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Assessment of the status of 4VWX/5 White Hake, 2001

Évaluation de l'état du stock de merluche blanche dans 4VWX/5 en 2001

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Abstract

White hake on the Scotian Shelf are managed as single unit 4VWX/5Zc, but may consist of sub-components. The assessment undertaken here considers this potential stock sub-structure as far as possible. The fishery has been under restricted management since 1996, and since 1999 has been a by-catch fishery only, with a quota cap placed on the fixed gear fishery < 45 ft. Catches have remained within quota limits. However, an analysis of the species composition of the catch indicates that in 4VW, most white hake is still landed as the main species. The status of white hake was analysed using data from DFO Research Surveys, Industry Sentinel Surveys and a Commercial Index for 4VsW. There are signs of recovery of white hake in the western stock area (4X/5), but there are no signs of recruitment of white hake in 2000 or 2001. The abundance of white hake in the eastern area (4Vn and 4VsW) continues to be very low, despite reduced catches. Here, it would appear that small fish are not surviving to grow into large fish, in contrast to the situation in the western stock area. An analysis of total mortality indicates that mortality on the eastern shelf has steadily increased since the late 1970s. In all areas, the mean length of fish has decreased over time, with a loss of larger fish in the populations, particularly in 4VW. A Traffic Light analysis summarises the status of white hake in 4VsW and in 4X/5.

Résumé

La merluche blanche de la plate-forme Scotian est gérée comme une seule unité (4VWX/5Zc), mais le stock pourrait être constitué de plusieurs composantes. La présente évaluation tient compte, dans la mesure du possible, de cette éventuelle sous-structure du stock. La pêche de cette espèce est restreinte depuis 1996; depuis 1999, il ne s'agit que d'une pêche accessoire, avec un plafond de prises imposé aux bateaux à engins fixes de taille inférieure à 45 pieds. Les prises n'ont pas dépassé les quotas. Mais une analyse de la composition spécifique des prises montre que dans 4VW, la plupart des captures de merluche blanche sont débarquées comme espèce principale. Nous avons analysé l'état du stock de merluche blanche à l'aide de données recueillies lors de relevés de recherche du MPO et de relevés de pêche sentinelle effectués par l'industrie et d'un indice de pêche commerciale pour 4VsW. La merluche blanche montre des signes de rétablissement dans la zone de stock occidentale (4X/5), mais elle n'a présenté aucun signe de recrutement en 2000 ou en 2001. Dans le secteur oriental (4Vn et 4VsW), l'abondance de la merluche blanche reste très faible malgré la réduction des prises. Il semblerait que dans cette région les petits poissons ne survivent pas pour atteindre une grande taille, comme c'est le cas dans la zone de stock occidentale. L'analyse de la mortalité totale indique que celle-ci a augmenté constamment depuis la fin des années 1970 sur la partie orientale de la plate-forme. Dans toutes les régions, la longueur moyenne du poisson a diminué avec le temps, les populations perdant leurs plus gros poissons, particulièrement dans 4VW. L'état du stock de merluche blanche dans 4VsW et 4X/5 est résumé au moyen d'une analyse des « feux de circulation ».

Introduction

White hake (*Urophycis tenuis,* Mitchell) on the Scotian Shelf and in the Bay of Fundy was added to the stock assessment agenda of the Department of Fisheries and Oceans (DFO) in 1995, and first assessed in 1996 (Fowler et al., 1996). Previously this species was managed only in the Gulf of St. Lawrence, the fishery for which was closed in 1995. Quota reductions for Scotian Shelf fisheries on more traditionally sought species (e.g. cod, haddock, pollock) have resulted in the re-direction of fishing effort on species such as white hake that were historically of insufficient commercial value to deliberately target.

Stock Structure and Management Units

The stock structure of white hake is not well understood, but does not appear to coincide with the boundaries of the current management regions. Based on a review of existing information pertaining to white hake stock distributions and spawning activity which demonstrated consistent discontinuities in distribution over time and differences in patterns of abundance over time evidenced (Fowler et al., 1996), we now assess North Atlantic Fisheries Organization (NAFO) Divisions 4Vn, 4VsW and 4X/5 as separate components of a stock complex. The present management units for white hake (*Urophycis tenuis*) are 4T, 4VWX+5Zc (Figure 1), and the United States part of 5Z plus 5Y and 6. It is likely that there are exchanges between white hake in 4X/5 and those in the US Gulf of Maine - Georges Bank stock unit, and between the 4V fish and the 4T Gulf of St. Lawrence stock unit.

Fisheries Management Activities

Before 1996 there were no restrictions on fishing effort for white hake in 4VWX and 5Zc. A Total Allowable Catch (TAC) was implemented for the first time in 1996 (see text Table), based on the 1995 Stock Status Report for white hake, which stated that catches should be restricted to the average landings of 2,500t observed during the 1970s. The fixed gear under 65' fleet sector was allocated 3420t. Other fleet sectors have been restricted with by-catch regulations: 20 % limit for the ITQ fleet under 65', 10 % limit for trawlers over 65'.

Table showing changes in management measures for 4VWX/5 White Hake since 1996.

Sector	Area	Measure	1996	1997	1998	1999	2000	2001
FG<65	4VW	TAC	500	700				
	4X	TAC	2000	2400	3500			
	5Zc	TAC	920					
FG<45	All	CAP				1750	1429	2224
MG<65	All	% by-catch	20	20	20	20	20	20
MG>65	All	% by-catch	10	10	10	10	10	10
MG<65	All	and CAP						
MG>65	All	and CAP						637
FG>45	All	CAP						

In 1997 the fixed gear less than 65’ TAC was reduced to 3100t. The TAC was restrictive to fishing until 1998, when the TAC was not reached. In 1999, the FRCC recommended that white hake be caught as by-catch only, and a quota cap was placed on the catch of the fixed gear fleet < 45 ft. In 1999, the quota cap was half of the 1998 TAC, and transfers between Community Management Boards were not permitted. The quota cap was reduced again in 2000 to 1429 t, while in 2001, it was increased to 2224 t, of which 1374 t had been caught, as of October 24, 2001. In addition, the mobile fleet and fixed gear > 45 ft was also managed on a quota cap basis in 2001. This quota cap in 2001 was 637 t, and as of October 24, 2001, 510 t had been caught. In 2000, the fixed gear industry reported difficulties staying within white hake catch restrictions while fishing for other species.

The Fishery

The fishery for white hake is essentially a Canadian fishery, with minimal foreign fishing activity (Table 1). The main foreign fishing has been by the USA. These landings came from 4X/5 and have been minimal since the revision of the Maritime Boundary between Canada and the USA in NAFO divisions 4X, 5Y and 5Z (Table 2).

Total landings peaked in 4VWX in 1987 and have since declined (Table 3, Figure 2). Landings from 4X/5 account for an increasing amount of the total catch, increasing from 67 % in 1987 to 85 % in 2000. Within 4X/5, 82 % of the catch has come from 4X since 1990. Within 4VW during the 1990s, around 60 % of the landings came from 4W and 20 % each from 4Vn and 4Vs (Figure 2b). The largest catches are taken from the Bay of Fundy and the Fundian Channel, while good catches are taken from Emerald Basin and the area around the 4WX line (Figure 2). Catches are also concentrated around the shelf edge and the Laurentian Channel.

Longline, gillnet and otter trawl < 65 ft catch almost all the white hake from 4VWX/5 (Table 4). Within 4VW, landings are dominated by longline gear, accounting for 82 % of landings since 1986 (Figure 3a). Until 1997, ‘other gears’ took a greater share of the catch than gillnet or otter trawl < 65 ft. In the early 1990s, this was largely due to Danish seiners in 4Vn catching groundfish. The peak in catch in 1994 was due to a by-catch of white hake by vessels targetting redfish, and the peak in 1996 was due to by-catch of white hake by large trawlers directing for silver hake. In 4X/5, longliners landed the larger part of the catch until 1996. Since 1998, the total catch by longline, gillnet and otter trawl < 65 ft has been very similar. There is little catch by other gears in 4X/5.

It is likely that white hake landings data prior to 1989 for mobile gear and 1993 for fixed gear are unreliable, particularly in 4X/5. Landings may be inflated due to cod being misreported as white hake, in order to circumvent catch restrictions on cod.

In addition landings data may be inaccurate since cusk, pollock and white hake were reported as an amorphous group called “shack”. Since 1989 there has been dockside monitoring of mobile gear catches and since 1993 it has been required that most fish in the catch be identified to the species level. Thus it is only in relatively recent years that any real confidence can be placed in the landings data.

In general, the fishery for white hake is a summer fishery in all areas, but there is some annual and spatial variation in this pattern (Table 5, Figure 4). In 4Vn, the fishery usually occurs from late spring to summer, with some activity in autumn in a few years, eg., 1997 (in 1995, the directed white hake fishery in 4Vn was closed from January to April in order to protect 4T white hake). In 4Vs, there is some level of fishing all year, with peaks during the summer months. Since 1999, the peaks have occurred in winter, from November to January. These fish are caught in 4Vc in the Laurentian Channel and could be due to white hake from 4T that migrate into the Laurentian Channel during the winter months. The fishery in 4W is predominately a summer fishery, with some activity in the first 6 months of the year. There have also been increased catches, relative to the summer catches, during January to March since 1998. White hake is caught in 4X year round, but there is a pronounced peak during the late spring to early autumn months. In 5Zc, there is no white hake landed until June, although the fishery then continues until December.

Analysis of Species Composition of the Catch

Since 1999, the FRCC has recommended that white hake should be a by-catch fishery only, with an overall CAP. Landing statistics from 4VWX/5Z were analysed to examine the catch patterns of white hake and to determine which gears and fisheries were most important in taking white hake as a by-catch species. All landings data for white hake with associated main species and gear were extracted from the ZIF database from 1986 to 2001, for NAFO areas 4Vn, 4Vs, 4W and 4X/5. Only the results since 1993 are shown (Table 6, Figure 5), due to the inaccuracies in reporting noted above.

4Vn

In 4Vn, most white hake was landed as by-catch until 1996 when the proportion of white hake taken as the main species increased to over 70 % (Figure 5). This proportion has remained high due to fishing by longline gear. Since 1993, 71 % of white hake landings in 4Vn were landed by longline gear, and since 1996, this increased to 93 %. Some of this white hake was caught as by-catch in cod and halibut directed fisheries, but most was caught as the main species in the catch (Figure 6a).

4Vs

In 4Vs, the proportion of landings with white hake as main species declined from 65 % in the mid-1990s to 44 % in 2000 (Figure 5). Longline gear accounts for most of the catch of white hake in 4Vs (90 %). During most of the 1990s, white hake was the main species in 65 – 80 % of longline landings (Figure 6b). In the last few years however this total has decreased, to 57 % of landings in 2000. The rest of the white hake is caught mostly as by-catch in halibut and cod fisheries, but is also caught alongside cusk.

4W

In 4W the proportion of white hake landed as main species declined from 85 % in 1995 to 64 % in 2000 (Figure 5). Longliners and gillnets land most of the white hake catch in 4W. Longline gear (Figure 6c) landed 83 % of white hake in 4W from 1993 to 2001. Most of this total was landed as main species and over 80 % was landed as main species in 1995 and 1996. This dropped to 68 % by 2000. Halibut is the main longline fishery that catches white hake as by-catch, although white hake are also caught along with cusk.

Gillnet gear lands around 12 % of the white hake in 4W. The proportion of white hake caught as main species and as a by-catch has varied since the early 1990s (Figure 6d) in the gillnet pollock fishery, peaking at almost 90 % of white hake as main species in 1994, and around 65 % of pollock as main species in 1999. It is likely that these data were mis-reported with pollock being reported as white hake from 1993 to 1996, and possibly later. Thus more white hake may have been landed as by-catch in the gillnet pollock fishery than is reported here. The peak in “others” in 2001, is due to fishing for dogfish, which landed 46 % of the by-catch of white hake.

4X/5

The proportion of white hake landed as main species in 4X/5 dropped from 73 % in 1993 to 28 % in 2001. In 4X, most of the catch of white hake is distributed between longline, gillnet and otter trawl < 65 ft. The longline gear (Figure 6e) accounts for 44 % of white hake landings in 4X from 1993 to 2001. The amount of white hake landed as main species decreased from 87 % in 1995 to 50 % since 1999. White hake is caught as a by-catch in the haddock and cod fisheries and together with cusk.

White hake landings in the 4X/5 gillnet fishery (Figure 6f) are usually taken as either main species or as by-catch in the pollock fishery. Even when landed as main species, most of the gillnetted white hake may be associated with the pollock fishery (directed white hake sets within pollock subtrips). The correspondence in patterns of white hake landings, as directed or by-catch, with pollock landings reinforces this impression: since 1991, the proportion of white hake and pollock landed by gillnets have been mirror images of one another.

Otter trawlers < 65 ft landed 21 % of the white hake in 4X from 1993 to 2001, with most of it taken as by-catch in other fisheries (Figure 6g). Fisheries for haddock and redfish currently represent the largest sources of white hake by-catch, while fisheries for pollock and cod are still important (they were much larger sources of by-catch in the recent past). Trawling for monkfish can also result in appreciable by-catches of white hake. Only 6 % of white hake caught by otter trawl has been the main species caught since 1996.

Longline gear in 5Zc accounted for 89 % of white hake landings from 1993 to 2001. The proportion of 5Zc white hake landed as main species caught by longline gear (Figure 6h) has declined from 81 % in 1993 to 25 % in 2000, most of the white hake in recent years being taken as by-catch in the haddock/cod fishery.

This analysis was intended to identify which fisheries were important as sources of white hake by-catch, with the implicit assumption that any white hake being landed since 1999 was as by-catch in another fishery. Although the overall proportion of white hake landed as the main species caught has declined since 1993, much of this decline is associated with the 1995-1998 period. Since 1999 and the apparent management of white hake as a by-catch fishery, the proportion of white hake taken as main species caught fell from 45 % to 39 %, a decline of only 6 %. In all NAFO areas within the management unit, much of the white hake catch continues to be taken as the main species caught. In some cases, such as longline fisheries in 4Vn, 4W and 4X, the predominance of white hake landings as main species caught is indicative of directed fisheries. White hake landings can be discerned as truly by-catch in 4X otter trawl fisheries on pollock, haddock and cod, as well as the 4X gillnet fishery for pollock. The average annual white hake by-catch for 1999-2000 in 4X was 1046 t, 66 % of long term average annual white hake landings in 4X.

Length Composition of Landings

Sampling of Canadian commercial catches for white hake length composition was rarely conducted until the mid 1990s (Table 7). A comparison of mean length in the catch in 4VW and 4X/5 indicates that the mean length of white hake caught by longline since 1993 is about 10 cm less in 4VW than it is in 4X/5 (Figure 7). In 4X/5, since 1995, gillnets catch the largest white hake, while longline and otter trawl catch a similar mean size.

There is a decline in mean size of fish caught by longline in 4VW from 1994 to 2000. In 4X/5, we do not see any trends per se, but rather sudden shifts in mean length between blocks of years for longline and otter trawl <65ft fisheries.

The size composition of the catch in 2000 and 2001 is compared in Figure 8. In both 4X/5 and 4VW fixed gear fisheries, there are less smaller fish and more larger fish in the 2001 catch relative to 2000. In 4X/5, otter trawl < 65ft catches cover the same size range and have a similar mode to longline catches, yet the size distribution shifted to smaller fish between 2000 and 2001. Thus mobile gear caught smaller fish in 2001 than in 2000 while fixed gear caught larger fish in 2001 than 2000.

Age Composition of Landings

There are three years of aging data available for commercial white hake in 4VWX/5 with which to estimate catch-at-age in the fishery. The white hake management unit covers a large area and differences in growth rates occur within this area for other gadid species, such as cod and haddock. The length composition analysis above showed that the mean length of white hake in 4VW longline catch is up to 10 cm less than in 4X/5 so differences in growth rate may also occur for white hake. Thus the age-length data were examined with the aim of dividing them between eastern and western Scotian shelf. There may also be differences in catch-at-age with gear and thus the data were also examined with the aim of dividing them into gear types.

Age-Length Keys

The age-length sampling is unevenly distributed through time, and among areas and gears. In 1998, 437 age-length readings were available, 678 in 1999 and 1119 in 2000. Comparisons of age-length keys between areas were conducted using only the year 2000 data, which provided the largest number of aged fish, while negating any potential for a year effect on results. However, there was no sampling of 4W in the year 2000 (or in 1998 or 1999), practically no sampling of 4Vs (25 fish), and only 302 fish were available from 4Vn (see Table 1 of Appendix 1). Most of the sampling (792 fish) derives from 4X/5. Comparison of age-length keys between gears was only possible for the western Scotian Shelf (4X/5). The 4Vs sampling was insufficient to compare the age-length keys with other areas, and was combined, on the basis of apparent similarities, with 4Vn, creating one 4V age-length key, until enough data become available to address the issue. There do appear to be differences in growth between 4V and 4X/5 (see Figure 9n and Table A2 (Appendix)). Fish in the western portion of the Scotian Shelf (4X/5) tend to be larger than fish to the east (4V) at the same age. This difference is most easily discerned among the more abundant ages sampled (4-6). There is also some suggestion of bimodality in the 4X/5 age-length key, which might be related to either different growth rates for males and females, or a mixture of stock components within the data. More data is needed to investigate these possibilities. The data in 4X/5 was split in various ways to try to reduce this scatter, but it remained and this may be due to differences in growth between males and females. In the end, the 4X/5 data was split into NAFO subdivisions 4Xopqrs5Ze and 4Xmn since fish in 4Xopqrs5Ze are longer at age than in 4Xmn, based on the available data. The age-length data in 4Xmn were insufficient to form an age-length key alone, so they were pooled with the 4V data on the basis that there are similarities between them. Thus, the age-length data were pooled into two areas, 4VWXmn, eastern Scotian Shelf and 4Xopqrs5Ze, western Scotian Shelf (Appendix, Table A3). The age-length data for 1998 and 1999 were also split in to these two areas to provide age-length keys for the eastern and western Scotian Shelf in 1998 and 1999.

There is a clear difference in the annual mean length at age curves for the eastern and western Scotian Shelf (Figure 9) for ages 5 and 6. At younger and older ages however, the curves are similar. This lack of differentiation of growth in the two areas may be due to insufficient sample sizes. It may also be due to similarity in growth.

Catch-at-age

The age-length keys for 1998, 1999 and 2000 were applied to the commercial catch-at-length data to estimate catch-at-age in the commercial fishery for these years on the eastern and western Scotian Shelf. The modal age in the fishery in all years and areas is 5, with the single exception of the eastern Scotian Shelf in 1999 where it is 4 (Figure 10). However, the fishery for white hake on the western Scotian Shelf catches older fish than the fishery on the eastern Scotian Shelf.

There was enough data from the western Scotian Shelf in 2000 to produce separate age-length keys for fixed and mobile gears, for which we derived separate catch-at-age estimates (Figure 11). The two gears have similar catch-at-age distributions, with only a slight difference in modal age between them.

In the length composition analysis discussed in the previous section it was shown that white hake caught by longline gear in 4VW is up to 10 cm less than in 4X/5, while the catch-at-age analysis shows the modal age in the catch to be the same in both areas in 2 out of 3 years. The age data compares longline in the eastern Scotian Shelf to all gears in the western Scotian Shelf. In 2000 the catch-at-age for longline gear can be compared to the fixed gear in the west. Here the modal age in the east is 5, and in the west is 6. It is unclear at present whether this represents a true age difference in catch by longline in east and west or a difference growth rates in the east and west, or both.

The effect of splitting the age-length keys into areas and gear are shown in Figure 12 where (a) plots catch-at-age when aggregate age-length keys are used, and (b) plots the data where separate age-length keys are used for area and gear in 2000 for the western Scotian Shelf. There are small differences between the two figures, but the overall pattern is the same. Since most of the catch comes from 4X/5, this result is not surprising.

Analysis of Catch Rates

In the 1998 assessment of white hake (Fowler 1998) a catch rate analysis was conducted on white hake using commercial catch per set data derived from logbook information. The analysis only used data from white hake-dominant sets by historically consistent white hake fishers (five consecutive years of white hake-dominant sets). Strong agreement between these commercial catch rates and those of the summer Research Vessel survey suggested this approach had generated a meaningful index of abundance. Unfortunately this analysis relies on data not available to assessors on a regular basis (raw logbook data), so does not allow for continuing application to future assessments.

For the 2001 assessment, a way was sought to replicate the type of analysis conducted in 1998 using data conventionally found in assessment databases. It was found that a conventional ZIF subset of the original 1998 catch per set data, organized as catch per subtrip and standardized to catch per fishing day, gave similar results as the original analysis in those cases where sufficient data was available to compare methods. This method was therefore applied to preliminary analyses of white hake catch rates for the 2001 assessment. Conventional ZIF data is used to represent catch rates for 1998 onwards. The 1990-1997 portion of the original 1998 catch per set data that could be standardized to catch per fishing day has been retained. As well, data for new index fishers added since 1998 has been updated from ZIF databases for the 1991-1997 period. This method gives more data for most years, 1990 and 1994 being notable exceptions for which much data was lost due to inability to standardize to days fished. However, these two years were poorly represented even in the 1998 catch per set data.

During review of assessment data by Fishing Industry representatives, concern was expressed that declining trends in the amount of effort represented by sets or subtrips might confound catch rates. As a result a representative analysis using gear-specific effort units (thousands of hooks for longliners, number of fleets for gillnets, and number of hours fished for otter trawlers) was performed in order to test this. Results were similar for otter trawl and gillnet datasets, but a decrease in the number of hooks deployed by longliners was evident post-1995, indicating that gear-specific effort measures were more appropriate for longline fisheries. As loss of data between the fishing day and gear-specific units of effort was minor, it was decided to replace all the fishing day models (including gillnet and otter trawl) with gear-specific catch per unit effort models.

An analysis of deviance using a generalised linear modelling approach with S-Plus 6.0 was conducted to determine the magnitude of influence of year, month and area on catch rate, and to compute predicted catch rates on an annual basis. An additional feature of the 2001 analysis relative to the 1998 analysis is the inclusion of the index fishers themselves as factors in the base model. This explicitly quantifies the intrinsic differences in catch rates between individual boats, this component of the variance being accounted for before attributing variance to other factors such as year, month, area. Variable sequencing among year, month and area in models was determined by comparing Akaike Information Criteria (AIC) for different models, which uses $\chi 2$ tests to determine the best fit from a set of possible models. The relative ranking of a given factor, in terms of explanatory power, is estimated by inclusion in and exclusion from iterative series of possible models, with calculation of AIC statistics, to achieve the most likely hierarchy of main effects for the model. Two-way interactions are then sequenced according to the main effects (i.e. if the main effects were ordered year, month, area then the interaction terms would be year:month, year:area, month:area). Note that constraining the index fishers to be accounted for first during modelling has no effect on predictions, and was only required for the 4Vn and 4Vs longline models. In all other cases the boat factor was sequenced first by the AIC.

Seven models were used to represent the major discernible fisheries for white hake:

Otter Trawl, 4Xpqr & 5Yb
Gillnet, 4Xmnopqr, 4Wk & 5Yb

Longline, 4Vn
Longline, 4Vc
Longline, 4Wgjkl
Longline, Inshore 4X/5 (4Xmoqr)
Longline, Offshore 4X/5 (4Xnp & 5Zjm)

The results from generalised linear modelling of these datasets are summarised in Table 9, and the predicted catch rates are plotted in Figure 13. Predicted values generated for the partial year 2001 are not plotted. Realize that since each model includes a particular boat as a base term for prediction, relative scaling between models should be disregarded (interpret and compare trends, not differences in magnitudes of catch rates between models). Figure 14 provides a comparison between predicted and observed catch rates for (a) 4VW and (b) 4X/5. Observed catch rates are depicted for entire datasets as well as subsets representing the prediction base values for months or unit areas where applicable. Predictions can diverge notably from observed data where interactions are a serious concern, but should reasonably reflect the observations for the prediction base if the model has merit.

In 4X/5, catch rates across all fleets have risen since 1998. This is compatible with observations by Industry of recent increases in white hake catchability in 4X/5. Prior to 1998, there is less consistency between catch rates of different gears in 4X/5. In 4VsW we see a decline in longline catch rates since the early 1990's, with the most recent years near record lows. The available 4Vn longline data series indicates a sharp increase in catch rates between 1996 and 1998, since which time they have only declined slightly.

During technical review of the catch rate series it was decided to combine the 4Vs and 4W longline models (Table 9 and Figure 14a) to provide an index of abundance of 4VsW white hake. This was considered appropriate due to the predominantly directed nature of this fishery. The combined model reinforces the declining trends in the two areas. The 4X/5 catch rates were not used as indices of abundance as only 33 % of white hake is landed as main species in 4X/5, catch rates are likely to be affected by varying management conditions, predicted catch rates were inconsistent between gears prior to 1998, and were incomplete, over the time period. The 4Vn catch rates were not used as an index of abundance because there is a likelihood that some of their catch is 4T white hake.

Resource Status

There are several sampling platforms from which data are available to assess the status of white hake. Traditionally, DFO research vessel (RV) otter trawl surveys have been used exclusively for this purpose. All the DFO surveys are stratified random surveys with standardised sampling protocols. The Summer (July) RV survey has the longest time series (1970 to present) and encompasses Scotian Shelf waters in 4VWX. The Spring (March) RV survey began in 1979 and ran until 1984. Originally it covered the Scotian Shelf, but when it was re-instituted in 1986 as the 4VsW cod survey, it only covered 4VsW. The Fall Survey, which again covered 4VWX shelf waters, was only conducted from 1978-1985.

In addition to the DFO research vessel surveys, there are a number of industry surveys that also provide data on white hake. The 4Vn Sentinel and 4VsW Sentinel Surveys each include stratified random sets with standardised sampling protocols which include detail sampling of white hake since 1995. These two surveys are similar in design to the DFO summer RV survey although they use longline rather than trawl gear, and the 4VsW Sentinel includes additional strata inshore of the standard DFO survey area. The Halibut Survey has been running since 1998 and uses halibut longline gear. The survey was initially stratified based on commercial catches of halibut and stations were selected in the first year by the skippers and have been fixed since then. The Halibut Survey samples deeper areas than any of the other surveys. The 4X Mobile (ITQ) Survey has operated since 1996 using <65' otter trawlers. The design is fixed stations, selected by the skippers in the first year but fixed since then. The ITQ Survey includes considerable inshore area, not sampled by the RV surveys, but this seems to be of little significance for white hake.

Abundance Trends

Summer research vessel trends in abundance and weight are shown in Figure 15 and Table 10 for 4Vs, 4Vn, 4W and 4X. In 4Vn, mean numbers and weight per tow were low in the 1970s, then increased to a peak in 1986. They then declined until 1992 and remained low until 2001 when both indices increased, in the case of numbers, to near record levels. This high abundance is due to several large catches of fish between 30 and 45 cm in length (Figure 16) which may be due to white hake from 4T. In 2000, four very large sets of small white hake (30-45 cm) were made in the Cape Breton Trough in 4T (Hurlbut and Poirier2001). In 2001, these fish were not observed in the 4T survey and may be the fish observed in 4Vn in 2001.

Abundance in 4Vs was low in the 1970s, peaked in the mid-1980s and has been low since 1987. The mean number per tow in 2001 is the lowest since 1978, and the mean weight per tow is the lowest since 1972. Similarly in 4W, abundance was low in the 1970s, peaked throughout the 1980s, and has been low since 1992. The mean weight per tow in the 1990s is the lowest in the data series and mean numbers per tow is low, as in the 1970s. Abundance in 4X in terms of both mean number and weight per tow was lower in the 1970s and 1990s than in the 1980s. There has been a declining trend since the early 1980s. Abundance has increased in 4X since 1997. However this increase, due to fish greater than 45 cm (Figure 18), may be due to annual variation within an overall declining trend. It is useful to consider the abundance of white hake in the Gulf of Maine and George's Bank, since 4X white hake might be contiguous with this stock. The Northeast Fisheries Science Centre spring and fall surveys (Northeast Fisheries Science Center 2001) mean numbers per tow were variable with no overall trend until around 1990, since when it has decreased. As in 4X, there has been an increase in abundance since 1997.

In general, all RV series show low abundance during the 1970s, increased abundance during the 1980s, and low abundance in the 1990s. This pattern is especially pronounced in 4VW and is seen in other gadid species such as 4Vn cod (Mohn et al 2001), 4VsW cod (Mohn et al 1998) and 4TVW haddock (Frank et al 2001).

The abundance trends (numbers per set) in the Industry surveys are difficult to interpret as the time series are still quite short, about 5 years in most cases. To provide some perspective on the trends they are compared with corresponding DFO RV indices (Figure 17). Also shown in Figure 17 for 4Vs and 4W is the commercial longline index described in the fishery section above.

In four of the five areas (4Vn, 4Vs, 4X and 5Z) there is general agreement on the trends in recent years amongst the various surveys. The one exception is 4W where catch rates by the Halibut and 4VsW Sentinel Surveys both increased rapidly over the last 3 and 4 years respectively. The DFO Summer RV survey and the commercial index remained stable over the same period and the DFO Spring RV survey declined.

Abundance of Large and Small Fish

An analysis of mean numbers of large fish (greater or equal to 45 cm) and small fish (less than 45 cm) in the Summer RV survey shows that the relative numbers of large and small fish in 4VW has changed since the late 1980s (Figure 18). Both large and small fish peaked during the 1980s: however, the average abundance of small fish is greater during 1990-2001 than it was in the 1970s, whereas the abundance of large fish is less. In the 4VsW Spring RV survey, the number of large fish represented in the survey area has been extremely low since 1987 (Figure 19). Thus in the 1990s and 2000s, small fish have greatly outnumbered large fish and the number of large fish has been low. This pattern is particularly noticeable in 4Vs and 4W. There are several reasons why this may be occurring:

(a) small fish are not surviving,
(b) the distribution of large fish has changed,
(c) growth rate has decreased and thus fish are smaller at age (this has been seen in 4TVW Haddock (Frank et al 2001), 4Vn cod (Mohn et al 2001), 4VsW cod Mohn et al 1998).

In 4X, the small and large fish track each other well, and on average, there are 33 % more large fish than small fish. The abundance of both large and small fish was greater during 1990-2001 than it was in the 1970s. Data from Georges Bank and the Gulf of Maine indicates that there has been an increase in small fish since the 1980s (Northeast Fisheries Science Center 2001).

Condition Factor

Condition is measured as the predicted weight of a fish at a given length and time. Here, condition was predicted for 45 cm (mature) white hake in 4Vn, 4Vs, 4W and 4X (Figure 20). There are no length weight data for 1986 to 1994, and thus there is a gap in the data series. There is no trend in any area. The mean condition factor is highest in 4Vs, and then 4Vn, and is lower in 4W and 4X. These differences may be related to differences in growth rate.

Mean Weight and Mean Length

Mean length and weight of white hake greater than 45 cm from the Summer RV survey was calculated to explore whether there has been any change in population structure. Fish 45 cm and larger were used to minimise the impact of variation in the abundance of incoming recruits to the population. The greatest changes in mean weights and lengths were in 4Vs and 4W (Figures 21 and 22). Both have declined throughout the time series. In 4W, the average weight of a 45+ cm white hake in the 1970s was 2.4 kg whereas in 1990 to 2001 it had declined to 1.4 kg. Length has similarly decreased from an average of 62.8 cm in the 1970s to 54.7 cm in 1990 to 2001. In 4Vn and 4X there is less sign of a decrease in either mean weight or length, but most values have been below their long term means during the 1990s, indicating some loss of large fish. Decreases in mean lengths and weights across all areas of the Scotian Shelf surveyed indicates loss of larger fish. Such a pervasive observation suggests that either they have been removed by mortality, or no longer grow to the larger sizes. An alternative explanation would require general redistribution of larger fish out of the entire area of the Scotian Shelf, such as moving to deeper depths off the edge of the Shelf.

An east-west trend in mean weights and lengths is also evident across areas of the Scotian Shelf (see table below), with the lowest values at the easternmost extent of the management area (4Vn), increasing through 4Vs and 4W to reach the highest values in 4X. This corresponds with the difference in size composition of the commercial landings between 4VW and 4X/5 noted previously.

Comparison of Indices within 4VWX

The table below summarises average values (1970-2001) for the indices described above for 4Vn, 4Vs, 4W and 4X. The mean catch rate in numbers per tow is greatest in 4Vn, while the greatest in mean weight per tow is in 4X. The lowest mean number and weight per tow is in 4W. The greatest proportion of the biomass (64 %) is in 4X. The mean weight and length of fish is least in 4Vs and in greatest 4X.

NAFO Area	Mean Nos/tow	Mean Wt/tow (Kg)	Proportion of biomass	Mean Wt of fish 45+ cm(Kg)	Mean length of fish 45+ cm
4Vn	15.8	10.7	0.09	1.19	51.8
4Vs	6.7	4.1	0.11	1.45	54.1
4W	3.3	3.5	0.15	1.89	58.5
4X	11.4	13.6	0.64	1.93	59.2

Distribution

Distribution can be measured in several ways. The simplest is simply to examine the distribution of catch from survey data. The Summer RV survey distribution

(Figure 23) reflects the distribution of commercial landings seen in Figure 2. Catches are greatest in the Bay of Fundy, in and around Emerald and LaHave Basins (around the 4WX boundary), along the edge of the Laurentian Channel and along most of the most of seaward slope of the Scotian Shelf. This pattern is consistent through the time series. However, in times of greater abundance, white hake expand their distribution on to the shallower banks. For instance, in the 1980s there is greater occupation of Western and Sable Banks. Averaging over the years, most of the biomass (64 %) has resided in 4X, with the rest of the stock split about equally among the remaining NAFO Divisions (15 % 4W, 11 % 4Vs, 9 % 4Vn). These Divisions represent unequal amounts of area, such that averaged catch rates (numbers or weights per set) do not correspond with biomass estimates (see table above). The lowest biomass of 9 % for 4Vn is associated with only 7 % of the survey area, giving 4Vn the highest catch rate of any Division.

The distribution of white hake in the 4VsW Sentinel Survey (Figure 24) has shown a consistent concentration in the western part of 4W around Emerald Basin and Emerald Bank. There are also consistent catches scattered along the slope edge of the survey area. The 4Vn Sentinel Survey (not shown) has very consistent catches along the edge of the Laurentian Channel. The Halibut Survey, which covers the entire Scotian Shelf (Figure 25) routinely samples to depths in excess of 500 m. The distribution on the shelf is consistent with the Sentinel results in 4VW and also the ITQ Survey results in 4X (Fowler et al 1996). The Halibut Survey consistently finds white hake in considerable numbers along the slope deeper than the area sampled by the other surveys as well as at the mouth of the Laurentian Channel, in the Fundian Channel and the Gully.

Distribution of Juveniles and Adults

A map of the distribution of small and large fish from the Summer RV survey (Figure 26) shows that there are differences in distribution with size. Small fish are distributed further up into the Bay of Fundy, whereas larger fish are more concentrated further south in the deeper part of the mouth of the Bay. On the Scotian Shelf, small white hake are found on the inner banks of 4VsW, while adults are found further offshore, in both summer and spring. It should be noted that there is considerable overlap in the distribution of small and large hake.

Area Occupied and Local Density

Another way to look at distribution is to examine how fish are distributed within their ranges. Two such measures of distribution are area occupied and local density. Area occupied measures how widely the species is distributed within an area, as the proportion of non-zero sets in the survey. Local density measures how concentrated white hake is where it is caught, and is measured as the catch rate in non-zero sets. These two distribution indices should be considered in conjunction with RV catch per tow (all sets). Local density was highly correlated with RV catch rate per two in all areas for white hake and was thus not considered further.

Large fish in every area show the same pattern with respect to area occupied (Figure 27). There are no clear trends until the early to mid-1980s, when the area occupied index declines in all cases. The area occupied by large fish in 4Vs and 4W has remained below the long-term mean, whereas it the long-term mean has been regained very recently in 4X and 4Vn. Small fish on the eastern side of the Scotian Shelf (4W, 4Vs, 4Vn) demonstrate a corresponding decline in area occupied to that of the large fish, but in recent years this index has recovered, and has varied about the long-term mean in all areas. These declines in area occupied for large and small fish parallel the declines in RV catch rates (Figure 18), indicating that the decrease in biomass has been accompanied by contraction in the distributional range of the stock.

In 4Vn, small fish were below the long-term mean from 1987 to 1993, but have otherwise fluctuated around the long term mean. The large inter-annual variation in abundance of small fish (Figure 18) coupled with this relative consistency in area occupied, supports the view that 4T fish are mixing in with 4Vn fish.

Distribution and Temperature

Temperature affects species by delimiting habitats and regulating biological processes that determine growth, mortality and reproductive rates. Most fish species may adjust their distribution in response to changes in water temperature. This can be accomplished by relocating horizontally to other areas, changing their depth preference (relocating vertically within the water column of the same area), or a combination of both. To estimate the potential for an impact of changing temperature on white hake, a stock status environmental index was created as the proportion of the seafloor associated with bottom temperatures within 6-10 ^{o}C. Called the temperature index, this reflects the temperature range occupied by white hake in 4W and 4X, as seen in the summer RV survey, and corresponds with historical estimates of the preferred temperature range of white hake. Markle et al (1982) reported that white hake < 50 cm showed maximum catch rates at 6-7 °C and 8-10 °C, while large fish showed even catch rates from 5 –10 °C.

There have been significant water temperature changes on the Scotian Shelf since the mid-1980s (Drinkwater et al 2001). Area occupied and the temperature index are plotted for small and large fish in 4W and 4X (Figure 28). In 4W, the trends in the area occupied and temperature indices for large white hake are similar from 1981 to 1989, both peaking in 1984 and subsequently decreasing. The temperature index decreases until 1987 and then levels out. However, the area occupied continued to decrease until 1994, before levelling out, and then rose back up in 1998. The 4W trend for area occupied by small fish is more variable than that for large fish, but also appears to correspond generally with the temperature index until it plateaus at a low level from 1987. Then the area occupied continues to decrease until 1995, rising back up since 1996.

In 4X, there is some consistency between the area occupied and the temperature indicator throughout the time series for large and small white hake, although the correlation is low.

The divergence between the area occupied and the temperature indicator in 4W during the 1990s suggests that the decline in area occupied is not primarily caused by redistribution as a result of water cooling. It is more likely to be due to a reduction in abundance.

Length and Depth Relationship – Industry Surveys

Distribution of white hake with depth appears to be influenced by the size (perhaps maturity) of the fish being examined. The predominance of white hake under 45 cm in the shallower inshore waters of the Bay of Fundy has been noted. Anecdotal information from Industry sources also suggests that small white hake (25-40 cm, based on sizes caught in commercial gears) may also occur in deeper offshore waters. The DFO RV surveys rarely sample deeper than 200 m, while most of the Industry surveys take regular samples from much greater depths. Conversely, the only two Industry surveys that provide white hake length data (4VsW Sentinel and Halibut surveys) rarely catch white hake under 30 cm due to the size selectivity of the commercial gear types used. The 4VsW Sentinel Survey data (Figure 29), pooled for 1996-2000, show that the mean, the maximum and the minimum length in 10 m depth bins actually decrease with depth down to about 180-200 m and then begin to increase again. The range of the mean is about 10 cm and is not likely to be statistically significant. The pattern is clearer in 4W than in 4Vs, probably due to the greater number of observations, however the 4Vs data are consistent with the pattern in 4W. In the Halibut Survey there are data for 4V, 4W and 4X. As with the Sentinel survey, the data are most numerous in 4W, less so in 4V and relatively sparse in 4X (Figure 30). The patterns in 4V and 4W are almost identical to those in the Sentinel survey, with a distinct minimum size in the depth range of 180-200 m. The range of the mean is also about 10 cm, possibly more in 4V. In 4X there appears to be a decline in mean size with depth to about 180 m however the subsequent increase in size at greater depths is not apparent. There are several large gaps in the depth range sampled for 4X that may be obscuring the pattern. Across both Industry surveys, in any area for which we can represent the depth range, we have a clear pattern of declining size of (probably mature) white hake to a minimum in the 180-200 m range, followed by increasing size with depth in waters below 200 m. It seems likely that the suspicion of offshore juveniles derives from fleet components that regularly fish to 200 m, but less frequently at greater depths.

Seasonal Differences in Abundance and Distribution

There is only one short block of years, 1979-1984 for which there are seasonal data from the spring, summer and fall RV surveys. These were examined by Fowler et al (1998) who concluded that the spring and fall series diverged from the summer series. The spring and summer RV catch rate series for 4VsW are updated in Figure 31: they decrease from the 1980s to the 1990s and remain low. White hake also exhibit differences in spatial distribution between spring and summer (Figure 32). In the spring, white hake are concentrated in deep water along the shelf edge in 4VsW, while in the summer, they are also found in large numbers in the shallower waters of the shelf proper.

Length Frequency Analysis - RV Survey

The summer RV survey catches a limited size range of white hake. Overall, the size range is from around 20 cm to 90 cm, although smaller and larger fish are occasionally caught. The absence of smaller and larger fish from the survey catch may be because the survey gear cannot sample these sizes of white hake or it may be that these sized white hake are distributed outside the survey area.

From the length frequency data from 4Vn it is evident that the whole size range of white hake are not captured by the survey in this area (Figure 33). The distribution is often narrow and unimodal and from 1995 to 1999, the distribution peaks at 40 cm. There is no evidence of modal progression during these years, and very little evidence in the other years. The mean size of fish is 42.4 cm, and the size range has contracted over time. Compared to the long-term mean, there are many more fish sized 31-46 cm in 2001, although there are fewer large fish.

In 4Vs the mean size over the time series was 40.8 cm. The size range has contracted over time (Figure 34), particularly during the late 1990s. Some small young of the year fish (7-10 cm) have appeared in several recent years, indicating possible incoming recruitment. However, there is no clear relationship between these small fish and the length frequency distribution in subsequent years. Very few fish of any size were caught in 2001 compared to the long-term mean.

The data for 4Vn and 4Vs are shown as percentiles of the accumulative length distributions (Figure 35) to demonstrate trends in size composition. In both areas, the 50th percentile, representing the median length in the survey, depicts the same trend as the mean length for 45+ cm fish from Figure 22. In both cases there is a decrease in the size of the largest fish through time (represented by the 90th percentile). The cumulative frequency plots portray the magnitude of this loss of larger fish relative to the historical size composition. The extent to which the trend is apparent in the lower percentiles indicates a decrease in the size of smaller fish too. A slight decline can even be seen in the 10th percentile.

Fish in 4W have the broadest size distribution, at least during the1970s, although the range has contracted over time (Figure 36). In some years it is possible to follow year classes. The average size over the time series is 44.9 cm. As in 4V, in 2001 the large fish are missing in 4W when compared to the long-term mean. Here though, there is also an absence of small fish, although there are some young of the year in 2001. The cumulative frequency distribution (Figure 37a) shows the long-term trend of loss of larger fish since 1980, as well as a recent short-term trend (since 1995) of the loss of smaller fish.

The increase in abundance in 4X since 1997 (Figure 15) was largely due to small fish until 2001, when the mode increased to 46-49 cm (Figure 38). This mode can be traced back to a recruitment pulse in 1999. However, there are no signs of recruitment of white hake in 2000 or 2001. Through several years in the 1990s, there were small but visible signs of recruitment of fish around 10 cm. The average length of fish in 4X is 48.8 cm. Again there is an absence of small fish in 2001 when compared to the 1970-2001 average and a loss of larger fish. As in 4W, the cumulative frequency distribution (Figure 37b) shows a long-term decrease in the size of larger fish since 1980 (corresponding with the trend in mean length of 45+ cm fish in Figure 22), as well as a recent (since 1999) decrease in the size of smaller fish.

Length Composition - Industry

Length frequency data from the 4VsW Sentinel Survey (Figure 39) and the Halibut Survey (Figure 40) cannot be directly compared to either the RV series or each other due to differences in the size selectivity of the sampling gears used. The Halibut Survey, with #14 circle hooks, rarely catches white hake under 50 cm. The 4VsW Sentinel Survey, with #12 circle hooks, rarely catches white hake under 35 cm. The usual lower end for RV Surveys, using otter trawls, is about 25 cm. In most years in the Sentinel Survey there are significant numbers of fish 55 cm and greater.

Growth and Mortality

There are currently no aged white hake data from the RV survey with which to estimate growth. In the past, Fowler et al (1996) and Fowler (1998) have used growth data from George's Bank to estimate growth and thus mortality. As there are now 3 years of aging data available from the commercial sampling program from the Scotian Shelf, this data was used to estimate growth on the eastern and western Scotian Shelf.

Estimation of Growth

Growth was estimated by fitting von Bertalanffy growth curves to pooled data for 1998-2000, separately for the eastern and western portions of the Scotian Shelf (Figure 41). Only fish sized 49 cm or greater were used to fit the curves since fish smaller than this are not sampled well by commercial gear. The curves were fitted by minimising the weighted sums of squares of the differences between the observed and the estimated values. Most of the weighting went to ages 4 to 6 as these were most numerous in the samples.

The optimal fit of the length at age data for the eastern Scotian Shelf was virtually a straight line with $L\infty$=607 cm, very slow growth (K=0.012), and t0=-3.211. In order to produce a more realistic growth curve, constraints were introduced. The $L\infty$ was constrained to $\leq$ 200 cm since the maximum size of white hake observed is around 135 cm (Scott and Scott 1988), and t0 was constrained to be ≥ -1.5. This produced a more reasonable fit. However, there is a very high correlation of $L\infty$ and K making estimation uncertain and producing many "optimal" combinations of $L\infty$ and K. The specific combination produced here was dependent on the starting values of the parameters. Particularly, if the start $L\infty$ is < 200 cm, then the estimate of $L\infty$ will be < 200 cm. However, if the start $L\infty$ is > 200cm, then the estimate is constrained to be 200 cm. For present purposes, these different combinations of

L_∞ and K produce very small differences in length at age estimates. It was not necessary to constrain L_∞ to fit a curve for the western Scotian Shelf. The estimates are given in the table below and the curves shown in Figure 41.

Von Bertalanffy Growth Parameters

	Western Scotian Shelf	Eastern Scotian Shelf
L_∞	142.4	169.6
K	0.086	0.061
t0	-1.5	-1.5

Growth on the eastern Scotian Shelf is slower than on the western Scotian Shelf, although by age 15, length at age is the same (Figure 42). These curves are compared to an RV-based growth curve for Georges Bank (K. Sosebee, NMFS, pers. Comm.) and a fishery-based growth curve for the Gulf of St. Lawrence (from 1985). Growth on Georges Bank is faster than on the Scotian Shelf. These results support the use of Scotian Shelf commercial aging data for analysing growth for Scotian Shelf white hake, since the Georges Bank growth parameters would overestimate growth on the Scotian Shelf. (Note that growth at ages 1-3 is estimated to be lower for the Georges Bank growth curve because this data comes from Research Survey caught fish, whereas the other data is all commercial data, which catches larger fish at age). Growth on the eastern Scotian Shelf is very similar to growth in the Gulf of St. Lawrence.

Mortality Estimation

In order to estimate mortality, Summer RV numbers at length in 4Xopqrs and 4VWXmn were converted to numbers at age using the von Bertalanffy growth curves for the eastern and western Scotian Shelf (Tables 11 and 12). This conversion results in fractional ages, ie, 4.2, 4.3, etc. Since the July RV Survey catches white hake half way through year, all fish aged 4.0 – 4.9 were grouped as 4 year old, all fish aged 5.0-5.9 were grouped as 5 year old etc. Fish less than 4 years old were not considered to be well modelled by the von Bertalanffy growth function (see above), so only fish ages 4 and older were used in the mortality analyses. This corresponds to fish 49+ cm. These fish can be considered to be fully recruited to the RV Survey (see Figures 33, 34, 36 and 38).

It should be noted that there is no age data for Scotian Shelf white hake for the 1970s or 1980s and thus it is not known if the growth rate has remained constant. If there have been growth rate changes, this will affect mortality estimates.

Three methods were used to estimate mortality, Paloheimo's Zs, Annual Catch Curves and Cohort Catch Curves. Paloheimo's Z's were estimated as Ln [numbers at age $(5\text{-}7)_{t+1}$/numbers at age $(4\text{-}6)_t$] for both the east and west areas. The Annual catch curves were fit for ages 4-7, 4-8 and 4-9 on the eastern Scotian Shelf and 4-8 and 4-9 on the western Scotian Shelf. Cohort catch curves were fit for ages 4-8 on the western Scotian Shelf and 4-7 on the eastern Scotian Shelf. Mortality was only estimated for years where a straight line could reasonably be fitted to the data. Both catch curve methods of estimate average mortality across years. In the annual catch curve method, the number at age in a given year is a product of the mortality experienced by this age group in the preceding years. So it encapsulates some mortality retroactively. The cohort catch curve method collapses several years of mortality into one estimate. Thus the 1991 estimate includes mortality in 1992, 1993 and 1994. So here, the mortality estimates encompass mortality in future years.

Eastern Scotian Shelf

There is high inter-annual variability in estimates of Paloheimo's Zs (Figure 43a). However, after a period of no trend in the 1970s, there is a clear upward trend in total mortality, beginning in the mid-1980s. It may have levelled off in the late 1990s.

Since there are few fish in 4VW older than age 7, only ages 4-7 gave estimates of Z over the majority of the time series. However, for comparative purposes, the Annual catch curve Zs were estimated where possible for ages 4-8 and 4-9. The three estimates give similar results (Figure 43b): there is an increase in total mortality beginning in the early 1980s, through to the 1990s. There has been a decrease in mortality from a high of 1.5 in 1994. Even with the limited age range of ages 4-7 for the cohort catch curve, there were not many cohorts in the time series that could be followed from one year to the next (Figure 43b). Mortality increased throughout the 1980s to a high of 1.5 in 1991. It has since declined.

Decadal averages for all methods indicate that there was an increase in Z from the 1970s to the 1990-2001 period (Table 13). Values of r^2 show that in general the fit of the catch curves to the data was reasonable. Total mortality estimates are comparable across methods, although the Paloheimo estimates are the highest. In the 1990-2001 period, mortality is high, 0.97 to 1.20. This is discussed further below in relation to estimates of relative fishing mortality.

Western Scotian Shelf

Estimates of total mortality using the Paloheimo method (Figure 44a) decreased from the early 1970s to the early 1980s, remained low, then increased through the 1990s. The magnitude of these changes is smaller than the magnitude of the changes observed on the eastern Scotian Shelf. The annual catch curve method depicts trends over time similar to Paloheimo's Z, with a decrease in mortality during the 1970s, then an increase from the 1980s to 2001 (Figure 44b). In the last few years, the two methods give opposite results: Paloheimo's Z decreased from 1996, whereas the annual catch curve estimates increased. Cohort catch curves could only be estimated for ages 4-8. There were no cohorts before 1985 or after 1996 for which it was possible to follow cohorts from one year to the next. Total mortality increased from the mid-1980s to the mid-1990s.

Decadal averages for all methods indicate that there was a decrease or no change in mortality from the 1970s to the 1980s, then an increase from the 1980s to the 1990-2001 (Table 14). Values of r^2 show that in general the fitting of the catch curves to the data was reasonable.

Relative Fishing Mortality

Relative fishing mortality is a crude measure of exploitation and is estimated as the commercial catch divided by the fishable biomass estimated from the summer RV survey, here defined as large fish (45+ cm). Relative fishing mortality was estimated for 4Vn, 4VsW and 4X (Figure 45). In 4Vn and 4VsW, there was a decrease in relative F from 1970 to the mid-1980s, then an increase to the early to mid-1990s. In 4VsW this increase was very large, peaking in 1996 and dropping, very sharply in 4VsW, to below the long term average in 1997. The increase in relative F in both areas from the late 1980s to early 1990s could be due to redirected fishing effort. However, it could also be due in part to improved reporting practises. In 4X there was a decrease in relative F from 1970 to the mid-1980s. Since then, relative F has generally varied around the mean.

Comparison of mortality on the eastern Scotian Shelf and western Scotian Shelf.

All three methods of estimating mortality depict higher mortality rates on the eastern Scotian Shelf than the western Scotian shelf. In the 1970s, mortality on the western Scotian Shelf decreased while there was no trend on the eastern Scotian Shelf. Since the 1980s, mortality in both areas has increased, but the increase on the eastern Scotian Shelf has been more sustained and of greater magnitude.

Some of the trend observed in total mortality can be explained by changes in fishing mortality. On the eastern Scotian Shelf, fishing mortality increased from the mid-1980s to the mid-1990s, paralleling the increase in total mortality. However, the rise in total mortality began before the rise in fishing mortality. Fishing mortality has declined since 1995, while the total mortality has remained stable. On the western Scotian Shelf, all estimates of mortality declined during the 1970s. Fishing mortality has remained relatively stable since then but total mortality increased.
Total mortality is comprised of fishing mortality and natural mortality. The differences between total and fishing mortality may be explained by changes in natural mortality. The simple subtraction (using the annual catch curve estimates of total mortality, and converting relative F to instantaneous F where F=-ln(% survivors) suggests that natural mortality has increased in both eastern and western portions of the Scotian Shelf.

Problems with the methodology

All the age-based methods used to estimate mortality assume that growth has been constant over the time period under consideration. Other stocks, including the adjacent white hake stock in 4T, 4TVW haddock and 4VsW cod, have experienced declines in growth rate, so it seems reasonable to expect that growth rate has declined for white hake on the Scotian Shelf. If so, it seems reasonable to expect that there have been growth changes on the Scotian Shelf too, and therefore that total mortality will be overestimated. Some portion of the loss of large white hake from the Scotian Shelf may be due to a reduction in growth rate.

The methods assume that the RV survey is consistently sampling the whole population of 4 to 7 or 8 year olds. The inter-annual variability observed in the RV abundance of large fish (Figure 18) is too large to be caused by annual changes in population abundance. It is more likely to be caused by fish moving in and out of the survey area, or to a poor match between stock distribution and set allocation within the sample area, or both.

The annual catch curve method assumes that (1) the stock is in a steady state, (2) the sample represents the mean population structure, (3) Z is constant over all size classes, (4) recruitment fluctuations are small and random and (5) the gear used (in this case trawling gear) has a selection curve where only the smaller animals are selected against. The second assumption was discussed above and the third and fourth assumptions are usually met if the descending limb appears straight (Pauly *et al.* 1980). Since the maximum age of fish used was 9 years old (approximately 80 cm), it should be safe to assume that they will be fully selected by the RV survey. The assumption of a steady-state is always precarious and should be used with caution. The cohort catch curve avoids the steady-state assumption by tracking a cohort through time. Paloheimo's method has the least assumptions but is most subject to inter-annual variability in abundance estimates.

White Hake Diet

White hake stomachs have been systematically collected from summer and spring RV surveys since 1999. Preliminary analyses of these data indicate that the diet of white hake is comprised of 40-60 % shrimp throughout 4VsWX (Figure 46). Invertebrates generally account for about 75 % of the diet in 4VsW and 60 % in 4X. The most common identifiable commercial fish species included in the remaining 25 % (4VsW) and 40 % (4X) of the diet are (both areas) cod, silver hake, flounders, and (just in 4VsW) redfish, haddock, and pollock. It should be noted that sample sizes were small, and that most of the white hake sampled were small fish (34-46 cm). Anecdotal information indicates that larger white hake are more piscivorous. However, it is more difficult to sample the stomachs of larger white hake since their stomachs frequently evert when the fish are raised from depth.

Discussion

The analysis above has been conducted on the basis of DFO management areas. However, white hake distribution may not fall so neatly into these areas, as discussed in Fowler et al 1996. The stock structure of white hake is not known, but it is likely that 4VWX/5 white hake is not a coherent unit. Fowler et al 1996 indicated that there might be three or more sub-stocks of white hake (at least separate components: eastern, central and western). White hake in 4X/5 may also be continuous with white hake in the Gulf of Maine and on George’s Bank (Fowler et al 1996). The abundance trends of white hake have been similar in these three areas (Hurlbut 1996, Fowler et al 1996, Hurlbut and Poirier 2001). White hake in 4Vn, and possibly along the Laurentian Channel in 4Vs, may be continuous with white hake in 4T (Hurlbut 1996). There may be a size cline of white hake moving from east to west. Fish are slightly larger at age on the western Scotian Shelf than the eastern Scotian Shelf and there are also more large fish. The length frequency plots in Figures 33-38 indicate that there is a broader size range of fish in 4X and 4W than there is in 4V.

The spawning patterns and behaviour of white hake on the Scotian Shelf and in the Bay of Fundy are also not well understood, as outlined by Fowler et al (1996). At most, there may be three spawning origins for white hake on the Scotian Shelf: the eastern Scotian Shelf may be derived from 4T/Laurentian Channel early summer spawning (Markle et al. 1982); Fahay and Able (1989) suggested that there may be two stocks of white hake with separate spawning schedules, one occuring in the late spring/early summer in slope waters off the Scotian Shelf and Georges Bank down to New England and the second a late summer/early autumn spawning population occurring in the Gulf of St. Lawrence and on the Scotian Shelf.

Hare et al (2001) have shown that white hake off the north-eastern US spawn offshore. They found small white hake larvae (< 5mm) in Slope Sea off the Middle Atlantic Bight in May and June. Such small larvae were not caught on the shelf. The authors hypothesised that white hake larvae actively cross the shelf/slope front to reach nearshore estuarine juvenile habitats. A similar mechanism may occur for the spring/early summer offshore spawning of white hake to the Scotian Shelf.

No evidence of nursery areas for juveniles have been found along the Atlantic coast, although some small fish are caught inshore in the Bay of Fundy in July and August. There are also anecdotal reports that the Bra D’ors Lakes in Cape Breton are a nursery area (T. Lambert, DFO, pers. Comm.). Markle et al (1982), on the basis of SSIP data on the distribution of pelagic juveniles around the coast of Cape Breton from May to July (and the lack of pelagics juveniles inshore on the southern half of Nova Scotia), have suggested that these fish may originate in the southern Gulf of St. Lawrence.

On the eastern Scotian Shelf (4VW), white hake abundance has been very low since the early 1990s, large fish have been lost from the population, area occupied by large fish has decreased and total mortality and fishing mortality have in increased. On the western Scotian Shelf, abundance of white hake has increased over the last 3-4 years, there has been a small change in population size structure, area occupied by large fish has decreased a little, total mortality has increased slightly since the 1980s and fishing mortality has had little trend over time.

The RV index of abundance of large and small fish suggests that on the eastern Scotian Shelf small fish are not surviving. It is possible that some or all of these fish are surviving, but have simply moved out of the area and are thus not detected by the survey. However, a preliminary analysis of the relationship between area occupied and temperature did not support the idea that this redistribution was due to temperature changes. If these small fish are lost to the population of large fish, this could have a serious effect on the production of white hake since a large white hake (90 cm) is 4 times more fecund than a small white hake (50 cm) (Markle et al 1982).

The lack of survival of small white hake may be due to some other factor. The apparent natural mortality is very high. Several other gadid species such as 4VsW cod, 4Vn cod and 4TVW haddock on the eastern Scotian Shelf are also experiencing apparent high natural mortality with minimal fishing mortality.

Traffic Light Analysis

White hake in 4VWX/5 are managed as three separate stock components, 4Vn, 4VsW and 4X/5. Traffic light analyses were conducted for white hake in 4VsW and 4X (Tables 15 and 16). No traffic light analysis was conducted for 4Vn (see below). These tables show the annual values of each indicator as a combination of three lights depending on whether they are among the best values for that indicator, among the worst or in between. For indicators such as stock biomass and recruitment, high values are good and have a green light and low values are bad and have a red light. However, for indicators such as mortality, high values are bad and are assigned a red light whereas low values are good and receive a green light. Intermediate values (midpoint between red and green) are yellow. A value between red and yellow is expressed as a pie with increasing amounts of red in the pie as the value approaches the red threshold or cut point. Similarly, a value between the midpoint and the green cut point becomes increasingly green in the pie as the green cut point is approached. Empty cells in the table indicate no observation for that year. Uncertainties about the appropriate cut point result in a broad yellow zone. The rationales for the cut points used are given in Tables 17 and 18.

In the traffic light analysis, indicators are summarised into groups which emphasise specific aspects of the resource. These groupings are called characteristics. The following outlook section is cast in terms of these characteristics.

Outlook

4VsW

Abundance

Abundance has remained very low since the early 1990s. Most indicators of abundance of 4VsW white hake have been poor since the early 1990s. However, the 4VsW Sentinel numbers per set and Halibut Survey numbers per set both show increasing trends over the last 3 to 4 years. The 4VsW Survey and Halibut Survey have a shorter time series than the RV Surveys and these different trends cannot be reconciled at this time.

Production

Production has been poor since 1990, and after some improvement, 2001 is the worst year of production since 1994. Indicators of productivity have been variable over time. Total mortality has increased since the 1970s, implying high natural mortality. It is not clear what is causing this mortality.

Relative Fishing Mortality

Relative fishing mortality has been low since 1997 after the introduction of a TAC and by-catch quotas in 1996.

Environment

Environment as measured by the area of suitable bottom temperature has increased recently, possibly indicating favourable environment conditions for white hake in 4VsW.

There do not appear to be any signs of recovery of 4VsW white hake, despite low fishing mortality in recent years. Small fish seen in the RV survey are not surviving and total mortality is increasing. Although it is possible that total mortality was overestimated in the 1980s due to changes in water temperature, this does not appear to be the case in the 1990s. Inconsistencies between relative fishing mortality and total mortality have preceded dramatic declines and collapses of other stocks. The status of white hake in 4VsW is poor and requires rebuilding.

4X

Abundance

Abundance has been poor during most of the 1990s, but has increased recently and continues to improve. Indicators of abundance of 4X white hake show increases over the last 3 to 4 years, and particularly in 2001, except the mean weight of large fish in the survey which has not improved.

Production

Production has declined since the 1980s and production in 2001 is the worst seen, suggesting that continued caution is required or the abundance recovery seen in

2001 may not be sustained. Indicators of productivity have been variable over time. Total mortality is higher in the 1990s than in the 1970s or 1980s, implying high natural mortality. It is not clear what is causing this mortality.

Relative Fishing Mortality

Relative fishing mortality has been low throughout most of the time series.

Environment

Environment as measured by the area of suitable bottom temperature has increased recently, possibly indicating favourable environment conditions for white hake in 4X.

White hake in 4X are showing signs of recovery. The improved abundance in 2001 follows good abundance of small fish in 2000. However production is poor in 2001. Total mortality is increasing while fishing mortality appears to be low. Similar inconsistencies have preceded dramatic declines and collapses of other stocks. The status of white hake in 4X has been poor but shows signs of recovery. Any increase in catches could jeopardise rebuilding.

4Vn

No traffic light analysis was conducted for 4Vn white hake. RV survey abundance of large 4Vn white hake has remained low during the 1990s, although the Industry surveys indicate increased abundance since 1998. The mean weight of large fish is below the long-term mean, and small fish seen in the RV survey do not appear to be surviving. A peak of abundance of fish 30-45 cm seen in 2001 may be due to fish from 4T. Overall, there is little sign of recovery of 4Vn white hake.

Summary

There are signs of recovery in western stock area, (4X/5) but the abundance of white hake in the eastern area (4Vn and 4VsW) continues to be very low despite reduced catches and warming water temperatures.

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Table 1. Nominal landings from 4VWX/5, by country as reported to NAFO and DFO statistics.

Year	Canada(1)	USA (2)	Cuba	Spain	France	Ireland	Japan	USSR	Total
1964	3137	612	-		-	-	-	-	3749
1965	7	352	-	146	-	-	-	-	505
1966	1617	97	-	13	-	-	-	-	1727
1967	900	202	-	229	-	-	-	-	1331
1968	1546	166	-	9	-	-	-	8	1729
1969	2412	120	-	41	-	-	-	-	2573
1970	2971	144	-	126	-	-	96	-	3337
1971	5004	177	-	18	-	-	135	-	5334
1972	5422	244	-	374	-	-	164	-	6204
1973	5779	99	-	16	-	-	5	-	5899
1974	5891	147	-	-	-	-	5	-	6043
1975	4677	112	-	-	-	-	-	-	4789
1976	3534	96	-	-	-	1	2	-	3633
1977	3410	182	-	-	-	-	-	48	3640
1978	3871	149	14	-	-	-	7	-	4041
1979	3284	443	1	-	-	-	3	-	3731
1980	4154	231	-	-	-	-	13	-	4398
1981	3832	650	-	-	-	-	1	-	4483
1982	5355	752	-	-	-	-	15	-	6122
1983	4500	1005	-	-	-	-	5	-	5510
1984	5379	960	-	-	-	-	7	-	6346
1985	5977	61	2	-	-	-	19	-	6059
1986	7929	164	-	-	20	-	30	-	8143
1987	8595	70	15	-	-	-	15	-	8695
1988	6001	27	-	-	-	-	1	-	6029
1989	5669	41	5	-	-	-	3	-	5718
1990	5874	140	-	-	-	-	2	-	6016
1991	4931	24	-	-	-	-	-	-	4955
1992	5868	6	1	-	-	-	-	-	5875
1993	6500	0	-	-	-	-	-	-	6500
1994	5224	-	-	-	-	-	-	-	5224
1995	5636	-	-	-	-	-	-	-	5636
1996	3892	-	-	-	-	-	-	-	3892
1997	3453	-	-	-	-	-	-	-	3453
1998	2085	-	-	-	-	-	-	-	2085
1999(2)	1935	...	...	...	...	...	...	...	1935
2000(2)	2442	...	...	...	...	...	...	...	2442
2001(2)	1555	...	...	...	...	...	...	...	1555

Landings for 2001 as processed in September.

(1) Canadian landings are taken from the NAFO database from 1964 to 1985, and then from the DFO ZIF database from 1986 onwards.
(2) NAFO data for 1999-2001 are incomplete. However, foreign catches of white hake in 4VWX/5 are considered minimal.

	4Vn				4Vs				4W				4X				5Y (2)				5Zjm/5Zc (2)			
Year	Canad	USA	Other	Total	Canad	USA	Other	Total	Canad	USA	Other	Total	Canad	USA	Other	Total	Canad	USA	Other	Total	Canad	USA	Other	Total
1964	192	0	0	192	23	2	0	25	320	6	0	326	2599	181	0	2780	3	339	0	342	0	85	0	85
1965	6	0	0	6	1	0	86	87	0	2	60	62	0	114	0	114	0	160	0	160	0	76	0	76
1966	348	0	0	348	9	0	13	22	433	0	0	433	827	0	0	827	0	33	0	33	0	64	0	64
1967	125	0	2	127	27	0	227	254	241	0	0	241	507	0	0	507	0	141	0	141	0	62	0	62
1968	138	0	0	138	33	0	17	50	325	0	0	325	965	0	0	965	5	96	0	101	80	70	0	150
1969	137	0	0	137	38	0	27	65	543	0	1	544	1660	43	7	1710	4	24	0	28	30	53	6	89
1970	182	1	6	189	47	0	36	83	718	2	21	741	1978	69	16	2063	12	20	0	32	34	52	143	229
1971	422	0	11	433	117	0	7	124	1453	4	1	1458	2912	62	29	3003	18	54	0	72	82	57	105	244
1972	173	0	26	199	95	0	176	271	1203	9	86	1298	3911	82	91	4084	8	60	0	68	32	93	159	284
1973	273	0	0	273	126	0	20	146	1445	5	0	1450	3818	25	0	3843	17	38	0	55	100	31	1	132
1974	223	0	0	223	137	0	5	142	1329	2	0	1331	3970	43	0	4013	36	63	0	99	196	39	0	235
1975	181	0	0	181	138	0	0	138	1336	2	0	1338	2876	34	0	2910	17	37	0	54	129	40	0	169
1976	262	0	0	262	157	0	0	157	756	1	2	759	2164	51	1	2216	0	20	0	20	195	24	0	219
1977	288	0	0	288	152	0	0	152	848	0	0	848	1953	99	0	2052	0	28	0	28	169	55	48	272
1978	202	0	0	202	242	0	15	257	769	0	4	773	2503	30	1	2534	20	35	0	55	135	84	1	220
1979	338	0	0	338	181	0	1	182	366	0	1	367	2148	12	0	2160	102	342	0	444	149	90	2	241
1980	585	0	0	585	369	0	0	369	341	0	1	342	2554	38	11	2603	14	86	0	100	291	107	1	399
1981	564	0	0	564	222	0	0	222	412	0	1	413	2180	184	0	2364	21	59	0	80	433	407	0	840
1982	414	0	0	414	204	0	0	204	595	0	14	609	3378	196	1	3575	352	299	0	651	412	257	0	669
1983	401	0	0	401	315	0	0	315	626	0	4	630	2348	246	1	2595	441	427	0	868	369	333	0	702
1984	237	0	2	239	298	0	3	301	688	0	2	690	3143	276	0	3419	479	354	0	833	534	331	0	865
1985	345	0	1	346	526	0	16	542	1105	0	4	1109	3048	61	0	3109	452	0	0	452	501	0	0	501
1986	373	0	25	398	518	0	20	538	1406	0	5	1411	4676	164	0	4840	307	0	0	307	648	0	0	648
1987	551	0	1	552	725	0	8	733	1588	0	21	1609	5072	70	0	5142	104	0	0	104	555	0	0	555
1988	323	0	0	323	376	0	1	377	788	0	0	788	3893	27	0	3920	86	0	0	86	534	0	0	534
1989	291	0	0	291	475	0	0	475	937	0	8	945	3161	41	0	3202	222	0	0	222	582	0	0	582
1990	190	0	0	190	310	0	0	310	1236	0	2	1238	3542	140	0	3682	50	0	0	50	546	0	0	546
1991	170	0	0	170	293	0	0	293	1076	0	0	1076	2807	24	0	2831	34	0	0	34	550	0	0	550
1992	158	0	0	158	301	0	0	301	829	0	1	830	3316	6	0	3322	127	0	0	127	1137	0	0	1137
1993	136	0	0	136	281	0	0	281	768	0	0	768	3561	0	0	3561	73	0	0	73	1681	0	0	1681
1994	224	0	0	224	213	0	0	213	598	0	0	598	3137	0	0	3137	98	0	0	98	955	0	0	955
1995	32	0	0	32	286	0	0	286	594	0	0	594	4194	0	0	4194	47	0	0	47	481	0	0	481
1996	68	0	0	68	126	0	0	126	522	0	0	522	2743	0	0	2743	60	0	0	60	372	0	0	372
1997	141	0	0	141	77	0	0	77	252	0	0	252	2546	0	0	2546	147	0	0	147	290	0	0	290
1998	138	0	0	138	105	0	0	105	193	0	0	193	1364	0	0	1364	57	0	0	57	228	0	0	228
1999(3	137	...	...	137	72	...	...	72	175	...	...	175	1342	...	...	1342	35	...	...	35	174	...	...	174
2000(3	74	...	...	74	52	...	...	52	223	...	...	223	1811	...	...	1811	58	...	...	58	224	...	...	224
2001(3	27	...	...	27	32	...	...	32	177	...	...	177	1186	...	...	1186	60	...	...	60	74	...	...	74

Landings for 2001 as processed in September.

(1) Canadian landings are taken from the NAFO database from 1964 to 1985, and then from the DFO ZIF database from 1986 onwards.
(2) USA landings in Subareas 5Yb and 5Zc from Sosebee et al 1998.
5Y: US landings until 1986 are for all 5Yb. Since 1986 there has been minimal US catch in Canadian 5Yb.
5Zc: Canadian landings until 1986 are for 5Zjm and US landings are for US Statistical areas 523 and 524. Since 1986, Canadian landings are mainly from 5Zc.
(3) NAFO data for 1999-2001 are incomplete. However, foreign catches of white hake in 4VWX/5 are considered minimal.

Table 3. Nominal landings from 4VWX/5, by area as reported to NAFO and DFO statistics. NAFO area 5Zc (c=Canada) has only existed since 1986. Landings prior to this refer to a larger area 5Zjm (Canadian and foreign catches) or US Statistical areas 523 and 524 (US catches).

Area / Year	4Vn	4Vs	4W	4X/5Y	5Zc	4VXW/5
1964	192	25	326	3122	85	3749
1965	6	87	62	274	76	505
1966	348	22	433	860	64	1727
1967	127	254	241	648	62	1331
1968	138	50	325	1066	150	1729
1969	137	65	544	1738	89	2573
1970	189	83	741	2095	229	3337
1971	433	124	1458	3075	244	5334
1972	199	271	1298	4152	284	6204
1973	273	146	1450	3898	132	5899
1974	223	142	1331	4112	235	6043
1975	181	138	1338	2964	169	4789
1976	262	157	759	2236	219	3633
1977	288	152	848	2080	272	3640
1978	202	257	773	2589	220	4041
1979	338	182	367	2604	241	3731
1980	585	369	342	2703	399	4398
1981	564	222	413	2444	840	4483
1982	414	204	609	4226	669	6122
1983	401	315	630	3463	702	5510
1984	239	301	690	4252	865	6346
1985	346	542	1109	3561	501	6059
1986	398	538	1411	5148	648	8143
1987	552	733	1609	5246	555	8695
1988	323	377	788	4006	534	6029
1989	291	475	945	3424	582	5718
1990	190	310	1238	3732	546	6016
1991	170	293	1076	2865	550	4955
1992	158	301	830	3448	1137	5875
1993	136	281	768	3633	1681	6500
1994	224	213	598	3235	955	5224
1995	32	286	594	4242	481	5636
1996	68	126	522	2803	372	3892
1997	141	77	252	2693	290	3453
1998	138	105	193	1421	228	2085
1999	137	72	175	1377	174	1935
2000	74	52	223	1870	224	2442
2001	27	32	177	1245	74	1555

Landings for 2001 as processed in September.

Table 4. Canadian landings (metric tons) of white hake by NAFO division and gear sectors for 1986 through Aug 2001.

YEAR	AFO DIVISION	Longline	Gillnet	Otter trawl < 65 ft	Other	Total	YEAR	AFO DIVISION	Longline	Gillnet	Otter trawl < 65 ft	Other	Total
1986	4VN	250	0	4	120	373	**1994**	4VN	61	0	16	147	224
	4VS	466	0	23	29	518		4VS	183	2	1	27	213
	4W	1185	149	44	29	1406		4W	551	28	0	19	598
	4X	1345	396	2892	44	4676		4X	1331	1041	684	81	3137
	5Y	0	57	163	0	220		5Y	0	64	33	0	98
	5ZE	103	1	217	3	324		5ZE	416	21	24	7	468
	1986 Total	**3348**	**602**	**3342**	**225**	**7518**		**1994 Total**	**2543**	**1156**	**758**	**281**	**4738**
1987	4VN	185	0	45	321	551	**1995**	4VN	15	0	12	6	32
	4VS	644	0	42	39	725		4VS	225	22	4	36	286
	4W	1407	85	55	41	1588		4W	498	51	26	20	594
	4X	2715	444	1858	55	5072		4X	2709	1179	284	22	4194
	5Y	0	70	19	0	90		5Y	0	41	6	0	47
	5ZE	233	1	35	14	283		5ZE	419	34	17	2	473
	1987 Total	**5184**	**601**	**2055**	**469**	**8309**		**1995 Total**	**3866**	**1327**	**349**	**85**	**5627**
1988	4VN	125	0	7	191	323	**1996**	4VN	53	1	11	3	68
	4VS	320	7	3	46	376		4VS	102	8	1	15	126
	4W	709	41	5	32	788		4W	345	57	2	117	522
	4X	2070	456	1291	77	3893		4X	1213	1155	350	25	2743
	5Y	0	36	1	0	38		5Y	0	51	9	0	60
	5ZE	91	17	43	7	159		5ZE	308	12	23	2	345
	1988 Total	**3315**	**558**	**1350**	**354**	**5578**		**1996 Total**	**2021**	**1284**	**395**	**163**	**3864**
1989	4VN	90	1	15	185	291	**1997**	4VN	135	1	2	2	141
	4VS	405	45	8	18	475		4VS	66	2	1	8	77
	4W	791	110	23	14	937		4W	210	37	2	2	252
	4X	2068	695	306	91	3161		4X	904	1210	409	23	2546
	5Y	0	212	5	1	218		5Y	0	130	6	0	136
	5ZE	219	29	8	3	259		5ZE	240	10	15	1	266
	1989 Total	**3573**	**1092**	**365**	**312**	**5341**		**1997 Total**	**1556**	**1389**	**435**	**37**	**3418**
1990	4VN	76	2	14	97	190	**1998**	4VN	130	0	1	6	138
	4VS	290	0	3	18	310		4VS	102	1	1	2	105
	4W	1039	148	25	24	1236		4W	151	38	1	4	193
	4X	2057	553	738	194	3542		4X	663	386	305	10	1364
	5Y	0	32	16	0	48		5Y	0	46	8	0	54
	5ZE	170	11	40	2	223		5ZE	200	8	10	1	218
	1990 Total	**3631**	**747**	**835**	**336**	**5549**		**1998 Total**	**1246**	**479**	**326**	**22**	**2072**
1991	4VN	57	2	18	93	170	**1999**	4VN	135	0	1	2	137
	4VS	275	0	0	18	293		4VS	64	2	0	6	72
	4W	944	78	9	45	1076		4W	148	24	2	1	175
	4X	1703	575	445	84	2807		4X	578	387	367	9	1342
	5Y	0	24	10	0	34		5Y	1	22	10	0	33
	5ZE	181	10	27	4	221		5ZE	150	9	10	0	169
	1991 Total	**3160**	**689**	**510**	**242**	**4602**		**1999 Total**	**1076**	**444**	**389**	**18**	**1927**
1992	4VN	42	0	17	98	158	**2000**	4VN	69	0	1	4	74
	4VS	283	0	2	17	301		4VS	50	0	0	1	52
	4W	723	73	4	30	829		4W	186	30	6	1	223
	4X	1857	586	795	78	3316		4X	683	547	561	21	1811
	5Y	4	68	53	0	125		5Y	1	47	5	0	54
	5ZE	973	58	25	5	1060		5ZE	187	17	14	1	218
	1992 Total	**3883**	**785**	**895**	**227**	**5790**		**2000 Total**	**1176**	**641**	**587**	**28**	**2432**
1993	4VN	41	0	32	63	136	**2001**	4VN	26	0	0	1	27
	4VS	274	0	1	6	281		4VS	29	1	0	2	32
	4W	704	55	0	9	768		4W	152	21	4	0	177
	4X	1842	1022	640	57	3561		4X	352	439	392	3	1186
	5Y	0	24	49	0	73		5Y	0	54	2	0	56
	5ZE	1496	50	22	5	1573		5ZE	61	8	4	0	72
	1993 Total	**4358**	**1151**	**743**	**139**	**6391**		**2001 Total**	**619**	**523**	**401**	**6**	**1550**

Table 5. Canadian landings (metric tons) of white hake by NAFO division and month for 1993 through the first half of 2001.

Year	Month	4Vn	4Vs	4W	4X/5Y	5Zc	*Total*
1993	Jan	0	11	7	13	1	*31*
	Feb	0	12	2	21	0	*35*
	Mar	0	7	15	90	0	*112*
	Apr	2	67	38	150	1	*259*
	May	42	80	109	658	145	*1032*
	Jun	56	39	79	767	638	*1579*
	Jul	20	34	131	442	303	*930*
	Aug	5	19	206	645	129	*1004*
	Sep	5	8	129	501	44	*686*
	Oct	3	3	47	250	99	*402*
	Nov	2	.	5	84	256	*347*
	Dec	0	3	0	13	66	*82*
	Total	*136*	*281*	*768*	*3633*	*1681*	***6500***
1994	Jan	.	2	0	22	0	*25*
	Feb	0	21	18	43	0	*82*
	Mar	34	6	23	16	0	*79*
	Apr	79	7	32	260	0	*379*
	May	15	30	31	464	3	*543*
	Jun	48	45	21	380	468	*962*
	Jul	26	54	105	560	273	*1018*
	Aug	8	23	170	452	143	*796*
	Sep	11	12	135	419	48	*626*
	Oct	1	8	54	375	6	*444*
	Nov	1	0	9	141	9	*161*
	Dec	0	5	1	102	3	*111*
	Total	*224*	*213*	*598*	*3235*	*955*	***5224***
1995	Jan		25	13	19	0	*57*
	Feb		16	1	23	0	*40*
	Mar		7	29	34	.	*70*
	Apr		28	59	465	.	*552*
	May	6	20	28	287	.	*341*
	Jun	2	19	63	650	171	*905*
	Jul	13	57	106	524	155	*855*
	Aug	6	67	93	337	62	*565*
	Sep	3	29	108	876	35	*1050*
	Oct	3	10	66	592	15	*685*
	Nov	1	6	28	273	35	*343*
	Dec	.	1	1	161	9	*172*
	Total	*32*	*286*	*594*	*4242*	*481*	***5636***

Year	Month	4Vn	4Vs	4W	4X/5Y	5Zc	*Total*
1996	Jan	.	8	0	18	0	*27*
	Feb	.	7	1	32	.	*40*
	Mar	.	2	9	24	.	*35*
	Apr	0	5	3	43	.	*51*
	May	3	24	24	958	.	*1010*
	Jun	12	15	52	77	10	*165*
	Jul	19	30	105	758	113	*1026*
	Aug	23	24	281	311	80	*718*
	Sep	9	6	31	220	40	*305*
	Oct	3	1	13	238	54	*309*
	Nov	0	2	2	100	54	*158*
	Dec	0	2	1	25	21	*49*
	Total	*68*	*126*	*522*	*2803*	*372*	***3892***
1997	Jan	.	6	1	3	.	*11*
	Feb	.	5	4	54	.	*64*
	Mar	.	3	3	47	.	*53*
	Apr	.	2	15	190	.	*206*
	May	1	4	11	209	.	*226*
	Jun	7	9	9	415	56	*497*
	Jul	22	12	60	693	73	*861*
	Aug	32	23	82	400	43	*581*
	Sep	47	4	50	374	14	*490*
	Oct	31	0	12	145	17	*205*
	Nov	0	3	2	92	49	*147*
	Dec	.	4	3	69	38	*114*
	Total	*141*	*77*	*252*	*2693*	*290*	***3453***
1998	Jan	.	8	3	18	.	*30*
	Feb	0	.	9	53	.	*62*
	Mar	.	.	15	48	.	*63*
	Apr	1	13	11	37	.	*61*
	May	18	3	10	86	.	*117*
	Jun	52	34	18	113	34	*251*
	Jul	33	14	45	282	75	*450*
	Aug	13	14	50	243	36	*356*
	Sep	17	7	27	283	19	*353*
	Oct	3	4	3	142	39	*191*
	Nov	1	4	2	51	19	*78*
	Dec	.	4	1	64	6	*74*
	Total	*138*	*105*	*193*	*1421*	*228*	***2085***

Year	Month	4Vn	4Vs	4W	4X/5Y	5Zc	*Total*
1999	Jan	.	6	4	28	0	*37*
	Feb	.	1	10	11	.	*23*
	Mar	.	5	16	10	.	*31*
	Apr	3	10	5	63	.	*81*
	May	16	8	8	71	0	*102*
	Jun	19	5	17	152	43	*236*
	Jul	34	6	32	330	51	*453*
	Aug	40	6	48	198	23	*315*
	Sep	22	3	31	225	16	*298*
	Oct	3	0	2	129	23	*156*
	Nov	0	6	4	103	17	*130*
	Dec	0	15	0	55	2	*73*
	Total	*137*	*72*	*175*	*1377*	*174*	***1935***
2000	Jan	1	13	7	38	0	*59*
	Feb	.	3	29	70	.	*101*
	Mar	0	8	26	79	.	*113*
	Apr	0	6	2	29	.	*37*
	May	30	4	5	93	.	*131*
	Jun	8	6	13	370	14	*411*
	Jul	13	1	37	403	52	*506*
	Aug	7	.	62	253	33	*354*
	Sep	13	0	32	222	36	*304*
	Oct	2	0	6	240	68	*316*
	Nov	.	9	2	49	18	*78*
	Dec	.	2	3	24	3	*33*
	Total	*74*	*52*	*223*	*1870*	*224*	***2442***
2001	Jan	.	15	27	93	.	*135*
	Feb	.	2	16	18	.	*36*
	Mar	.	2	21	51	.	*73*
	Apr	0	1	0	55	.	*57*
	May	4	3	3	113	0	*123*
	Jun	6	6	13	275	8	*307*
	Jul	7	0	45	438	34	*524*
	Aug	10	3	47	198	29	*287*
	Sep	.	.	5	5	4	*14*
	Oct					`	
	Nov						
	Dec						
	Total	*27*	*32*	*177*	*1245*	*74*	***1555***

Table 6. Proportion of white hake landed as main species.

	4Vn	4Vs	4W	4X	5Y	5Zc	**4VWX/5**
1993	0.35	0.65	0.82	0.71	0.56	0.78	**0.73**
1994	0.25	0.61	0.70	0.61	0.74	0.66	**0.61**
1995	0.22	0.67	0.85	0.73	0.62	0.58	**0.72**
1996	0.75	0.68	0.68	0.68	0.58	0.39	**0.65**
1997	0.92	0.57	0.72	0.53	0.67	0.48	**0.56**
1998	0.81	0.72	0.57	0.37	0.32	0.45	**0.45**
1999	0.76	0.51	0.58	0.31	0.06	0.32	**0.37**
2000	0.83	0.44	0.64	0.36	0.57	0.21	**0.39**
2001	0.71	0.33	0.61	0.29	0.51	0.00	**0.33**

Table 7. National Sampling Program inventory of white hake sampling for the Scotian Shelf since 1988.

Number of samples

		4V	4W	4X/5
Longline	1988	.	.	1
	1989	.	.	1
	1993	1	.	4
	1994	1	1	6
	1995	.	7	14
	1996	1	1	8
	1997	3	1	12
	1998	8	.	8
	1999	14	1	8
	2000	21	.	13
	2001	10	2	9
Gillnet	1988	.	.	1
	1995	.	.	5
	1996	.	.	3
	1997	.	.	9
	1998	.	.	6
	1999	.	.	3
	2000	.	.	2
	2001	.	.	11
Otter Trawl	1993	.	.	2
	1994	.	.	1
	1995	6	.	2
	1996	5	.	1
	1997	1	.	3
	1998	.	.	6
	1999	.	.	5
	2000	.	.	10
	2001	.	.	9

Number of fish measured

		4V	4W	4X/5
Longline	1988	.	.	265
	1989	.	.	173
	1993	268	.	1200
	1994	353	268	1595
	1995	.	1418	3673
	1996	109	9	1735
	1997	703	51	2721
	1998	1366	.	1454
	1999	4901	191	1920
	2000	4966	.	3134
	2001	2907	263	2495
Gillnet	1988	.	.	34
	1995	.	.	1115
	1996	.	.	722
	1997	.	.	1871
	1998	.	.	1270
	1999	.	.	406
	2000	.	.	452
	2001	.	.	2031
Otter Trawl	1993	.	.	369
	1994	.	.	250
	1995	919	.	247
	1996	666	.	266
	1997	129	.	669
	1998	.	.	791
	1999	.	.	1260
	2000	.	.	2105
	2001	.	.	1990

Table 8. Mean lengths from commercial sampling of the longline fishery in 4X/5.

		1993	1994	1995	1996	1997	1998	1999	2000	2001
Eastern 4X	4Xn	57.3	58.5	56.0	58.4	58.8	59.8		64.4	69.1
	4Xo		57.9		57.2	73.9	62.0		67.5	
Western 4X/5	4Xp	62.9		61.2		69.8	66.5	59.5	64.8	63.5
	4Xq		66.7	72.9		64.5	81.1	89.6		76.4
	5Zj	63.3	68.9	69.8	64.9	69.8	64.1	62.5	64.1	70.4

Table 9. Results of generalized linear modelling of white hake catch per unit effort for Scotia/Fundy landings by index fishers. Predictions for 2001, a partial year,are not shown

Otter Trawl, 4Xpqr & 5Yb, Tons per Hour

Effect	Df	Deviance Explained	Residual Df	Resid Deviance	F-Value	Pr(F)
NULL			1065	1193		
BOAT	19	153	1046	1041	9.57	0.000
MLAND	11	37	1035	1004	4.00	0.000
AREA	3	16	1032	987	6.42	0.000
YLAND	11	24	1021	964	2.58	0.003
MLAND:AREA	21	50	1000	914	2.83	0.000
YLAND:MLANI	71	128	929	785	2.16	0.000
YLAND:AREA	20	23	909	762	1.36	0.132

Percent Explained = 36%

Prediction for 4Xq in October

Year	Retransformed Mean	Variance	Catch	Effort
1990	0.496	0.737	2.3	4.5
1991	0.295	0.557	26.4	89.5
1992	0.117	0.568	179.2	1533.0
1993	0.218	0.611	131.8	604.5
1994	0.206	0.539	112.6	546.2
1995	0.176	0.648	28.9	163.6
1996	0.175	0.667	16.7	95.5
1997	0.348	0.719	7.6	21.7
1998	0.033	0.754	4.3	132.2
1999	0.231	0.730	4.4	19.0
2000	0.838	0.723	17.6	21.0

Gillnet, 4Xmnopqr, 4Wk & 5Yb, Tons per Fleet

Effect	Df	Deviance Explained	Residual Df	Resid Deviance	F-Value	Pr(F)
NULL			1789	1686		
BOAT	49	542	1740	1144	22.31	0.000
YLAND	10	135	1730	1010	27.20	0.000
MLAND	7	31	1723	978	8.98	0.000
AREA	7	10	1716	969	2.74	0.008
YLAND:MLANI	39	83	1677	886	4.28	0.000
YLAND:AREA	45	68	1632	818	3.05	0.000
MLAND:AREA	30	25	1602	794	1.67	0.013

Percent Explained = 53%

Prediction for 4Xp in July

Year	Retransformed Mean	Variance	Catch	Effort
1990	0.006	0.638	0.7	127.1
1991	0.014	0.554	2.2	158.9
1992	0.029	0.625	8.5	293.0
1993	0.047	0.536	56.4	1189.2
1994				
1995	0.038	0.322	269.2	7094.6
1996	0.038	0.319	422.1	11096.2
1997	0.033	0.232	332.4	10132.2
1998	0.003	0.640	34.5	13644.3
1999	0.044	0.513	59.7	1367.8
2000	0.045	0.544	124.5	2770.0

Longline, 4VN, Tons per Thousand Hooks

Effect	Df	Deviance Explained	Residual Df	Resid Deviance	F-Value	Pr(F)
NULL			114	51		
BOAT	4	6	110	45	5.74	0.000
YLAND	6	14	104	31	9.29	0.000
MLAND	6	7	98	25	4.35	0.001
YLAND:MLANI	11	2	87	22	0.87	0.568

Percent Explained = 57%

Prediction for July

Year	Retransformed Mean	Variance	Catch	Effort
1995	0.022	0.539	0.2	10.5
1996	0.011	0.520	0.0	0.7
1997	0.158	0.402	21.6	136.4
1998	0.250	0.245	25.1	100.6
1999	0.242	0.176	44.5	183.7
2000	0.196	0.278	19.0	97.0

Longline, 4Vc, Tons per Thousand Hooks

Effect	Df	Deviance Explained	Residual Df	Resid Deviance	F-Value	Pr(F)
NULL			565	581		
BOAT	25	197	540	384	17.82	0.000
YLAND	11	90	529	294	18.61	0.000
MLAND	10	12	519	282	2.82	0.002
YLAND:MLANI	41	71	478	211	3.91	0.000

Percent Explained = 64%

Prediction for July

Year	Retransformed Mean	Variance	Catch	Effort
1990	0.230	0.297	27.4	119.0
1991	0.179	0.240	95.5	534.5
1992	0.357	0.262	150.1	421.0
1993	0.137	0.227	120.3	878.1
1994	0.080	0.497	13.8	171.5
1995	0.096	0.299	69.8	726.3
1996	0.083	0.257	43.9	528.6
1997	0.162	0.315	25.4	156.1
1998	0.267	0.312	40.7	152.8
1999	0.087	0.415	8.6	98.7
2000	0.137	0.356	5.0	36.6

Table 9 (cont). Results of generalized linear modelling of white hake catch per unit effort for Scotia/Fundy landings by index fishers.

Longline, 4Wgjkl, Tons per Thousand Hooks

Effect	Df	Deviance Explained	Residual Df	Resid Deviance	F-Value	Pr(F)
NULL			963	965		
BOAT	55	334	908	631	12.78	0.000
YLAND	11	40	897	591	7.69	0.000
AREA	3	14	894	577	9.74	0.000
MLAND	11	11	883	566	2.17	0.014
YLAND:AREA	30	54	853	512	3.78	0.000
YLAND:MLAN	73	116	780	396	3.36	0.000
MLAND:AREA	28	38	752	357	2.88	0.000

Percent Explained = 63%

Prediction for 4Wl in July

Year	Retransformed Mean	Variance	Catch	Effort
1990	0.038	0.589	13.6	361.0
1991	0.099	0.546	43.2	437.4
1992	0.052	0.387	68.4	1312.2
1993	0.066	0.411	78.3	1189.2
1994	0.027	0.567	18.8	689.5
1995	0.060	0.307	193.1	3216.3
1996	0.061	0.305	132.8	2192.5
1997	0.075	0.318	67.9	904.4
1998	0.041	0.394	52.0	1276.4
1999	0.044	0.465	47.5	1078.2
2000	0.028	0.325	71.4	2594.7

Longline, 4Wgjkl & 4Vc, Tons per Thousand Hooks

Effect	Df	Deviance Explained	Residual Df	Resid Deviance	F-Value	Pr(F)
NULL			1529	1617		
BOAT	60	484	1469	1133	15.58	0.000
YLAND	11	98	1458	1035	17.13	0.000
AREA	4	18	1454	1017	8.68	0.000
MLAND	11	19	1443	998	3.32	0.000
YLAND:AREA	41	90	1402	908	4.23	0.000
YLAND:MLAN	80	193	1322	715	4.66	0.000
MLAND:AREA	38	51	1284	665	2.58	0.000

Percent Explained = 59%

Prediction for 4Vc in July

Year	Retransformed Mean	Variance	Catch	Effort
1990	0.238	0.333	41.0	450.4
1991	0.186	0.241	138.8	750.8
1992	0.318	0.254	218.6	1588.6
1993	0.117	0.210	198.6	1329.3
1994	0.082	0.544	32.6	76.1
1995	0.105	0.252	262.9	2226.3
1996	0.082	0.229	176.7	1178.9
1997	0.141	0.269	93.2	561.5
1998	0.198	0.284	92.7	781.2
1999	0.097	0.377	56.1	479.8
2000	0.141	0.514	76.4	1116.8

Longline, Inshore (4Xmoqr), Tons per Thousand Hooks

Effect	Df	Deviance Explained	Residual Df	Resid Deviance	F-Value	Pr(F)
NULL			571	574		
BOAT	65	255	506	319	7.72	0.000
AREA	3	1	503	319	0.47	0.706
YLAND	10	16	493	303	3.07	0.001
MLAND	9	8	484	295	1.82	0.062
AREA:YLAND	20	21	464	273	2.12	0.004
AREA:MLAND	17	29	447	244	3.36	0.000
YLAND:MLAN	32	34	415	211	2.08	0.001

Percent Explained = 63%

Prediction for 4Xq in June

Year	Retransformed Mean	Variance	Catch	Effort
1990	0.040	0.387	7.7	194.5
1991	0.000	0.024	3.4	########
1992	0.616	1.851	26.3	42.7
1993	0.026	0.445	41.0	1583.5
1994				
1995	0.177	0.485	293.5	1658.1
1996	0.051	0.609	117.8	2325.5
1997	0.012	0.645	81.4	6835.4
1998	0.028	0.564	106.1	3827.6
1999	0.003	0.601	35.1	12679.8
2000	0.282	0.561	29.2	103.7

Longline, Offshore (4Xnp & 5Zjm), Tons per Thousand Hooks

Effect	Df	Deviance Explained	Residual Df	Resid Deviance	F-Value	Pr(F)
NULL			2033	1768		
BOAT	82	371	1951	1398	8.30	0.000
YLAND	10	93	1941	1305	17.04	0.000
MLAND	11	88	1930	1217	14.72	0.000
AREA	3	29	1927	1187	18.00	0.000
YLAND:MLAN	77	148	1850	1039	3.53	0.000
YLAND:AREA	25	39	1825	1000	2.86	0.000
MLAND:AREA	19	18	1806	983	1.70	0.030

Percent Explained = 44%

Prediction for 4Xp in June

Year	Retransformed Mean	Variance	Catch	Effort
1990	0.718	0.620	26.8	37.3
1991	0.216	0.624	28.2	130.5
1992	0.263	0.446	191.4	728.3
1993	0.362	0.285	478.1	1319.0
1994				
1995	0.164	0.204	1286.4	7841.9
1996	0.127	0.427	522.3	4099.5
1997	0.150	0.256	278.2	1856.9
1998	0.122	0.403	176.4	1445.5
1999	0.191	0.285	126.1	660.8
2000	0.285	0.296	157.4	552.5

Table 10a. Summer RV survey stratified mean numbers per tow, with standard error.

Year	4Vn Units	4Vn Stratified mean	4Vn Standard error	4VS Units	4VS Stratified mean	4VS Standard error	4W Units	4W Stratified mean	4W Standard error	4X Units	4X Stratified mean	4X Standard error
1970	284815	4.05	2.57	906225	1.16	0.73	1463825	3.99	0.97	1449332	23.78	18.36
1971	284815	7.10	6.25	918682	1.12	0.79	1463825	1.34	0.38	1484160	3.92	0.87
1972	284815	10.64	10.63	918682	0.33	0.13	1463825	1.65	0.47	1572461	4.70	1.28
1973	284815	7.64	3.31	918682	2.86	1.38	1463825	2.10	0.63	1572461	14.41	7.57
1974	284815	5.80	2.53	918682	9.40	8.94	1349932	4.15	0.79	1572461	8.27	2.50
1975	284815	3.27	2.44	918682	2.27	1.02	1463825	1.85	0.40	1572461	22.99	12.33
1976	200074	24.47	20.37	720302	2.92	0.99	1463825	2.62	0.62	1527379	5.77	1.54
1977	284815	16.97	15.89	918682	2.79	2.00	1463825	2.46	0.75	1572461	6.59	1.56
1978	284815	9.56	7.92	906479	1.09	0.42	1463825	3.79	0.97	1522972	6.57	1.95
1979	284815	4.37	2.69	918682	1.32	0.41	1463825	1.26	0.25	1447213	4.22	0.84
1980	284815	9.66	8.59	918682	1.36	0.52	1463825	1.55	0.53	1572461	2.11	0.39
1981	284815	15.17	6.98	918682	12.73	9.55	1463825	4.19	1.71	1572461	5.26	1.74
1982	284815	35.79	28.38	906479	7.07	4.86	1463825	4.58	1.59	1572461	6.88	1.74
1983	284815	13.68	9.40	918682	25.15	2.61	1463825	5.42	2.74	1572461	25.51	8.53
1984	284815	13.90	9.03	918682	16.22	9.57	1463825	5.77	1.70	1558818	10.89	2.65
1985	284815	43.68	30.86	918682	28.95	11.01	1463825	3.50	0.93	1572461	9.40	2.39
1986	284815	50.62	22.95	918682	6.96	2.60	1463825	8.60	2.03	1572461	23.90	5.27
1987	284815	10.39	3.05	918682	4.02	1.50	1463825	3.91	0.96	1572461	13.05	3.26
1988	284815	17.20	10.04	918682	7.81	5.71	1463825	5.74	1.41	1572461	7.94	2.80
1989	284815	35.02	23.07	918682	5.97	4.49	1463825	5.60	2.37	1572461	8.35	1.35
1990	284815	7.29	4.12	918682	2.51	0.71	1366033	4.61	0.77	1572461	14.13	5.09
1991	284815	12.66	8.30	918682	3.20	0.58	1463825	2.56	0.46	1572461	19.43	5.85
1992	284815	3.65	2.66	918682	9.68	3.82	1463825	2.12	0.51	1572461	31.35	3.76
1993	284815	20.18	15.87	918682	3.50	1.39	1463825	2.45	0.90	1572461	10.10	1.68
1994	284815	15.73	4.22	918682	1.82	0.78	1463825	2.49	0.69	1572461	8.89	1.26
1995	284815	7.72	4.82	918682	10.75	6.34	1463825	2.35	1.15	1572461	12.37	2.17
1996	284815	15.46	6.56	918682	7.48	2.78	1463825	1.98	0.60	1487381	14.77	1.57
1997	284815	16.08	10.10	819788	20.47	14.61	1463825	2.26	0.92	1572461	4.59	1.08
1998	284815	8.44	7.55	918682	4.41	2.52	1463825	3.33	0.96	1572461	4.92	1.33
1999	284815	6.08	3.57	918682	1.86	0.84	1395100	2.79	0.76	1572461	5.94	0.84
2000	284815	6.63	3.76	918682	6.42	2.92	1463825	4.04	1.18	1572461	9.51	1.31
2001	284815	47.64	27.61	918682	1.12	0.42	1463825	1.76	0.58	1572461	12.59	4.40

Table 10b. Summer RV survey stratified mean weight per tow, with standard error.

	4Vn			4VS			4W			4X		
Year	Units	Stratified mean	Standard error	Units	Stratified mean	Standard error	Units	Stratified mean	Standard error	Units	Stratified mean	Standard error
1970	284815	5.21	3.27	906225	0.72	0.47	1463825	6.92	2.39	1449332	30.27	23.26
1971	284815	4.30	3.82	918682	0.93	0.52	1463825	1.50	0.55	1484160	4.27	0.65
1972	284815	10.38	10.38	918682	0.44	0.16	1463825	2.68	0.71	1572461	6.73	1.29
1973	284815	6.14	2.82	918682	3.21	1.30	1463825	3.01	1.03	1572461	16.36	6.86
1974	284815	5.41	2.42	918682	4.83	4.19	1349932	6.21	2.76	1572461	8.16	1.43
1975	284815	1.92	1.46	918682	1.52	0.59	1463825	2.67	0.74	1572461	22.17	8.68
1976	200074	16.57	13.05	720302	2.59	1.08	1463825	2.64	0.70	1527379	7.47	1.59
1977	284815	13.38	12.17	918682	3.20	2.37	1463825	4.57	1.54	1572461	10.51	3.38
1978	284815	10.32	8.07	906479	1.64	1.00	1463825	3.62	0.98	1522972	11.18	3.41
1979	284815	4.66	3.00	918682	1.47	0.57	1463825	2.02	0.43	1447213	7.43	1.46
1980	284815	7.64	6.36	918682	1.14	0.31	1463825	2.38	0.86	1572461	5.30	1.11
1981	284815	16.24	7.56	918682	9.93	6.41	1463825	3.76	1.23	1572461	9.23	3.93
1982	284815	22.25	14.21	906479	4.20	2.46	1463825	4.37	1.25	1572461	9.31	2.07
1983	284815	7.10	3.75	918682	10.39	1.04	1463825	4.29	1.30	1572461	32.50	11.44
1984	284815	9.66	7.32	918682	13.67	7.61	1463825	8.91	3.20	1558818	15.93	4.45
1985	284815	30.82	21.32	918682	23.26	9.82	1463825	4.47	0.84	1572461	14.10	2.76
1986	284815	44.45	24.40	918682	6.64	1.83	1463825	9.30	2.51	1572461	23.21	5.18
1987	284815	10.61	3.44	918682	2.11	0.69	1463825	5.16	1.19	1572461	18.98	4.59
1988	284815	12.25	6.60	918682	3.91	2.36	1463825	5.18	1.16	1572461	12.01	4.64
1989	284815	17.69	11.31	918682	2.47	1.64	1463825	4.01	1.00	1572461	10.48	1.81
1990	284815	4.58	2.47	918682	1.94	0.90	1366033	4.21	1.18	1572461	19.38	8.18
1991	284815	5.52	2.76	918682	2.87	0.75	1463825	3.19	0.50	1572461	21.92	10.23
1992	284815	2.10	1.14	918682	4.45	1.94	1463825	1.30	0.28	1572461	27.90	5.19
1993	284815	11.54	9.69	918682	1.63	0.61	1463825	1.74	0.60	1572461	10.28	2.25
1994	284815	7.13	2.32	918682	1.09	0.55	1463825	1.49	0.48	1572461	6.91	0.75
1995	284815	2.78	1.78	918682	4.78	2.74	1463825	0.93	0.35	1572461	13.48	2.07
1996	284815	8.82	4.02	918682	2.47	0.83	1463825	1.05	0.38	1487381	20.69	2.93
1997	284815	9.20	4.74	819788	8.95	6.55	1463825	1.37	0.76	1572461	5.96	2.02
1998	284815	4.67	3.91	918682	1.92	0.99	1463825	1.81	0.54	1572461	4.98	1.98
1999	284815	3.31	1.60	918682	1.06	0.71	1395100	1.73	0.41	1572461	6.67	1.12
2000	284815	3.47	2.02	918682	1.74	0.86	1463825	2.75	0.90	1572461	7.24	1.13
2001	284815	22.36	13.23	918682	0.67	0.28	1463825	1.56	0.65	1572461	15.86	4.50

Table 11. Numbers at age (000s) in the eastern Scotian Shelf (4VWXmn).

AGE	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985
1	1530	645	199	1239	1519	1046	1157	315	1011	369	331	3285	2270	13427	1263	2019
2	1029	2128	673	2263	7868	2293	5334	2315	2852	1364	1705	9145	13048	13105	11034	13488
3	625	490	1595	1064	2752	1003	2773	3446	1511	713	2235	5045	4080	4758	5263	15418
4	1049	545	2176	1339	1549	992	1308	2730	1735	521	1516	5656	1515	1908	4544	9338
5	910	241	925	403	855	319	760	747	1458	293	570	2102	677	349	2050	1798
6	778	127	538	407	414	243	200	843	484	363	191	1540	816	273	1439	1031
7	1148	229	212	405	614	160	59	594	462	249	193	394	484	122	850	389
8	472	114	115	99	440	189	45	89	114	95	157	305	188	240	225	164
9	101	22	48	116	99	80	146	39	57	20	120	7	120	73	264	83
10	0	0	44	59	60	0	0	0	0	106	29	26	45	13	105	0
11	0	45	7	45	0	16	66	0	91	0	0	0	0	55	46	141
12	0	0	0	24	0	52	0	0	0	10	28	0	0	0	0	0
13	68	0	0	0	44	0	0	37	0	50	0	0	0	0	75	8
14	0	0	0	73	44	0	0	0	16	0	0	0	0	0	75	0
15	0	0	0	0	0	9	0	0	0	0	0	0	0	0	0	0
16	0	0	0	0	0	0	0	37	0	0	0	0	11	0	0	13
17	0	0	0	0	0	0	0	0	0	0	0	0	0	55	0	0
Age 4+	4525	1323	4064	2969	4119	2059	2583	5117	4417	1707	2803	10029	3855	3089	9673	12966
Age 7+	1788	411	425	820	1301	506	316	797	740	530	526	731	848	559	1640	799

AGE	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
1	3964	2001	3602	6050	1923	2560	2408	2204	3351	3358	3329	5111	2607	994	4811	2577
2	8272	2971	7911	9827	3086	2978	7096	5783	3371	8356	7213	13633	5637	3630	4861	9070
3	6947	1896	3658	4131	2093	1103	1917	2533	800	1219	1817	2837	1772	1179	1518	3363
4	7512	2707	2505	1993	2194	1317	899	1218	1133	726	1064	1825	889	813	1302	1652
5	3169	1105	897	384	872	969	184	316	389	201	343	338	230	201	513	183
6	1403	742	895	433	440	1074	138	133	137	133	0	148	83	47	138	49
7	727	182	408	120	147	122	85	39	11	16	0	0	22	47	43	88
8	346	304	156	161	0	0	0	11	44	0	0	0	0	0	0	0
9	130	78	68	0	37	37	0	0	0	0	0	0	0	0	0	0
10	0	44	0	53	0	0	0	0	0	0	0	0	0	0	0	0
11	96	63	0	0	0	0	0	0	0	0	0	0	0	10	0	0
12	34	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
13	34	0	6	0	37	0	0	0	0	0	0	0	24	0	0	0
14	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
15	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
16	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
17	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Age 4+	13450	5225	4935	3145	3727	3519	1306	1716	1714	1075	1407	2311	1249	1118	1995	1971
Age 7+	1366	671	638	334	221	159	85	50	55	16	0	0	46	57	43	88

Table 12. Numbers at age (000s) in the western Scotian Shelf (4Xopqrst).

Age	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985
1	2474	1213	464	1216	1340	2571	637	920	1384	1250	29	1545	1150	1967	1003	1609
2	4337	893	2741	3124	1762	16879	2330	2388	1126	1430	225	1308	2648	5107	2902	2779
3	8546	967	913	8994	1361	5138	2599	881	1056	1177	519	623	2592	10623	3039	1545
4	11297	403	1128	6846	1618	5876	1388	1746	1781	1341	566	1312	1592	14340	3682	3010
5	3315	511	391	1718	854	1450	449	1205	977	336	254	732	386	3510	2194	1403
6	3151	633	434	1445	849	1474	443	839	1412	721	322	1555	725	1270	1770	1641
7	1151	417	358	1016	916	1112	359	824	1073	434	224	1319	610	861	1193	998
8	645	156	285	537	357	921	221	592	419	368	512	1104	553	783	684	962
9	219	66	239	396	306	365	106	541	261	321	378	441	296	1076	290	659
10	0	0	0	0	27	19	128	51	0	225	0	0	67	295	32	41
11	47	0	0	80	39	153	30	129	0	23	43	187	162	94	100	22
12	0	0	0	0	0	0	20	0	112	0	0	0	0	62	62	0
13	105	0	62	0	0	17	0	22	0	23	51	0	0	0	0	0
14	0	0	62	0	0	0	0	0	0	0	43	0	0	0	0	0
15	0	0	53	0	0	17	0	0	0	0	0	0	0	0	0	23
16	0	0	0	0	0	0	39	0	49	0	0	0	0	0	0	0
17	0	17	22	0	0	0	0	0	49	0	0	0	0	0	0	0
18	123	0	0	0	0	0	0	0	0	0	0	0	0	0	32	0
19	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
20	0	0	0	0	0	0	0	0	0	0	0	0	27	0	0	0
21	0	0	0	0	0	0	20	0	0	0	0	0	0	0	0	0
22	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4+	20053	2204	3036	12038	4967	11405	3204	5949	6132	3792	2393	6649	4417	22293	10038	8759
7+	2290	656	1082	2030	1646	2605	924	2159	1963	1394	1251	3050	1715	3172	2392	2705

Age	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
1	6822	1486	1686	1768	2224	4281	4940	2157	3812	1862	1512	907	1583	1502	2640	15
2	12515	3267	2247	2636	3491	8524	12106	3238	3000	3974	2120	1529	2042	1699	6005	1261
3	4567	4575	1302	2805	4647	5459	14711	2231	1868	3646	3241	1042	932	1752	2011	5830
4	6736	4954	1896	2539	5246	5646	11192	3357	1939	4212	5900	1124	902	1989	2159	7901
5	1810	1379	1638	727	2171	1535	2588	1623	743	1178	3347	704	454	965	368	2638
6	1716	1536	1487	690	1719	1683	1569	1624	745	2104	3852	853	321	474	818	890
7	1706	1745	929	881	1513	1836	612	657	346	741	1766	502	274	131	506	932
8	833	989	727	701	715	861	1201	300	163	287	442	258	187	58	140	203
9	374	350	264	229	240	157	330	16	63	187	7	139	156	89	53	93
10	225	0	22	0	128	0	0	0	62	114	0	0	0	0	0	10
11	0	90	46	32	0	125	0	0	0	66	44	0	63	0	0	31
12	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
13	0	56	0	22	0	66	0	0	0	0	50	0	20	0	0	0
14	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
15	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
16	0	0	21	0	0	0	0	0	0	0	0	0	0	29	0	0
17	0	0	0	0	27	0	0	0	0	0	0	0	0	0	0	0
18	30	0	66	0	0	0	0	0	0	0	0	0	0	0	0	0
19	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
20	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
21	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
22	0	0	0	0	0	0	0	0	0	0	0	0	0	65	19	0
4+	13430	11100	7096	5821	11759	11909	17492	7577	4061	8889	15407	3580	2378	3801	4063	12698
7+	3168	3231	2075	1865	2623	3044	2143	973	634	1395	2309	899	700	373	718	1269

Table 13. Mortality Estimates, eastern Scotian Shelf .

	Paloheimo's Zs	Annual Catch Curve, Ages 4-7		Ages 4-8		Ages 4-9		Cohort Catch Curve (Ages 4-7)	
	ln(5-7/4-6)	Z	R^2	Z	R^2	Z	R^2	Z	R^2
1970	1.52								
1971	-0.61	0.32	0.49	0.32	0.65	0.50	0.77		
1972	1.10	0.75	0.99	0.74	1.00	0.75	1.00		
1973	0.13	0.36	0.60	0.52	0.80	0.47	0.84		
1974	1.36	0.35	0.66	0.29	0.69	0.44	0.79		
1975	0.42	0.57	0.90	0.40	0.77	0.42	0.86		
1976	0.04	1.06	0.97	0.93	0.96			0.54	0.99
1977	0.59	0.45	0.71	0.71	0.82	0.80	0.90		
1978	1.40	0.51	0.87	0.66	0.91	0.70	0.95		
1979	0.21	0.20	0.65	0.36	0.78	0.57	0.80		
1980	-0.57	0.73	0.89						
1981	1.55	0.83	0.95	0.75	0.96				
1982	1.40	0.32	0.76	0.45	0.86	0.49	0.92		
1983	-0.54	0.85	0.90	0.52	0.64	0.52	0.76	0.36	0.96
1984	0.91	0.54	0.98	0.69	0.95	0.61	0.94	0.99	0.89
1985	0.83	1.01	0.96	0.96	0.97	0.91	0.98	1.09	0.98
1986	1.78	0.78	1.00	0.76	1.00	0.79	1.00	1.26	0.93
1987	0.73	0.85	0.95	0.62	0.84	0.66	0.91	0.95	0.99
1988	1.52	0.55	0.89	0.63	0.94	0.69	0.96	0.89	0.86
1989	0.66	0.83	0.87	0.62	0.80			0.93	0.75
1990	0.48	0.88	0.99			0.82	1.00	1.40	0.98
1991	2.11	0.70	0.67			0.78	0.88	1.47	0.93
1992	0.92	0.74	0.87					1.30	0.95
1993	1.13	1.12	0.99	1.15	1.00				
1994	1.56	1.49	0.95						
1995		1.19	0.93					1.13	0.95
1996	1.06							1.08	0.98
1997	1.93							1.29	0.89
1998	1.40	1.21	1.00					0.73	0.89
1999	0.43	1.00	0.89						
2000	1.81	1.16	1.00						
2001		1.01	0.72						
Decadal averages									
1970s	0.62	0.51		0.55		0.58		0.54	
1980s	0.83	0.73		0.67		0.67		0.92	
1990-2001	1.20	0.97		0.80		0.76		1.13	
1970-2001	0.91	0.77		0.64		0.64		1.03	

Table 14. Mortality Estimates, western Scotian Shelf.

	Paloheimo's Zs	Annual Catch Curve Ages 4-9		Ages 4-8		Cohort Catch Curve (Ages 4-8)	
	ln(5-7)/(4-6)	Z	R^2	Z	R^2	Z	R^2
1970	2.43	0.73	0.97	0.68	0.95		
1971	0.27	0.78	0.98				
1972	-0.76	0.25	0.77	0.28	0.72		
1973	1.34	0.52	0.92	0.56	0.90		
1974	-0.20	0.31	0.85	0.30	0.75		
1975	1.95	0.44	0.85	0.40	0.74		
1976	-0.23	0.43	0.91	0.39	0.84		
1977	0.09	0.23	0.95	0.26	0.95		
1978	1.03	0.36	0.80	0.28	0.65		
1979	1.10	0.21	0.50	0.23	0.41		
1980	-1.15						
1981	0.74						
1982	-0.74						
1983	1.31						
1984	0.64	0.47	0.96	0.40	0.98		
1985	0.15	0.40	0.77	0.26	0.80	0.46	0.94
1986	0.79	0.48	0.88	0.42	0.78	0.61	0.87
1987	0.66	0.40	0.77	0.30	0.60		
1988	0.78	0.37	0.87	0.25	0.94		
1989	-0.31	0.34	0.69			0.73	0.90
1990	0.59	0.54	0.92	0.44	0.92	0.69	0.93
1991	0.62	0.56	0.78	0.36	0.69	0.80	0.95
1992	1.37	0.60	0.83	0.59	0.73	0.74	0.89
1993	1.28			0.57	0.94	0.53	0.66
1994	-0.16	0.64	0.96	0.57	0.95	0.66	0.73
1995	-0.18	0.60	0.89	0.58	0.82	1.01	0.96
1996	1.85			0.58	0.83	0.76	0.83
1997	0.94	0.40	0.90	0.33	0.84		
1998	0.07	0.33	0.95	0.37	0.95		
1999	0.71	0.72	0.91	0.91	0.99		
2000	-0.29	0.63	0.80	0.52	0.65		
2001		0.85	0.96	0.84	0.94		
Decadal averages							
1970s	0.70	0.43		0.37			
1980s	0.29	0.41		0.33		0.60	
1990-2001	0.62	0.59		0.55		0.74	
1970-2001	0.54	0.48		0.45		0.70	

Table 15. Traffic Light Table for 4VsW White Hake.

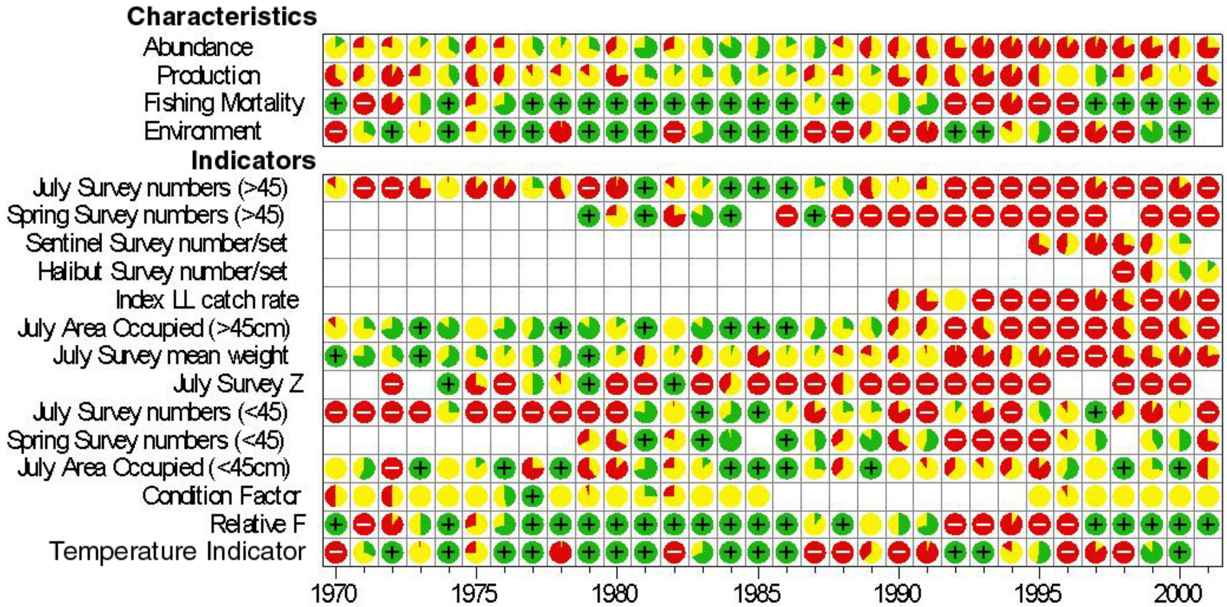

Table 16. Traffic Light Table for 4X White Hake.

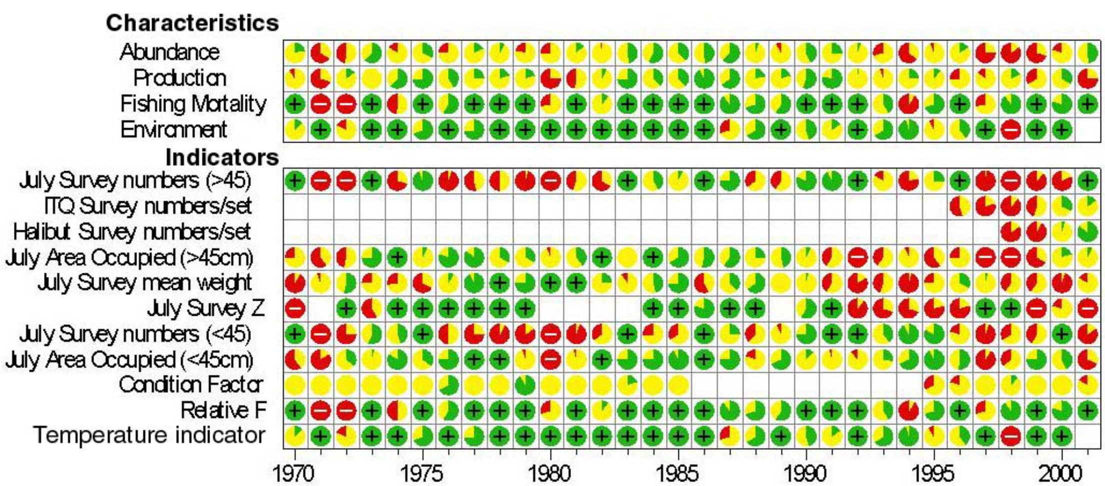

Table 17. Description of traffic light boundary points, weights and rationale for 4VsW.

Indicator	Green Boundary	Red Boundary	Characteristic	Weight
Summer RV N 45+ cm	6,000,000	2,000,000	Abundance	1
	This value cuts across the peaks during the 1980s	This value represents the low abundance years in the early 1990s.		Down-weighted because this is an indirect index of abundance
Spring RV 45+ cm	7,500,000	1,500,000	Abundance	1
	This value cuts across the large peak during the 1980s	This value represents the low abundance years in the 1990s.		
4VsW Sentinel	30	4	Abundance	1
	This is a short time series and thus its true range is uncertain. The green value was set a little above the highest observed in the time series in order to make this uncertainty explicit	This represents the low end of the data series.		
Halibut no/set	20	5	Abundance	1
	This is a short time series and thus its true range is uncertain. The green value was set a little above the highest observed in the time series in order to make this uncertainty explicit	This represents the low end of the data series.		
Index LL	0.4	0.1	Abundance	1
	Boundary chosen for consistency with the summer RV survey	Boundary chosen for consistency with the summer RV survey		
Area Occupied 45+	0.3	0.15	Abundance	0.5
	This value represents a plateau from the mid 1970s to the early 1980s	It is assumed that a 50% reduction in area occupied is bad.		Down-weighted because this is an indirect index of abundance
July Survey Mn Wt 45+	1.25	0.5	Abundance	0.5
	This represents the high mean weight values in the 1970s	This represents the worst years in the data series, during the 1990s.		Down-weighted because this is an indirect index of abundance
RV Z	0.4	0.6	Production	1
	This is based on $F_{0.1}$ for cod plus an assumed natural mortality of 0.2..	This is based on F_{max} for cod plus an assumed natural mortality of 0.2..		
RV N< 45 cm	15,000,000	4,000,000	Production	1
	This value cuts across the main peak in the data series	This value represents the low abundance years in the 1970s.		
Spring RV< 45 cm	6,000,000	1,500,000	Production	1
	This value cuts across the peaks during the 1980s	This value represents the low abundance years in the early 1990s.		
Area Occupied < 45 cm	0.3	0.15	Production	0.5
	This value represents the high range of the data points	Although there is a decline in the data series it is unclear what value is really bad. Thus a low of 0.15, 50% of the green was used		Down-weighted because this is an indirect index of production
Condition Factor	780	680	Production	0.5
	No trend in CF data, therefore no definite good or bad. This value is slightly below a single high value	No trend in CF data. This value is slightly below the minimum observed. NB. This indicator has a plateau in order to convey uncertainty		Down-weighted because this is an indirect index of production
Relative F	0.2	0.4	Mortality	1
	This is based on $F_{0.1}$ for cod.	This is based on F_{max} for cod.		
Area > 6C	60	50	Environment	1
	This value represents a plateau from the early 1970s to the early 1980s	This value represents the low values in the data series		

Table 18. Description of traffic light boundary points, weights and rationale for 4X.

Indicator	Green Boundary	Red Boundary	Characteristic	Weight
RV N 45+ cm	15,000,000	4,000,000	Abundance	1
	This value cuts across a series of peaks in abundance	This value represents the low end of the data series		
ITQ no/set	9	2	Abundance	1
	This is a short time series and thus its true range is uncertain. The green value was set a little above the highest observed in the time series in order to make this uncertainty explicit	This is the lowest value in the time series and corresponds to a low in the RV series.		
Halibut no/set	35	5	Abundance	1
	This is a short time series and thus its true range is uncertain. The green value was set a little above the highest observed in the time series in order to make this uncertainty explicit	This is the lowest value in the time series and corresponds to a low in the RV series.		
Area Occupied 45+ cm	0.6	0.3	Abundance	0.5
	This value represents a plateau from the early 1970s to the early 1980s	This value represents the low end of the data series, observed in the 1990s		Down-weighted because this is an indirect index of abundance
July Survey Mn Wt 45+	1.8	0.8	Abundance	0.5
	This value represents the best mean weights in the times series, which were observed in the 1970s	This value represents the low end of the data series.		Down-weighted because this is an indirect index of stock structure
July Survey Z	0.4	0.6	Production	1
	This is based on $F_{0.1}$ for cod plus an assumed natural mortality of 0.2..	This is based on F_{max} for cod plus an assumed natural mortality of 0.2..		
RV N< 45 cm	9,000,000	3,000,000	Production	1
	This value represents the base of the three main peaks in the data series	This value represents the low abundance years in the data series		
Area Occupied < 45 cm	0.5	0.25	Production	0.5
	This value represents a broad range of peaks in the data series	Although there is a decline in the data series it is unclear what value is really bad. Thus a low of 0.25, 50% of the green was used.		Down-weighted because this is an indirect index of production
Condition Factor	740	650	Production	0.5
	No trend in CF data, therefore no definite good or bad. This value is slightly above the highest CF value seen	No trend in CF data. This value is slightly below the minimum observed. NB. This indicator has a plateau in order to convey uncertainty.		Down-weighted because of the uncertainty associated with this indicator.
Relative F	0.2	0.4	Mortality	1
	This is based on $F_{0.1}$ for cod.	This is based on F_{max} for cod.		
Area 6-10 C	80	50	Environment	
	This value represents a plateau from the early 1970s to the early 1980s	This value represents the low end of the data series, observed in the early 1970s and 1990s		1