Northwest Atlantic Fisheries Organization

Serial No. N5254 **NAFO SCR Doc. 06/33**

SCIENTIFIC COUNCIL MEETING – JUNE 2006

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

D.W. Kulka, C.M. Miri, and M.R. Simpson

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

Abstract

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 bycatch 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 659 and 1109 t in 2004 and 2005. 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 2005 was 2.5% 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, particularly on the Grand Banks is summarized by Kulka *et al*. (2005a) and history of the assessment and management of this species is summarized in Kulka *et al*. (2005b). 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. In most management areas, this species has undergone severe declines and is either under moratorium or is in a depleted state, including on the Grand Banks, NAFO Div. 3LNOPs (Kulka *et al*., 2005b)

Although not regulated by quota in Canadian waters, fishery closures due to high bycatch 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. Based on limited available data, 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 3NO. However, Kulka *et al.* (2005) noted that all evidence indicates that white hake form a single spawning component within NAFO Div. 3N, 3O, and Subdiv. 3Ps. It was 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 different stages (YOY, juvenile, mature adults) as various year-classes mature. Thus this update deals with white hake on the Grand Banks as a unit.

Kulka *et al.* (2005b) noted that after several years of large catches resulting in a large Z of 0.7, in 2004, the 1999 year-class was about 7% of its abundance in compared to 2000. NAFO Scientific Council indicated that the current TAC of 8 500 tons is unsustainable (NAFO, 2005). As an update to the first request for advice on the status of the Grand Banks white hake, this paper presents information on abundance trends and catches of white hake in both NAFO Div. 3NO and 3NOPs (following on the definition of stock structure in Kulka *et al*., 2005a).

Methods

Survey Data

Data from 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) was used 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 (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).

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. 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. Table 1 enumerates the Engel and Campelen survey sets by NAFO Division, survey season and depth.

Standard sets from the seasonal surveys, spring and autumn (Table 1a and c) are used to estimate index of abundance (STRAP2) and biomass**.** Eighty-two percent of sets containing white hake were sampled for length by sex in both spring and Fall 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). 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 (1996-2005), 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.

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). 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 imit by other countries were compiled from NAFO STATLANT-21A statistics. Both sources represent NAFO Scientific Council "greed values" In recent years, the largest portion of white hake landings was recorded as directed, but bycatch data in other fisheries are included.

Results and Discussion

Survey Coverage

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 of white hake. However, white hake were occasionally captured in new shallow coastal strata, which were introduced in 1995. Shallow captures were sporadic and at densities (numbers per tow) far less than at >50 m along the southern Grand Banks (Table 1).

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 trawl data were used only to examine historical abundance and biomass summed over all sizes captured; as an independent time series.

Survey Estimates

Survey estimates of relative biomass, abundance, and average fish size (biomass/abundance) are presented for spring and autumn in NAFO Div. 3NOPs and for Div. 3NO (Table 2; Fig. 2a). Survey numbers per tow with confidence intervals are presented in Fig. 2b. NAFO Subdiv. 3Ps was not surveyed during autumn. Thus, the spring index is used as the main indicator of changes in relative abundance; and fish NAFO Div. 3NO and Subdiv. 3Ps area treated as a stock unit (refer to Kulka *et al*., 2005b for details). Engel (1972 to spring 1995) and Campelen (autumn 1995 to date) are presented separately; as the two series reflect changes in biomass and abundance at different scales and with a different mix of stages.

The relative biomass of white hake peaked approximately every ten years during the period when Canadian stratified survey data were available: 1975-1978 and 1986-1988 (Table 2, Fig. 2). 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 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 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 steep increase in between 1998 and 1999 (Table 2, 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 before observed. 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 that are spawned in the spring. About 25 weeks later, the spring survey picks up the previous year's cohort (Kulka *et al.* 2005a). 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 fluctuated until the late 1980s; then declined into the early 1990s (Fig. 2a and b). An average fish weight of 2 kg in Div. 3NOPs in the 1970s and 1980s dropped to about 1 kg in the mid-1990s 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 class trends (Fig. 2c), Length of <26 cm corresponds 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.*, 2005b for a complete description of the stages). The 1999 year-class produced a spike in 2000, a subsequent increase then decline in abundance of older juveniles and finally an increase in adults (particularly in Div. 3NO; Fig. 2c). The lower panel shows large changes in proportion of each of these stages in Div. 3NO as they move into and out of the area as they grow and why assessing only Div. 3NO would not reflect changes in the entire population. Kulka *et al.* (2005b) described in detail the manner in which these three life stages distribute differently on the Grand Banks, juveniles mainly in the Laurentian Channel, mature adults along the southwest slope of the Grand Bank.

Information on white hake numbers (1988-1995) and abundance (1997-2005) at length from Canadian Engel surveys are presented in Fig. 3. 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 and 1999 based on a 25-cm mode (Fig. 3b-d). The largest year-class since 1999 was produced in 2004 but it is small in comparison, about 6% of the size of the 1999 year-class.

An estimated growth rate of about 2.5 cm per month for the 1999 year-class corresponds to the dominant 25-cm mode of white hake seen in the following year's spring survey. 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 6 (spring 2000 to 2005) to provide an estimate of growth in white hake on the Grand Banks (Fig. 4, upper). Growth was also modeled without the 0.25 and 0.5 points (Fig. 4, lower). The results must be considered as preliminary because a) only 6 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. A 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 more points are added to the model.

L_∞ of 64 cm (males) and 82 cm (females) for age 1 to 6 (age 0.25 and 0.5 not included) in the model is lower than what has been reported in other locations (see Table 3). 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 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.

Given that the IYGPT young-of-the-year findings described a predominance of 1-year-old fish in 2000 (Kulka *et al.*, 2005a), 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. 5). However, year-classes since 1999, comparatively speaking, have been extremely small, each female producing up to one (surviving to age one) young, from 2000 to 2003 and 2 young in 2004. Survival at this rate is not sufficient to maintain or increase size of the stock.

The dominance of the 1999 year-class is also reflected in the stage based analysis of abundance illustrated in Fig. 6. 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 adult abundance is similar in magnitude to juvenile abundance, a result of the 1999 year-class fish reaching maturity.

An estimate of change in the relative abundance of 1999 year-class was done for the period 2000 to 2005 (Fig. 7). Only 2.5% of the abundance of the 1999 year-class in 2000 remains in 2005. An estimate of Z (total mortality) for the 1999 year-class is 0.7 for that period (Fig. 8). 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 2002-2003, coupled with low recruitment. Current *F* is has almost completely depleted the 1999 year-class.

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 bycatch 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 been Atlantic cod (*Gadus morhua*) reported as hake.

EU-Spain and EU-Portugal commenced a directed fishery for white hake in 2002 in Div. 3NO in the NRA (Fig. 9). In 2002-2003, 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. In 2004-2005, about half the catch came from the NRA. There was no directed fishery by EU-Spain in 2004-2005 and catches were minimal in the NRA in those two years. Total catch in 2005 was slightly higher than in 2004 due to an increase in the Canadian catch in Div. 3Ps (Fig. 9).

Reported catches of white hake in NAFO Div. 3NO and Subdiv. 3Ps, all countries combined peaked in 1987 at approximately 8 000 tons in 3NO (with about half of that reported by non-Canadian sources as bycatch and 1 300 tons in 3Ps (Table 4, Fig. 10), then declined from 1988 to 1994, averaging 2 090 tons in 3NO and 950 tons in 3Ps. However, as noted above, the accuracy of the reported catches prior to the late 1980s are uncertain.

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 in 3NO was at its lowest in 1995-2001 (455 tons in 3NO, 639 tons in 3Ps) then increased sharply to approximately 5 366 tons in 3NO, 871 tons in 3Ps in 2002 and 7 174 tons in 3NO, 1 057 tons in 3Ps in 2003. Most the catch comprised the very large 1999 years class that recruited to the fishery in 2002. Total catch decreased to 659 tons in 3NO, 1 275 tons in 3Ps in 2004 and 1 109 tons in 3NO, 1 510 tons in 3Ps in 2005.

Since 1989, the reported directed fishery has contributed, on average, about 50% of the annual Canadian catch, ranging from 30-70% (Fig. 11). 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 (Kulka *et al*., 2005a). In this hake/skate/monkfish fishery, the main species caught changes from day to day indicating the mixed nature of that fishery.

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. 12) except in the non-Canadian (NRA) fisheries where otter trawls are exclusively used to fish white hake.

Relative *F* is higher in Div. 3NO compared to Subdiv. 3Ps, particularly in recent years due mainly to catches in the NRA (Fig. 13). 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. Current relative *F* is about 20%

Conclusions

NAFO Div. 3LNOPs white hake abundance and biomass is at its lowest level since 1999. It has undergone wide fluctuations since the beginning of the Canadian stratified random surveys in 1971, primarily the result of occasional production of large year-classes from very low SSB. 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 (2005 abundance was 2.5% of that in 2000). Although a TAC for white hake in the NRA was 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 too large to be effective in sustaining this stock. This is particularly the case presently given the lack of significant recruitment since 1999.

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. If and when recruitment occurs, it will take 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.

Thus, regeneration of this depleted stock is obviously dependant on the recruitment and survival of large year-classes from the presently low SSB and such recruitment has not occurred since 1999. Therefore, at best, it will be at least several years following a year of good recruitment before there are enough white hake on the Grand Banks again to support more than a minor bycatch fishery. When good recruitment will occur is not predictable.

Sources of Uncertainty

Sources of uncertainty for this stock in term s of it structure, data deficiencies, problems with the survey series and fishery statistics elaborated by Kulka *et al.*, 2005b remain unchanged.

Outlook

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 has now (2005) has diminished to only 2.5% 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 minimize pressure on the depleted SSB and sustain growth and survival of larger year-classes to maturity. The current TAC of 8 400 tons far exceeds this amount. A quota for 2007 and 2007 of ~400 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 sufficient recruitment to sustain a larger catch occurs.

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.

References

Bishop, C.A. 1994. Revisions and additions to stratification schemes used during research vessel surveys in NAFO Subareas 2 and 3. NAFO SCR Doc. 94/43, 10 p.

Bundy, A., M. Fowler, W. MacEachen, and P. Fanning. 2001. Assessment of the status of 4VWX/5 White Hake, 2001. DFO Can. Sci. Advisory Res. Doc. 2001/98, p.

Doubleday, W.G. 1981. Manual on groundfish surveys in the Northwest Atlantic. NAFO Sci. Coun. Studies No. 2.

Fowler, M., J. Black, R. Mohn, and M. Sinclair. 1996. 4VWX and 5Zc white hake 1996 stock assessment. DFO Can. Sci. Advisory Res. Doc. 96/103.

Fowler, M. 1998. 4VWX and 5Zc white hake 1998 stock assessment. DFO Can. Sci. Advisory Res. Doc. 98/103.

González, F. and J.L. del Río 2004. Catches of white hake (*Urophysis tenuis*) in NAFO Regulatory Area, 2000-2003.

Hurlbut, T., D. Swain, R., G. Poirier, and G. Chouinard. 1997. The Status of White Hake (*Urophycis tenuis,* Mitchill) in the southern Gulf of St. Lawrence (NAFO Division 4T) in 1996. DFO Can. Sci. Advisory Res. Doc. 97/68.

Hurlbut, T., and G. Poirier. 2001. The status of White Hake (*Urophycis tenuis,* Mitchill) in the southern Gulf of St. Lawrence (NAFO Division 4T) in 2000. DFO Can. Sci. Advisory Res. Doc. 2001/1024, 61 p.

Kulka, D.W., and E.M. DeBlois. 1996. Non-traditional groundfish species on the Labrador Shelf and Grand Banks, Wolffish, Monkfish, White hake, and Winter (Blackback) Flounder. DFO Can. Sci. Advisory Fish. Res. Doc. 96/97.

Kulka, D.W., and M.R. Simpson. 2002. The status of White Hake (*Urophycis tenuis*), in NAFO Division 3L, 3N, 3O, and Subdivision 3Ps. DFO Atl. Fish. Res. Doc. 02/055, 76 p.

Kulka, D.W., K. Sosebee, C.M. Miri, and M.R. Simpson. 2004. The status of White Hake (*Urophycis tenuis*), in NAFO Division 3L, 3N, 3O, and Subdivision 3Ps. NAFO SCR Doc. 04/57, Ser. No. N5011, 22 p.

Kulka, D.W., C.M. Miri, and M.R. Simpson. 2005a. Distribution and aspects of life history of White Hake (*Urophycis tenuis*, Mitchill 1815) on the Grand Banks of Newfoundland. NAFO SCR Doc. 05/60, Ser. No. N5146, 40 p.

Kulka, D.W., C.M. Miri, and M.R. Simpson. 2005b. The Status of White Hake (*Urophycis tenuis*, Mitchill 1815) in NAFO Division 3L, 3N, 3O and Subdivision 3Ps. NAFO SCR Doc. 05/66, Ser. No. N5151, 62 p.

Musick, J.A. 1969. The comparative biology of two American Atlantic hake, *Urophycis chuss* and *U. tenuis* (Pisces Gadidae). Ph.D. thesis, Harvard U.

NAFO 2005. Scientific Council Report. NAFO Sci. Coun. Rep. June 2005, Pt A.

NEFSC [Northeast Fish. Sci. Cent.] 2001. 33rd Northeast Regional Stock Assessment Workshop (33rd SAW). Stock Assessment Review Committee (SARC) Consensus Summary of Assessments. NMFS/Northeast Fish. Sci. Cent. Ref. Doc. Woods Hole Lab. Ref. Doc. 01-18, 281 p.

Smith, S.J., and G.D. Somerton. 1981. STRAP: A user-oriented computer analysis system for groundfish research vessel survey data. Can. Tech. Rep. Fish. Aquat. Sci. 1030:iv + 66 p.

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

Table 2.1Biomass, abundance and mean weight of white hake from spring research vessel surveys, 1971-2005. 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				2,707	354		3,061	61				1,556	61		1,617	5.80				1.74			
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			5,051	0				2,055	0		2,055					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					2,545			2,545			0		1,508	0		1,508					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	234	**906**	7,981	**13374**	5,762	8,215	14,280	13,977	176	**748**	7,250	**10,628**	6,904	7,426	11,376	14,330	1.33	**1.21**	1.10	**1.26**	0.83	1.11	**1.26**	0.98
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
2005	20	539	5,932	4,739	5,249	5,952	5,278	11,201	36	109	9,725	4,001	5,506	9,761	4,110	15,267	0.56	4.94	0.61	1.18	0.95	0.61	1.28	0.73

Table 3. 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 4. Reported landings of white hake by NAFO Division and country (Canada versus other countries), 1985-2005.

	3N			**3O**			**3NO**		**3Ps**	**3NOPs**
Year	**Can**	**non-Can**	**All**	**Can**	**non-Can**	**All**	**STATLANT 21A**	**STACFIS**	**STATLANT 21A Can**	**Can + non-Can**
1985	101	1,542	1,643	3,178	4,348	7,526	9,169	8,129	1,156	10,307
1986	297	473	770	1,818	1,564	3,382	4,152	3,550	1,242	5,042
1987	1,314	4,019	5,333	1,730	1,016	2,746	8,080	8,064	1,318	9,394
1988	828	866	1,694	1,053	127	1,180	2,874	2,921	695	3,572
1989	878	5	883	1,094	29	1,123	2,006	2,075	709	2,705
1990	830	228	1,058	1,061	15	1,076	2,134	2,291	1,441	3,613
1991	19	1,507	1,526	950	2	952	2,478	2,613	1,480	3,958
1992	18	0	18	1,617	19	1,637	1,655	1,658	1,244	2,863
1993	19	0	19	1,028	19	1,047	1,066	1,054	741	1,798
1994	16	20	36	258	4	262	298	2,017	382	681
1995	0	5	5	206	2	208	213	222	420	609
1996	0	28	28	488	2	490	518	519	362	1,083
1997	0	92	92	486	6	492	584	587	315	991
1998	0	81	81	127	9	136	217	222	562	716
1999	44	51	95	307	13	320	414	422	575	985
2000	21	124	145	393	29	422	567	578	718	1,677
2001	16	52	68	494	49	543	612	633	753	1,541
2002	0	1,220	1,220	979	3,133	4,112	5,332	6,718	759	6,203
2003	0	2,688	2,688	415	3,053	3,468	6,156	4,823	880	7,213
2004	0	170	170	334	148	482	652	1,267	1,096	1,927
2005	1	3	4	685	177	862	866	866	1,510	2,466

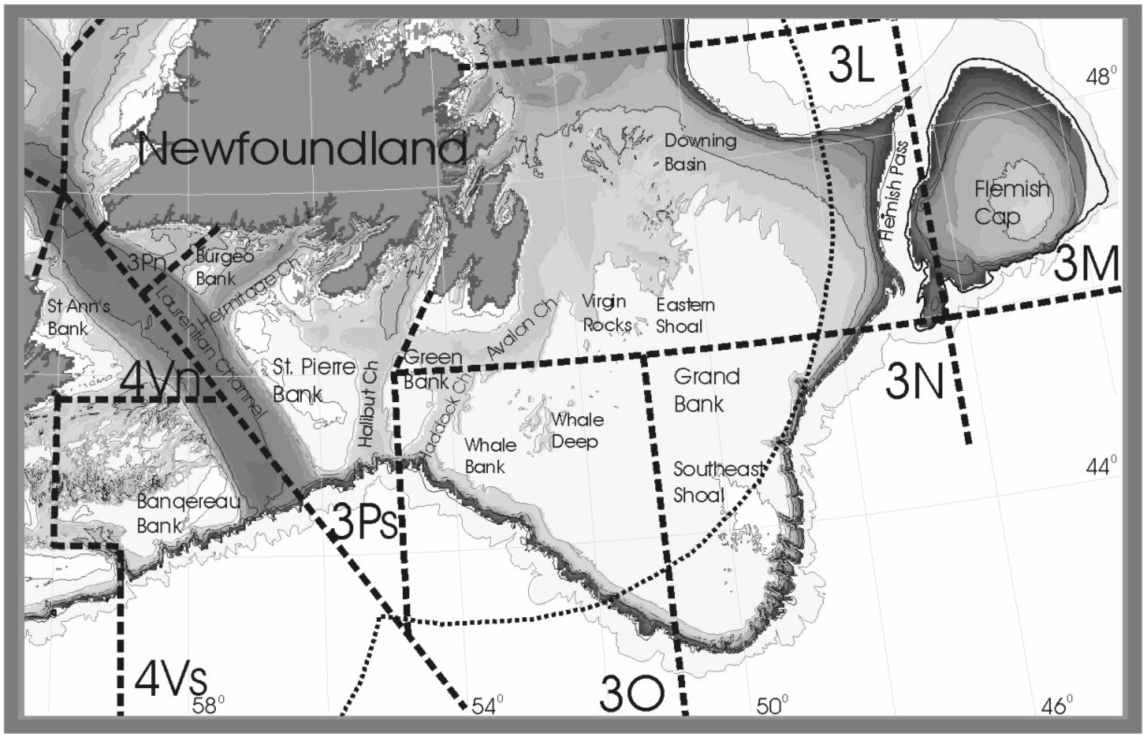


Fig. 1. Map of the Grand Banks showing various banks, basins, and NAFO Divisions. Thick dotted lines delineate NAFO Divisions. The thin dotted curved line shows Canada's 200-mile-limit: delineating Canadian territory from the NAFO Regulatory Area.

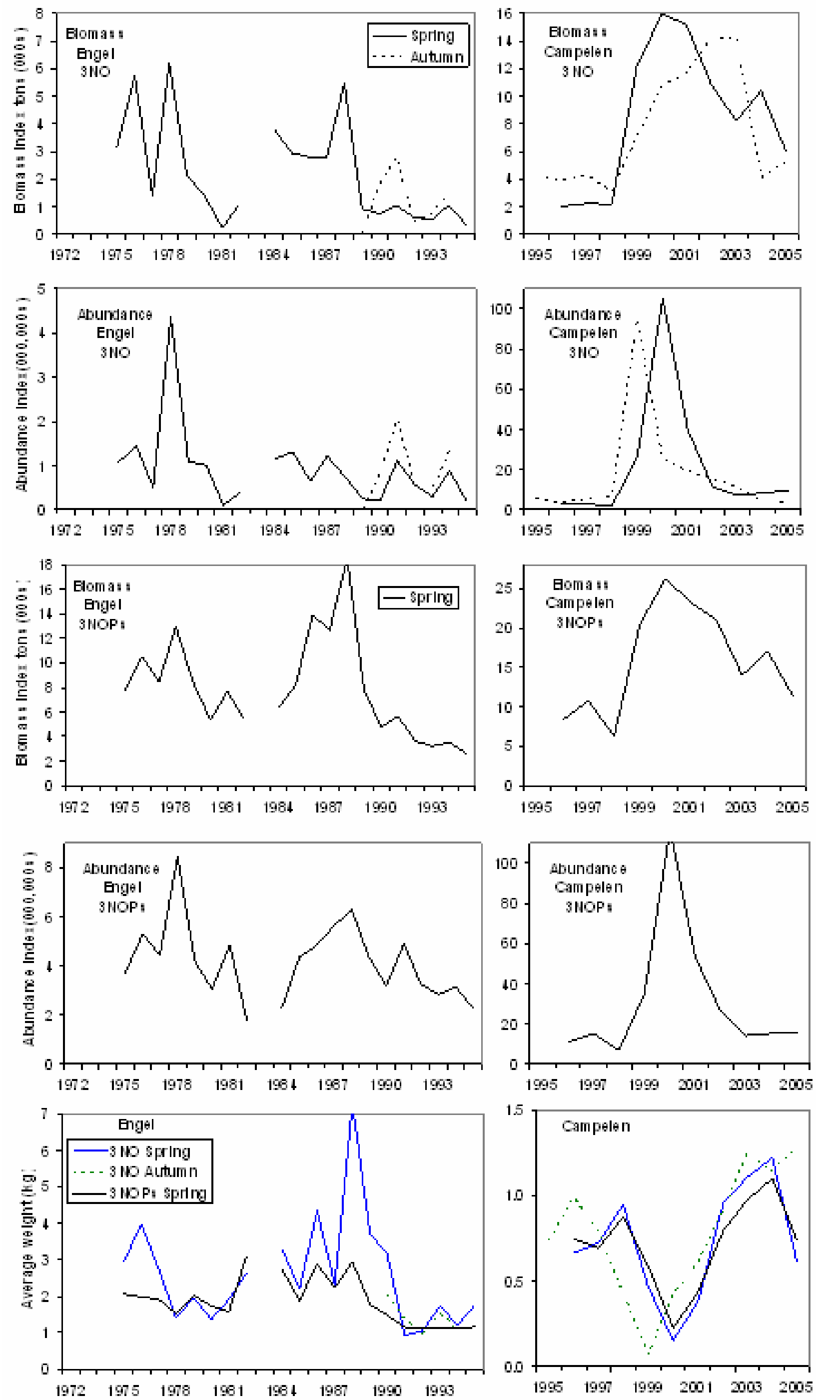


Fig. 2a. Canadian spring and autumn research survey biomass and abundance indices, and average weights for white hake in NAFO Div. 3NO and Subdiv. 3Ps, 1972-2005. Engel and Campelen time series are unstandardized. See Table 1 for an inventory of areas not surveyed.

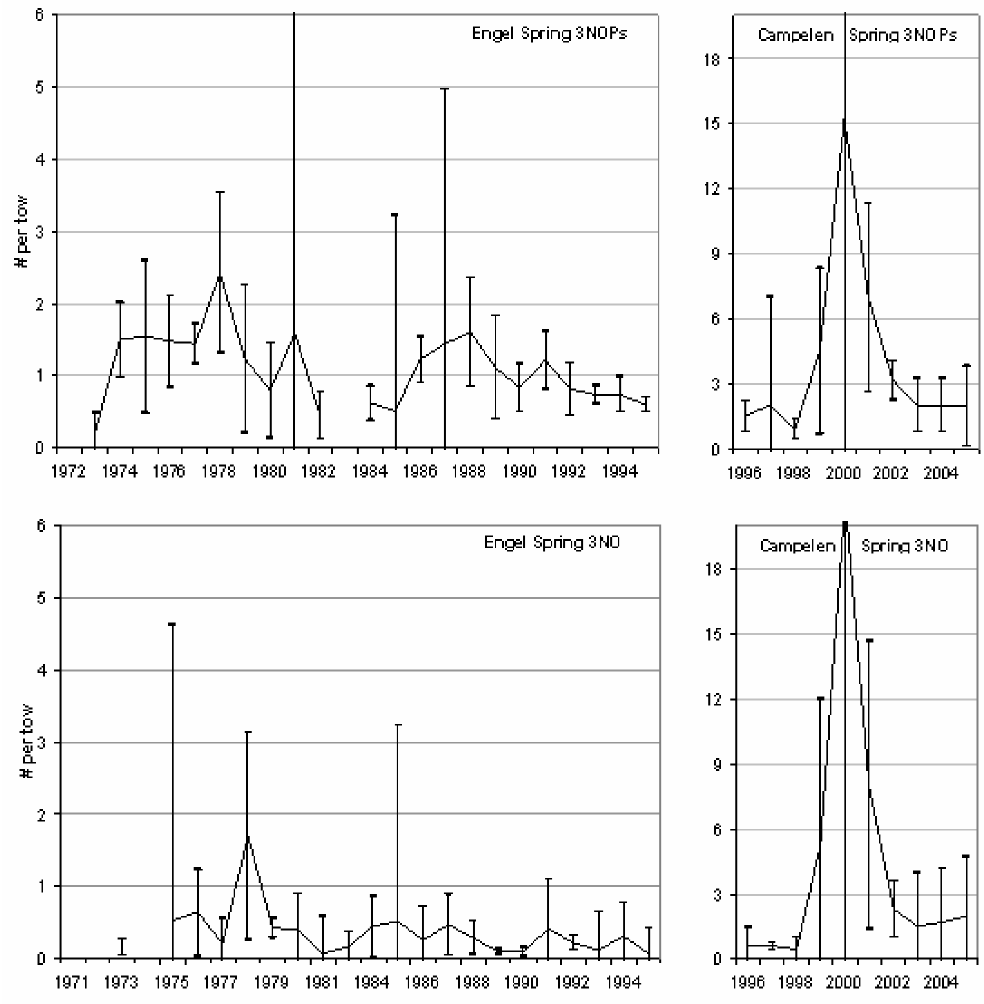


Fig. 2b. Kg per tow of white hake from Canadian spring research surveys in NAFO Div. 3NO and Subdiv. 3Ps, 1972-2005. Both time series are unstandardized. See Table 1 for an inventory of areas not surveyed.

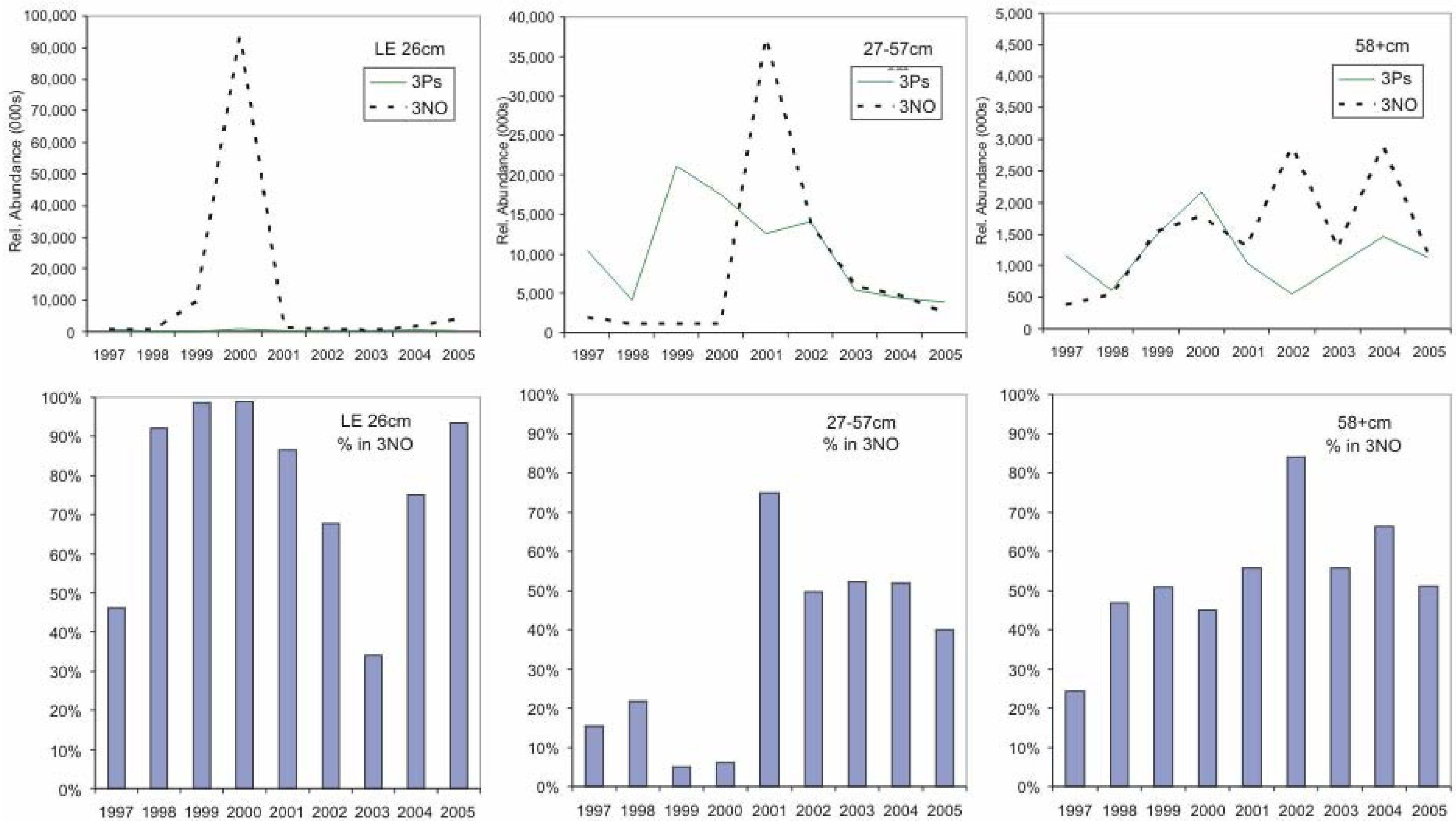


Fig. 2c. Relative abundance of white hake by life stage, 1997-2005: Less than or Equal to 26 cm is mainly year-class-1; 27-57cm contains mainly juveniles; and 58+cm is mainly mature fish. Upper panel: Relative abundance ('000s). Lower panel: Percent in NAFO Div. 3NO.

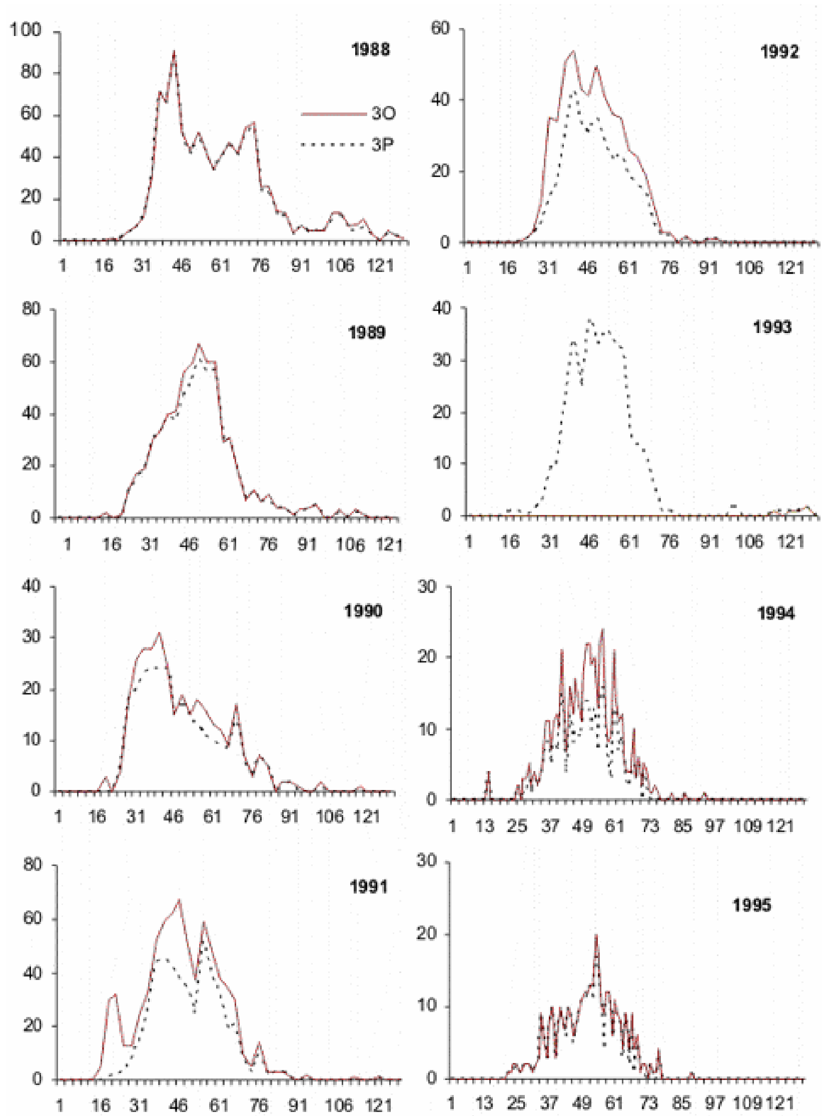


Fig. 3a. Number of white hake at length (in cm on X-axis) from Canadian spring research surveys in NAFO Div. 3O and Subdiv. 3Ps, 1988-1995.

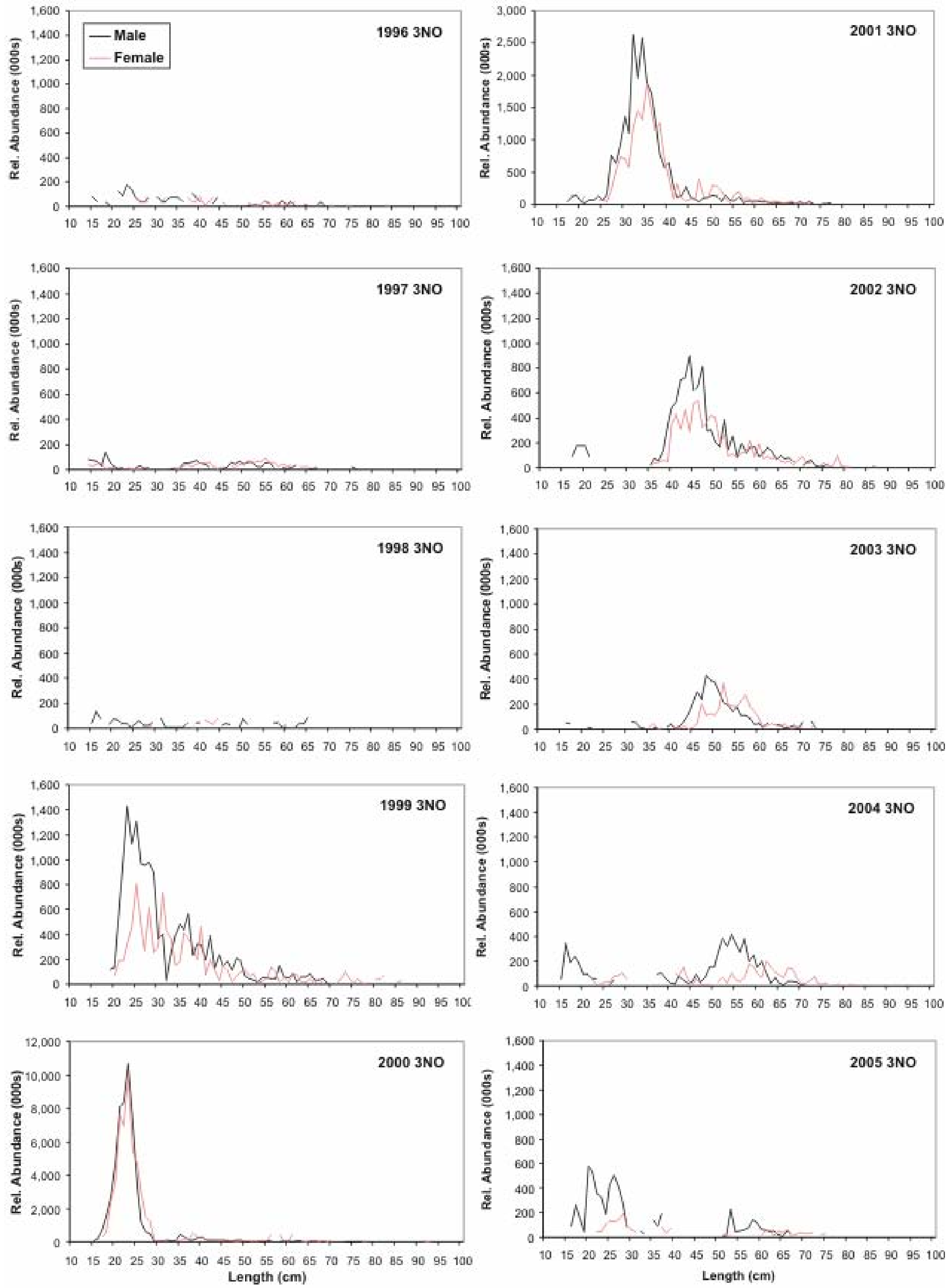


Fig.3b. Relative abundance at length of male and female white hake from Canadian spring research surveys in NAFO Div. 3NO, 1996-2005.

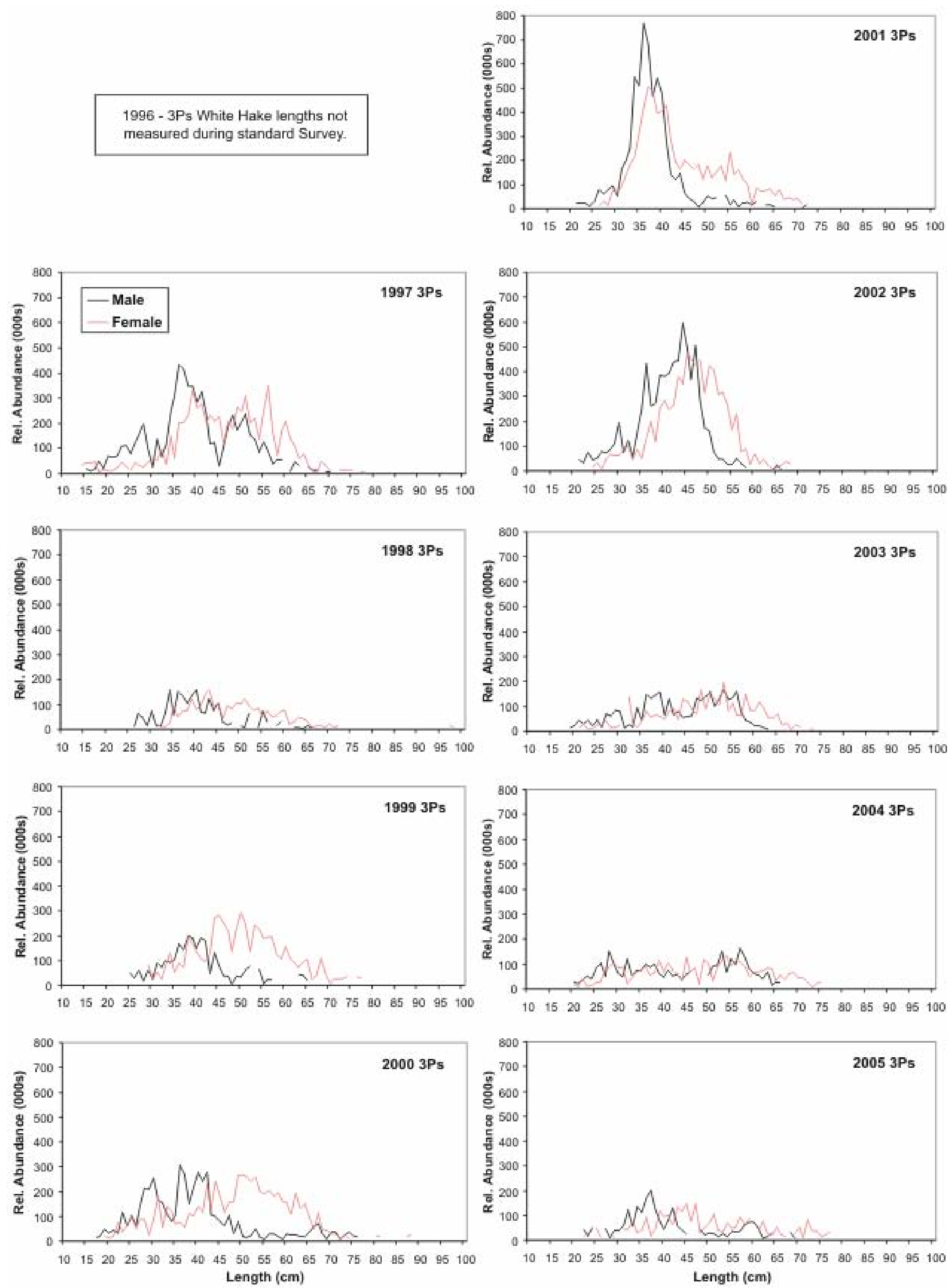


Fig. 3c. Relative abundance at length of male and female white hake from Canadian spring research surveys in NAFO Subdiv. 3Ps, 1997-2005.

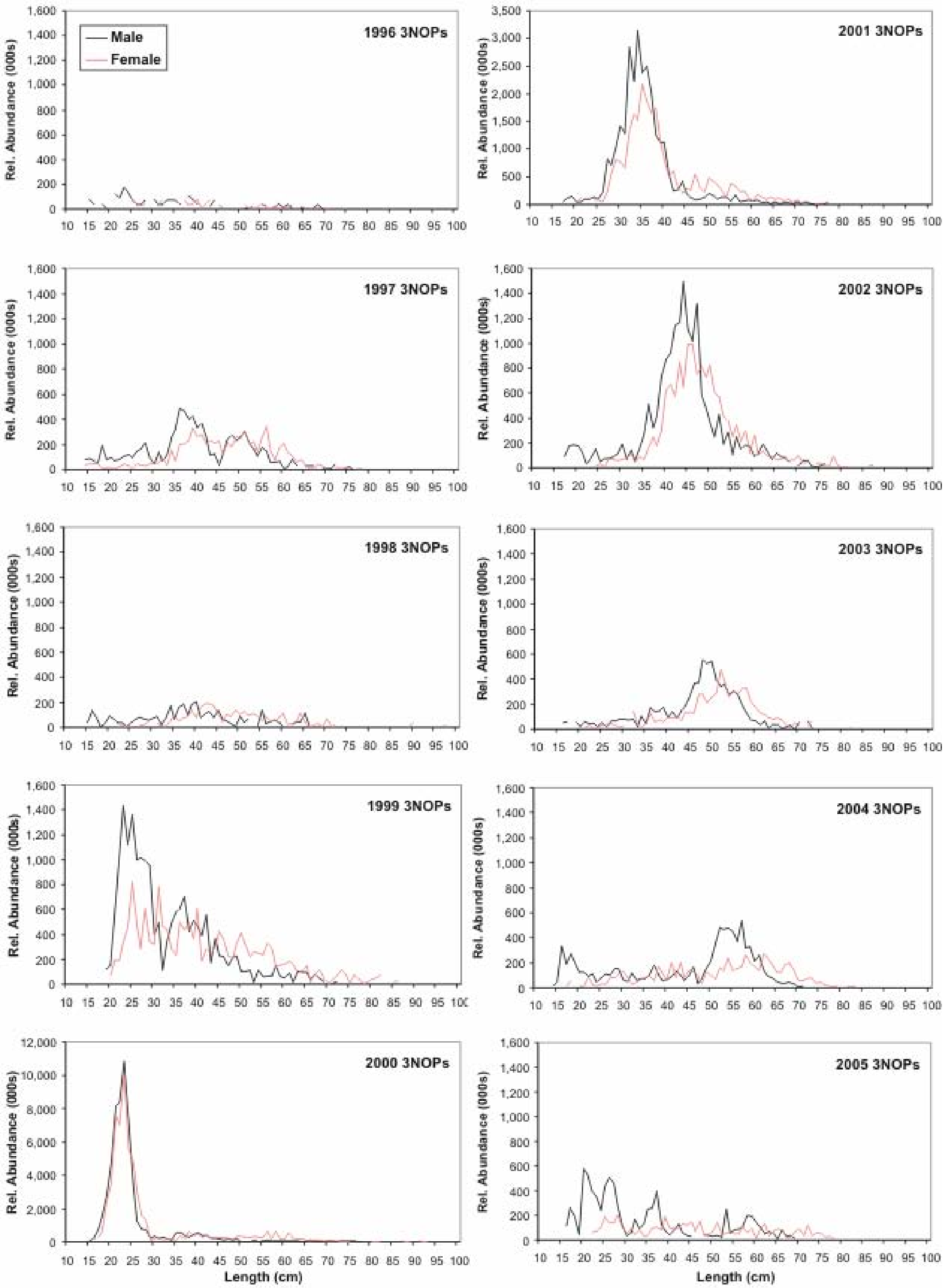


Fig. 3d. Relative abundance at length of male and female white hake from Canadian spring research surveys in NAFO Div. 3NO and Subdiv. 3Ps, 1996-2005.

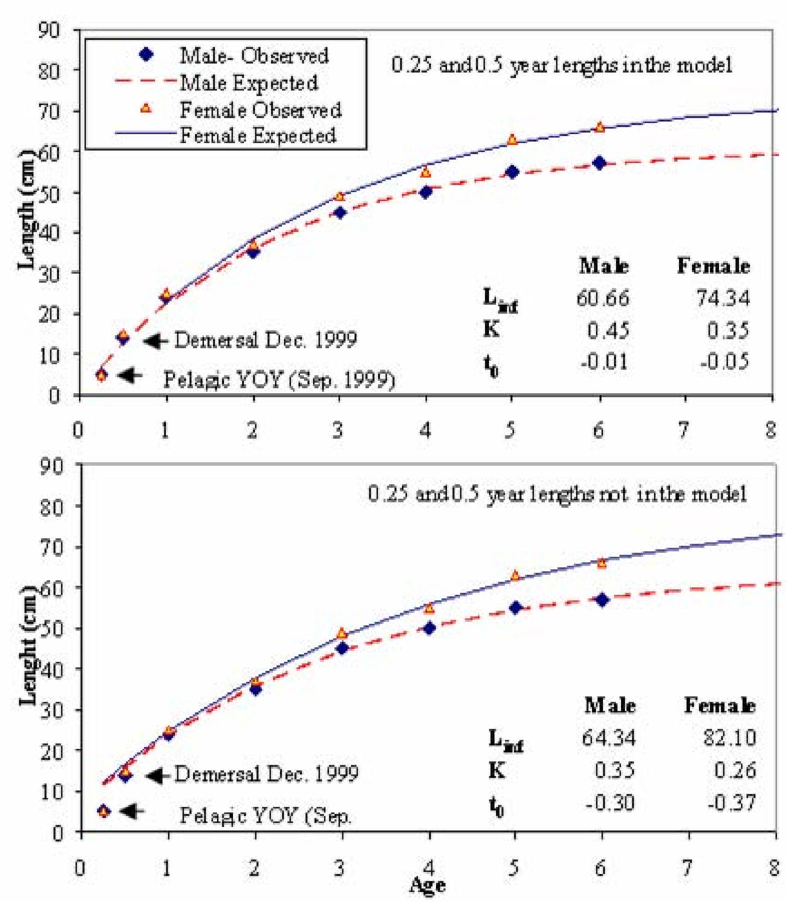


Fig. 4. Von Bertalanffy growth curves by sex for the 1999 year-class based on preliminary data. **Upper**: Observed size at age was derived from mean length of the mode of the 1999 year-class at age 1 through 5 (2000 to 2004). **Lower**: The length at age 0.25 and age 0.5 was included in the model. Annual values of length were taken from spring (Apr.-Jun.) surveys.

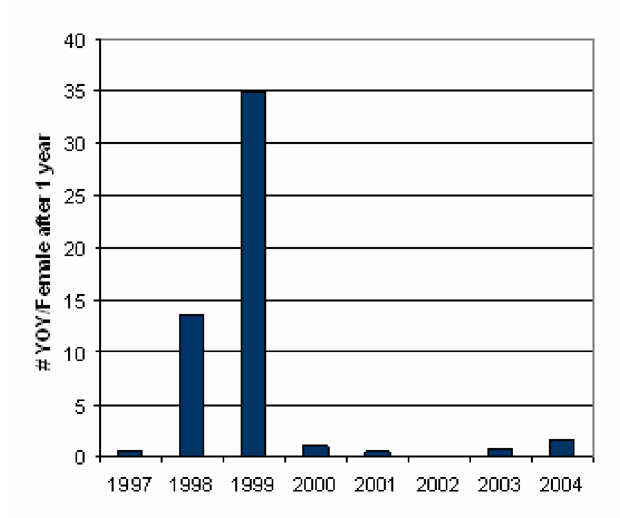


Fig. 5. Recruit per spawner expressed as number of young-of-the-year males and females (YOY produced per female) from Canadian Campelen spring surveys in NAFO Div. 3NO and Subdiv. 3Ps, 1997-2004.

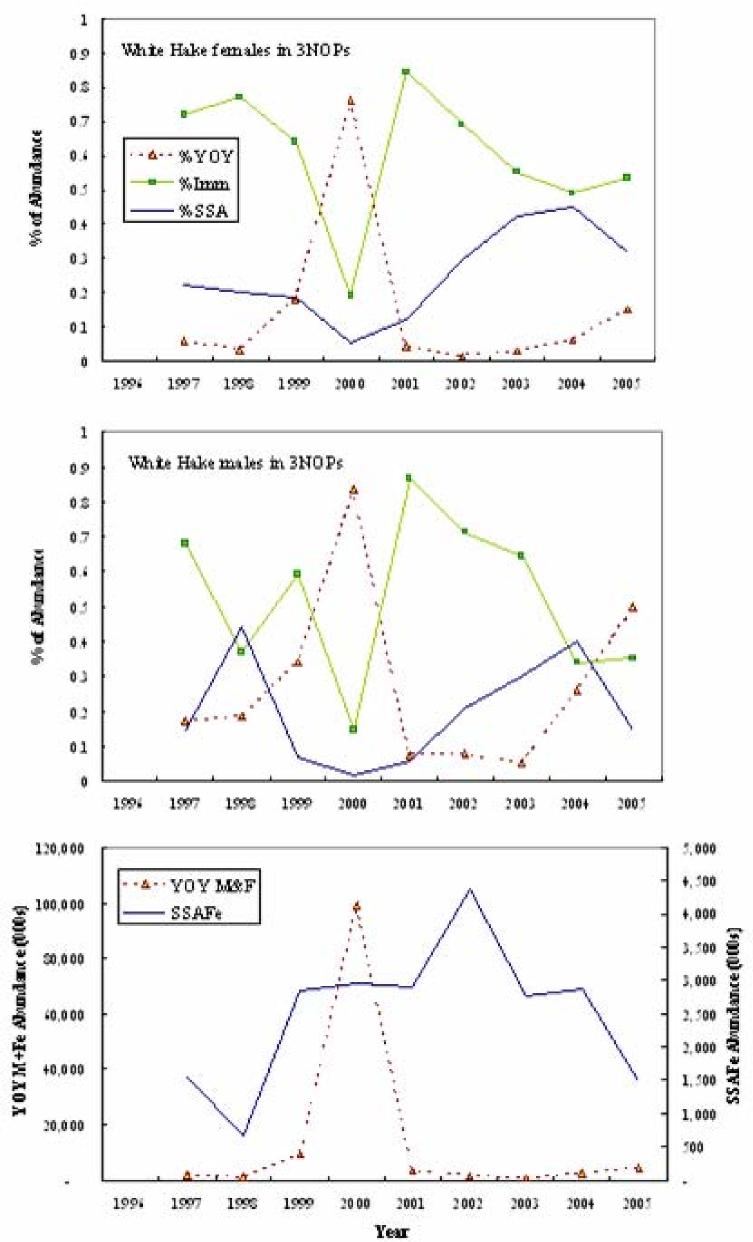


Fig. 6. Staged trends in relative abundance of young-of-the-year (YOY) and female spawning biomass (SSAFe) from Canadian Campelen spring surveys in NAFO Div. 3NO and Subdiv. 3Ps, 1996-2005.

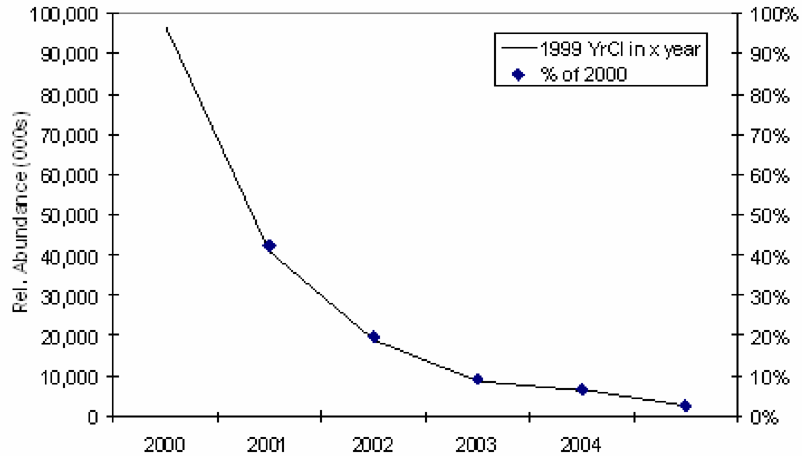


Fig. 7. Change in the relative abundance of the 1999 year-class, estimated by modal analysis, 2000 to 2004.

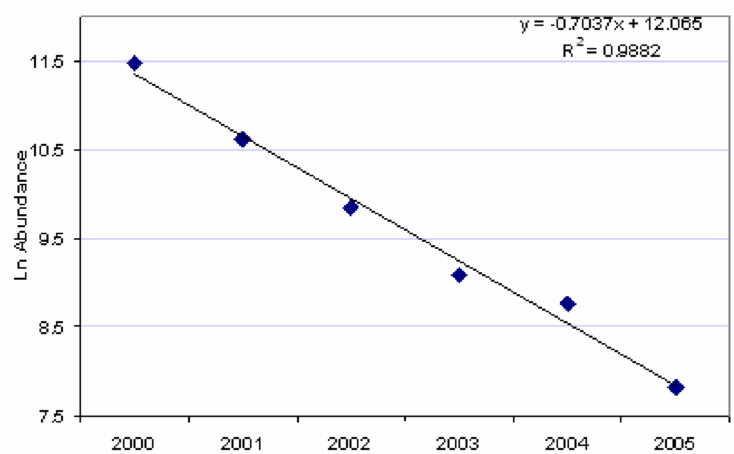


Fig. 8. Ln Abundance of the 1999 year-class 2000-2004. Slope is Z for 2000-2003.

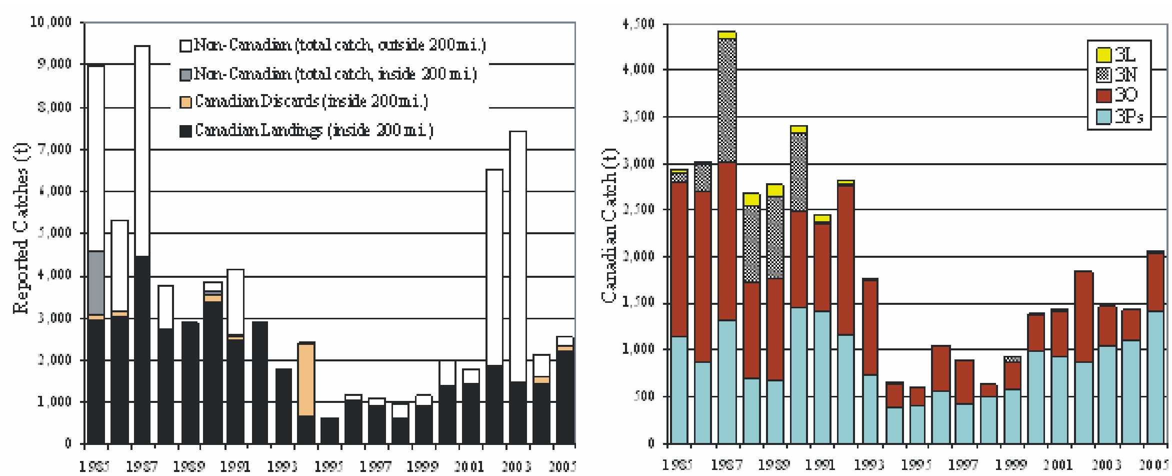


Fig. 9. Landings of white hake in NAFO Div. 3LNO and Subdiv. 3Ps, 1985-2005. Canadian landings were tabulated from ZIF, non-Canadian landings were collated from NAFO statistics for years prior to 2002, and from STACFIS since. The 2005 statistics are preliminary.

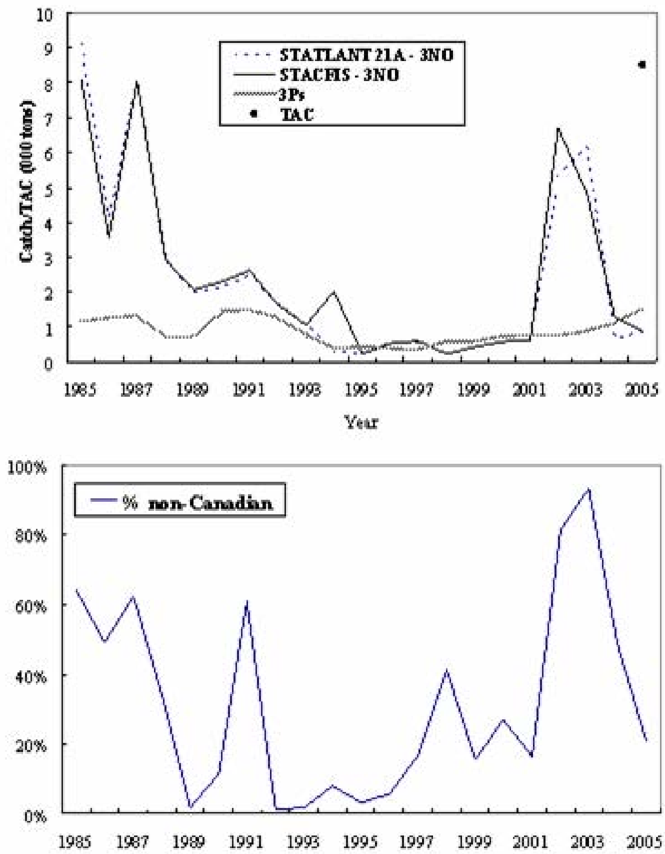
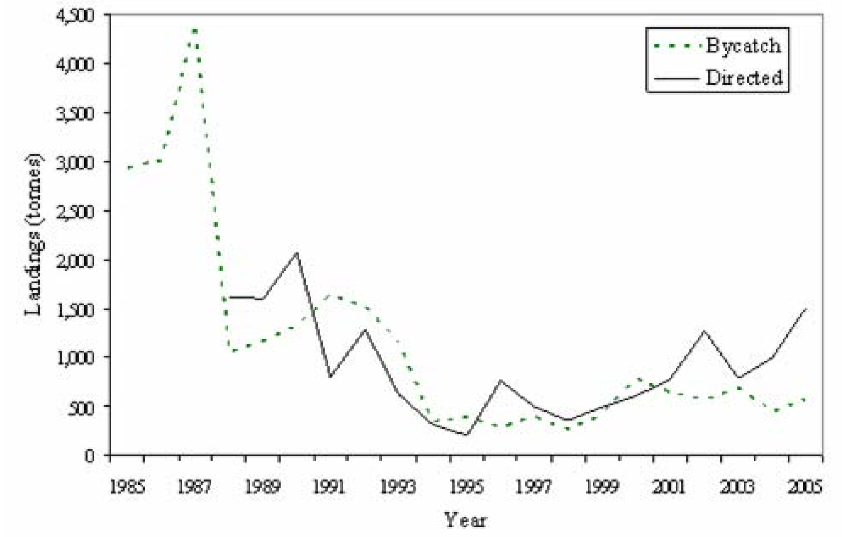
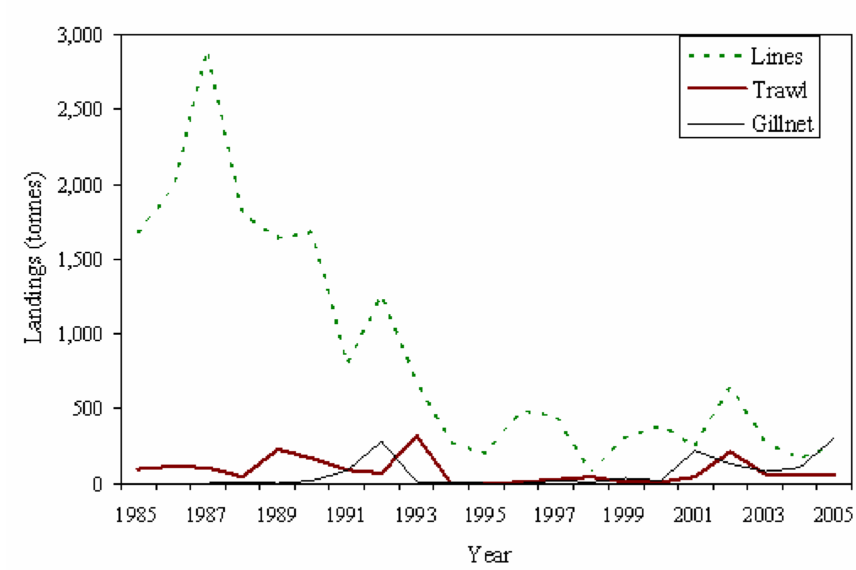


Fig. 10. Upper panel: Total reported catch of white hake and TAC in NAFO Div. 3NO and Subdiv. 3Ps, 1985-2005. Lower panel: Percent of white hake taken by non-Canadian fleets in the NAFO Regulatory Area (Div. 3NO in the NRA), 1985-2005.



Year	3L		3N		3O		3PS		
	Bycatch	Directed	Bycatch	Directed	Bycatch	Directed	Bycatch	Directed	Total
1985	32		101		1,665		1,138		2,936
1986	17		297		1,818		876		3,007
1987	80		1,314		1,705		1,314		4,413
1988	105	16	183	644	365	672	405	282	2,672
1989	80	45	235	642	416	671	432	248	2,770
1990	36	38	190	640	383	670	714	727	3,398
1991	70		16	3	362	585	1,194	207	2,438
1992	42		7	12	466	1,132	1,016	147	2,821
1993	3		17	1	545	464	580	152	1,763
1994			16	0	76	181	249	134	657
1995	2				153	52	244	151	603
1996	1				134	354	154	411	1,054
1997	0		0		173	313	217	189	893
1998	1		0		76	51	187	311	626
1999	0		23	20	76	230	321	249	920
2000	1		21		83	309	678	297	1,390
2001			5	11	150	344	495	424	1,430
2002	1		0		205	774	368	500	1,847
2003	0		0		144	271	537	517	1,469
2004			0		176	159	269	828	1,431
2005	3	20	0		115	504	449	972	2,063

Fig. 11. Directed and non-directed Canadian white hake landings in NAFO Div. 3LNOPs, 1985-2005. Data do not include discards at sea.



Year	Gillnet		Lines		Trawl		Other		Total
	Bycatch	Directed	Bycatch	Directed	Bycatch	Directed	Bycatch	Directed	
1985			1,666		100		0		1,766
1986			1,971		116		27		2,115
1987			2,904		107		8		3,019
1988	13		487	1,306	32	10	17		1,865
1989	1		490	1,149	117	114	44	50	1,965
1990	1	20	479	1,205	81	86	11		1,883
1991	17	67	288	509	72	12	2		967
1992	172	108	215	1,035	67		20		1,616
1993	9		233	446	297	18	24	2	1,028
1994	6		87	181	0	0			274
1995	0	1	153	51	0				206
1996	2		126	354	6				488
1997	9	6	137	306	27				486
1998	9		22	51	46				127
1999	32	0	56	250	11				350
2000	17	1	77	309	11				414
2001	50	171	60	183	45	0			511
2002	47	85	72	568	86	121			979
2003	49	30	30	242	66				415
2004	70	39	46	120	60				334
2005	25	279	34	225	56				619

Fig. 12. Canadian white hake landings in NAFO Div. 3LNOPs by gear type and mode (directed or bycatch), 1985-2005. Data do not include discards at sea.

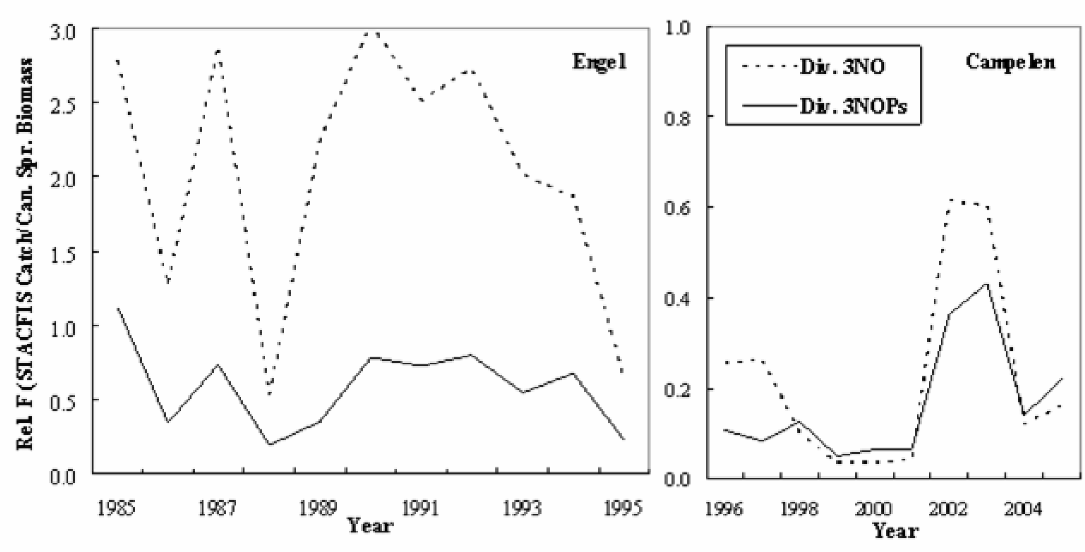


Fig. 13. Relative *F* index (= STACFIS agreed commercial catch/Canadian Campelen spring survey biomass) for white hake in NAFO Div. 3NO and 3NOPs. Both time series are unstandardized.