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Evaluation of Cusk (*Brosme brosme*) in Canadian Waters

Évaluation du brosme (*Brosme brosme*) dans les eaux canadiennes

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Abstract

There is little known of cusk life history or genetics making it impossible to identify separate evolutionarily significant units of the population in the Northwest Atlantic. Cusk are distributed from Cape Cod to Labrador but are concentrated mostly in the Gulf of Maine and the Western Scotian Shelf. Catches in the summer RV survey in 4VWX decreased after the 1970's and remained stable after a dramatic decline in 1992. Total numbers caught in 8 of the last 10 years in the entire survey area were below 20 individuals, compared to an average of about 67 from 1970-1990. There has also been a decline in CPUE in the longline fishery since the early 1990's, but this is of a lesser magnitude. The distribution of cusk caught in the summer RV survey has decreased in area and is concentrated in the Gulf of Maine. However the halibut survey and commercial landings data reveal that cusk are still present throughout most of the area along the shelf edge and on the western portion of the Scotian Shelf where commercial longlining occurs.

Résumé

On en connaît peu sur le cycle vital et la génétique du brosme, ce qui rend impossible la détermination d'unités évolutionnaires significatives distinctes parmi la population du Nord-Ouest de l'Atlantique. Le brosme peuple les eaux situées entre Cape Cod et le Labrador, mais il est présent en plus grand nombre dans le golfe du Maine et dans la partie ouest de la plate-forme Scotian. Le nombre de prises dans le cadre des relevés scientifiques estivaux dans 4VWX a diminué après les années 1970 et est demeuré stable après une baisse dramatique en 1992. Dans la zone d'étude, le nombre total de prises pour huit des dix dernières années était inférieur à 20, comparé à une moyenne d'environ 67 entre 1970 et 1990. Depuis le début des années 1990, les PUE de la pêche à la palangre ont également diminué, mais de façon moins marquée. Les relevés scientifiques estivaux révèlent que l'aire de répartition du brosme a diminué, et que celui-ci se retrouve principalement dans le golfe du Maine. Cependant, les données de débarquements commerciaux et du relevé sur le flétan montrent que le brosme est toujours présent dans la majeure partie de la zone longeant la lisière de la plate-forme Scotian et dans la partie ouest de celle-ci, où se pratique une pêche commerciale à la palangre.

Introduction

Under the proposed Species at Risk Act (SARA), the assessment of species status and designation of risk categories are the responsibility of the Committee on Status of Endangered Wildlife in Canada (COSEWIC). Fisheries and Oceans Canada holds information and expertise that are essential to COSEWIC in assessing status and extinction risk for many aquatic species. This document was prepared as a review of DFO's holdings of information on cusk in order to make it available to COSEWIC for their species evaluation. In addition to an inventory of data, we attempted to provide context to the data and also to address specific terms of reference, which were reviewed during a national DFO meeting. The terms of reference for cusk can be found in Appendix I. For the complete terms of reference and meeting proceedings see CSAS proceedings 2002/007.

Cusk Ecology

Cusk (*Brosme brosme*) is a solitary, sedentary, slow swimming species, found throughout the North Atlantic. In Canadian waters it is most common in the Gulf of Maine and Western Scotian Shelf (Figure 1). They prefer a rocky bottom, or gravel and occasional mud but seldom sand (Scott and Scott 1988). Based on July research surveys, cusk occur in temperatures ranging from 3 to 11ºC with most being caught in the 6-10ºC range. Most of the cusk in the survey data is caught at depths of 75-150 metres. This survey mainly covers the shallower part of their distribution. They are caught in the deepest sets in the survey (600 m) and the proportion of sets with cusk is much higher in strata deeper than 150m. Further evidence that cusk distribution extends beyond the depth range of the survey can be gleaned from studies in the North-eastern Atlantic. Bergstad (1991) found that cusk were caught to depths of 600 m in the Norwegian Deep with highest catches at greater than 200 m. Hareide and Garnes (2001) found that cusk were caught up to 1100 meters along the Reykjanes and Mid-Atlantic ridges. Catches were highest at 700m, 1000m, and 600m at three stations, moving from North to South.

Ichthyoplankton and literature data (Oldham 1966) indicate that spawning on the Scotian Shelf occurs from May to August, peaking in June (Figure 2). The buoyant eggs are 1.3-1.5 mm in diameter with a pinkish oil globule. The pelagic larvae are about 4 mm when hatched, migrating to the bottom when they have grown to approximately 50 mm in length. Males appear to grow slightly faster than females, (reaching 45 cm at five years of age) and appear to mature more rapidly (Oldham 1966).

The diet of cusk on the Scotian Shelf is not well known as their stomachs generally evert when they are brought to the surface. Stomach contents data from the 1960's and the 1990's indicate that invertebrates, crabs, shrimps, and krill in particular, make up most of their diet. A variety of fish species have also been found in cusk stomachs. Cusk have, on occasion, been found in the diets of cod and halibut. There is no record of cusk occurring in seal stomachs on the Scotian Shelf.

Cusk are caught as a bycatch, mainly in the cod, haddock and pollock longline fisheries (Table 1). The current bycatch limitation of 1000t for Northwest Atlantic Fisheries Organization (NAFO) divisions 4VWX was first implemented in 1999.

Data Sources

In this report we have compiled the available information on cusk from Fisheries and Oceans Canada (DFO) groundfish, egg and larval, research surveys, industry surveys, and Canadian commercial fisheries data. A list of data sources, including geographical, seasonal and temporal coverage, is found in Table 2.

<u>Research Survey data</u>

Groundfish surveys

The DFO research vessel bottom-trawl surveys in the Maritimes region include 5 main survey series: the summer research vessel (RV) survey, the spring RV survey, the fall RV survey, the 4VsW Cod survey and the Georges Bank 5Z spring survey. All follow a random stratified design, stratification being based primarily on depth. There was a change in vessel in 1981/1982 and gear in 1982 (from a Yankee 36 to the Western IIA), affecting the summer, spring, and fall survey series. The effect of these changes on cusk catch rates is unknown. The research survey data are generally considered to be of high quality and resolution. They include hydrographic information, detailed fish sampling and spatial and temporal data. The catchability of cusk to the survey gear is unknown but considered very low. Bottom trawls are not effective in catching cusk due to the species' preference for rough, rocky bottom or untrawlable bottom, such as the area between Browns and German Banks. This area of cusk concentration, as indicated in commercial landings, is avoided in the RV surveys. These surveys sample only part of cusk's distribution concentrating on the trawlable bottom and depths less than 150 m.

Of the 5 surveys, the summer RV survey data is the longest time series at 32 years and thus provided the most information. There has been an average of 169 tows and 50 cusk caught per year. Four additional deeper water 'redfish' strata were undertaken since 1995. These were examined separately. Only 3 cusk were caught in these shelf-edge strata in 7 years therefore no further analysis of these strata was undertaken.

The spring and fall surveys were of the same design as the summer survey but only covered 1979-1984 and 1978-1984 respectively. Data from the 4VsW Cod survey and the Georges Bank survey are available from 1986 to present. Different strata were used in the 1986 Georges Bank survey therefore that year was omitted from analyses. The catches in both surveys are low.

Since 1980 a total of only 26 cusk has been caught in the Newfoundland spring and fall research surveys combined. These data were not analysed further.

Pre-1970 surveys
The purpose of these non-standard groundfish surveys was to increase biological knowledge on a variety of groundfish species. A total of 91 surveys were conducted between 1958 and 1969, with good seasonal coverage. The area surveyed was generally within 4TVWX, focussing on 4VW. 5 different vessels using 3 bottom trawl configurations were used during these surveys. Due to the variety of survey designs, area and seasonal coverage, vessel and gear employed and tow duration, no useful analyses were possible.

Ichthyoplankton surveys
Abundance and distribution information on cusk eggs was obtained from the Scotian Shelf Ichthyoplankton Program (SSIP) surveys (1295 eggs). This was a series of ichthyoplankton surveys in the Scotian Shelf between 1976 and 1982. Sampling covered the entire shelf area for all months except April when the area surveyed was limited to the central portion of the shelf. Only one egg was found between October and April. Cusk eggs can be confused with mackerel eggs. Eggs coded as cusk/mackerel were not included in the plots of egg distribution and so the numbers caught are considered conservative.

A total of 54 larval cusk were caught in the Bay of Fundy and Georges Bank larval fish surveys, which occurred between 1975 and 1999. These surveys were conducted in order to estimate larval herring abundance. These larval herring surveys took place during March /April and October/November, outside cusk's spawning season, and so the low numbers were not unexpected. These data were not analysed further.

<u>Industry surveys</u>

There are several industry surveys that we investigated for information on cusk. These surveys all began in the mid-1990’s, so none provided information on the pre-decline period.

The ITQ (Individual Transferable Quota) survey is a bottom-trawl survey that has taken place every July since 1995. It is conducted in 4X by four commercial trawlers at approximately the same time as the summer RV survey. The area surveyed includes shallower strata than those in the RV surveys. Few cusk are caught in this survey therefore the data were not used.

The monkfish survey is also a bottom-trawl survey. It ran every October from 1995-1999 in 4WX5YZ. Few cusk are caught in this survey therefore the data were not used.

The skate survey is a bottom trawl survey that takes place in the spring and the fall. It began in 1995. Bycatch of other species is generally small. There are no records of cusk in this survey, likely due to the use of the large 8” mesh on the gear.

The 5Z fixed gear is a longline survey on the Canadian portion of Georges Bank. It has taken place every summer since 1995. Cusk are caught frequently in this survey however these data were not analysed. Standardisation is difficult due to inconsistent survey design among years. Also, not all data are currently available.

The 4VsW sentinel survey is an annual longline survey of groundfish. It has taken place every fall since 1995. Although it samples the Eastern Scotian Shelf where cusk are fewer, they have been caught every year in this survey.

Of the industry surveys, the halibut longline survey in 3PO4VWX provided the most information on cusk, including catch weight and distribution data. This longline survey, which began in 1998, includes a fixed station survey and a commercial index component. It is particularly useful in that it includes some deeper areas that are not sampled in the summer RV survey. Also, longline gear is much more effective at sampling cusk than a bottom trawl and is not limited to areas with trawlable bottom. We used weights rather than numbers when analysing these data because non-target species are weighed but not always counted.

Commercial fishing data

Reported cusk catches in the commercial landings and the International Observer Program (IOP) data were examined for this report. The reliability of the landings data has been questioned anecdotally, particularly of those data before 1999. Before this time there was no catch limit on cusk. It has been suggested that other species, such as cod, were landed as cusk when quotas were exceeded.

We analysed catch rates and landings for longliners targeting cod, haddock, pollock, and cusk in 4Xmonpqu. We did not include data from 4Xlsx because trips were infrequent in these areas and landings represented less than 1% of total landings for the fleet. Data from earlier than 1988 lacked the resolution required for meaningful analyses. In earlier years landings from small longliners (tonnage class 1) were aggregated and so individual trip information data could not be obtained. We limited the analyses to longliners catching groundfish since this sector has the highest cusk landings.

Results

Evolutionarily significant units

There is insufficient data to determine if there are separate evolutionarily significant units (ESU), i.e. distinct populations, for cusk within Atlantic Canada. The distribution of cusk is concentrated in the western Scotian Shelf-Gulf of Maine area with a discontinuous distribution north to Labrador. No known genetic research has been done to compare cusk from different areas in Atlantic Canada and little is known of their life history. The larval data from the SSIP indicate one continuous spawning period from May to August (Figure 2) and thus do not suggest multiple spawning components. Research in cusk genetics and/or life history is required to resolve the question of distinct ESU's for cusk in the Northwestern Atlantic.

Trends in abundance

Trends

The longest time series of cusk abundance indices is the summer RV survey, which began in 1970. Cusk catches in this survey are low and have been declining since the mid-1970's and have remained well below the pre-1990 average of 67 fish since 1993 (Figure 3, Table 3). There was a vessel and gear change in 1982 that may have affected cusk catchability, however, the decreasing trend is still obvious in the 1982-2001 period where the same vessel was used for all years.

Catches were also low in the spring and fall surveys. Comparison of catches in the spring RV, fall RV and summer RV surveys revealed no seasonal changes in cusk catchability (Figure 4) to the bottom trawl. The highest abundances in all three surveys were in the Gulf of Maine and near La Have and Emerald basins (Figure 5). A decline in cusk abundance is also seen in the U.S. National Marine Fisheries Service (NMFS) fall survey of the Gulf of Maine and Georges Bank (Figure 6) however, it precedes the decline seen in the DFO summer RV survey by a few years.

Cusk are caught only in small numbers on the edge of the bank in the DFO spring Georges Bank RV survey (Figures 7, 8, Table 3). Catches are consistently low and with no trend over time. Very few cusk are caught in the 4VsWCod survey (Figure 9). Since 1992 cusk have been caught only in 1995 and 2000 (Table 3).

Cusk catches have varied from 3 to 6 kg/1500 hooks during the 7 years of the fixed station portion of the 4VsW sentinel survey (Figure 10). The highest catches were in 2001. Mean number caught is not available because fish are not always counted, although the catch is always weighed.

The halibut survey, begun in 1998, provides little information on temporal trends in cusk abundance. The distribution and abundance of cusk caught (Figures 11, 12, and 13) suggest that cusk are still found on the western Scotian Shelf and along the entire shelf edge, contrary to what is seen in the summer RV survey. These differences are likely due to the differences in gear type used and location of sets. The halibut survey uses longline and samples deeper, warmer waters, which cusk prefer, whereas the summer RV survey uses a bottom trawl, which is less effective at catching cusk. The commercial index portion of the survey is concentrated along the edge of the shelf (Figure 12). The fixed station portion of the survey covers much of the Scotian Shelf, and shows cusk widely distributed across the western Scotian Shelf (Figure 13).

Commercial landings data from the longline fishery in 4X revealed a decrease in cusk landings and CPUE since 1992 (Figure 14). The decrease in CPUE lags behind the decrease in cusk catches in the summer RV survey by two years. CPUE from 1994-2001 is at 40% of the 1988-1992 rate, whereas the survey catches from 1993-2001 have been at 20% of the 1988-1991 level. Cusk landings from all commercial fisheries combined in the Maritimes region have also declined and have been at an historical low from 1994 to the present (Figure 15). It should be noted that anecdotal information suggests that there was much misreporting of cusk in the landings data before 1999. Until 1999 cusk catches were unregulated and so other species were landed as cusk when quotas were exceeded. This would result in artificially raised estimates for historical landings and CPUE, thus exaggerating the decline in catches.

Length frequency samples from the commercial fishery indicate that the full length-range remains present in the population. The maximum length reported for cusk sampled in 1963-64 was 97cm (2453 measured), in 2001 it is 109cm. (Figure 16).

Sources of decline

We undertook several analyses in an effort to better understand the causes of decline in abundance in the cusk population. There was no dramatic increase in landings from the commercial fisheries (Figure 15) to suggest overfishing. The catches in the late 1980's and early 1990's were in fact lower than historical levels. However the size of individuals caught in the summer RV survey has decreased (Figure 17) which is consistent with overexploitation in a size selective fishery, such as longline. In contrast, the size range in commercial catches is as great as ever. The mode may have shifted, although this is difficult to tell given the small number of samples. The average weight for cusk in the Halibut survey ranges between 1.5 and 3.6 Kg annually. This survey catches 1000’s each year. The RV Survey does not see enough cusk to be taken as the only source for this data. Furthermore, cusk on the banks are known to be smaller on average than those in deeper water (Oldham, 1966). There has been a change in the cusk seen by the RV survey but perhaps they have just moved to an area better sampled in the halibut survey.

We compared the bottom temperatures of sets in the 4X portion of the summer RV survey before and after the dramatic decline in catches for evidence of changes in environmental regime (Figure 18). We found no difference between the two periods. We compared the bottom temperature for sets where cusk were caught and saw no change in temperature preference (Figure 19). In an analysis of long-term trends of water temperature in Georges Basin, where cusk are concentrated, there has been only slight variation in temperature since the early 1970's, except for the very cold conditions in 1998 (Drinkwater *et al*, 2001).

The causes of the decline in the cusk catches in the summer RV survey and the decrease in CPUE remain unknown. The decrease in catches in the survey could be due to a decline in the population and/or a shift of the population to waters not sampled by the survey.

Trends in distribution

Historical distribution of cusk in the Northwestern Atlantic based on survey and commercial catch data extends from Labrador to Cape cod. Maps from the 1960's show a patchy distribution with a concentration in southwest Nova Scotia (Figures 20 and 21). This discontinuous distribution is also seen currently.

Two analyses of the summer survey were performed; the first was of the proportion of non-zero sets and second was of the fraction of the area surveyed containing 75% of the total catch. The proportion of non-zero sets has been decreasing from a peak in 1976, with a dramatic decline from 1988 to present (Figure 22). The reduction of sets containing cusk is assumed to be correlated to population size and so may be an indication of a decrease in abundance and not in distribution. Another possible explanation for the reduction in non-zero sets is that the fish have moved into deeper waters or untrawlable areas, which are not as well sampled as the shelf area. If the reduction of catches in the summer RV survey were due to changes in distribution we might find evidence of a shift in the distribution within the survey area. In order to examine this hypothesis, we divided the sets into shallow (less than 150 m) and deep water (equal to or greater than 150 m) sets and then calculated the proportion of non-zero sets. If the cusk were moving into deeper waters, one would expect to see a greater decline in non-zero shallow sets than in the deeper water sets. However a similar rate of decline was seen in the two areas (Figure 23).

We also looked for changes in the proportion of the summer RV survey area where 75% of cusk were caught. Figure 24 illustrates a decline in this area from approximately 12% in the 1970's to approximately 3%, almost exclusively in the Gulf of Maine, in the current period. This is however strongly correlated to the number of non-zero sets. With so few cusk caught during the survey, any reduction in numbers will likely also be reflected in a change in number of sets where they are caught.

Contrary to what is seen in the summer RV survey where cusk are limited to the Gulf of Maine, they are still commonly found on the western Scotian shelf and along the shelf edge in the Halibut survey (Figures 12, 13). Unfortunately the time series is not long enough to examine for changes in distribution over time. Commercial landings data also indicate that their distribution is more widespread than is indicated by the summer RV survey (Figure 25).

We analysed the range and prevalence of cusk in the longline groundfish fishery from 1995 to present. Range is the proportion of 5-minute square units in 4X where cusk was reported, and prevalence is the proportion of trips that report cusk. From 1991 to 1993 there are data for only a small proportion of trips. In some cases this is because no position information was available, 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. The results suggest there has been no change in the proportion of the 4X area occupied by cusk since 1991, and that cusk are still widespread and common (Figures 25 and 26).

<u>Trends in abundance of mature individuals</u>

Individuals greater than 50 cm in length in the summer RV survey were considered mature for this analysis. Juvenile and mature cusk are found in the same areas according to the IOP length frequency data (Figure 27). Numbers have decreased dramatically (Figure 28), as has the proportion of mature individuals in the survey (Figure 29). Multiplying the number per tow caught in the survey by the number of trawlable units could be used as a minimum estimate of abundance. Using this method, the number of mature individuals (stratified total numbers from the summer RV survey) in the area sampled by the summer RV survey is 270 000. This number is based on very small actual numbers caught, and is not adjusted for the apparently low catchability of cusk. It is also based on only a portion of cusk's distribution in Canadian waters.

The commercial catch in 2001 has been calculated at over 1,000,000 individuals (calculated from landings data as 1,033,280 and length frequencies from port samples from each area). Given the broad length/age range in the catch (all lengths up to 109 cm, which, based on Oldham (1966), would be >13yrs) it is likely that exploitation rate is at most in the range seen for cod and haddock within the region (12-25%). Cusk are caught almost exclusively on hook and line, thus it would seem unlikely that they are subject to a higher fishing mortality than cod and haddock, which have substantial additional fishing pressure from otter trawl, which accounts for half of the landings for these fish. Furthermore, the fishery does not cover the known extent of cusk distribution. The halibut survey indicates cusk are found at greater depth than 400-500 m, which is as deep as the fishery generally extends, and also along the shelf edge in areas east of 4X, where there is very limited longline fishing. This indicates the population must be in the range of several million fish, an order of magnitude higher than estimates from the RV survey. Given that fishing effort has declined since the 1980’s, it is also likely that exploitation rate has declined. It follows that the decline in landings of roughly 50-60% may equal or exceed the decline in population abundance.

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Appendix I. Terms of Reference for Cusk

C. Specific objectives

1. Species information

The purpose of the first part of the meeting is to ensure that information on these species held by DFO is made available to COSEWIC (including the authors of status reports on these species and the Chairs of the COSEWIC Marine Fish Species Specialist Group) so that status assessments based on the best available information can be conducted.

The meeting will review information on distribution, abundance and life history characteristics of these species which could be used by COSEWIC to determine, following its assessment guidelines and criteria, whether a risk category is justified. Discussion on each species will begin with a consideration of the available information on population differentiation, which could support a COSEWIC determination of which populations would be suitable for assessment.

Documentation produced by this part of the meeting will include Research Documents summarising the available information on these species and Proceedings documenting discussions at the meeting.

A detailed description of the information to be produced for each species follows. In addition, information on life history and ecological characteristics will be reviewed for each species to allow a general assessment of the resilience or general vulnerability of the species. The following information will be reviewed to the extent that it is available:

- growth parameters : age (and/or length) at maturity, maximum age (or length), growth parameters
- fecundity, production of young per year
- early life history pattern, duration of planktonic larval life
- specialised niche or habitat requirements

Cusk

1. Review the evidence, if any, that there are separate evolutionarily significant units for Cusk within Atlantic Canada, smaller than the range of the species.
2. For Cusk in Canada as a whole, and for ESUs identified in 1 (if any):
   a. Summarize overall trends in population size (abundance) over as long a period as possible, and in particular for the past 10 years or three generations (whichever is longer);

b. Where declines have occurred over the past 10 years or three generations, summarize the degree to which the causes of the declines are understood, and the evidence that the declines are a result of natural variability, habitat loss, bycatch from fishing, or other human activity;

c. Where declines have occurred, particularly over the past 10 years or three generations, summarize the evidence that the declines have ceased, are reversible, and likely time scales for reversibility.

3. For Cusk in Canada as a whole, and for ESUs identified in 1 (if any):

   a. Summarize current area of occupancy (in km^2)

   b. Summarize changes in area of occupancy over as long a time as possible, and in particular, over the past 10 years or three generations.

   c. Summarize any evidence that there have been changes in the degree of fragmentation of the overall population, or a reduction in the number of meta-population units.

4. For Cusk in Canada as a whole, and for ESUs identified in 1 (if any):

   a. Tabulate the best scientific estimates of the number of mature individuals

   b. If there are likely to be fewer than 10,000 mature individuals, summarize trends in numbers of mature individuals over the past 10 years or three generations, and, to the extend possible, causes for the trends.

   c. If there are estimated to be fewer than 1,000 mature individuals, summarize available information on the degree to which these individuals may be densely aggregated for at least part of the year, and if aggregated, the possible threats to those aggregations.

For All Species:

17. As time allows, review status and trends in other indicators of the status of each of the species that would be relevant to evaluating the risk of extinction of the species, the likelihood of imminent or continuing decline in the abundance or distribution of the species, or otherwise be of value in preparation of COSEWIC Status Reports.

Table 1. Cusk landings by gear type and area, in tonnes

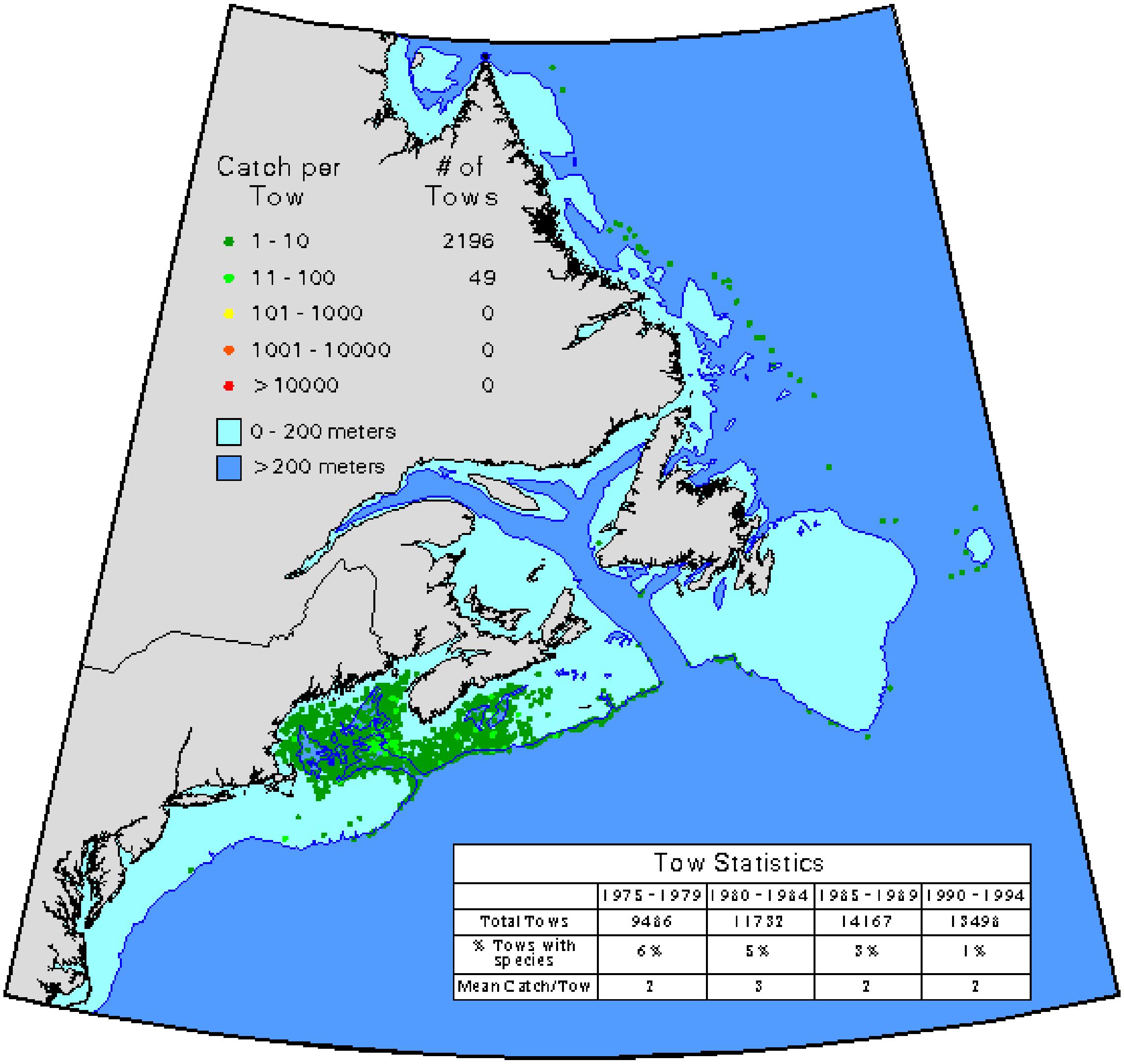
	Bottom Trawl				Longline				Gillnet				Miscelaneous				
	4W	4X	5YZ	All	4W	4X	5YZ	All	4W	4X	5YZ	All	4W	4X	5YZ	All	Total
1986	3	30	2	34	225	1308	124	1657	6	14	0	21	1	287	0	287	2000
1987	7	81	7	95	301	2832	253	3386	13	105	0	118	0	136	1	137	3736
1988	2	49	22	74	176	2144	345	2666	6	35	0	41	1	50	0	51	2832
1989	3	40	3	45	327	2074	643	3044	5	70	2	77	2	121	5	127	3294
1990	2	34	6	42	519	2231	460	3210	11	41	0	52	2	142	0	143	3447
1991	22	48	4	73	525	2891	611	4028	5	35	0	40	0	151	1	151	4293
1992	14	30	2	46	466	3395	832	4693	8	74	12	93	2	179	15	196	5028
1993	3	49	2	55	258	1863	572	2693	3	53	1	57	1	74	3	77	2882
1994	1	50	5	56	185	1076	165	1427	3	44	1	49	0	37	5	42	1574
1995	1	37	2	40	218	1433	177	1828	0	23	2	25	1	37	0	38	1931
1996	1	14	2	17	128	976	188	1293	1	25	1	27	1	29	2	31	1368
1997	1	22	2	25	142	1401	145	1688	1	22	1	23	2	31	1	34	1770
1998	0	51	4	56	152	1219	137	1508	1	19	1	21	0	15	0	15	1600
1999	1	32	2	35	126	735	115	976	1	14	1	16	0	5	0	5	1032
2000	1	26	1	28	97	735	188	1020	0	14	2	16	0	9	0	9	1073
2001	1	33	2	37	81	976	340	1397	1	14	1	16	1	4	0	5	1454
Total	62	627	68	757	3927	27291	5296	36515	66	602	26	694	13	1306	31	1350	39315

Table 2. Data sources examined.

	RV SURVEYS									INDUSTRY SURVEYS						COMM FISHING	
SERIES	Summer	Spring	Fall	Georges	4VsWcod	Nfld	Nfld	SSIP	BOF larval	4VsW Sentinel	Skate	Monkfish	ITQ	5Z Fixed Gear	Halibut	IOP	Landings
SEASON	Summer	Spring	Fall	Spring	Spring	Fall	Spring	All	Spr/Fall	Fall	Spr/Fall	Fall	Summer	Summer	Summer	All	All
GEAR	BT	BT	BT	BT	BT	BT	BT	Larval	Larval	LL	BT	BT	BT	LL	LL	All	All
AREA	4VWX	4VWX	4VWX	5Z	4VsW	2GHJ3KLMNO	3LNOP	4VWX5Z	4WX5Z	4VsW	4VW	4WX5YZ	4X	5Z	3PO4VWX	4VWX5YZ	4WX5YZ
1970	X																
1971	X																
1972	X																
1973	X																
1974	X																
1975	X								X								
1976	X							X	X								
1977	X							X	X							X	
1978	X		X					X	X							X	
1979	X	X	X					X	X							X	
1980	X	X	X			X	X	X	X							X	
1981	X	X	X			X	X	X	X							X	
1982	X	X	X			X	X	X	X							X	
1983	X	X	X			X	X		X							X	
1984	X	X	X			X	X		X							X	
1985	X					X	X		X							X	
1986	X			X	X	X	X		X							X	X
1987	X			X	X	X	X		X							X	X
1988	X			X	X	X	X		X							X	X
1989	X			X	X	X	X		X							X	X
1990	X			X	X	X	X		X							X	X
1991	X			X	X	X	X		X							X	X
1992	X			X	X	X	X		X							X	X
1993	X			X	X	X	X		X							X	X
1994	X			X	X	X	X		X		X					X	X
1995	X			X	X	X	X		X	X	X	X	X	X		X	X
1996	X			X	X	X	X		X	X	X	X	X	X		X	X
1997	X			X	X	X	X		X	X	X	X	X	X		X	X
1998	X			X		X	X		X	X	X	X	X	X	X	X	X
1999	X			X	X	X	X		X	X	X	X	X	X	X	X	X
2000	X			X	X	X	X			X	X		X	X	X	X	X
2001	X			X	X	X	X			X	X		X		X	X	X

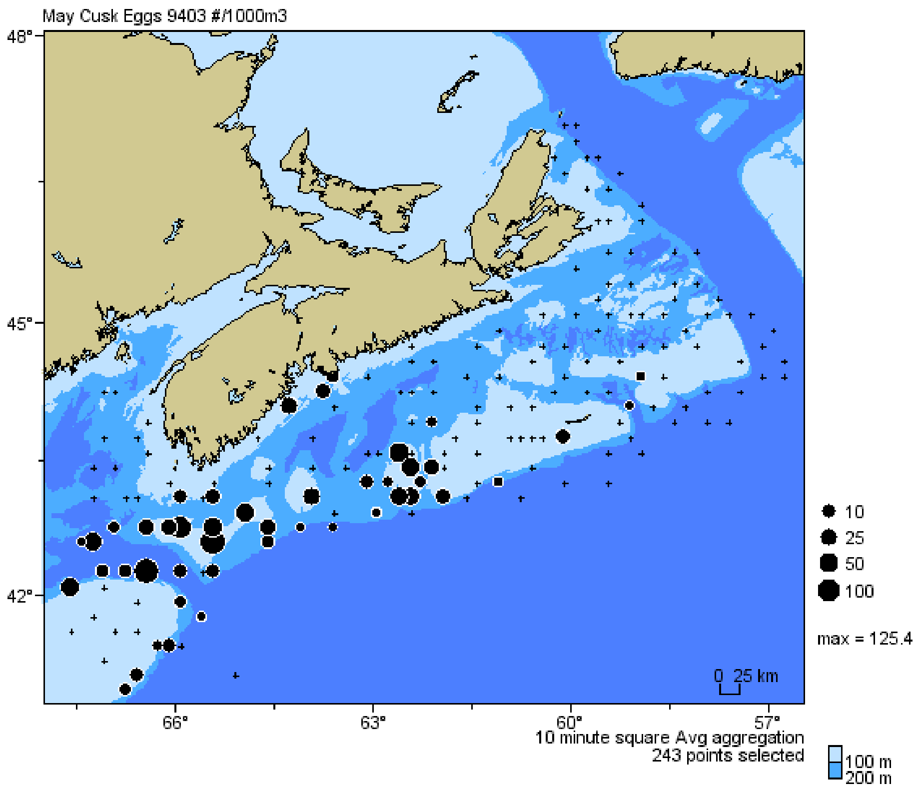
Table 3. Total numbers of cusk caught in the RV surveys, all areas, by year

YEAR	SUMMER	FALL	SPRING	4VWCOD	GEORGES
1970	48				
1971	60				
1972	91				
1973	80				
1974	109				
1975	89				
1976	76				
1977	105				
1978	74	8			
1979	81	49	44		
1980	30	63	41		
1981	65	74	54		
1982	92	82	143		
1983	50	53	91		
1984	69	45	69		
1985	41				
1986	30			9	13
1987	75			2	13
1988	62			8	7
1989	41			4	8
1990	41			2	5
1991	48			2	0
1992	30			0	3
1993	11			0	1
1994	14			0	0
1995	12			2	1
1996	14			0	1
1997	22			0	1
1998	15				2
1999	10			0	3
2000	17			2	2
2001	18			0	3
Total	1620	374	442	31	63



Tow Statistics				
	1975 - 1979	1980 - 1984	1985 - 1989	1990 - 1994
Total Tows	9486	11732	14167	13498
% Tows with species	6 %	5 %	3 %	1 %
Mean Catch/Tow	2	3	2	2

Figure 1. Distribution of cusk in research surveys (from ECNASAP).



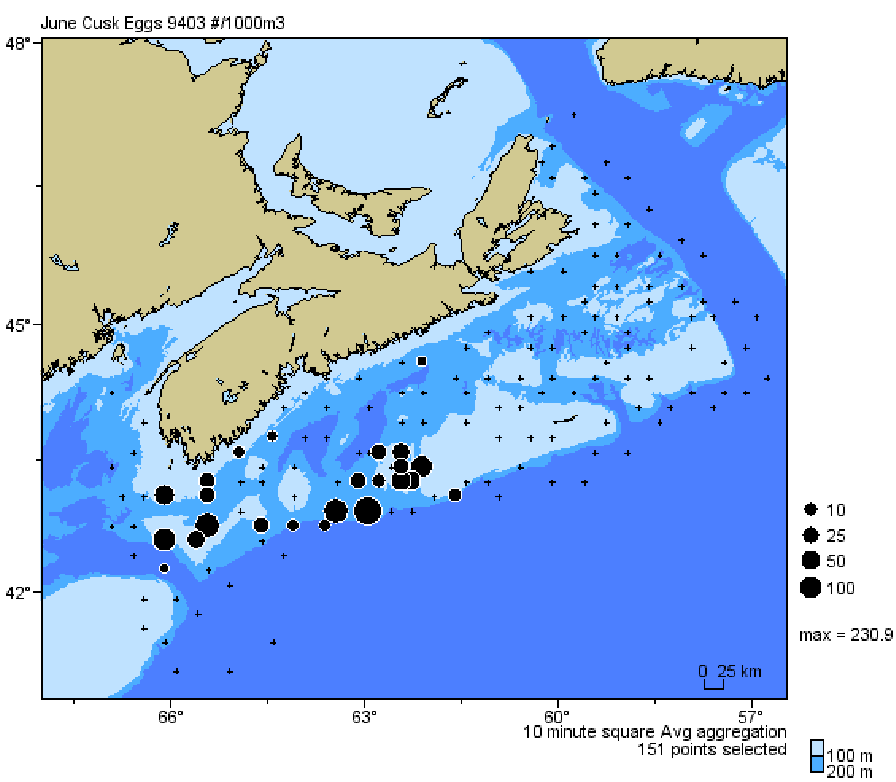
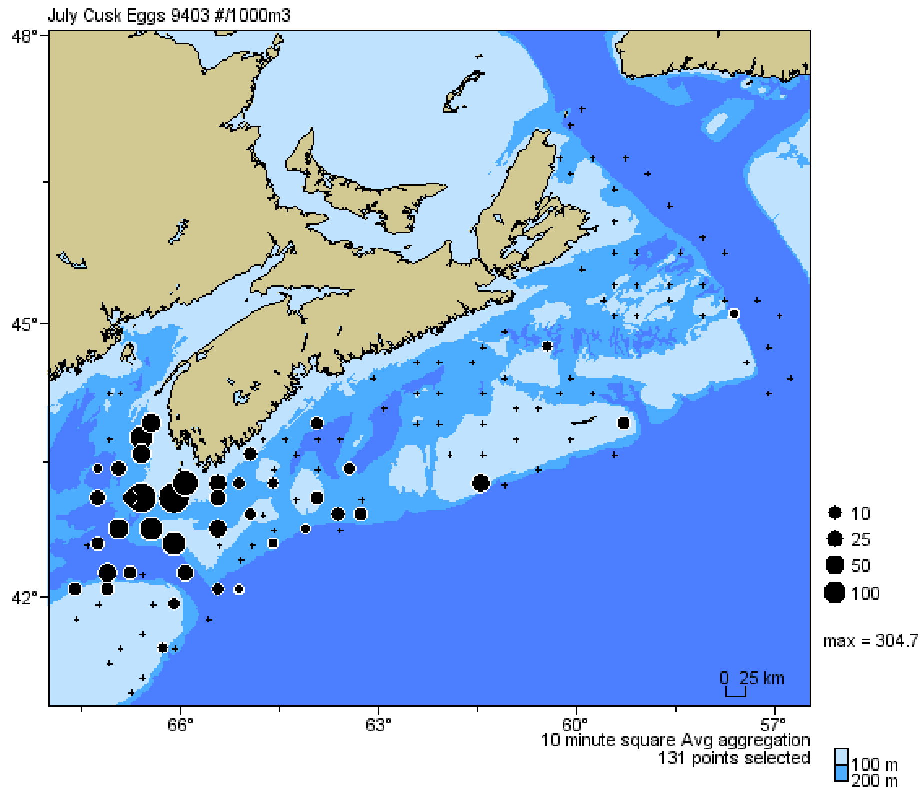


Figure 2. Spatial and temporal distribution of cusk eggs caught during the SSIP.



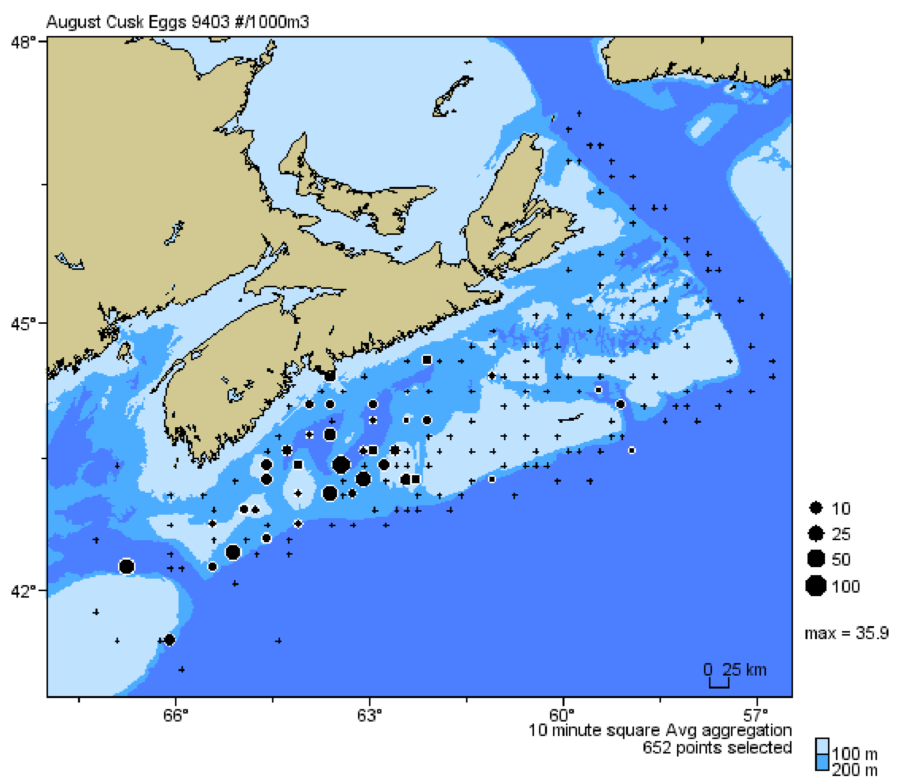


Figure 2 continued.

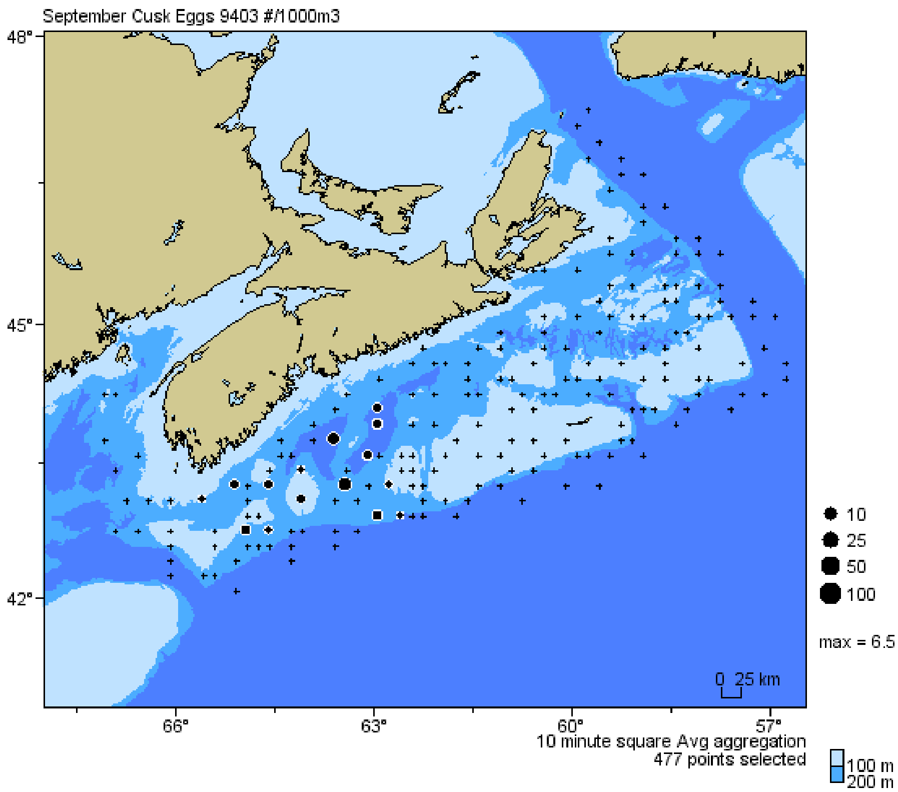


Figure 2 continued.

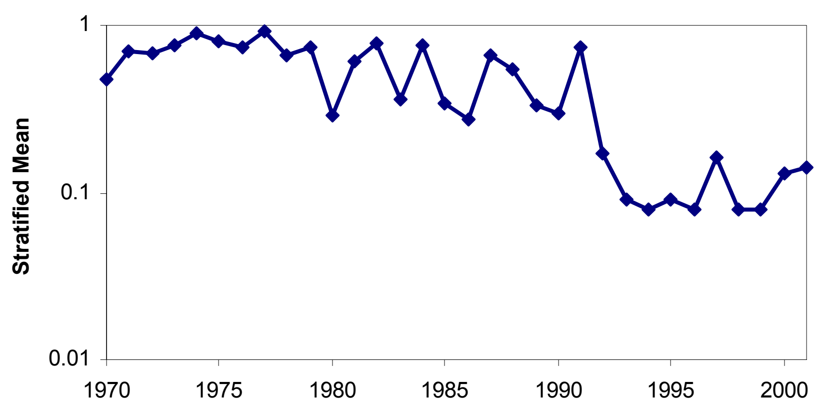


Figure 3. Cusk stratified mean number per tow in summer 4VWX groundfish research survey.

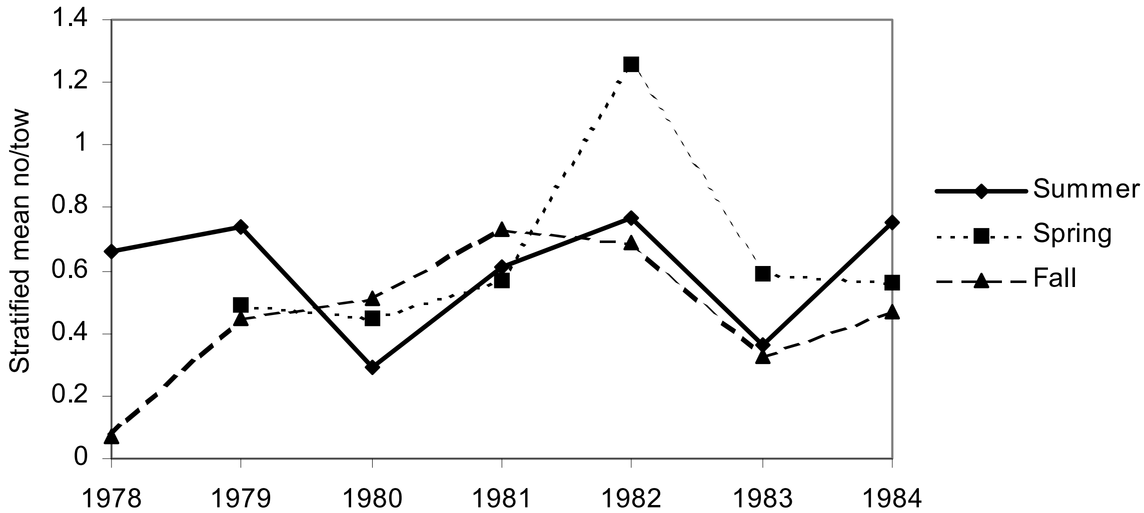


Figure 4. Comparison of cusk catches in the spring, summer, and fall RV surveys, stratified mean number per tow.

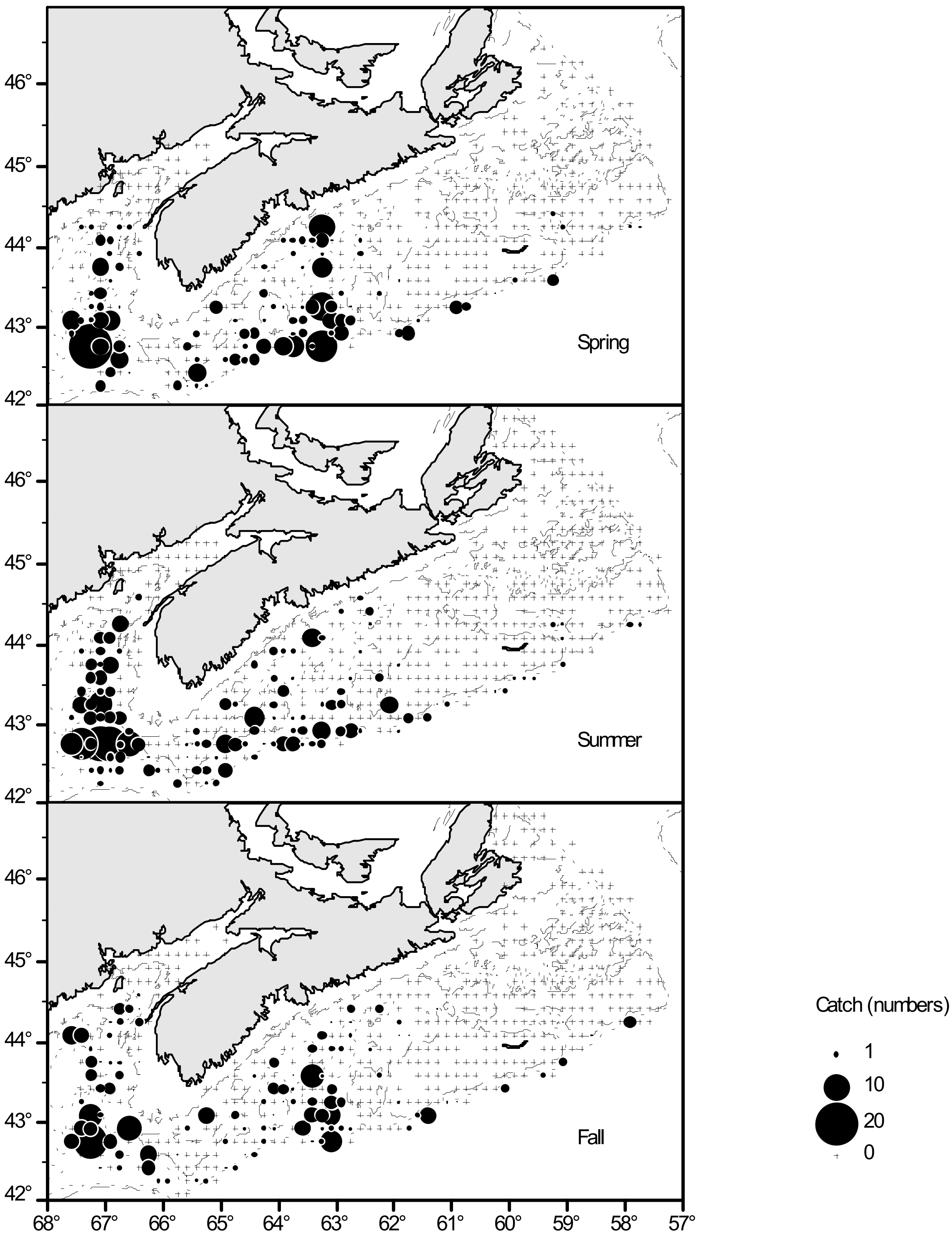


Figure 5. Distribution of cusk catches in the spring, summer and fall research surveys 1978-1984, mean number per tow aggregated by 10-minute².

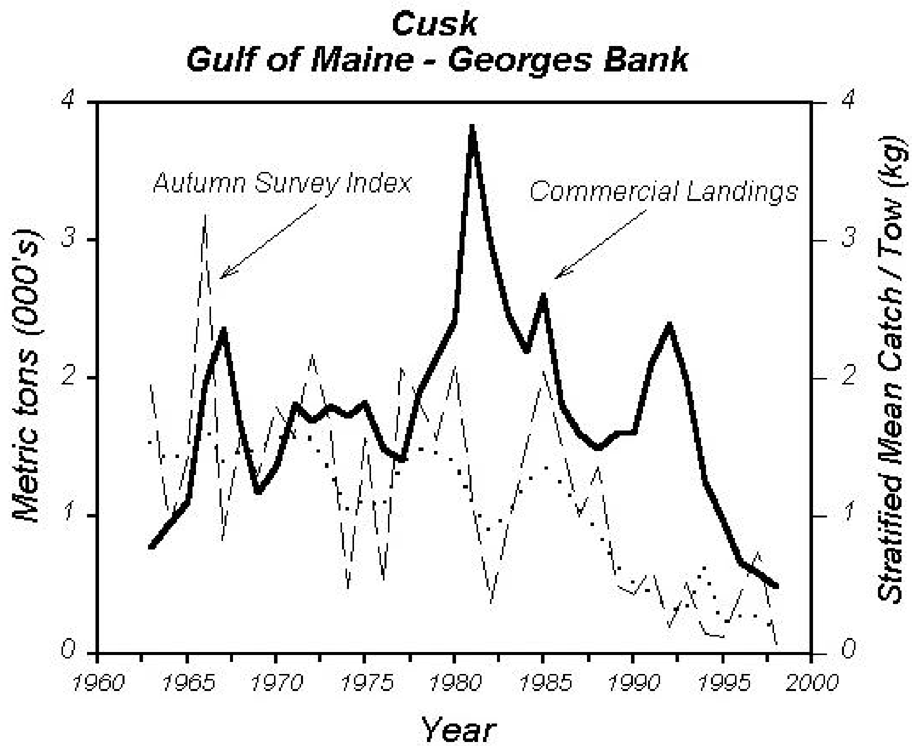


Figure 6. U.S. RV survey indices and commercial landings of cusk (from O'Brien 2000).

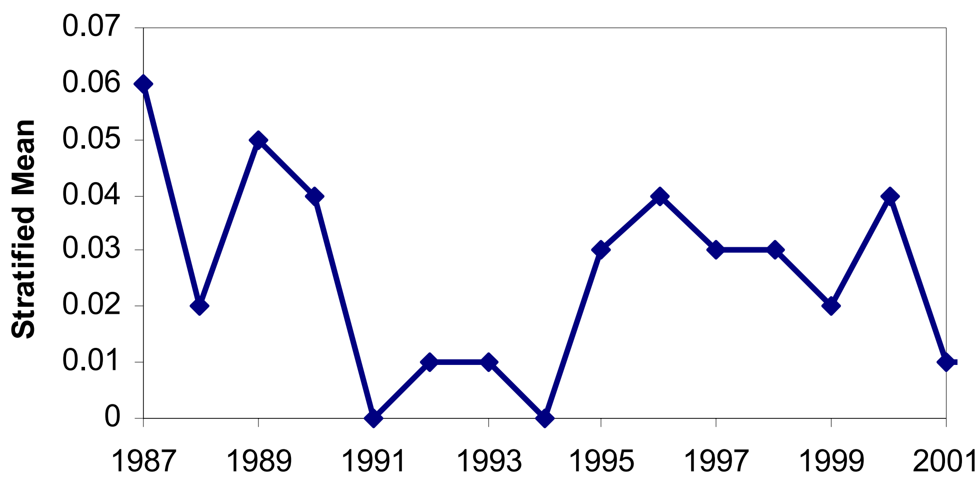


Figure 7. Cusk stratified mean number per tow in Georges Bank spring RV survey.

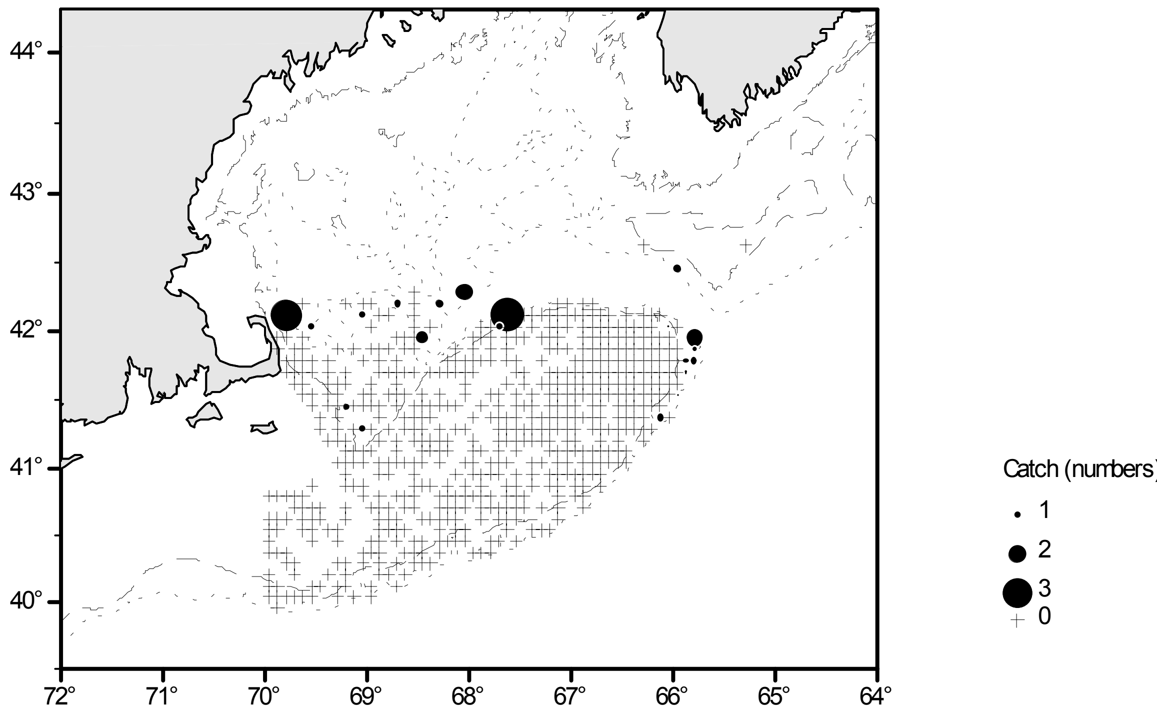


Figure 8. Location of cusk catches, summed for all years, in Georges Bank survey, aggregated by 5 minute².

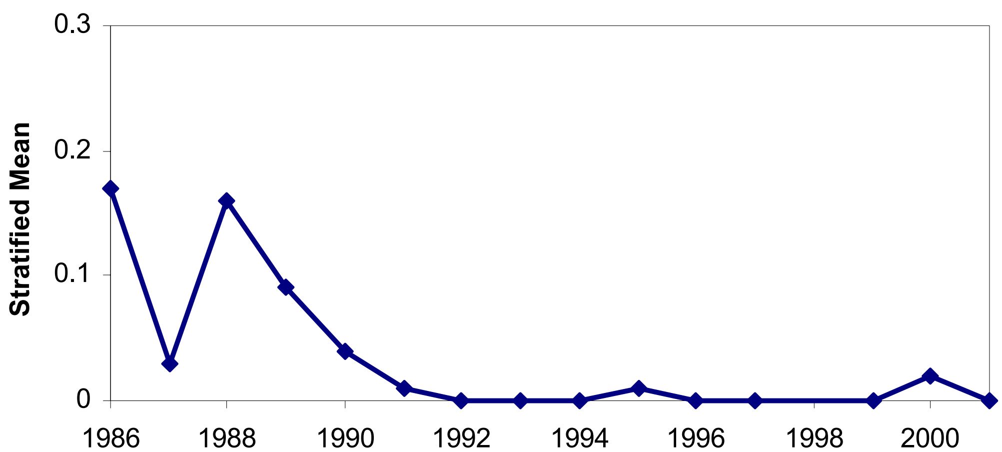


Figure 9. Stratified mean number per tow in 4VsW cod research vessel survey.

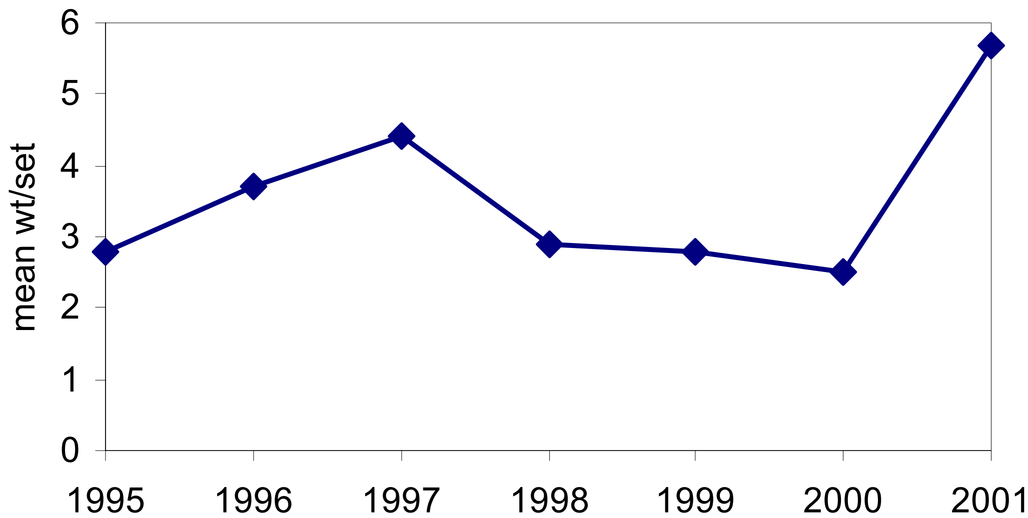


Figure 10. Mean catch (kg/1500 hooks) from the random station portion of the 4VsW sentinel survey.

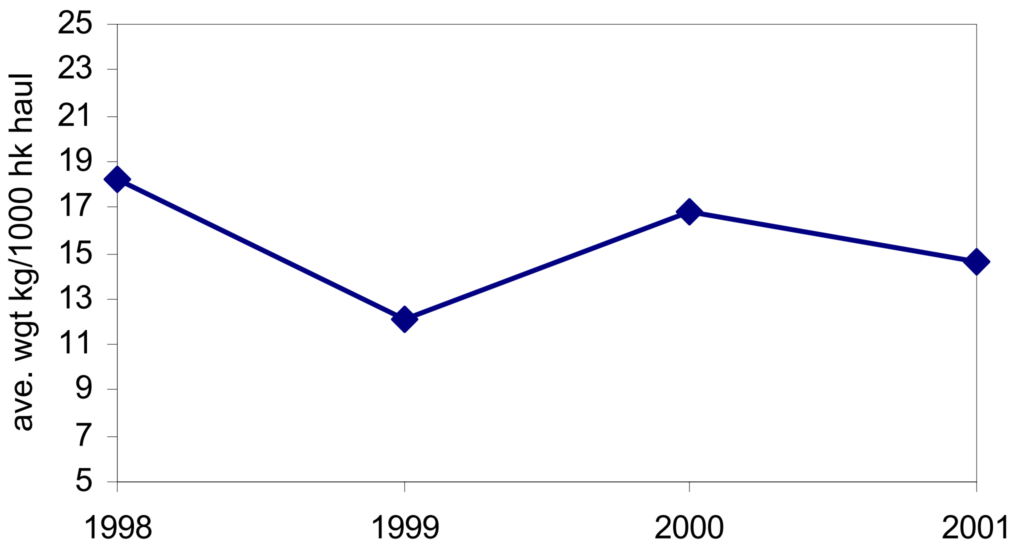


Figure 11. Mean catch of cusk (kg/1000 hook haul) from the fixed station portion of the Halibut survey.

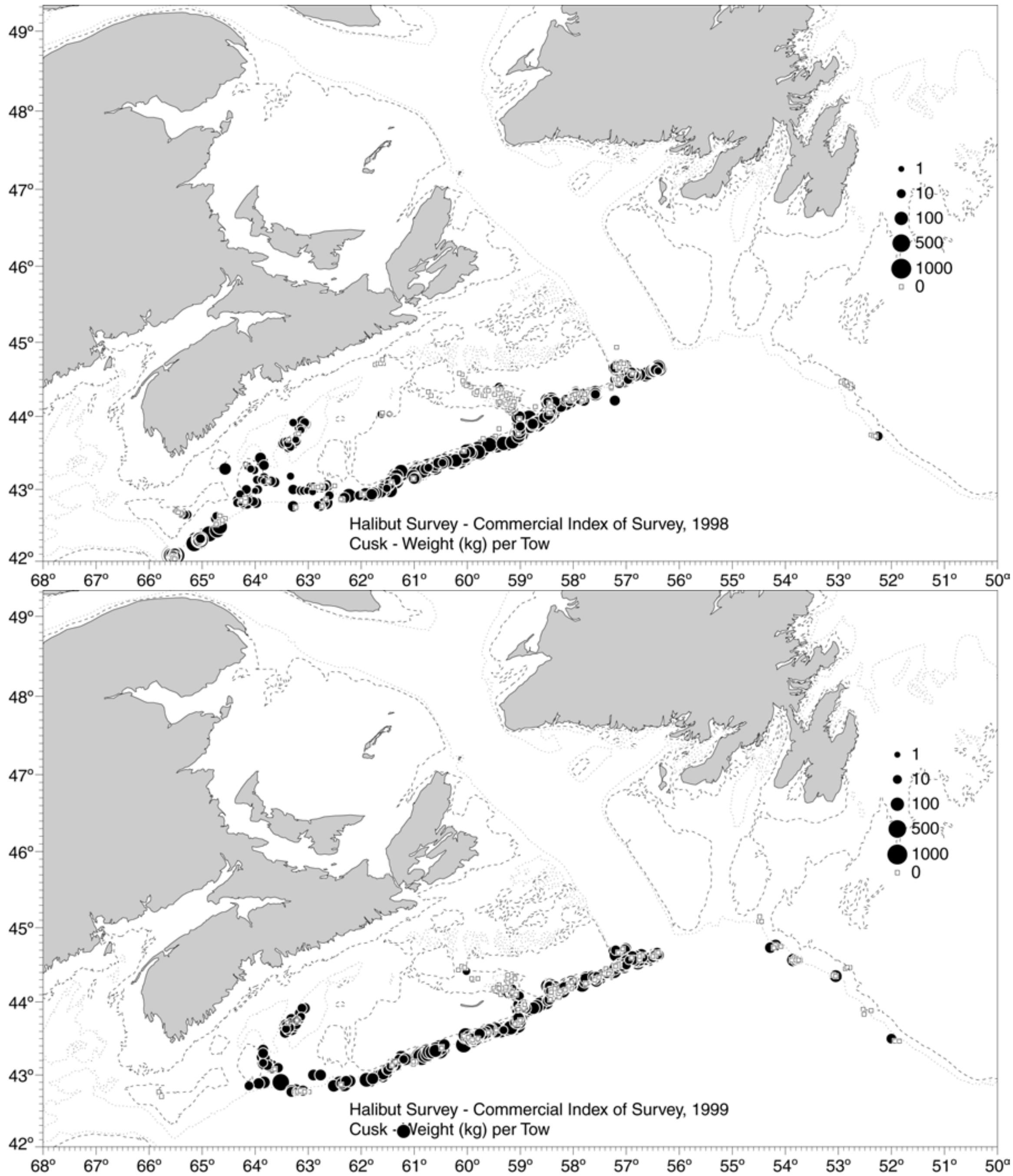
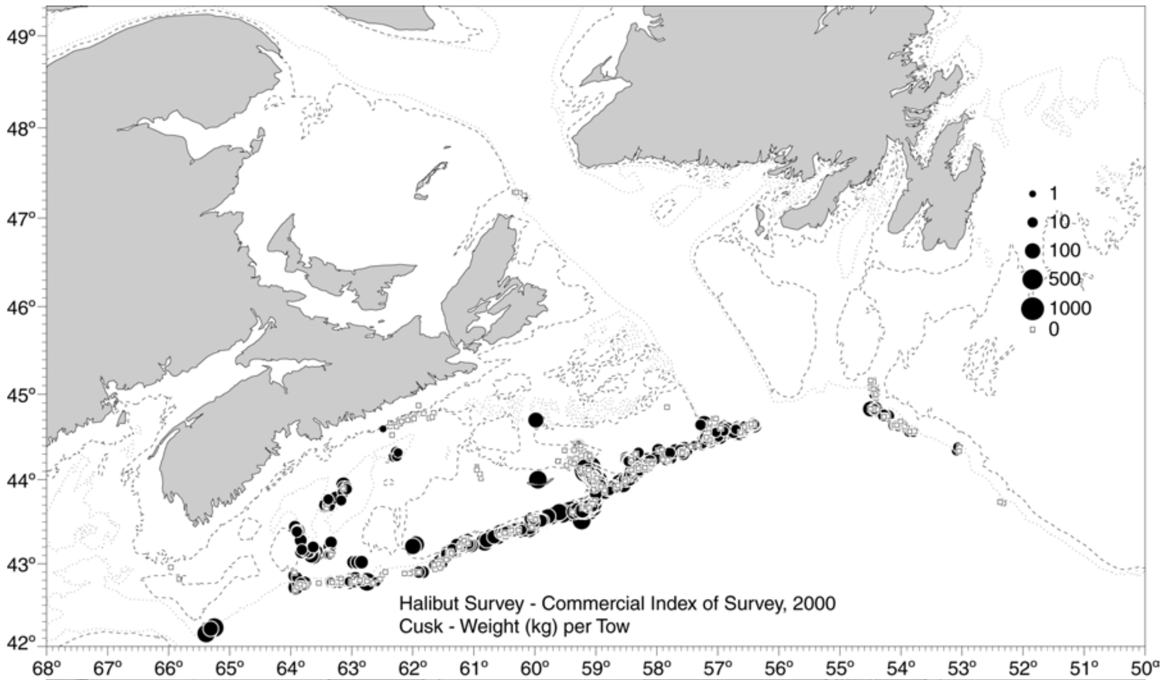


Figure 12. Distribution and magnitude of cusk catches (kg/1000hooks) in the commercial index portion of the halibut survey.



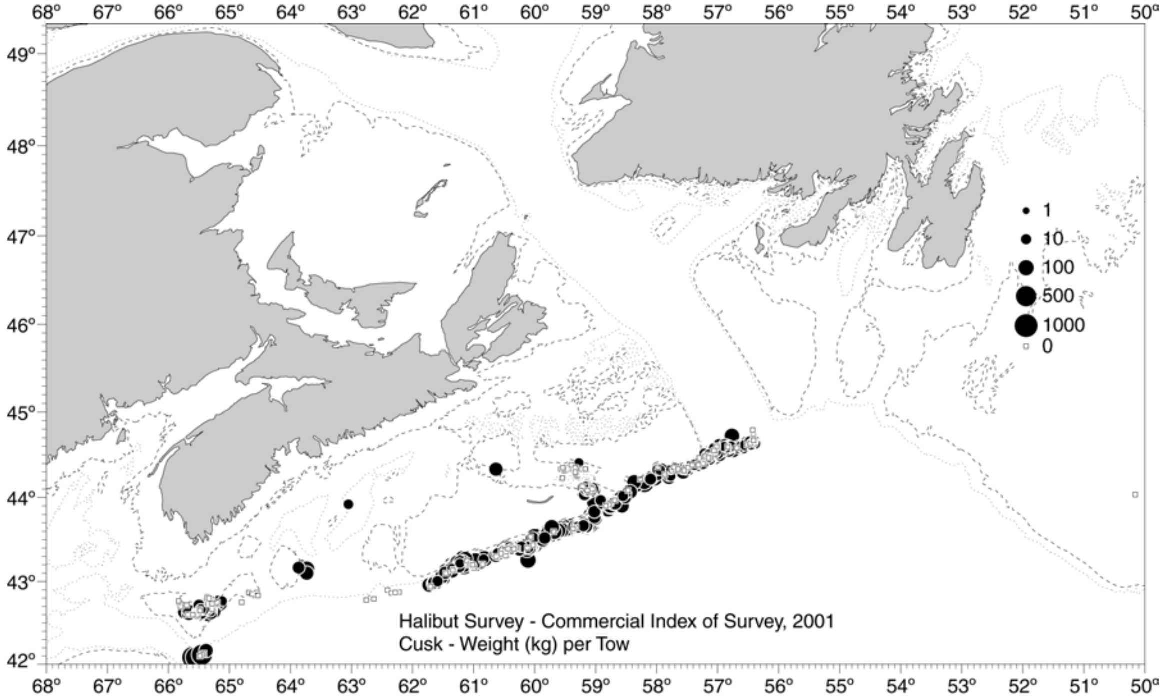


Figure 12 continued.

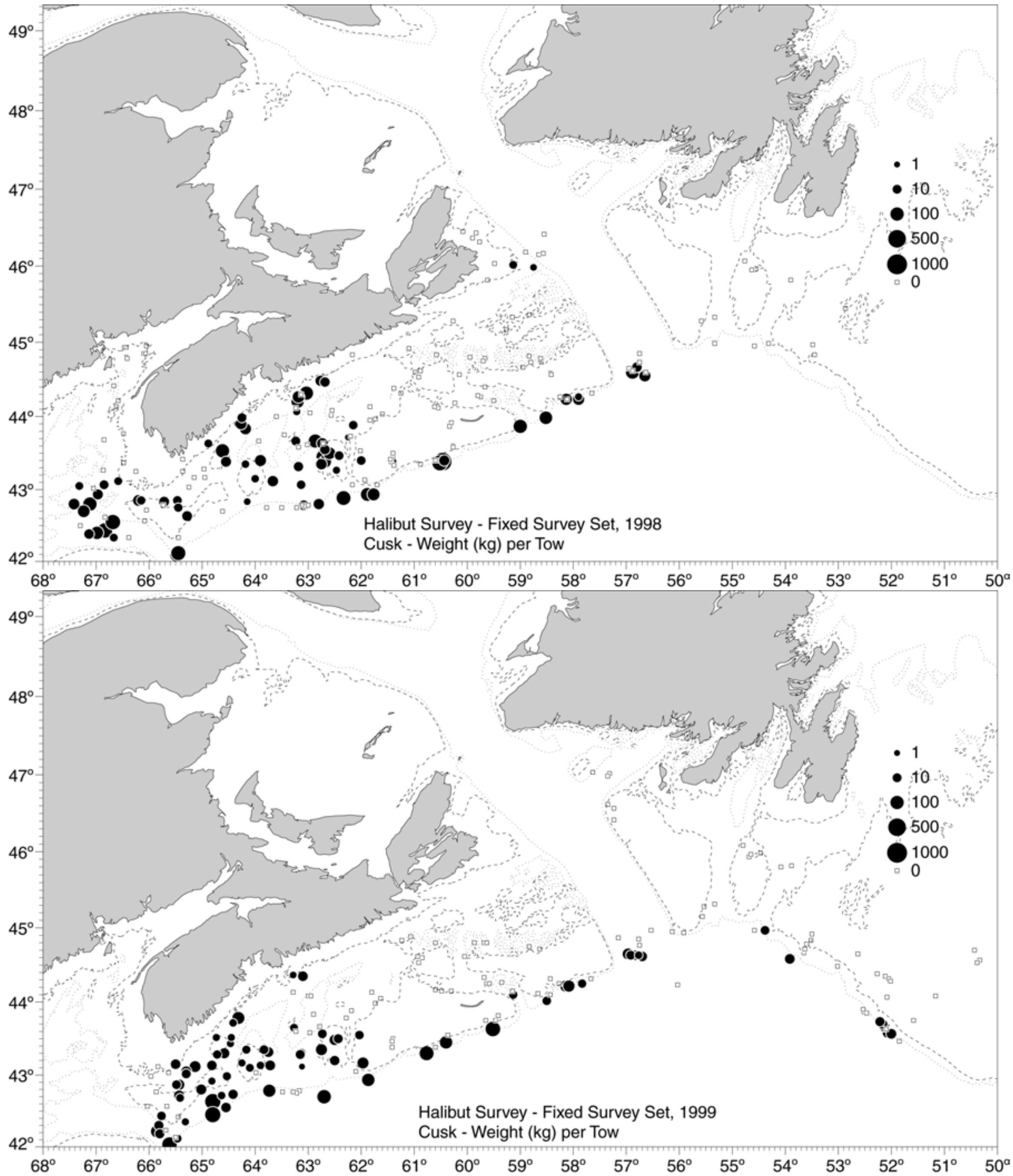
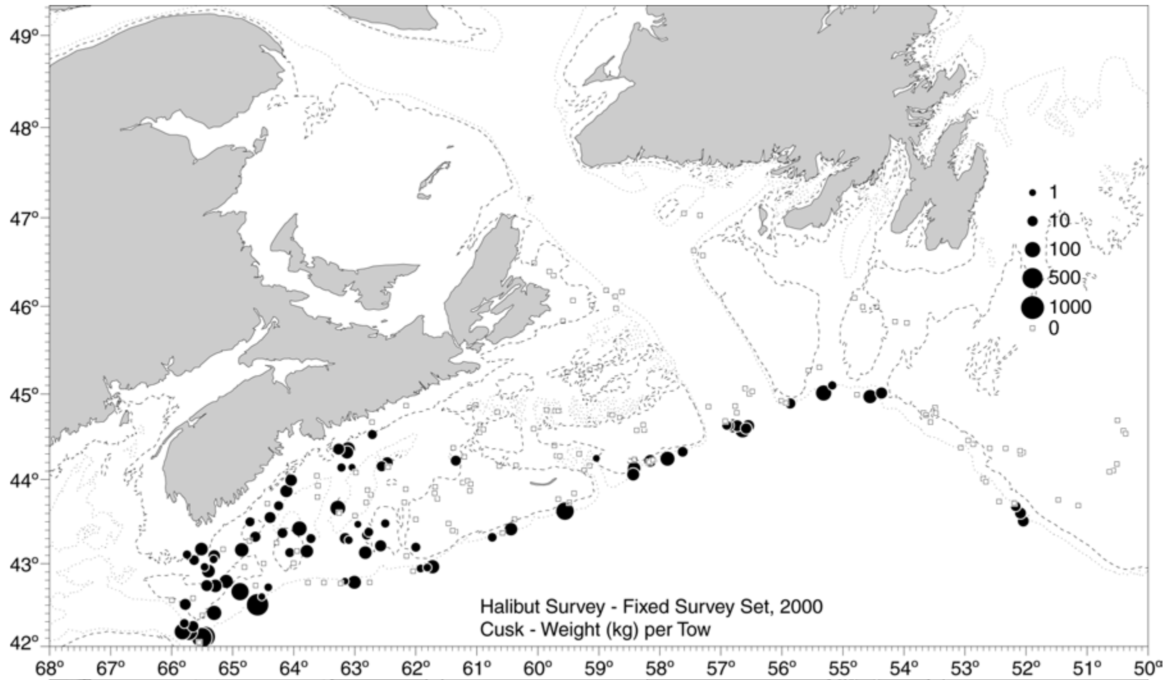


Figure 13. Distribution and magnitude of cusk catches (kg/1000 hooks) in the fixed set portion of the Halibut survey.



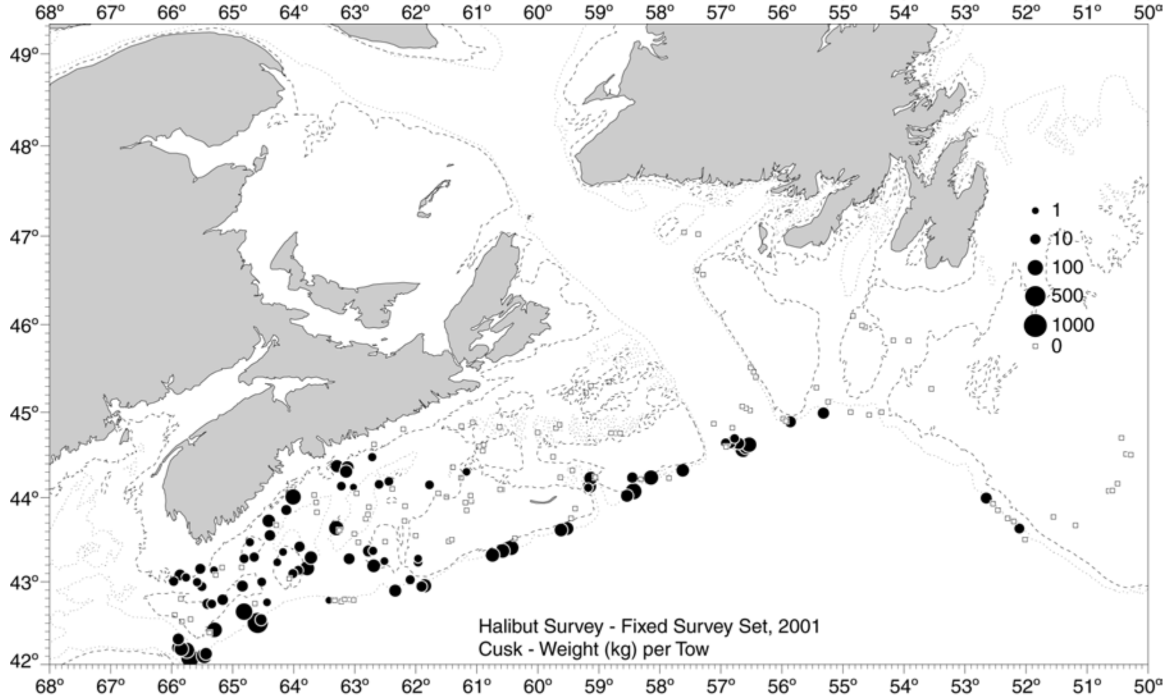


Figure 13 continued.

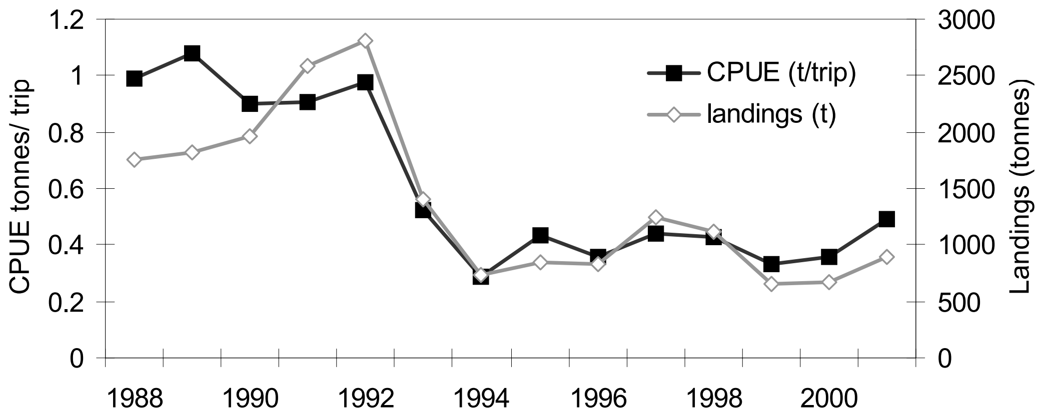


Figure 14. Cusk catch rate and landings for groundfish longliners (main species in the catch cod, haddock, pollock or cusk) in 4Xmnopqru.

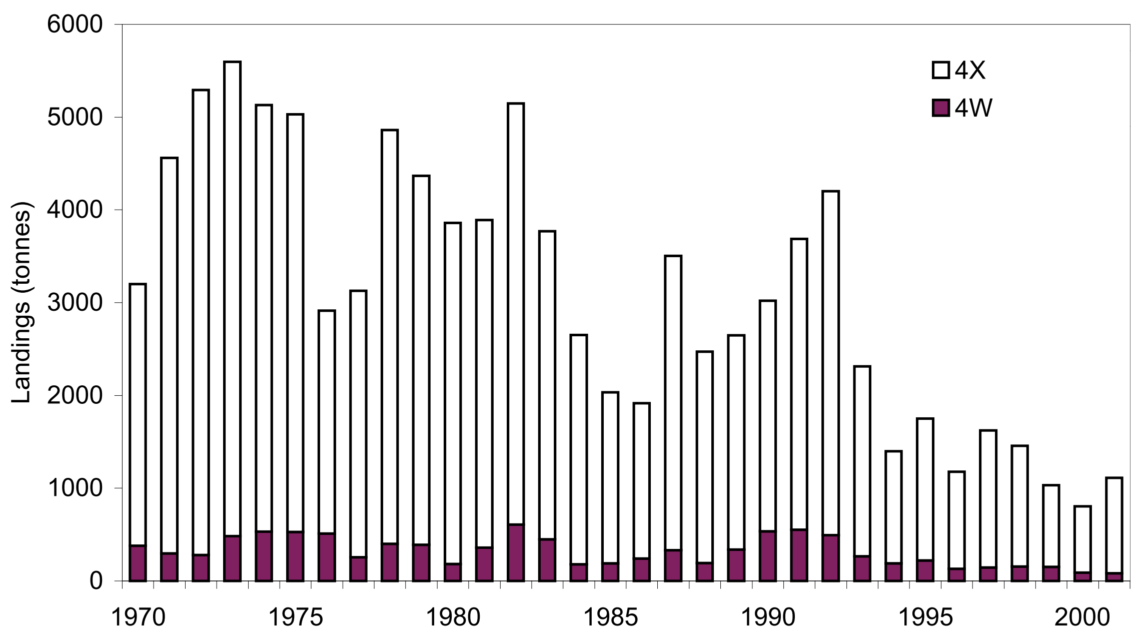


Figure 15. Cusk landings (tonnes) from Canadian waters, all sectors.

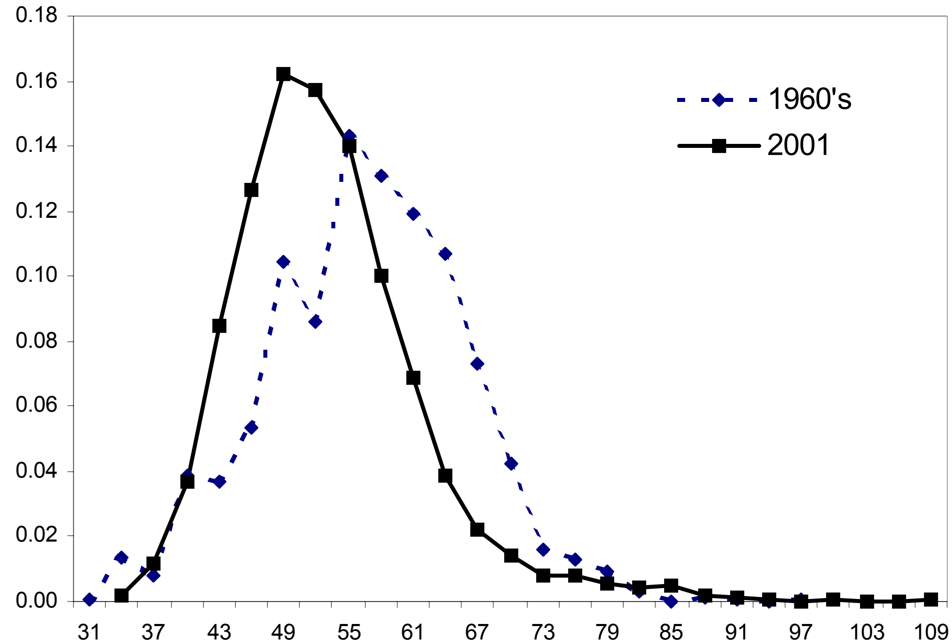


Figure 16. Historical and current size distribution (cm) of cusk in commercial landings.

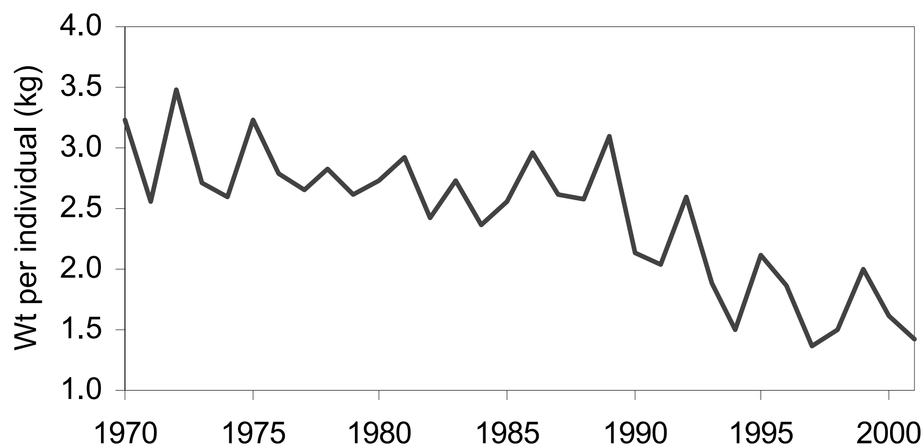


Figure 17. Average weight (kg.) per individual cusk in summer groundfish survey.

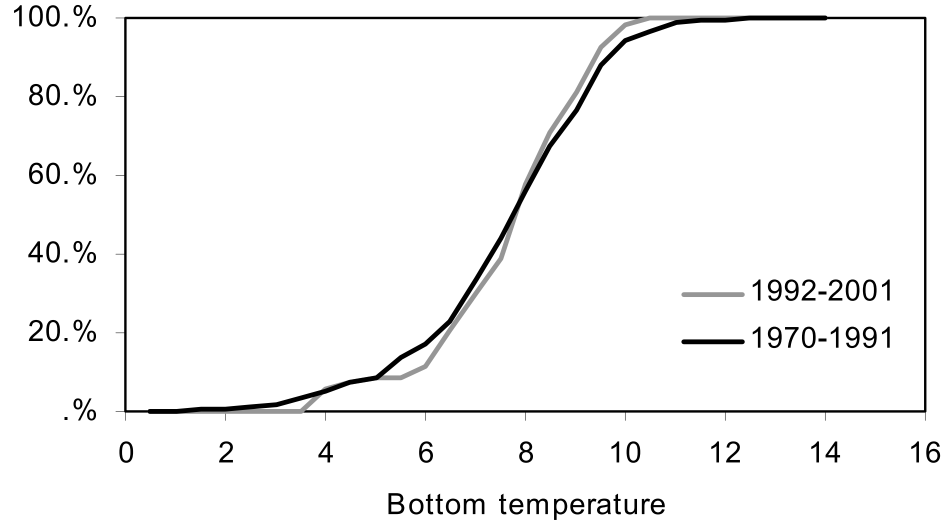


Figure 18. Cumulative frequency of non-zero sets by temperature from the 4X portion of the summer RV survey.

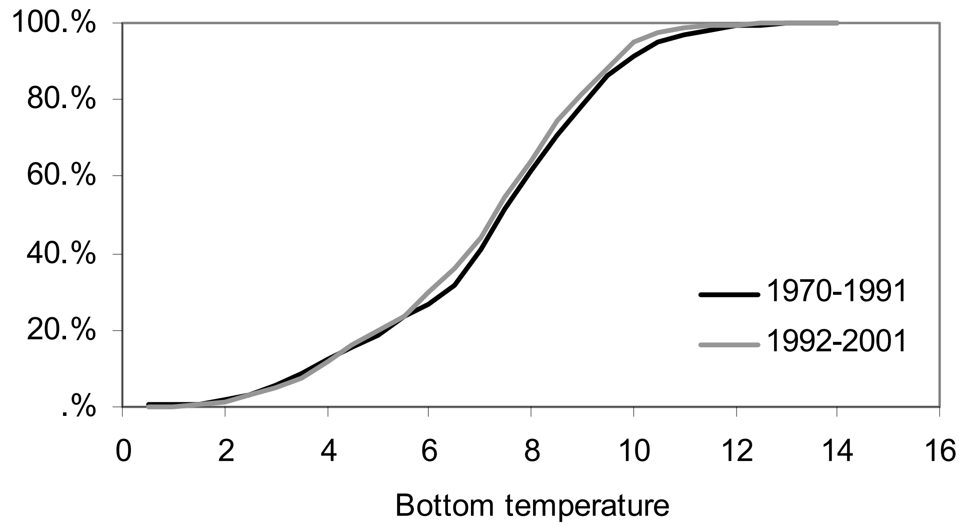


Figure 19. Cumulative frequency of sets by temperature in the 4X portion of summer RV survey.

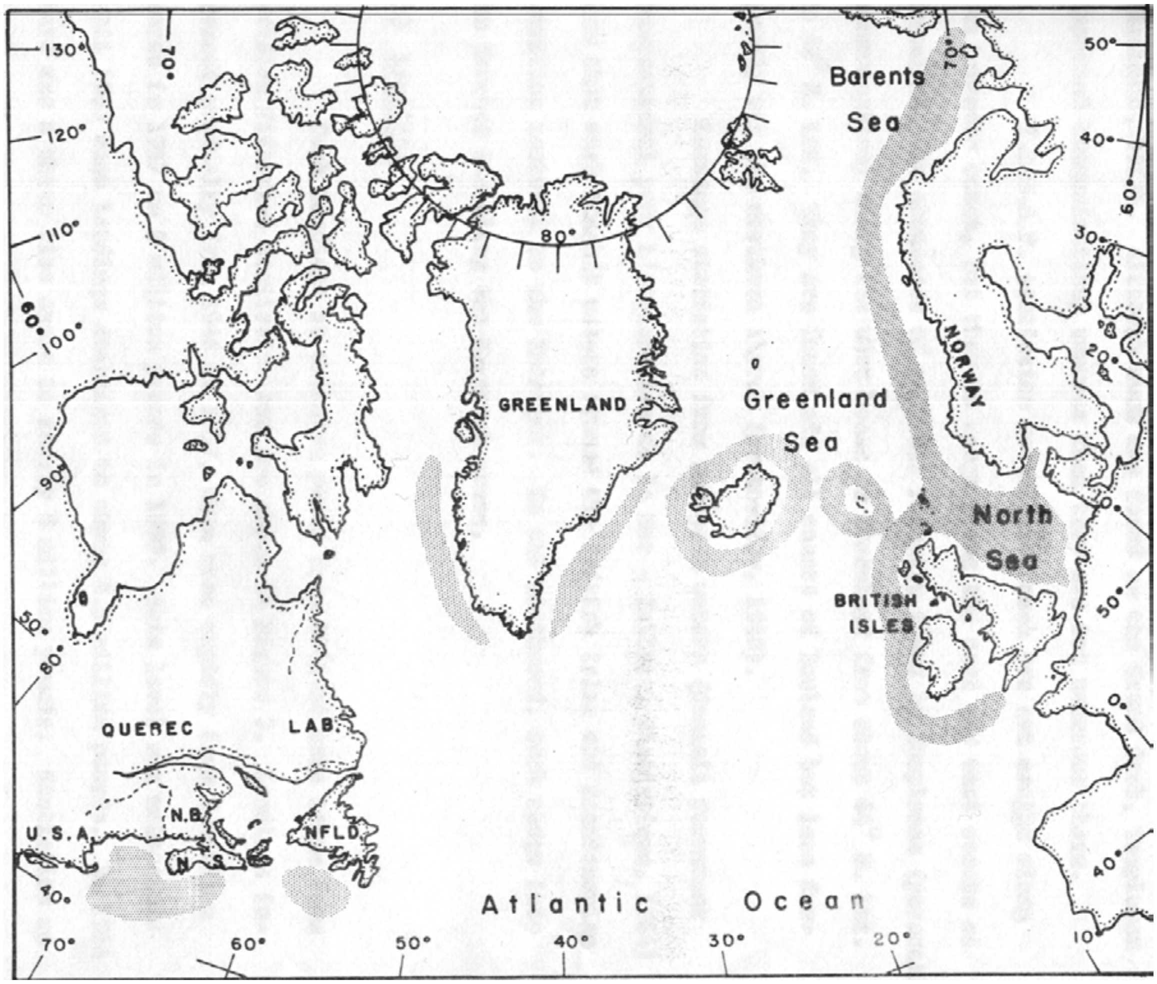


Figure 20. Historical distribution of cusk (from Oldham 1966).

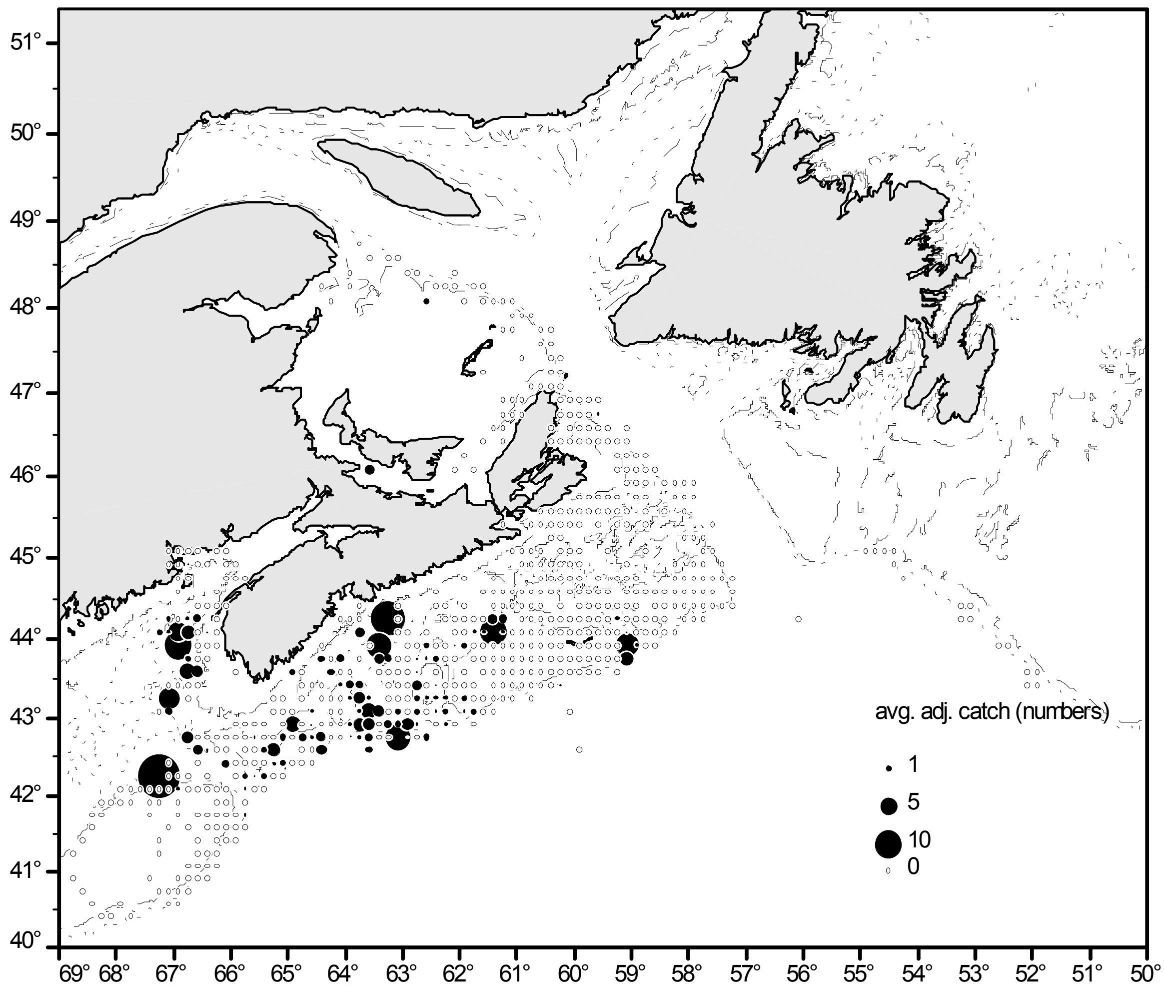


Figure 21. Distribution and magnitude of cusk catches from the pre-1970 research surveys, numbers adjusted to 1.75nm tows.

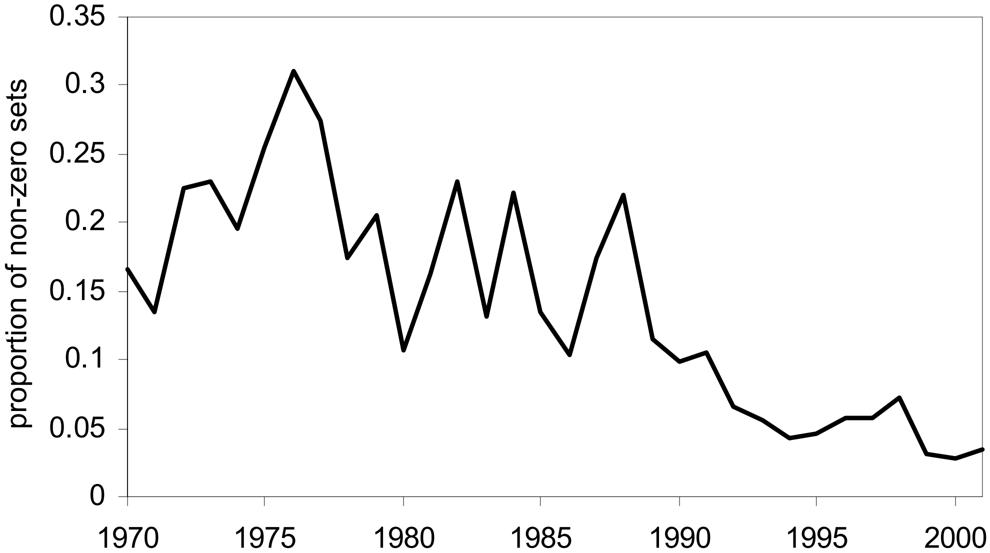


Figure 22. Proportion of sets where cusk were caught in the summer RV survey.

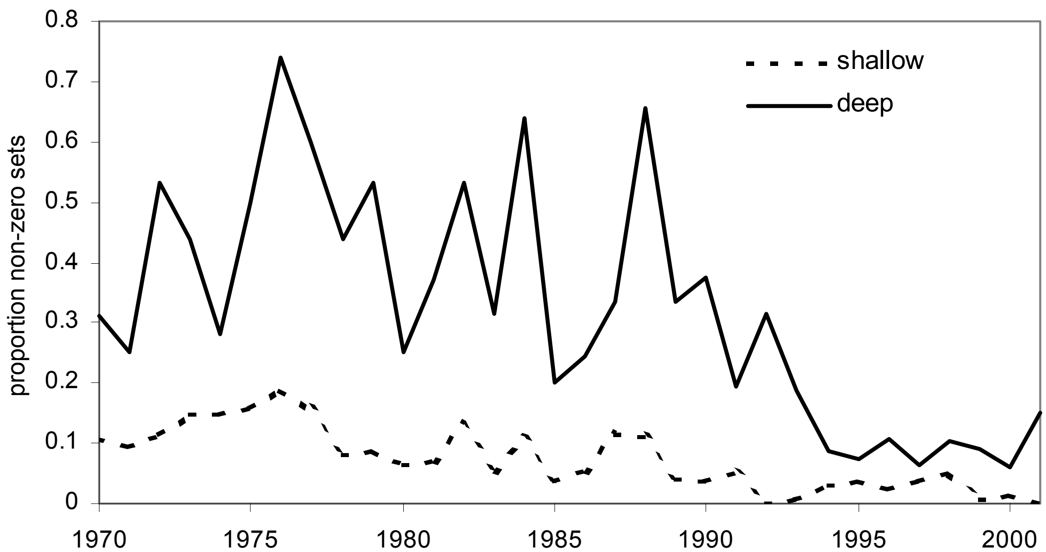


Figure 23. Proportion of shallow (<150m) and deep non-zero cusk catches in the summer RV survey.

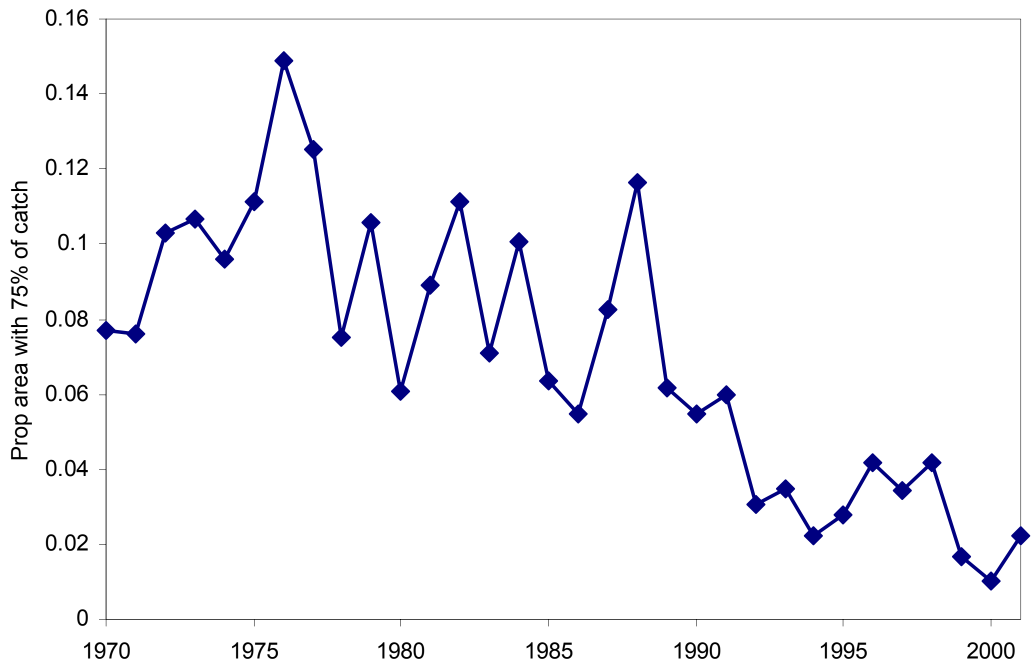


Figure 24. Fraction of the area surveyed containing 75% of total cusk caught.

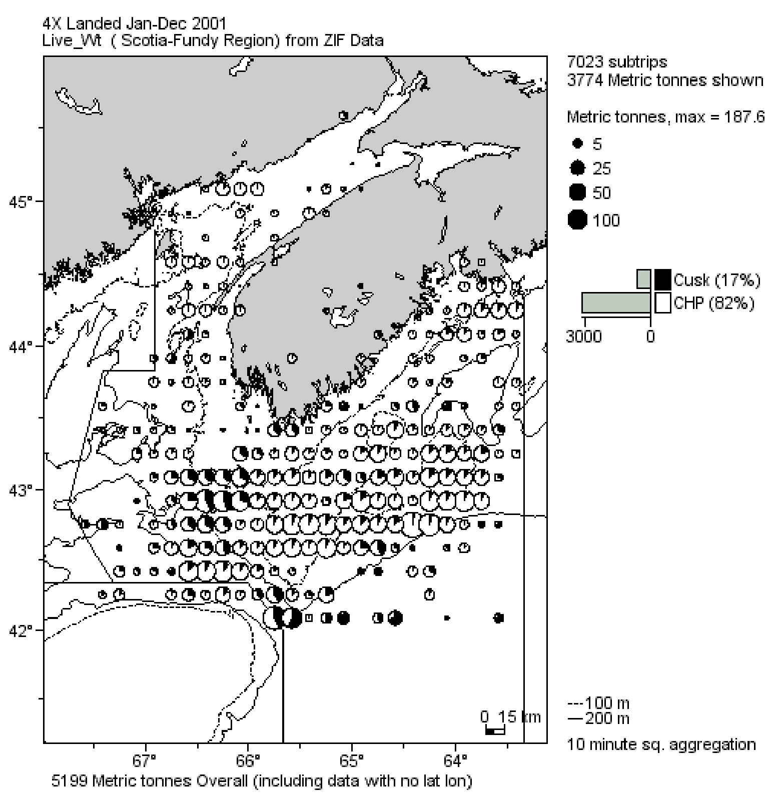


Figure 25. Distribution of cusk landings in the 4X-longline groundfish fishery, and the proportion of landings comprised by cusk versus cod, haddock and pollock combined (CHP).

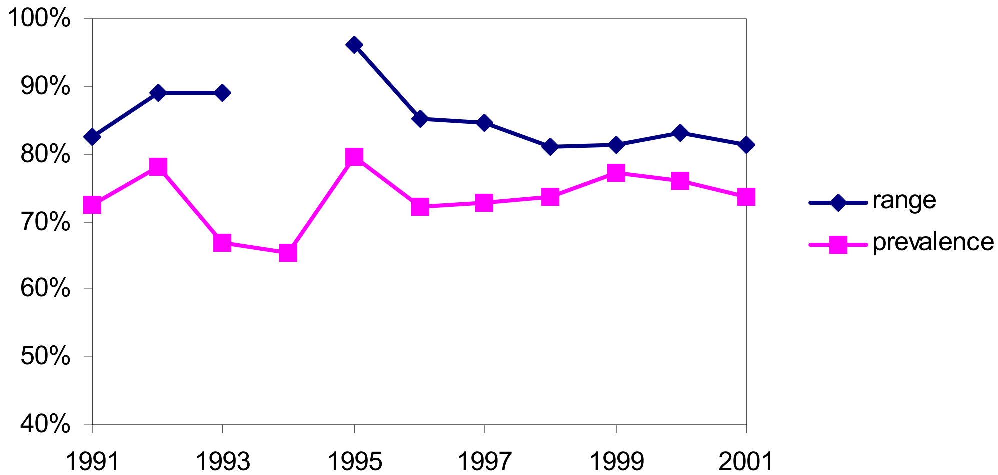


Figure 26. Range (proportion of 5 minute^2 geographic blocks with longline effort where cusk were caught) and prevalence (proportion of longline trips which landed cusk) of cusk in the groundfish longline fishery in 4X.

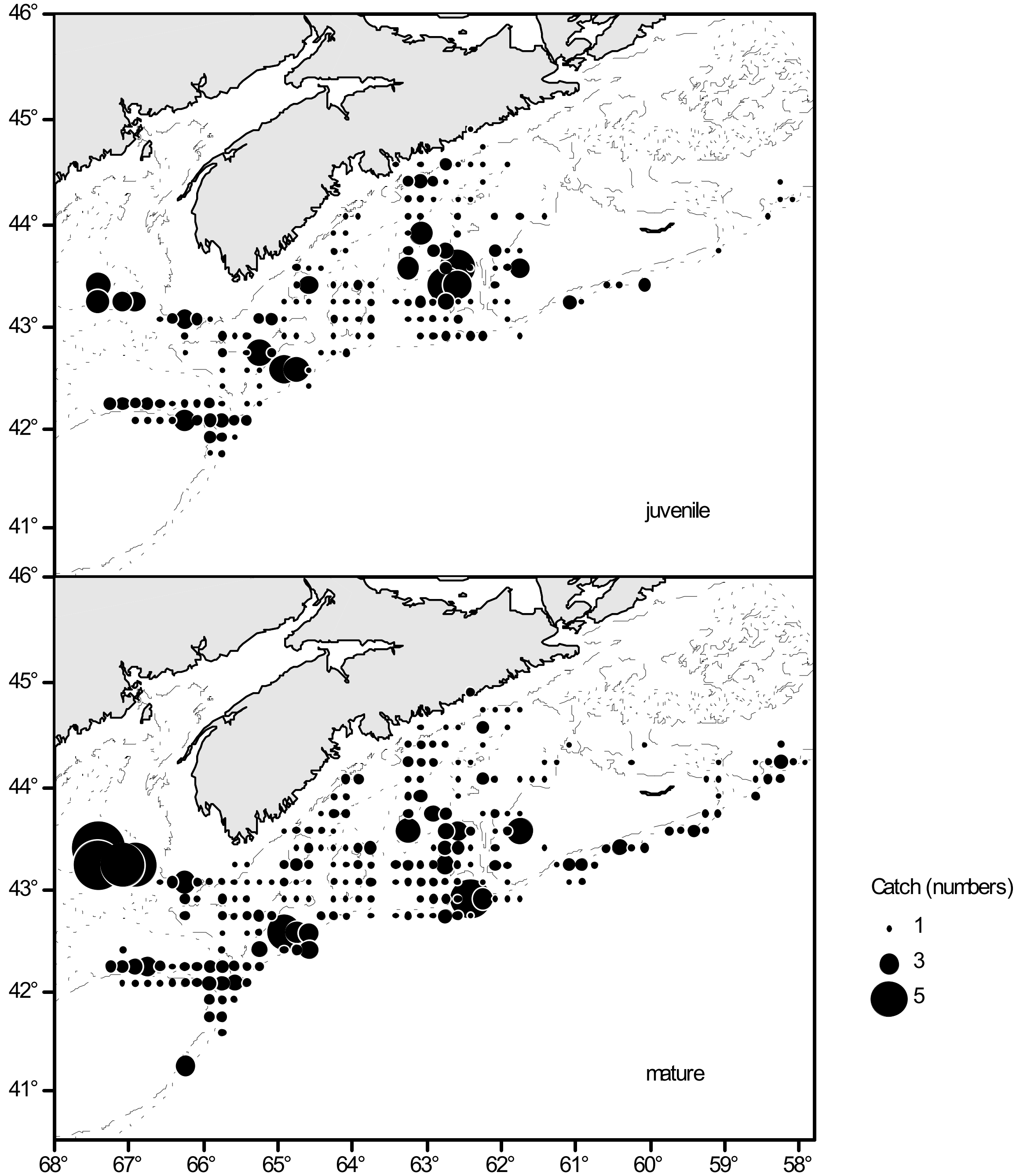


Figure 27. Distribution of juvenile and mature cusk caught by longline (IOP1985-2001) numbers aggregated by 10-minute square.

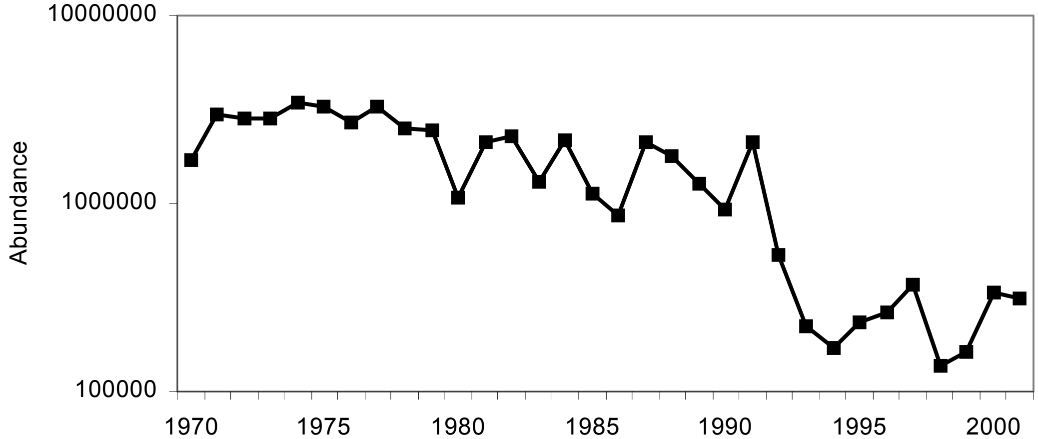


Figure 28. Stratified total numbers of mature (>50 cm.) cusk estimated from the summer RV survey.

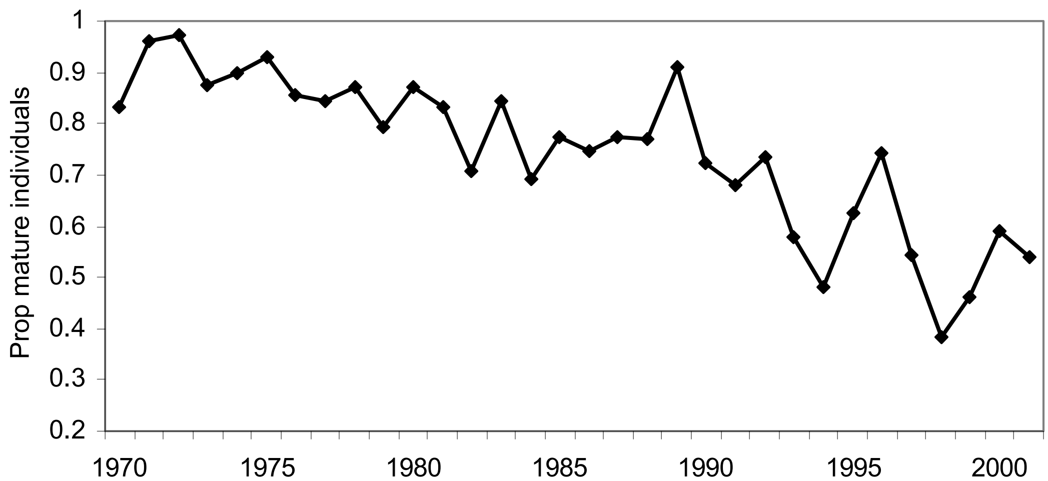


Figure 29. Proportion of cusk mature (>50 cm.) in the summer RV survey.