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The status of White hake (*Urophycis tenuis*), a non-traditionnal species in NAFO Divisions 3L, 3N, 3O and Subdivision 3Ps

by

D. W. Kulka and F. K. Mowbray

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

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Abstract

With the decline in "traditional" groundfish resources in the waters around Newfoundland, interest in the exploitation of alternate species including white hake (*Urophycis tenuis*) has increased. Presently there is a limited directed fishery for white hake on the southern Grand Banks although it is more commonly taken in mixed fisheries with cod, monkfish and skate. There is no quota for the hake fishery in NAFO Div. 3LNO and Subdivision 3Ps and effort is regulated only by closures due to excessive bycatch of other species. This paper provides: a review of fishery catch, effort, and catch composition; an analysis of abundance, biomass and size composition from research vessel surveys and an examination of spatial distribution, for white hake in NAFO Div. 3LNO and Subdiv. 3Ps, 1995-1998. Abundance has declined to lowest historic levels (perhaps stable since the early 1990's) although locale and spatial extent of the stock has remained constant since the start of stratified research surveys in the 1970's. White hake distribution is restricted to a narrow band along the southwest edge of the Grand Banks and into the Laurentian and Hermitage Channels. Here, bottom temperatures are warmest (2.5-60 C) and bottom depth ranges from 100 to 700 m. The hake distribute deeper in the spring than in the fall and as a result sustain similarly warm conditions between seasons. A 12-120 cm range of total lengths observed from research surveys has changed little over the years.

Résumé

Le déclin des ressources « traditionnelles » en poisson de fond dans les eaux voisines de Terre-Neuve a donné lieu à un intérêt accru pour d'autres espèces, notamment la merluche blanche (*Urophycis tenuis*). Actuellement, cette espèce fait l'objet d'une pêche dirigée limitée dans la partie sud des Grands Bancs bien qu'elle soit plutôt capturée, au moment de pêches mixtes, avec la morue, la baudroie et la raie. Il n'existe pas de quota pour la pêche de la merluche dans les divisions 3LNO et la sous-division 3Ps de l'OPANO et l'effort de pêche n'est régi que par les fermetures imposées suite à des captures accidentelles excessives d'autres espèces. On trouve dans le présent document un examen des captures, de l'effort et de la composition des prises, une analyse de l'abondance, de la biomasse et de la composition par tailles des captures par navire de recherche et un examen de la répartition spatiale de la merluche blanche dans les divisions 3LNO et la sous-division 3Ps de l'OPANO, de 1995 à 1998. L'abondance a chuté aux valeurs les plus faibles jamais notées (mais est peut-être stable depuis le début des années 1990), bien que localement et spatialement le stock soit demeuré constant depuis le début des relevés de recherche stratifiés, au cours des années 1970. La répartition de la merluche blanche est restreinte à une étroite bande longeant la bordure sud-ouest des Grands Bancs et pénétrant dans les chenaux Laurentien et Hermitage, où les températures au fond sont les plus élevées (2,5-6,0 oC) et la profondeur se situe entre 100 et 700 m. La merluche se rencontre plus en profondeur au printemps qu'à l'automne et demeure donc dans des zones de températures semblables au cours des saisons. La gamme des longueurs totales de 12 à 120 cm obtenue au moment des relevés de recherche a peu changé au cours des ans.

INTRODUCTION

In Atlantic waters, commercially exploited populations of white hake (*Urophycis tenuis*) are found in the Gulf of Maine, on the Scotian Shelf, in Gulf of St. Lawrence and on the Grand Banks off Newfoundland (Fig. 1). The location of the most important Canadian fisheries and correspondingly, area of greatest abundance is the southern Gulf of St. Lawrence (NAFO Div. 4T). Given its status as the third most important commercial groundfish resource in this Division until a moratorium on fishing in 1995, it has been assessed over a long period by: Beacham and Nepszy (1980), Clay *et al.* (1986), Clay (1986 and 1987), Clay and Hurlburt (1988, 1989 and 1990), Hurlburt and Chouinard (1992), Chadwick and Robichaud (1993), Hurlburt *et al.* (1994), Morin and Hurlburt (1994), Anon (1994), Anon (1995), and Hurlburt *et al.* (1995, 1996, 1997). Substantial amounts of white hake are also landed from the Scotian Shelf (Divisions 4VWX) but these stock components were not assessed until 1996 then again in 1997 (Fowler 1998). Landings and biomass have been relatively stable since the 1970's although recently, hake in this area is thought to be in decline. In American waters to the south in the Gulf of Maine, Lang et *al.* (1996) reported that landings of white hake have increased to substantial levels since the late 1960's. Thus, it is a species of some commercial value in the southern extent of Canadian waters and northern American waters.

The focus of this paper is white hake in the waters around Newfoundland in Divisions 3L, 3N, and 3O and Subdivision 3Ps comprising Grand, Whale, Green and St. Pierre Banks and collectively known as 3LNOPs (Fig. 1). Muir (1978) and Kulka and Deblois (1996) reported significant concentrations of hake in a relatively restricted area along the south and western fringe of the Grand Banks. North of this area, they are uncommon. Historically in this area, white hake was commonly taken as bycatch, particularly with cod and in mixed fisheries. It was also occasionally reported as the directed species. Prior to the mid-1980's, a significant portion of the reported landings comprised foreign catches. Although catch records have existed for years from the Grand Banks, it is a relatively minor commercial groundfish species in terms of landings in this area as described in Kulka and Deblois (1996).

With the decline of many traditional Canadian Atlantic groundfish resources in the early 1990's, interest turned to the exploitation of alternate species. White hake and other common bycatch species from various Grand Bank ground fisheries such as skate and monkfish became the focus as replacement fisheries for those under moratorium. An experimental trawl fishery for hake was carried out in 1993 in NAFO Div. 3O and Subdiv. 3Ps with limited success. Since 1994, closures due to high bycatch of regulated species have restricted catches to the lowest level observed

In spite of low catches but in consideration of the increased interest in this and other "non-traditional" species, it was assessed for the first time in 1996 by Kulka and Deblois (1996). This paper elaborates the second assessment of 3LNOPs white hake. There is no research directed for white hake in Newfoundland waters, although catch data have been collected during groundfish research surveys in 3LNOPs. Biological characteristics, such as length, sex and maturity stage are available from a portion of research survey data, but no ages or fish weights are available. Sampling of the commercial fishery is sparse and limited to length frequencies. This paper reviews available information on the distribution and biology of white hake, fishery statistics, and research vessel survey information on biomass and abundance from north-east of the Laurentian Channel to the Labrador Shelf. No VPA or other traditional stock assessment techniques are applied since ages are not available and size composition of the commercial catches is not well known. Alternatively, information from both research surveys and the commercial fisheries are used to examine hake distributions and fishery exploitation patterns (1986-1997). Distributional patterns observed may reflect population changes and may also provide some basis for defining management units.

Review of the Biology

White hake in the Northwest Atlantic range from Cape Hatteras to southern Labrador (Musick 1974). Concentrations of this species occur in the southern Gulf of St. Lawrence, on the southwestern Grand Banks, the Scotian Shelf, in the Bay of Fundy and the Gulf of Maine. It is rare north of Lat. 49^0. Hake are found over a wide range of depths from less than 200 to about 1000 m, and tolerate water temperatures from just above 0^0C to 21^0C although primarily inhabiting 5-11^0C over most of their range. Only two previous studies, Muir (1978) and Kulka and Deblois (1996) report on hake distribution and abundance in 3LNOPs. The latter study, reported a restricted and fairly constant distributional range over the last five decades on the southwestern Grand Banks although they indicated a significant shift to deeper waters in the 1990's.

Given its importance as a groundfish resource in the Gulf of St. Lawrence, much of the past research is from this area. Musick (1974) noted that generally, the diet of white hake is dominated by other fish species (i.e., cod, herring, flatfish, etc.). Specifically, Coates et al. (1982) described hake diet in the Gulf of St. Lawrence. Clay *et al.* (1992), Fowler et *al.* (1996), Hurlburt and Clay (1990) and Hurlburt et *al.* (1996) have studied stock discrimination for this species for the Gulf of St. Lawrence and the Scotian Shelf. Collectively, they reported on several geographically separate components or stocks with some overlap ranging from the Gulf of St. Lawrence to the Gulf of Maine. Clay and Clay (1991), Beacham (1983) and Hunt (1982) have looked at age validation, size and maturation. In spite of the work cited above, much remains to be learned about white hake stock structure and life history, particularly with respect to the Grand Banks component where none of this type of work has been done.

METHODS

Research Data

Data on white hake have routinely been collected during research vessel surveys for the various areas around Newfoundland. A summary of the stratified-random survey design adopted by the Newfoundland 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 can be found in Bishop (1994). Also, there has been a change in survey gear after the spring 1995 survey, from Engel 145 to Campelen 1800 bottom trawls. Gear conversion factors for amounts and sizes of fish caught were derived for the major species but not for white hake. Thus, the catch rate data and resulting biomass and abundance indices are at a different scale between the spring of 1995 and subsequent surveys. This change in gear/scale is delineated on the various tables and figures. CTD, BT, or XBT equipment was used to record bottom temperatures at all tow locations. These data were used to examine the relationship between hake distribution and bottom temperature.

Trawl data from both spring and fall stratified random surveys in Divisions 3L, 3N, 3O and Subdivision 3Ps (spring only) were used to estimate biomass and abundance and examine trends in average size of the white hake from 1985 to 1997 using STRAP (Smith and Somerton 1981). STRAP estimates biomass (and numbers of fish) by areal expansion within each of a series of pre-defined strata. These strata estimates are then added over the survey area. Two sets of estimates are provided. A 'core' estimate which includes only strata that have been surveyed throughout the years and an 'all' estimate that includes new deep water and inshore strata which have been added in recent years. Extra sets related to diurnal studies that were not part of the standard survey are included in both estimates. Primarily due to the addition of new strata, the total surveyed area has changed over the years. In 1996-97, the area surveyed was 294,589 km^2, in 1994-95 it was 283,321 km^2 and from 1986-1993 it was 255,542 km^2.

An estimate of white hake biomass for 1995 to 1997, spring and fall was also calculated using the SPANdex (SPANS index) method (after Kulka et *al.* 1996, methods detailed in Kulka 1998). This method, employing potential mapping (Burke 1997) transforms points to fish density surfaces by placing a circle around each point and averaging the values of all points that fall within the circle. The circle size selected (38 km diameter) provided the most complete coverage of the survey area, minimizing gaps in the density surface and 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, the 1000 m depth contour or the 3L and 3Ps NAFO (Sub)division lines. This resulted in a survey area similar in size to the cumulative size of the STRAP strata. However, occasional gaps still occurred in the density surface when distances between adjacent survey sets exceeded 76 km. This caused differences in total survey area as calculated by SPANS.

The surface created by potential mapping was post-stratified into 15 classes defined by fish density, each stratum covering approximately the same amount of area. Mean catch rate per area trawled and the area of the density strata was used to calculate biomass for each strata as described in Kulka (1998).

SPANS was also used to investigate the spatial distribution of white hake from RV survey data (Campelen sets, 1995 to 1998, spring and fall). For this analysis, the data used for the estimation of fall biomass/abundance using STRAP was supplemented with additional Campelen sets from special surveys in Div. 3Ps in August. Catch rates (kg per standard tow) for individual sets (point data) were converted to surfaces depicting fish density using potential mapping as described above. For the resulting maps, black areas represent the highest density of hake (highest catch per tow) fading to light grey, the lowest. White areas depict no catch.

Density distributions were plotted for the spring (1996 to 1998 combined and separate years) and fall (1995 to 1997 combined and separate years). The strata class bounds (catch per tow legend values) were held constant across years (a single legend for all years) so that varying amounts of each grey shade depicting a density level would reflect relative changes in density. Similarly, bottom temperature maps were created for both the spring and fall period using 15 strata of equal area varying from –1.4 to 5.6+ ^{0} C.

In most cases, white hake taken during the research cruises were measured for total length. Catch length frequencies (number of fish measured) were plotted by NAFO Division, survey period and year from 1986 to 1997. Sex and maturity were recorded for a subsample (about 10%) of these sets and these data were used to calculate maturity ogives by Division.

Fishery data

Hake landings were compiled using statistical records contained within the Zonal Interchange Database (ZIF) for the Canadian fishery. Landings from other countries were compiled from NAFO statistics and are considered to be minimum estimates. A portion of the landings was recorded with hake as the directed species. However, this approach probably identifies only a portion of the directed fishing since some catch records in ZIF may assign the directed species as mixed or unidentified when in fact hake was the target.

Since 1993, observers have been deployed on approximately 8 % of fishing days targeting hake. Observers collect set by set information of the catches using methods as described in Kulka and Firth (1987). This information was used to examine distribution of fishing effort and catch rates. The potential mapping method used to create the distribution maps of the fishing activity from observer records is described in the previous section. The fishing patterns observed were compared to distribution of white hake as determined from research vessel surveys.

Limited length measurements of white hake collected by port samplers or fishery observers are plotted and compared to the fish sizes caught in the research surveys. Commercial length frequencies were recorded in 1 cm. length classes as were RV survey data since 1993. Length frequencies collected from research surveys prior to 1993 were recorded in 3 cm. class intervals.

RESULTS AND DISCUSSION

Biology and Distribution

Survey estimates of biomass, abundance and fish size derived using STRAP are presented separately for spring and fall (Table 1a and 1b). In spring, the biomass of white hake was concentrated primarily in Subdiv. 3Ps and to a lesser extent in Div. 3O. Except in 1986, only a few sets per year containing hake have been observed in Div. 3N. In 3L where it was rare, only six sets with hake have been observed since 1995.

Over all, based on spring survey data, hake on the Grand Banks have undergone a dramatic reduction in the biomass (and abundance) indices from an average of about 13,000 t in 1986-88 to less than 3,000 t in 1992-95 (Fig.2 and 3). This reduction follows on an earlier period of decline in the early 1980's (Kulka and Deblois 1996). Declines in hake populations were also observed in the Gulf of St. Lawrence and on the Scotian Shelf during the late 1980's and early 1990's (Hurlburt *et al.* 1997 and Fowler *et al.* 1996).

Both biomass and abundance on the Grand Banks remained low until the change of gear in the fall of 1995 from Engels to Campelen. The sharp increase observed in 1996 in Fig. 2 is the result of the change in gear. As such, biomass index levels since 1995 cannot be directly compared with the preceding years, However, if the 2.2 Engels to Campelen biomass conversion factor calculated for some other major groundfish species is valid for white hake, recent years data would suggest a fairly steady state since about 1990. Compared to the spring, fall estimates in 3O (Subdiv. 3Ps was not surveyed in the spring) were somewhat higher in 1990-91 and 1995-97 but similar in 1992-94.

SPANdex (Kulka 1998) estimates of white hake biomass (Campelen years only) were considerably higher than those derived with STRAP (Table 2a and 2b). Trends over time however were similar in three of four instances (Fig. 4). Differences between estimates from the two methods may be attributed to different set selection criteria. Sets from other surveys (not used for STRAP) such as those specifically used to study redfish were used for the SPANdex calculations. Problems involved in making a straight-line cut-off at 3O and 3Ps boundaries (when there were no survey data on the bank in 3Ps) with SPANS software also contributed to the differences.

Trends in mean weight of hake (catch weight divided by the corresponding number of hake) matched those of abundance. Mean weight declined considerably from 1986-1991 particularly in Div. 3O (from about 4 kg. to less than 2 kg.) but has remained more or less stable since (Fig. 5). Mean weights were highest in Div. 3O (about the same in Subdiv. 3Ps since 1991) and were lowest in Div. 3N.

White hake were not measured for total length in all research survey sets, or in all years. For this reason, length frequencies are presented as the number measured only, not extrapolated to total numbers caught. The sizes of fish measured in both spring and fall surveys ranged from 9-130 cm total length but fell mainly between 25 and 85 cm (Fig. 6 & 7). Length frequency distributions of hake caught in 3O and 3P were similar in most years. White hake greater than 85 cm have not been caught in any numbers since 1991 in either season. Likewise, modes of fish <25 cm appear only in 1991 and 1997. The substantial proportion of 25 cm mode fish observed in both the spring and fall of 1997 may indicate a significant incoming year class, certainly the best sign of small fish in recent years. White hake ranging of 2.5 to 11 cm were taken in the previous year, 1996, in the pelagic IYGPT (International Young Gadoids Pelagic Trawl) tows (Dalley and Anderson 1997) in Aug.-Sept. They occurred in the largest numbers observed since the start of the pelagic survey in 1994 near the surface in an area just to the north-east of the adult distribution (Fig. 8). An estimated growth rate of about 2.5 cm per month (Hurlburt *et al.* 1997) for this 1996 year class would correspond with the 25 cm mode of hake seen in the 1997 bottom trawl surveys on the Grand Banks.

These pelagic hake, if similar in their life history attributes to those in the Gulf of St. Lawrence (as described by Hurlburt et *al.* 1997) were young of the year spawned in the spring taken just prior to settling. Similarly, for the Gulf of St. Lawrence, Hulburt et *al.* (1997) noted not only a strong incoming year class in 1996 but also in 1995 (refer to a discussion of stock affiliations below).-In areas further to the south in the Gulf of Maine, Bay of Fundy and southern Scotian Shelf, pelagic juveniles are found earlier, in May-June as reported by Fahay and Able (1989) and Fowler et *al.* (1996) suggesting earlier spawning to the south. Fowler (1998) noted a pulse of 30-40 cm fish in the 4V (Scotian Shelf) survey estimate, but it disappeared in 1998. He speculated that it was a transient component of hake from the Laurentian Channel that the surveys pick up irregularly. Although both bottom trawls used in RV surveys retained a large range of sizes, it appears from the length data presented in Fig. 6 and 7 that the catchability of smaller fish with the Campelen trawl is greater than with the Engels trawl. The reverse is true for larger fish. This change in catchability further hinders inter-annual comparisons.

Kulka and Deblois (1996) showed that white hake biomass from research surveys has been consistently concentrated in a narrow band along the southwestern edge of the Grand Banks and into the Laurentian Channel at an average depth of about 250 m from 1970 to 1989 and at 350 m since. It appears that white hake occur in deeper waters on the Grand Banks compared to the Gulf of St. Lawrence, Scotian Shelf and Gulf of Maine (Hulburt et *al.* 1997, Fowler et *al.* 1996, Fahay and Able 1989). This difference is due perhaps to their preference for warmer water as discussed later.

For 1995-1997, the spatial distribution of Grand Bank hake (with the exception of the shift in depth) is similar to that previously noted (Kulka and Deblois 1996). There has been no major change in its range over the last twenty-five years in spite of a substantial reduction in density (Fig. 9). Hake distributions were similar between spring and fall, particularly in Div. 3O. In Subdiv. 3Ps, they were perhaps more densely aggregated at the edge of the bank along the Laurentian and Hermitage Channels later in the year compared to the spring. It should be noted that in the fall figure, some sets were done in Aug., not part of the standard fall survey sets that occurred later. These Aug. sets were also done on the Subdiv. 4Vn side of the line. This area was not surveyed in the spring. Both spring and fall distribution patterns were similar among the three years (Fig. 10 & 11). Seasonal abundance distribution patterns were similar to those of biomass (Fig. 12). In both spring and fall mean fish weight tended to be higher along the southwestern edge of the Grand Banks than along the Laurentian Channel (Fig. 13). This may be one reason for the concentration of fishing effort along the southwestern edge as described later. The few fish recorded in Div. 3O and 3L in the fall tended to be large individuals.

While no stock discrimination work has been carried out for hake on the Grand Banks, its distribution is continuous across the Laurentian Channel onto the Scotian Shelf and up into the Gulf of St. Lawrence. This suggests some level of affiliation or mixing of hake in the adjacent areas of Div. 4T in the Laurentian Channel and Div 4V on the northeast Scotian Shelf (this paper and Fowler et *al.* 1996). Hurlburt et *al.* (1996) concluded that there were two stock components in the Gulf of St. Lawrence, one in the Laurentian Channel. It is this deep component that forms a continuous distribution not only with the 4Vn (southwest side of the Laurentian Channel) component as reported by Fowler et *al.* (1996) but also with the Grand Banks concentrations that extends through Subdiv. 3Pn and Div. 4R in the Laurentian Channel into Div. 4T.

Gonad maturity stages of white hake caught by RV surveys were available for Div. 3O and Subdiv. 3Ps in some years. However, on average, maturity stage was recorded for less than one third of the catch. Nonetheless, when maturity stages were available, length at maturity (length at which 50% of hake were sexually mature or L_{50}) was calculated for each combination of sex and area (Table 3 and Fig. 14). As with other gadoids, males were found to mature at smaller sizes than females. Size at maturity for males (50% mature at about 41 cm) did not differ greatly between the two divisions, nor were they very different between the two time periods. For females, there was greater variation between areas. For example, size at 50% mature in Div. O was 48 cm in the earlier period and 60 cm in the later period. In 3Ps they were 60 cm in the earlier period and 52 cm in the later period. However, small sample size may have contributed to some of difference in mean size at 50% maturity observed between Div. 3O and Subdiv 3Ps. What these differences mean in terms of stock differentiation between 3O and 3Ps given the apparently continuous distribution between the two areas is unclear.

In an attempt to identify differences in spatial distribution with respect to maturity, the percent of mature hake in each set (1995-1998) was mapped (Fig. 15). A preliminary inspection indicated that males and females were distributed in a similar manner with regard to sexual maturity. With very few exceptions, catches along the extreme shelf edge of the Grand Banks tended to be dominated by mature fish while immature fish predominated in catches more inshore. Hake caught in Hermitage Channel (3Ps) were nearly exclusively immature fish while those in the Laurentian Channel tended to be mature.

Fig. 16a compares available area by depth to the depth distribution of hake. In 1995-1997, while only 39% of the available habitat within the surveyed area fell between 151 to 700 m bottom depth, 98% of biomass of hake, both spring and fall was located within that depth range (Fig. 16b, density and Fig. 16c, biomass). Most (73%) of the biomass was concentrated between 200 and 500 m in the spring while 87% occurred in 100-350 m in the fall. For the period 1976-90, Kulka and Deblois (1996) found that hake in the spring were found at an average depth of about 250 m. For 1991-94, the average depth had increased to 350 m, similar to what was observed for 1995-98 (this study).

Fig. 17, comparing cumulative area and biomass further illustrates the seasonal differences. This analysis resembles the CDF or cumulative distribution function (Smith and Page 1996) used to compare available habitat with distribution of the species. The biomass line fell below the available area line at all depths less than 700 m indicating preferential occupation of deeper waters, more so in the spring.

Water masses on the Grand Banks are a mix of cold, low salinity waters that are transported into the area by the Labrador Current. Spring and fall bottom temperature distributions are similar (Fig.18) but in the fall, temperatures are about 0.5^0 C warmer averaged over the entire area. Over the inner portion of the continental slope at depths of 200+ m, comparatively warmer (and saline) conditions occur particularly along the western edge of the Grand Banks and up into the Laurentian Channel where temperatures average in the 3 to 5^0 C range. The warm slope water extends furthest onto the shelf along the southwestern edge of the Grand Bank and the southern St. Pierre Bank. A warm area also occurs on the shelf over the Southeast Shoal (30-80 m) and in the Laurentian Channel where temperatures above 4^0 C can be found. The coldest areas where temperatures are less than 0^0 C are found in the waters surrounding the Avalon Peninsula both spring and fall, although more extensively in the spring. Annual plots show similar patterns from year to year with some variation in extent of warm and cold areas (Fig. 19 and 20).

Given that white hake spend most of their time near the bottom, the bottom temperatures used in this analysis can be considered the ambient conditions. Fig 21, panel A shows that the extent of the available habitat (area within temperature strata) varied between spring and fall. In the spring, cold areas were more extensive, particularly in the -0.54 to 0.24^0 C range. The inner portion of Subdiv. 3Ps was not sampled in the fall, in part explaining the reduced area of cold water shown in Fig. 16 for the fall. Also in the fall, there was a larger extent of water warmer than 5^0 C, this around the periphery of the bank and on the Southeast Shoal. The distribution of white hake in relation to bottom temperature indicates that they were distributed highly dis-proportionately across available habitat. Hake are found only on the warmest parts of the banks, almost exclusively where bottom temperature exceeded 2.3^0 C in the spring and 4.4^0 C in the fall. Comparing panels A and C in the spring and (fall) respectively, only 28% (spring) and 23% (fall) of the surveyed area had bottom temperatures that exceeded 2.3 and 4.4^0 C, but this is where 99.8 and 97.3% of the biomass of hake occurred.

Fig. 22, comparing cumulative area and biomass in relation to ambient temperature (resembling the Smith and Page 1996 CDF technique) further illustrates the seasonal differences. Spring and fall distributions of hake were extremely non-thermal neutral. Thus, hake differentially distribute in warmer waters on the Grand Banks, more so in the spring. Bottom water temperatures above about 3^0 C and depths of 150 to 500 m are the preferred habitat for hake on the Grand Banks. This compares with Fowler et *al.* (1996) who for the Scotian Shelf found that the best catches of both juveniles and adults were taken between 3 and 8^0 similar to the Grand Banks but at depths much shallower than on the Grand banks, between about 20 and 220 m. The similarity between distribution with respect to temperature but not depth between the two areas suggests that temperature preference most affects distribution of white hake.

The Fishery

According to the 1997 Groundfish Conservation Harvesting Plan (CHP), any groundfish permit holder could request a license condition to direct for hake. The only limitation in the CHP regarding the location and timing of these directed fisheries applied to vessels < 65' with fixed gear wishing to fish in 3Ps. Vessels in this category could only be issued a permit to fish during the period Apr.1 through Dec. 31. Other vessel size/gear combinations could apply to direct for hake at any time or location within 3LNOPs. However, the timing, duration and areas permitted for individual licenses were at the discretion of DFO Fisheries Management Branch. Consequently the timing, duration and location of fishing varied among fishers depending on the area requested, when the license was applied for, the potential for cod bycatch, and the homeport of the fisher making the request. Some licenses were given for only one trip only while others covered longer time periods. In 1997, approximately 15 licenses were issued to vessels <65' fishing offshore 3Ps, while around 12 were in effect for offshore 3O. These were in addition to large vessel licenses (65-100 ft.), 2-3 of which were given for 3Ps and 3-4 of which for 3O. Offshore 3Ps fisheries were closed June 6. A few vessels 35-64 ft. were licensed to fish inshore 3Ps (inside 12 nmi) in August. No closures resulted from excessive catches of small fish (<45 cm) in any of these fisheries, although closures due to excessive bycatch of other groundfish species (defined as the greater of 5% or 1250 kg/trip) were common. Exceeding bycatch limits was the primary cause for closures and low catches. Restrictions on incidental white hake catches while directing for other groundfish species were the same as specified above. When directing for hake the following gear restrictions applied: *gillnets*, 6 inch minimum mesh size; *hook and line*, #14 circle or equivalent. There was no TAC set for white hake in 3LNOPs in 1997.

Until 1992, both Canadian and non-Canadian fishers landed white hake. Since then, only Canadian landings have occurred (Fig. 23). Although interest in fishing hake has increased in recent years, landings have decreased. Annual Canadian catches, which averaged about 3,000 t from 1985 through 1992, declined to near 1,800 t in 1993 and have averaged about 640 t in the last four years. This decline is due to both decreased landings of incidental hake catch from other groundfish fisheries (many of which are still under moratorium), and limited effort in the directed fishery which has been frequently shut down due to excessive bycatch of regulated species (i.e. cod). Prior to 1988, all white hake landings were from incidental catch. But, since 1989 the directed fishery has contributed, on average, about 50 % of the annual Canadian catch, ranging from 30-60%. (Fig. 24).

In most years prior to 1995, the majority of commercial catches were taken with long lines. However, in recent years gillnet catches have increased to a point where they are now of equal importance. Trawls have rarely contributed a large proportion of the total catch except as bycatch (Fig. 25).

The majority of landings occurred in the latter half of the year. Gillnet catches typically peaked in August or September, whereas longline catch peaked in June-July and again near the end of the year (Table 4, Fig.26). Fishery observer data indicated that longlines are fished more frequently on the shelf edge in Div. 3O whereas gillnets were the gear of choice in Subdiv. 3Ps (Fig. 27). Regularity in the timing of gillnet catch in 3Ps probably reflects seasonal constraints on the fishery due to cod bycatch problems as opposed to hake availability.

Gillnets were used only in a small area in Subdiv. 3Ps. No trends are evident in the spatial distribution of gillnet catch rates (fishery observer data). For longlines, the eastern most grounds tended to have better catches than their western counterparts (Table 5, Fig. 28). While comparable data on size composition of these catches was not available, a limited number of commercial length frequencies were available, though not all combinations of gear and year were covered. Nonetheless, the available data suggest that longline catches contained a larger range of sizes, and more large fish, than did catch from gillnets or trawls (Fig. 29).

CONCLUSION AND PROGNOSIS

Although the range of white hake has remained relatively constant over the years, there has been a shift to deeper waters in recent years. This change was concurrent with a dramatic reduction in biomass. Based on spring surveys, hake biomass had declined to an all time low by 1990, remaining at low levels through 1995. A change in gear from Engel to Campelen in fall 1995 likely affected catchability of white hake in research surveys. Given this change in gear, biomass index levels since 1995 cannot be directly compared with the preceding years, but if one applies the 2.2 conversion factor as calculated for some other major groundfish species, recent years data would suggest a fairly steady state since about 1990. Most likely, the biomass has remained at its lowest historic level. Fall biomass indices for Div. 3O are greater than those from spring surveys but had a similar trend over time. Seasonal differences in Subdiv. 3Ps are unknown as the area is not surveyed in the fall.

Also concurrent with declining biomass was a decrease in the mean length and weight of hake. Although hake larger than 85 cm were consistently caught in earlier years, subsequent to 1990 they have been captured infrequently indicating a continuing weak spawning biomass. This truncation in length composition is a contributing factor to the decrease in mean fish weight observed in survey catches and may be indicative of stock stress. On the positive side, is the first appearance of a mode of 25 cm fish, young of the previous year. This is the only appearance of significant amounts of fish of this size since 1991 (1991 and 1997 the only years since 1988). How this translates into future biomass will be monitored.

Sources of Uncertainty

Little is known about white hake in 3LNOPs as there has been no directed research on this species. Ages are not available, and data on length, individual weights, and maturity of fish in research survey catches is incomplete. Thus, signs of changes in the population related to length at age or year class composition cannot be detected. There has been almost no sampling of commercial catches and thus information on fishing mortality is restricted to undifferentiated (by size or age) weights of removals. No information on stock affiliation is available except for distributional evidence of some overlap or mixing between Subdiv. 4Vn on the Scotian Shelf and Div. 4T in the Gulf of St. Lawrence. As previously noted, current biomass levels (since 1995) cannot be compared to previous years due to the change in research survey gear. Likewise, comparisons of size over time are difficult as length information has not been collected routinely. Statistics of bycatch from earlier years may be incomplete. Current catch records may not be adequate for separating landings originating from by-catch and those from any directed fishery. Also, it is likely that some hake landed in Newfoundland waters and reported as red hake, are actually white hake.

Outlook

Since recent biomass indices cannot be related to those of previous years, the current state of the stock cannot be properly assessed. However, the declining trend in the survey biomass observed prior to the change in gear, coupled with declines in the numbers of large fish captured in research surveys are reasons for concern. In contrast, the distributional range of the species has not changed, as has been observed in some depleted groundfish stocks (although they distributed deeper within the range) and a mode of small fish was observed in 1997.

White hake landings occur both as bycatch and from a directed fishery. Catches are currently below historical averages. However, it is not clear whether these low catches reflect a change in abundance or whether it is a result of limited effort due to bycatch restrictions or some combination.

At present, closures due to bycatch of other species are the only limit on directed fishery effort. If this constraint was removed, catches could increase beyond acceptable levels. Given the uncertainty of current stock abundance, a precautionary TAC should be considered.

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Table 1a. Biomass, abundance and mean weight of white hake from spring research vessel surveys, 1986-1998. Surveys were conducted with an Engels trawl (1986- fall 1995) and Campelen (spring 1996- 1998). Estimates are given separately for "core" strata (those covered in all surveys) and "all" strata (includes new deep water and inshore strata added in recent years).

Biomass (tonnes)

Trawl	Year	Div. 3L Core	Div. 3L All	Div. 3N Core	Div. 3N All	Div. 3O Core	Div. 3O All	Div. 3P Core	Div. 3P All	All Divisions Core	All Divisions All
Engels	1986	0		356		2438		11105		13899	
	1987	0		43		2752		9866		12661	
	1988	0		32		5431		13005		18468	
	1989	0		0		925		6884		7809	
	1990	0		0		754		3988		4742	
	1991	0		0		1039		4591		5630	
	1992	0		0		606		3008		3614	
	1993	0		0		522		2929		3451	
	1994	0	0	0	0	1066	1079	2433	2433	3499	3512
	1995	0	0	0	0	334	334	2334	2334	2668	2668
Campelen	1996	0	0	4	4	2020	2020	6282	6282	8306	8306
	1997	0	0	4	4	2221	2221	8449	8507	10674	10732
	1998	0	0	7	7	2198	2198	4015	4164	6220	6369

Abundance (thousands)

Year	Div. 3L Core	Div. 3L All	Div. 3N Core	Div. 3N All	Div. 3O Core	Div. 3O All	Div. 3P Core	Div. 3P All	All Divisions Core	All Divisions All
1986	0		70		574		4186		4830	
1987	0		95		1114		4438		5647	
1988	0		63		690		5533		6286	
1989	0		0		251		4130		4381	
1990	0		0		236		2941		3177	
1991	0		0		1118		3800		4918	
1992	0		0		574		2699		3273	
1993	0		0		301		2670		2971	
1994	0	0	0	0	880	885	2274	2274	3154	3159
1995	0	0	0	0	189	189	2104	2104	2293	2293
1996	0	0	75	75	2982	2982	8089	8089	11146	11146
1997	0	0	91	91	2987	2987	12239	12432	15317	15510
1998	0	0	79	79	2225	2225	4777	4952	7081	7256

Mean Weight (kg)

Year	Div. 3L Core	Div. 3L All	Div. 3N Core	Div. 3N All	Div. 3O Core	Div. 3O All	Div. 3P Core	Div. 3P All	All Divisions Core	All Divisions All
1986			5.086		4.247		2.653		2.878	
1987			0.453		2.470		2.223		2.242	
1988			0.508		7.871		2.350		2.938	
1989					3.685		1.667		1.782	
1990					3.195		1.356		1.493	
1991					0.929		1.208		1.145	
1992					1.056		1.114		1.104	
1993					1.734		1.097		1.162	
1994					1.211	1.219	1.070	1.070	1.109	1.112
1995					1.767	1.767	1.109	1.109	1.164	1.164
1996			0.053	0.053	0.677	0.677	0.777	0.777	0.745	0.745
1997			0.044	0.044	0.744	0.744	0.690	0.684	0.697	0.692
1998			0.089	0.089	0.988	0.988	0.840	0.841	0.878	0.878

Table 1b. Biomass, abundance and mean weight of white hake from fall research vessel surveys, 1986-1998. Surveys were conducted with an Engels trawl (1986- fall 1995) and Campelen (spring 1996- 1998). Estimates are given separately for "core" strata (those covered in all surveys) and "all" strata (includes new deep water and inshore strata added in recent years).

Campelen Engels

Biomass (t)

	Div. 3L		Div. 3N		Div. 3O		Div. 3P		All Divisions	
Year	Core	All	Core	All	Core	All	Core	All	Core	All
1986	0	0	0	0	0		0	0	0	0
1987	0	0	0	0	0		0	0	0	0
1988	0	0	0	0	0		0	0	0	0
1989	0	0	0	0	0		0	0	0	0
1990	0	0	0	0	1784		0	0	1784	0
1991	0	0	0	0	2805		0	0	2805	0
1992	0	0	22		471		0	0	493	0
1993	0	0	0		748		0	0	748	0
1994	0	0	0	0	1445	1445	0	0	1445	1445
1995	0	0	94	94	4099	4099	0	0	4193	4193
1996	0	0	6	6	3960	3960	0	0	3966	3966
1997	0	0	72	72	4192	4192	0	0	4264	4264
1998										

Abundance (thousands)

	Div. 3L		Div. 3N		Div. 3O		Div. 3P		All Divisions	
Year	Core	All	Core	All	Core	All	Core	All	Core	All
1986	0	0	0	0	0	0	0	0	0	0
1987	0	0	0	0	0	0	0	0	0	0
1988	0	0	0	0	0	0	0	0	0	0
1989	0	0	0	0	0	0	0	0	0	0
1990	0	0	0	0	863	0	0	0	863	0
1991	0	0	0	0	2047	0	0	0	2047	0
1992	0	0	63	0	448	0	0	0	511	0
1993	0	0	0	0	490	0	0	0	490	0
1994	0	0	0	0	1341	1341	0	0	1341	1341
1995	0	0	306	306	5409	5409	0	0	5715	5715
1996	0	0	143	143	3850	3850	0	0	3993	3993
1997	0	0	64	64	5361	5361	0	0	5425	5425
1998										

Mean Weight (kg)

	Div. 3L		Div. 3N		Div. 3O		Div. 3P		All Divisions	
Year	Core	All	Core	All	Core	All	Core	All	Core	All
1986										
1987										
1988										
1989										
1990					2.06721				2.06721	
1991					1.3703				1.3703	
1992			0.34921		1.05134				0.96477	
1993					1.52653				1.52653	
1994					1.07755				1.07755	
1995			0.30719		0.75781				0.73368	
1996			0.04196		1.02857				0.99324	
1997			1.125		0.78194				0.78599	
1998										

Table 2a - SPANdex index of abundance for white hake from fall research vessel surveys in NAFO Divisions 3L, 3N, 3O and 3P.

Fall 1995

Density Class	Set Count	3LNOP Area	Mean Kg per tow	Biomass kg	Biomass t	Stdev	% of Biomass	Cum. % of Area	% of Area
1	263	241,932	0.0	0	0	0.0	0.00%	100.0%	100.0%
2	10	5,460	0.0	0	0	0.0	0.00%	100.0%	27.1%
3	7	6,527	0.0	2,793	3	0.0	0.02%	100.0%	25.5%
4	8	6,061	0.0	10,376	10	0.1	0.07%	100.0%	23.5%
5	14	5,374	0.1	22,999	23	0.2	0.16%	99.9%	21.7%
6	7	5,657	0.0	0	0	0.0	0.00%	99.8%	20.1%
7	9	5,662	0.6	133,275	133	0.8	0.91%	99.8%	18.4%
8	8	7,922	0.3	94,932	95	0.7	0.65%	98.8%	16.7%
9	8	6,374	0.8	229,144	229	1.5	1.56%	98.2%	14.3%
10	8	6,251	2.4	644,739	645	3.6	4.38%	96.6%	12.4%
11	12	5,253	1.8	393,426	393	3.6	2.67%	92.3%	10.5%
12	12	4,650	4.1	813,943	814	5.3	5.53%	89.6%	8.9%
13	18	8,566	5.6	2,045,643	2,046	7.3	13.90%	84.1%	7.5%
14	15	6,500	9.5	2,653,867	2,654	12.7	18.03%	70.2%	4.9%
15	9	9,806	18.3	7,671,593	7,672	26.0	52.13%	52.1%	3.0%
Sum	408	**331,995**	2.90	**14,716,730**	***14,717***	4.13	**100.00%**	**0.0%**	**0.0%**

Fall 1996

Density Class	Set Count	3LNOP Area	Mean Kg per tow	Biomass kg	Biomass t	Stdev	% of Biomass	Cum. % of Area	% of Area
1	247	247815	0.0	0	0	0.0	0.00%	100.0%	100.0%
2	3	4588	0.0	1,964	2	0.0	0.01%	100.0%	20.4%
3	9	5205	0.0	0	0	0.0	0.00%	100.0%	18.9%
4	4	4333	0.0	3,709	4	0.0	0.01%	100.0%	17.3%
5	8	4276	0.5	96,991	97	0.8	0.35%	100.0%	15.9%
6	4	3700	0.9	147,266	147	1.0	0.54%	99.6%	14.5%
7	7	4585	2.5	486,641	487	2.4	1.78%	99.1%	13.3%
8	9	3956	2.9	482,524	483	3.1	1.76%	97.3%	11.9%
9	7	5014	5.1	1,087,952	1,088	5.2	3.97%	95.6%	10.6%
10	5	5572	5.0	1,185,182	1,185	9.0	4.32%	91.6%	9.0%
11	6	4380	5.0	937,263	937	7.2	3.42%	87.3%	7.2%
12	14	6822	10.5	3,068,541	3,069	17.7	11.19%	83.8%	5.8%
13	3	3395	42.5	6,179,490	6,179	32.4	22.54%	72.6%	3.6%
14	3	5601	24.4	5,853,677	5,854	33.0	21.35%	50.1%	2.5%
15	6	2167	85.0	7,880,287	7,880	176.0	28.75%	28.7%	0.7%
Sum	335	**311,409**	12.29	**27,411,485**	***27,411***	19.19	**100.00%**	**0.0%**	**0.0%**

Fall 1997

Density Class	Set Count	3LNOP Area	Mean Kg per tow	Biomass kg	Biomass t	Stdev	% of Biomass		% of Area
1	251	241,932	0.0	0	0	0.0	0.00%	100.0%	100.0%
2	8	5,460	0.0	0	0	0.0	0.00%	100.0%	27.1%
3	10	6,527	0.1	36,314	36	0.3	0.07%	100.0%	25.5%
4	10	6,061	0.6	155,637	156	1.2	0.31%	99.9%	23.5%
5	15	5,374	1.0	225,393	225	2.0	0.45%	99.6%	21.7%
6	11	5,657	0.4	84,737	85	0.8	0.17%	99.2%	20.1%
7	9	5,662	2.9	697,879	698	5.4	1.38%	99.0%	18.4%
8	9	7,922	3.7	1,261,233	1,261	4.2	2.50%	97.6%	16.7%
9	6	6,374	8.5	2,313,265	2,313	7.0	4.58%	95.1%	14.3%
10	9	6,251	8.2	2,183,017	2,183	9.9	4.32%	90.5%	12.4%
11	8	5,253	8.6	1,942,400	1,942	11.8	3.85%	86.2%	10.5%
12	18	4,650	9.3	1,842,814	1,843	13.9	3.65%	82.4%	8.9%
13	10	8,566	16.9	6,195,584	6,196	18.9	12.27%	78.7%	7.5%
14	7	6,500	40.1	11,152,363	11,152	44.0	22.08%	66.5%	4.9%
15	2	9,806	53.4	22,418,846	22,419	9.4	44.39%	44.4%	3.0%
Sum	383	**331,995**	10.24	**50,509,482**	***50,509***	8.59	**100.00%**	**0**	**0**

Table 2b - SPANdex index of abundance for white hake from fall research vessel surveys in NAFO Divisions 3L, 3N, 3O and 3P.

Spring 1996

Density Class	Set Count	3LNOP Area	Mean Kg per tow	Biomass kg	Biomass t	Stdev	% of Biomass	Cum. % of Area	% of Area
1	337	271,248	0.0	0	0	0.0	0.00%	100.0%	100.0%
2	4	5,276	0.0	0	0	0.0	0.00%	100.0%	22.6%
3	7	4,966	0.0	2,125	2	0.0	0.01%	100.0%	21.0%
4	7	4,538	0.0	3,884	4	0.0	0.03%	100.0%	19.6%
5	9	3,142	0.0	5,379	5	0.1	0.04%	100.0%	18.2%
6	8	4,610	0.0	1,973	2	0.0	0.01%	99.9%	17.3%
7	7	5,675	0.3	77,720	78	0.5	0.55%	99.9%	15.9%
8	6	8,001	0.2	65,060	65	0.4	0.46%	99.4%	14.3%
9	7	5,471	2.6	615,800	616	3.0	4.33%	98.9%	11.9%
10	11	5,013	2.4	510,613	511	2.6	3.59%	94.6%	10.3%
11	8	4,810	7.1	1,453,340	1,453	5.9	10.23%	91.0%	8.8%
12	10	4,803	0.7	152,111	152	1.2	1.07%	80.8%	7.4%
13	6	5,748	12.1	2,979,054	2,979	8.2	20.96%	79.7%	6.0%
14	9	6,290	10.8	2,896,546	2,897	9.0	20.38%	58.7%	4.3%
15	10	8,449	15.1	5,449,241	5,449	14.8	38.34%	38.3%	2.5%
Sum	446	348,040	3.42	14,212,848	14,213	3.05	100.00%		

Spring 1997

Density Class	Set Count	3LNOP Area	Mean Kg per tow	Biomass kg	Biomass t	Stdev	% of Biomass		% of Area
1	296	268,409	0.0	0	0	0.0	0.00%	100.0%	100.0%
2	11	3,902	0.0	1,670	2	0.0	0.01%	100.0%	21.1%
3	6	5,263	0.0	4,505	5	0.0	0.02%	100.0%	20.0%
4	9	4,959	0.1	16,979	17	0.1	0.09%	100.0%	18.4%
5	10	4,919	0.2	44,209	44	0.3	0.22%	99.9%	17.0%
6	4	3,997	0.2	27,370	27	0.2	0.14%	99.7%	15.5%
7	7	7,477	0.4	118,399	118	0.7	0.60%	99.5%	14.3%
8	8	5,040	1.4	308,449	308	1.7	1.55%	98.9%	12.1%
9	13	4,978	1.5	313,177	313	1.9	1.58%	97.4%	10.7%
10	7	7,519	2.9	929,984	930	2.4	4.68%	95.8%	9.2%
11	10	4,645	2.6	518,852	519	2.9	2.61%	91.1%	7.0%
12	7	5,449	7.0	1,623,093	1,623	4.2	8.17%	88.5%	5.6%
13	6	5,089	7.9	1,709,699	1,710	5.0	8.60%	80.3%	4.0%
14	7	4,267	8.7	1,592,416	1,592	9.5	8.01%	71.7%	2.5%
15	12	4,316	68.6	12,665,813	12,666	142.5	63.73%	63.7%	1.3%
Sum	413	340,229	6.76	19,874,615	19,875	11.44	100.00%		

Table 3 - Length at maturity (L50) of white hake caught during R.V. surveys in NAFO Divisions 3O and 3P, 1988-1998. Each cell contains L50 (cm) (top) and the sample size (bottom).

	Div. 3O		Div. 3P	
Year	Female	Male	Female	Male
1988			61	46
	(12)	(7)	(546)	(292)
1989			55	37
	(0)	(0)	(410)	(175)
1990			58	43
	(1)	(0)	(95)	(74)
1991	43	40		
	(77)	(80)	(0)	(0)
1992	46	40		
	(38)	(31)	(0)	(0)
1993				
	(3)	(0)	(0)	(0)
1994	55	46	55	37
	(43)	(38)	(33)	(14)
1995	55	43		
	(43)	(38)	(0)	(0)
1996	52	40	49	40
	(24)	(44)	(42)	(25)
1997	70	43	46	40
	(242)	(275)	(78)	(90)
1998	58	40	61	40
	(29)	(70)	(58)	(57)

Table 4. Domestic landings of white hake in NAFO divisions 3LNOP, by gear type and month, 1985-1997.

Gear	Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Not rec.
Gillnet	1985	0	0	0	0	0	0	0	0	0	0	0	0	195
	1986	0	0	0	0	0	0	0	0	0	0	0	0	342
	1987	0	0	0	0	0	0	0	1	0	0	0	0	423
	1988	0	1	9	7	15	0	1	0	0	0	0	0	191
	1989	0	0	0	0	0	0	1	0	1	0	0	0	189
	1990	0	0	0	0	0	12	36	17	3	2	0	0	416
	1991	0	1	1	8	81	238	204	73	30	29	10	0	475
	1992	1	39	59	94	340	56	51	1	0	0	8	5	536
	1993	0	0	1	34	40	10	0	0	0	1	0	0	332
	1994	0	0	0	0	0	0	0	0	0	0	0	0	68
	1995	0	0	0	0	0	0	5	91	70	44	0	0	78
	1996	0	0	1	25	2	3	7	124	69	1	0	0	71
	1997	0	0	0	1	4	11	15	31	75	1	0	0	124
Lines	1985	0	0	0	12	72	73	0	0	9	2	0	0	2,337
	1986	0	0	0	0	0	0	0	0	0	0	0	0	2,446
	1987	0	0	19	4	0	0	0	0	0	0	0	0	3,757
	1988	103	63	114	275	318	294	450	257	43	125	86	43	176
	1989	80	139	215	206	439	282	174	152	63	72	26	16	321
	1990	41	252	106	337	460	168	315	240	235	85	16	5	424
	1991	60	34	115	208	238	77	81	39	120	75	33	19	43
	1992	23	64	132	227	221	101	166	162	146	136	42	9	48
	1993	26	26	31	138	93	99	131	66	41	0	19	3	241
	1994	7	15	14	31	9	56	46	58	63	68	26	0	56
	1995	12	3	18	29	15	90	29	28	0	0	41	11	11
	1996	4	4	2	9	9	0	50	32	40	64	105	29	0
	1997	27	16	8	3	0	14	39	8	70	72	59	17	8
Trawl	1985	0	11	6	14	3	2	5	1	6	2	4	2	174
	1986	4	8	11	5	6	0	1	0	0	2	3	2	134
	1987	1	3	7	19	8	3	1	1	3	0	1	1	98
	1988	9	4	14	16	9	3	10	0	4	3	0	1	0
	1989	8	3	6	21	17	11	3	2	5	4	3	11	187
	1990	33	8	73	8	12	1	0	1	4	5	6	14	49
	1991	8	7	16	37	8	56	1	1	0	2	2	2	3
	1992	9	34	20	9	2	1	6	0	1	4	14	27	1
	1993	31	26	10	10	10	7	32	16	13	103	96	36	0
	1994	1	2	1	17	67	2	1	2	1	12	8	2	0
	1995	2	0	0	2	0	0	1	1	5	3	1	0	0
	1996	1	1	6	1	0	0	0	2	1	1	2	1	0
	1997	0	2	6	0	2	2	17	6	1	1	2	1	0

Table 5 - Observed Fishery Summary Statistics for White Hake, 1995-1997.

Gillnet Observed Fishery

		t/100 nets				Catch (t)					Depth (m)			
Month	Sets	MIN	MAX	MEAN	STDDEV	SUM	MIN	MAX	MEAN	STDDEV	MIN	MAX	MEAN	STDDEV
5	35	0.01	1.21	0.27	0.23	1.9	0.00	0.24	0.05	0.05	144	307	193	31
8	190	0.02	12.16	2.22	2.25	105.1	0.01	3.97	0.55	0.61	76	293	200	34
9	117	0.03	9.66	1.45	1.66	42.5	0.01	2.42	0.36	0.42	152	293	209	27
10	34	0.03	11.25	3.19	3.15	23.4	0.00	2.30	0.69	0.67	166	362	204	36
All	376	0.01	12.16	1.89	2.20	173.0	0.00	3.97	0.46	0.56	76	362	202	32

Longline Observed Fishery

		t/1000 hooks				Catch (t)					Depth (m)			
Month	Sets	MIN	MAX	MEAN	STDDEV	SUM	MIN	MAX	MEAN	STDDEV	MIN	MAX	MEAN	STDDEV
2	20	0.00	0.01	0.00	0.00	1.2	0.01	0.36	0.06	0.08	173	914	512	207
3	13	0.00	0.86	0.20	0.36	2.0	0.00	0.55	0.16	0.22	488	969	680	150
5	8	0.00	0.01	0.00	0.00	0.3	0.00	0.12	0.04	0.04	161	366	229	67
7	118	0.00	0.01	0.00	0.00	2.6	0.00	0.20	0.02	0.03		582	274	122
8	32	0.00	0.20	0.02	0.04	2.0	0.00	0.37	0.06	0.09	101	362	185	84
9	58	0.00	0.36	0.03	0.06	4.7	0.00	0.73	0.08	0.12	98	401	294	54
10	188	0.00	2.10	0.27	0.38	59.6	0.00	1.86	0.32	0.40	46	549	298	105
11	95	0.00	0.02	0.00	0.00	4.6	0.00	0.33	0.05	0.05	102	600	288	135
12	80	0.00	1.19	0.16	0.27	15.6	0.00	1.66	0.19	0.33	95	428	178	96
All	612	0.00	2.10	0.11	0.27	92.5	0.00	1.86	0.15	0.28	46	969	284	142

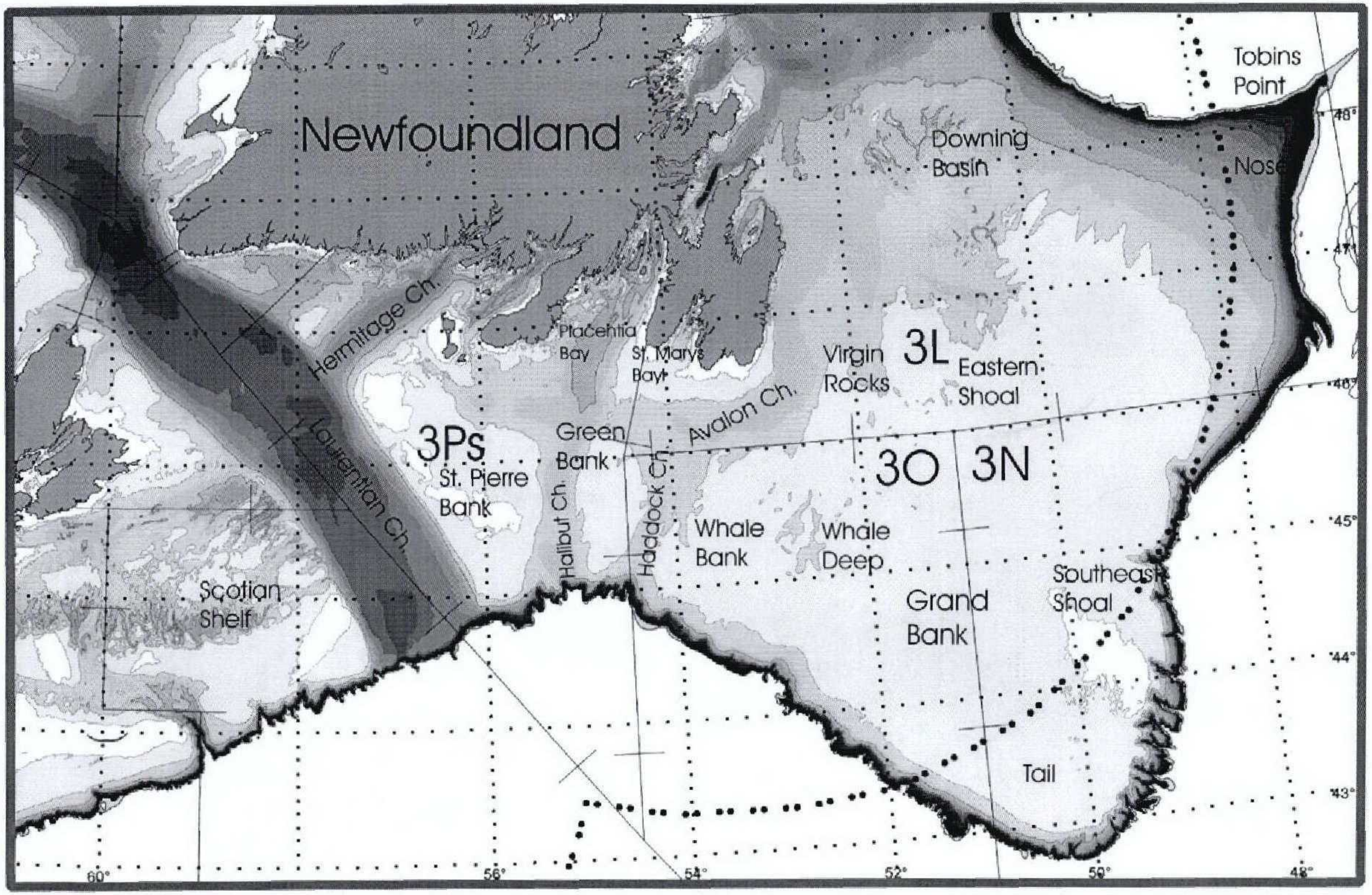


Figure 1- Study area for white hake showing NAFO Divisions, the 200 mile limit, specific locations and bathymetry (0 to 450 m by 50 m then 500 to 1000 m by 100 m).

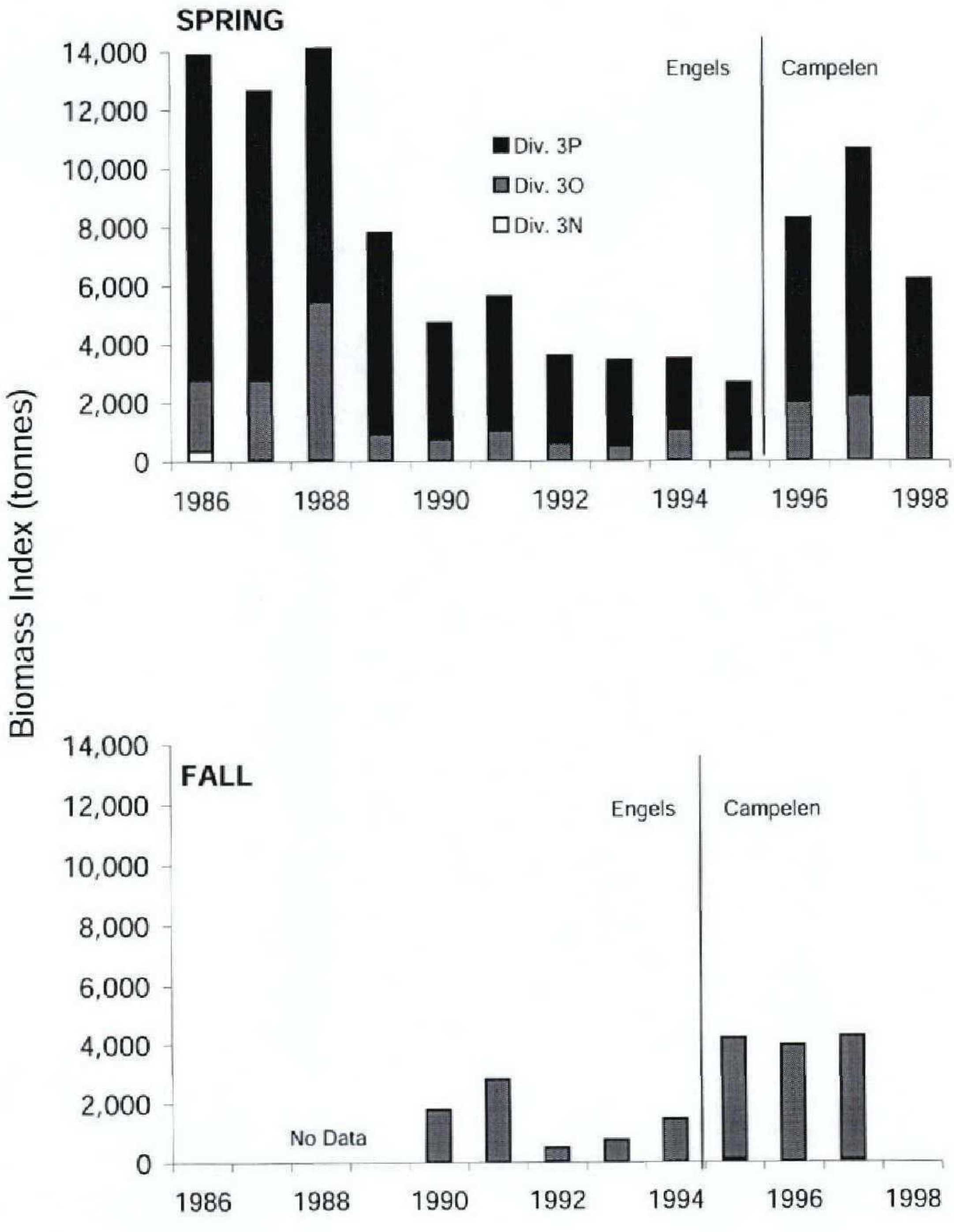


Figure 2 - Spring and fall research survey biomass indices for white hake in NAFO Divisions 3L, 3N, 3O and subdivision 3Ps, 1986-1998. Data for 1998 are incomplete.

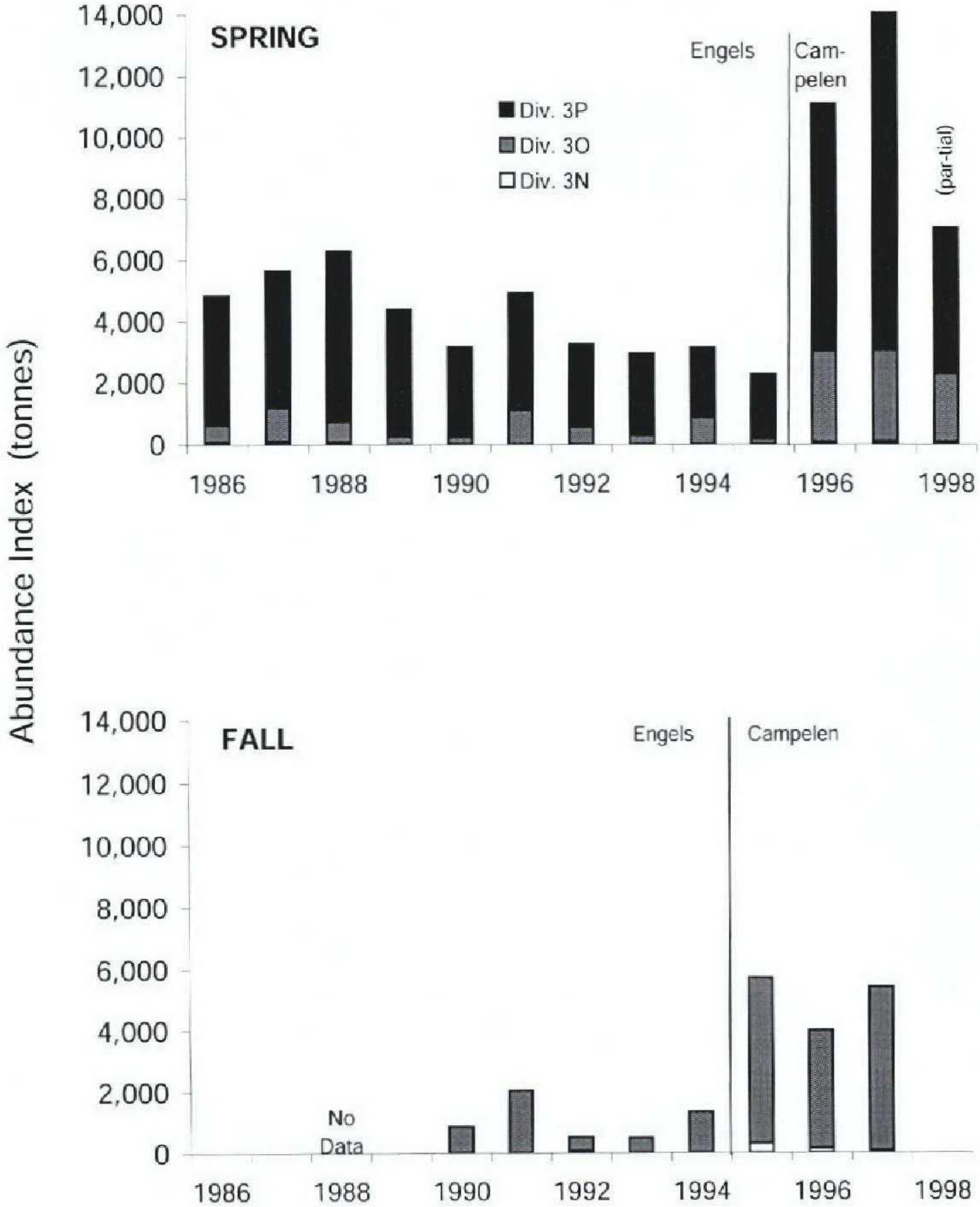


Figure 3 - Spring and fall research survey abundance indices for white hake in NAFO Divisions 3L, 3N, 3O and subdivision 3Ps, 1986-1998. Data for 1998 are incomplete.

Year	SPANdex Fall	Strap Fall	SPANdex Spring	Strap Spring
1995	4,083	4,193		2,668
1996	11,253	3,966	14,213	8,306
1997	8,254	4,264	19,875	10,674
(Includes Laur Ch sets) 1995	14,717			
(Includes Laur Ch sets) 1996	27,411			
(Includes Laur Ch sets) 1997	50,509			

Year	SPANdex Fall	Strap Fall	SPANdex Spring	Strap Spring
1995				
1996	175.61%	-5.41%		211.32%
1997	-26.65%	7.51%	39.84%	28.51%

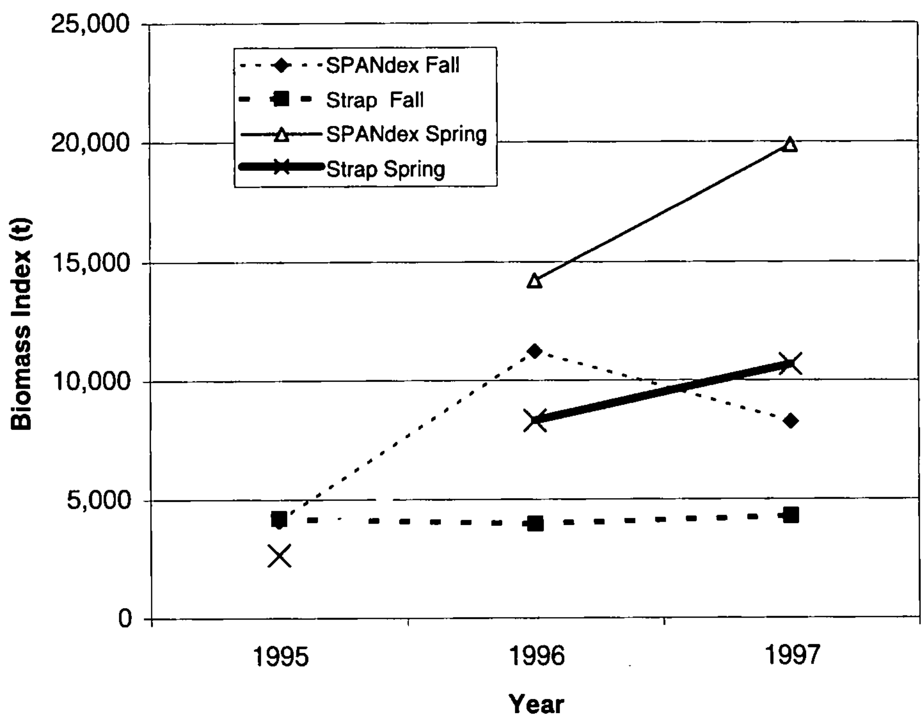


Figure 4 - A comparison of biomass indices for white hake from spring and fall research vessel surveys, 1995 - 1997.

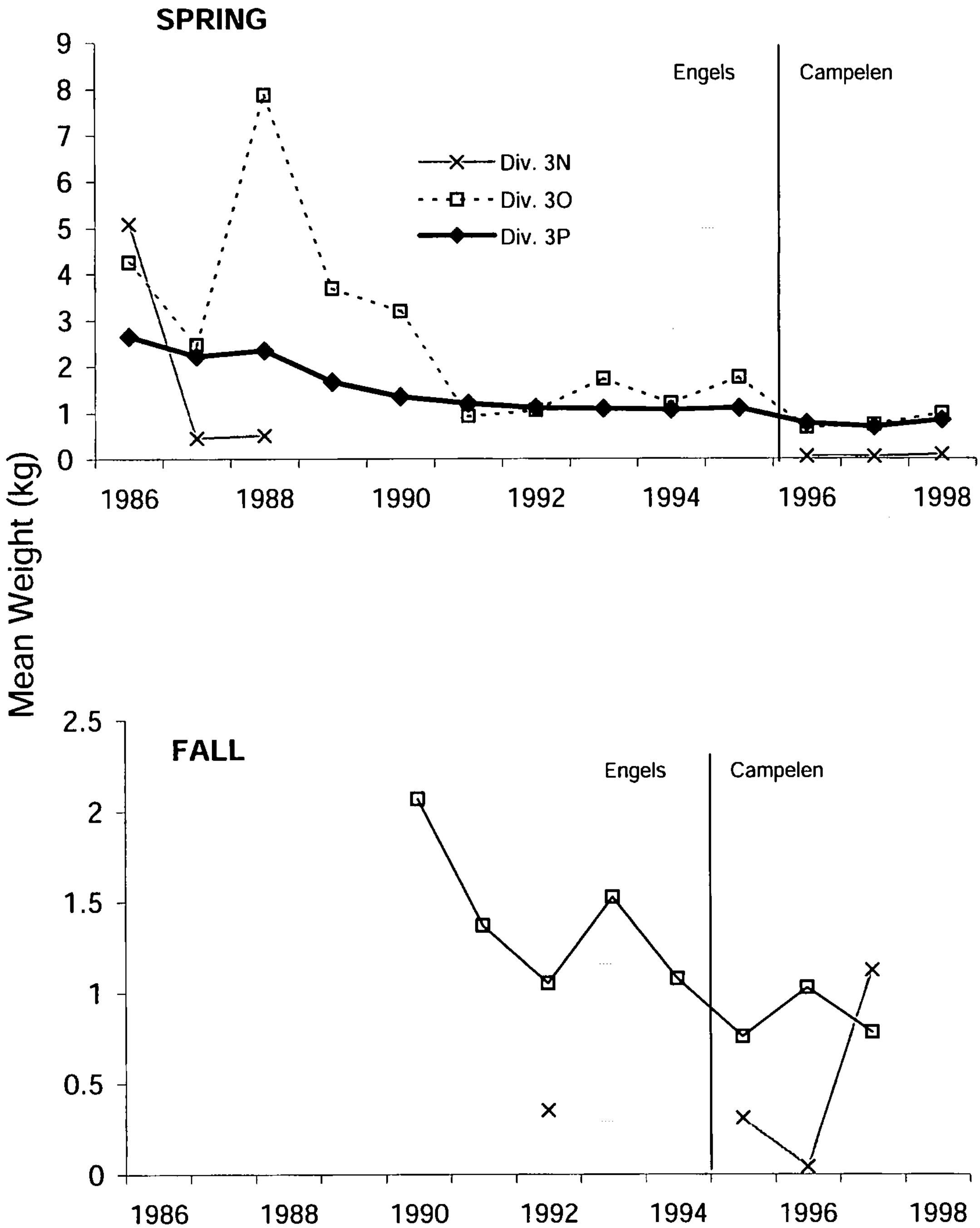


Figure 5 - Mean weight of white hake in spring and fall research surveys in NAFO divisions 3L, 3N, 3O and subdivision 3Ps, 1986-1998. Data for 1998 are incomplete.

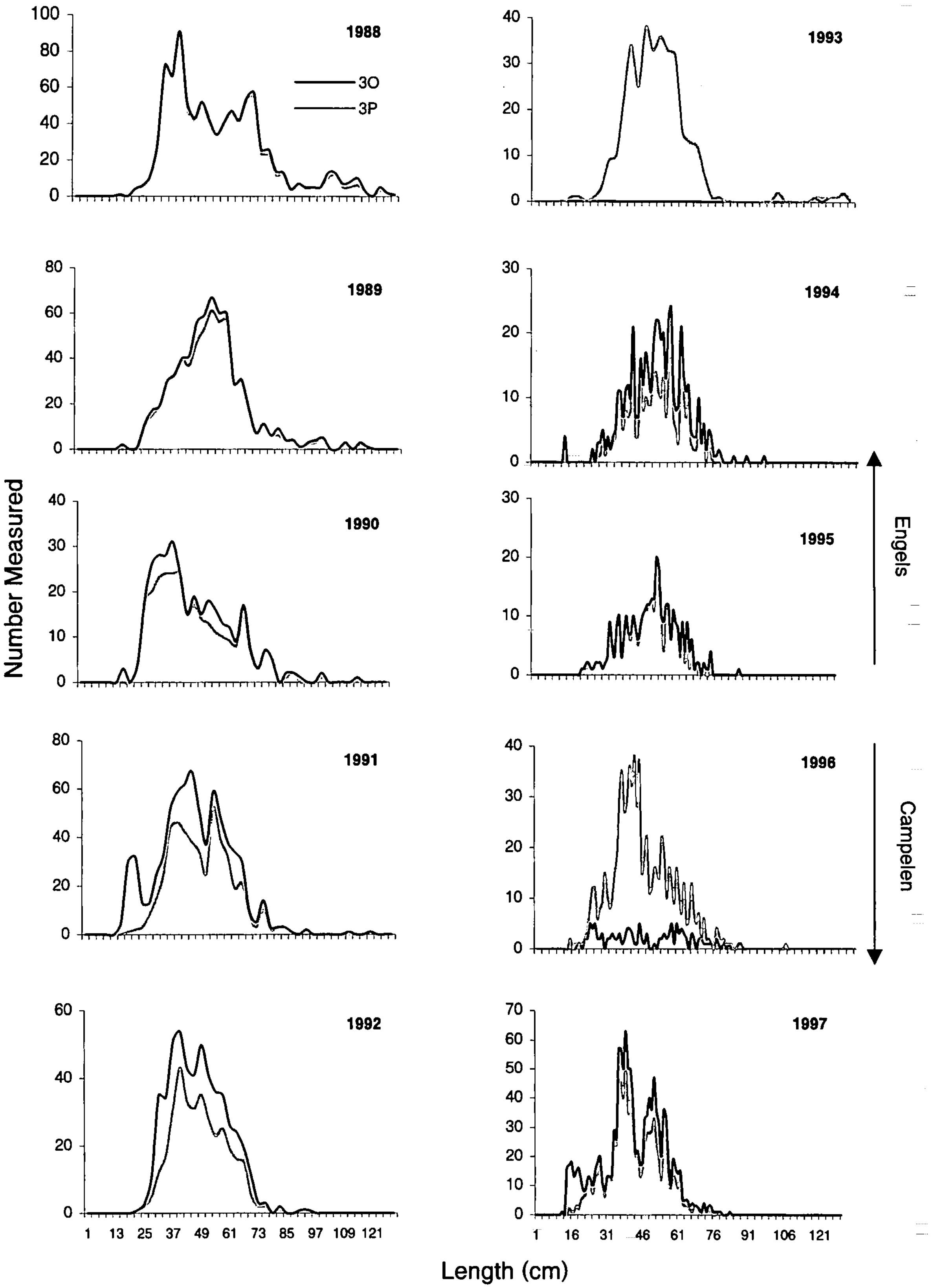


Figure 6 - Length frequencies of white hake caught in NAFO divisions 3O (solid line) and 3P (dashed line) during spring groundfish research in surveys, 1988-1997.

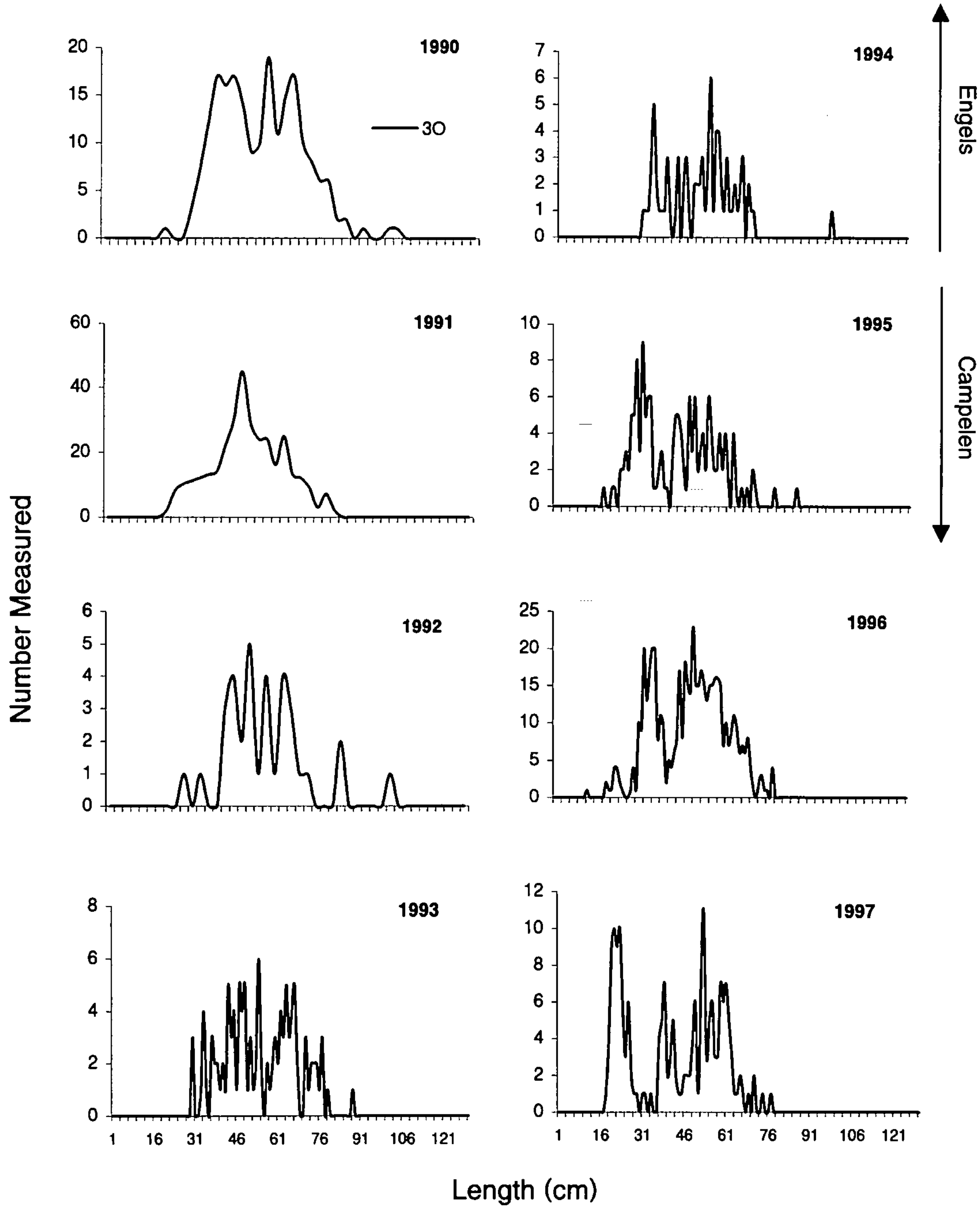


Figure 7 - Length frequencies of white hake caught in NAFO divisions 3O during fall groundfish research in surveys, 1990-1997.

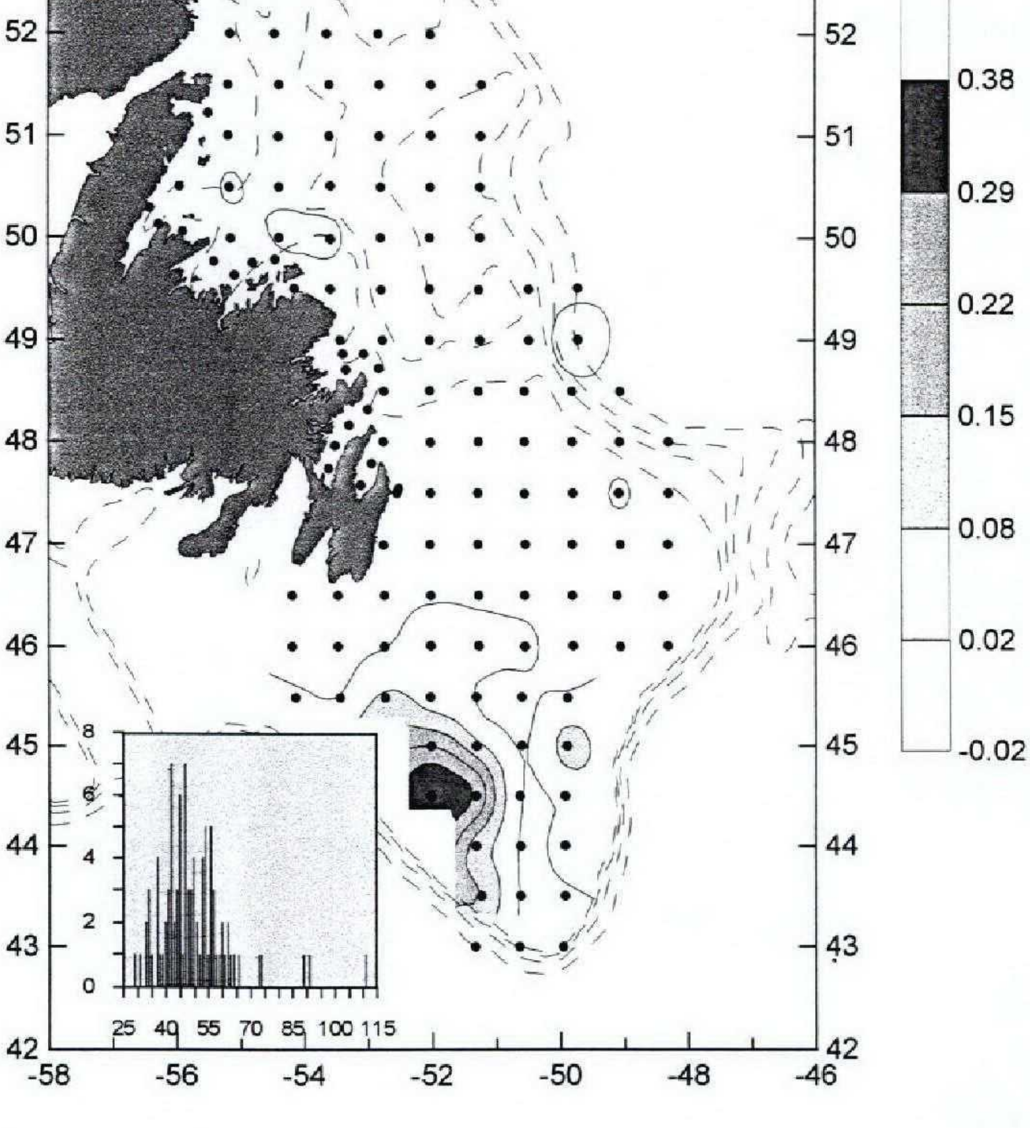


Figure 8 – Distribution and size of white hake taken in the 1996 (Aug.-Sept.) IYGPT pelagic trawl survey (after Dalley and Anderson 1997).

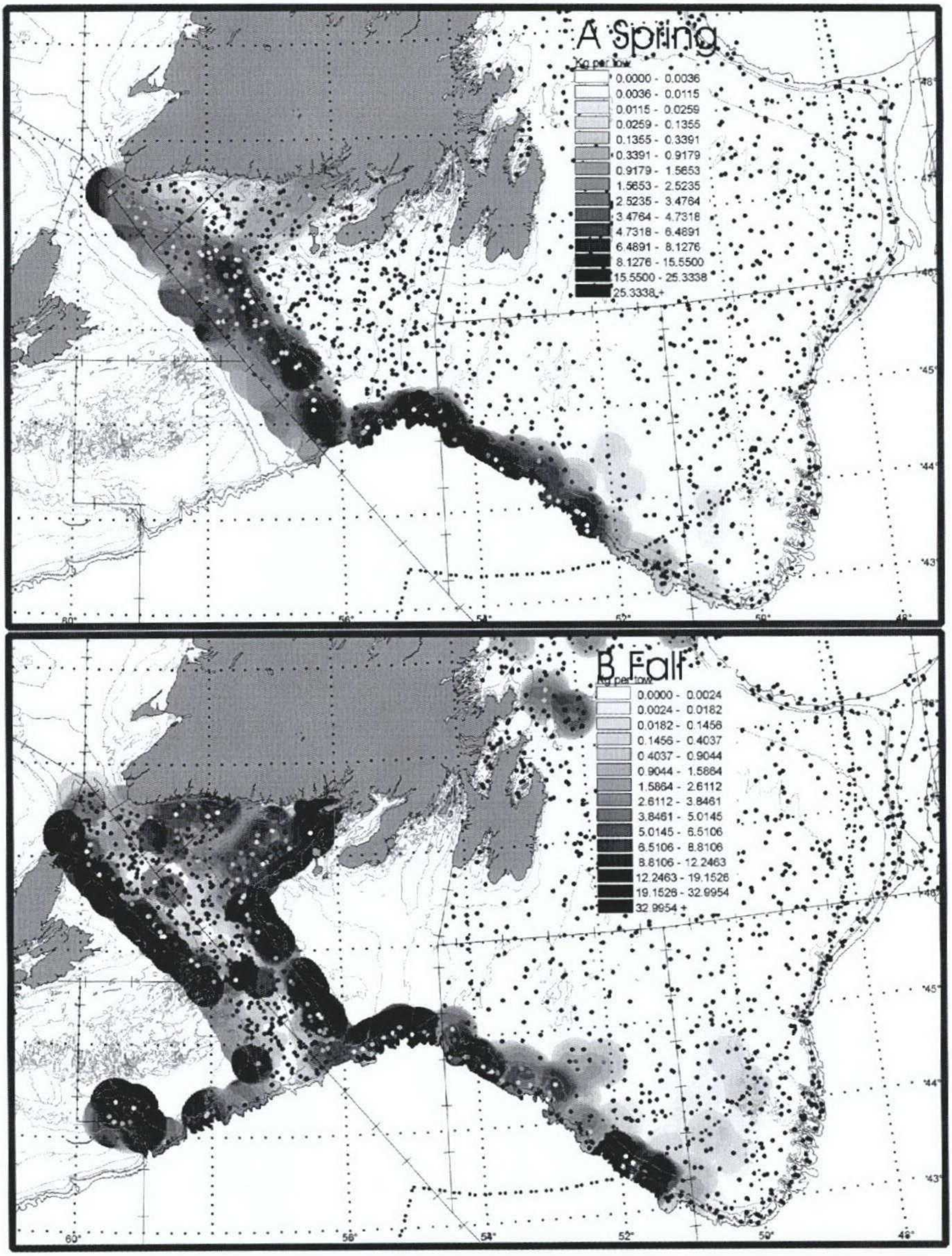


Figure 9 - Biomass of white hake from 1995 to 1998 combined research vessel survey Campelan trawls combined shown as weight (kg) per tow. Darker areas denote areas of denser concentrations of hake. Points signify survey set locations in reverse grey shade.

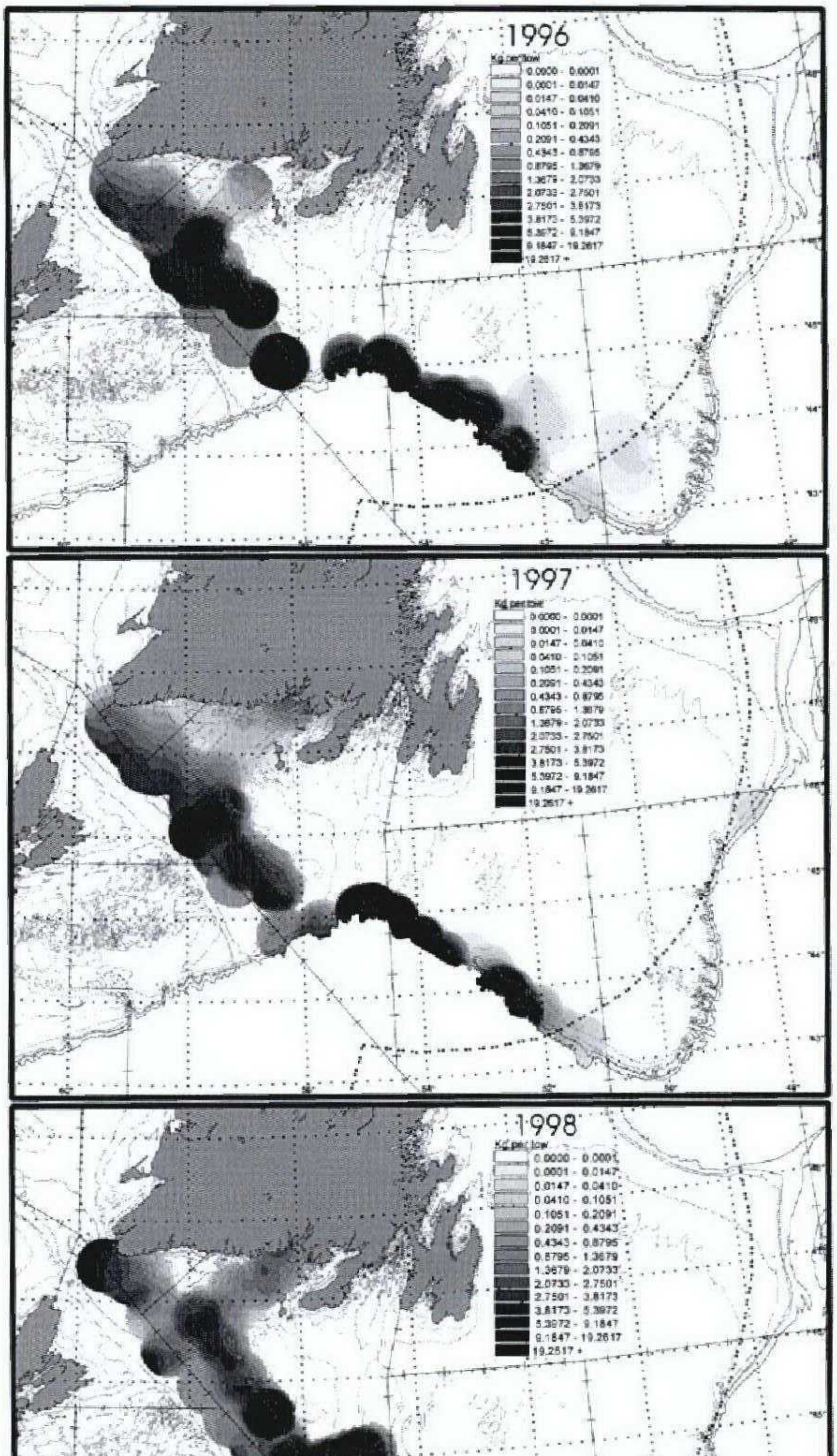


Figure 10 - Biomass of white hake from spring research surveys, 1996 to 1998 shown on the same scale to illustrate changes among years. For 1998, data were available only for NAFO Divisions 3P and 3N.

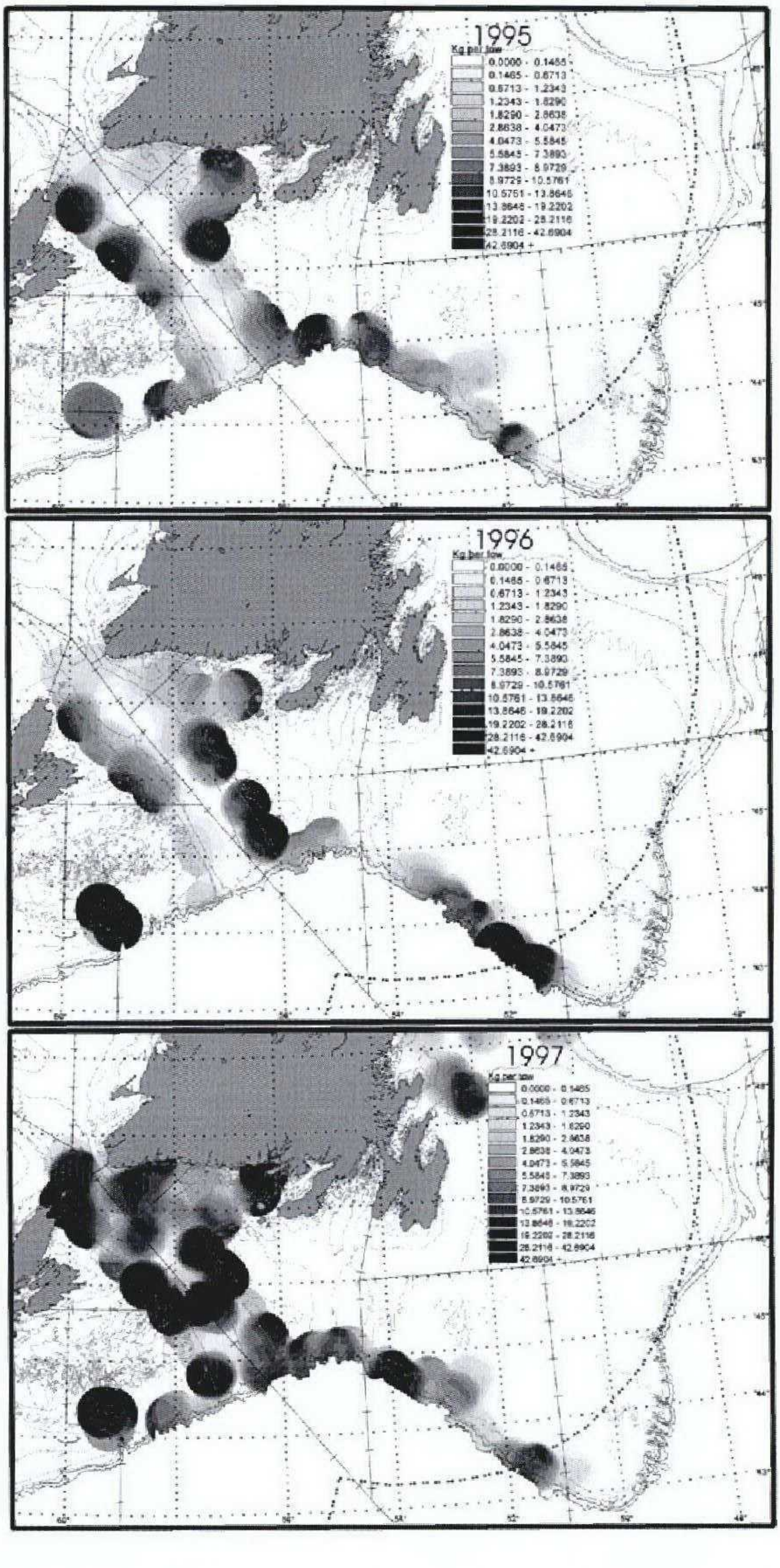


Figure 11 - Biomass of white hake from fall research surveys, 1995 to 1997 shown on the same scale to illustrate changes among years.

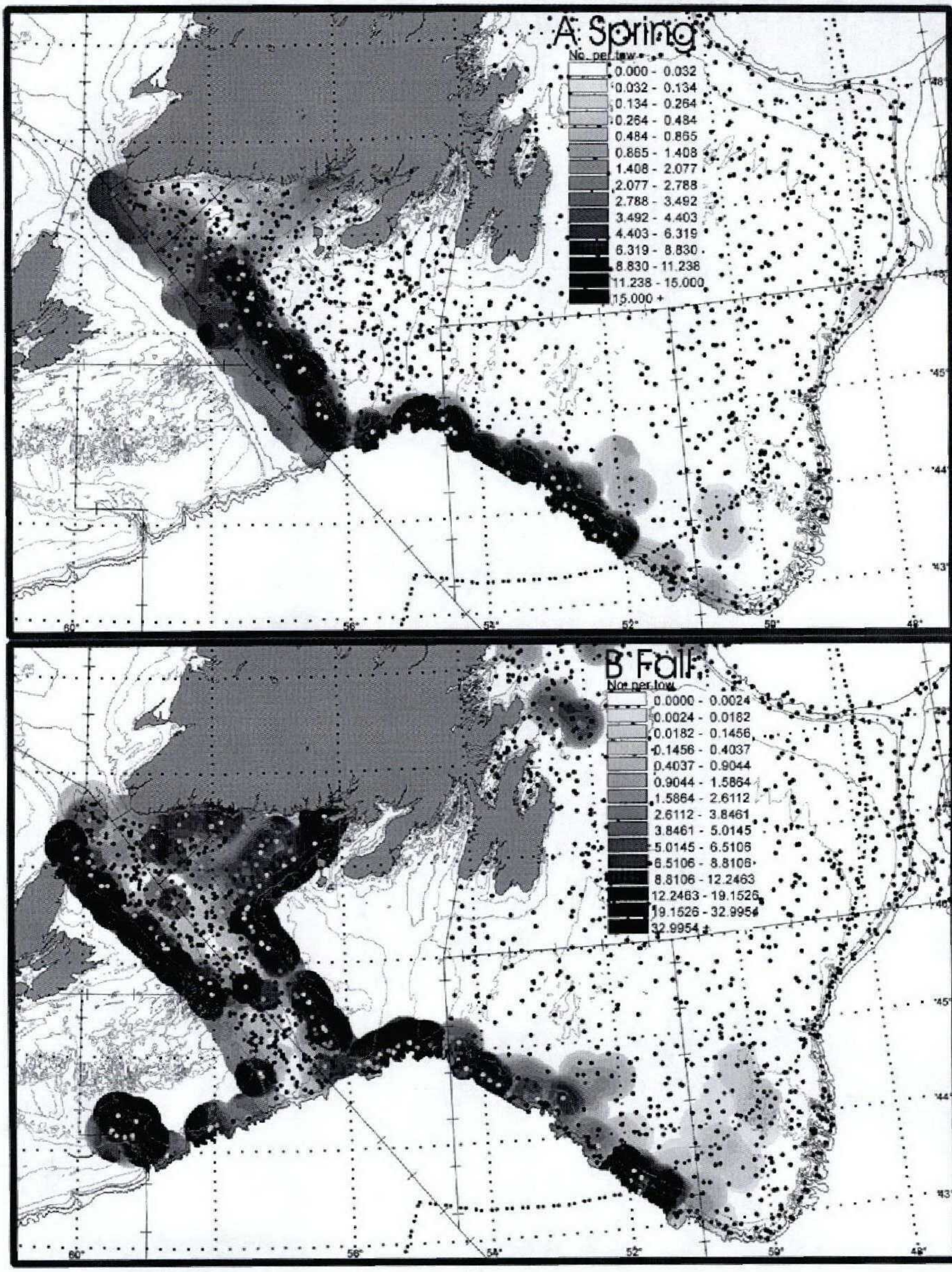


Figure 12 - Abundance of white hake from 1995 to 1998 combined research vessel survey Campelan trawls combined shown as numbers of fish per tow.

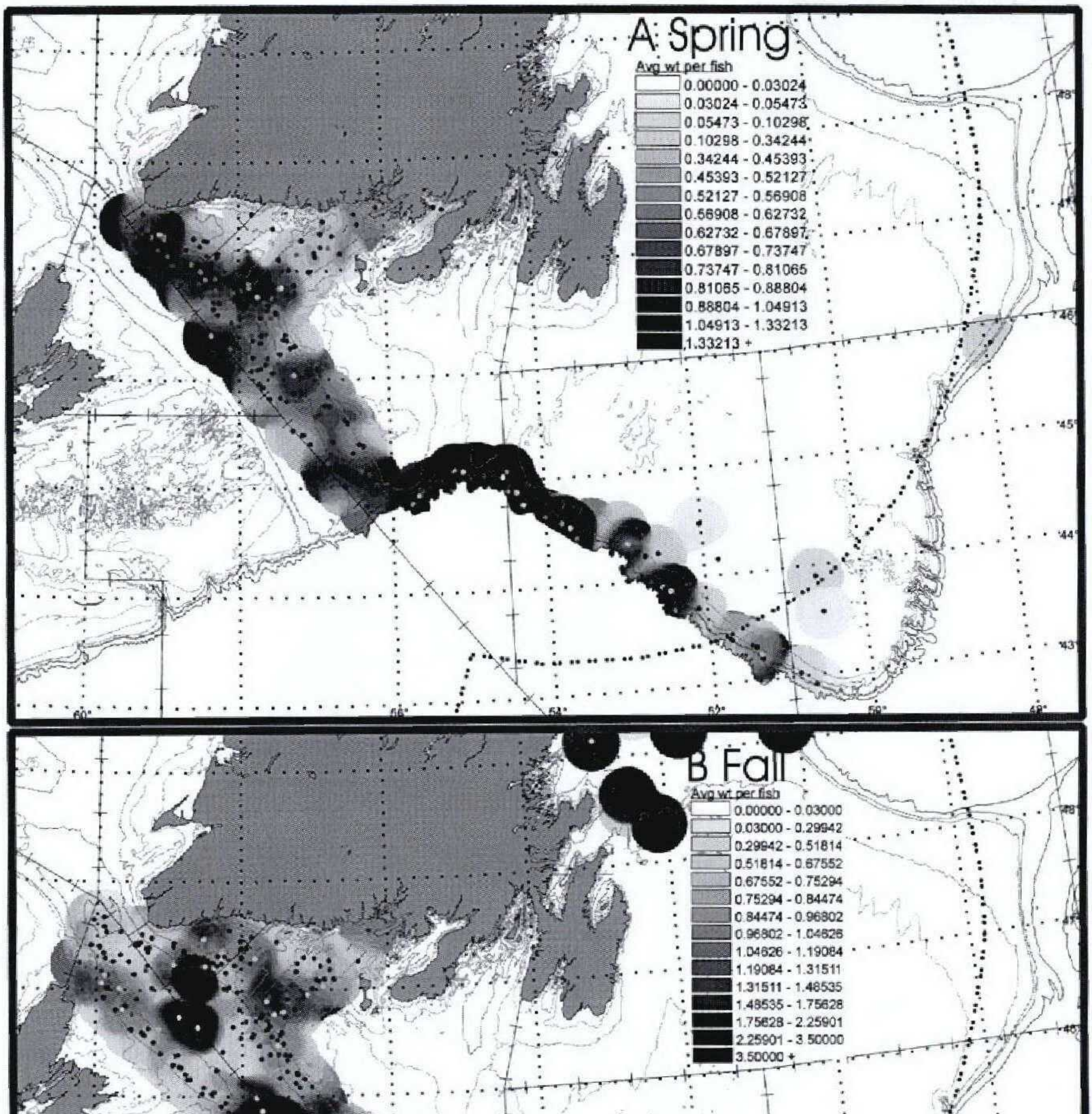


Figure 13 - Size distribution of white hake from 1995 to 1998 combined research vessel survey Campelan trawls combined shown as average weight per fish.

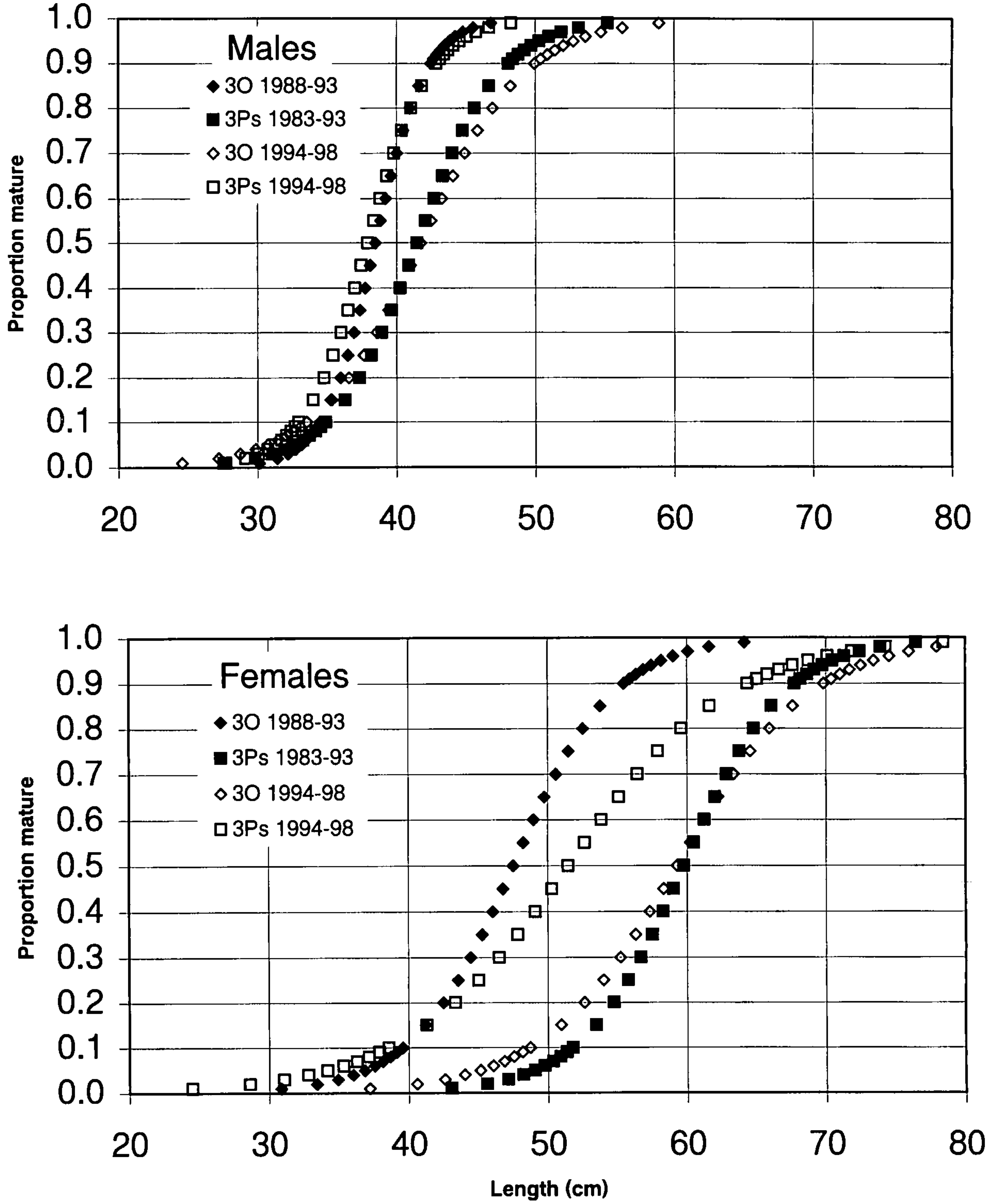


Figure 14 - Maturity ogives for white hake by sex, NAFO (sub)division and time period on the Grand Banks.

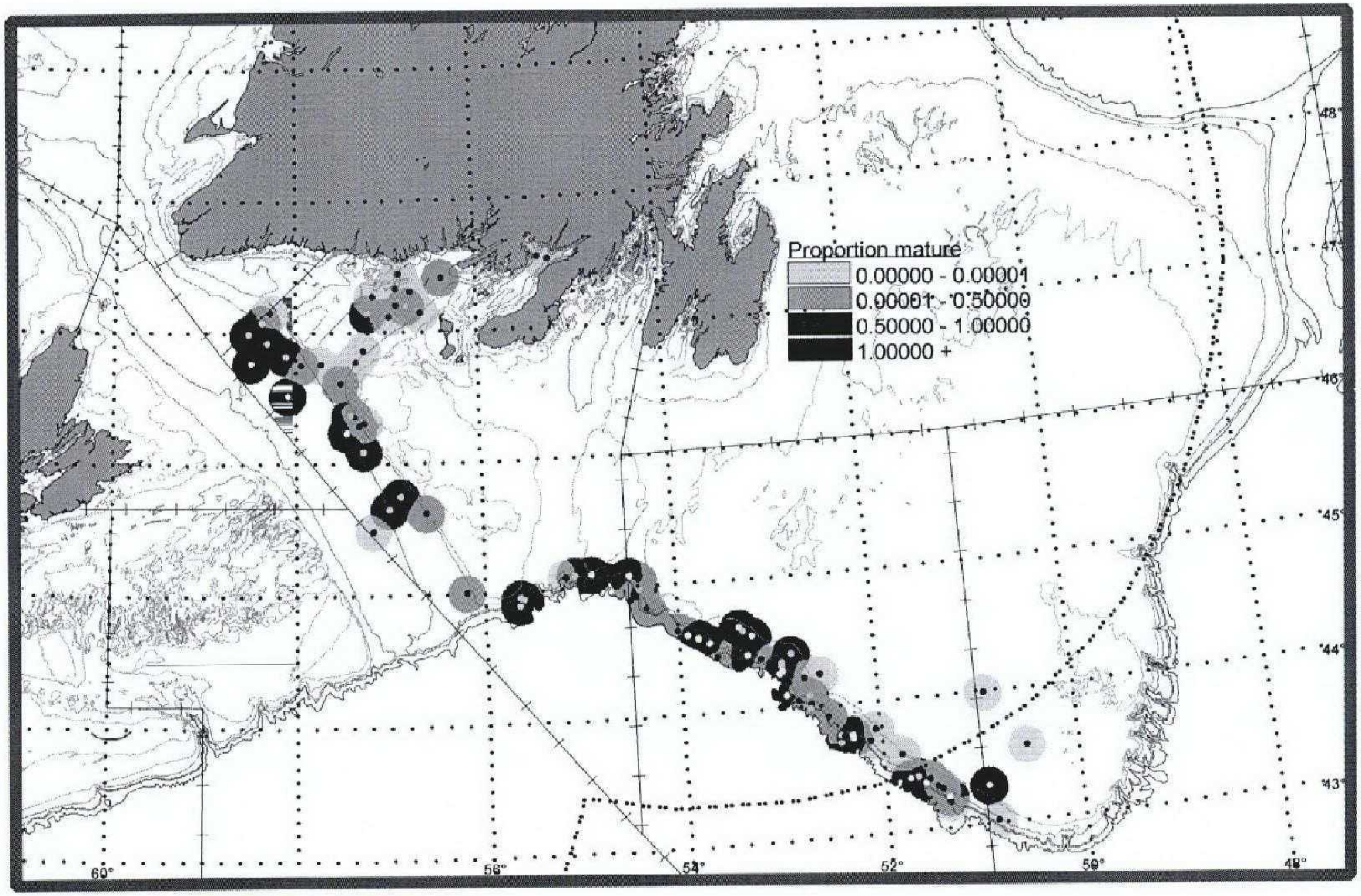


Figure 15 - Proportion of mature vs. immature white hake based on research survey data from 1996-1998. Darker areas denote areas with greater proportions mature.

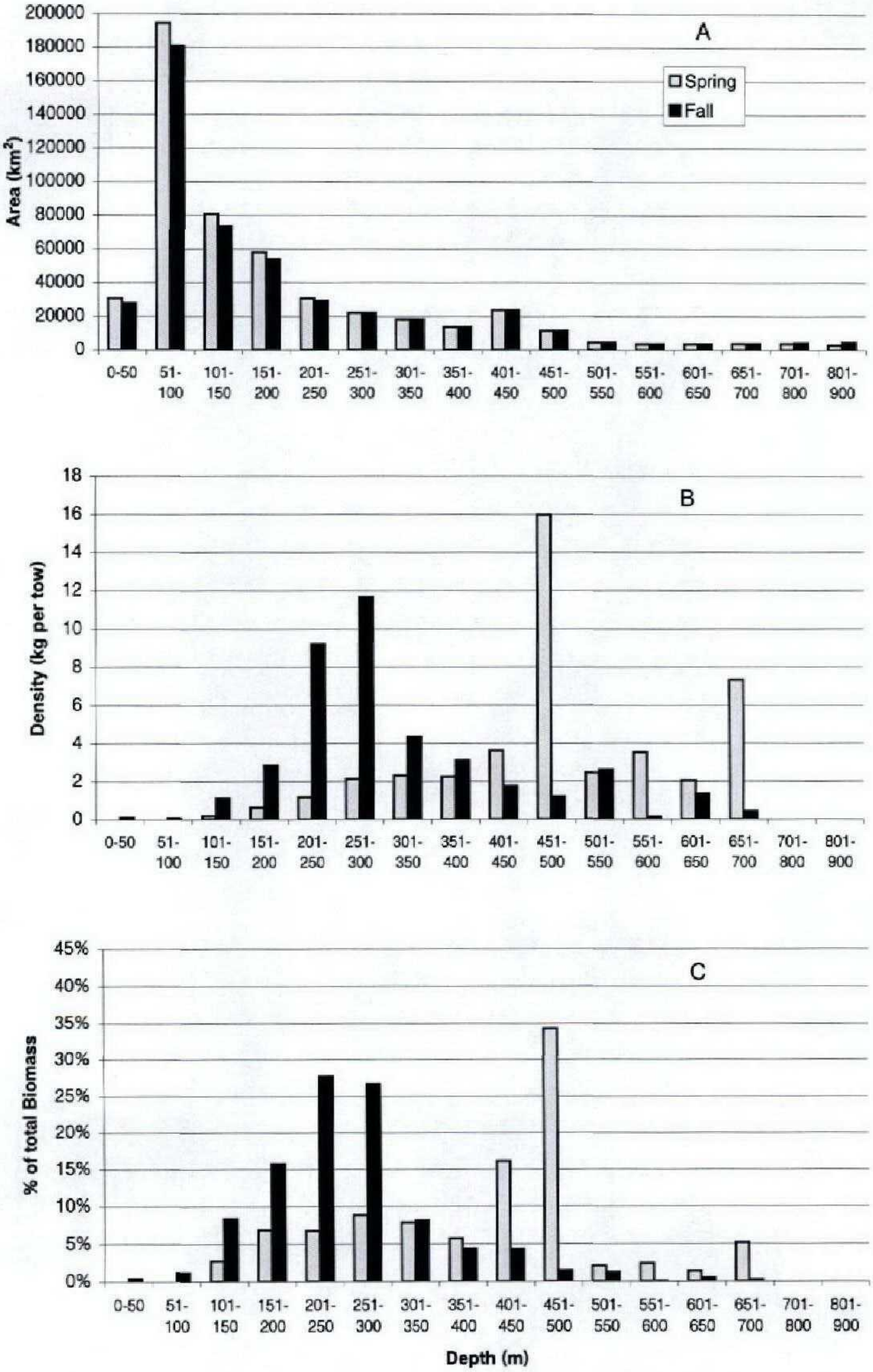


Figure 16 - Available habitat at depth in the survyed area (A) in relation to white hake density at depth (B) and percent of biomass at depth (C) comparing spring and fall surveys.

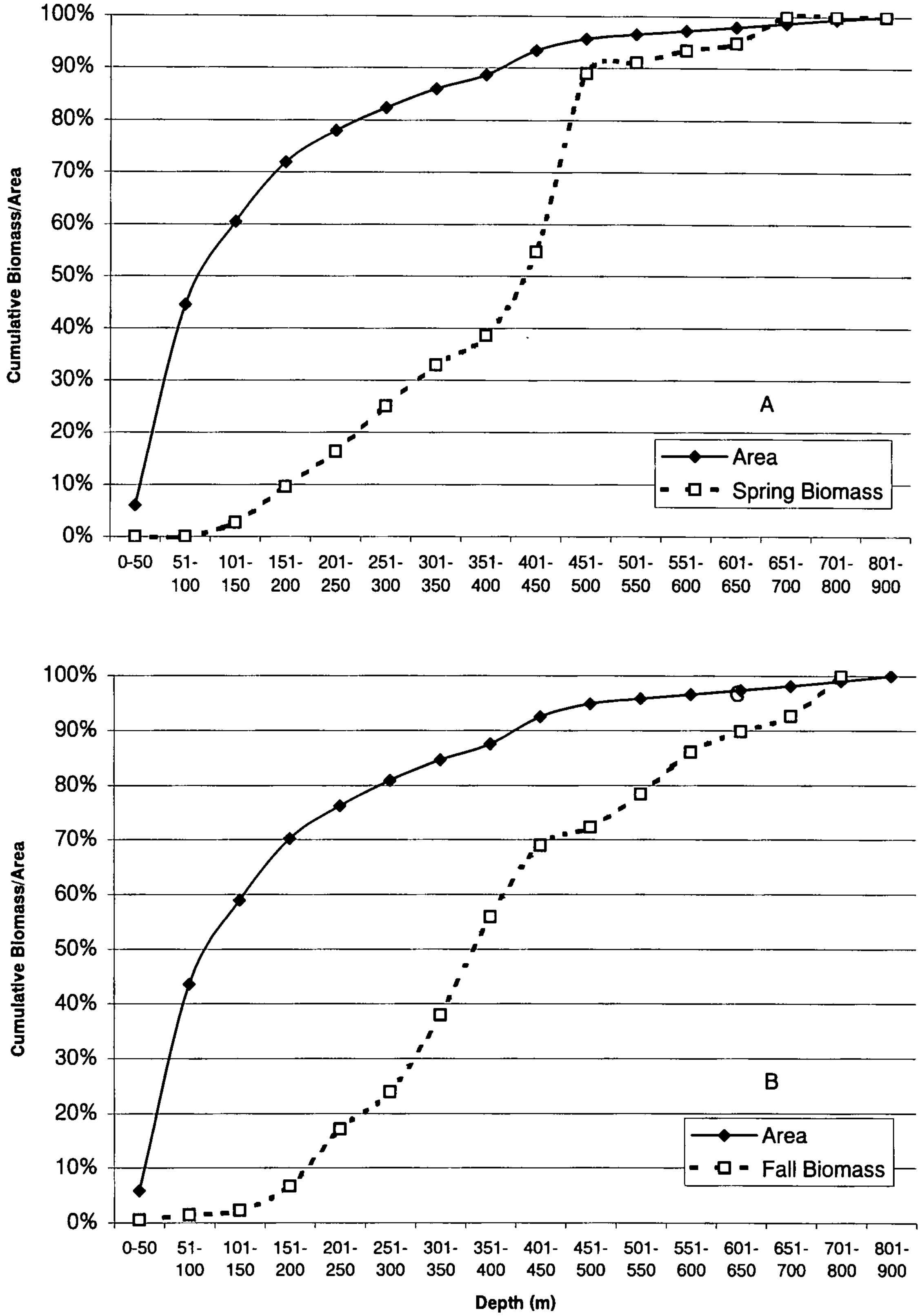


Figure 17 - Cumulative biomass of white hake versus cumulative available habitat at depth comparing the spring (A) and fall (B) survey periods.

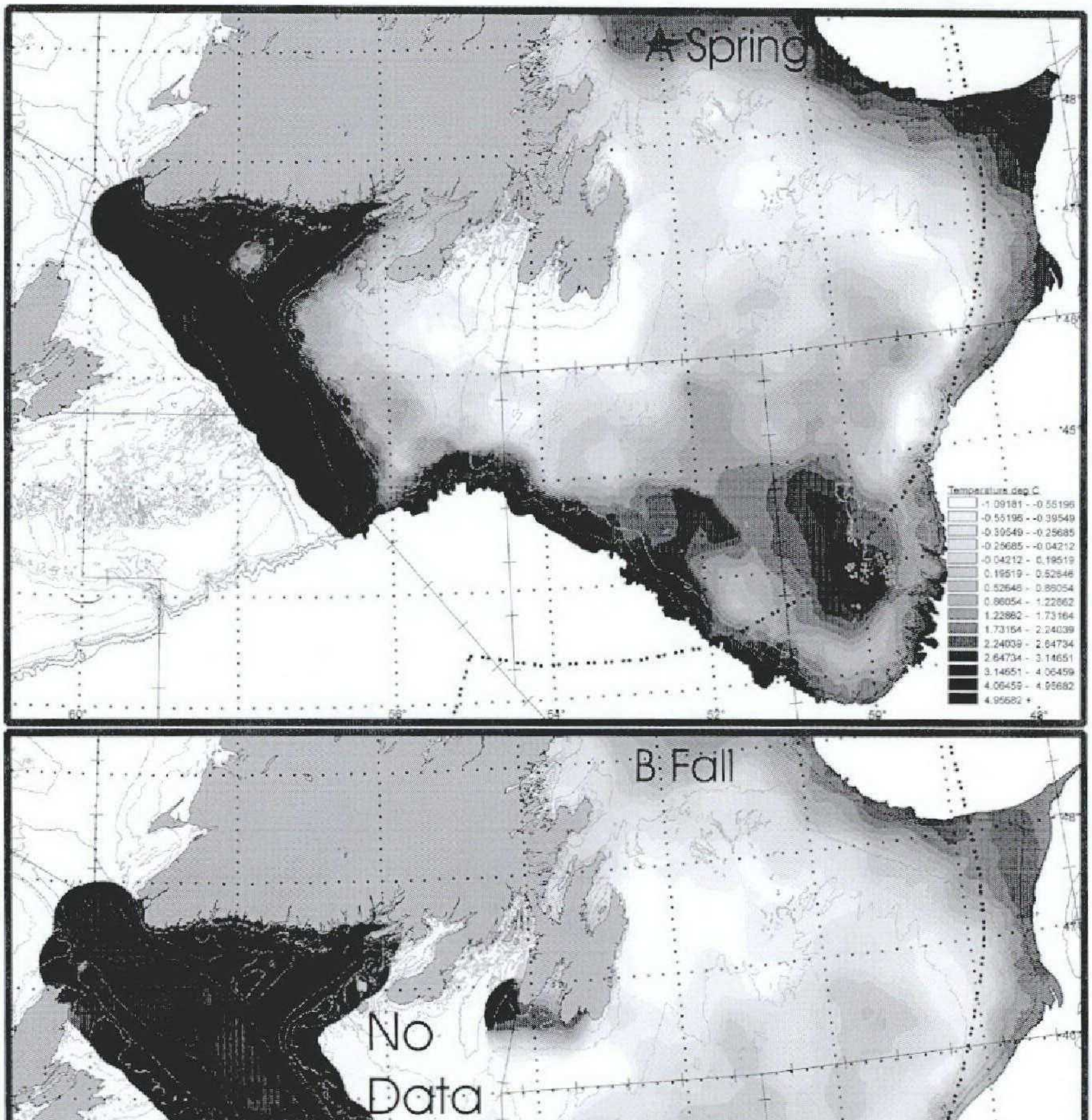


Figure 18 - Spring and fall bottom temperatures collected during research vessel surveys averaged over the period 1995 - 1997. No data are available for NAFO Div. 3Ps except along the Laurentian Channel and the southern slope in the fall.

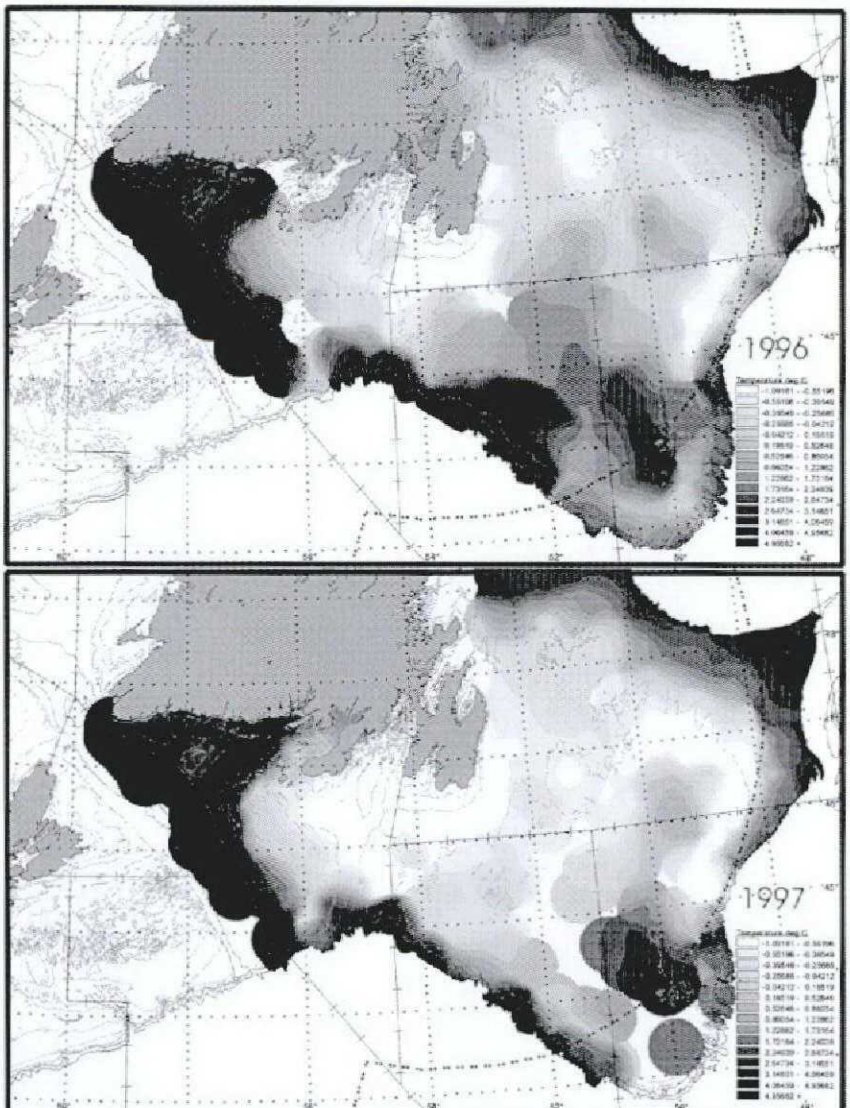


Figure 19 - Spring bottom temperature collected during research vessel surveys shown annually, 1995-1997. No data are available for NAFO division 3Ps except along the Laurentian Channel and southern slope.

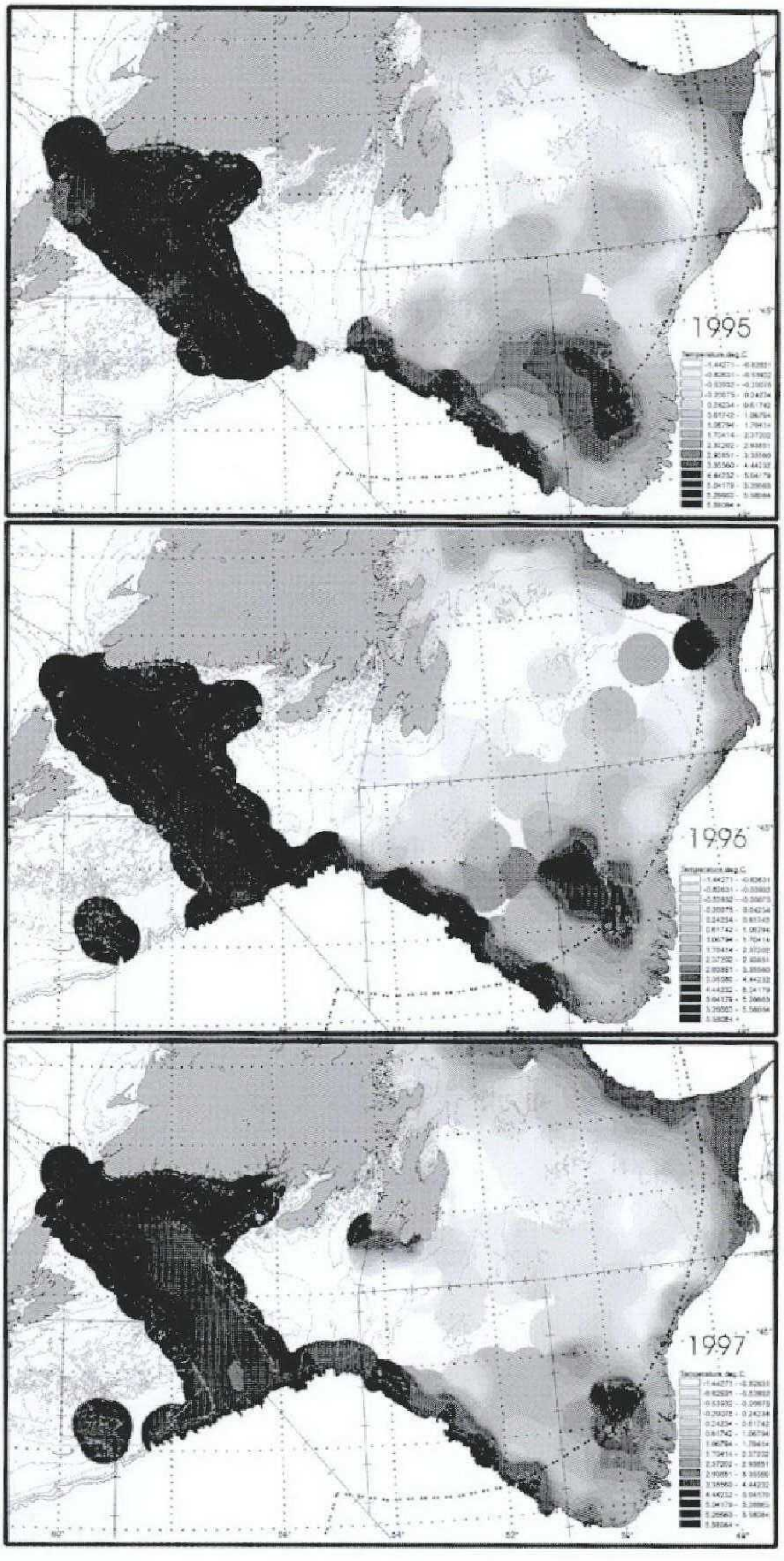


Figure 20 - Fall bottom temperature collected during research vessel surveys shown annually, 1995-1997. No data are available for NAFO division 3Ps except along the Laurentian Channel and southern slope.

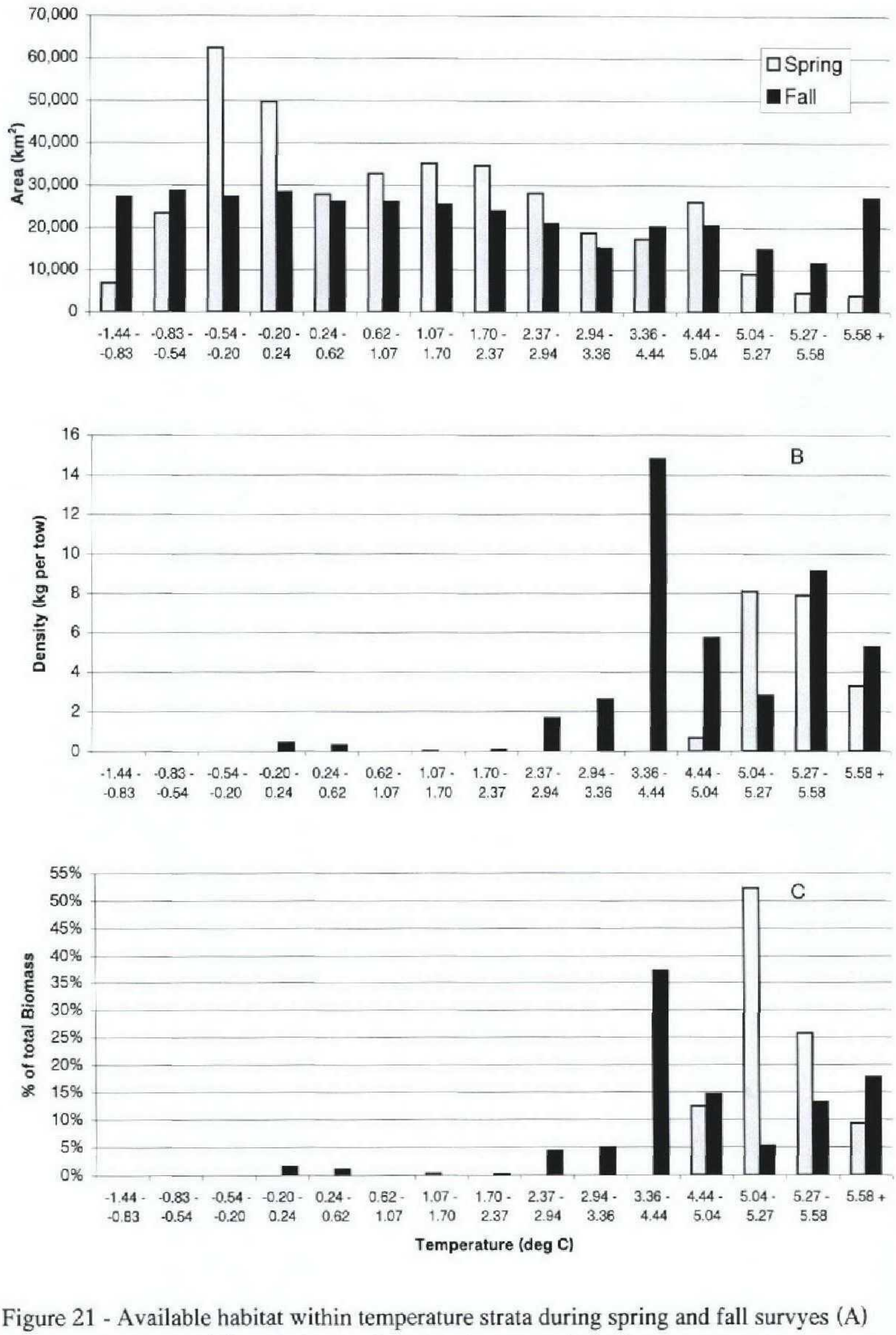


Figure 21 - Available habitat within temperature strata during spring and fall survyes (A) compared to density (B) and biomass (C) of white hake within the temperature strata.

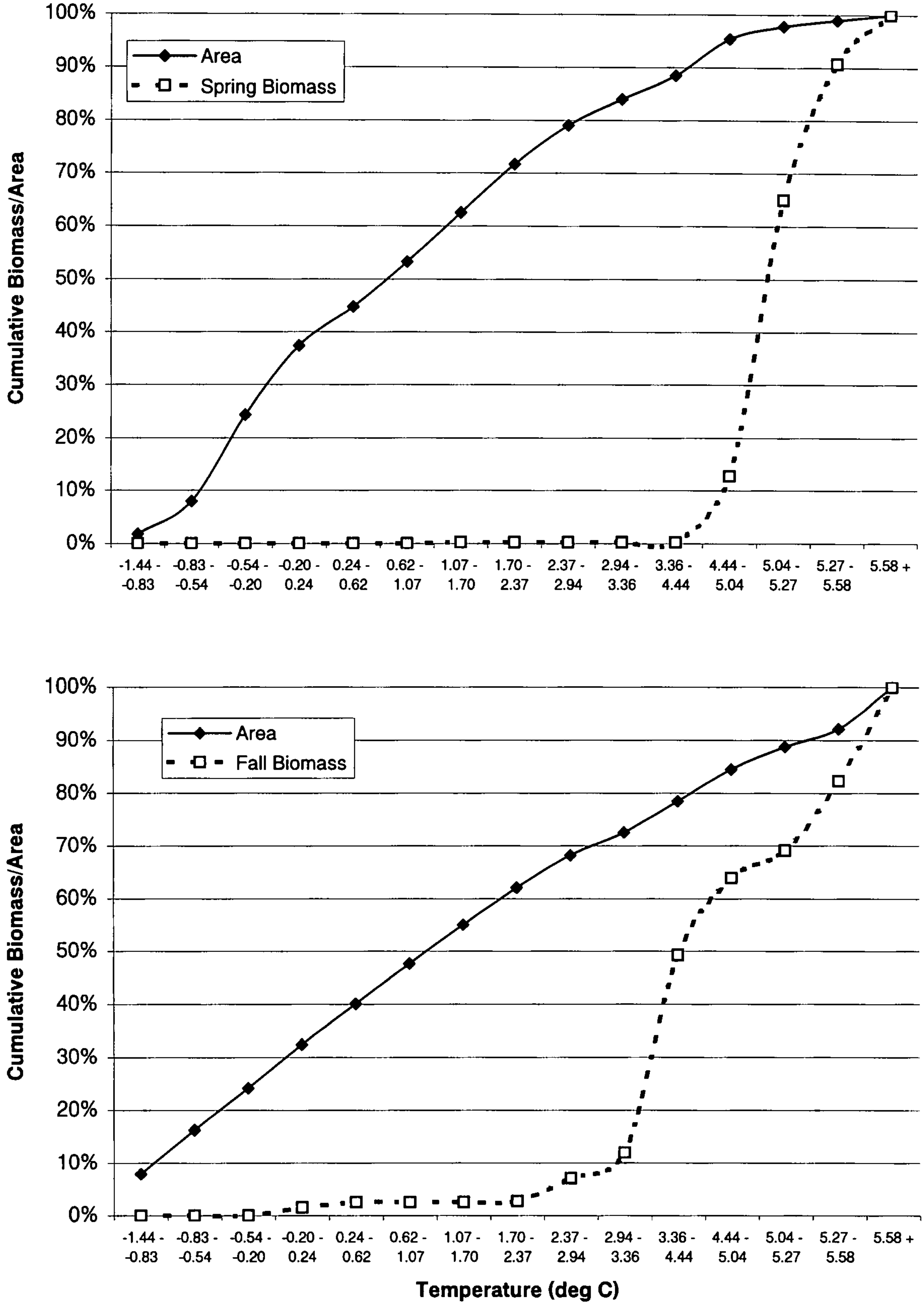
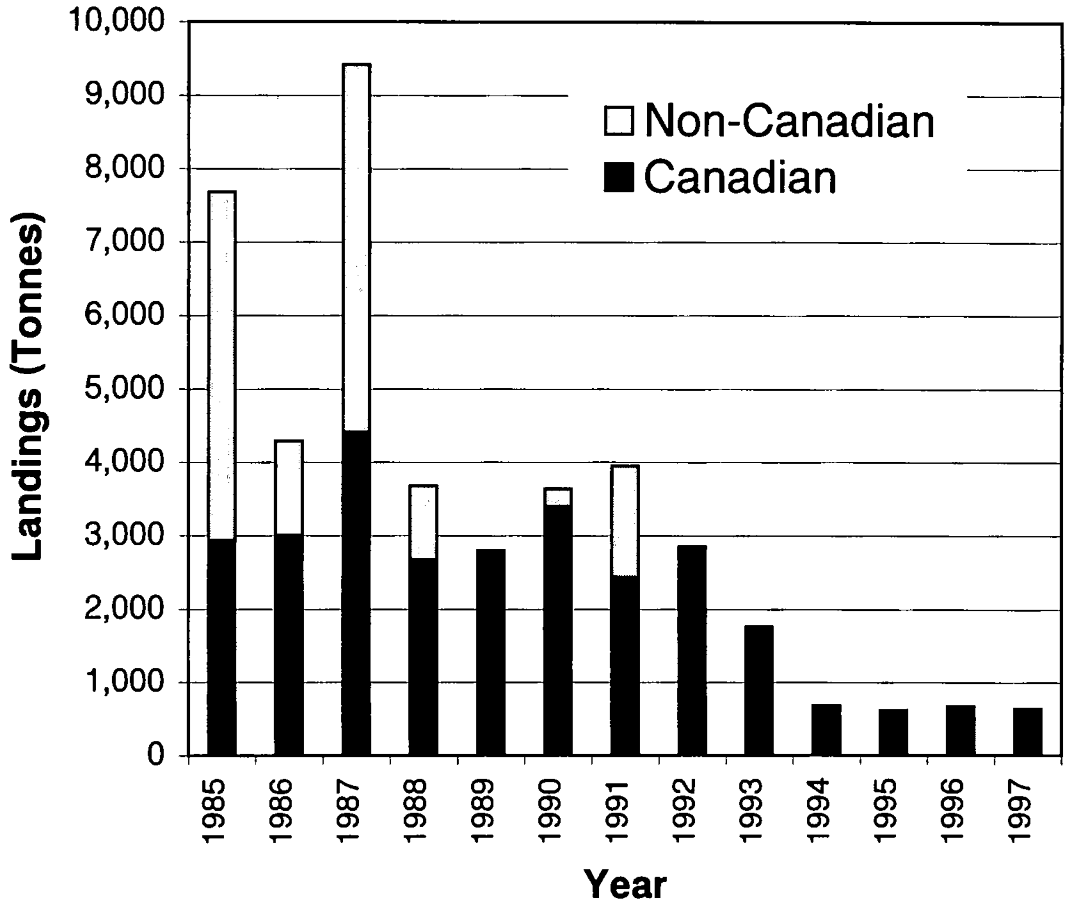
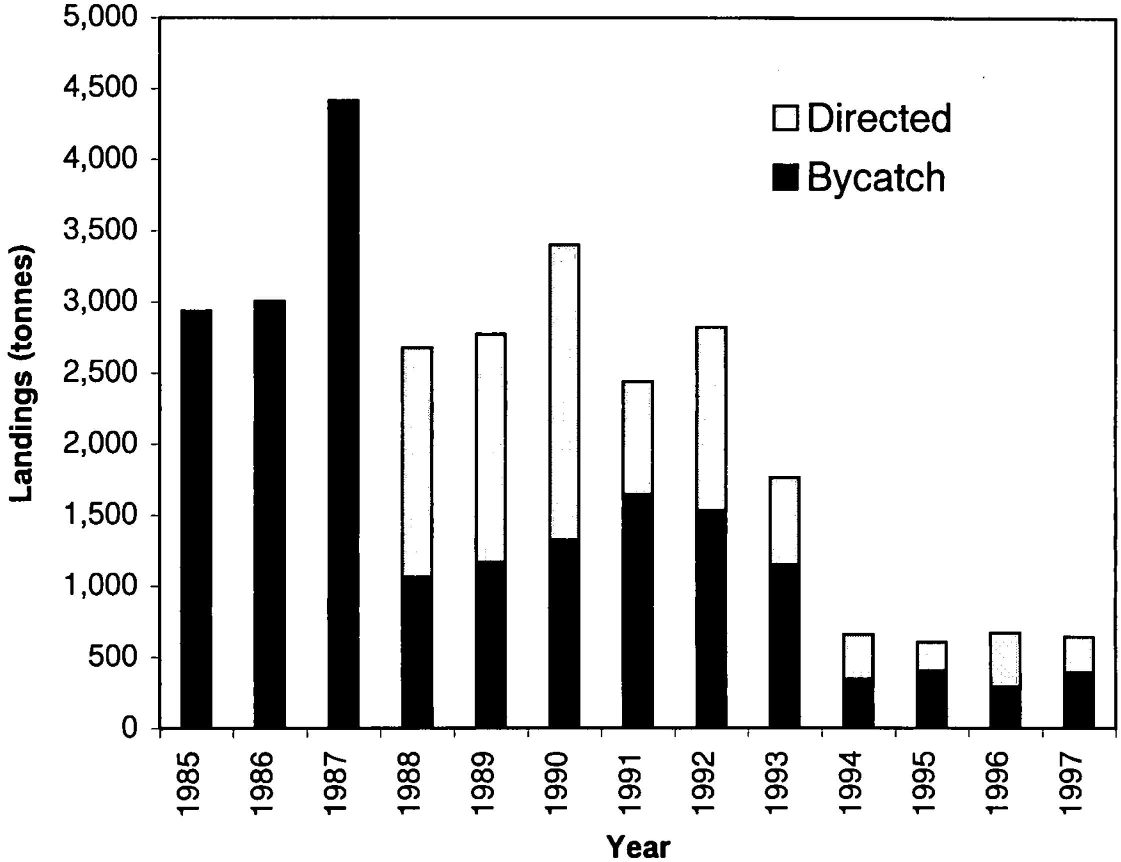


Figure 22 - Cumulative biomass of white hake versus cumulative available habitat at depth comparing the spring (A) and fall (B) survey periods.



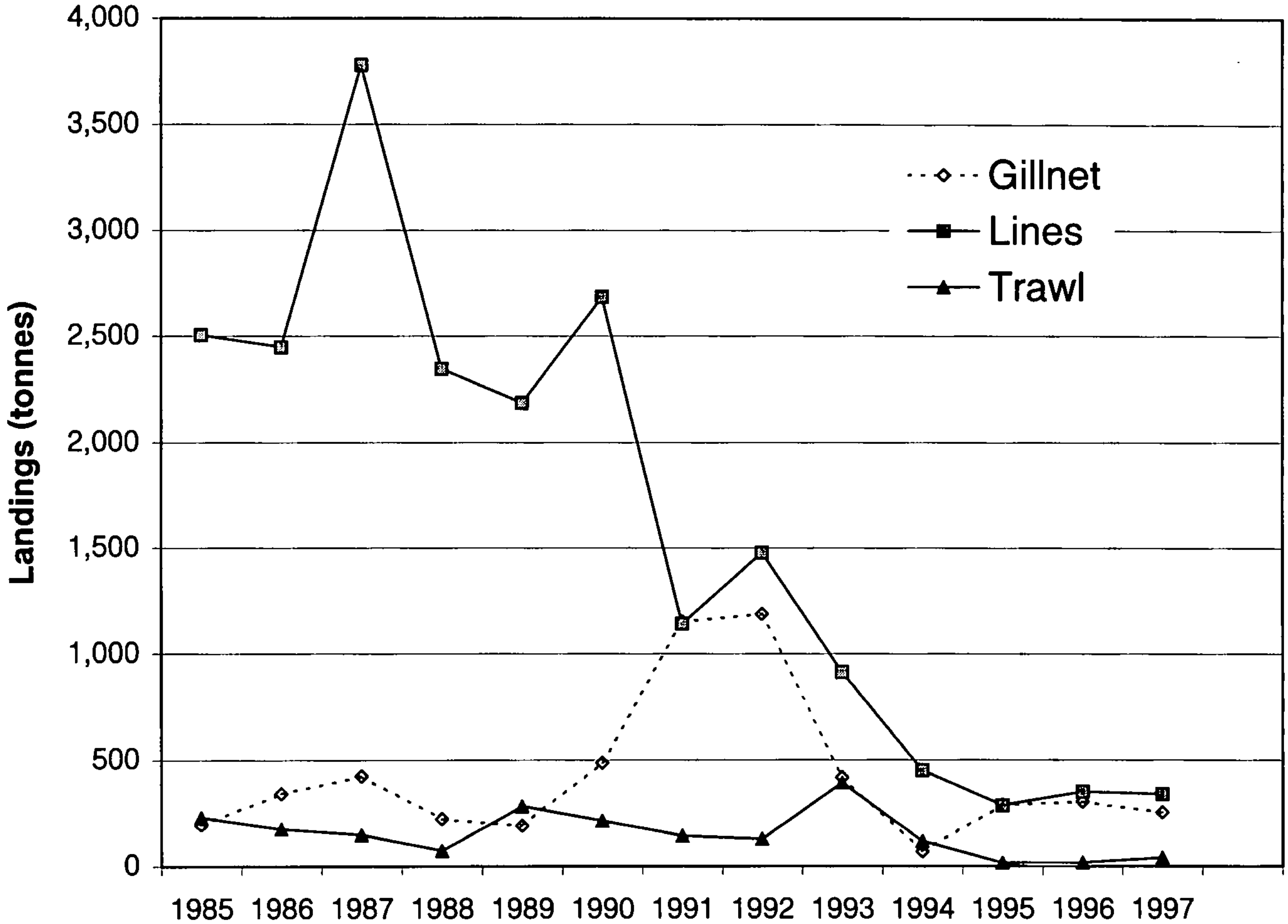
	3L		3N		3O		3Ps		
Year	Domesti	Foreign	Domestic	Foreign	Domestic	Foreign	Domestic	Foreign	**Total**
1985	32	17	101	1,542	1,665	3,185	1,138		7,680
1986	17		297	21	1,818	1,252	876	14	4,294
1987	80		1,314	4,019	1,705	990	1,314		9,422
1988	121	17	828	867	1,037	111	687	12	3,679
1989	125		878	5	1,087	23	680	3	2,801
1990	75	7	830	228	1,053	7	1,441		3,640
1991	70	5	19	1,507	948		1,401		3,950
1992	42		18		1,598		1,163	36	2,857
1993	3		19		1,009		732		1,763
1994		4	16	20	258	4	383		685
1995	2	10		5	206	1	396		619
1996	1				311	1	360		673
1997	0		0		329		312		641

Figure 23 - Landings of white hake in NAFO divisions 3LNOP, 1985-1997. Domestic landings were tabulated from ZIF files, foreign landings were collated from NAFO statistics.



	3L		3N		3O		3PS		
Year	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	177	154	205	672
1997	0		0		173	156	216	95	641

Figure 24 - Directed and non directed domestic landings of white hake in NAFO divisions 3LNOP, 1985-1997.



	Gillnet		Lines			Other			Trawl		
Year	Bycatch	Directed	Bycatch	Directed	ns	Bycatch	Directed	ns	Bycatch	Directed	ns
1985	195		2,504			8			225		4
1986	342		2,446			44			172		3
1987	424		3,780			63			142		5
1988	223		741	1,604		30			60	10	3
1989	192		749	1,435		64	50		151	121	9
1990	466	20	720	1,963		14			121	93	0
1991	1,052	99	461	680	0	4		0	125	16	2
1992	1,018	169	358	1,120		28			116	1	9
1993	314	103	420	492	0	38	2	0	355	20	18
1994	69		135	315		21			116	0	0
1995	174	116	198	88		13		0	15	0	
1996	115	189	156	193		3			16	0	
1997	177	78	171	168		1			40	0	

Figure 25 - Domestic landings of White Hake in NAFO divisions 3LNOP by gear type and mode (directed or bycatch) from 1985 through 1997.

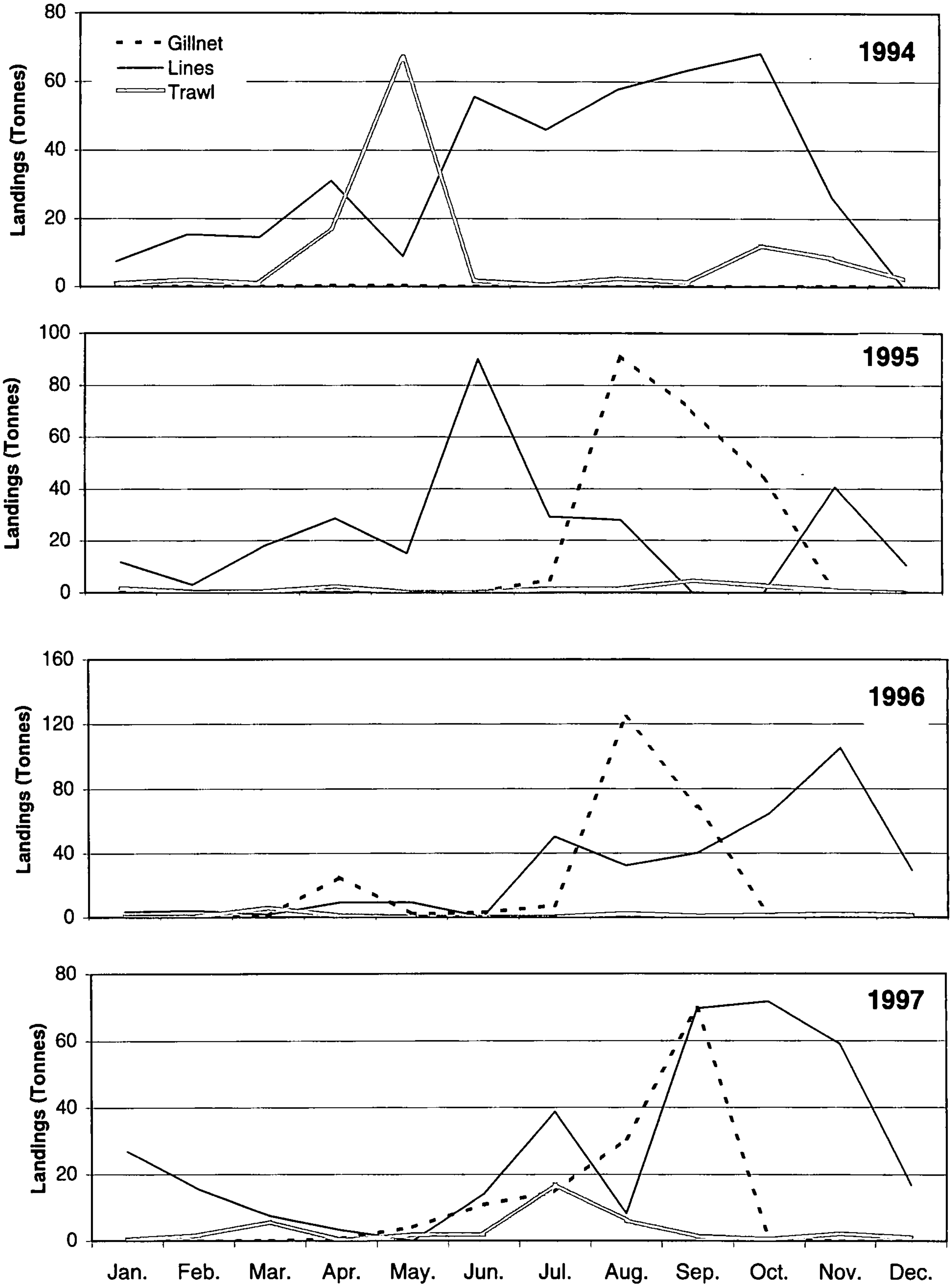


Figure 26 - Monthly domestic landings of white hake in NAFO divisions 3LNOP, 1994-1997. Landing records for which no month was recorded are excluded.

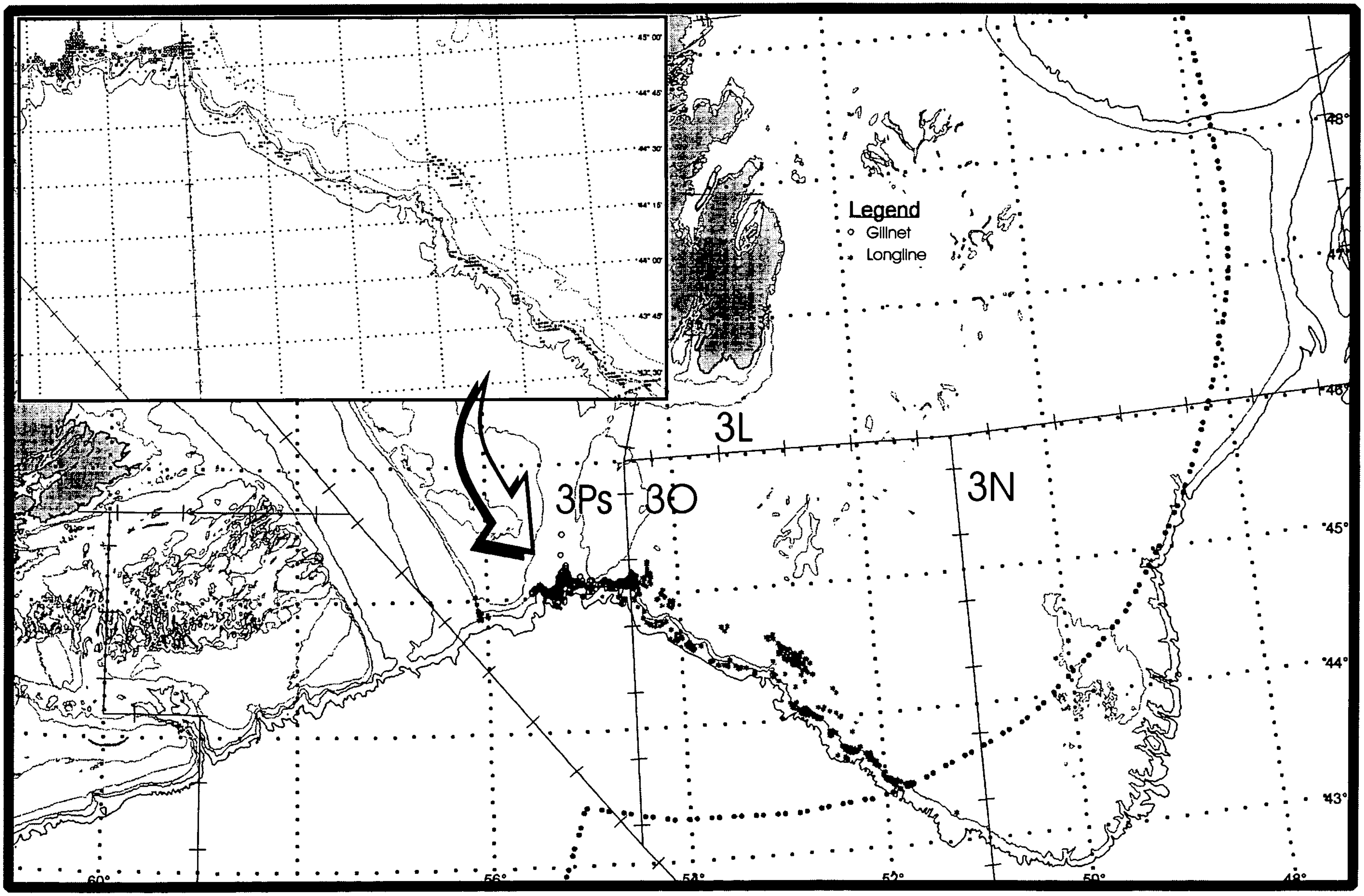


Figure 27 - Location of the observed Canadian white hake fishery in NAFO Divisions 3L, 3N, 3O and 3Ps from 1993 (the first year of the fishery) to spring 1998. Different symbols denote different gears used. The box in the upper left corner is a blow up of the main fishing grounds.

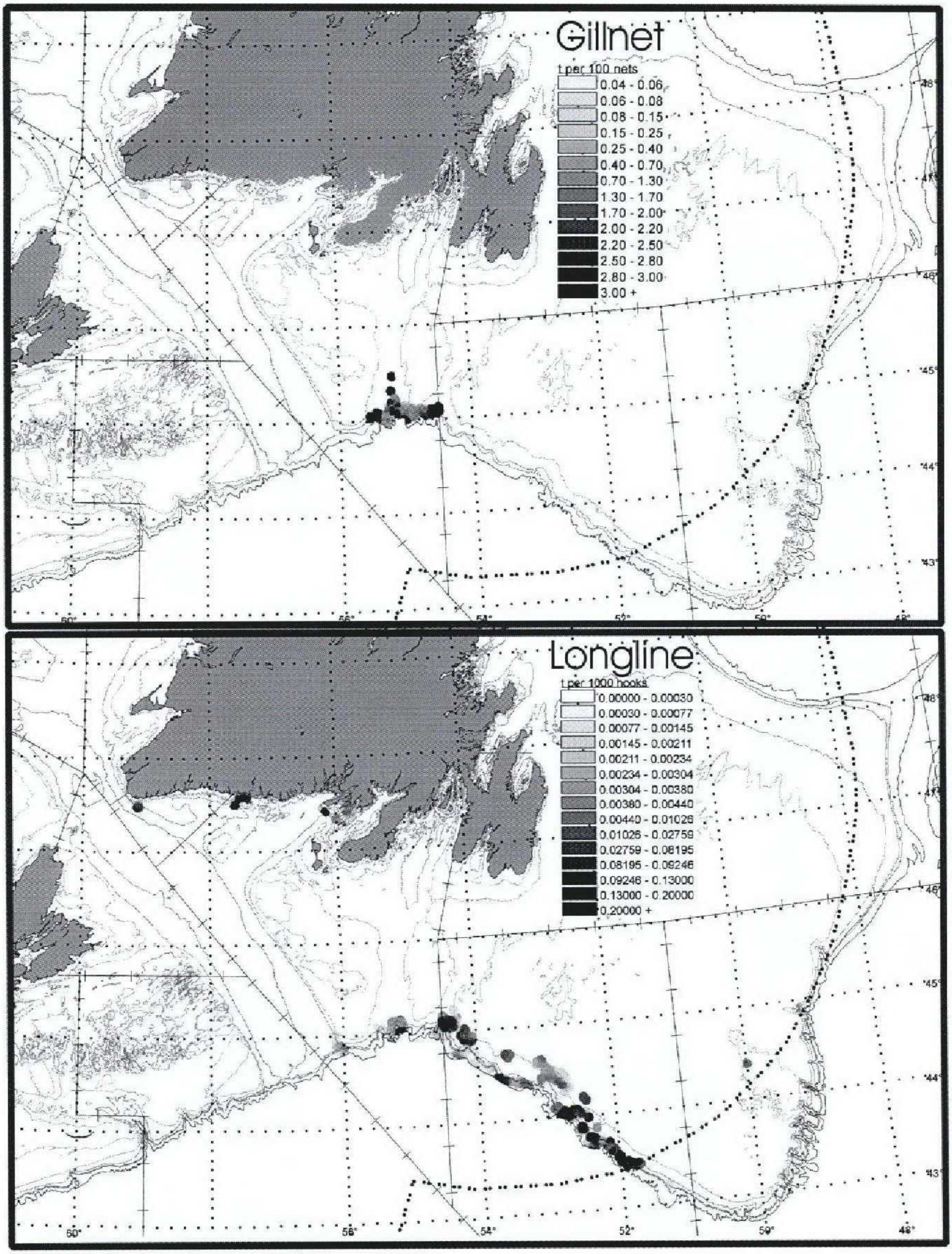


Figure 28 - Catch per unit effort distribution for the observed gillnet and longline white hake directed fisheries, 1995-1997.

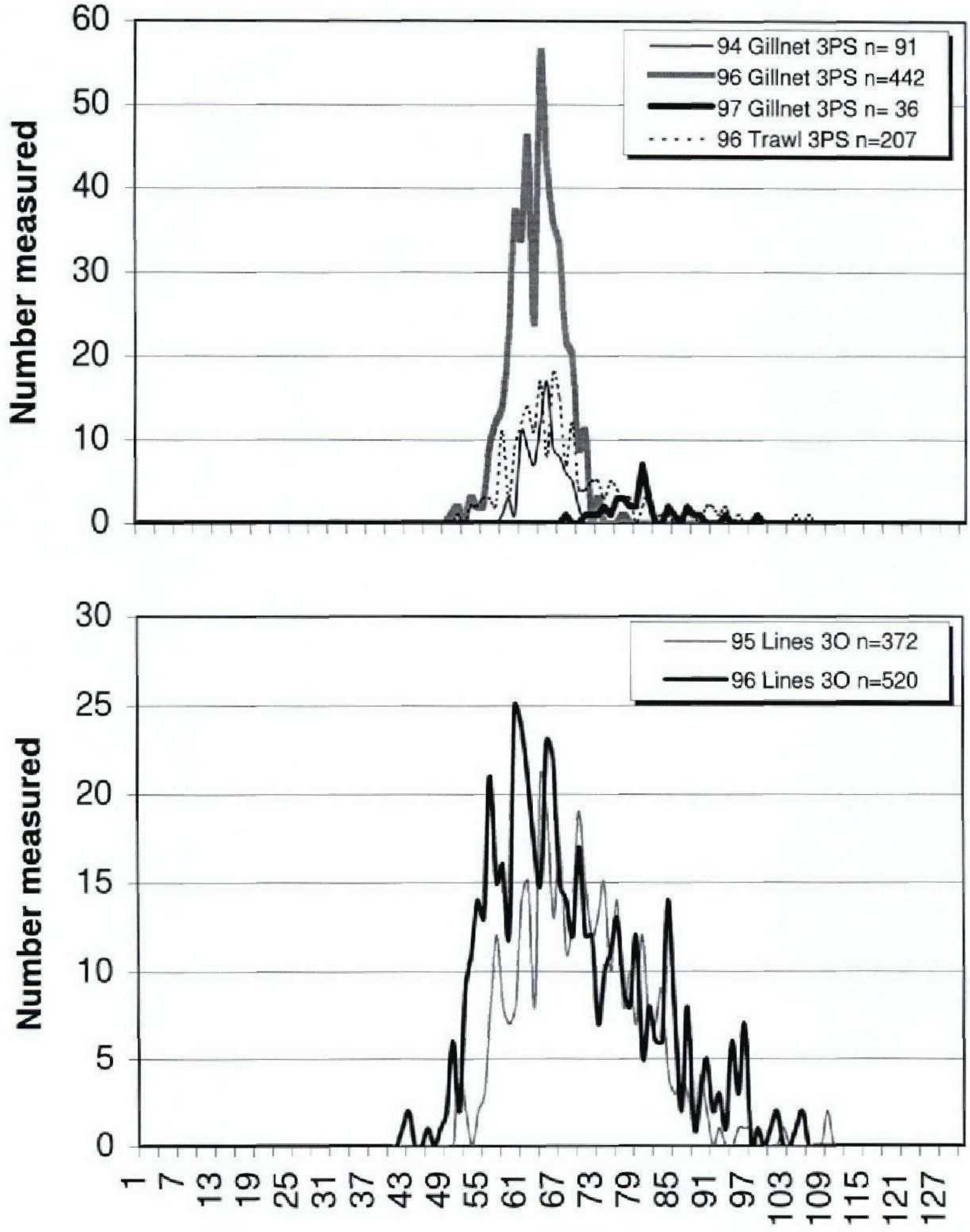


Figure 29 Length frequencies of White Hake caught with gillnets, trawl s and long lines in NAFO divisions 3O and 3Ps, 1994-1996.