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Assessment of the Status, Threats and Recovery Potential of Cusk (*Brosme brosme*)

Évaluation de l'état, des menaces et du potentiel de rétablissement du brosme (*Brosme brosme*)

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ABSTRACT

In May 2003, the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) assessed cusk (*Brosme brosme)* as threatened. Cusk are currently under consideration for addition to Schedule 1 of the *Species at Risk Act* (SARA). The recovery potential assessment (RPA) will inform the listing decision, socio-economic analyses, and consultations with the public. Should this species be legally listed as threatened or endangered, the RPA will also inform the recovery strategy.

Cusk abundance has declined since the 1970s; however, there are insufficient data to determine the degree of decline. There is conflicting evidence as to whether cusk abundance has continued to decline since the late 1990s. There has been no reduction in the range of cusk in Canadian waters. Cusk do not seem to have disappeared from any areas where they have been caught historically.

A reasonable strategy for recovery would be to achieve an increasing trend in abundance, as measured by an appropriate index. A reasonable spatial target would be to avoid any human-induced reduction in range and distribution. Fishing is the only known major source of human-induced mortality for cusk. Canadian cusk landings from the North Atlantic Fisheries Organization (NAFO) divisions 4VWX and subarea 5 have ranged from 790 metric tonnes (t) to 1490t between 1999 and 2006. The majority of these landings are from the groundfish longline fishery in 4X and 5Z. Minimum cusk mortalities in lobster fisheries were estimated to be 226t in Lobster Fishing Area (LFA) 34 in 2005/2006 and 22t in LFA 41 in 2005/2006, and 169t in LFA 34 in 2006/2007.

Adult cusk prefer structured, hard bottom habitat and a depth range of 400m to 600m. The preferred habitat of juvenile cusk is not known. Habitat does not appear to be, nor is likely to become, a limiting factor to cusk survival and recovery. There are no known threats that have reduced cusk habitat quantity or quality.

RÉSUMÉ

En mai 2003, le Comité sur la situation des espèces en péril au Canada (COSEPAC) a procédé à une évaluation du brosme et a jugé qu'il était menacé. À l'heure actuelle, on envisage de l'ajouter à la liste figurant à l'annexe 1 de la *Loi sur les espèces en péril* (LEP). L'évaluation du potentiel de rétablissement (EPR) éclairera la décision relativement à l'inscription sur la liste, les analyses socioéconomiques, ainsi que les consultations auprès du public. Si cette espèce est inscrite légalement sur la liste, l'EPR éclairera également la stratégie de rétablissement.

L'abondance du brosme a diminué depuis les années 1970; toutefois, on ne dispose pas de suffisamment de données pour déterminer l'ampleur du déclin. Il y a des éléments d'information contradictoires quant à savoir si l'abondance du brosme a continué de diminuer depuis la fin des années 1990. L'aire de répartition du brosme dans les eaux canadiennes n'a pas diminué et l'espèce ne semble avoir disparu d'aucune des zones où on la capturait par le passé.

Une stratégie de rétablissement raisonnable serait celle d'atteindre une tendance croissante de l'abondance, telle que mesurée par un indice approprié. Un objectif spatial raisonnable consisterait à éviter toute réduction d'origine anthropique dans l'aire de répartition et dans la distribution. La pêche est la seule grande source connue de mortalité d'origine anthropique chez le brosme. Les débarquements canadiens de brosme en provenance des divisions 4VWX+5 de l'Organisation des pêches de l'Atlantique Nord-Ouest (OPANO) se sont situés entre 790 tonnes métriques (tm) et 1 490 tm de 1999 à 2006. La majorité de ces débarquements viennent de la pêche du poisson de fond à la palangre dans 4X et 5Z. La mortalité minimale du brosme dans la pêche du homard en 2005-2006 a été estimée à 226 tm dans la zone de pêche du homard (ZPH) 34, à 22 tm dans la ZPH 41 et à 169 tm dans la ZPH 34 en 2006-2007.

Le brosme adulte préfère les habitats structurés au fond dur situés dans des profondeurs de 400 à 600 m. On ne sait pas quel est l'habitat de prédilection du brosme juvénile. L'habitat ne semble ni être, ni risquer de devenir un facteur limitatif à la survie et au rétablissement du brosme. Il n'y a pas de menaces connues ayant occasionné une baisse de la quantité et de la qualité de l'habitat.

INTRODUCTION

Cusk (*Brosme brosme*) are currently under consideration for addition to Schedule 1 of the *Species at Risk Act* (SARA). The recovery potential assessment (RPA) will inform the listing decision, socio-economic analyses and consultations with the public. Should this species be legally listed as threatened or endangered, the RPA will also inform the recovery strategy.

The most recent stock status report for cusk was written in 1998 (DFO 1998). An evaluation of cusk in reference to extinction risk was prepared and reviewed during the 2002 National Advisory Process (NAP) (DFO 2002). A research document addressing the terms of reference set out for the NAP is available (Harris *et al.* 2002). COSEWIC (Committee on the Status of Endangered Wildlife in Canada) designated cusk as threatened in May 2003 based on a new status report. The rationale provided for this designation was:

> "The main population of this large, slow-growing, solitary bottom-living fish resides in the Gulf of Maine/Southeastern Scotian Shelf and has been in decline since 1970. Over 3 generations, the decline rate is over 90%, and the fish occurs in fewer and fewer survey trawls over time. Fishing, unrestricted until 1999, is now capped but remains a source of mortality. This species is in a monotypic North Atlantic genus." (COSEWIC 2003, p. iii)

Following COSEWIC's assessment, Department of Fisheries and Oceans Canada (DFO) prepared an allowable harm assessment (DFO 2004), which was reviewed during a NAP meeting convened in October 2004. In April 2006, following consultations with the Provinces, Aboriginal peoples, stakeholders and the public, the Governor in Council (GiC) referred the assessment back to COSEWIC for further information and consideration. The GiC recommended that the cusk assessment be returned to COSEWIC since all available information was not used. The explanation provided was that significant emphasis was placed on trawl survey data, which may have exaggerated the decline of cusk. Cusk are a bottom-dwelling species best measured by tools that can reach cusk at greater depths, such as the available longline surveys and commercial catch data; these tools suggest cusk may be more abundant than indicated in the assessment. In December 2006, COSEWIC reaffirmed the original assessment without reassessing the species, citing an absence of new information that would lead to a change in the status of this species. Thus, the species is once again being considered for listing on Schedule 1 of the SARA.

SARA is intended to protect species at risk of extinction in Canada and promote their recovery. SARA includes prohibitions on killing, harming, harassing, capturing or taking individuals of species listed as threatened or endangered on Schedule 1. SARA prohibits sale or trade of individuals of such species (or their parts), damage or destruction of their residences or destruction of their critical habitat. SARA also specifies that a recovery strategy must be prepared for species that are listed as threatened or endangered. The provisions of these recovery strategies will have to address all potential sources of harm, including harvesting activities, in a way that will not jeopardize the survival and recovery of the populations concerned.

Section 73 (2) of the SARA provides the competent ministers with the authority to permit normally prohibited activities affecting a listed species, its critical habitat, or its residence, even though they are not part of a previously approved recovery plan. Such activities can only be approved if: 1) they are scientific research relating to the conservation of the species and conducted by qualified persons; 2) they will benefit the species or are required to enhance its chance of survival in the wild; or 3) affecting the species is incidental to the carrying them out.

The decision to permit allowable harm and the development of a recovery strategy must consider the species' current situation and its recovery potential, the impacts of human activities on the species and its ability to recover, as well as alternatives and measures to reduce these impacts to a level which will not jeopardize the survival and recovery of the species. Therefore, a species recovery potential assessment process was established by DFO Science Branch in order to provide the information and scientific advice required to meet the various requirements of the SARA, such as the authorization to carry out activities that would otherwise violate the SARA, as well as the development of recovery strategies. In the case of a species that has not yet been added to Schedule 1, such as cusk, the scientific information also contributes to the decision on whether or not to add the species to the list. Consequently, the information is used when analyzing the socio-economic impacts of adding the species to the list as well as during subsequent consultations, where applicable.

SPECIES ECOLOGY

Cusk is a solitary, sedentary, slow swimming species (Colette and Klein-MacPhee 2002), found across the northern North Atlantic from the United States, north to Greenland, across to Iceland, Svalbard, along the Murmansk Coast, and south in the Northeast Atlantic to Ireland. It has also been found along the mid-Atlantic Ridge (Figure 1). In Canadian waters, cusk is most common in the Gulf of Maine, Western Scotian Shelf, and along the edge of the Scotian Shelf to Banquereau Bank (see Figure 2 for locations of oceanographic features) although it has been caught from Cape Cod, in the United States, to Labrador. It is rare in the Gulf of St. Lawrence and the inner Bay of Fundy. Cusk prefer a hard, rocky bottom or gravel (Svetovidov 1948, Bigelow and Schroeder 1953, Oldham 1972, Scott and Scott 1988, Colette and Klein-MacPhee 2002) and have been observed hiding in crevices (Hovland and Judd 1988, Freiwald *et al.* 2002, Jones *et al.* 2009). Cusk is considered a deep-water species although it has been observed, albeit less commonly, in shallow waters as well.

Bergstad (1991) found that cusk were caught up to depths of 600m in the Norwegian Deep. In their longline surveys, Hareide and Garnes (2001) found that cusk were caught to depths of 1100m at 2 locations, on the Reykjanes Ridge and on the Hecate Seamount. At these sampling stations, catches were highest at 700m, 1000m and 600m, respectively. Cusk were among the most numerous of species caught in the 3 locations sampled. In the Halibut Industry survey off Nova Scotia and Newfoundland, the largest set of cusk (907kg) was caught at around 560m (DFO Maritimes Industry Surveys Database). The sets with the highest catch per unit effort (CPUE), grouped by 50-metre bins, peaked between 400-600m, with cusk caught at depths as great as 1185m. There were no sets deeper than this; thus, if cusk extend below this depth, they would not have been detected in this survey.

Magnusson *et al.* (1997) reported that cusk spawn from April to July off the south and southwest coasts of Iceland, from March to April in Ireland, the Hebrides and Rockall areas, from April to June in the Faeroes, and from April to May along the Norwegian Shelf. Ichthyoplankton data (DFO Maritimes Scotian Shelf Ichthyoplankton Program Surveys, Bay of Fundy and Georges Bank Larval Fish Surveys) and maturity studies (Oldham 1972, Collette and Klein-MacPhee 2002) indicate that spawning on the Scotian Shelf occurs from May to August, and peaks in June. Port samplers examining catches from the western Scotian Shelf and Gulf of Maine have observed cusk in spawning condition as early as March (G. Donaldson, DFO port sampler, pers. comm.). Cusk are among the most fecund fish (Bigelow and Schroeder 1953). Oldham (1966) reported a range in fecundity of 100,000 eggs in a 56cm fish to 3,927,000 eggs in a 90cm fish. The buoyant eggs are 1.3-1.5mm in diameter with a pinkish oil globule. Hatched pelagic larvae are about 4mm and migrate to the bottom when they have grown to approximately 50mm in length.

In the Northeast Atlantic, most cusk reach maturity by 40-45cm when they are at 8 to 10 years of age. No significant difference in growth rate has been observed between the sexes (Magnusson *et al.* 1997). The otoliths of larger fish are very difficult to read. The oldest fish aged was estimated to be approximately 20 years (Bergstad and Hareide 1996, Magnusson *et al.* 1997). Recently, radiocarbon bomb dating methods have been used to estimate the age of cusk from Canadian waters (L. E. Harris unpubl. data). This ageing effort has returned older age estimates, including an 82cm fish aged at 39 years (the longest reported cusk from Canadian waters is 118cm (DFO Maritimes Industry Surveys Database). These new ageing data also suggest that cusk may reach maturity at 10 years in contrast to previous estimates of 5-6 years. Oldham (1972) found that males do not grow faster than females although they mature more rapidly. He reported lengths at which 50% of the specimens were mature of 43.5cm for males and 50.7cm for females. Studies are currently underway to determine if the length at maturity in Canadian waters has changed since Oldham's work.

The largest cusk recorded in Canadian waters were caught in the Halibut Industry longline survey (largest specimen measured 118cm) (DFO Maritimes Industry Surveys Database). Fish less than 40cm were seen infrequently in port sampling (DFO Maritimes Port Sampling Database), the 4VsW Sentinel survey (DFO Maritimes Industry Surveys Database), and the Halibut Industry survey. The smallest recorded specimens from these data sources were 31cm, 33cm and 31cm, respectively. Juveniles have been caught in annual DFO bottom trawl surveys, but catches in these surveys were low for all sizes of cusk (n=2,755 from 1970 to 2007; DFO Maritimes Regional Ecosystem Surveys Database). If nursery areas exist for juvenile cusk, they have not yet been reported.

In the Northwest Atlantic, the diet of cusk is not well known as their stomachs generally evert when they are brought to the surface (Scott and Scott 1988, Bergstad 1991). An examination of 143 stomachs with contents revealed that cusk diet consists of an assortment of fish and invertebrate species, crabs and shrimps in particular (L.E. Harris unpubl. data). Cusk have, on occasion, been found in the diets of cod (*Gadus morhua*) and halibut (*Hippoglossus hippoglossus*) (DFO Maritimes Stomach Database).

Commercial Fishing

Cusk are caught in a number of fisheries. In Atlantic Canada, most landings are from the groundfish longline fishery targeting cod and haddock (Table 1). Catches by trawlers are low due to cusk's behaviour of hiding in crevices and their preferred rocky habitat (Oldham 1972). Gillnet catches are also low, presumably due in part to the fish's sedentary nature. Cusk can be legally landed and sold from these groundfish fisheries; however, a bycatch cap of 1000t for Northwest Atlantic Fisheries Organization (NAFO) divisions 4VWX (Figures 2 and 3) was introduced in 1999. In 2003, this cap was reduced to 750t for 4VWX+5, where it has remained since. The effectiveness of this mitigation measure is unknown since the exploitation rate is unknown.

Cusk caught in other fisheries, such as lobster and crab pot and trap fisheries, are discarded. They are most often dead when discarded due to the tendency of their stomachs to evert when brought to the surface.

DATA SOURCES AND METHODS

Industry Survey Data

Two industry surveys were investigated for information on cusk: the 4VsW Sentinel survey and the Halibut Industry survey. These surveys began in 1995 and 1998, respectively, and hence provide only short time series. Both surveys use longline gear, which is much more effective for sampling cusk than other gear types due to the species' preference for rocky bottom and its habit of hiding in crevices (Oldham 1972).

The 4VsW Sentinel survey is an annual longline survey of groundfish. Although it samples the Eastern Scotian Shelf, where cusk are fewer, they have been caught every year (DFO Maritimes Industry Surveys Database). Since the number of sets was reduced from over 200 between 1995 and 2000 to 53 in 2004 to 2006, data from the survey were not analysed further because of the short time series and the lack of comparability between survey years.

The Halibut Industry survey, which covers most of 4VWX and parts of 3OPs (Figure 3) provided valuable information on cusk, including catch magnitude and distribution (DFO Maritimes Industry Surveys Database). It is particularly useful because it includes some deeper areas of cusk's distribution along the shelf edge. Cusk were caught throughout the survey area. This survey includes a fixed station and a commercial index component. Catch weights rather than numbers are available because most species caught in the survey are weighed but not always counted. The catch rates in the Halibut Industry survey were adjusted to kilograms per 1000 hooks. Only fixed stations that were occupied in all years were included. The percent of these stations where cusk were caught in each year was also examined to provide an index of distribution.

Commercial Fishing Data

Reported cusk catches in the commercial landings database were examined for this assessment. The reliability of the landings data has been questioned anecdotally, particularly those data before 1999 when the bycatch cap was implemented. Previously there was no catch limit for cusk. It has been suggested that other species, such as cod, were landed as cusk when target species quotas were exceeded. This would have artificially raised estimates for historical landings and catch per unit effort of cusk, and exaggerated the decline in catches. Length frequency information from the port sampling program was also summarised.

It should be noted that the quota year changed in 1999. Prior to 1999, the quota year was the same as the calendar year. In 1999, the quota year ran from January 1999 to March 31, 2000. Starting with 2000, subsequent quota years ran from April 1 to March 31. Statistics presented were calculated accordingly.

Catch rates for longliners targeting groundfish in the Maritimes region were analysed. Analyses were restricted to longliners catching groundfish since this sector has the highest cusk landings (greater than 95% of all landings since 1990) (Table 1). Most landings of cusk are from southwestern Nova Scotia, from unit areas 4Xnopqu (Figure 3). Areas of marginal cusk habitat (sandy or muddy bottoms) and low cusk catches, such as the Bay of Fundy, were not included. Trips were used as the measure of effort. The number of days at sea is not available for 1994 and was sporadically recorded prior to that, making trip the only reliable metric of effort (Gavaris 1996). No effort information is available for small longliners (gross registered tonnage <24.9) in earlier years because frequently the commercial vessel number was not recorded and landings from several vessels and/or trips were aggregated (Gavaris 1996). These were excluded from analyses by only using data from tonnage class 2 and 3 vessels (25-149.9 gross registered tonnes). Thus, the analysis began with the start of the zonal interchange format (ZIF) time series in 1986.

In 2003 and 2007, cusk landings were high during the first half of the fishing year. In an effort to keep landings from further surpassing the bycatch cap of 750t, cusk closures were implemented for longliners in vessel classes less than 65 feet starting in December in 2003 to the end of the quota year and at the end of September in 2007 to the end of the quota year for vessels less than 45 feet. Thus, the 2003 CPUE represents the period of April to November, whereas the 2007 CPUE is for the period of April to September. CPUE was calculated only for the July to September period for all years in order to have a consistent index over time. It is in these months that most cusk are landed. Only using data from these months for analyses also removes any influence of changes in fishing year on CPUE.

Indices of distribution of cusk in the longline groundfish fishery were investigated as range and prevalence from 1991 and 1986 to present, respectively. Range is the percentage of 5-minute square units in 4X where cusk was reported, and prevalence is the percentage of trips that report cusk. Up to 1994, there are data for only a small proportion of trips. In some cases this is because no position information was available, whereas in others it is because data were often not recorded for small vessels prior to 1995. There are no data for range in 1994 because location was not recorded for fixed gear that year.

Special Sampling

There is much anecdotal evidence to suggest that cusk are caught as bycatch in invertebrate trap fisheries. Therefore, a special sampling project was undertaken to estimate bycatch in the lobster fishery in Lobster Fishing Area 34 (LFA 34) (Figure 4). This area was chosen because it is believed to be an area of higher cusk density based on the distribution of longline catches. Also, with almost 1000 lobster license holders, there is a large amount of fishing effort. More limited sampling was undertaken in LFA 41, the ‘offshore’ lobster area, which also encompasses some areas of high cusk landings in the longline fishery.

Cusk were legally landed from the lobster fishery until 1999. Industry members state that efforts have been made since then to reduce bycatch of cusk; however, undetermined numbers of cusk are still being caught. Although these fish are released, they are often dead or moribund, so a portion is currently unreported fishing mortality. Some members of industry suggested that the catch is quite low since the fishing effort is highest close to shore, where cusk are less common. Others suggested that the catches are quite high despite efforts to avoid the fish because they are so widespread and common. Sampling was required to quantify this source of mortality.

At-sea sampling began in the 2005/2006 fishing season after a few pilot sampling trips in 2004. Technicians were tasked with recording all cusk captured in a trip, as well as recording detailed information on both lobster and cusk. To enable calculation of mortality rate, the condition of each fish as it was released from the trap was recorded using the following scale: alive - healthy, alive - stomach everted, dead - stomach everted, dead - stomach not visible, dead and decomposing. This only provides a measure of immediate mortality because discarded live fish that perish after release would have been described as alive. The number of traps with cusk and the total number of traps hauled were also recorded. Sampling effort was distributed to get good spatial coverage of LFA 34 (Figure 5). At-sea sampling also took place in LFA 41 but on a more limited basis (Figure 6). There were only 8 fishing licenses in this area at the time of this study, and fishing trips were much longer thereby limiting sampling opportunities. A total of 201 fishing trips were sampled in LFA 34 between 2004 and 2007 (Table 2). 7 trips were sampled in LFA 41 in the 2005/2006 fishing year (Table 2).

To estimate bycatch, the sampling data and the fishing effort data were first tabulated by LFA and time period (Table 3). Spatially, the fishing effort for the fleet and samples were made to conform as well. LFA 34 was divided into 4 sampling areas, termed inshore, midshore, channel, and offshore (Figure 5), based on cusk distribution inferred from survey and longline catch, bathymetry and bottom type. These areas were defined by aggregations of grid squares. Not all grid squares were sampled within LFA 34 but each of the 4 sampling areas was. In LFA 41, no samples were collected from the area known as Southeast Browns Bank (Figure 6). Thus, fleet effort was only determined for Crowell Basin, Georges Bank, Georges Basin and Southwest Browns Bank.

The first step in the processing of the sample data was to aggregate the effort (sum of traps hauled) and catch (sum of the number of cusk caught) by trip. Each trip was identified with a location based on the average latitude and longitude given for the beginning of a string of traps. A second step was required for the LFA 34 data. It had to be associated with grid squares within the LFA and these grid squares were grouped into areas. The sampling data for LFA 41 were not divided spatially due to the comparatively low sampling effort.

The bycatch rate in LFA 34 was calculated for each area. The time dimension (year and season) was dropped in favour of spatial resolution on the assumption that space rather than season or year had a greater influence on cusk distribution. Cusk are not thought to undertake seasonal migrations (Colette and Klein-MacPhee 2002), and there is no reason to assume that their distribution would have changed between the 2005/2006 and 2006/2007 fishing years. The bycatch rate (sum of cusk caught/sum of traps observed) was calculated for each of the 4 areas in LFA 34 (Table 2). These ratios, scaled by the respective fleet effort (traps hauled) in comparable areas and time periods, yielded estimates of the number of cusk caught. LFA 41 was sampled during the 2005/2006 fishing season and has only one estimate of bycatch rate for the entire area (Table 2). Cusk bycatch, in metric tonnes, was calculated by applying the length-weight relationship of cusk calculated from port sampling and survey data to the average length of fish caught in each of the 5 areas for which an estimate was calculated. The same length was used in all time periods.

Nonparametric bootstrap replicates (R=999) of the ratio statistic were calculated using ordinary resampling methods. For each distribution of the bootstrapped statistic, 95% equi-tailed 2-sided nonparametric bootstrap confidence intervals were generated (Table 2). These were a normal approximation. Also, each distribution's mean and bias relative to the original ratio were determined.

RESULTS

Industry Survey Data

Catches in the fixed station portion of the Halibut Industry survey (only stations that were sampled in all years) fluctuate without trend (Figure 7). The 2007 value was the highest in the time series. The catch at station 73 was the highest in that year (272kg) and was also highest in the fixed station portion of the time series. To put the large 2007 catch at station 73 in context, the next highest catch in the data analysed was 225kg, whereas the highest catch in the Halibut survey data when examining all sets was 907kg. CPUE was recalculated excluding station 73 in all years to see if that catch was driving the pattern. In the second analysis, the 2007 point remained high; the second highest in the time series.

The percent of stations with cusk has fluctuated without trend (Figure 8). This suggests that cusk still occupy the same areas (within the area surveyed) as at the beginning of the times series in 1998. No reduction in distribution is evident.

Commercial Fishing Data

CPUE begins to decline in 1993 after more restrictive management measures were implemented in the groundfish fishery. CPUE has been below the long-term mean since 1999 (Figure 9), which was the year a bycatch cap was first implemented. In this most recent time period, the years with the highest CPUE were 2003 and 2007. In both years, there were closures to cusk for certain longliner vessel classes due to high landings. When CPUE was examined only for the period between July and September (Figure 10), to provide a consistent time series over all years, these years no longer had among the highest CPUE since 1999. Thus, the initial pattern may have been an artefact of how CPUE was calculated (only partial year). Interestingly, in the summer of 2007, several fishers stated that cusk was difficult to avoid and reported very high catches.

The analysis of longline effort (Figure 11) revealed that the number of trips increased to a peak in 1992 and has since declined. A similar pattern can be seen for all gear sectors in 4X (Gavaris 1996, Clark *et al.* 1998). This is due largely to more restrictive quotas, which were implemented to reduce fishing mortality to more sustainable levels. Landings have decreased since the 1970s and early 1980s (Figure 11). This may be due in part to misreported landings in earlier years. It has been suggested that before the bycatch cap, quota species, such as cod and haddock, were landed as cusk to avoid surpassing quotas. It is not known to what extent this was done. As with effort, a decrease in landings was seen after 1992. Since the implementation of the bycatch cap in 1999, landings have been the lowest in the time series (apart from 1996).

Range (proportion of 5-minute square units in 4X where cusk was reported) and prevalence (proportion of trips that report cusk) of cusk in the longline groundfish fishery suggest that there has been no change in the proportion of the 4X area occupied by cusk. Both indices are high (mean range is 84% and prevalence is 71%) (Figure 12) and suggest that, despite decreases in CPUE, cusk are still widespread and common.

Special Sampling

The analysis of the bycatch in the lobster fishery yielded bycatch estimates of 461t of cusk in the 2005/2006 fishing season and 344t in the 2006/2007 fishing season in LFA 34 (Table 3). A small amount of trips in LFA 34 were not assigned to a grid number and so could not be used in the calculation of fishing effort. If these trips were included in the analysis, the bycatch estimates would have been higher.

The percentage of cusk bycatch recorded as any of the conditions apart from ‘alive and healthy’ can be considered fishing mortality. Around half of the fish of LFA 34 (49%) were dead or moribund. This translates to estimated mortalities of 226t in 2005/2006 and169t in 2006/2007 (Table 3). There is likely additional mortality of the discarded ‘alive and healthy’ fish, so these estimates should be considered conservative. Even when the stomach was not everted, sudden expansion of the gas bladder could cause damage to internal organs. Blisters under the skin were seen in cusk that appeared otherwise healthy. The effects of these blisters on long-term survival are not known. In addition, fish bycatch is sometimes used as bait, which would increase the mortality in this fishery although this could not be estimated. Although approximately 200 trips were sampled in LFA 34 during this study, this is a small percentage of all trips and 0.2% to 0.6% of all traps hauled, so bycatch estimates are approximate.

In LFA 41, the estimate of cusk bycatch in Crowell Basin, Southwest Browns Bank, Georges Basin and Georges Bank was 25t in 2005/2006 (Table 3). Based on an instantaneous mortality of 86%, fishing mortality was 22t. Only a small part of LFA 41 was sampled so uncertainty is high. These estimates are considered conservative because mortality is likely higher in discarded fish as some will perish after being returned to the water. Also, it does not take into account cusk used as bait.

INFORMATION IN SUPPORT OF A RECOVERY POTENTIAL ASSESSMENT

PHASE I: ASSESS CURRENT SPECIES STATUS

Present Species Status and Trajectory for Abundance, Range and Number of Populations

Abundance

Cusk abundance appears to have declined since the 1980s. Based on survey data, this decline has ceased. The commercial fishing CPUE may be declining slightly still.

The CPUE in the Halibut Industry survey has no trend (Figure 7). The Halibut Industry survey suggests that any decline has stabilised. The CPUE in commercial longline landings has decreased since 1986 (Figures 9, 10). The average rate decreased from 1.52t per trip from 1986 to 1992, to 0.92t per trip from 1993 to 1998, and then to 0.64t per trip since the bycatch cap in 1999. It appears that there may be a slight decline in the most recent time period. This decrease could be influenced by changes in fishing behaviour brought on by more restrictive quotas on target species (cod and haddock) in early 1993. The implementation of a bycatch cap on cusk in 1999 and a further reduction in 2003 also may be influencing these trends. A third consideration is that catch of other species were landed as cusk in early years, which would have inflated the CPUE. It is difficult to say to what extent abundance has declined using the commercial landings CPUE. Anecdotal information from lobster and groundfish fishermen suggests that cusk are abundant and are difficult to avoid while fishing.

Distribution

There does not appear to be a reduction in the spatial distribution of cusk.

The percent of stations where cusk was caught in the fixed station portion of the Halibut fishery has fluctuated without trend since 1998 (Figure 8). Plots of the magnitude and distribution of cusk catches (Figure 13) in all stations sampled suggest that cusk are still commonly found in the core areas of their distribution (Western Scotian Shelf and along the shelf slope). It is difficult to detect trends over time since not all stations are sampled in all years. For example, an apparent absence of cusk along the edges of the eastern portion of Sable Island Bank and in the Gully, in the most recent time period, is likely due to a lack of sampling in these areas rather than a reduction in cusk's distribution. There has been no change in range or prevalence of cusk in the groundfish longline fishery in 4X. These indices suggest cusk are widespread and common in this fishery. Anecdotal information also suggests that cusk are common and widespread in both the longline and lobster fisheries.

Number of Populations

There is insufficient data to determine if there are distinct populations of cusk within Atlantic Canada.

There is no evidence of spatially separated populations of cusk; rather they seem to form one continuous distribution from the Gulf of Maine to the Grand Banks. Little is known of their life history, and no studies have been undertaken to compare cusk caught in different areas. The larval data from the Scotian Shelf Ichthyoplankton Program indicate one continuous spawning period from May to July or August, and thus, do not suggest recruitment pulses of multiple spawning components. Although no genetic research information is currently available to compare cusk in different areas in Atlantic Canada, a genetic study to determine if there are distinct populations is underway.

Amount and Type of Habitat Necessary for Survival and Recovery

A very rough estimate of the amount of cusk's primary habitat is 100,000km². This area includes the Canadian portion of the Gulf of Maine, the Western Scotian Shelf and the edge of the Eastern Scotian Shelf, where cusk are most frequently caught. The full range of cusk in Canadian waters, including areas of low occurrence, is much greater.

Cusk exhibit a preference for a hard, rocky bottom (Svetovidov 1948, Andriyashev 1964, Oldham 1966, Colette and Klein-MacPhee 2002). They are most frequently found on rough substrate with boulders, rocks, or pebbles. They are occasionally found on mud but rarely on sand (Bigelow and Schroeder 1953, Colette and Klein-MacPhee 2002). In a study comparing abundance of selected fish species in coral (*Lophelia pertusa*) reefs and non-coral habitats off southwestern Norway, cusk were found to be equally abundant in both habitats (Husebo *et al.* 2002).

Globally, their depth range is reported to be from about 20m to 1100m (Svetovidov 1948, Andriyashev 1964, Oldham 1966, Hareide and Garnes 2001, Colette and Klein-MacPhee 2002). In Canadian waters, the deepest recorded catches were at 1185m; the deepest sets in the Halibut Industry survey (DFO Maritimes Industry Surveys Database). It is not known if cusk occur deeper than that. The largest set of cusk (907 kg) in the Halibut Industry survey was caught at around 560m. The sets with the highest CPUE (kg/1000 hooks), grouped by 50-metre bin, peak between 400-600m.

Potential Recovery Targets

There are no reliable estimates for historical or current absolute abundance of cusk. The magnitude of any decline is also unknown. The recovery target presented at the RPA meeting proposed that, in light of the paucity of information, a reasonable target would be to assess cusk abundance and show a stable or increasing trend in abundance indices.

Following discussion during the meeting, the following recovery target was agreed upon: a stock of the size observed in the mid to late 1980s, prior to the large and abrupt decline in the indices of stock status available from that period. However, a reliable measure of the current magnitude of stock size relative to that period is not available. Accordingly, a practical interim strategy would be to promote measures that result in an increasing trend in cusk abundance.

There is no evidence for a reduction in the area occupied by cusk. A reasonable recovery target would be to maintain current distribution.

Residence Requirements

Under the *Species at Risk Act*, Threatened and Endangered species residences are protected. In section 2(1) the act defines residence as:

> "a dwelling-place, such as a den, nest or other similar area or place, that is occupied or habitually occupied by one or more individuals during all or part of their life cycles, including breeding, rearing, staging, wintering, feeding or hibernating"

Cusk do not have any known dwelling-place similar to a den or nest during any part of their life cycle; hence, the concept of "residence" does not apply.

PHASE II: SCOPE FOR MANAGEMENT TO FACILITATE RECOVERY

Major Potential Sources of Human-Induced Mortality and Harm

The only known major source of human-induced mortality is fishing mortality. Major potential sources of non-lethal harm are not known at this time and are not thought to be a concern.

Most landings are from the groundfish longline fleet (Figure 14). Landings between 2003 and 2006 ranged from 790t to 1063t with a mean of 869t. In years where closures to cusk were in place, there would be some unreported mortality if cusk were caught and discarded.

Estimated fishing mortality was 226t in 2005/2006 and 169t in 2006/2007 in LFA 34 and 22t in LFA 41 (only part of LFA) in 2005/2006.

The fishing mortality in the lobster fishery in other areas is not known.

The fishing mortality in other invertebrate trap fisheries is not known.

Activities to Increase Productivity or Survivorship

Productivity and survivorship are not thought to be limiting factors for cusk. There are no known activities that could increase productivity. Survivorship of cusk could not be increased aside from reducing fishing mortality.

Likelihood that Habitat is a Limiting Factor to Achieving Recovery Targets

Habitat is not thought to be limiting for this species.

Magnitude by which Current Threats have Reduced Habitat Quantity and Quality

There are no known major threats which have reduced habitat quantity or quality.

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TABLES

Table 1. Landings of cusk in metric tonnes (t) by area and gear type in a quota year. The definition of quota year changed in 1999. Prior to 1999, the quota year was the same as calendar year. In 1999, the quota year ran from January 1999 to March 31st, 2000. Starting with 2000, subsequent quota years ran from April 1st to March 31st. A bycatch cap of 1000t for NAFO divisions 4VWX was first implemented in 1999. In 2003, this cap was reduced to 750t for 4VWX+5, where it has remained since.

	Longline				Bottom Trawl				Gillnet				Misc				
Quota Year	**4VW**	**4X**	**5ZE**	**Total**	**4VW**	**4X**	**5ZE**	**Total**	**4VW**	**4X**	**5ZE**	**Total**	**4VW**	**4X**	**5ZE**	**Total**	**Grand Total**
1970	239	2518	805	3562	71	92	6	170	0	92	6	98	76	168	0	244	4075
1971	200	3682	1002	4883	116	169	30	316	0	169	30	200	0	375	0	376	5774
1972	201	4419	751	5370	44	227	13	284	0	227	13	241	0	346	10	356	6252
1973	442	4728	563	5733	63	127	22	211	0	127	22	148	10	230	12	252	6344
1974	531	4348	486	5364	31	68	10	109	0	68	10	78	2	154	17	173	5724
1975	92	4081	397	4570	6	114	26	147	0	114	26	140	0	248	16	265	5122
1976	573	2158	235	2966	14	93	17	124	0	93	17	110	2	58	0	61	3261
1977	245	2548	196	2989	26	64	10	100	0	64	10	74	19	159	0	178	3342
1978	402	4067	365	4833	46	122	49	217	1	122	49	172	9	87	2	98	5321
1979	414	3635	487	4536	26	101	22	148	1	101	22	124	0	176	0	177	4985
1980	221	3253	600	4075	29	81	62	172	1	81	62	144	0	201	0	201	4593
1981	382	3207	1967	5556	38	82	14	133	3	82	14	99	0	117	2	119	5908
1982	672	4248	1138	6058	18	41	19	79	1	41	19	61	0	87	0	87	6285
1983	524	3036	595	4154	9	39	7	55	4	39	7	50	1	62	0	63	4322
1984	243	2298	476	3017	5	30	1	37	1	30	1	32	0	41	0	42	3128
1985	208	1652	298	2158	14	26	1	40	1	26	1	27	0	127	0	128	2352
1986	309	1308	124	1741	5	30	1	36	6	14	0	21	1	287	0	287	2086
1987	456	2832	253	3541	13	81	6	101	13	105	0	118	2	136	1	139	3900
1988	263	2145	326	2754	4	49	21	75	6	35	0	41	4	50	0	55	2925
1989	423	2073	642	3139	4	40	2	46	5	70	2	77	2	121	5	128	3391
1990	591	2231	460	3282	5	34	6	44	11	41	0	52	2	142	0	144	3522
1991	636	2891	611	4139	24	48	2	74	5	35	0	40	0	151	1	151	4404
1992	486	3395	827	4714	17	30	1	48	8	74	12	93	2	179	15	196	5051
1993	306	1863	572	2741	4	49	1	55	3	53	1	57	1	74	3	77	2931
1994	287	1076	165	1529	2	50	4	58	4	44	1	49	0	37	5	42	1678
1995	286	1433	177	1896	3	37	1	42	0	23	2	25	1	37	0	38	2001
1996	162	976	188	1326	1	14	2	17	1	25	1	27	1	29	2	31	1401
1997	170	1401	145	1716	1	22	2	26	1	22	1	23	2	31	1	34	1799
1998	185	1219	136	1540	1	51	4	56	1	19	1	21	0	15	0	15	1633
1999	177	825	114	1117	2	35	2	39	1	15	1	16	0	5	0	5	1177
2000	107	682	186	977	1	27	1	29	0	14	2	16	0	9	0	9	1031
2001	99	990	340	1431	2	34	2	39	1	15	1	17	0	4	0	4	1490
2002	95	821	308	1225	1	36	1	38	0	12	1	13	0	3	0	3	1279
2003	*68*	*647*	*304*	*1019 **	1	26	1	28	0	12	0	13	0	3	0	3	*1063*
2004	68	455	256	779	2	30	0	32	0	6	0	6	0	1	0	1	818
2005	50	603	118	773	0	23	1	24	0	5	0	6	0	1	0	1	804
2006	32	575	153	761	1	19	2	22	0	4	0	5	0	3	0	3	790
2007**	*46*	*723*	*130*	*899****	*0*	*12*	*0*	*12*	*1*	*5*	*0*	*6*	*0*	*0*	*0*	*0*	*918*

*   December 1st 2003 cusk closures for certain vessel classes of longline

** Data are to November 2007 only

*** September 26th 2007 cusk closures for certain vessel classes of longline

Table 2. Sampling effort and cusk bycatch rate: number of trips sampled, number of traps observed, number of cusk observed and cusk bycatch rate (cusk caught per trap observed with 95% confidence intervals) from the lobster fishery for the 4 sample areas in LFA 34 and for LFA 41.

Area	Trips (#s)	Traps obs.	Cusk (#s)	Cusk/trap (95% CI)
LFA 34 Channel	24	8750	1110	0.127 (0.023, 0.223)
LFA 34 Inshore	86	28761	26	0.001 (0.000, 0.002)
LFA 34 Midshore	85	31727	823	0.026 (0.009, 0.042)
LFA 34 Offshore	6	2345	43	0.018 (0.001, 0.035)
LFA 41	7	14390	721	0.050 (0.013, 0.087)

Table 3. Total lobster fishing effort (traps hauled), estimated bycatch of cusk (numbers and metric tonnes) and estimated cusk mortality (metric tonnes) for the 2005/2006 and 2006/2007 fishing seasons in LFA 34 and for 2005/2006 season in LFA 41.

Lobster Fishing Area	**Sampling Area**	**2005/2006** Effort	Bycatch (#s)	Bycatch (mt)	Mortality (mt)	**2006/2007** Effort	Bycatch (#s)	Bycatch (mt)	Mortality (mt)
LFA 34	Channel	848614	107653	146		613477	77824	106	
	Inshore	9769197	8831	11		6857205	6199	8	
	Midshore	7203055	186848	293		5526472	143357	225	
	Offshore	418086	7666	10		243374	4463	6	
	Total for LFA 34	18238952	310998	**461**	**226**	13240528	231843	**344**	**169**
LFA 41	LFA 41	277184	13888	**25**	**22**				

FIGURES

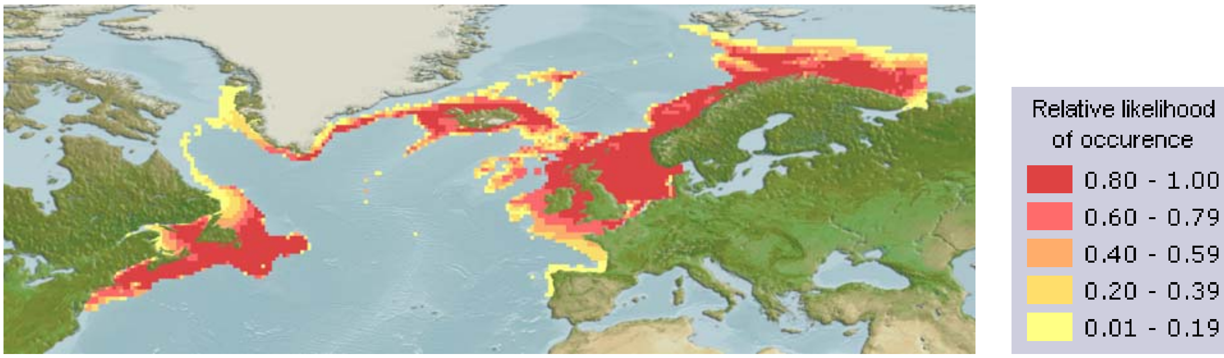


Figure 1. Global distribution of cusk (from http://www.fishbase.org).

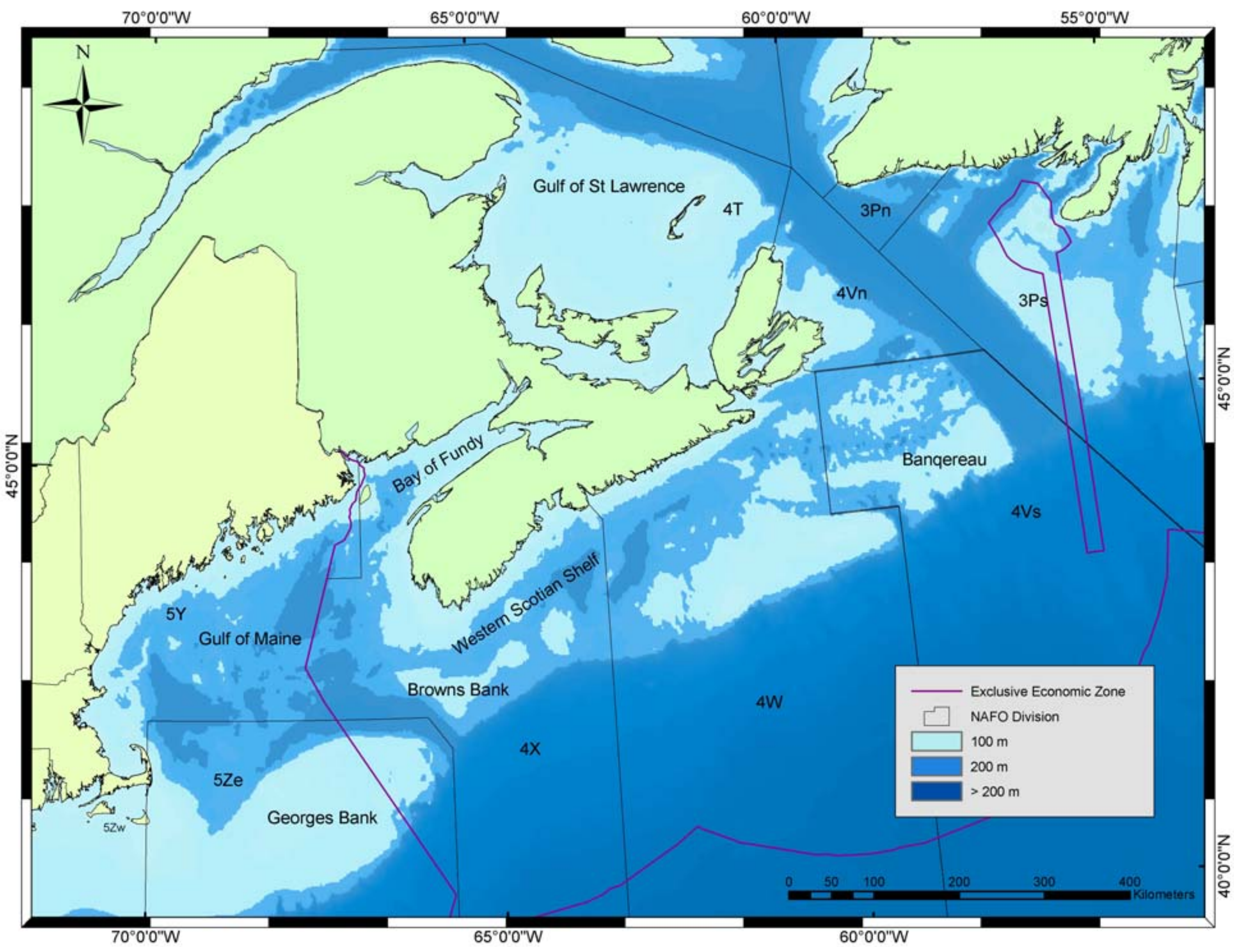


Figure 2. Oceanographic features referred to in the text.

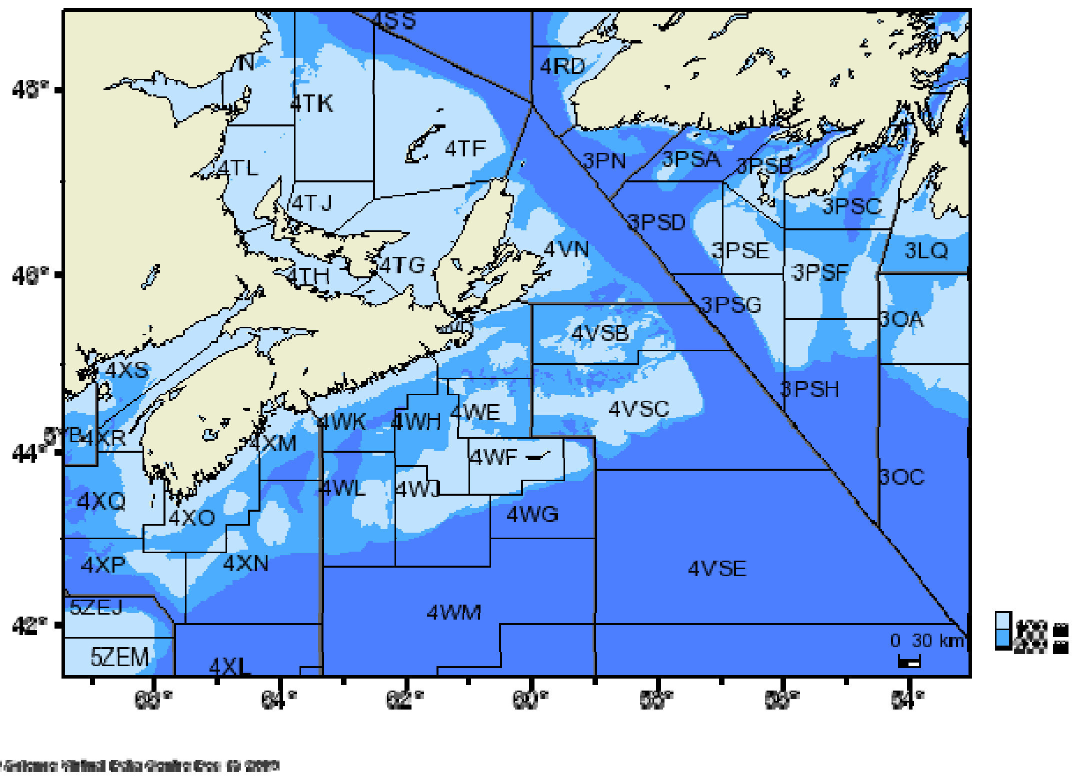


Figure 3. NAFO unit areas referred to in the text.

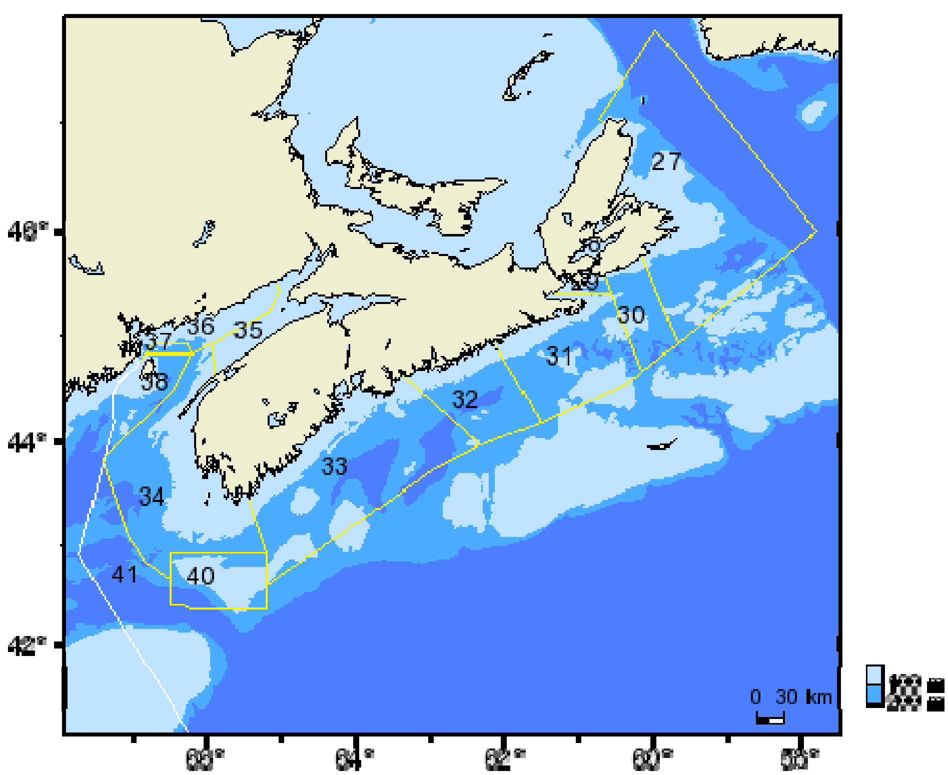


Figure 4. Lobster Fishing Areas (LFAs) mentioned in the text.

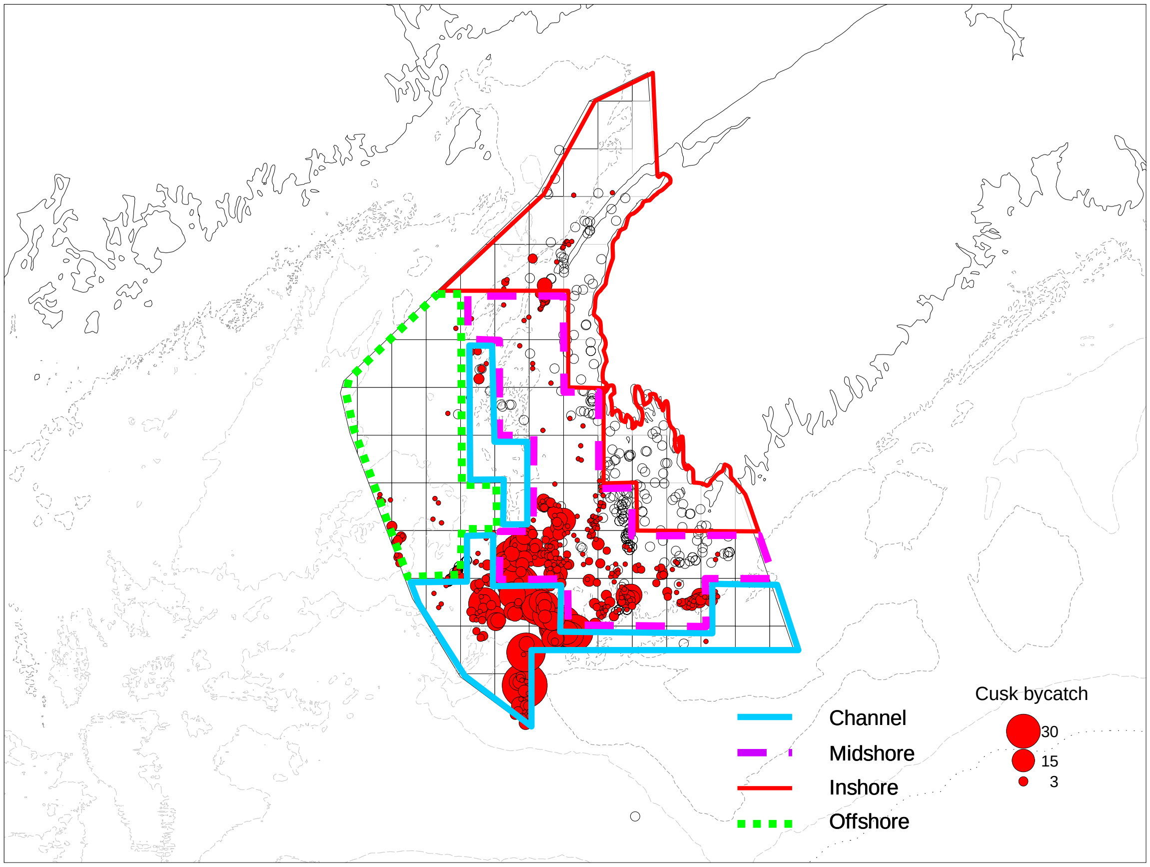


Figure 5. Cusk bycatch sampling distribution in lobster trips in LFA 34. Circles show the magnitude and distribution of cusk catches (numbers) in the lobster traps. Empty circles represent trips where no cusk were caught. The location of sampling areas, 100m, 200m and 1000m depth contours are also indicated.

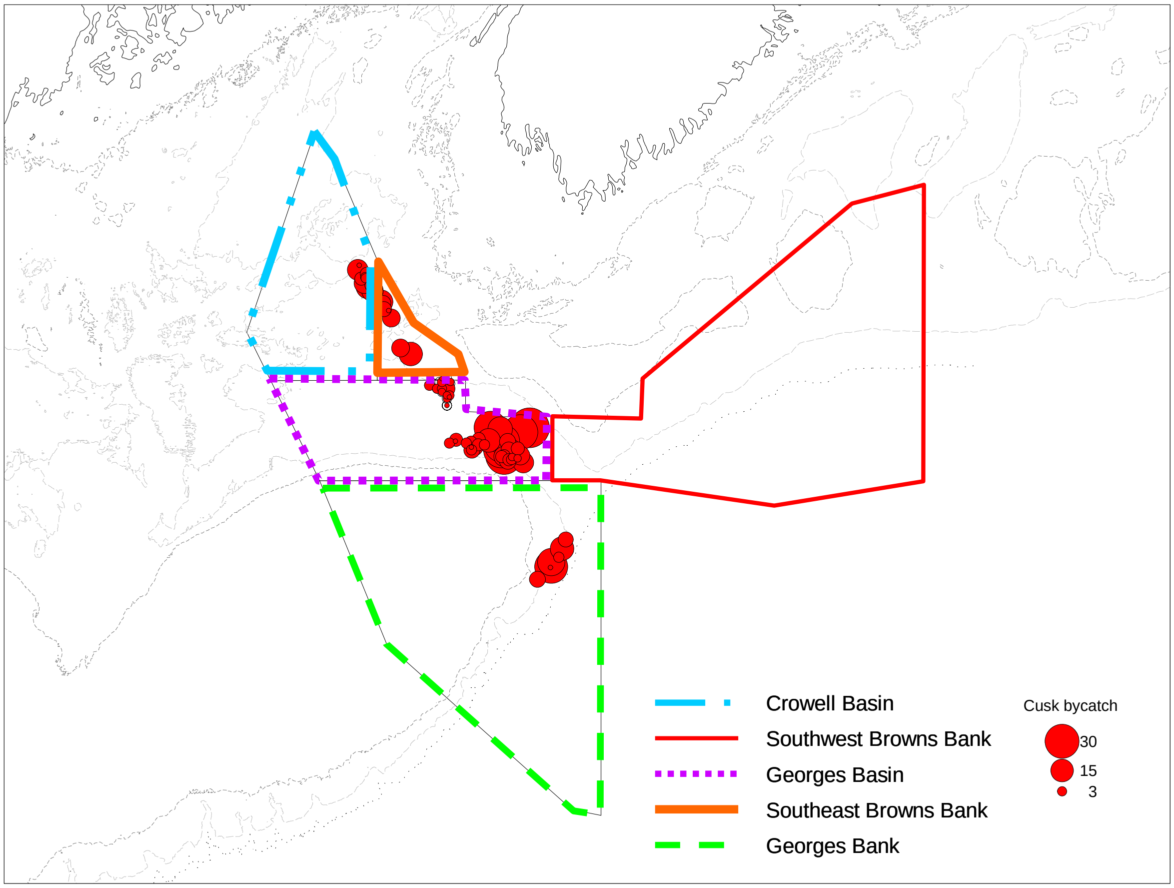


Figure 6. Cusk bycatch sampling distribution for cusk in lobster trips in LFA 41 and location of sampling areas. Depth contours of 100m, 200m and 1000m are also indicated. The circles represent cusk catches (numbers) per string of traps hauled.

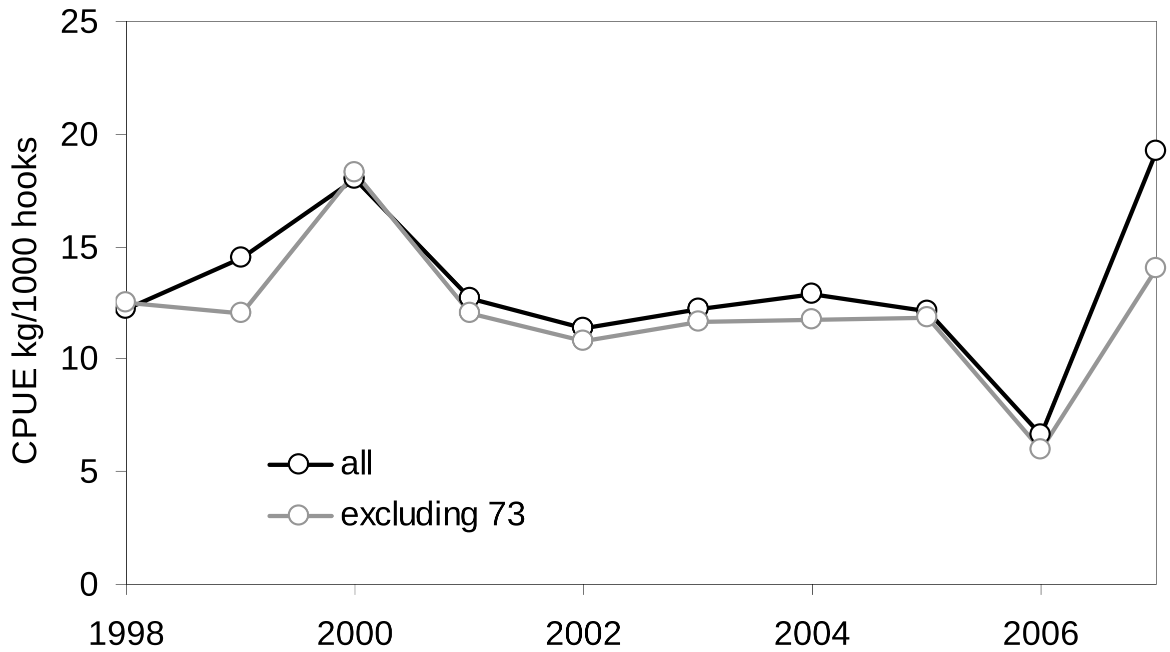


Figure 7. CPUE (kilograms/1000 hooks) of cusk in the Halibut Industry survey. Only fixed stations that were visited in all years were included in the analysis.

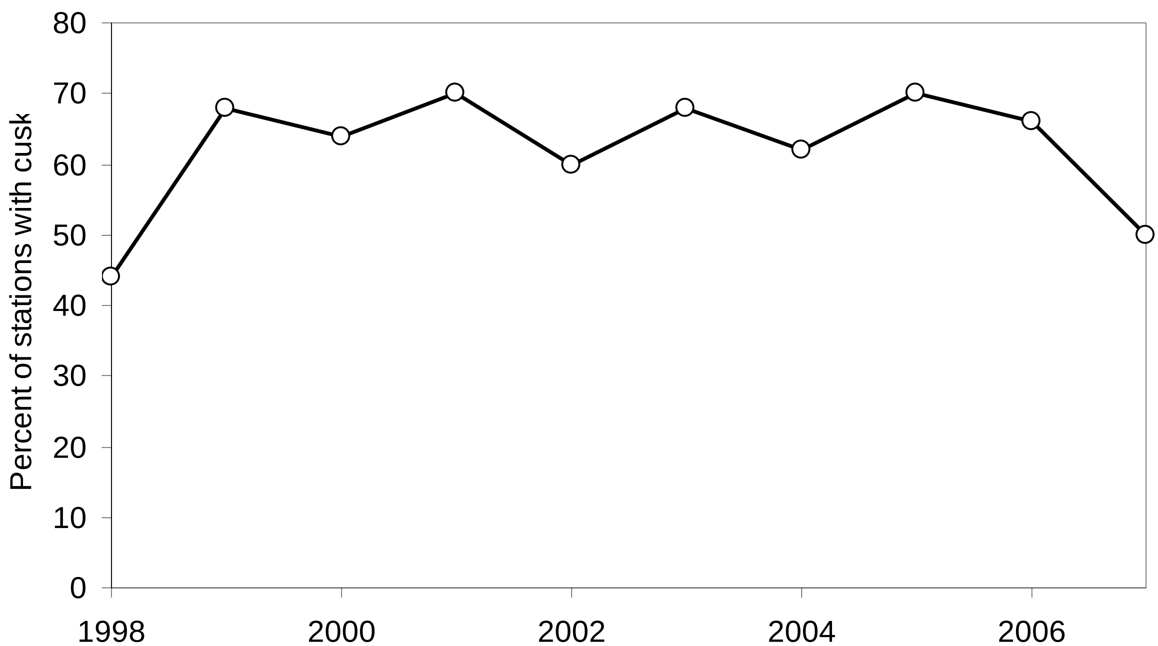


Figure 8. Percent of stations in the fixed station portion of the Halibut Industry survey where cusk were caught. Only stations that were visited in all years were included.

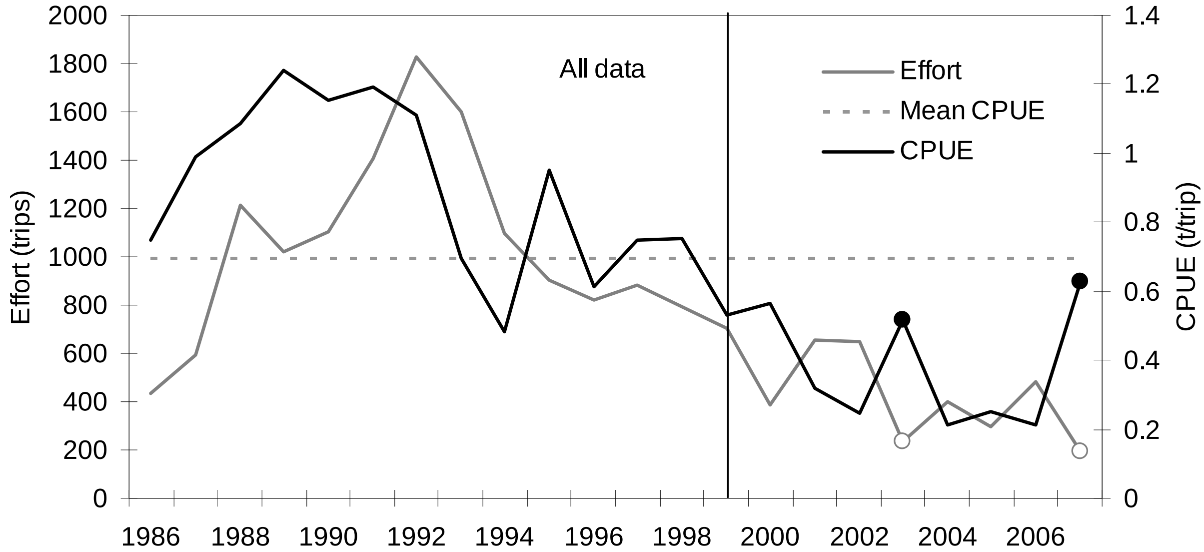


Figure 9. Catch per unit effort (metric tonnes/trip) of cusk by quota year in the longline fishery in 4Xnopqu, prosecuted by vessels in tonnage classes 2 and 3. Dashed line represents long-term mean. Due to cusk closures to longliners, 2003 is only represented by April-November and 2007 is only represented from April-September (indicated by circles). A bycatch cap of 1000t for longliners in 4VWX was first implemented in 1999 (indicated by vertical line). It was reduced to 750t for longliners in 4VWX+5 in 2003, where it has remained.

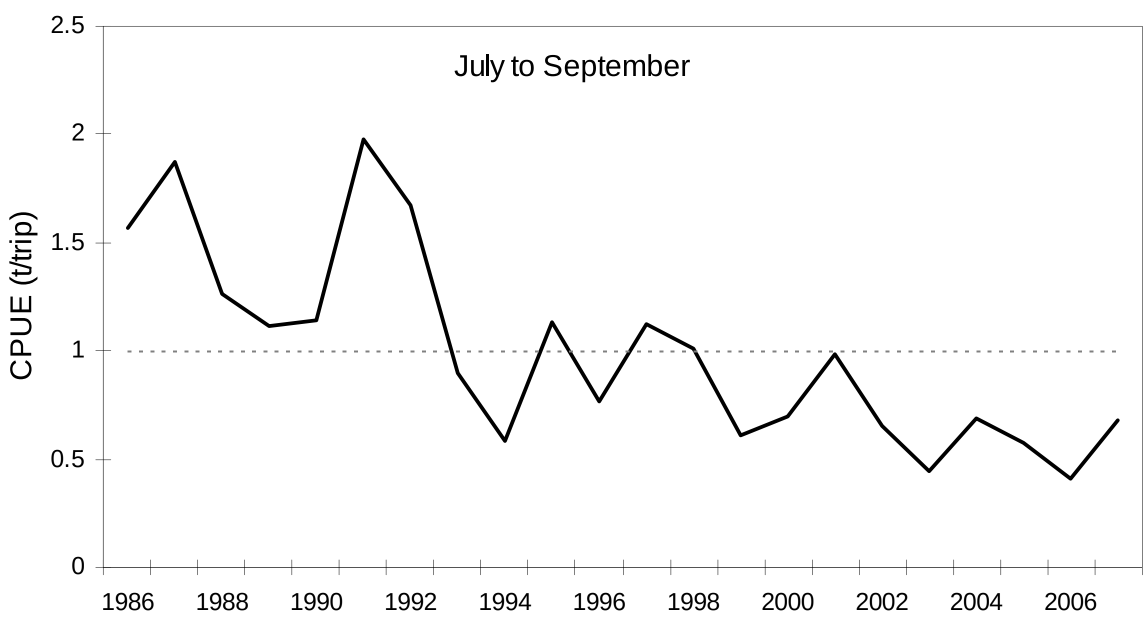


Figure 10. Catch per unit effort (metric tonnes/trip) of cusk by quota year from July to September in the longline fishery in 4Xnopqu, prosecuted by vessels in tonnage classes 2 and 3. Dashed line represents long-term mean. A bycatch cap of 1000t for longliners in 4VWX was first implemented in 1999. It was reduced to 750t for longliners in 4VWX+5 in 2003, where it has remained.

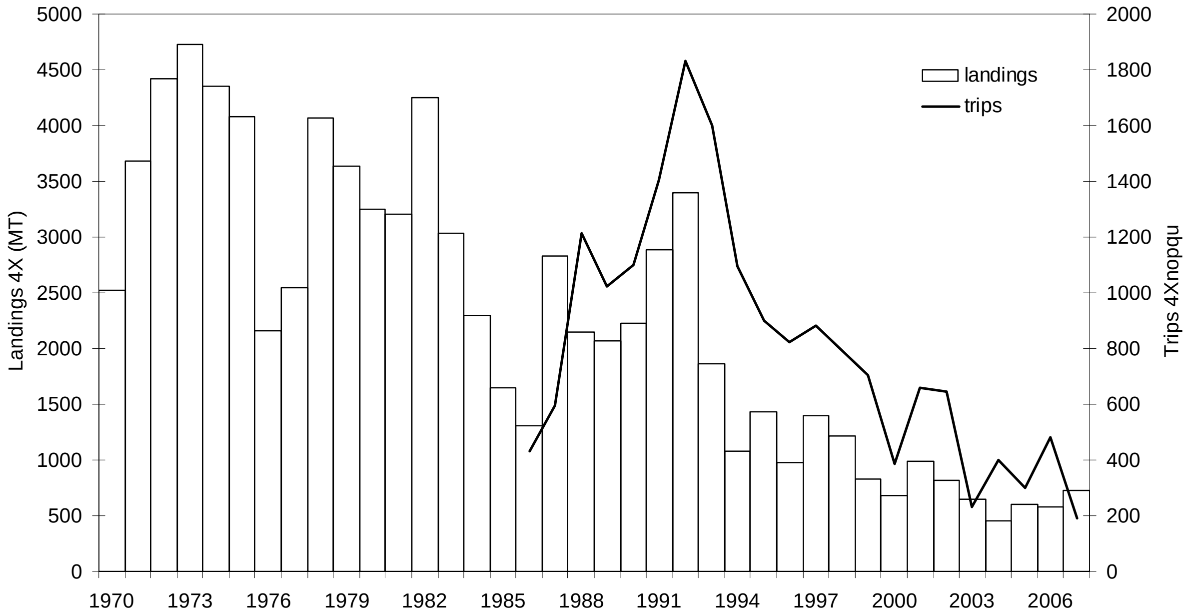


Figure 11. Groundfish longliner landings (metric tonnes) of cusk in 4X and effort (number of trips) in 4Xnopqu of longliners in tonnage classes 2 and 3 by quota year. A bycatch cap of 1000t was first implemented in 1999. It was reduced to 750t in 2003, where it has remained. Due to cusk closures to longliners, 2003 is only represented by April-November and 2007 is only represented from April-September.

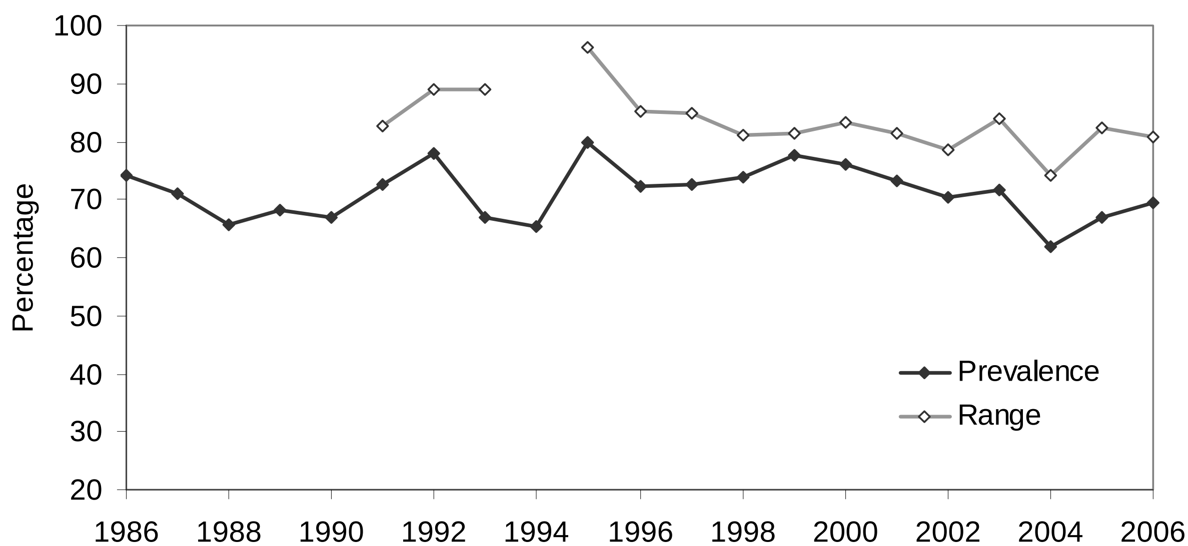
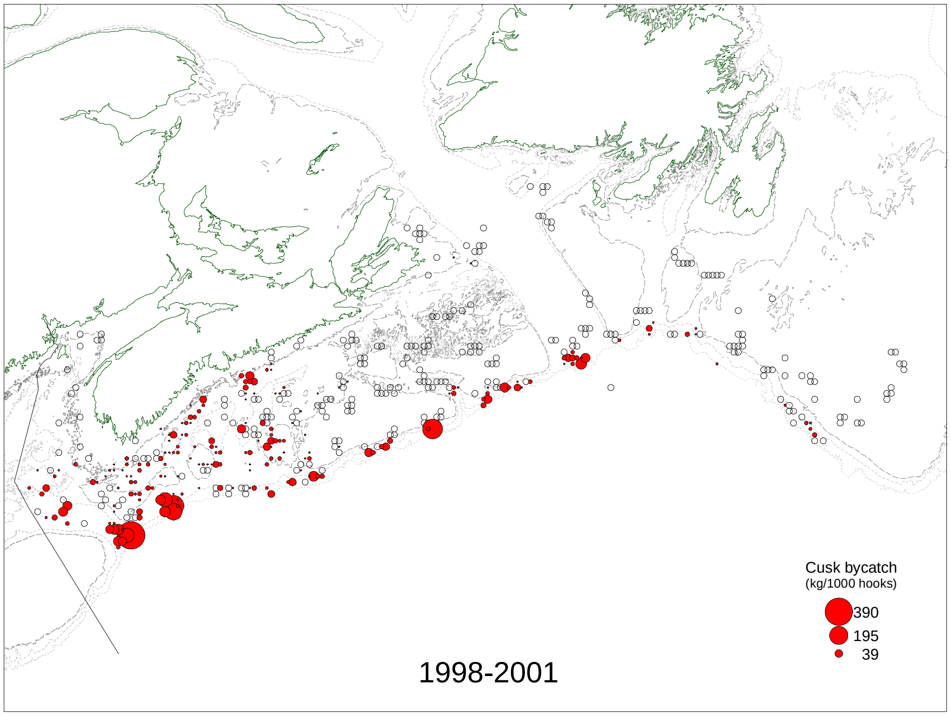


Figure 12. Range (percentage of 5 minute2 geographic blocks with longline effort where cusk were caught) and prevalence (percentage of longline trips which landed cusk) of cusk in the groundfish longline fishery in 4X.



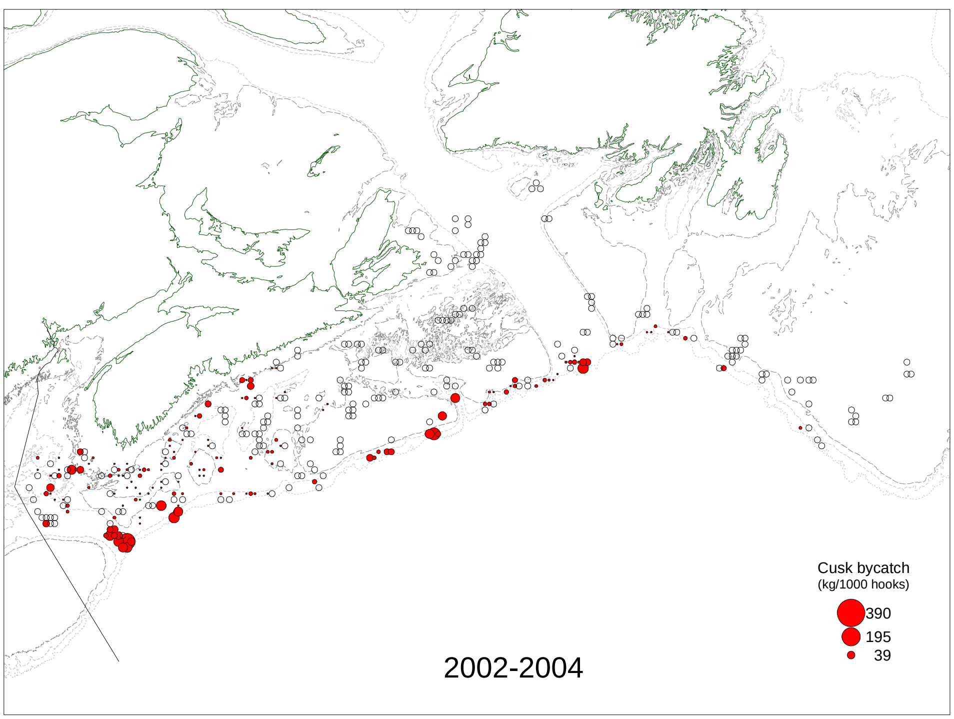


Figure 13. Distribution and magnitude of cusk catches in the Halibut Industry survey averaged by 5 minute squares. Panels represent 1998 to 2001, 2002 to 2004 and 2005 to 2007 (continued on next page).

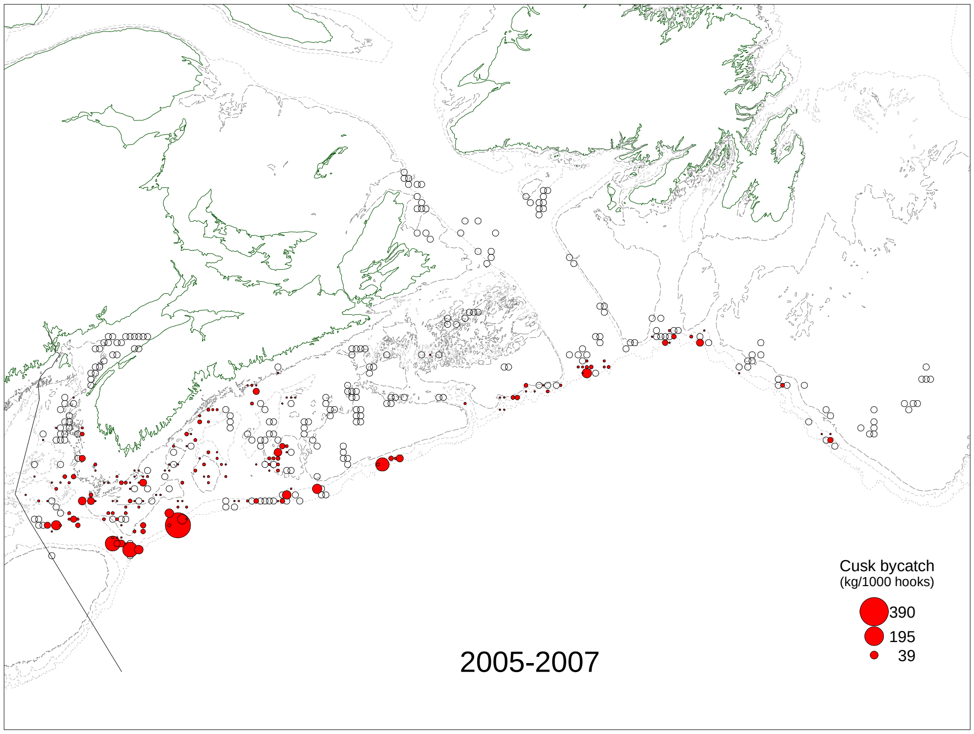


Figure 13 continued. Distribution and magnitude of cusk catches in the Halibut Industry survey averaged by 5 minute squares. Panels represent 1998 to 2001, 2002 to 2004 and 2005 to 2007.

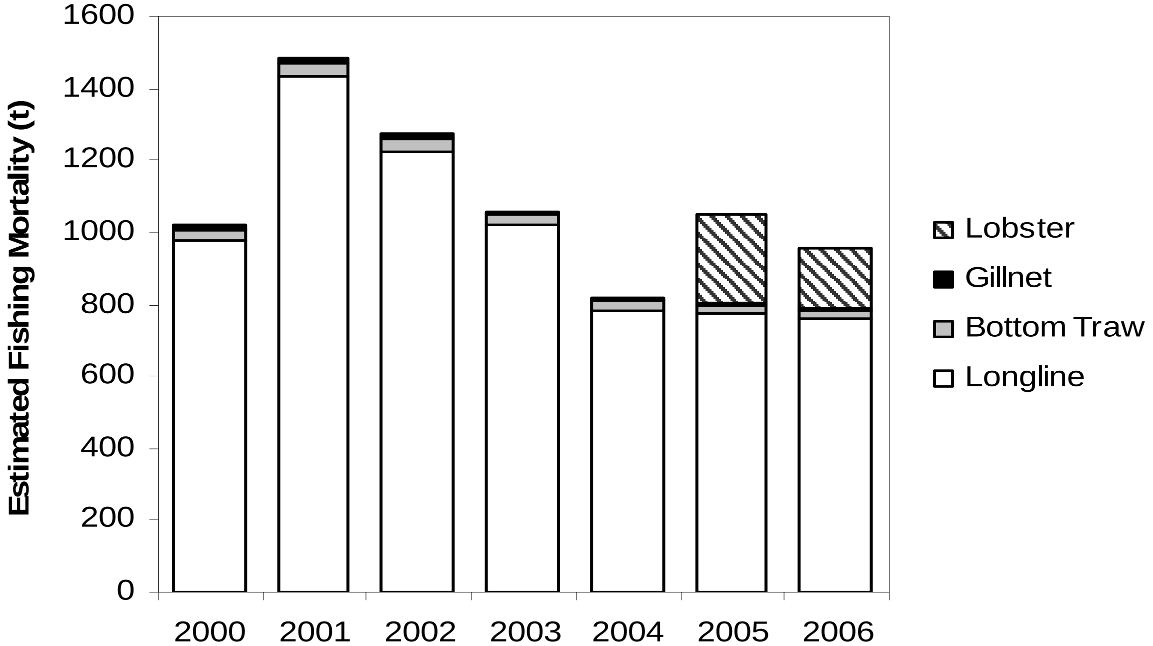


Figure 14. Estimates of human-induced mortality of cusk (metric tonnes) in 4VWX+5 by fishery.