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

État de la merluche blanche *(Urophycis tenuis)* des divisions 3LNO et de la sous-division 3Ps de l'OPANO

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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, 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 Subdivision 3Ps, 1985-1998. By 1995, abundance had declined to lowest historic levels. However in 1999-2001, the biomass and abundance indices increased dramatically due to recruitment, and particularly a very large 1999 year class. Locale and spatial extent of the stock remained relatively constant since the start of stratified research surveys in the 1970's, restricted to a narrow band along the southwest edge of the Grand Banks and into the Laurentian and Hermitage Channels where bottom temperatures are warmest (> 4 C^0). White hake occupied a wide range of bottom depths along the slope from 150 to 800 m. Range of total length of hake has changed little over the years 12-120 cm. However, a very large 1999 year class resulted in a dominant mode of 25 cm (1 year old) fish in the 2000 survey and a 40 cm mode (2 year olds) in 2001.

RÉSUMÉ

En raison du déclin des ressources « traditionnelles » en poisson de fond dans les eaux de Terre-Neuve, on s'intéresse davantage à la pêche d'autres espèces, dont la merluche blanche (*Urophycis tenuis*). Cette dernière est présentement l'objet d'une pêche dirigée limitée dans le secteur sud des Grands Bancs, où elle est plus communément récoltée dans le cadre de la pêche mixte de la morue, de la baudroie et de la raie. La pêche de la merluche blanche dans les divisions 3LNO et la sous-division 3Ps de l'OPANO n'est pas assujettie à un quota, l'effort n'étant réglementé que par le biais de fermetures en raison de prises accessoires démesurées d'autres espèces. Sont ici présentés : un examen des prises, de l'effort et de la composition des prises; une analyse des données sur l'abondance, la biomasse et la composition des prises selon la longueur recueillies dans le cadre de relevés de navire de recherche; et un examen de la distribution spatiale de la merluche blanche dans les divisions 3LNO et la sous-division 3Ps de 1985 à 1998. Dès 1995, l'abondance avait chuté, pour atteindre un creux historique. Mais les indices de biomasse et d'abondance ont grimpé en flèche de 1999 à 2001 en raison du recrutement, donnant lieu en particulier à une très abondante classe d'âge 1999. L'étendue locale et spatiale du stock est demeurée relativement constante depuis le début des relevés de recherche stratifiés dans les années 1970, le stock demeurant confiné à une bande étroite le long de la limite sud-ouest des Grands Bancs se prolongeant dans les chenaux Laurentien et Hermitage, où les températures au fond sont les plus élevées (> 4 0C). La merluche blanche fréquentait une vaste gamme de profondeurs sur le talus, soit entre 150 à 800 m. La plage de longueur totale a peu varié au fil des années, s'étalant entre 12 et 120 cm. Par contre, une très abondante classe d'âge 1999 a donné lieu à un mode dominant de 25 cm (poissons de 1 an) dans le relevé de 2000 et à un mode de 40 cm (poissons de 2 ans) dans le relevé de 2001.

INTRODUCTION

White hake (*Urophycis tenuis*) is a bottom dwelling species distributed in the Northwest Atlantic from Cape Hatteras to southern Labrador, reaching its peak abundance in the Gulf of St. Lawrence, on the Scotian Shelf and in the Gulf of Maine. Correspondingly, the location of the most important Canadian fisheries is the southern Gulf of St. Lawrence (NAFO Div. 4T) and on the Scotian Shelf and Georges Bank (NAFO Divisions 4VWX and 5). These stocks have been the object of directed fishing effort and their status as a commercial resource assessed for years 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), Hurlburt *et al.* (1995, 1996, 1997) and Hurlbut and Poirier (2001) for the Gulf of St. Lawrence stock and Fowler et al. (1996) and Fowler (1998) for the Scotian Shelf stock. The Georges Bank/Gulf of Maine stock is assessed by the USA. The authors note that the NAFO Divisions 4VWX and 5 stock structure is complex, fragmented and contiguous with adjacent stocks i.e. 4V contiguous with 4T, 4X with Georges Bank/Gulf of Maine.

Formerly the most abundant and commercially important stocks, the Gulf of St. Lawrence, Scotian Shelf and Gulf of Maine components have declined in recent years. The 4T stock was the third most important commercial groundfish resource in the Gulf of St. Lawrence, until a moratorium on fishing in 1995. While recent recruitment has led to an increase in abundance there since 1996, the population remains low in relation to the 1970's-1980's (Hurlbut and Poirier 2001). On the Scotian Shelf, landings were stable from the 1970's to the late 1990's (Fowler et *al.* 1996). However, abundance estimates are currently at record lows and as a result there has been no directed fishery since 1999. Lang et *al.* (1996) reported that landings of white hake in the Gulf of Maine region have increased to substantial levels since the late 1960's. The 2001 assessment for that stock stated that it was over-fished and recommended a level of fishing mortality close to zero.

White hake are also found in the waters south and east of Newfoundland in Divisions 3L, 3N, and 3O and Subdivision 3Ps (collectively known as 3LNOPs) as illustrated in Fig. 1. Here, its distribution is more restricted, confined largely to an area associated with the warmest bottom temperatures along the southwest fringe of the Grand Banks (Kulka and Mowbray 1998). North of this area, white hake occur only sporadically in time and space. Prior to the mid-1990's, white hake in this area were usually only taken as bycatch. Unlike the stocks in the Gulf of St. Lawrence, and Scotian Shelf, it was rarely reported as a 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 was a relatively minor component of the total commercial landings as described in (Kulka and Mowbray 1998).

However, 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 as well as other common bycatch species such as thorny skate, monkfish and wolffish became the focus of attention for new or expanded fisheries. An experimental trawl fishery for hake was carried out in 1993 in NAFO Div. 3O and Subdiv. 3Ps with limited success. Given the increased interest in this stock, it was assessed for the first time in 1996 (Kulka and DeBlois1996). Since that time, although not regulated through quotas, closures due to high bycatch of regulated species have restricted catches to the lowest level observed (Kulka and Mowbray 1998).

At present, there is no research directed for white hake in Newfoundland waters, although catch information has been collected during groundfish research surveys in Divisions 3L, 3N, and 3O and Subdivision 3Ps (collectively known as 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 a small sample of length frequencies.

This paper updates Kulka and Mowbray (1998) and reviews available information on white hake: distribution and biology, fishery statistics, and research 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 the research surveys and the commercial fisheries are used to examine hake distributions and fishery exploitation patterns (1986-2001). 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 on the southwestern Grand Banks, in the southern Gulf of St. Lawrence, on the Scotian Shelf and in the Gulf Maine. Over a wide range of depths from less than 50 m to about 1000 m, white hake tolerate water temperatures from just above 1^0C to 21^0C, but are mainly associated with 5-11^0C over most of its range. While they are a relatively well studied (and managed) species in other areas (refer to references listed below), only three previous studies, Muir (1978), Kulka and DeBlois (1996) and Kulka Mowbray (1998) report on hake distribution and abundance on the Grand Banks (NAFO Divs. 3LNOPs). These studies show that white hake on the Grand Banks are at the limit of their temperature range and thus are spatially restricted to a small section on the southwestern Grand Banks, with little variation in their distribution during the last five decades. It appears that white hake occur in deeper waters at the northern extent of its distribution on the Grand Banks and in the Gulf of St. Lawrence due perhaps to their preference for warmer water that is restricted to the outer parts of the southern Grand Banks. It was also noted that there was a significant shift to deeper waters along the slope in the 1990's (Kulka and Mowbray 1998) although distance associates with this shift is small.

Musick (1974) noted that the diet of white hake is dominated by other fish species (i.e., cod, herring, flatfish, etc.). 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. Collectively, they reported on several geographically separate components or stocks with some overlap 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. Given its importance as a groundfish resource in the Gulf of St. Lawrence, much of the past research is from this area. 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.

METHODS

Research Data

Data on white hake has 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).

As well, there was a change in survey gear after the spring 1995 survey, from Engels 145 to Campelen 1800 bottom trawls. To synchronize the information derived from the two gears conversion factors for amounts and sizes of fish caught were derived for the major species but not for minor species, including white hake. Thus, the catch rate data and resulting biomass and abundance indices are on a different scale between the spring of 1995 and subsequent surveys. The two periods must be considered as unrelated time series. The change in scale is delineated on the various tables by spatial separations and on the figures by lines.

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 2001 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 added over the survey area. Estimates based on sets from strata that have been surveyed throughout the years compared to estimates that include deep water and inshore strata which have been added in recent years yield very similar results for white hake (refer to Kulka and Mowbray 1995). Thus data from the new strata are included in the estimates of 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 to date, the area surveyed was 295,000 km^2 in 1994-95 it was 283,000 km^2 from 1986-1993 was 255,000 km^2. CTD, BT, or XBT gear was used to record bottom temperatures at all tow locations. These data were used to examine the relationship between hake distribution and bottom temperature.

Potential mapping in SPANS used to investigate the spatial distribution of white hake from survey data (Engel and Campelen sets, 1950 to 2001, spring and fall). Potential mapping (Anon 2000) 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 (9 km diameter) provided complete coverage of the survey area while minimizing gaps in the density surface and thus maximizing spatial resolution. The study area periphery was isolated using a 'cookie cut' technique (referred to as a basemap cut in SPANS). This resulted in a density surface bounded on all sides by either land, the 1000 m depth contour . The resulting map was then post-stratified into 15 classes defining density of the fish, each covering approximately the same amount of area. Details of the methods are described in Kulka (1998).

Distributions were plotted for the spring and fall, using Engels and Campelen sets. The data were separated into 4 periods: 1950 to 1970, 1971-1988, 1989-1995 and 1996-2001. The latter three time periods were chosen to correspond with biologically different periods. From 1950 to 1970, sampling in the form of line surveys was incomplete but is included to provide a more complete time series. From 1971 to 1988, white hake were relatively abundant whereas 1989-1995 was a period of decline in the abundance. The final period, 1996-2001 represents a period of low but increasing abundance. The strata class bounds (numbers per tow) were held constant across year groups so that varying amounts of each grey shade displayed depicting a density level would reflect relative changes in density over time.

Similarly, bottom temperature maps were created for both the spring and fall period using 15 strata of equal area varying from –1.9 to 5.4+ ^{0} C corresponding to the year groupings for the distribution maps. Weight per tow of white hake was overlaid on the bottom temperature maps and over depth contours to describe distribution with respect to temperature and depth.

White hake were measured for total length for most survey sets. Catch length frequencies (number of fish measured) were plotted by NAFO Division, survey period and year from 1986 to 2001. Sex was recorded for a subsample (about 10%) of these sets and these data were used to calculate maturity ogives by NAFO Division. Gonad maturity stages of white hake were available for Divisions 3O and 3Ps in some years. However, on average, maturity stage was recorded for less than one third of the catch. Nonetheless, when maturity information was available. length at maturity (length at which 50% of hake were sexually mature (L_{50}) was calculated for each combination of sex and area (see Table 3).

Fishery data

Landings from white hake directed fishing and bycatch from other fisheries were compiled using statistical records contained within the Zonal Interchange Database (ZIF) for the Canadian fishery. Landings from other countries were compiled from NAFO Table 5 statistics. A portion of the landings was recorded with hake as the directed species. However, this approach probably identifies only a portion of the directed effort since a substantial records indicate the directed species as mixed or unidentified. Generally, white hake in NAFO Divisions 3LNOP make up a component of a mixed fishery directed for monkfish and skate as well as hake.

Since the start of the fishery in 1994, observers have been deployed on at approximately 8 % of the fisheries taking white 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 is described above. 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 survey data since 1994 (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 the spring and fall (Table 1a and 1b, Fig. 2a and 2b). However, only NAFO Divisions 3L and 3O were surveyed during the fall and thus, the spring index is used as the main indicator of changes in relative abundance.

The biomass of white hake peaked about every ten years during the period when stratified survey data were available to estimate biomass, 1971-2001. During the period when the Engels trawl was employed, the index peaked at about 8,000 t in 1975-1978 and about 14,000 t in 1986-1988 (Table 1a and Fig. 2a). Between 1989 and 1995, white hake under went a substantial decline. This corresponds with declines that were observed for a substantial number of other species at about the same time (Atkinson et al. 1994). The average index of biomass for 1992-1995 was only 23% of the biomass for the period 1986-1988. Declines in hake populations were also observed on the Gulf of St. Lawrence and the Scotian Shelf during the late 1980's and early 1990's (Hurlbut *et al.* 1997 and Fowler *et al.* 1996).

The sharp increase observed in 1996 in the spring and in 1995 in the fall is the result of the change in survey gear. Given the concurrent change in gear types, biomass index levels since 1996 (spring) and 1995 (fall) cannot be directly compared with the preceding years. However, if one applies a conversion factor derived by averaging of the last three years when the Engels gear was used divided by the average of the first three years when the Campelen gear was deployed, one can speculate on the relativity between the two periods. The average biomass index for the period 1999-2001 was almost 3 times higher that for the period 1996-1998. The difference between these two time periods was even more dramatic in terms of abundance, about a 6 times difference in numbers between the two periods 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 (converted) biomass index is comparable to the 1975-1978 peak. The reader is cautioned that this comparison is no more than speculation since as is pointed out in the Methods, no size and age based conversion experiments were done for white hake. As well, the size and age composition between the two periods is very different as described below.

Fall biomass and abundance estimates, presented for the period 1990-2001 were constrained to NAFO Divisions 3LNO (no surveys in Div. 3P in the fall). They show a similar dramatic increase in Divs. 3N and 3O between 1995-1998 and 1999-2000 (2001 data not available, Table 1b, Fig. 1b). Biomass in these areas doubled and abundance underwent a 10 times increase. Of particular interest is the large increase in biomass in Div. 3N, to proportions previously not observed (refer to discussion of distribution of this biomass in Div. 3O below). This index confirms the increase that was observed in the spring surveys.

Prior to 1998, the spring biomass of white hake was concentrated primarily in Subdiv. 3Ps (southern edge of the St. Pierre Bank and eastern edge of the Laurentian Channel) and to a lesser extent in Div. 3O (southwest slope of the Grand Bank). In most years, only a few sets per year have been observed in Div. 3N (eastern Grand Bank) to contain white hake. The largest biomass estimates in this area tend to occur during periods of peak biomass. In Div. 3L (northern Grand Bank) where they are even more rare, only six sets with hake having been observed since 1995. STRAP did not yield a biomass estimate for this area given that no more than one set was observed in any given stratum. After 1998, the majority of biomass occurred in NAFO Div. 3O and white hake reappeared in NAFO Div. 3N. In the adjacent NAFO Div. 3M (Flemish Cap), a fishery observer recorded and measured white hake (one year olds) taken as bycatch in 9 shrimp directed commercial sets in 2001. In past years, the surveys on the Flemish Cap only occasionally recorded white hake. All of this suggests a broadening of the distribution of the species over the past three years although the areas of concentration have remained relatively constant (see discussion of distribution below).

Trends in mean weight declined in concordance with the declining biomass and abundance in the late 1980's/early 1990's, particularly in Div. 3O but has remained more or less stable since (Fig. 2). Comparing the sizes between the two survey gears suggests that the Campelen gear likely capture slightly smaller fish on average although the change between 1991 and 1996 is not large. However, since the early 1990's, there have been fewer large fish. The average fish weight of 2 kg in Div. 3N in the 1970's and 1980's dropped to about 1 kg in the mid-1990's for Engels gear. After the change to Campelen gear in 1996, average weight reached their lowest level in 1999-2001, particularly in Div. 3O, an area once containing the largest fish.

The reduction in size of white hake started well before the change in survey gear as is reflected in the length of fish observed (Fig. 3). Since white hake were not measured for total length in all research survey sets or in all years, length frequencies are presented as the number measured only. The sizes of fish measured in both spring and fall ranged from 9-130 cm total length (Fig. 3a, spring and 3b, fall). Modes of the length frequency distributions for Divs. 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 indicating an absence of older adults for an extended period. Prior to 1997, a significant sized mode of fish 25 cm (1 year old fish according to aging done by Hurlbut and Poirier 2001 in the Gulf of St. Lawrence) appeared only once, in 1991, indicating poor recruitment between 1986 and 1997. Given this situation (and high levels of fishing during that period, described below), it is not surprising that the population under went a decline in the late 1980's/early 1990's.

However, the spring 1997-2000 Campelen surveys were dominated by one year old fish. Very large 25 cm modes were observed, particularly in 1999 and 2000. In the fall of 1999 (Div. 3O), the 25 cm mode was absent although a mode of very small fish (10-20 cm) was observed. Taking into consideration the presence of one year old fish in 1997-2000 (and their predominance in 2000), the increase in the biomass index in 1999-2001 and the very large increase in abundance during that period suggests that recruitment was high during this period (refer also to IGYPT young of the year findings described below as supporting evidence). This is certainly the best sign of small fish in recent years. Few one year old fish (25 cm mode) was observed in 2001 but a mode averaging about 37 cm (mainly 2 and some 3 year olds according to aging done by Hurlbut and Poirier 2001) dominated. This indicates that the very large 1999 year class observed in the 2000 Campelen survey has persisted into 2001 as 2 year olds.

Some caution is required in comparing 1996-2001 patterns to earlier years, particularly at the small end of the fish size spectrum since the relative catchability of small fish by Engels and Campelen gear (with a smaller mesh than Engels) is unknown. Although both bottom survey trawls retained a large range of sizes, it appears that the catchability of smaller fish with the Campelen trawl is greater than with the Engels trawl and the reverse is true for larger fish. This possible change in catchability further hinders inter-period comparisons.

The Campelen survey (1995 to date) results, described above, indicate a sharp increase in small fish in all areas since 1997. The IGYPT (International Young Gadoids Pelagic Trawl) survey occurred between 1996 and 2000. Only a few sets out of range and depth of white hake were prosecuted in 2000 and the survey has since been discontinued. This short survey series, taking place near surface (36 m) in Aug.-Sept. (Dalley and Anderson 1998) on the Grand Banks confirmed recruitment in all years surveyed, 1996-1999 (Table 2). These pelagic white hake, if similar in their life history attributes to those in the Gulf of St. Lawrence (Markle et *al.* 1992 indicated that spring spawned fish were pelagic during the late summer whereas further south in the Gulf of Maine, pelagic juveniles were found earlier, in May-June as reported by Fahay and Able, 1989) were young of the year and were sampled just prior to settling. An estimated growth rate of about 2.5 cm per month would correspond with the 25 cm mode of white hake seen in the following years bottom trawl survey (refer to Fig. 3 spring and fall). The largest observed 1999 year class detected by the IGYPT survey dominated the 2000 spring frequency as a 25 cm mode and continued as a 37 cm mode into 2001 as described above.

Fig. 4 shows that white hake young of the year (IGYPT survey) were taken over much of the shallow part of the Grand Bank but primarily on the southern tip west and overlapping the SE Shoal. This area is just north of the main concentration of adults inhabiting the southwest slope. White hake in the size range of 2.5 to 7 cm (refer to Fig. 8 Kulka and Mowbray 1998) were taken during the various years. Fig. 5 shows that 1996 and more so 1999, were the highest recruitment years, the 1999 concentrations located slightly to the west of those in 1996.

Distributions were plotted for the spring and fall, Engels and Campelen sets separate and combined (Fig. 6). The data were separated into 4 periods: chosen to correspond with biologically different periods as illustrated in Fig. 2: 1971-1988, white hake were relatively abundant whereas 1989-1995 was a period of decline in the abundance. The final period, 1996-2001 represents a period of increasing abundance. From 1950-1970, sampling in the form of line surveys was incomplete but is included to provide a more complete time series.

The spatial distribution of Grand Banks white hake has changed little over the time period surveyed. Kulka and Deblois (1996) showed that since 1950 white hake biomass from research surveys has been consistently occupied a narrow band along southwestern edge of the Grand Banks and into the slope of the Laurentian Channel, contiguous with white hake located NAFO Div. 4T. The most apparent change in distribution in 1989-1995 compared to the periods before and after. In 1996-2001, white hake occupied a larger (wider) area along the southwest slope of the Grand Bank and they also occupied at higher concentrations on the shelf area of the southern Grand Bank than was previously observed.

This change in the area of occupation is also reflected in a change in depth occupied by white hake. In other areas (Gulf of St. Lawrence, Scotian Shelf, Gulf of Maine), white hake are reported to occur mainly at depths of between 50-200m (Hurlbut and Poirier 2001, Fowler 1998). However, on the Grand Banks, a significant proportion of biomass distributes deeper than 200 m due to their preference for the warm water that is restricted to the deeper parts of the southern Grand Banks. Fig. 7 upper panel shows that the majority (66%) of the area within NAFO Divs. 3LNOP has associated depths < 200 m. whereas a substantial proportion of white hake (58% in 1971-1988, 78% in 1989-1995 and 65% in 1996-2001) is distributed at depths greater than 200 m in the spring (Fig.7). The greater proportion of biomass below 200 m in 1989-1995 is due to colder bottom waters on the bank during that period (see the preceding discussion on the narrowing of the distribution along the southwest slope and following section for a discussion of distribution in relation to temperature). The re-expansion onto the shelf in 1996-2001 was concurrent with warming temperatures during that period. Also, Kulka and Mowbray (1998) showed that white hake were distributed at shallower depths in the fall when bottom temperatures were warmer, This pattern is reflected in Fig. 6g, lower panel.

Spring bottom temperature from research surveys is presented in Fig. 8 for the same three time periods for which the fish were mapped: 1971-1988, 1989-1995 and 1996-2001. The most noticeable difference between periods is the increased area in 1989-1995 where bottom temperatures was $<0.9^{\circ}$ C. As well, the bottom water on the southeast shoal was cooler during that period (waters > 4° C was largely absent) and the inner limit of the band of warm water along the southwest slope was deeper. In the spring, water exceeding 4° C was seen inside the 100 m contour in that area after 1996 but was exclusively outside that line in 1989-1995 (very similar to the fall distribution across all years).

In terms of bottom temperature, white hake biomass was primarily restricted (90%) to areas > 4° C (Fig. 9) and this varied little over the time period examined. Kulka and Mowbray (1998) showed this to be the case for both spring and fall and they also noted that there was no significant relationship between hake size (mean weight) and bottom temperature. Thus, any changes in bottom temperatures are expected to affect the distribution of white hake and that was what was observed: a contraction during the cool period of the early 1990's and subsequent expansion during the late 1990's. This reduction in distribution also coincided with a period of declining stock size and apparent low recruitment whereas the recent warm period coincided with increased recruitment.

As with other gadoids, males were found to mature at smaller sizes than females (Tables 3). Size at maturity did not differ greatly between the two divisions or the time periods examined. Kulka and Mowbray (1998) mapped the percent of mature hake based on 1995-1998 survey data. They found that males and females were distributed in the same manner with regard to sexual maturity. With very few exceptions, catches along the extreme edge of the Grand Banks tended to be dominated by mature fish while immature fish (and smaller) predominated in catches closer to shore or at shallower depths. For example, white hake caught in Hermitage Channel (3Ps) near the south coast were nearly exclusively immature fish and limited samples from west of the SE Shoal were also immature.

The Fishery

In 1987, reported landings of white hike peaked at about 9,000 t, about half of that total reported by non-Canadian sources although in all but 2 years up to 1991, reported catches were 3,000-4,000 t (Fig. 11). After 1992, only Canadian landings have been reported. With the restriction of fishing activity by other countries to areas outside of the 200 mile limit, non-Canadian landings fell to zero except for small amounts reported in 1994-1998.

Although interest by the Canadian industry in fishing hake has increased in recent years, landings have remained low, at less than 1,000 t since 1994. 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 800 t since. This decline is due to both decreased incidental hake catch from the reduced 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 reported as incidental catch. Since 1989 the reported directed fishery has contributed, on average, about 50 % of the annual Canadian catch, ranging from 30–70%. (Fig. 11, Table 4). This abrupt change may reflect a change in the manner that white hake were reported. Fig. 12 shows that in recent years, the majority of white hake are taken in a mixed fishery with monkfish and skate and are reported as Unspecified fisheries. In this hake/skate/monkfish fishery, the main species caught changes from day to day indicating the mixed nature of that fishery. They are also taken as bycatch with halibut, cod and a host of other groundfish.

In most years prior to 1995, the majority of commercial catches were taken with longlines.

However, in recent years gillnets have risen while longline catches have declined to a point where they are now of equal importance. Trawls have rarely contributed a large proportion of the total catch (Fig. 13).

The majority of landings occurred in the latter half of the year partly due to regulations. Gillnet catches typically peaked in August or September, whereas longline catches were spread out over the year (Table 5, Fig.14). Fishery observer data indicated that longlines are fished more frequently on the shelf edge in 3O whereas gillnet grounds straddle the border of NAFO Div. 3O and 3P after 1997 (Fig. 16). Kulka and Mowbray (1998) reported a similar pattern in earlier years. 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 and monkfish availability.

An overlay of the observed fishing grounds (1998-2001) with the 1996-2001 distribution map shows that for the most part, fishing sets occurred where the survey distribution predicted the highest concentrations (Fig. 15). The commercial CPUE and concentration of sets were clustered where # per tow from the survey were highest (inset, lower panel of Fig. 15).
No trends are evident in the spatial distribution of gillnet catch rates (fishery observer data), although the catch rates to the west of the Div. 3P line yielded better catch rates in 1998-2001 than grounds to the east. (Fig. 15 and Table 6). 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, available data suggest that longline and otter trawl catches contained a larger range of sizes than did catch from gillnets (Fig. 16). Otter trawl and longline sizes showed a fairly wide range from about 46 to 110 cm. Gillnet catches were restricted to 46 to 80 cm in most years. The widest range of sizes for this gear were taken in 2001. It should be noted that the commercial gears have not taken significant amounts of the year classes recently produced.

According to the 1998-2001 Groundfish Conservation Harvesting Plan (CHP), any groundfish license holder could request a permit to direct for white 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 NAFO Divisions 3NOPs. Vessels in this category could only be issued a permit to fish during the period Apr.1 through Dec. 31 (changed to Mar.31-Dec. 31 after 1999). However, the timing, duration and areas permitted in individual license conditions 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 potentiality for cod bycatch, and the home port of the fisher making the request. Some vessels received permits for only one trip one trip only while others received permits for multiple trips depending on compliance to management issues. In 1998-2000 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.

In 2001, 24 fishers were issued permits for total of 37 trips. Fifteen fishers directed for white hake over 21 trips (with 4 trips that included 3Ps activity). No closures resulted from excessive catches of small fish (<45 cm) in any of these fisheries. Restrictions on incidental white hake catch 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 for white hake in 3LNOPs.

The 2001 Conditions of License in 3LNO specified the following:

- Permit eligibility was based on fisher's 3LNO Skate/Monkfish performance in 1998, 1999 and 2000. Eligibility for subsequent permits for the year was based on performance of previous trip.
- Area: White Hake fishing permitted in NAFO Divisions 3NO only.
- Fishing Gear: Fishers were permitted to fish gillnets and longlines but not both during the same fishing trip. Only gillnets of 50 fathoms each, with a minimum 6 inch mesh size and a maximum 8 1/2 inch mesh size were allowed.
- Trips Periods: Permits were issued for 14 day trips.
- It was mandatory to return all gear to port with the vessel at the end of the fishing trip. Fisher were not permitted to fish any groundfish species in any fishing areas until all of white hake gear was removed from the water.
- By-catch of any closed species of 200 lbs or less on a daily basis was not counted for by-catch calculation purposes.
- Hail Requirements: Fishers were required to report daily, the round weight of all species caught each day and other information in a daily hail to DFO.
- An at-sea observer was required for first 3NO trip of the year and/or if fishing two NAFO areas in same trip. Assigning of observers for subsequent permits was subject to previous trip performance or at random selection.
- One hundred percent observer coverage was mandatory for new entrants, 100% self-funded observer coverage was mandatory for fishers who in previously years exceeded by-catch limits and 50% observer coverage was mandatory for fishers who in previously years did not exceed by-catch limits.

CONCLUSION AND PROGNOSIS

White hake in 3LNOPs is managed as a stock unit but whether it actually forms a single breeding population or is part of a larger stock is unknown. Distribution analyses show that they are contiguous with the Gulf of St. Lawrence (4T) stock with no apparent separation along the Laurentian Channel. On the other hand, the recent recruitment observed appears to have taken place mainly in NAFO Div. 3N and 3O, less so in Subdiv. 3Ps. Thus, issues of appropriate stock management units remain unanswered.

White hake in 3LNOPs have undergone significant changes in recent years. Based on spring surveys, hake biomass in both Divs. 3O and 3Ps had declined to an all time low by 1994. Concurrent with declining biomass during the late 1980's - early 1990's was a decrease in the mean length and weight of hake although it would appear that the size at maturity has not changed in recent years. White hake larger than 85 cm consistently caught in earlier years, after 1990 have been captured infrequently. This truncation in length composition (plus the substantial recent recruitment) is a contributing factor to the decrease in mean fish weight observed in survey catches.

Following the period of declining biomass due to low recruitment and increased fishing pressure, recent recruitment, in particular, the 1999 large year class has resulted in a sharp rise in abundance, particularly in NAFO Divs. 3NO. Fall indices for Div. 3O are greater than those from spring surveys but had a similar trend over time. The higher fall index is likely the result of more white hake available to the gear given their expansion onto the shelf along the southwest slope concurrent with the expanded area of warmer bottom water temperatures at that time of year. Seasonal differences in 3Ps are unknown as the area is not surveyed in the fall.

The reduction in mean fish weight since 1997 is due not to a further truncation in the larger sizes (as was the case in early 1990's) but to the substantial recruitment observed in some years since. Large numbers of young of the year, particularly in 1996 and 1999 first seen in the IGYPT surveys produced the large modes of one year old fish in the Campelen catches, confirming sustained recruitment since 1996. Although there is evidence of recruitment in more than one year since 1994, in 2000, the 1999 year class dominated the population, hence the very large estimate of abundance in that year. Recruitment at this level is not evident in the Engels surveys back to 1986 but it is not known if recruitment was low during all those years or whether low catchability of small (one year old) fish for that gear prevented their capture. The decline in the population during that period suggests that poor recruitment was a part of the picture.

As noted under Sources of Uncertainty, interpreting changes in the status of the stock over the longer term has been confounded by a change in the survey gear. However, if one uses the ratio of average biomass (and abundance) in the last three years that Engels gear was used (1993-1995) to the first three years that the Campelen gear (1996-1998) as a rough proxy for converting total biomass between gears, the "converted" average value for 1999-2001 is comparable to the peak observed in the late 1980's. In terms of abundance, the numbers would be an all time high although most are attributable to a single (1999) year class. Relative catcability with respect to size of fish is unknown, thus, comparing the two survey periods is at best speculative.

Biomass and abundance trends back to the start of stratified sampling in 1971 suggests a cyclic changes in the population over time. Sustained growth of this stock in the coming years is dependant on survival of the recent good year classes and further (sustained) recruitment to rebuild the spawning component. However, for this highly fecund species, it would appear that production and survival of large year classes is sporadic leading to natural cycles of the population. If the patterns observed since the 1970's is representative, one might speculate that even if fishing pressure were to remain low, the recent good recruitment may not be sustained over the longer term.

Although no fragmentation or latitudinal reduction of the area occupied by white hake occurred during the period of decline, they were compressed into a narrower band along the southwest slope of the Grand Bank, likely as a result of the narrower band of 4^0+ C temperature on the bottom during that period. Since 1995, white hake has expanded their area along the slope comparable to the pre-1988 period.

Thus, a combination of recruitment (due possibly to more favorable environmental conditions) and reduced fishing mortality have resulted in a recent increase in the population size and expansion of the extent of the distribution to pre-1988 levels. It would appear that given the appropriate environmental conditions, the current (low) level of exploitation not only allows the population to sustain itself but to grow. Sustained recruitment as has been observed in recent years is the key to recovery of the population. However, it will be several years before the recent year classes reach maturity to replenish the adult component of the population. The strong 1999 year class has showed good survival through 2001. As well, although the species is unregulated by quota, fishing pressure has remained at a relatively low level since 1993 (less than 1200 t removals annually). A note of caution: should market conditions improve for this species and the bycatch problem be resolved, catches could increase substantially. If this occurs, given the very low spawning biomass, a pre-cautionary quota may need to be considered.

Sources of Uncertainty

Little is known about white hake in the 3LNOPs area as there has been no directed research on this species. No information on stock affiliation is available although there appears to be overlap of the Scotian Shelf, Gulf of St. Lawrence and Grand Banks stocks in the vicinity of the Laurentian Channel. As well, most of the recent recruitment has accrued to NAFO Div 3O suggesting that there may be some disassociation between that area and the Laurentian Channel.

Ages are not available, and data on length, individual weights, and maturity of fish in research survey catches is incomplete. There has been little sampling of commercial catches although this situation has improved in recent years such that it known that fish are given at least 3 years before being taken in commercial gears. Most recently, valuable source of information on recruitment, the IGYPT survey has been eliminated.

Current biomass levels cannot be compared to previous years (prior to 1996) due to the change in research survey gear. Although biomass has increased substantially (1999-2001), how current levels compare to the 1980's cannot be determined. Likewise, comparisons of size of fish in Campelen vs. Engels gears is not possible, leaving the questions of relative recruitment and proportion of adults in the population between the two periods.

Statistics of bycatch from earlier years may be incomplete. Because it is often of less value than the directed species, discarding could have resulted in a bias in the landing statistics in earlier years. Reported catches of white by non-Canadian fleets may not reflect true catches. 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 although this is more of a problem elsewhere.

Outlook

Since recent biomass indices cannot be related to those of previous years, the current state of the stock cannot be properly assessed in relation to earlier years. The declining trend in the survey biomass observed prior to the change in research gear, and declines in the numbers of large fish captured in research surveys were reasons for concern. However, the sharp increase in biomass and abundance in 1999 due to recruitment and the expansion of white hake onto the bank along the southwest edge of the Grand Bank are positive signs that the populations may be undergoing recovery.

White hake landings occur both as bycatch and from a directed fishery. Catches are currently below historical averages. However, the low catches in recent years are a result of reduced effort for other fishing grounds that overlap white hake distribution and bycatch restrictions leading to closures of the directed mixed fishery. Low catch rates related to the low abundance adults and relatively low market value may also play a role. Good survival of the recent recruitment should result in recruitment to the fishery and increased catch rates over the next few years.

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 may need to be considered if market value increases or bycatch problems are alleviated. The current level of exploitation has not only allowed the population to sustain itself but to increase. Environmental conditions over which we have no control also appear to play a role.

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Table 1a. Biomass, abundance and mean weight of white hake from spring research vessel surveys, 1986-2001. Surveys were conducted with an Engels trawl (1986- fall 1995) and Campelen (spring 1996- 2001).

	Biomass (tonnes)					Abundance (thousands)					Mean weight (kg)			
	3N	3O	3Ps	All Div		3N	3O	3Ps	All Div		3N	3O	3Ps	All Div
1971	0	0			1971	0	0			1971				
1972	354	0	2,707	3,061	1972	61	0	1,556	1,617	1972	5.80		1.74	1.89
1973	36	1,532	465	2,033	1973	11	327	247	585	1973	3.25	4.69	1.88	3.47
1974	0	0	5,051	5,051	1974	0	0	2,055	2,055	1974			2.46	2.46
1975	0	3,173	4,499	7,672	1975	0	1,080	2,646	3,726	1975		2.94	1.70	2.06
1976	110	5,623	4,783	10,516	1976	32	1,413	3,856	5,301	1976	3.43	3.98	1.24	1.98
1977	50	1,339	7,084	8,473	1977	43	466	3,935	4,444	1977	1.17	2.87	1.80	1.91
1978	0	6,188	6,754	12,942	1978	0	4,362	4,058	8,420	1978		1.42	1.66	1.54
1979	165	1,978	6,310	8,114	1979	34	1,065	3,078	4,177	1979	4.85	1.86	2.05	1.94
1980	0	1,385	3,968	5,353	1980	0	1,015	2,053	3,068	1980		1.36	1.93	1.74
1981	139	96	7,448	7,682	1981	29	93	4,743	4,865	1981	4.78	1.03	1.57	1.58
1982	0	1,058	4,356	5,415	1982	0	400	1,340	1,740	1982		2.65	3.25	3.11
1983	0	0	2,545	2,545	1983	0	0	1,508	1,508	1983			1.69	1.69
1984	258	3,531	2,559	6,349	1984	57	1,085	1,179	2,321	1984	4.53	3.25	2.17	2.74
1985	46	2,878	5,303	8,227	1985	9	1,315	3,045	4,369	1985	5.16	2.19	1.74	1.88
1986	356	2,438	11,105	13,899	1986	70	574	4,186	4,830	1986	5.09	4.25	2.65	2.88
1987	44	2,752	9,866	12,662	1987	95	1,114	4,438	5,647	1987	0.46	2.47	2.22	2.24
1988	32	5,432	13,005	18,469	1988	63	690	5,533	6,286	1988	0.51	7.87	2.35	2.94
1989	0	925	6,884	7,809	1989	0	251	4,130	4,381	1989		3.69	1.67	1.78
1990	0	754	3,988	4,742	1990	0	236	2,941	3,177	1990		3.19	1.36	1.49
1991	0	1,039	4,591	5,630	1991	0	1,118	3,800	4,918	1991		0.93	1.21	1.14
1992	0	606	3,008	3,614	1992	0	574	2,699	3,273	1992		1.06	1.11	1.10
1993	0	522	2,731	3,253	1993	0	301	2,559	2,860	1993		1.73	1.07	1.14
1994	0	1,079	2,433	3,512	1994	0	886	2,274	3,160	1994		1.22	1.07	1.11
1995	0	334	2,334	2,668	1995	0	189	2,104	2,293	1995		1.77	1.11	1.16
1996	4	2,020	6,282	8,306	1996	75	2,982	8,089	11,146	1996	0.05	0.68	0.78	0.75
1997	4	2,221	8,507	10,732	1997	91	2,987	12,432	15,510	1997	0.04	0.74	0.68	0.69
1998	7	2,205	4,007	6,219	1998	79	2,249	4,765	7,093	1998	0.09	0.98	0.84	0.88
1999	20	12,194	8,236	20,450	1999	29	26,010	8,654	34,693	1999	0.69	0.47	0.95	0.59
2000	30	15,900	10,234	26,164	2000	716	104,360	11,743	116,819	2000	0.04	0.15	0.87	0.22
2001	269	14,908	8,092	23,269	2001	517	39,384	13,792	53,693	2001	0.52	0.38	0.59	0.43

Table 1b. Biomass, abundance and mean weight of white hake from fall research vessel surveys, 1986-2001. Surveys were conducted with an Engels trawl (1986- fall 1995) and Campelen (spring 1996- 2001).

FALLsurveys

Biomass (tonnes)

Year	Div. 3N	Div. 3O	Div. 3Ps	All Divisions
1986	0	0	0	0
1987	0	0	0	0
1988	0	0	0	0
1989	0	0	0	0
1990	0	1784	0	1784
1991	0	2805	0	2805
1992	22	471	0	493
1993	0	748	0	748
1994	0	1445	0	1445
1995	94	4099	0	4193
1996	6	3960	0	3966
1997	72	4192	0	4264
1998	171	2896	0	3067
1999	3028	4043		7071
2000	1165	9551		10716
2001				

Abundance (thousands)

Year	Div. 3N	Div. 3O	Div. 3Ps	All
1986	0	0		0
1987	0	0		0
1988	0	0		0
1989	0	0		0
1990	0	863		863
1991	0	2047		2047
1992	63	448		511
1993	0	490		490
1994	0	1341		1341
1995	**306**	**5409**		**5715**
1996	**143**	**3850**		**3993**
1997	**64**	**5361**		**5425**
1998	**2036**	**5079**		**7115**
1999	**83220**	**11583**		**94803**
2000	**2875**	**22750**		**25625**
2001				

Mean Weight (kg)

Year	Div. 3N	Div. 3O	Div. 3PS	All
1986				
1987				
1988				
1989				
1990		2.067		2.067
1991		1.370		1.370
1992	0.349	1.051		0.965
1993		1.527		1.527
1994		1.078		1.078
1995	**0.307**	**0.758**		**0.734**
1996	**0.042**	**1.029**		**0.993**
1997	**1.125**	**0.782**		**0.786**
1998	**0.084**	**0.570**		**0.431**
1999	**0.036**	**0.349**		**0.075**
2000	**0.405**	**0.420**		**0.418**
2001				

Table 2. Number of sets, average number of young of the year white hake per sets and average weight of fish per set taken in IGYPT trawls, 1996-2000. Average trawl depth was 30 m below the surface.

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

Table 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	
	F	M	F	M
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)
1999				
2000				
2001				

Table 4. Landings of white hake from 1985-2001 by NAFO Division, country (Canada vs. other countries) and gear. Area and gear are broken out by directed vs. bycatch fisheries.

	3L		3N		3O		3P		
Year	**Canadian**	**Foreign**	**Canadian**	**Foreign**	**Canadian**	**Foreign**	**Canadian**	**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	103		28	488	1	565		1,186
1997	0	128	0	92	486	6	407		1,119
1998	1	254	0	81	127	8	498	1	970
1999	0		44		307		570		920
2000	64		4		47		616		731
2001	19	0	0	0	252	0	642	0	913

	3L		3N		3O		3P		
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	354	154	411	1,054
1997	0		0		173	313	217	189	893
1998	1		0		76	51	187	311	626
1999	0		3	40	76	231	259	310	920
2000	10	53	4		28	19	373	243	731
2001	0	19	0	0	214	38	398	244	913

	Gillnet		Lines		Trawl		Other		Total
Year	**Bycatch**	**Directed**	**Bycatch**	**Directed**	**Bycatch**	**Directed**	**Bycatch**	**Directed**	
1985	195		2,504		229		8		2,936
1986	342		2,446		175		44		3,007
1987	424		3,780		147		63		4,413
1988	223		741	1,604	63	10	30		2,672
1989	192		749	1,435	160	121	64	50	2,770
1990	466	20	720	1,963	121	93	14		3,398
1991	1,052	99	461	680	127	16	4		2,438
1992	1,018	169	358	1,120	126	1	28		2,821
1993	314	103	421	492	373	20	38	2	1,763
1994	69		135	315	116	0	21		657
1995	174	116	198	88	15	0	13		603
1996	115	377	156	387	16	0	0		1,051
1997	178	165	172	336	40	1			892
1998	134	263	58	100	68		0		623
1999	191	80	109	501	34	0			916
2000	240	175	132	139	41	1			728
2001	305	89	175	320	23	0	1	0	913

Table 5. Canadian landings of white hake in NAFO Divisions 3LNOP, by gear type and month , 1985-2000.

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
	1998	0	0	0	0	2	11	145	125	95	11	7	0	0
	1999	4	1	0	1	4	27	66	99	50	4	16	0	0
	2000	2	3	11	0	5	63	86	190	55	1	0	0	0
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
	1998	6	6	16	15	5	8	17	9	21	22	30	4	0
	1999	37	83	83	25	20	70	14	50	83	72	65	8	0
	2000	10	94	97	16	10	31	2	0	11	0	0	0	0
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
	1998	2	3	7	6	20	15	2	1	2	2	6	3	0
	1999	2	10	6	0	0	4	1	2	4	1	1	2	0
	2000	1	25	7	6	1	0	0	1	0	0	0	0	0

Table 6. Summary statistics of CPUE, catch and depth for the observed white hake fisheries, 1998-2001.

AllYears		NAFO Div			
Gear		3O	3Pn	3Ps	All
GN	Average CPUE	0.42		0.83	0.58
	Sum of Catch	29.69		34.49	64.18
	Average Depth (m)	156		210	176
	Minimum Depth	93		126	93
	Maximum Depth	410		359	410
LL	Average of CPUE		0.02	0.04	0.03
	Sum of Catch		0.92	0.69	1.61
	Average of Depth		229	241	233
	Min of Depth		225	241	225
	Max of Depth		232	241	241

1998		NAFO Div		
Gear		3Pn	3Ps	All
GN	Average CPUE		1.20	1.20
	Sum of Catch		29.65	29.65
	Average Depth (m)		213	213
	Minimum Depth		183	183
	Maximum Depth		320	320
LL	Average of CPUE	0.02		0.02
	Sum of Catch	0.04		0.04
	Average Depth (m)	225		225
	Minimum Depth	225		225
	Maximum Depth	225		225

1999		NAFO Div	
Gear		3Ps	3Ps
GN	Average CPUE	1.17	1.17
	Sum of Catch	2.69	2.69
	Average Depth (m)	235	235
	Minimum Depth	183	183
	Maximum Depth	329	329

2000		NAFO Div		
Gear		3O	3Ps	All
GN	Average CPUE	0.07	0.31	0.10
	Sum of Catch	1.62	0.73	2.35
	Average Depth (m)	153	269	167
	Minimum Depth	93	183	93
	Maximum Depth	410	359	410

2001		NAFO			
Gear		3O	3Pn	3Ps	All
GN	Average CPUE	0.52		0.10	0.44
	Sum of Catch	28.07		1.43	29.49
	Average Depth (m)	156		187	162
	Minimum Depth	109		126	109
	Maximum Depth	251		320	320
LL	Average CPUE		0.02	0.04	0.03
	Sum of Catch		0.88	0.69	1.57
	Average Depth (m)		232	241	237
	Minimum Depth		232	241	232
	Maximum Depth		232	241	241

Table 7. Commercial length frequency statistics for the 1994-2001 white hake catches.

Gear	Div.	Year	Mean	Median	StDev	Min	Max	Mode	N
Otter		1996	68	65.5	9.12	51	106	66	207
trawl		1999	90	91.5	12.13	54	114	96	179
		2000	78	76.5	13.38	51	116	66	118
	3PS		78	74.5	15.02	51	116	66	504
Total			**78**	**74.5**	**15.02**	**51**	**116**	**66**	**504**
Gillnet		1999	73	72.5	7.08	46	102	72	240
		2001	70	69.5	11.13	34	100	71	670
	3O		71	70.5	10.27	34	102	71	910
		1994	64	64.5	2.73	58	70	65	91
		1996	63	63.5	4.00	50	77	64	442
		1997	80	79.5	6.13	68	98	80	36
		1998	69	68.5	6.04	37	100	70	1,284
		2000	62	62.5	7.16	41	88	66	158
		2001	69	68.5	6.81	54	104	70	347
	3PS		68	67.5	6.65	37	104	70	2,358
Total			**69**	**67.5**	**7.98**	**34**	**104**	**70**	**3,268**
Longline		1995	70	69.5	9.57	51	109	64	372
		1996	68	65.5	11.97	42	105	60	520
		1998	67	64.5	9.78	50	107	65	336
		2001	68	68.5	13.37	44	98	73	103
	3O		68	66.5	10.99	42	109	65	1,331
		1998	51	50.5	10.77	36	94	52	29
		2000	56	56.5	6.47	43	72	50	56
		2001	55	55.5	9.22	32	82	50	514
	3PN		55	54.5	9.11	32	94	50	599
		1998	74	70.5	11.26	58	113	67	344
		1999	72	70.5	9.68	46	107	71	946
		2001	57	56.5	8.86	38	97	61	613
	3PS		67	66.5	12.16	38	113	71	1,903
Total			**66**	**64.5**	**12.32**	**32**	**113**	**61**	**3,833**
Midwater		2001	52	50.5	9.02	36	78	44	173
trawl	3PS		52	50.5	9.02	36	78	44	173
Total			**52**	**50.5**	**9.02**	**36**	**78**	**44**	**173**
Shrimp		2001	20	20.5	2.81	12	28	21	1,623
trawl	3M		20	20.5	2.81	12	28	21	1,623
Total			**20**	**20.5**	**2.81**	**12**	**28**	**21**	**1,623**
All			59	64.5	20.79	12	116	21	9,401