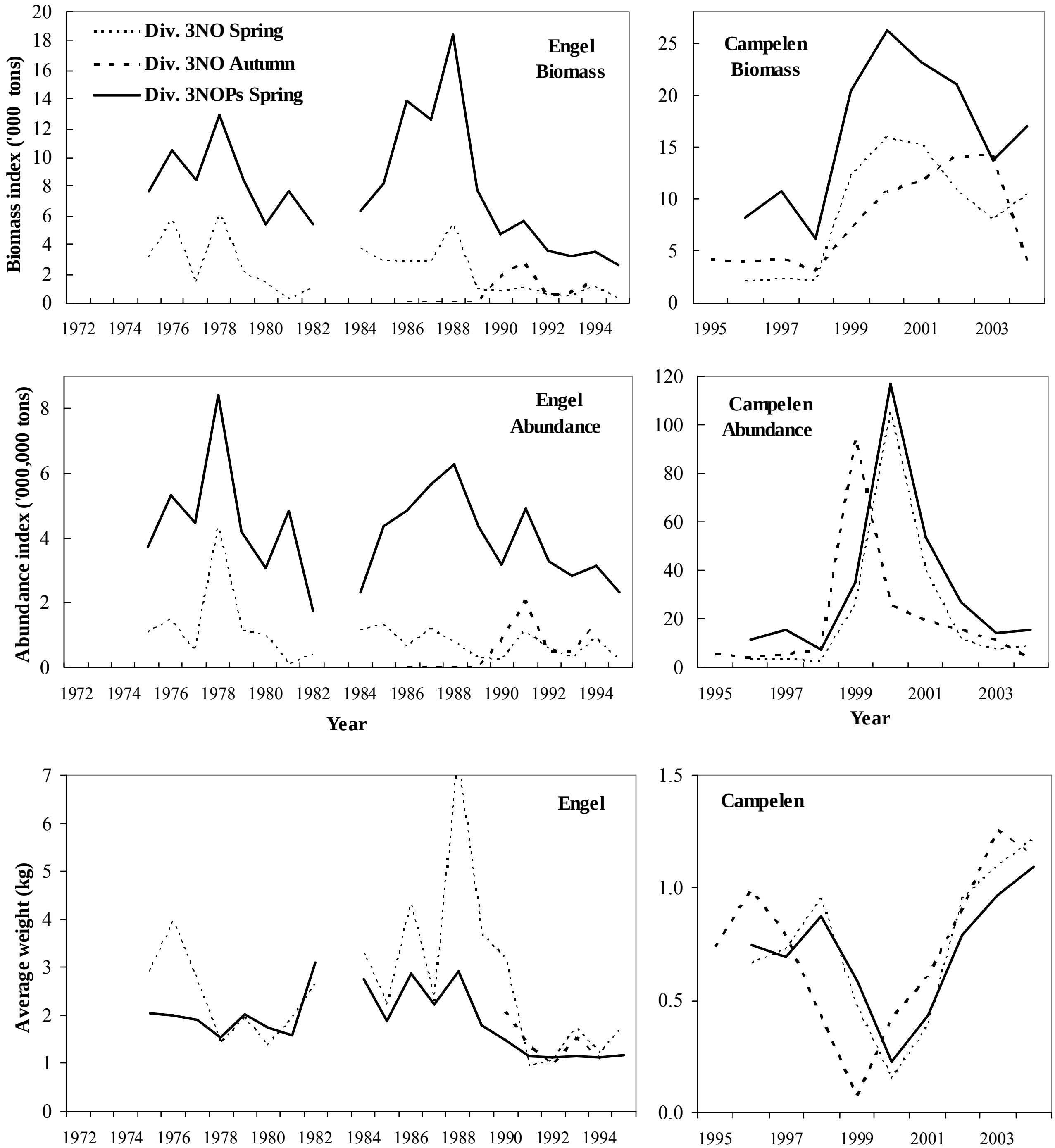


Fig. 2a. Canadian spring and autumn research survey biomass and abundance indices, and average weights for white hake in NAFO Divisions 3N, 3O, and Subdivision 3Ps, 1972-2004. Both time series are unstandardized. See Table 1 for an inventory of areas not surveyed.

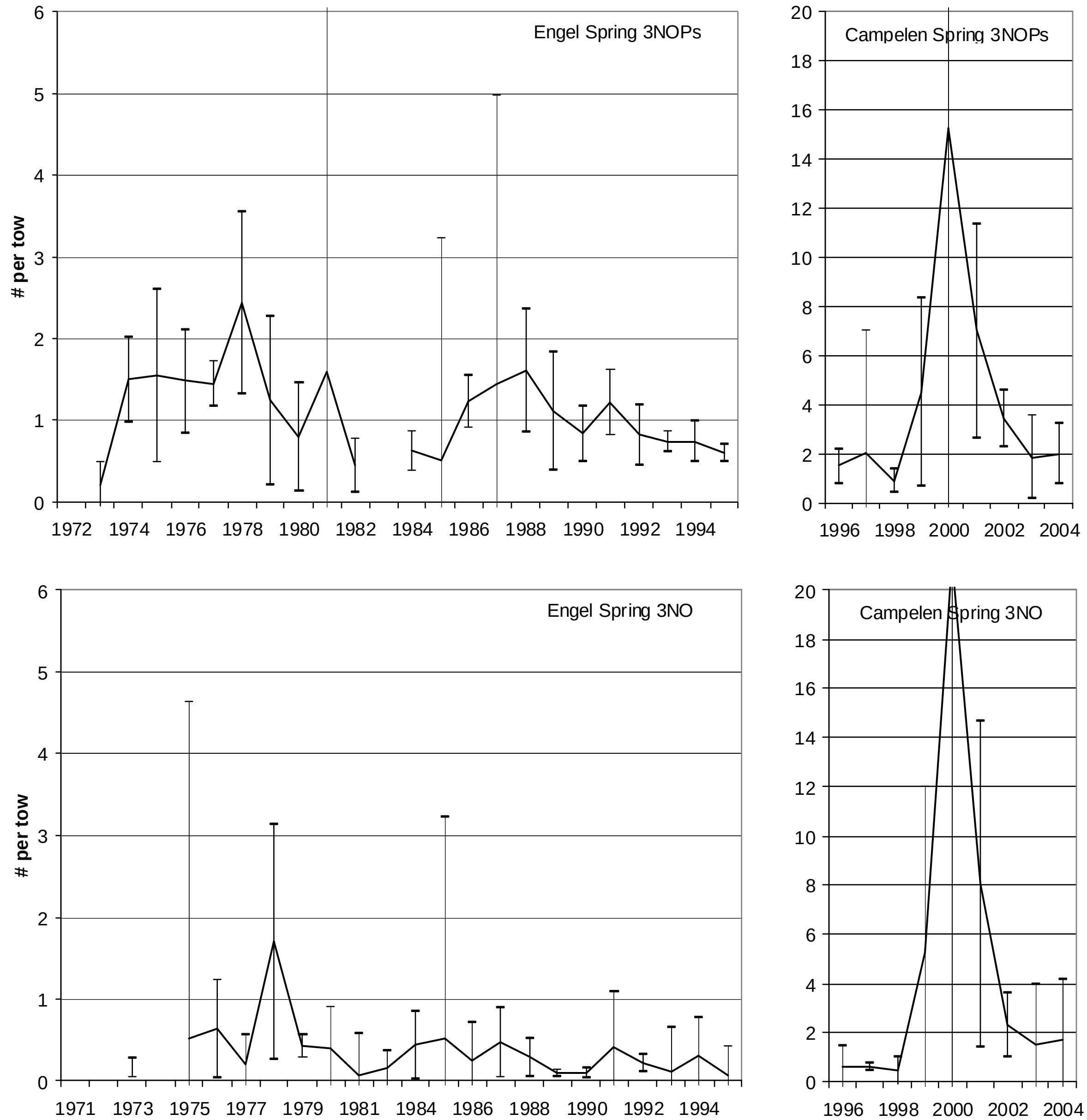


Fig. 2b. Kg per tow of white hake from Canadian spring research surveys in NAFO Divisions 3N, 3O, and Subdivision 3Ps, 1972-2004. Both time series are unstandardized. See Table 1 for an inventory of areas not surveyed.

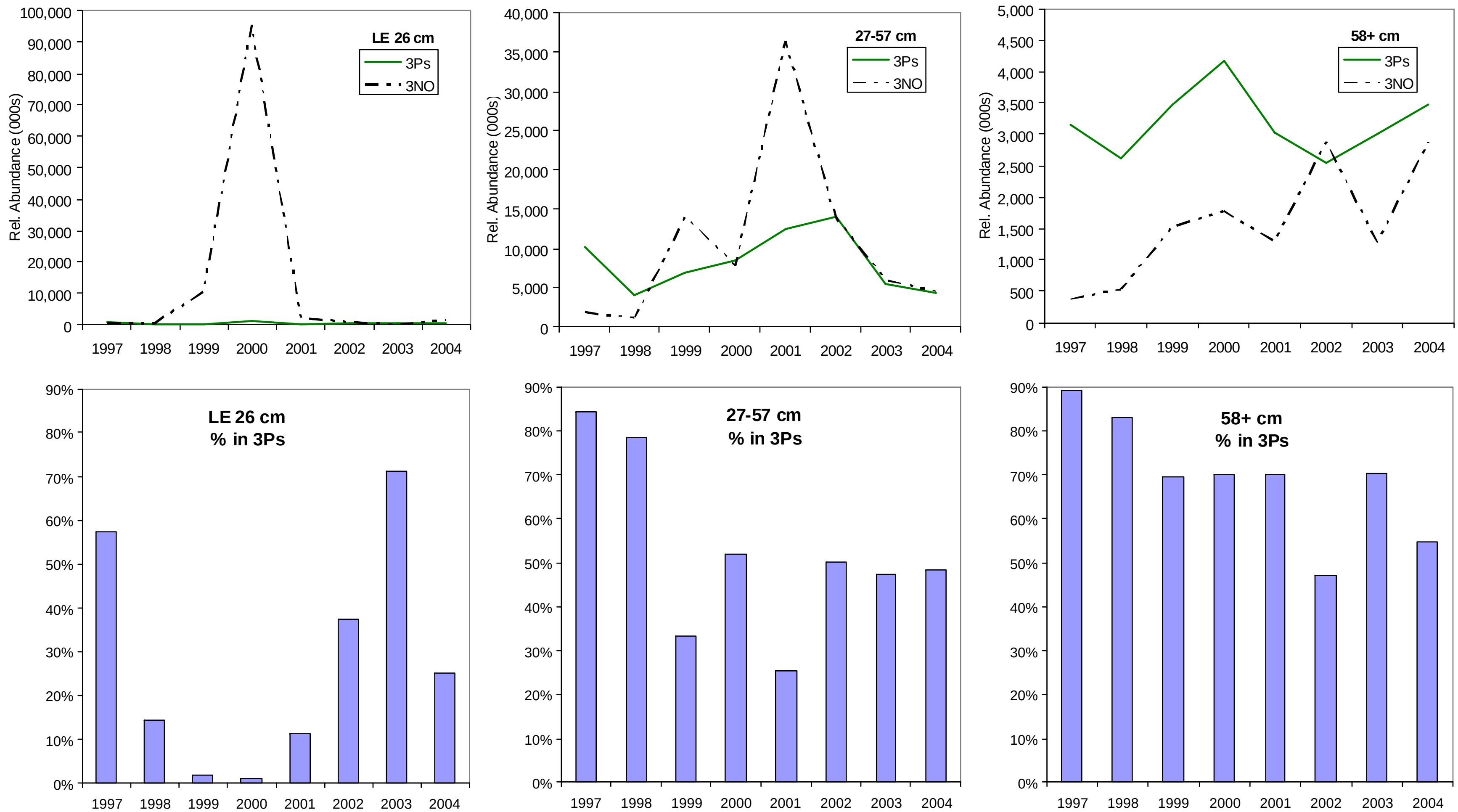


Fig. 2c. Relative abundance of white hake by life stage, 1997-2004: Less than or Equal to 26 cm is mainly year-class-1; 27-57 cm contains mainly juveniles; and 58+ cm is mainly mature fish. Upper panel: Relative abundance (000s). Lower panel: Percent in NAFO Subdivision 3Ps.

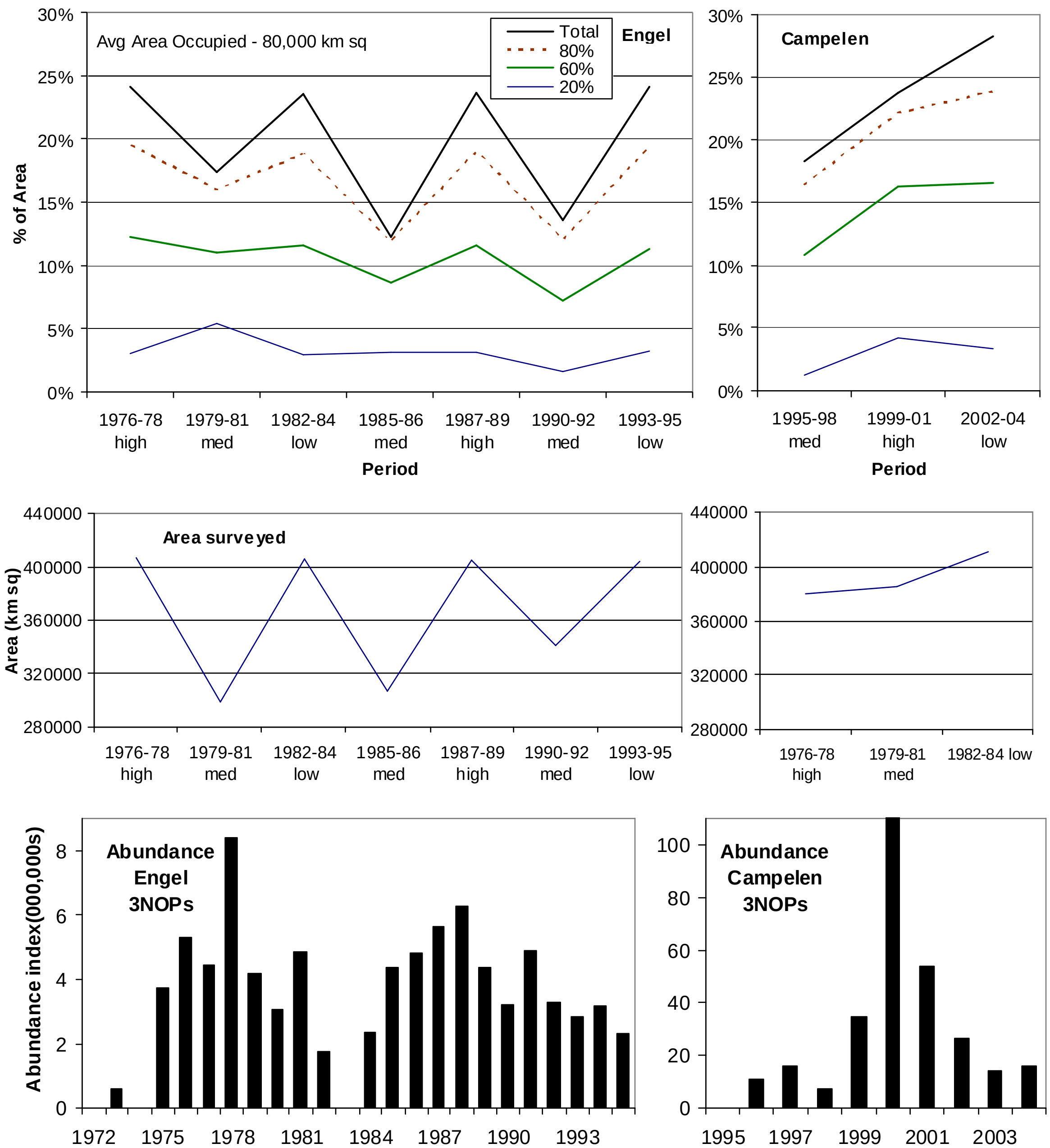


Fig. 3. Upper panel: Percent of total surveyed area occupied by white hake on the Grand Banks. 20% refers to 29% of the area where the density (kg per tow) of white hake was greatest. Middle panel: Total area surveyed during the spring research vessel survey. Lower panel: Abundance of white hake in NAFO Div. 3NO and Subdiv. 3Ps; based on spring surveys, 1972-2004. Both time series are unstandardized.

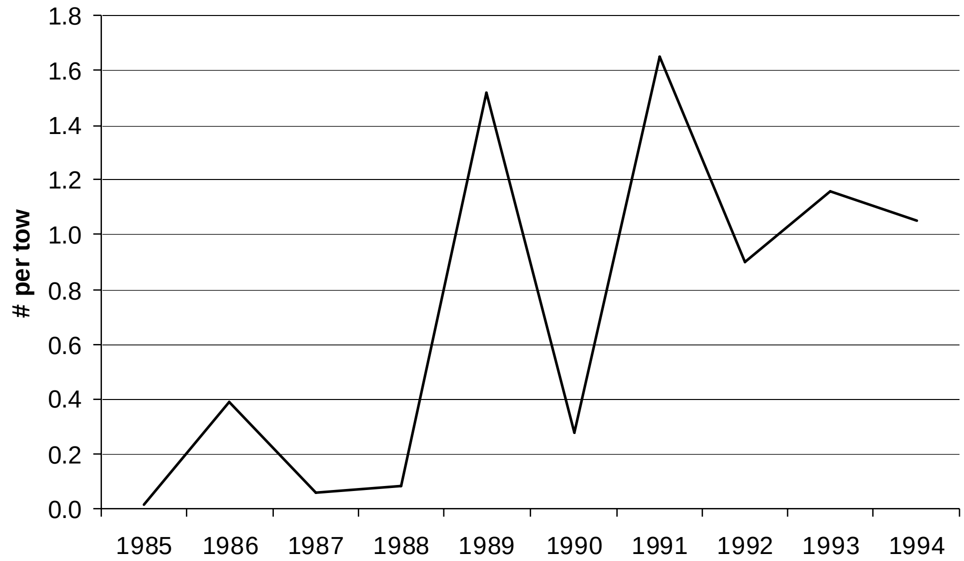


Fig. 4. Canadian juvenile research survey in 1985-1994: numbers per tow. This survey series was not spatially consistent.

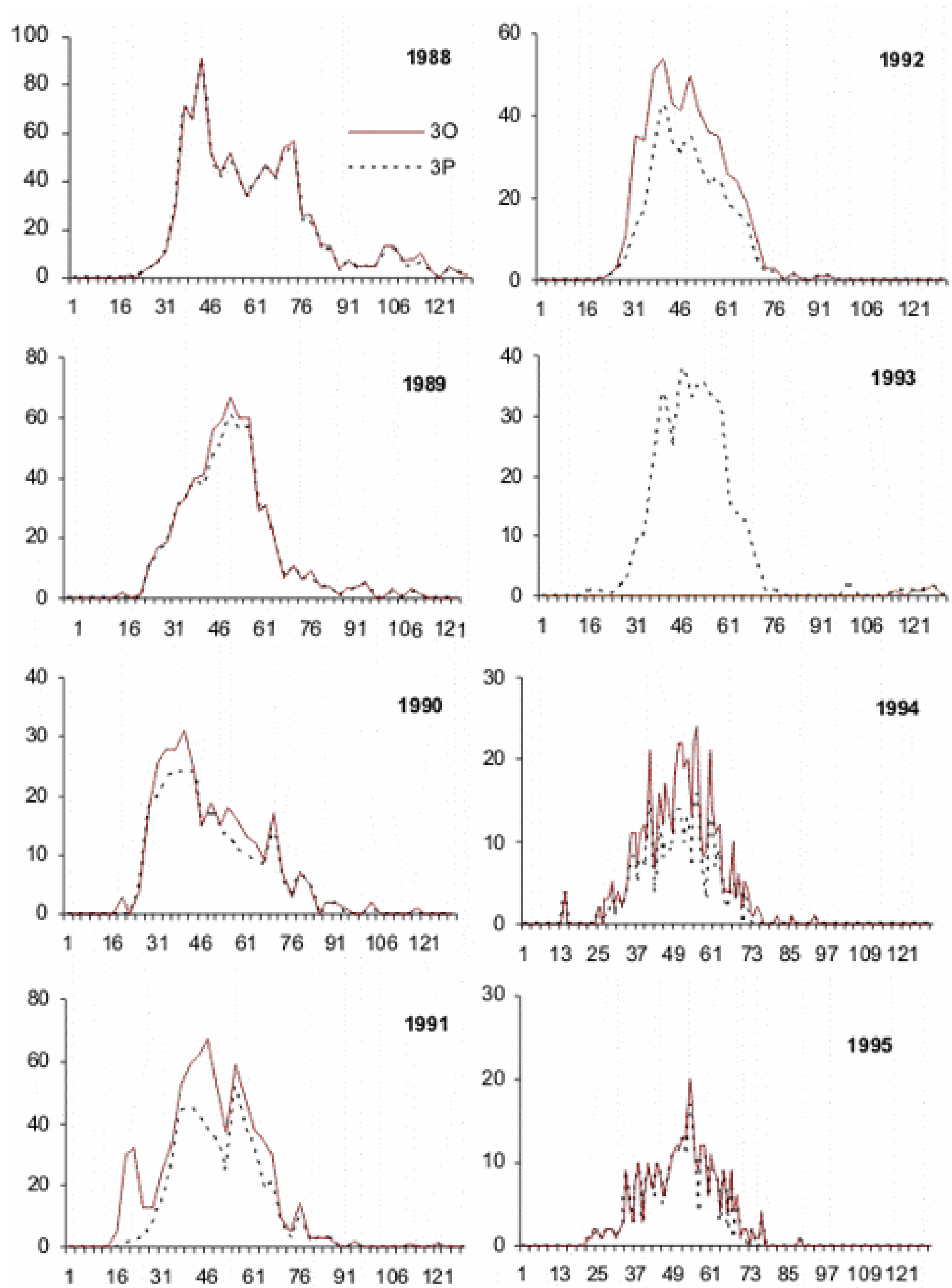


Fig. 5a. Number of white hake at length (in cm on X-axis) from Canadian spring research surveys in NAFO Div. 3O and Subdiv. 3Ps, 1988-1995.

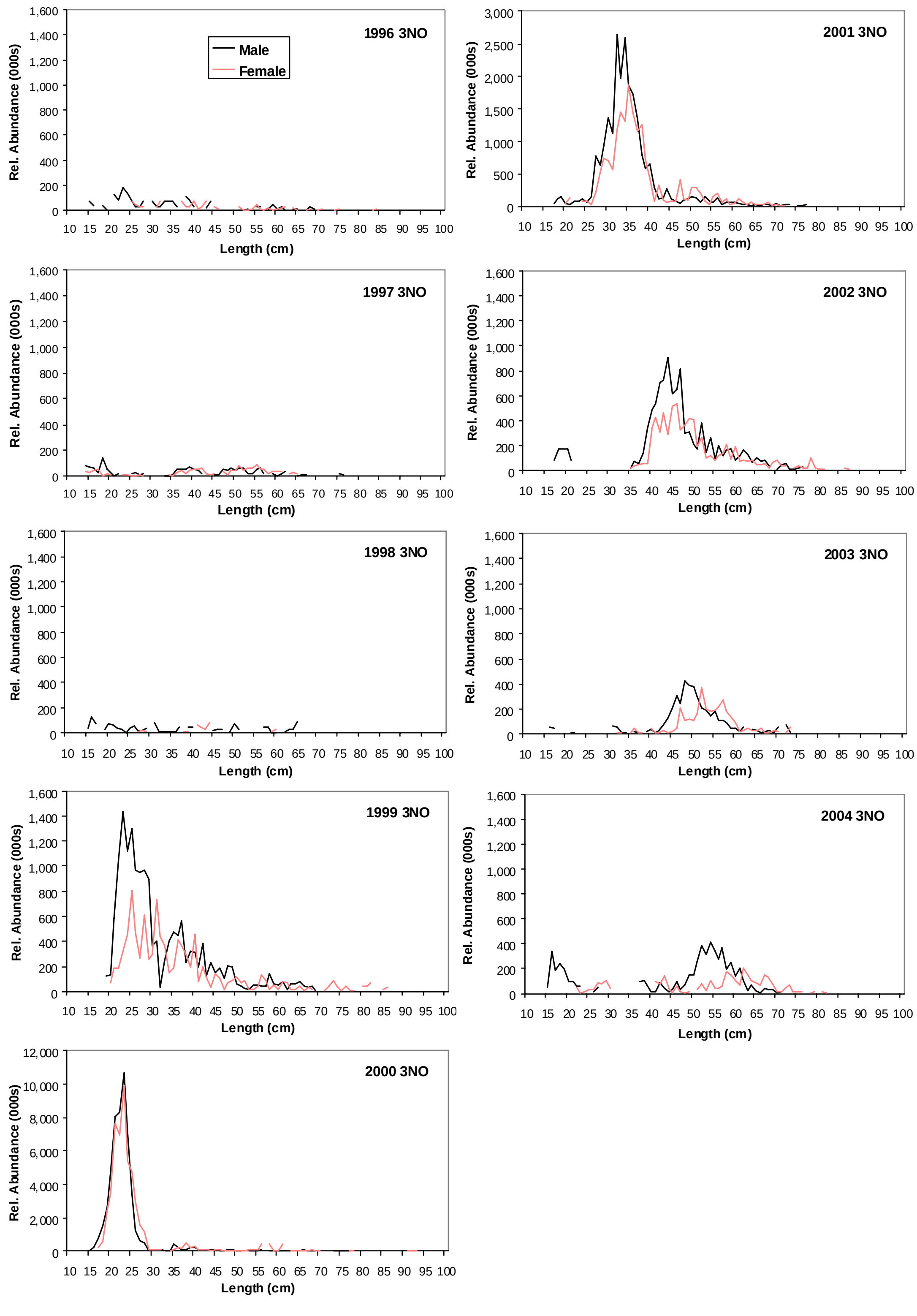


Fig. 5b. Relative abundance at length of male and female white hake from Canadian spring research surveys in NAFO Div. 3NO, 1996-2004.

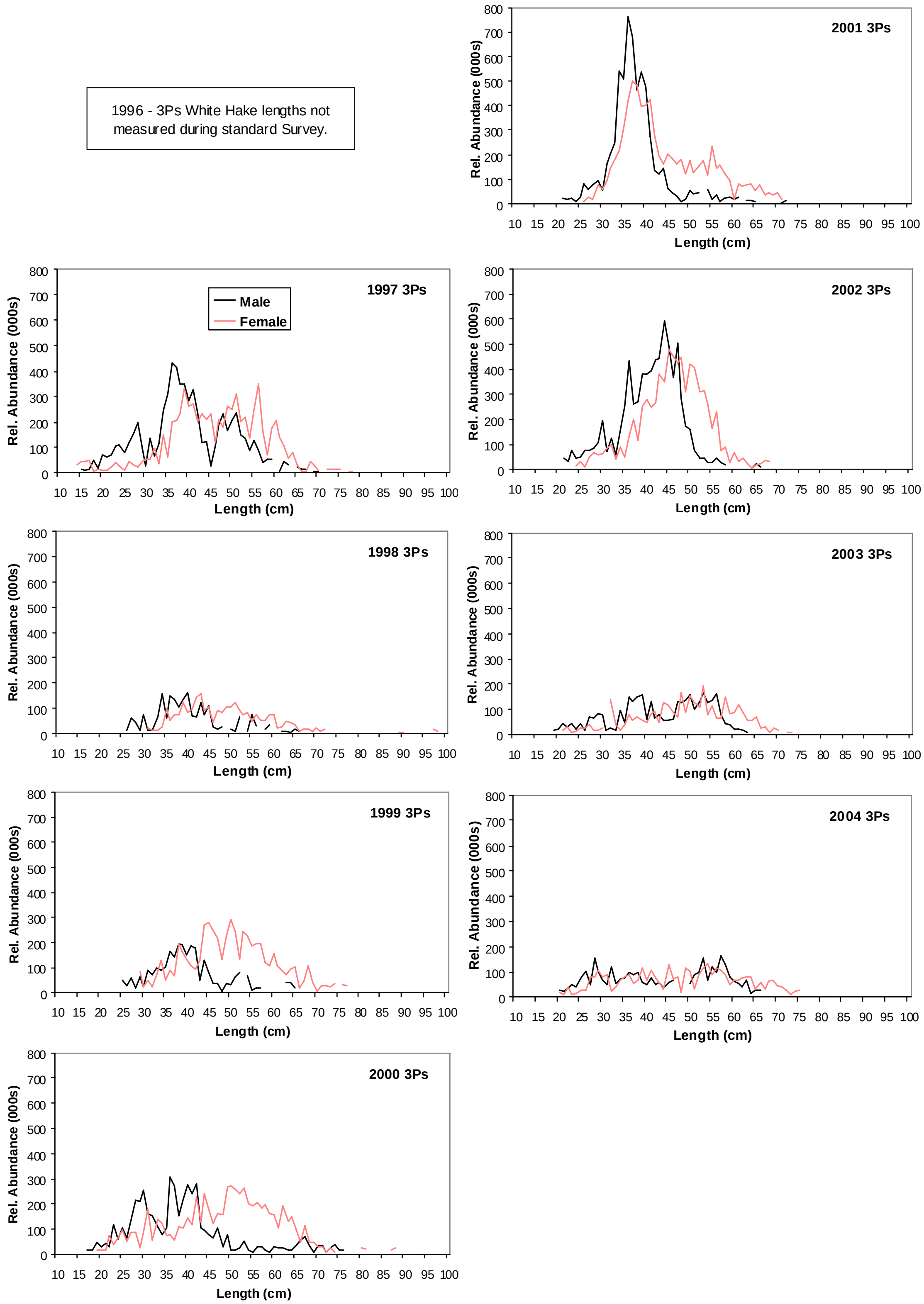


Fig 5c. Relative abundance at length of male and female white hake from Canadian spring research surveys in NAFO Subdiv. 3Ps, 1997-2004.

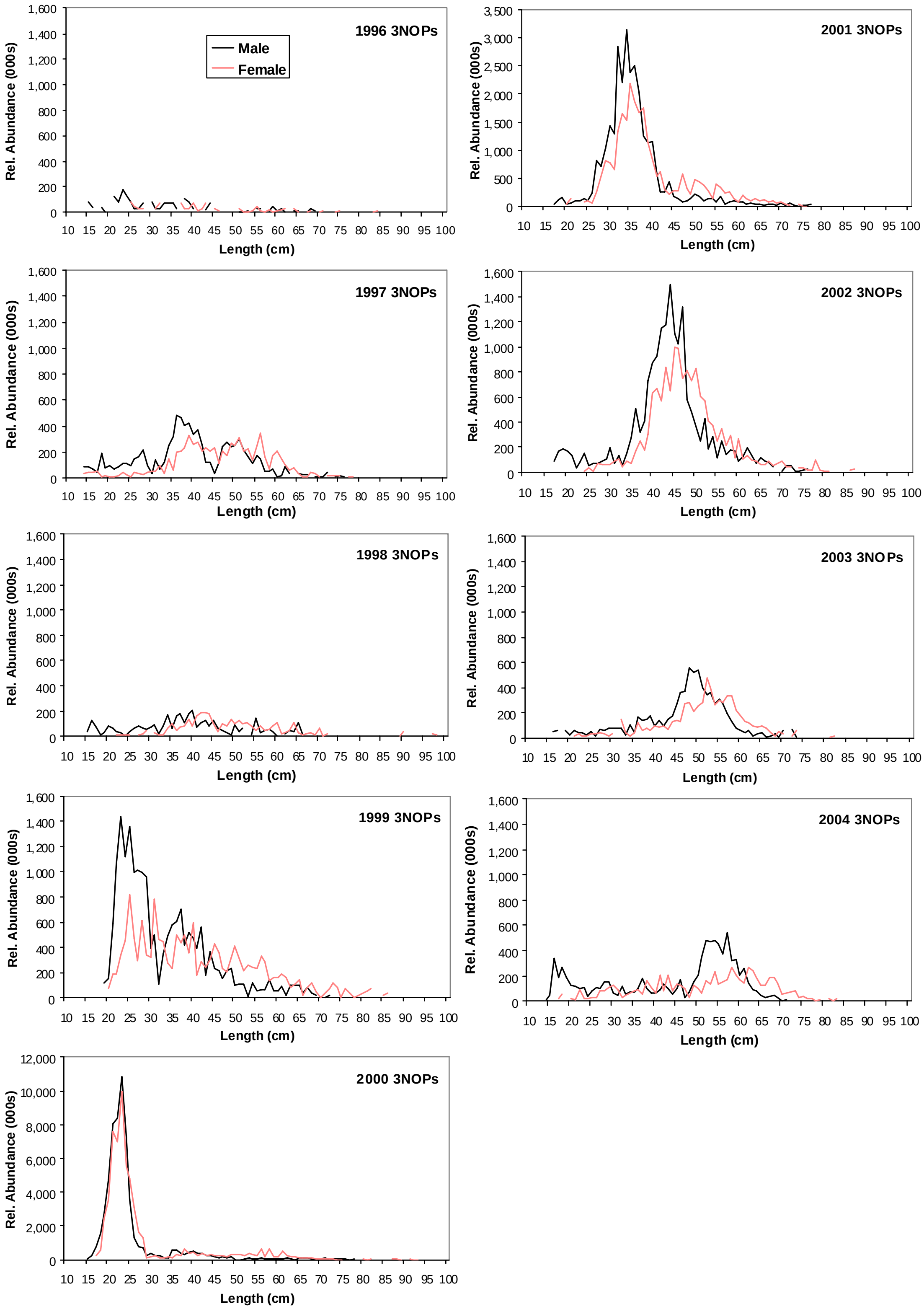


Fig. 5d. Relative abundance at length of male and female white hake from Canadian spring research surveys in NAFO Div. 3NO and Subdiv. 3Ps, 1996-2004.

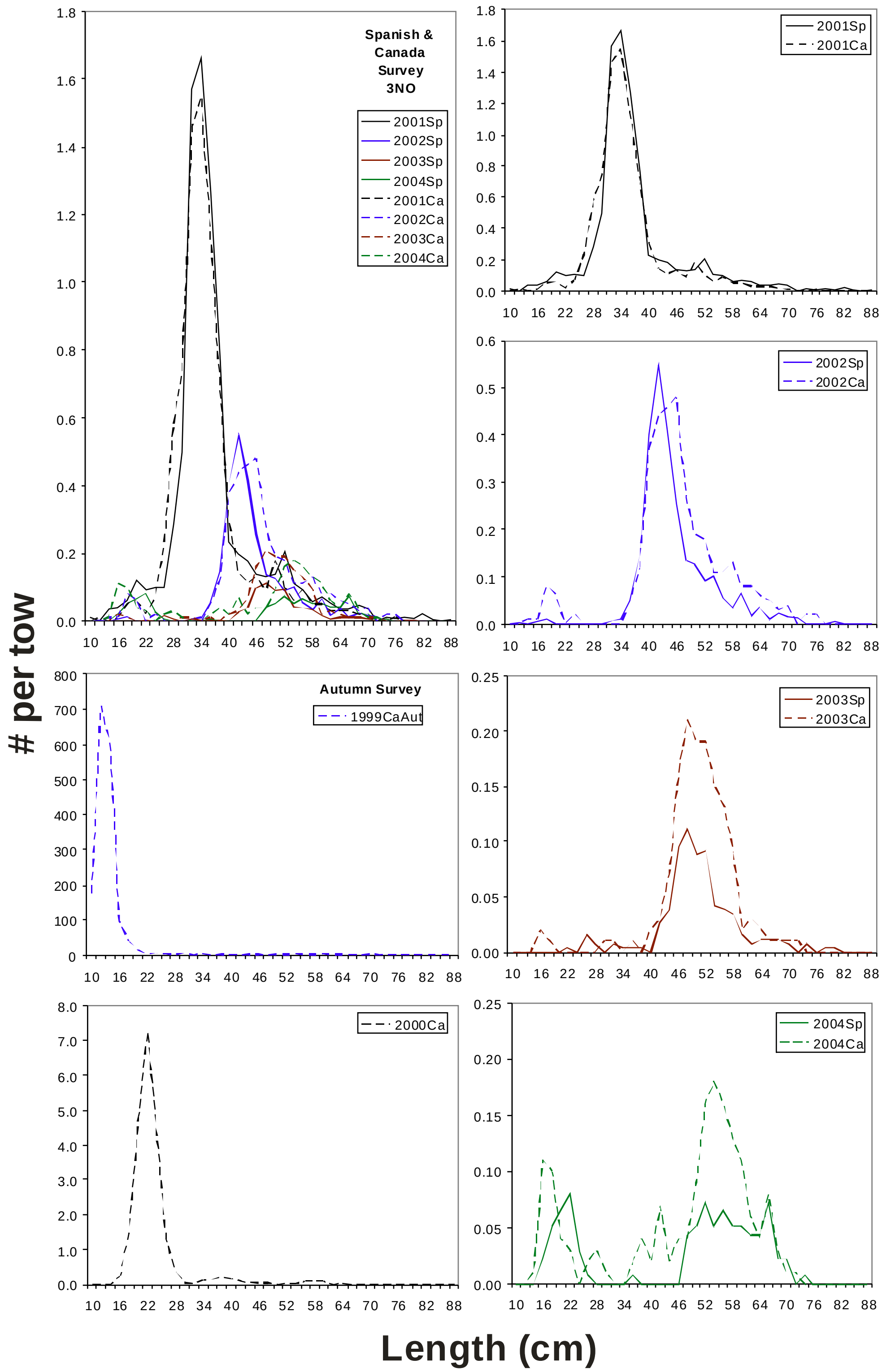
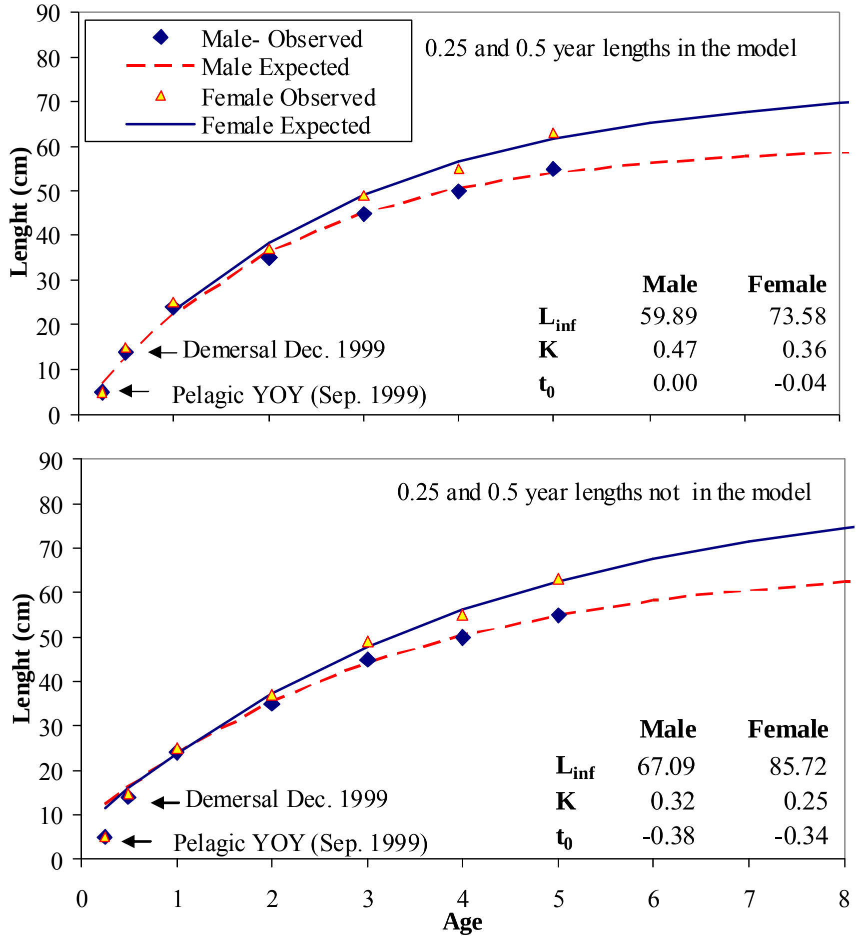


Fig. 5e. Abundance at length from Canadian Campelen and Spanish Campelen spring research surveys in NAFO Div. 3NO (outside Canada's 200-mile-limit for Spanish surveys), 1999-2004. Number per tow was calculated using mean catches.



Fig/ 6. Von Bertalanffy growth curves by sex for the 1999 year-class based on preliminary data. **Upper**: Observed size at age was derived from mean length of the mode of the 1999 year-class at age 1 through 5 (2000 to 2004). **Lower**: The length at age 0.25. and age 0.5 was included in the model. Annual values of length were taken from spring (Apr.-Jun.) surveys.

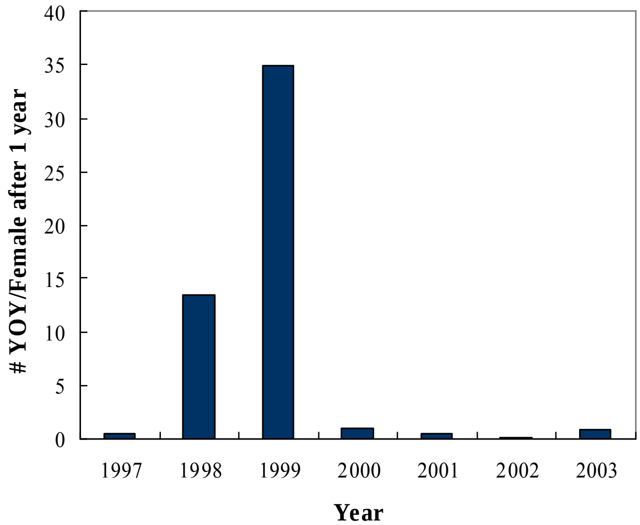


Fig. 7. Recruit per spawner expressed as number of young-of-the-year males and females (YOY produced per female) from Canadian Campelen spring surveys in NAFO Div. 3NO and Subdiv. 3Ps, 1997-2003.

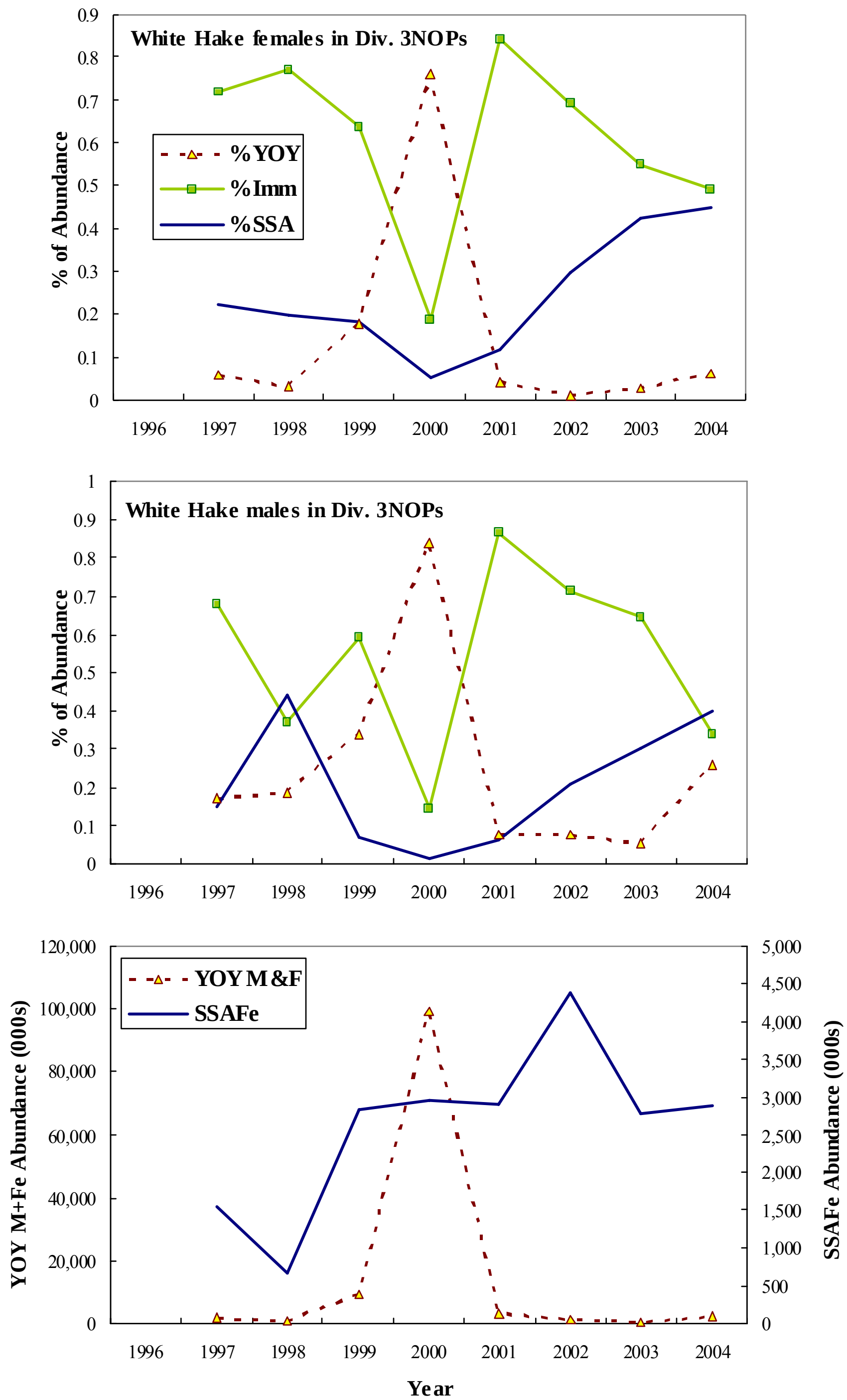


Fig. 8. Staged trends in relative abundance of young-of-the-year (YOY) and female spawning biomass (SSAFe) from Canadian Campelen spring surveys in NAFO Div. 3NO and Subdiv. 3Ps, 1996-2004.

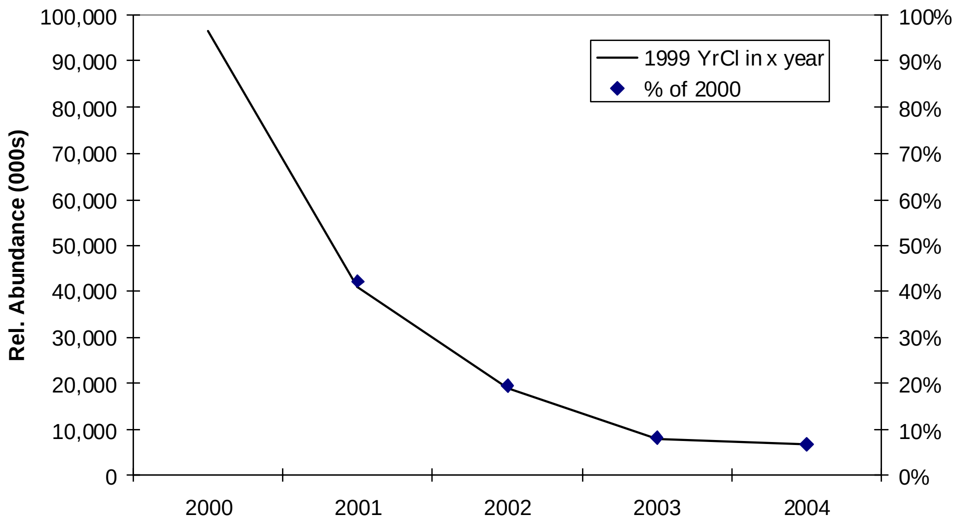


Fig. 9. Change in the relative abundance of the 1999 year-class, estimated by modal analysis, 2000 to 2004.

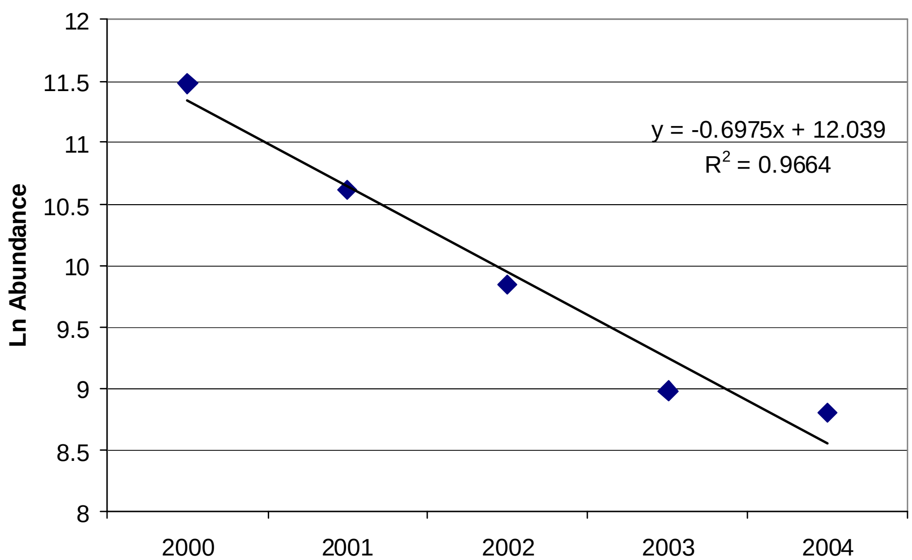


Fig. 10. Ln Abundance of the 1999 year-class 2000-2004. Slope is Z for 2000-2003.

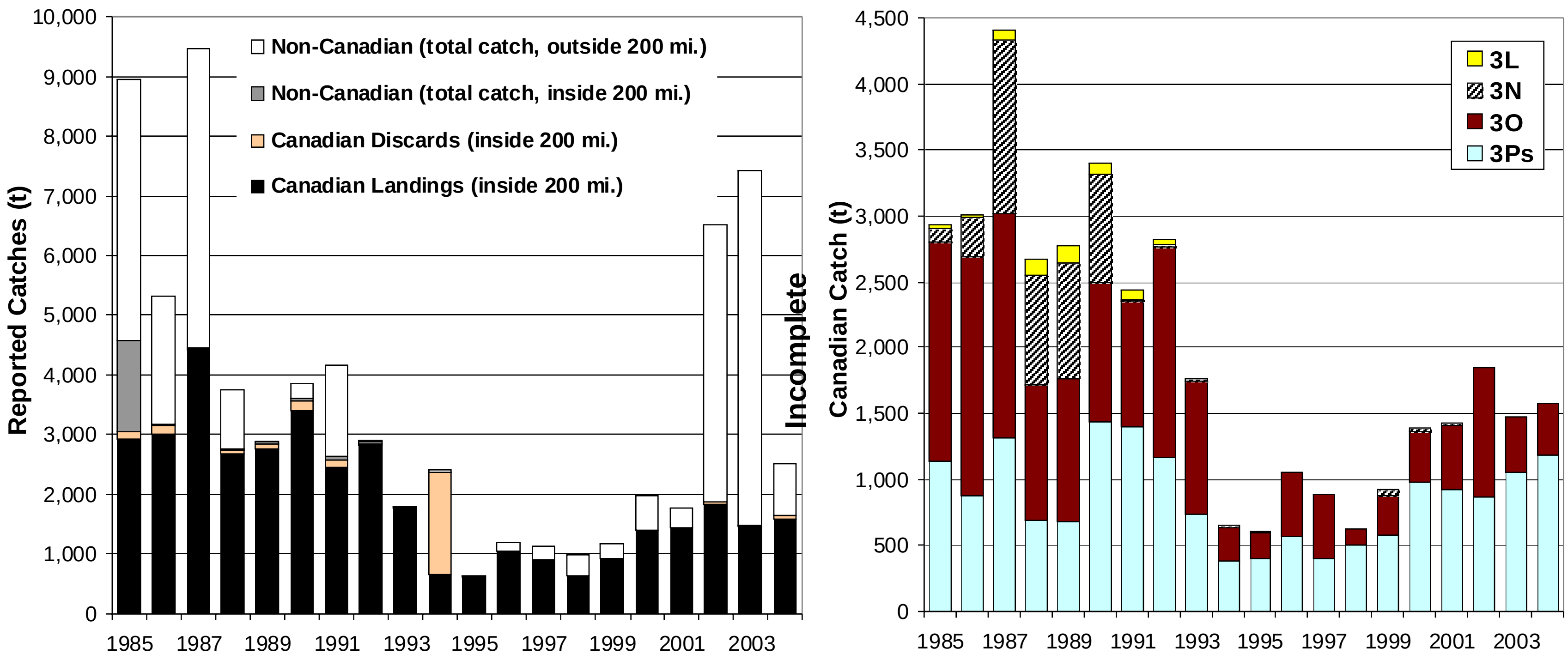


Fig. 11. Landings of white hake in NAFO Divisions 3LNO and Subdivision 3Ps, 1985-2004. Canadian landings were tabulated from ZIF, non-Canadian landings were collated from NAFO statistics for years prior to 2002, and from STACFIS since. The 2004 statistics are preliminary.

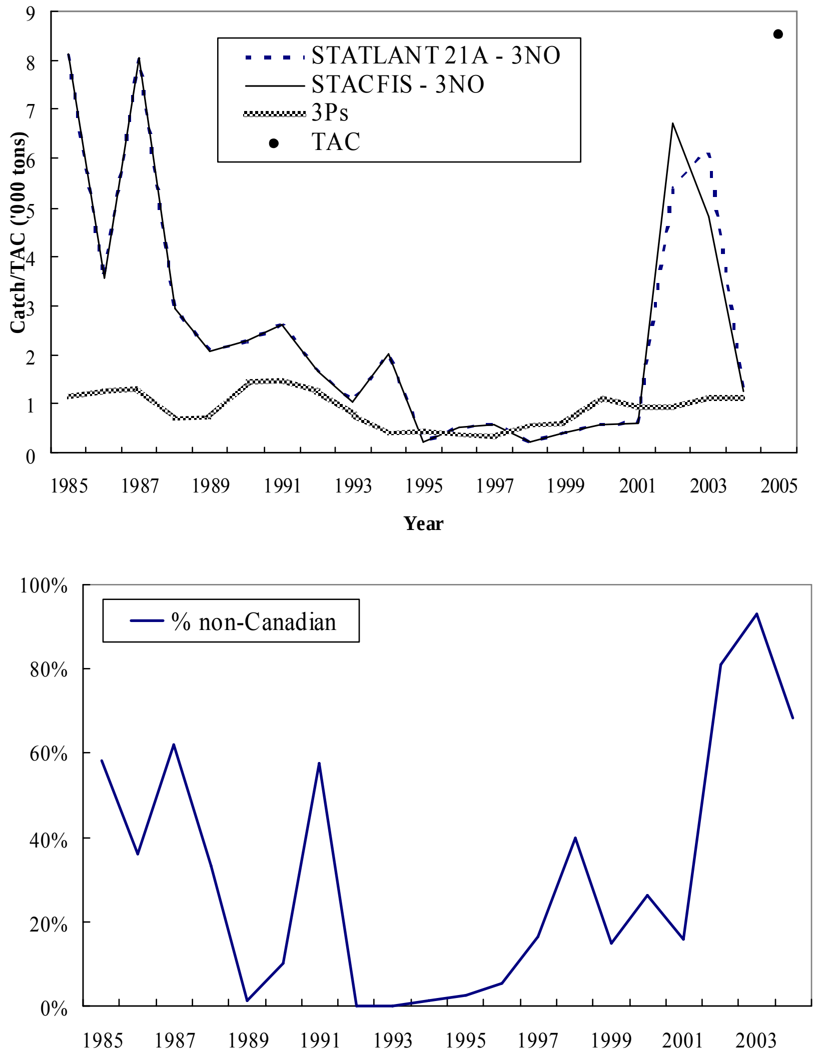
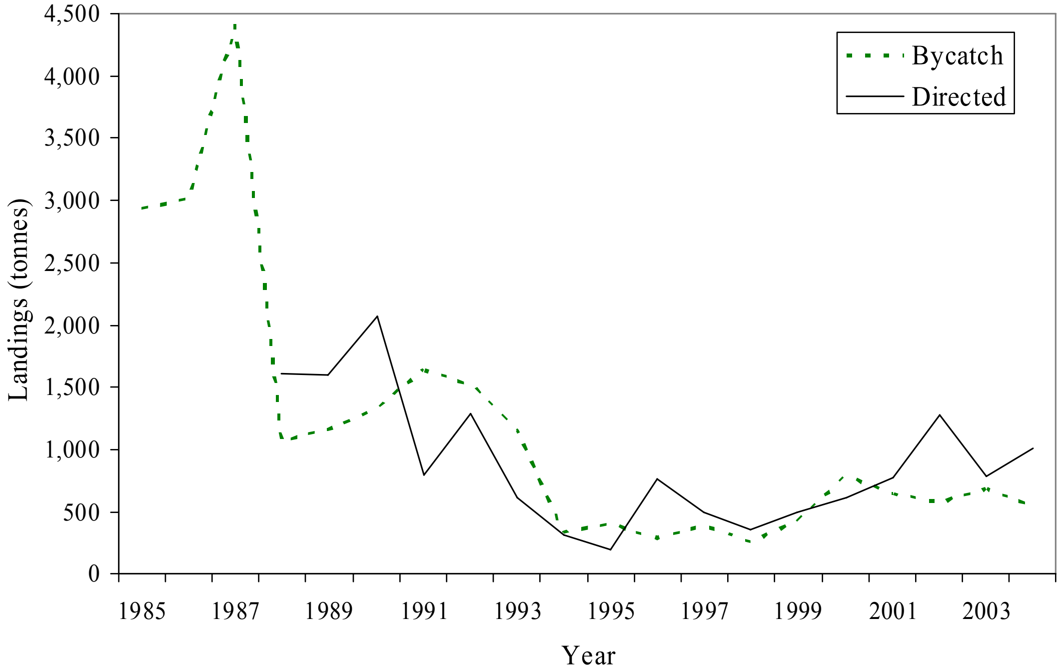
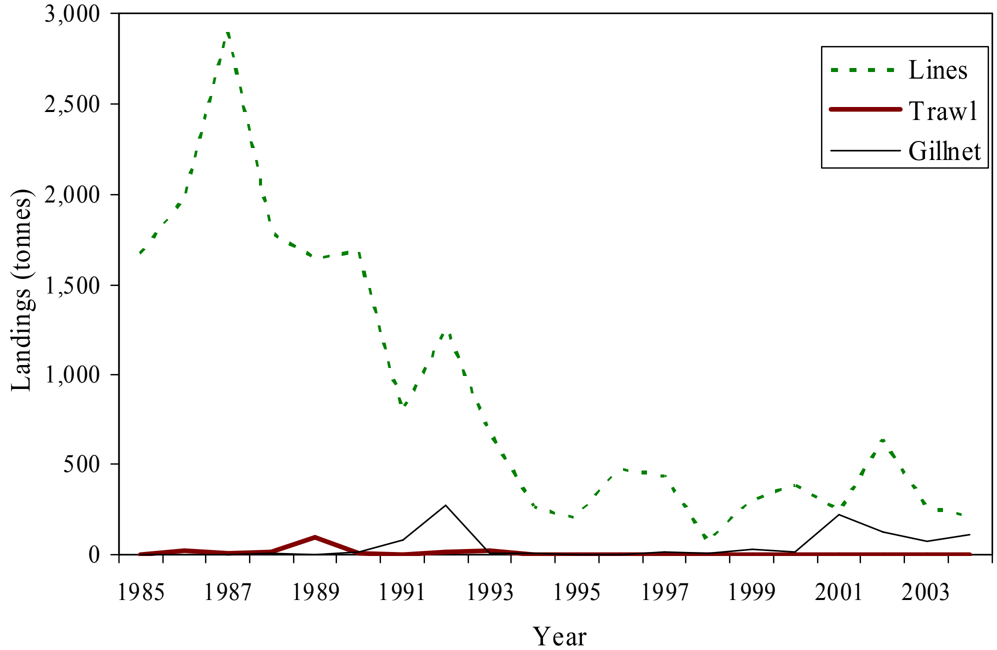


Fig. 12. Upper panel: Total reported catch of white hake and TAC in NAFO Div. 3NO and Subdiv. 3Ps, 1985-2005. Lower panel: Percent of white hake taken by non-Canadian fleets in the NAFO Regulatory Area (Div. 3NO in the NRA), 1985-2004.



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	0
1986	17	0	297	0	1,818	0	876	0	3,007	3,007	0
1987	80	0	1,314	0	1,705	0	1,314	0	4,413	4,413	0
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	0	0	0	200	185	354	833	1,572	554	1,018

Fig. 13. Directed and non-directed Canadian white hake landings in NAFO Divisions 3LNOPs, 1985-2004. Data do not include discards at sea.



Year	Gillnet		Lines		Trawl		Total	Bycatch and Directed		
	Bycatch	Directed	Bycatch	Directed	Bycatch	Directed		Gillnet	Lines	Trawl
1985	0	0	1,666	0	100	0	1,766	0	1,666	0
1986	0	0	1,971	0	116	0	2,087	0	1,971	27
1987	0	0	2,904	0	107	0	3,011	0	2,904	8
1988	13	0	487	1,306	32	10	1,847	13	1,793	17
1989	1	0	490	1,149	117	114	1,872	1	1,640	93
1990	1	20	479	1,205	81	86	1,871	21	1,684	11
1991	17	67	288	509	72	12	965	84	796	2
1992	172	108	215	1,035	67	0	1,597	280	1,250	20
1993	9	0	233	446	297	18	1,002	9	678	26
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	0
1997	9	6	137	306	27	0	486	15	443	0
1998	9	0	22	51	46	0	127	9	73	0
1999	32	0	56	250	11	0	350	33	306	0
2000	17	1	77	309	11	0	414	18	385	0
2001	50	171	60	183	45	0	511	221	244	0
2002	47	85	72	568	86	121	979	132	640	0
2003	49	30	30	242	66	0	415	79	271	0
2004	82	32	65	154	54	0	386	113	219	0

Fig. 14. Canadian white hake landings in NAFO Divisions 3LNOPs by gear type and mode (directed or by-catch), 1985-2004. Data do not include discards at sea.

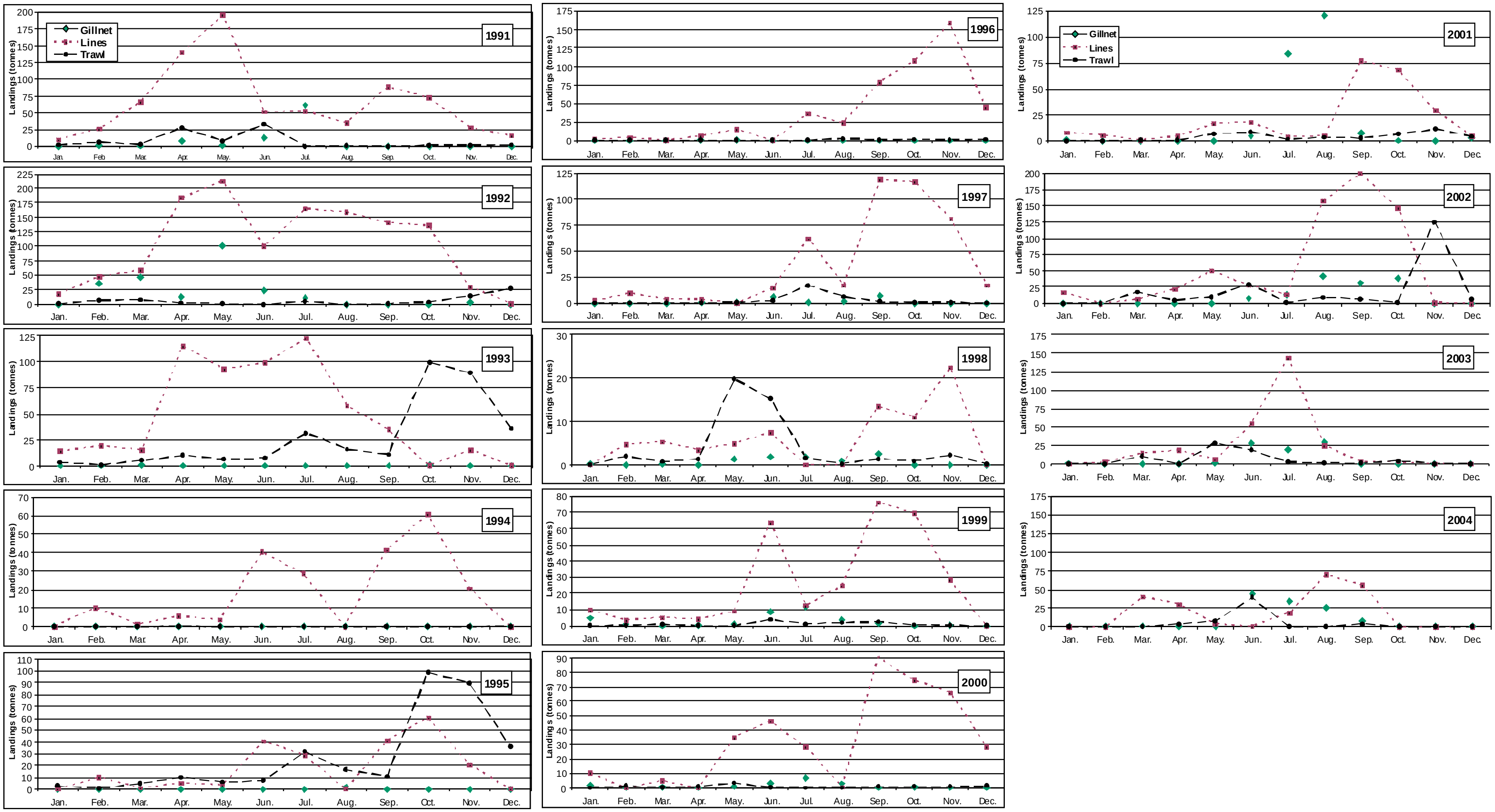


Fig. 15. Canadian landings of white hake in NAFO Divisions 3NO and Subdivision 3Ps by month and gear type, 1985-2004.

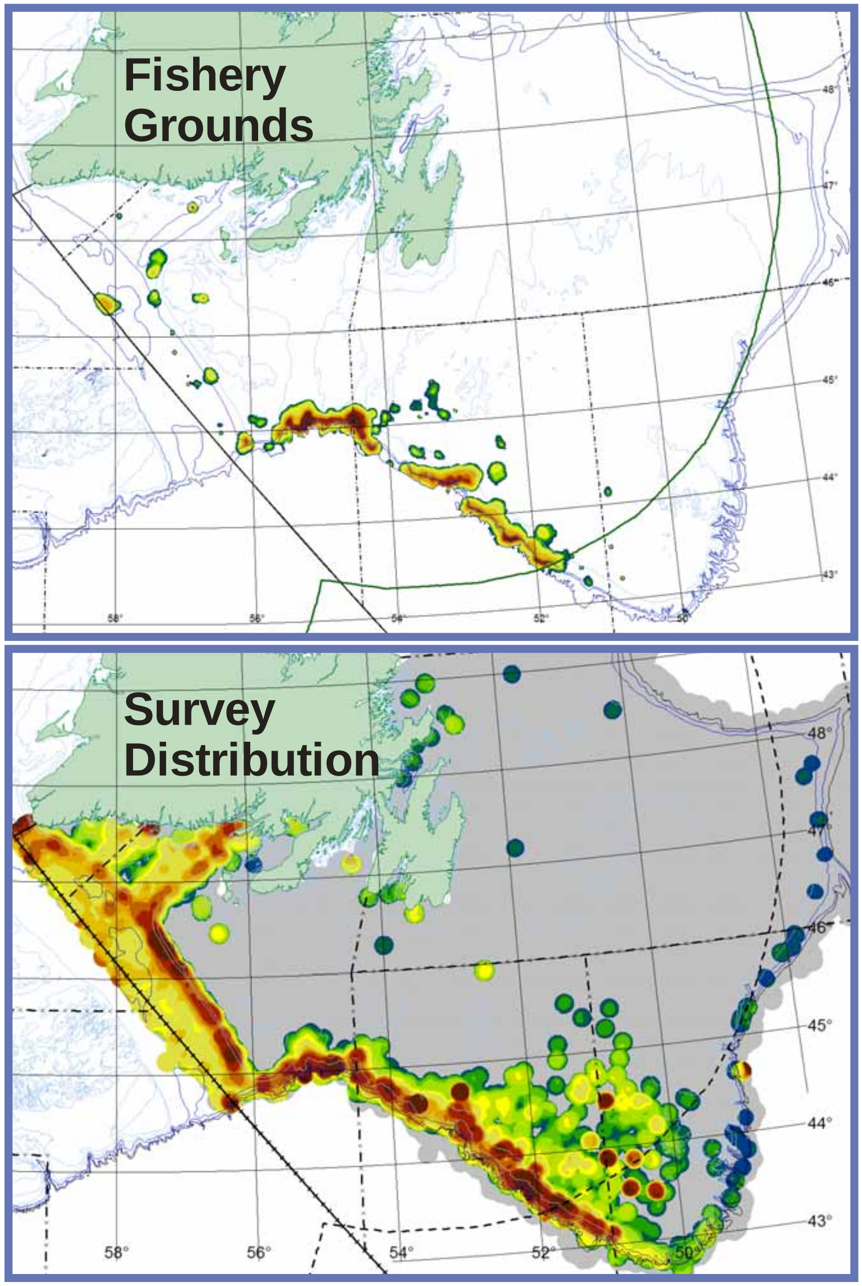


Fig. 16. Distribution of commercial fishing effort where the highest catch rates of white hake were achieved in 1991-2004 (upper) as compared to the distribution of white hake, brown representing highest densities of white hake (lower).

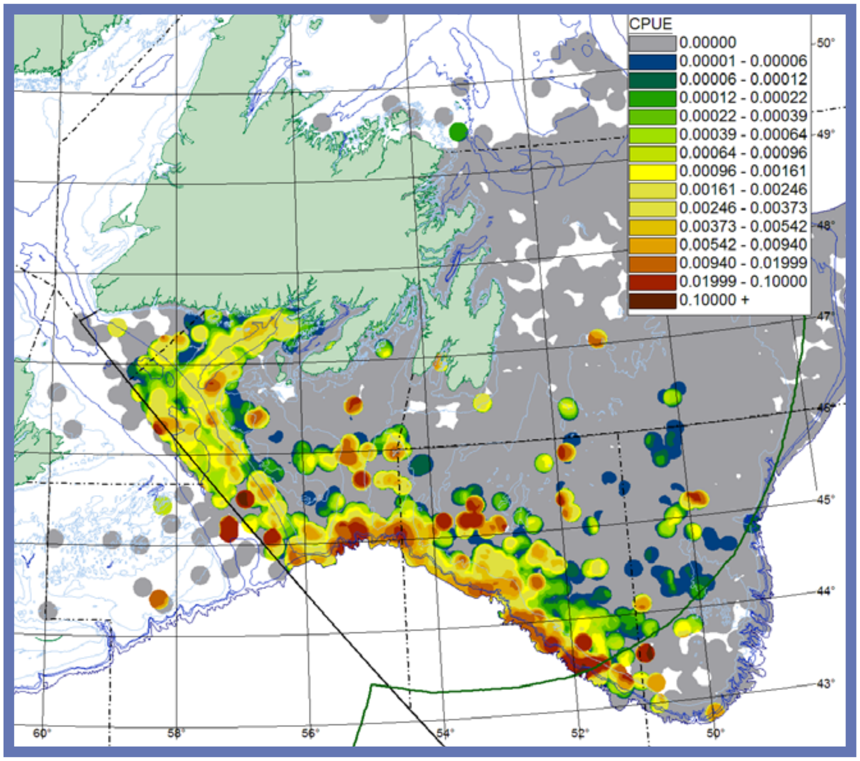


Fig. 17. Catch rate of white hake in the various fisheries on the Grand Banks, 1991-2004: gears combined – gillnet as t/net, longline as t/hook and trawl as t/hour.

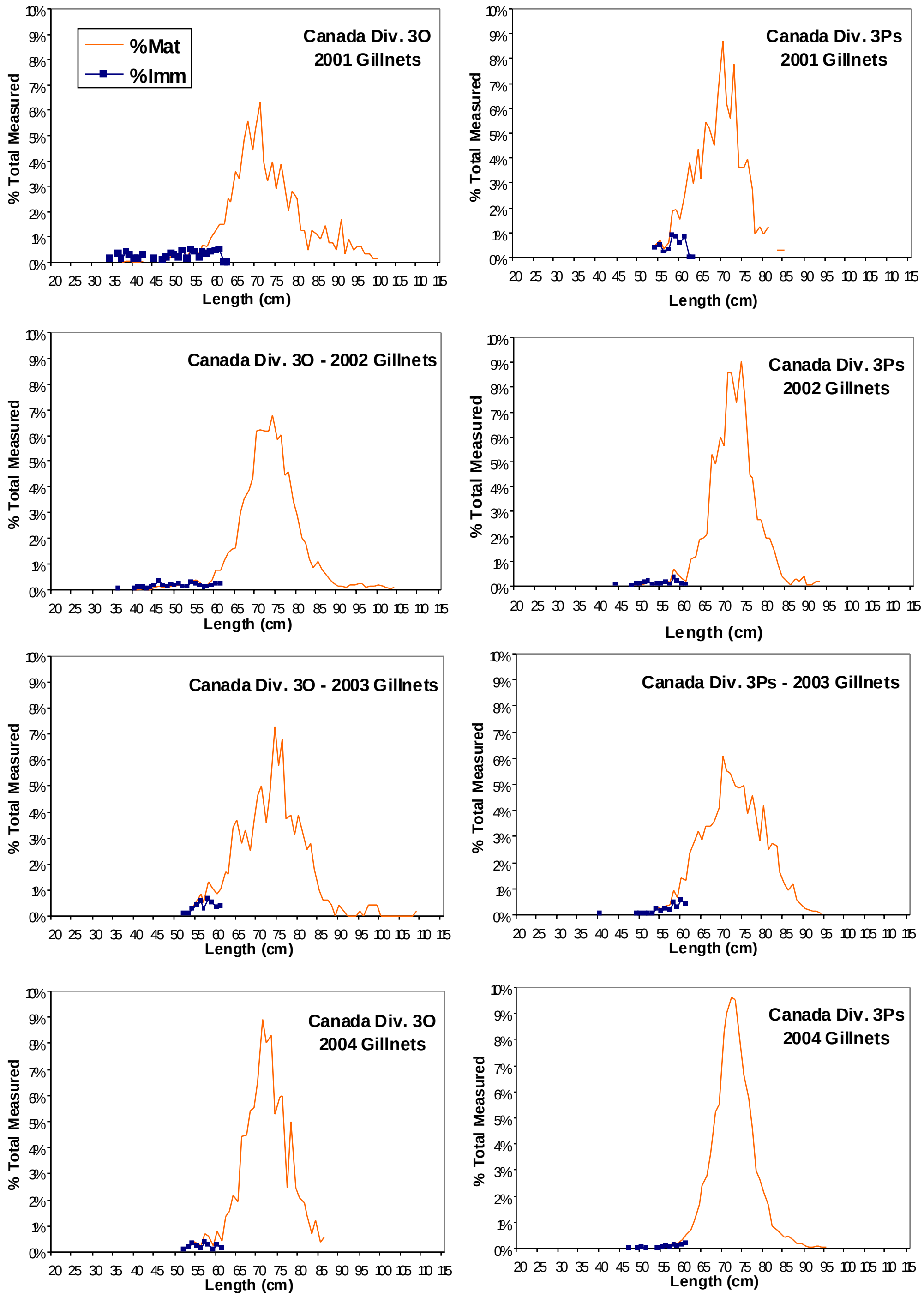


Fig. 18a. Size of fish caught in the various Canadian commercial gillnets, 2001-2004.

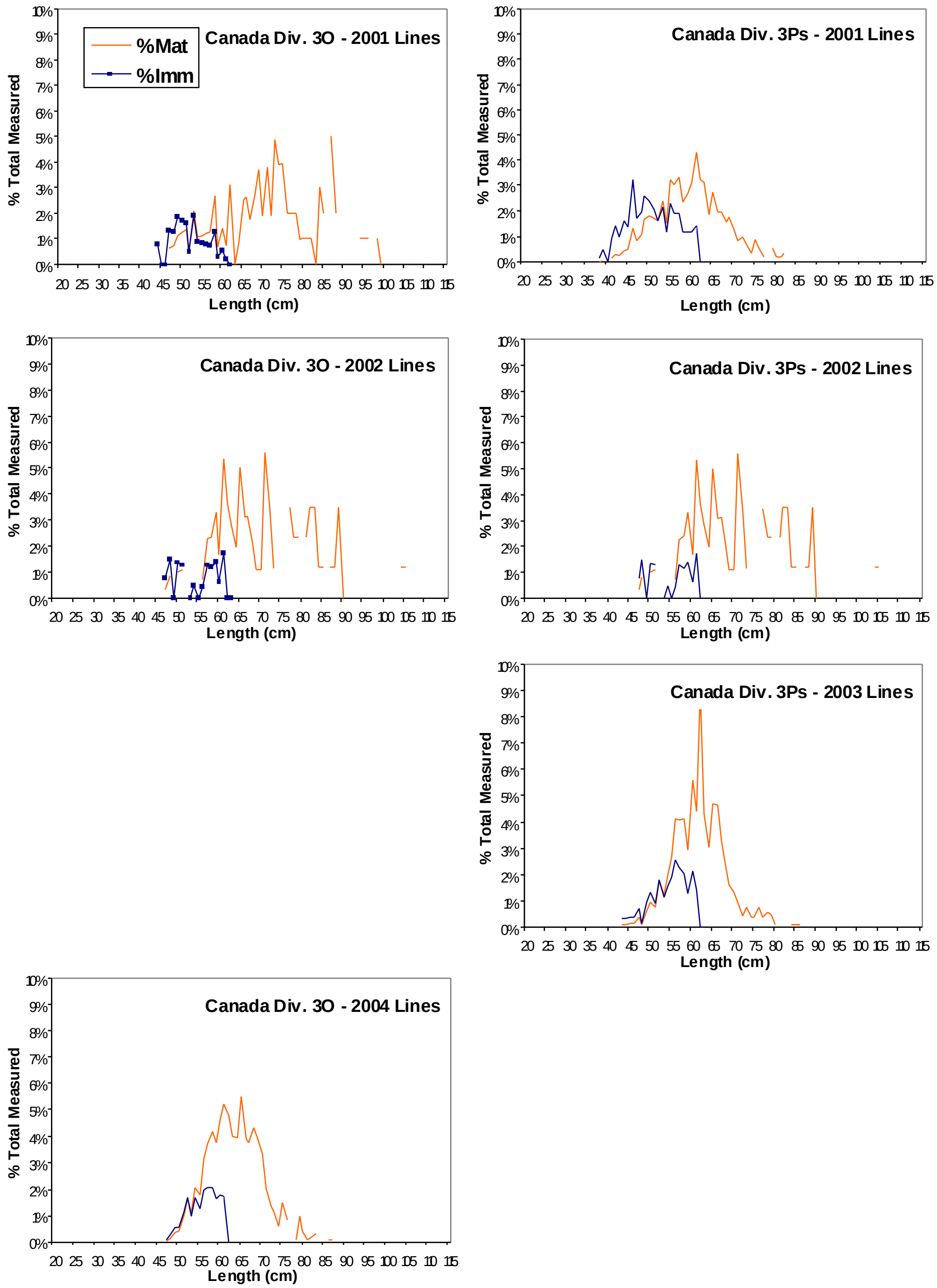


Fig. 18b. Size of fish caught in the various Canadian commercial longlines, 2001-2004.

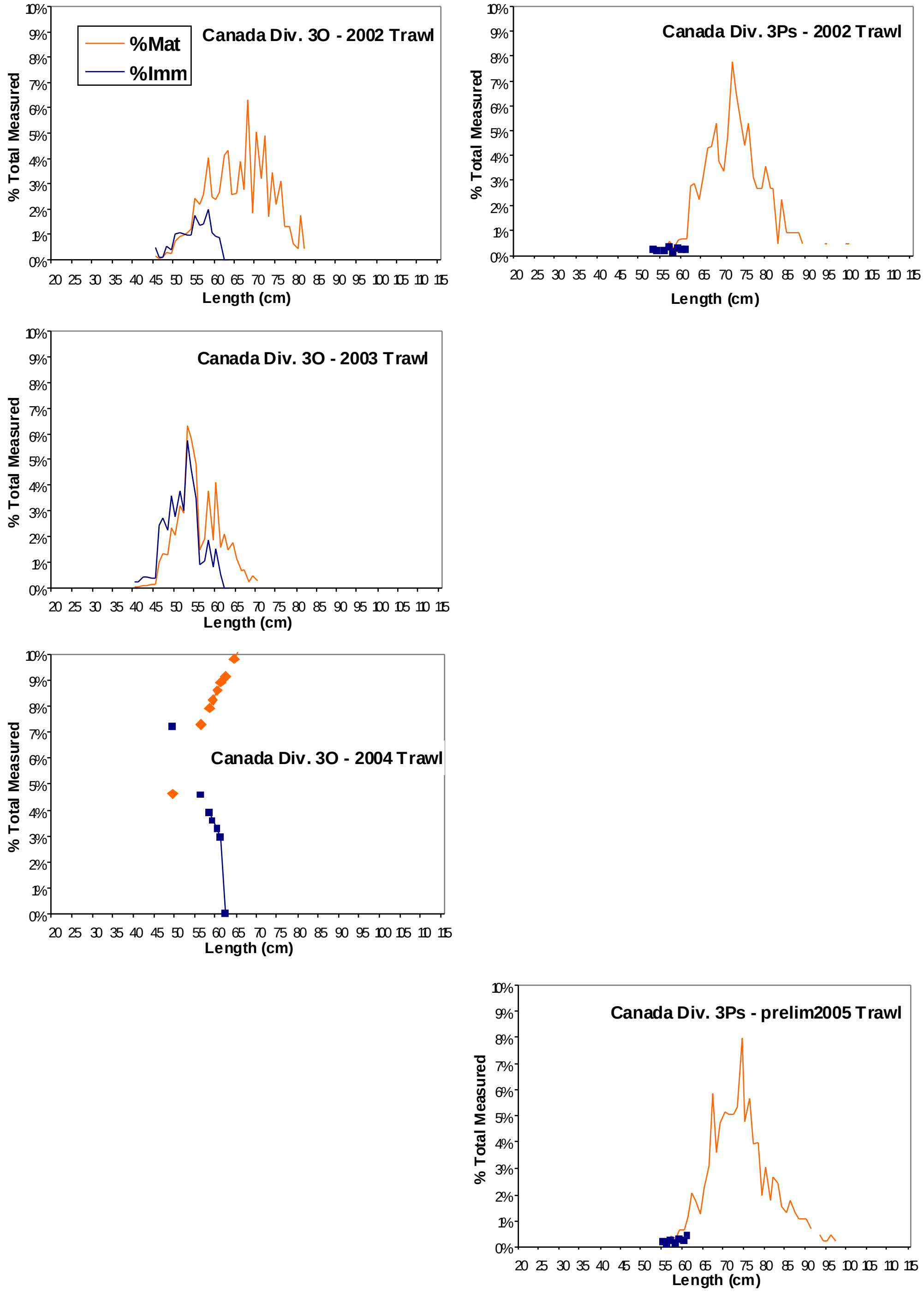


Fig. 18c. Size of fish caught in the various Canadian otter trawls, 2002-2004.

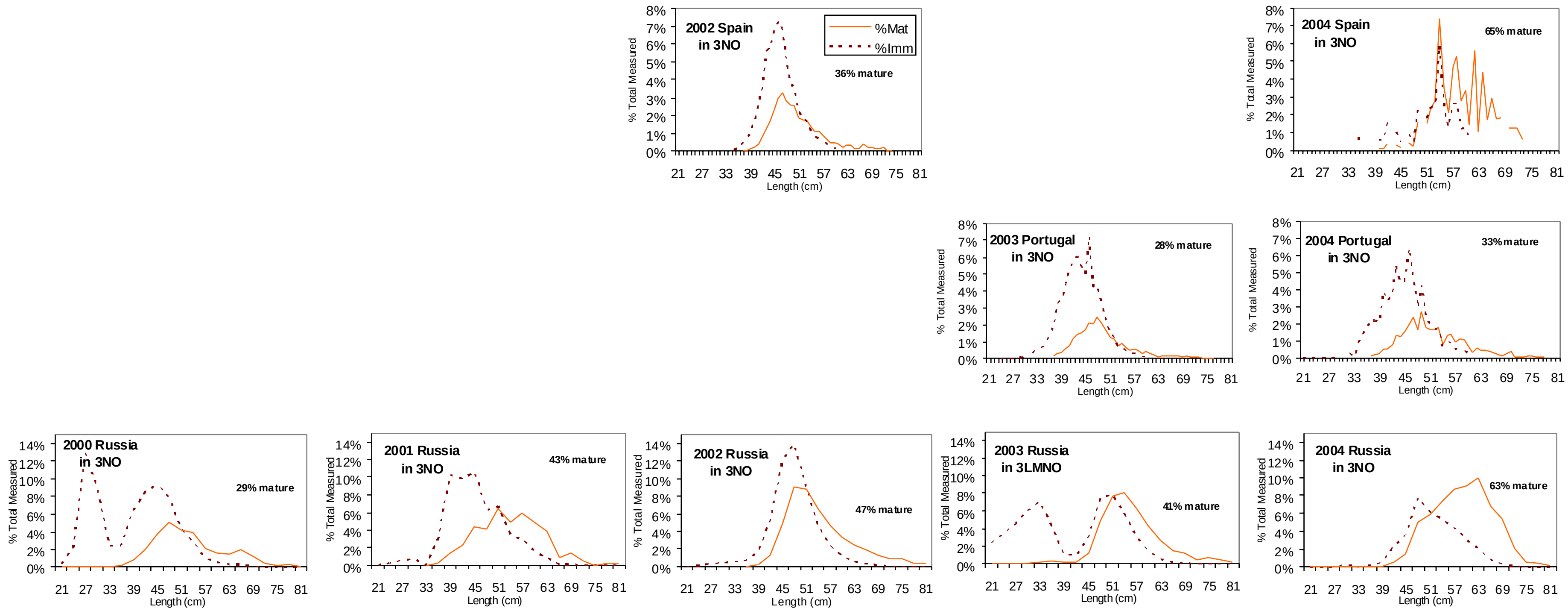


Fig. 18d. Available size frequency data for white hake caught in the non-Canadian commercial trawl fishery in the NRA, 2001-2004. The frequencies are partitioned into immature and mature fish using an ogive averaged over sexes and years (2001-2004).

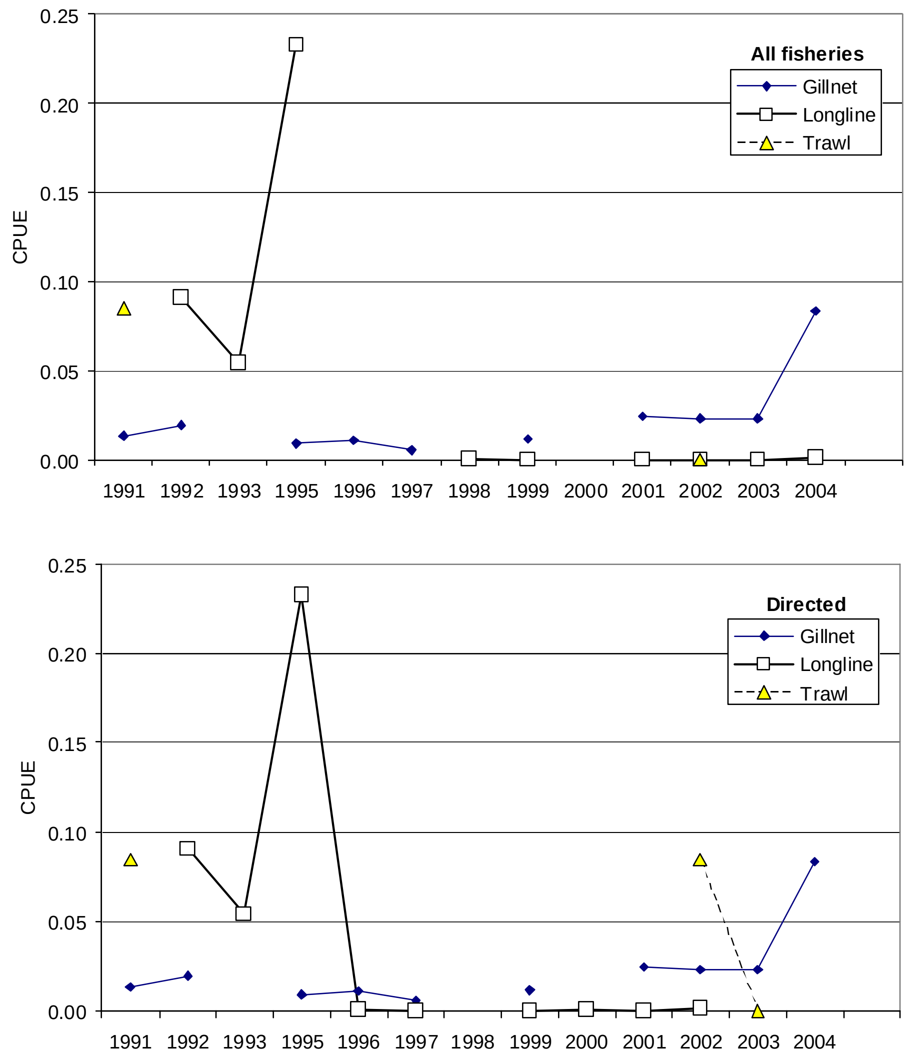


Fig. 19a. Catch rates of white hake in Canadian fisheries on the Grand Banks in 1991-2004, fleet sectors combined

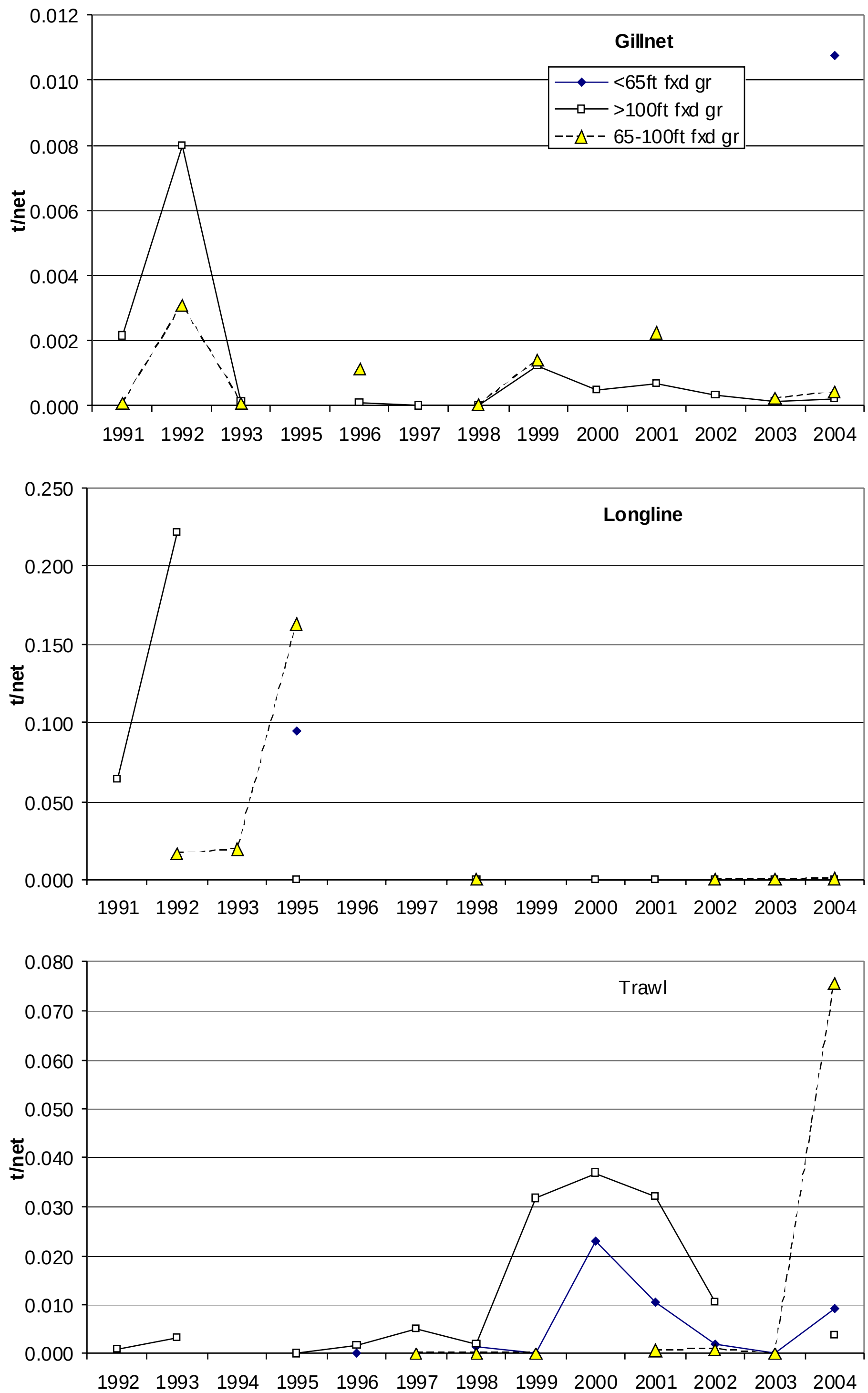


Fig. 19b. Catch rates of white hake in Canadian fisheries on the Grand Banks in1991-2004, by gear and fleet sectors.

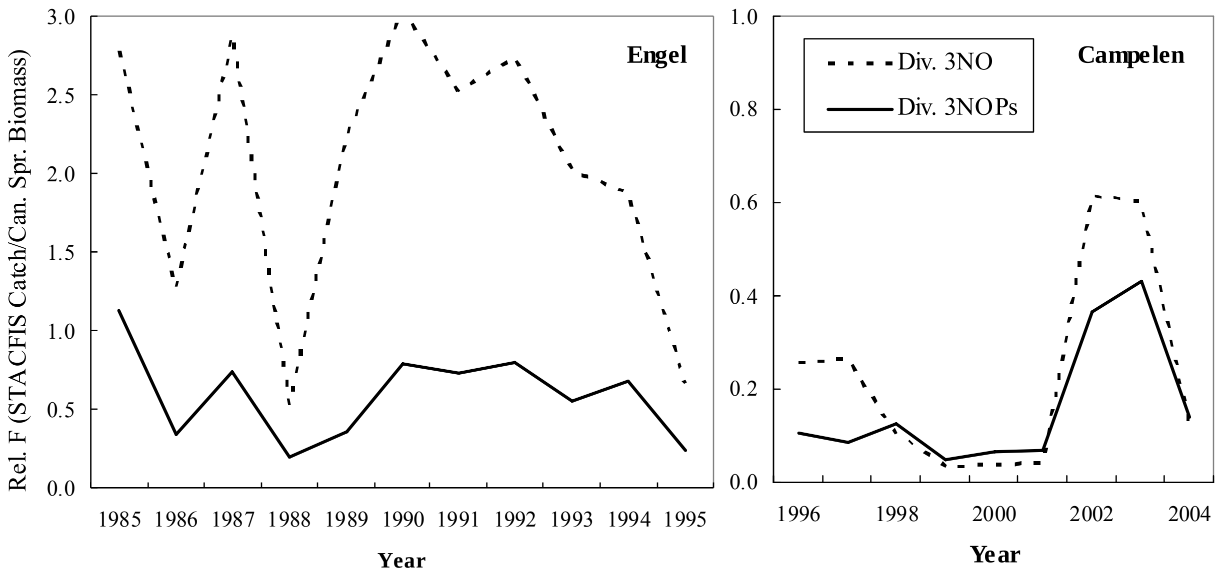


Fig. 20. Relative F index (= STACFIS agreed commercial catch/Canadian Campelen spring survey biomass) for white hake in NAFO Div. 3NO and 3NOPs. Both time series are unstandardized.