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

by

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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 Divisions 3LNO and Subdivision 3Ps and effort is regulated only by closures due to excessive by-catch 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, 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 1970s, 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). 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.

Introduction

White hake (*Urophycis tenuis*) is a bottom dwelling species of the Family Gadidae 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. Historically, the location of the Canadian fisheries was the southern Gulf of St. Lawrence (NAFO Div. 4T), on the Scotian Shelf and Georges Bank (NAFO Div. 4VWX and 5). These stocks have been the object of directed fishing effort for years 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.

Formerly among the most abundant and commercially important stocks in the Gulf of St. Lawrence, Scotian Shelf and Gulf of Maine, these 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

1970s-1980s (Hurlbut and Poirier 2001). On the Scotian Shelf, landings were stable from the 1970s to the late-1990s (Fowler et *al*. 1996). However, abundance estimates are currently at 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-1960s. 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 abundance in the waters south and east of Newfoundland in Div. 3L, 3N, and 3O and Subdiv. 3Ps (collectively known as 3LNOPs, 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-1990s, white hake in this area were usually only taken as by-catch. Unlike the stocks in the Gulf of St. Lawrence, and Scotian Shelf, it was rarely reported as a directed species. Prior to the mid-1980s, 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 Simpson, 2002).

However, with the decline of "traditional" Atlantic groundfish resources in the early-1990s, Canadian interest turned to the exploitation of alternate species. White hake as well as other common by-catch 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 DeBlois,1996) then again in 1998 (Kulka and Mowbray, 1998) and 2002 (Kulka and Simpson, 2002). Since that time, although not regulated through quotas, closures due to high by-catch of regulated species restricted catches by Canadian vessels to the low levels (Kulka and Simpson, 2002).

Review of the Biology

White hake range from Cape Hatteras to southern Labrador in the northwest Atlantic (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 <50 m to about 1 000 m, white hake tolerate water temperatures from 1-21°C, but are mainly associated with 5-11^{0}C 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 Div. 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 1990s (Kulka and Mowbray, 1998) although distance associates with this shift is small.

Various authours Hurlbut and Poirier (2001) for the Gulf of St. Lawrence stock and Fowler et al. Fowler (1998) have noted that the NAFO Div, 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. Over its entire range, including the Grand Banks, the population structure of this species is poorly understood.

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.

At present, there is no research directed for white hake in Newfoundland waters, although catch information has been collected during groundfish research surveys in Div, 3L, 3N, and 3O and Subdiv, 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.

Purpose

This marks the first time that NAFO Scientific has examined the status of white hake. The purpose of this paper is to address a specific set of questions posed by the Fisheries Commission. The FC requested Scientific Council, at a meeting in advance of the 2003 Annual Meeting, to provide the following with respect to white hake in Div. 3NO.

a) Information on the fishing mortality on white hake in Div. 3NO in recent years, as well as information on by-catches of other groundfish in the 3NO white hake fishery;

b) Information on abundance indices and the distribution of the stock in relation to groundfish resources, particularly for the stocks which are under moratorium;

c) Information on the distribution of white hake in Div. 3NO, as well as a description of the relative distribution inside and outside the NAFO Regulatory Area;

d) Advice on reference points and conservation measures that would allow for exploitation of this resource in a precautionary manner;

e) Information on annual yield potential for this stock in the context of (d) above;

f) Identification and delineation of fishery areas and exclusion zones where fishing would not be permitted, with the aim of reducing the impact on the groundfish stocks which are under moratorium, particularly juveniles;

g) Determination of the appropriate level of research that would be required to monitor the status of this resource on an ongoing basis with the aim of providing catch options that could be used in the context of management by Total Allowable Catch (TAC); and

h) Information on the size composition in the current catches and comments on these sizes in relation to the size at sexual maturity.

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).

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 Div. 3L, 3N, 3O and Subdiv. 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. From 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. 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 1 000 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).

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 2003. 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 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 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.

Fishery data

Landings from white hake directed fishing and by-catch 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 STATLANT 21A 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 Div. 3LNOP make up a component of a mixed fishery directed for monkfish and skate as well as hake. For 2003, the agreed STACFIS catch is compared to the reported statistics.

Since the start of the fishery in 1994, observers have been deployed on approximately 8% of the Canadian 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

Following are responses to the questions posed by the Fisheries Commission of NAFO.

a) Information on the fishing mortality on white hake in Div. 3NO in recent years, as well as information on by-catches of other groundfish in the Div. 3NO white hake fishery.

No estimates of fishing mortality were available. However, catches of white hake in Div. 3NO are summarized in the following Table 1. Between 1985 and 1993, catches were substantially higher than in the following 8 years (1994 to 2001). While there was no directed fishery during that early period. ground-fisheries that captured significant amounts of white hake incidentally during that period, were directed toward cod, redfish, halibut and Greenland halibut.

Canada commenced a directed species for white hake in 1994 in Div. 3N, 3O and 3Ps but the majority of the fishery took place in Subdiv. 3Ps; catches in Div. 3NO were restricted to a few hundred tons per year.

The large increase in catches observed in 2002 and 2003 was attributed mainly to EU-Spain and EU-Portugal fishing primarily in Div. O just outside Canada's 200 mile limit. Figure 1 shows the total catch trajectory for 1985-2003.

An examination of NAFO Research Reports did not identify white hake as a directed species for countries other than Canada although the majority of the catch (~80% was attributable to EU-Spain and EU-Portugal).

Information on by-catches of other groundfish in the 3NO white hake fishery was available for Canada and Spain. Canadian fisheries observer data from 1997-2003 shows that white hake comprises 85% of the catch in the Canadian gillnet fishery and 55% in the Canadian longline fishery (Table 2). Monkfish was the dominant by-catch in the gillnet fishery. For species under moratorium, cod dominated in longline catches but American plaice by-catch was negligible. Estimated amounts of cod taken as by-catch averaged 109 tons annually from 1994-2003 given that the Canadian longline fishery took an average of 332 tons annually during that period.

White hake were also taken as a by-catch in the Canadian redfish, monkfish, halibut fisheries and to a lesser extent in the Canadian skate and Greenland halibut fisheries in relatively small amounts.

González and del Río (2004) reported on catches of white hake in the Spanish Fisheries. It was noted that before 2002, the catch of white hake was < 300 tons per year, taken as by-catch Greenland halibut, skate and redfish. However, Spanish catches increased substantially in 2002 and 2003. The authours noted that this increase was the result of directed fishing effort.

b) Information on abundance indices and the distribution of the stock in relation to groundfish resources, particularly for the stocks which are under moratorium.

White hake biomass and abundance fluctuates widely (Fig. 2 and Table 3). During the period observed, both abundance and biomass peaked fairly regularly; in the late-1970s, the late-1980s and lastly in the early-2000s. Due to a change in the survey gear in 1996 from Engel to Campelen 1800 trawl, the relative magnitude of the last peak in relation to the earlier peaks cannot be determined. However, the abundance peak in 2000, amounting to 140 000 000 individuals, mostly one year of age was the highest on record. This peak followed a large signal (large estimates of larvae) in the pelagic IGYPT survey conducted in 1999 (Kulka and Simpson, 2002). Very small average sizes were recorded in the recent surveys indicating a large component of juvenile fish.

Figure 3 shows that the distribution of white hake was restricted to the southwest extent of Div. 3NO at depths of about 150-350 m. Kulka and Miri (2002) showed that the distribution of white hake has varied little over time going back to the 1950s. There was also little seasonal variation observed. White hake tended to occur slightly more onto the Bank as the waters warmed in the fall but the vast majority of the biomass remained along the shelf edge (Kulka and Mowbray, 1998).

Figure 4 shows that there was a significant degree of overlap in the distribution of cod and American plaice and much less overlap with yellowtail flounder. By-catch in the Canadian fishery (Table 2) corroborates this observation: in particular cod but also American plaice were taken in the Canadian gillnet and longline fisheries.

González and del Río (2004) mapped the white hake Spanish fishing grounds for 2000-2003. The fishing positions closely match where the Canadian survey data predict where commercially exploitable concentrations would occur. The fishing set locations also match closely with the location the overlap analysis predicts where Atlantic cod and Americans plaice overlap to the highest degree with white hake. Overlap was high over about 40% of the area for cod and over about 60% of that area for American plaice. This suggests that there is potential for significant by-catch of cod and plaice in the area where white hake were most densely concentrated.

c) Information on the distribution of white hake in Div. 3NO, as well as a description of the relative distribution inside and outside the NAFO Regulatory Area.

White hake is a temperate species and juveniles and adults are restricted to a narrow band along the southwest slope of the Grand Bank in Div. 3NO, corresponding with warm bottom waters. Figure 3 shows that white hake straddle the 200 mile limit in Div. 3N and 3O. Spring and fall survey data from 2002 and 2003 show that on average 11% of the abundance of white hake occurs outside of the 200 mile limit (Table 4). The distribution of white hake is such that only a small portion of the Tail of the Grand Bank contains sufficient concentrations for commercial exploitation.

d) Advice on reference points and conservation measures that would allow for exploitation of this resource in a precautionary manner.

Although sufficient information was not available to formulate reference points for white hake in Div. 3NO, initial conservations measures in the form of quota control should be considered. Between the 1970s and the early-1990s, the population of white hake on the Grand Banks (Div. 3LNOPas) underwent steep declines during a time when fishing mortality was low (Fig. 5). At present (the past 3 years), the stock is again declining Thus, it seems unlikely that the current high level of exploitation of white hake is sustainable.

e) Information on annual yield potential for this stock in the context of (d) above;

A surplus production model was attempted for white hake in Div. 3NO. However, the model did not converge. The differences between the Camplelen and the Engels may have contributed to this problem. The uncertainty of the catch data back through time may also contribute to the inability of the model to fit the data. However, main reason is that this highly fecund species undergoes large (natural) fluctuations in abundance independent of the level of exploitation.

f) Identification and delineation of fishery areas and exclusion zones where fishing would not be permitted, with the aim of reducing the impact on the groundfish stocks which are under moratorium, particularly juveniles.

Although adult components of cod and American plaice overlap the distribution of white hake (see Fig. 4), juvenile distributions of those species are mainly associated with the Southeast Shoal, an area that is well to the northwest of the distribution of white hake. An area closed to fishing intended to protect juvenile cod would not significantly overlap with the areas of high density of white hake along the shelf edge (where fishing for that species occurs). If data from fisheries can verify that there is low capture of juveniles, exclusion zone(s) would not necessarily be beneficial.

g) Determination of the appropriate level of research that would be required to monitor the status of this resource on an ongoing basis with the aim of providing catch options that could be used in the context of management by Total Allowable Catch (TAC);

- Recent work on maturity may permit the examination of life stage dis-aggregated trends such as SSB/recruitment relationships. Derivation of exploitation indices series for various life stage components, particularly the SSB, can provide some of the input required to derive reference points and conservation limits.

- Age based analyses of the population would yield more options in terms of providing management advice for the stock. Grand Banks white hake have not previously been aged, but the species has been aged elsewhere.
- Spatial dynamics of various population components should be examined in relation to environmental and fishery related influences to better understand the factors that affect the population status.
- White hake extend continuously over a wide area, well beyond Div. 3NO. Research is required to determine stock structure of the species.
- Fishing mortality and its effects on the population are not well understood. Continued and enhanced collection of information on size, sex and maturity of commercial catches of white hake is required to define the effects of fishing on the population.
- Analysis of detailed, geo-referenced commercial fishery data for NAFO Div. 3NO corresponding to the directed white hake fishery in the NRA is required to quantify by-catch levels and to spatially define species interactions.
- Information on annual yield potential and reproductive potential is required to provide quantitative fisheries management advice.
- The application of assessment models that may allow Scientific Council to provide quantitative fisheries management advice for this stock should be examined.

h) Information on the size composition in the current catches and comment on these sizes in relation to the size at sexual maturity.

Maturity ogives have been estimated for this stock for 1988-93 and 1994-1998 (Kulka and Simpson, 2002) and 1996 to 2003. The estimates of L_{50} for 3O females from 1988 to 1998 ranged from 47 cm to 60 cm. The values of L_{50} range from 50 cm in 1996 to 61 cm in 2000. The exception was 69 cm observed in 1997. Most of the estimates fall between 54 cm and 60 cm. All of these estimates are higher than those estimated for other stocks of white hake (4T-44 cm (Stock Status Report A3-12, 2002), 4VWX-35-45 cm (DFO Stock Status Report A3-10 and 12 2001), NAFO Subarea 5+6 – 35 cm (NEFSC, 1999), which indicates that size of maturity increases with latitude.

Information on length composition in the fishery was available for Spain in 2002 (SCR Doc. 04/22), Russia (SCS Doc. 04/03), Portugal (SCS Doc. 04/05) in 2003 and Canada (1994-2001, Kulka and Miri, 2002) (Fig. 6, Table 5).A line is drawn at 57 cm to represent an average value of L_{50} to delineate the proportion of mature fish in the various fisheries.

Table 5 shows that the majority of the catches of Russia, Spain and Portugal comprise immature fish while Canadian catches largely comprise mature fish.

Conclusion

White hake in 3LNOPs has previously been managed as a stock unit but whether it actually forms a single breeding population or is part of a larger stock is unknown. This paper focused on a portion of that stock, that part that straddles the 200 mile limit. Distribution analyses show that the distribution on the Grand Banks is continuous across the 3O-3Ps border and contiguous with white hake in the Gulf of St. Lawrence (4T). 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.

Little is known about white hake on the Grand Banks 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.

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 1980s 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 by-catch 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.

White hake undergoes large and fairly regular fluctuations in abundance that are at least in part independent of exploitation levels. Based on spring surveys, hake biomass in Div. 3O (and 3Ps) has declined to an all time low by 1994. Concurrent with declining biomass during the late-1980s to early-1990s was a decrease in the mean length and weight of hake although it would appear that the size at maturity has changed little 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 in the 1990s, recruitment, in particular, the large 1999 year-class resulted in a sharp increase in abundance, particularly in NAFO Div. 3NO. However, since 2001, the stock has once again gone into decline. Greatly increased fishing mortality in 2002 and 2003 as a result of a new fishery in the NRA will likely accelerate the decline.

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Table 1. Reported catches of white hake in Div. 3NO, 1985-2003. Blank means no reported catch, zero means <1 ton.

	3N			3O			3NO	
Year	Can	non-Can	All	Can	non-Can	All	STATLANT 21A	STACFIS
1985	101	1,542	1,643	3,301	3,185	6,486	8,129	8,129
1986	297	21	318	1,980	1,252	3,232	3,550	3,550
1987	1,314	4,019	5,333	1,740	990	2,730	8,064	8,064
1988	828	867	1,695	1,115	111	1,226	2,921	2,921
1989	878	5	883	1,169	23	1,192	2,075	2,075
1990	830	228	1,058	1,226	7	1,233	2,291	2,291
1991	19	1,507	1,526	1,087	0	1,087	2,613	2,613
1992	18	0	18	1,640	0	1,640	1,658	1,658
1993	19	0	19	1,035	0	1,035	1,054	1,054
1994	16	20	36	1,977	4	1,981	2,017	2,017
1995	0	5	5	216	1	217	222	222
1996	0	28	28	490	1	491	519	519
1997	0	92	92	489	6	495	587	587
1998	0	81	81	133	8	141	222	222
1999	44	51	95	314	13	327	422	422
2000	21	124	145	404	29	433	578	578
2001	16	52	68	516	49	565	633	633
2002	0	1,220	1,220	1,048	3,133	4,181	5,401	5,401
2003	0	***1,708***	1,708	441	***955***	1,396	3,103	5,083

Table 2. Catch composition the Canadian white hake fishery. Data are derived from the Canadian Fishery Observer Program.

	% of Total Catch	
Species	Gillnet	Longline
WHITE HAKE	85.2%	54.9%
MONKFISH	10.6%	0.0%
HADDOCK	1.1%	3.7%
COD	0.6%	17.7%
POLLOCK	0.5%	0.0%
Lithodes maja	0.4%	8.9%
HALIBUT	0.3%	8.3%
PLAICE	0.2%	0.0%
SPINY DOGFISH	0.2%	0.1%
SNOW CRAB	0.1%	0.0%
SKATES NS	0.1%	3.7%
SWORDFISH	0.1%	0.0%
Thorny SKATE	0.1%	0.1%
Other	0.4%	2.6%

Table 3. Biomass and abundance indices from the spring and fall of 1972-3002. Data are unconverted Engel units prior to 1996 and Campelen units thereafter.

	Biomass (tonnes)				Abundance (thousands)				Mean weight (kg)		
	3N	3O	3NO		3N	3O	3NO		3N	3O	3NO
1971	0	0		1971	0	0		1971			
1972	354	0	354	1972	61	0	61	1972	5.80		5.80
1973	36	1,532	1,568	1973	11	327	338	1973	3.25	4.69	4.64
1974	0	0	0	1974	0	0	0	1974			
1975	0	3,173	3,173	1975	0	1,080	1,080	1975		2.94	2.94
1976	110	5,623	5,733	1976	32	1,413	1,445	1976	3.43	3.98	3.97
1977	50	1,339	1,389	1977	43	466	509	1977	1.17	2.87	2.73
1978	0	6,188	6,188	1978	0	4,362	4,362	1978		1.42	1.42
1979	165	1,978	2,143	1979	34	1,065	1,099	1979	4.85	1.86	1.95
1980	0	1,385	1,385	1980	0	1,015	1,015	1980		1.36	1.36
1981	139	96	234	1981	29	93	122	1981	4.78	1.03	1.92
1982	0	1,058	1,058	1982	0	400	400	1982		2.65	2.65
1983	0	0	0	1983	0	0	0	1983			
1984	258	3,531	3,789	1984	57	1,085	1,142	1984	4.53	3.25	3.32
1985	46	2,878	2,924	1985	9	1,315	1,324	1985	5.16	2.19	2.21
1986	356	2,438	2,794	1986	70	574	644	1986	5.09	4.25	4.34
1987	44	2,752	2,796	1987	95	1,114	1,209	1987	0.46	2.47	2.31
1988	32	5,432	5,464	1988	63	690	753	1988	0.51	7.87	7.26
1989	0	925	925	1989	0	251	251	1989		3.69	3.69
1990	0	754	754	1990	0	236	236	1990		3.19	3.19
1991	0	1,039	1,039	1991	0	1,118	1,118	1991		0.93	0.93
1992	0	606	606	1992	0	574	574	1992		1.06	1.06
1993	0	522	522	1993	0	301	301	1993		1.73	1.73
1994	0	1,079	1,079	1994	0	886	886	1994		1.22	1.22
1995	0	334	334	1995	0	189	189	1995		1.77	1.77
1996	4	2,020	2,024	1996	75	2,982	3,057	1996	0.05	0.68	0.66
1997	4	2,221	2,225	1997	91	2,987	3,078	1997	0.04	0.74	0.72
1998	7	2,205	2,212	1998	79	2,249	2,328	1998	0.09	0.98	0.95
1999	20	12,194	12,214	1999	29	26,010	26,039	1999	0.69	0.47	0.47
2000	30	15,900	15,930	2000	716	104,360	105,076	2000	0.04	0.15	0.15
2001	269	14,908	15,177	2001	517	39,384	39,901	2001	0.52	0.38	0.38
2002	96	10,808	10,904	2002	105	11,334	11,439	2002	0.91	0.95	0.95
2003	234	7,981	8,215	2003	176	7,250	7,426	2003	1.33	1.10	1.11

Table 4. Proportion of white hake in Div. 3NO outside Canada's 200 mile limit, based on Canadian spring and autumn surveys.

Spring

		Abundance			
Year	NAFO	Inside 200	Outside 200	Total	% outside
2002	**3NO**	**10,244,811**	**1,194,274**	**11,439,085**	**10.44%**
2003	**3NO**	**6,607,484**	**818,648**	**7,426,132**	**11.02%**
					10.73%

Autumn

		Abundance			
	NAFO	Inside 200	Outside 200	Total	% outside
2002	**3NO**	**12,576,804**	**2,983,995**	**15,560,799**	**19.18%**
2003	**3NO**	**10,725,945**	**650,069**	**11,376,013**	**5.71%**
					12.45%

Table 5. Size range and size at maturity of white hake in the commercial fishery.

Country	Area	Gear	Year	Size Range (cm)	Percent mature (at 47 cm)	Percent mature (at 57 cm)
Canada	3O	Gillnet	1999	46-106	99	96
			2001	33-106	98	96
	3O	Longline	1995	50-108	99	100
			1996	40-107	98	99
			1998	33-110	99	97
			2001	45-100	99	88
Portuagal	3NO	Otter trawl	2003	16-88	61	5
Spain	3NO	Otter trawl	2002	31-84	46	7
Russia	3NO	Otter trawl	2003	12-99	43	17

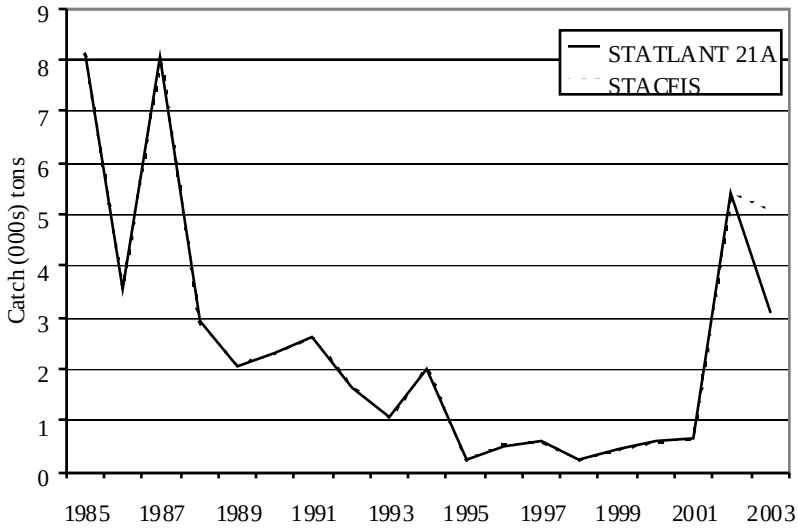


Fig. 1. Catch history for white hake in Div. 3NO, 1985-2003.

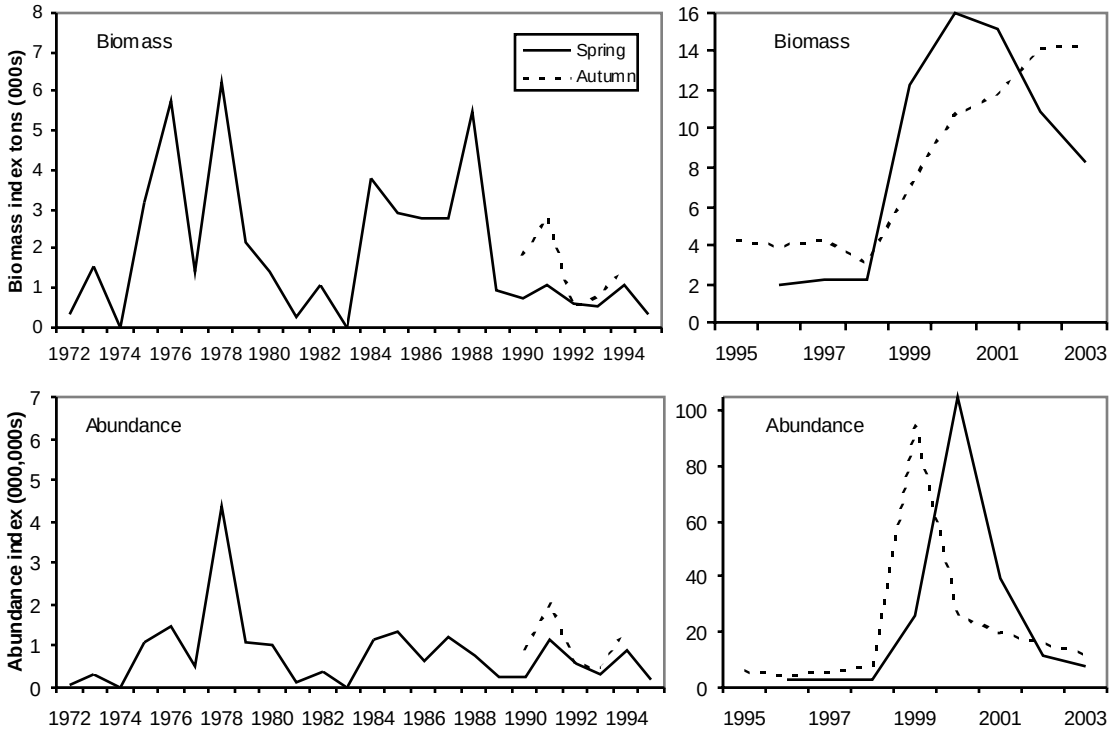


Fig. 2. Biomass and abundance indices for white hake in Div. 3NO. Campelen gear was used from 1996 onward, Engel before that time. The two time periods are not standardized.

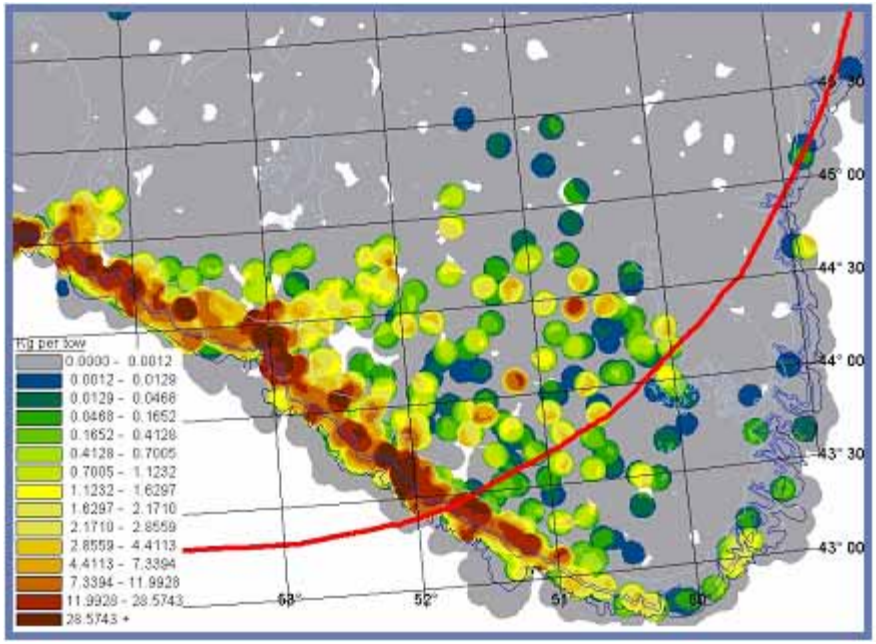


Fig. 3. Distribution of white hake in Div. 3NO based on Canadian spring and autumn surveys, 1996-2003. Red areas denote areas of highest density of white hake. Grey denotes surveyed areas with no catch.

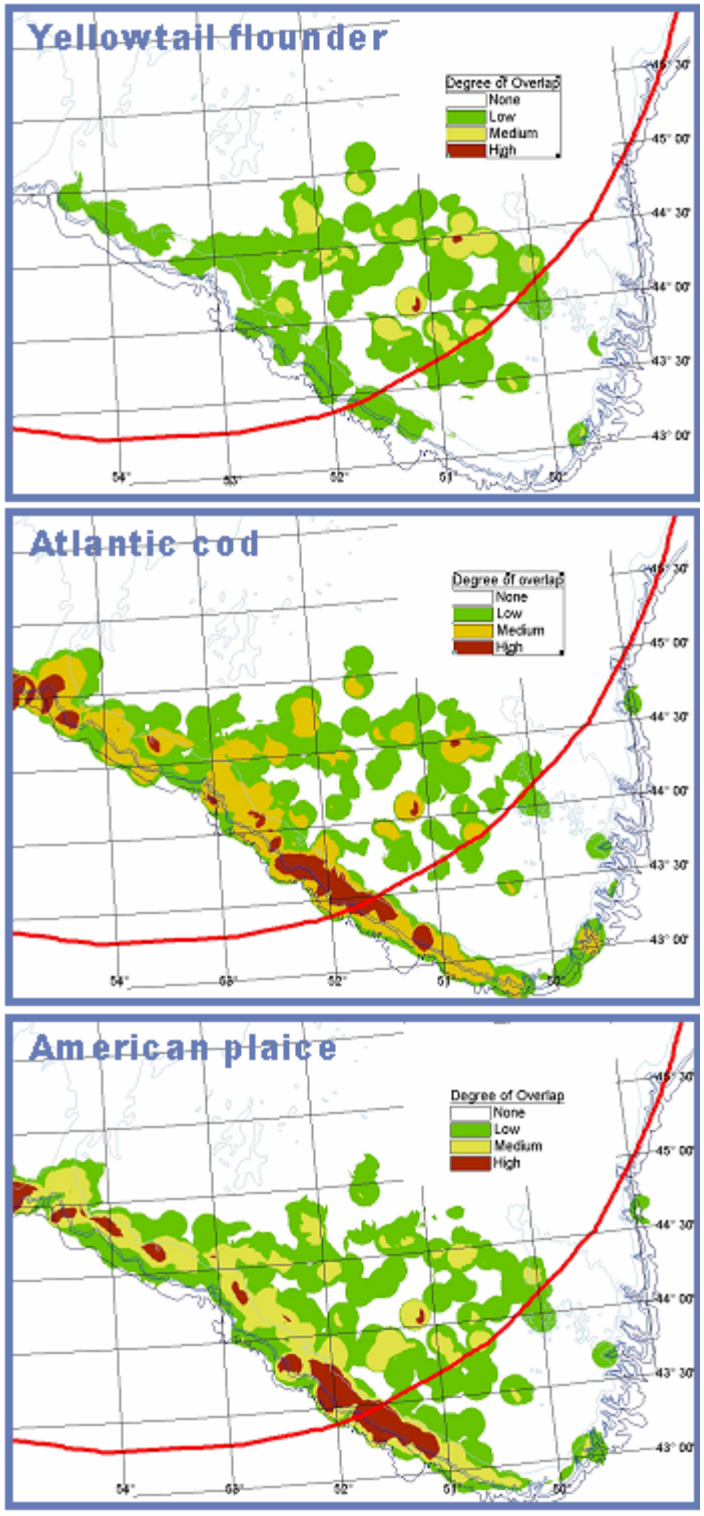


Fig. 4. Degree of overlap of white hake with yellowtail flounder, Atlantic cod and American plaice in Div. 3NO. Data are based on Canadian spring and fall survey data, 1996-2003. High (red area) refers to areas where the top 10% of catch rates of the two species co-occurred.

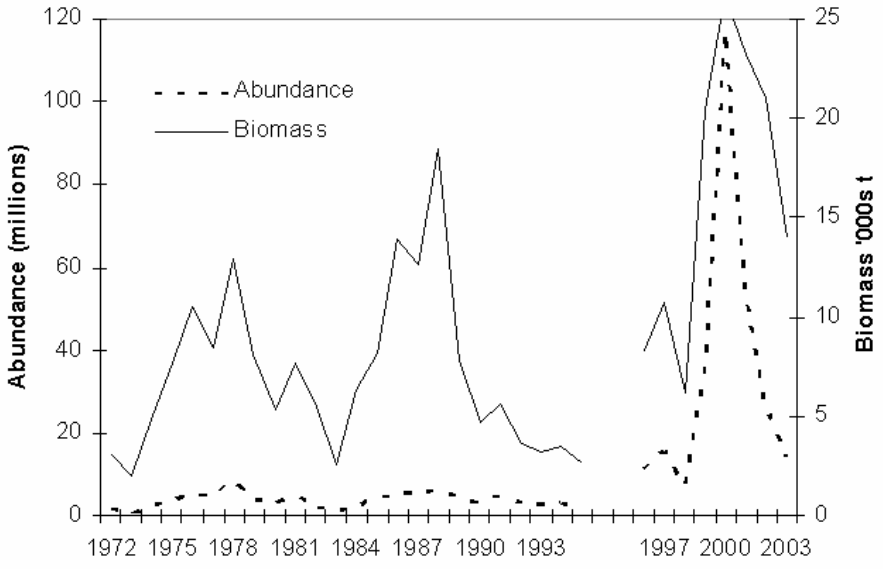
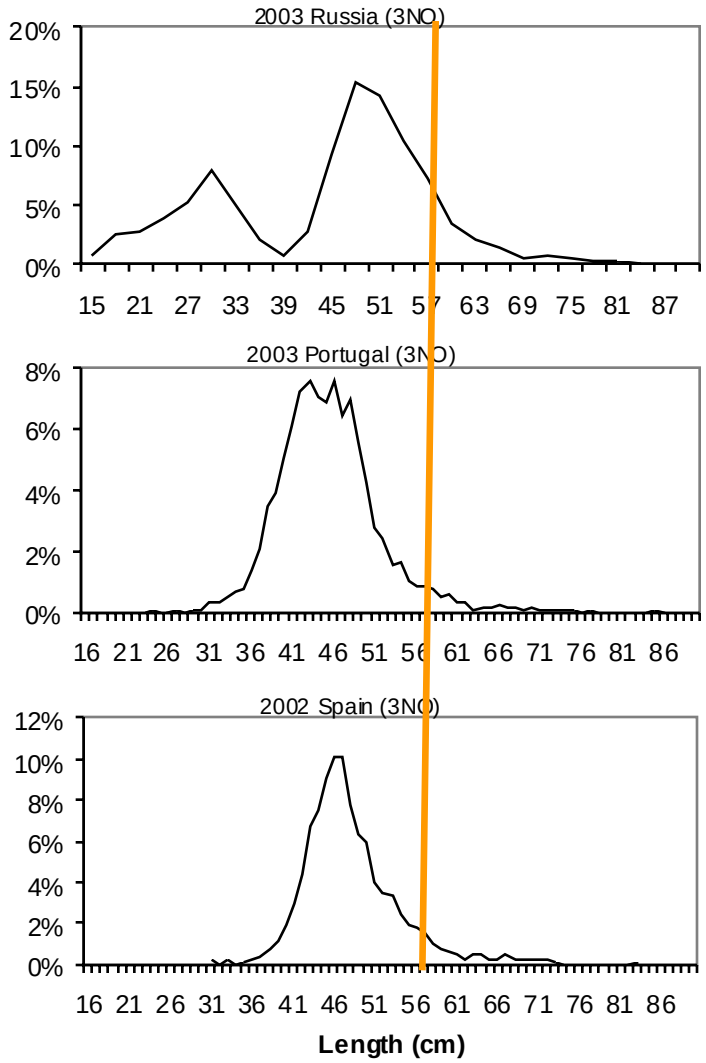


Fig. 5. Minimum trawlable biomass and abundance based on spring surveys in NAFO Div. 3LNOPs.



Fig/ 6a. Size of white hake in the commercial catches of Russia, Portugal and Spain in Div. 3NO in relation to the size at maturity.

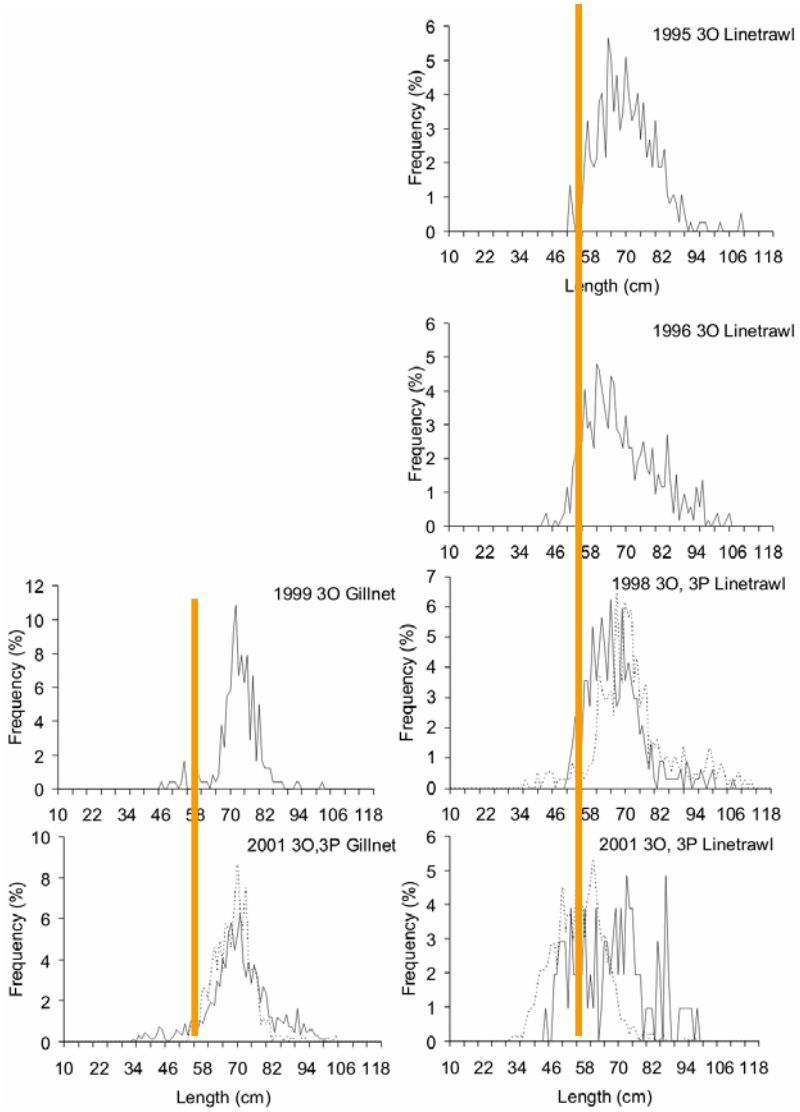


Fig. 6b. Size of white hake in the commercial catches of Canada in Div. 3NO in relation to the size at maturity.