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June 2007

Mapping Spatial and Temporal Distribution of Spawning Areas for Eight Finfish Species Found on the Scotian Shelf

by

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ABSTRACT

Data collected during the Department of Fisheries and Oceans (DFO), Maritimes, research vessel (RV) surveys was used to map the timing and spatial distribution of eight selected finfish species found on the Scotian Shelf. A Geographic Information System used maturity data collected on these surveys to produce trend surface maps illustrating spawning distribution. These maps show that spawning had occurred over much of the area covered during the Scotian Shelf RV surveys with the highest numbers of spawning individuals found in the spring and early summer. Some species had a spatially and temporally localized spawning while others were more dispersed in their spawning activities. The highest numbers of spawning individuals were found on Western, Emerald, Sable Island and Browns banks. For many species included in the study, most spawning occurred in March and July with some other smaller peaks occurring in the fall.

Les données recueillies lors des relevés effectués par les navires de recherche du MPO, Région des Maritimes, ont permis de cartographier la distribution spatiotemporelle de huit espèces de poissons du plateau néo écossais. Grâce à un système d'information géographique, on a produit, à partir des données sur la maturité des poissons recueillies lors de ces relevés, des cartes illustrant la répartition du frai. Ces cartes montrent que le frai est réparti sur la plupart de la zone couverte par les relevés effectués sur le plateau néo écossais, et que les plus grands nombres de reproducteurs sont observés au printemps et au début de l'été. Si, chez certaines espèces, la répartition du frai est ponctuelle, tant dans le temps que dans l'espace, les activités de frai sont plus dispersées chez d'autres espèces. Les plus fortes populations de reproducteurs ont été observées sur les bancs Western et Émeraude, ainsi que sur les bancs de l'île de sable et de Brown. Pour la plupart des espèces étudiées, les périodes de frai les plus actives ont été observées en mars et en juillet, avec quelques pointes moins importantes à l'automne.

INTRODUCTION

This study used a Geographic Information System (GIS) to model and map Department of Fisheries and Oceans (DFO) research vessel (RV) survey data to illustrate the spatial and temporal distribution of spawning intensity for selected finfish species found on the Scotian Shelf. These maps could be used by industry, government and the regulatory bodies to help minimize any potential impacts on the environment that may occur as a result of oil and gas exploration. Having knowledge of the distribution of spawning fish species in a region where there is active oil/gas development would help lessen any disruption to the life history of those species.

This current work followed from an Environmental Studies Research Funds project that used research vessel data to map the distribution of spawning areas for selected species found on the Grand Banks of Newfoundland and Labrador. A project report was written, peer-reviewed and published as part of the DFO Technical Report series and is publicly available. (Ollerhead et al., 2004)

The study area covered the entire Scotian Shelf including NAFO divisions 4Vs, 4W and 4X eastward from 66o west covering an area of over 151,000 km2. A map of the study site is shown in Figure 1.

The Scotian Shelf project studied American plaice *(Hippoglossoides platessoides)*, Atlantic cod *(Gadus morhua)*, Haddock *(Melanogrammus aeglefinus)*, Redfish *(Sebastes spp.)*, Silver hake *(Merluccius bilinearis)*, White hake *(Urophycis tenuis)*, Witch flounder *(Glyptocephalus cynoglossus)* and Yellowtail flounder *(Limanda ferruginea)*.

METHODS

The methodology used in this study was taken directly from the 2004 NL project where a GIS was used to map spawning distributions of selected finfish species found on the Grand Banks. The methods developed and used to map the Grand Banks spawning distributions were applied to the Scotian Shelf survey data. Because of the similarity between the two studies a summarized method will be presented and those requiring more detailed information are referred to Ollerhead et al., 2004, for further reading.

Length-Sex-Maturity (LSM) data were used to model and map the spawning distributions. LSM data uses a visual inspection of the gonads to determine the maturity of an individual. The maturity levels used in the Scotian Shelf RV surveys are found in Table 1 (Hunt, 1996). Individuals were said to be in spawning condition if the gonads indicated that they were actively spawning or were to begin spawning very soon; these are shown in Table 1 as Stages 4 and 5, Ripe and Spawning.

Monthly spawning distribution maps were created for each species where data were available. These maps provide species-specific perspectives of spawning activity on the Scotian Shelf for the time periods sampled. To provide an overall view of spawning activity, monthly distribution maps were created that combined the data for all species together.

As all species were not caught in every set, the amount of data available for mapping varied from species to species. This variability is reflected in the spawning distribution maps by the spatial extent and the period of years that each map represents. This monthly variability in the number of sets and hence the amount of data available is often large. March, July and October comprised a large percentage of the surveys that were mapped in this project.

For any survey that collected LSM data, not every set caught fish. These zero-catch sets are shown in grey on the maps and are included to illustrate the survey extent and provide a measure of fishing effort. Fishing effort maps were developed to show the survey extents for the individual species maps as well as the combined data maps. The effort maps were created by determining the years when LSM data for a species were measured and then mapping all sets that fell within that time period, whether or not they were successful in catching the species of interest.

DATA MANAGEMENT

The required data were extracted from the DFO archives at the Bedford Institute of Oceanography, reformatted and imported into a local Oracle database. Oracle (Oracle RDBMS, v8.1.7, Oracle Corporation) is a powerful data management tool and was used to analyze the data and organize it into a GIS compatible format. Data were extracted and files were created for every species for every month where data were available. These files were then imported into the SPANS GIS (TYDAC Research Inc.) for modeling.

POTENTIAL MAPPING

The models for this study were produced using potential mapping from the SPANS GIS (PCI Geomatics) software. This modeling technique uses the discrete point information of the survey data to create continuous, or near continuous, trend surfaces representing a selected attribute of the point data. In this study, the attribute modeled was the number of spawning females in each set and the resulting trend surfaces represented the average number of spawning females.

Potential mapping begins by creating a grid over the entire study area and using this grid to build a modeled surface. After the grid has been established, a sampling radius is chosen for the data points. The sampling radius is a parameter that determines the 'area of influence' around each data point. This radius is chosen as the smallest value that creates a continuous surface with the minimal number of gaps while still expressing the variability in the data (Kulka et al. 2003). Too small a sampling radius will result in the areas of influence not overlapping and will fail to create a continuous surface. A huge sampling radius would have an averaging effect and could potentially obscure any trends in the data. Through a series of trials it was determined that the optimum sampling radius for the volume and distribution of these data was 14 km. The sampling radius was kept constant for all species in the study. These parameters are illustrated in Figure 1a.

Once all parameters have been set, the model computes the values for each grid cell that will make up the interpolated surface. This calculation is done by averaging the values for each data point whose sampling radius overlaps the centre of the grid cell as shown in Fig. 1a. The point data Z-values are weighted by the behaviour dictated by the decay rate. The modeled grid cells were then classified into one of eight predetermined legend categories. The GIS calculated the legend categories to create maps that reflected approximately equal distributions of each category in order to create an easy to read map product.

Potential mapping is well suited to RV data that are often highly variable and have an uneven spatial distribution (Burke, 1997). This technique has been used with this type of data by Kulka (1998) and Kulka et al. (2003).

MAP PRODUCTION

The resulting trend surface models were then exported to MapInfo (v7.0 MapInfo Corporation), another GIS application, where a standard colour scheme was applied and legends and other annotations were added. These maps were then imported into a desktop publishing application, CorelDraw v13 (Corel Corporation), where the titles were added and the final layout work was done in preparation for publishing.

RESULTS

AMERICAN PLAICE (Hippoglossoides platessoides)

March and July had, by far, the greatest concentrations of spawning American plaice on the Scotian Shelf. Spawning fish were found during other times of the year but to a much lesser extent. The spawning maps show that the highest densities were found on Western, Sable Island and Banquereau Banks. Excluding March, July and October, many months had a very limited survey extent while others were only represented by a few years of surveys. Refer to Fig. 2a-j.

ATLANTIC COD (Gadus morhua)

Spawning Atlantic cod were found on the Scotian Shelf in most months when the RV surveys were conducted, with the greatest numbers found in March and another, smaller peak in February. The largest spring catches of spawning individuals were found on Browns, Emerald and Western banks. Spawning Atlantic cod occurred over much of the Scotian Shelf; however, the largest concentrations were found along the eastern edges of the shelf. July also showed a smaller area of higher catches in 4Vn, east of Cape Breton Island. Refer to Fig. 3a-j.

HADDOCK (Melanogrammus aeglefinus)

The greatest numbers of spawning haddock were found in March through to July. Most of the March spawning peak was found on Browns, Lehave and Emerald banks and to a lesser extent east of Sable Island. March had the highest density of catches as well as the greatest spatial extent. Some months that were surveyed saw no haddock catches at all. The April to July peak occurred on Browns, Lehave and Baccaro banks. Refer to Fig. 4a-j.

REDFISH (Sebastes spp.)

Spawning redfish on the Scotian Shelf were sparse. The models show the highest intensity spawning having occurred in March and July. The March peak was found at the northern extent of the study site in the deeper waters of the Laurentian Channel, while the July peak was found in the Lehave and Roseway Basins. Some months had very few surveys where redfish were caught. Refer to Fig. 5a-j.

SILVER HAKE (Merluccius bilinearis)

The greatest concentrations of spawning Silver hake were found in July, which represents over 30 years of survey data. Some spawning individuals were found in other months but in very limited numbers and spatial extent. The July spawning peak was found to occur over much of 4W, including Sable Island, Western and Emerald Banks and extending northward onto the Banquereau Bank. Refer to Fig. 6a-j.

WHITE HAKE (*Urophycis tenuis*)

Spawning white hake were found in very limited numbers on the Scotian Shelf with the largest catches of spawning individuals occurring in July. The largest portion of the spawning individuals was found on Emerald and Western Banks. Some months had a very few surveys with a very limited spatial extent. Refer to Fig. 7a-i.

WITCH FLOUNDER (*Glyptocephalus cynoglossus*)

Spawning witch flounder were not found in great abundance on the Scotian Shelf. The largest numbers of spawning witch flounder were found in July with some smaller, sporadic catches in March and August. The spawning intensity maps show the highest intensity spawning occuring on the Sable Island and Banquereau banks. Refer to Fig. 8a-j.

YELLOWTAIL FLOUNDER (*Limanda ferruginea*)

The greatest abundances of spawning Yellowtail flounder were found in March and July. Both spawning peaks identified covered a large portion of the Scotian Shelf, including Emerald, Sable Island, Western, Middle and Browns Banks. The July peak had a greater spatial extent than the March peak. Both months saw large concentrations at the northern end of the shelf with a smaller area of higher catches at the southern tip of the shelf. Refer to Fig. 9a-j.

COMBINED SPAWNING MAPS

Spawning was found to have occurred over much of the Scotian Shelf at various times of the year. The most spawning occurred in March and July and covered a great deal of the Scotian Shelf. The widest spatial distribution of spawning individuals was found in July, while the greatest densities occurred in March. Surveys were conducted in all months, except for January and May. Some months had a very limited sampling program and data were not available for all areas of the Scotian Shelf. Refer Fig. 10a-j.

DISCUSSION

This study mapped the spawning distribution and timing for eight selected finfish species found on the Scotian Shelf. The maps represent the spawning distributions that occurred within the spatial and temporal scope of the research vessel surveys. Spawning could have occurred on other areas of the banks at the same time in areas that not been surveyed.

There was often considerable monthly variability in the quantity and spatial distribution of survey sets. By far the largest numbers of fishing sets representing the largest spatial extent were found in March, July and October. It is critical to note the years represented on each of the figures because some maps show data from a single year of surveys, while another may present as many as 30 years of data.

Where and when spawning occurs may change over time. The distributions may change spatially by occurring on other parts of the shelf or temporally with a change in the timing of the spawning peaks. The maps presented here provide a static, historical description of the spawning distributions and do not account for any such variability that may be present.

CONCLUSIONS

The Scotian Shelf is home to a complex ecosystem as well as a flourishing oil and gas industry. It is hoped that this project will help those who manage and utilize the resources found on the Scotian Shelf to protect the fisheries resources from any potentially harmful effects from oil/gas development. These maps could be used to help those in industry plan the timing and location of their exploration activities so that any impacts on biotic resources can be minimized.

ACKNOWLEDGEMENTS

The authors would like to thank the Environmental Studies Research Funds for the financial support that made this project possible. The Bedford Institute of Oceanography (BIO) of the Department of Fisheries and Oceans, Maritimes Region, provided the RV data used for the modeling and map production. They also wish to thank Joe Hunt of the BIO who provided advice and supporting information to accompany the RV data, and Dave Kulka who reviewed this manuscript.

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TABLE 1. MATURITY STAGES USED IN SURVEYS, AFTER HUNT (1996)

	Male	Female
Stage 1 – Immature	Ovaries small and firm; pale pink or reddish and somewhat transparent	Testes slender; appear as a clear, crimped and slender string
Stage 2 – Ripening 1	Ovaries slightly larger than 1 but still small and firm; contains microscopic, yellow or reddish yellow, opaque eggs; blood capillaries showing	Testes grow gradually in size; pinkish or flesh coloured; blood capillaries showing
Stage 3 – Ripening 2	Ovaries occupy about half of the ventral cavity; reddish and numerous blood vessels; opaque eggs are now visible to naked eye and give the ovaries a granular appearance	Testes occupy about half of the ventral cavity; begin to turn white, with fine, rather conspicuous blood vessels; no milt runs when pressure is applied
Stage 4 – Ripe	Has a few clear eggs at the earliest stage progressing to having mainly clear eggs, but eggs do not extrude freely with slight pressure. Spawning has not started.	Testes distinctly wavy white and quite distended; large lobes; a small amount of milt may be forced by pressure.
Stage 5 – Spawning	As stage 4 but eggs running freely on slight pressure	Testes very white and fully extended; milt runs freely at the slightest pressure.
Stage 6 – Spent	Ovaries soft, flabby and bloody; practically no eggs remain; purple in colour	Testes shrunken and reddish; vas deferens prominent against irregular surfaces of testes; some blood left in the organ
Stage 7 – Recovering	Membrane purplish and ovaries fairly baggy, no eggs visible	Testes resume pale pink colour; traces of blood in organ; vas deferens wrinkled and string-like
Stage 8 – Resting	Looks very much like Stage 1, but is found in large fish; ovary larger than in 1; also membrane thicker and not as transparent as in 1	Testes larger than in 1; surface regular, some greyish pink in colour.

Figure 1.
Study Area

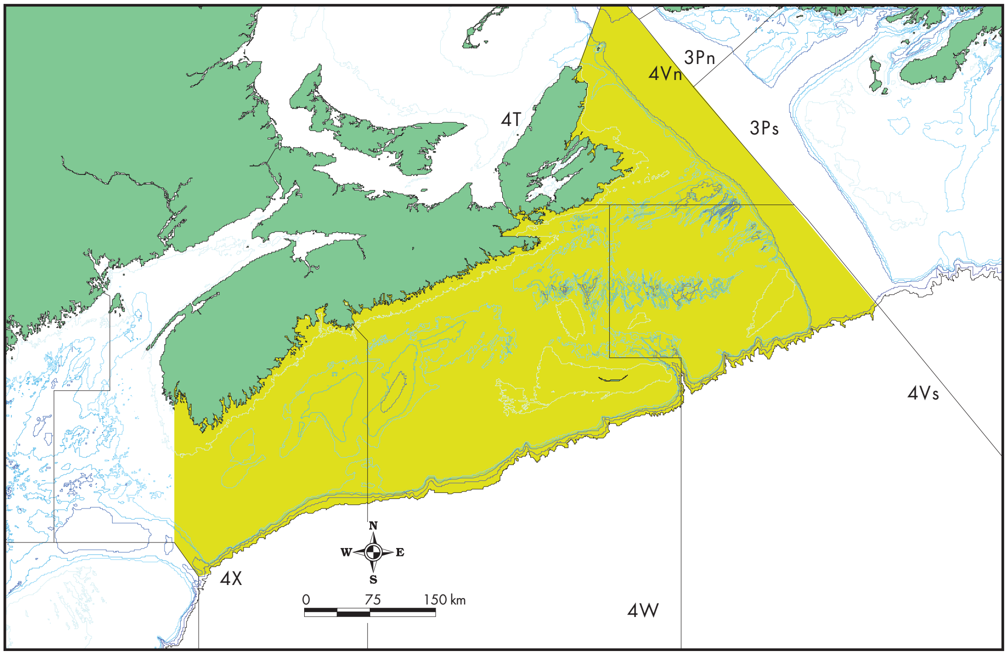

Figure 1 a.
Potential Mapping Parameters

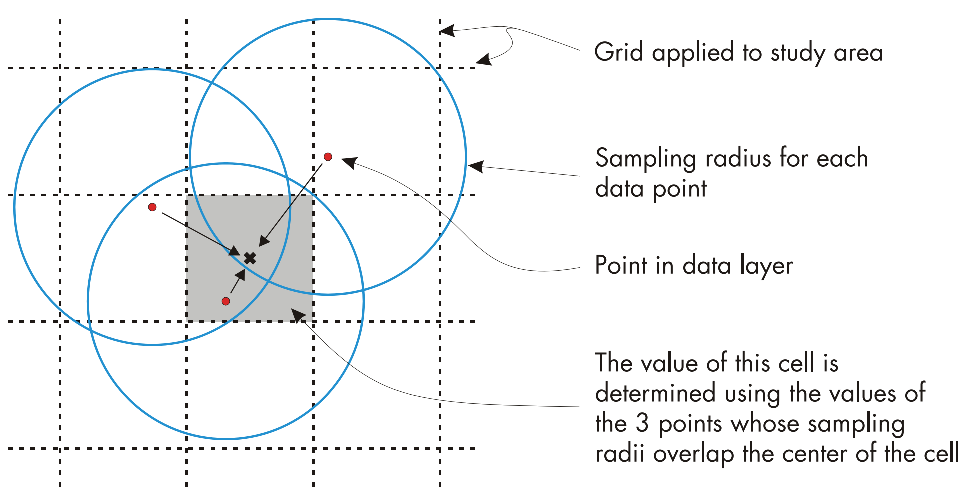

Figure 2 a.
February distribution of spawning American plaice, 1981. The 0 class represents survey sets where no fish were caught.

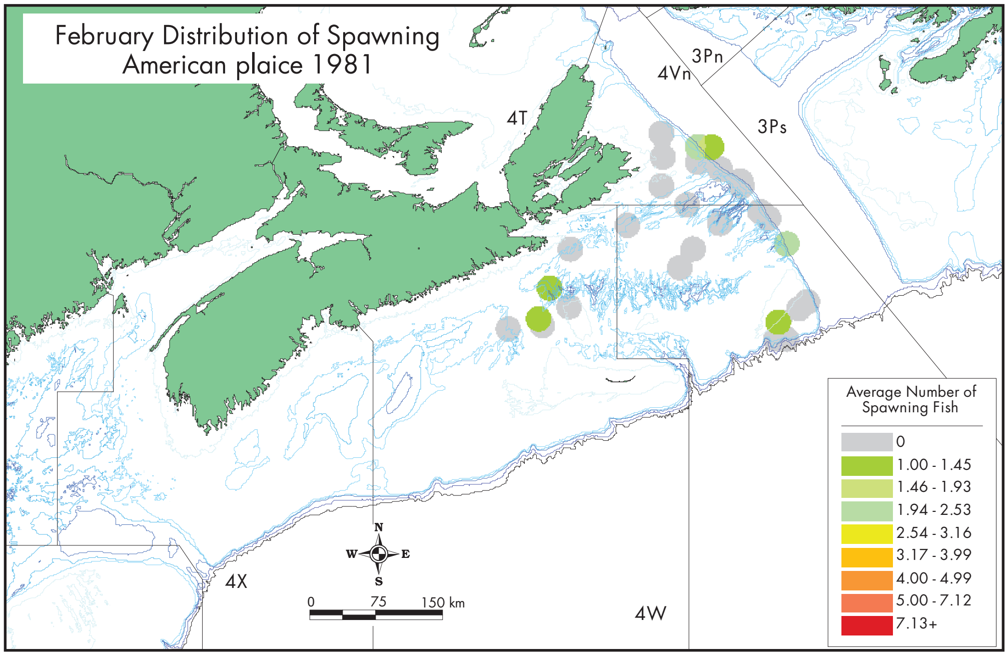

Figure 2 b.
March distribution of spawning American plaice, 1979-1984. The 0 class represents survey sets where no fish were caught.

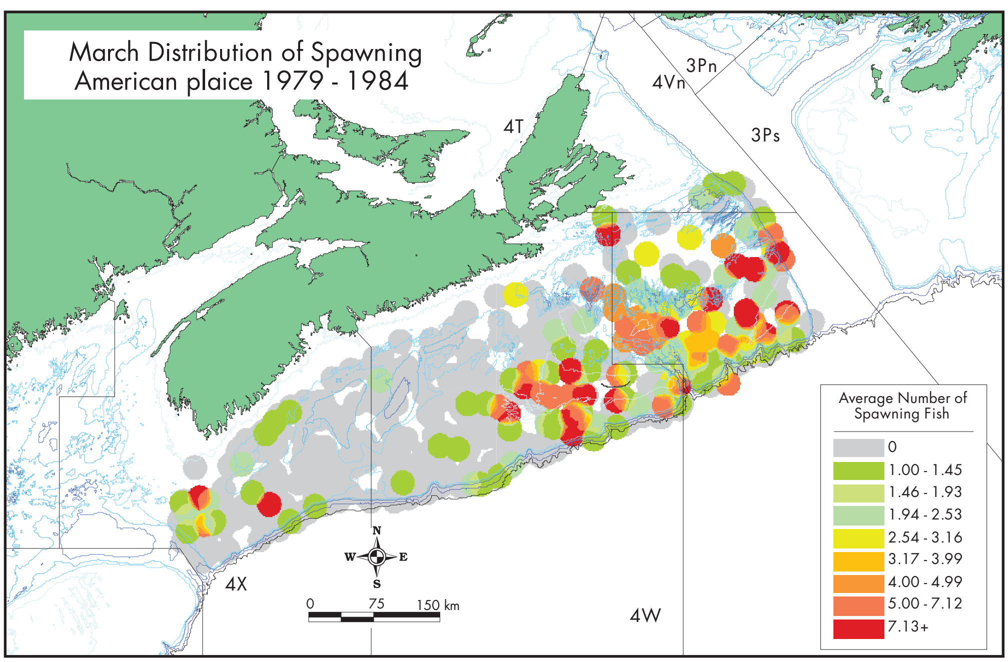

Figure 2 c.
April distribution of spawning American plaice, 1983. The 0 class represents survey sets where no fish were caught.

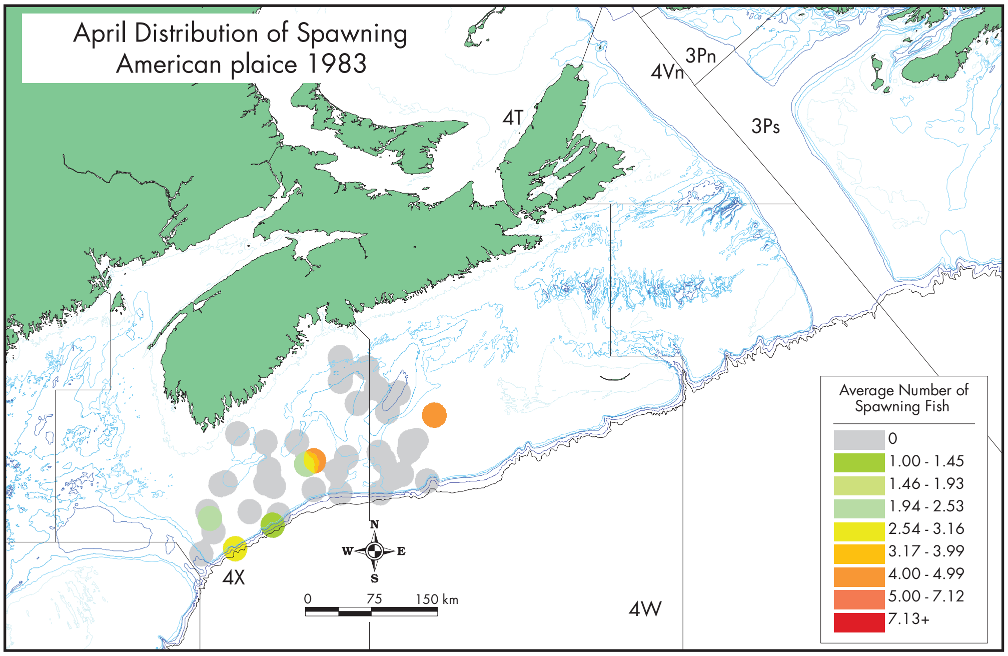

Figure 2 d.
June distribution of spawning American plaice, 1972. The 0 class represents survey sets where no fish were caught.

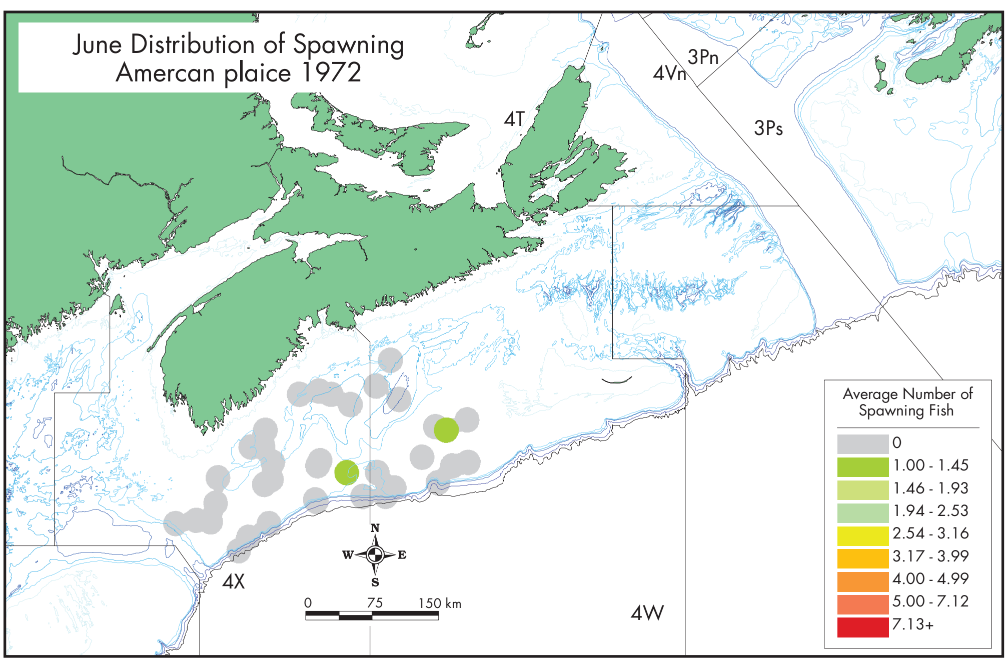

Figure 2 e.
July distribution of spawning American plaice, 1970 - 1996. The 0 class represents survey sets where no fish were caught.

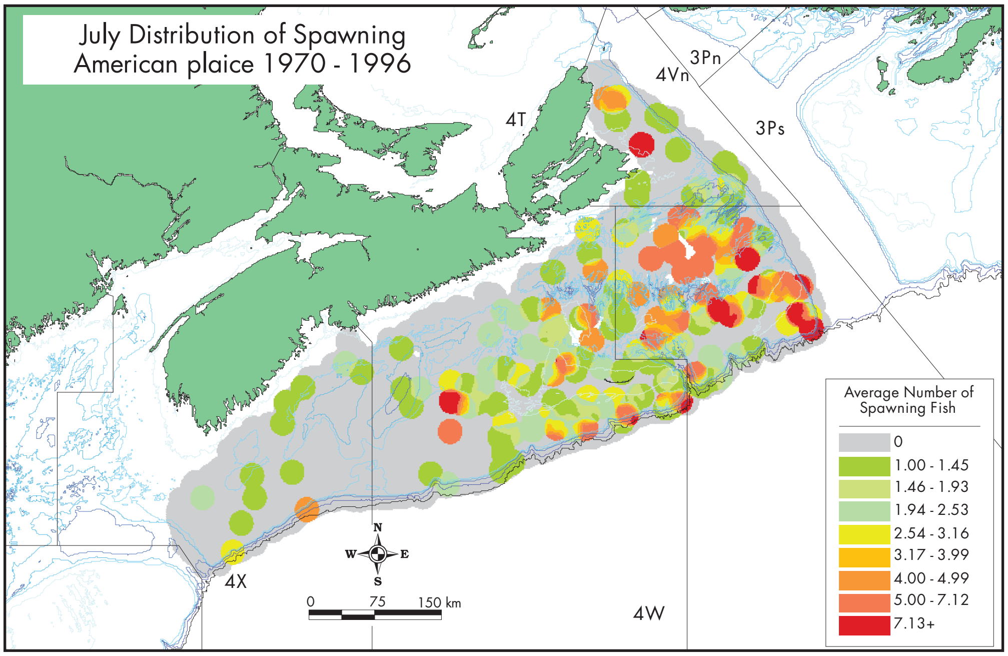

Figure 2 f.
August distribution of spawning American plaice, 1973 - 1984. The 0 class represents survey sets where no fish were caught.

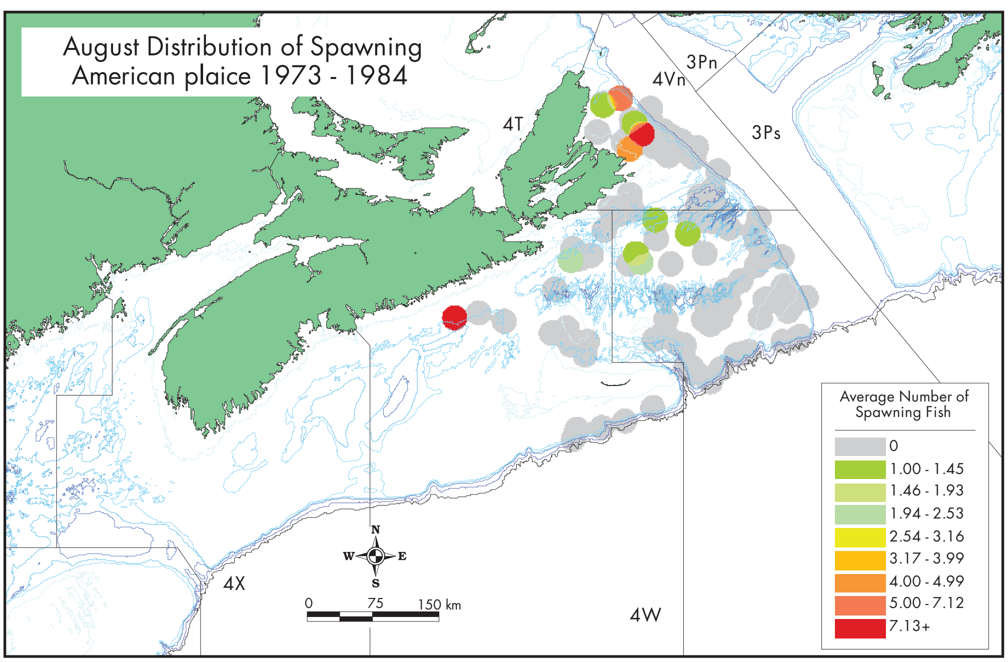

Figure 2 g.
September distribution of spawning American plaice, 1980 - 1982. The 0 class represents survey sets where no fish were caught.

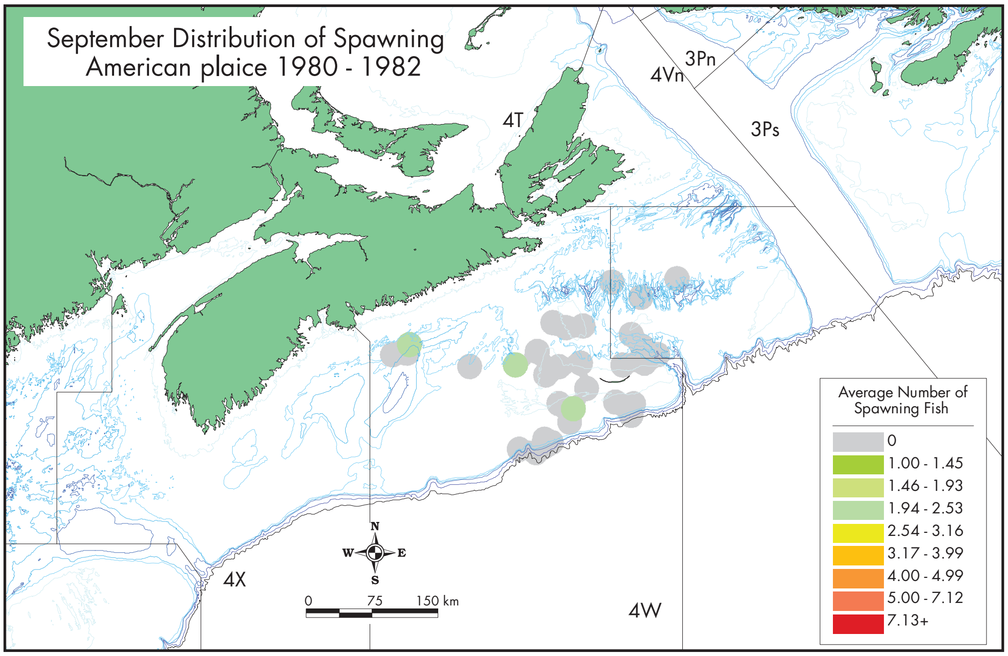

Figure 2 h.
October distribution of spawning American plaice, 1979 - 1984. The 0 class represents survey sets where no fish were caught.

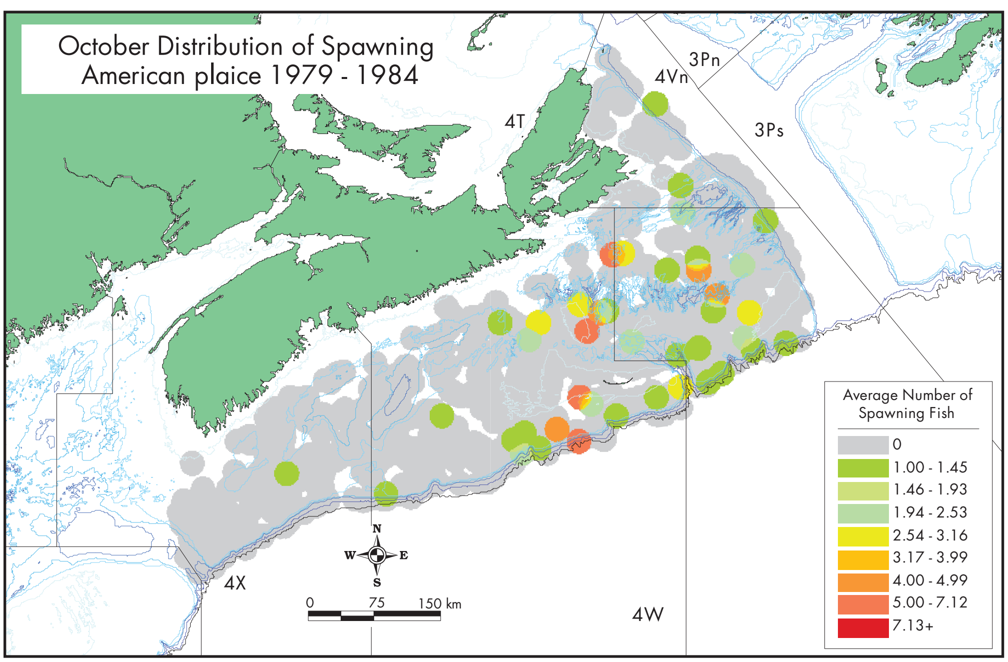

Figure 2 i.
November distribution of spawning American plaice, 1978 - 1984. The 0 class represents survey sets where no fish were caught.

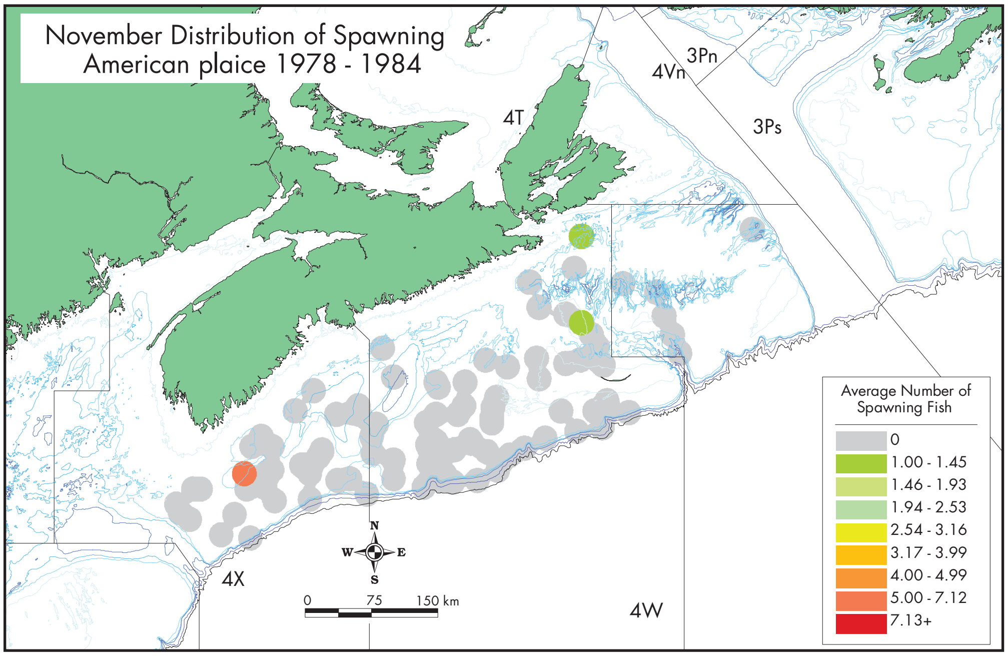

Figure 2 j.
December distribution of spawning American plaice, 1978. The 0 class represents survey sets where no fish were caught.

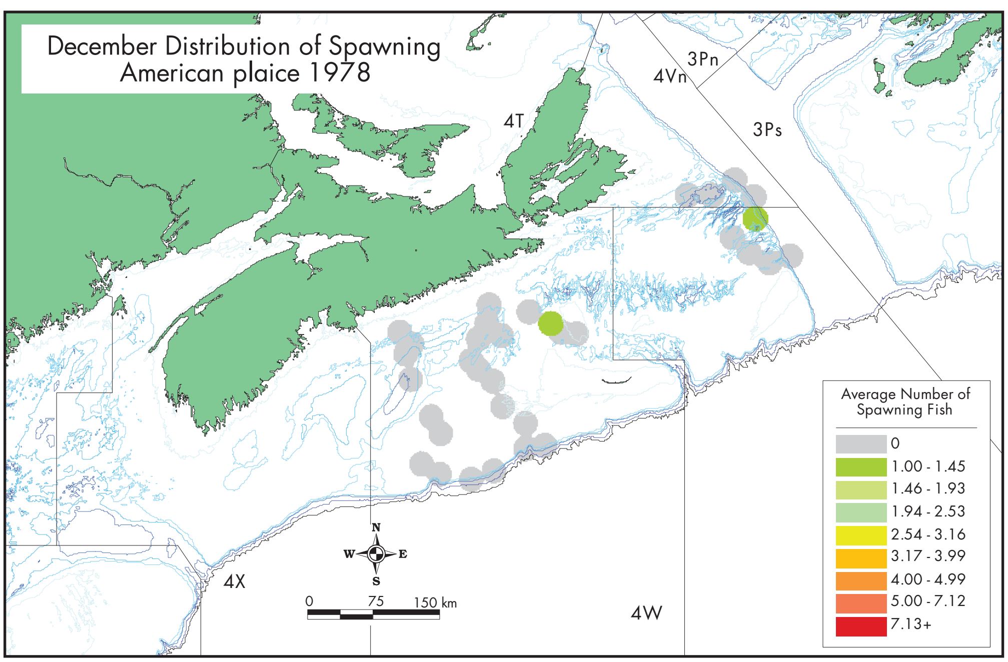

Figure 3 a.
February distribution of spawning Atlantic cod, 1981 - 2001. The 0 class represents survey sets where no fish were caught.

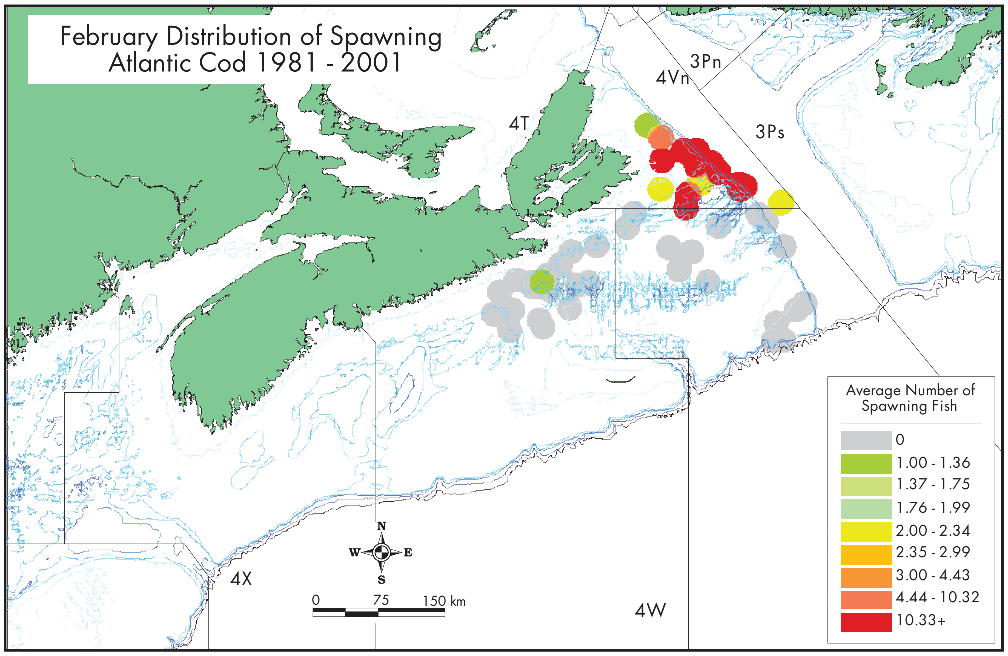

Figure 3 b.
March distribution of spawning Atlantic cod, 1979 - 2005. The 0 class represents survey sets where no fish were caught.

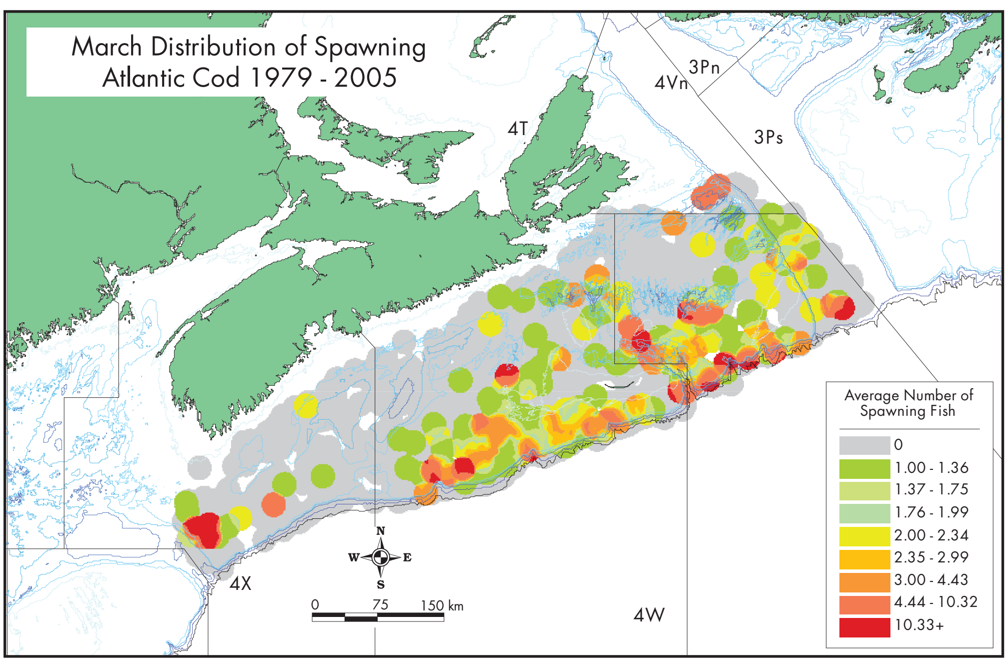

Figure 3 c.
April distribution of spawning Atlantic cod, 1983 - 1987. The 0 class represents survey sets where no fish were caught.

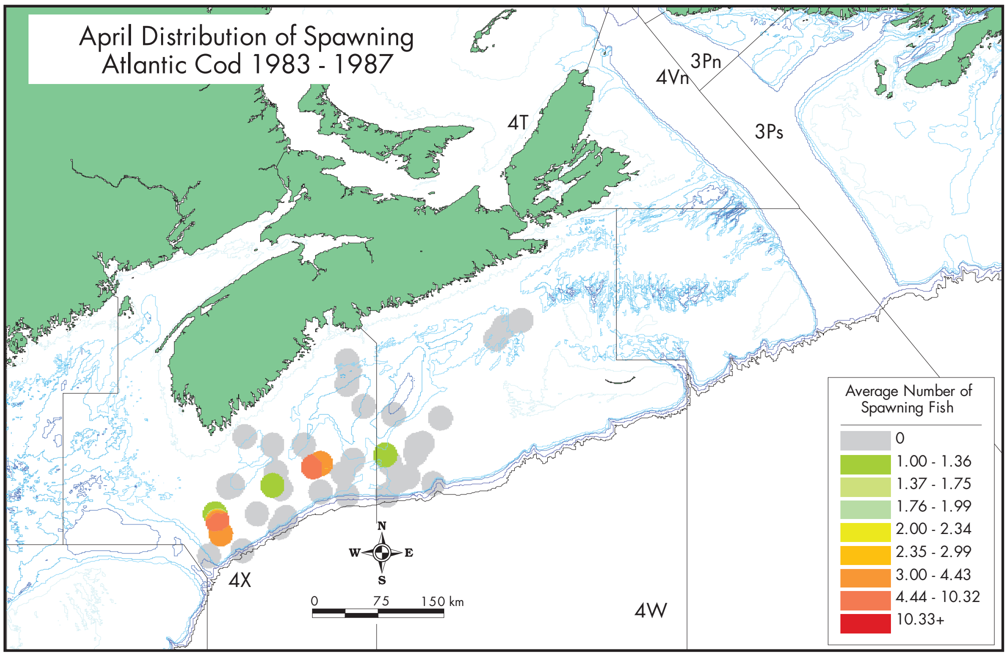

Figure 3 d.
June distribution of spawning Atlantic cod, 1972. The 0 class represents survey sets where no fish were caught.

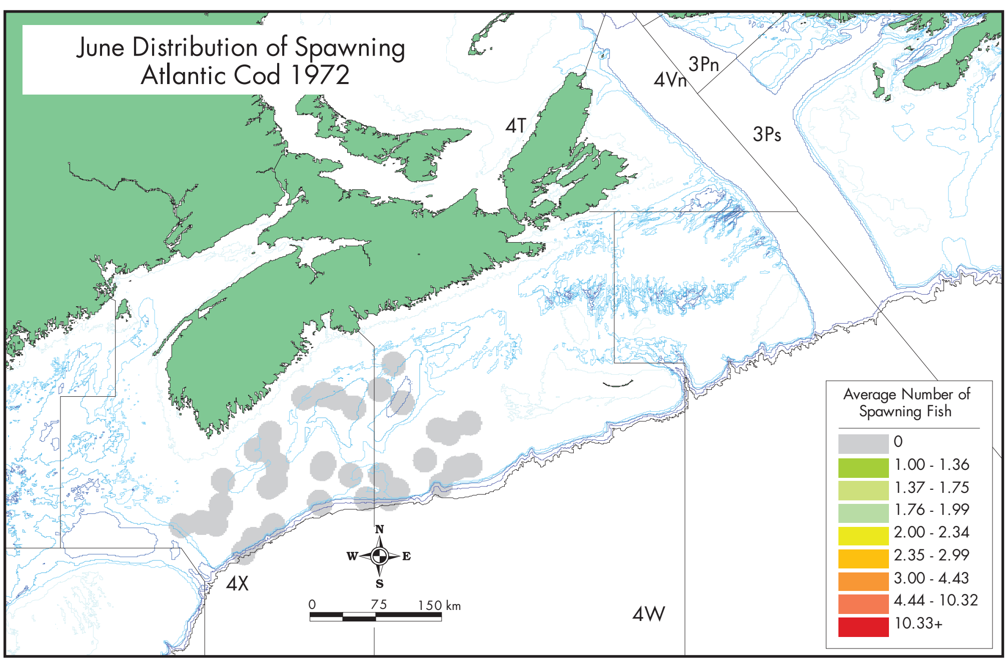

Figure 3 e.
July distribution of spawning Atlantic cod, 1970 - 2001. The 0 class represents survey sets where no fish were caught.

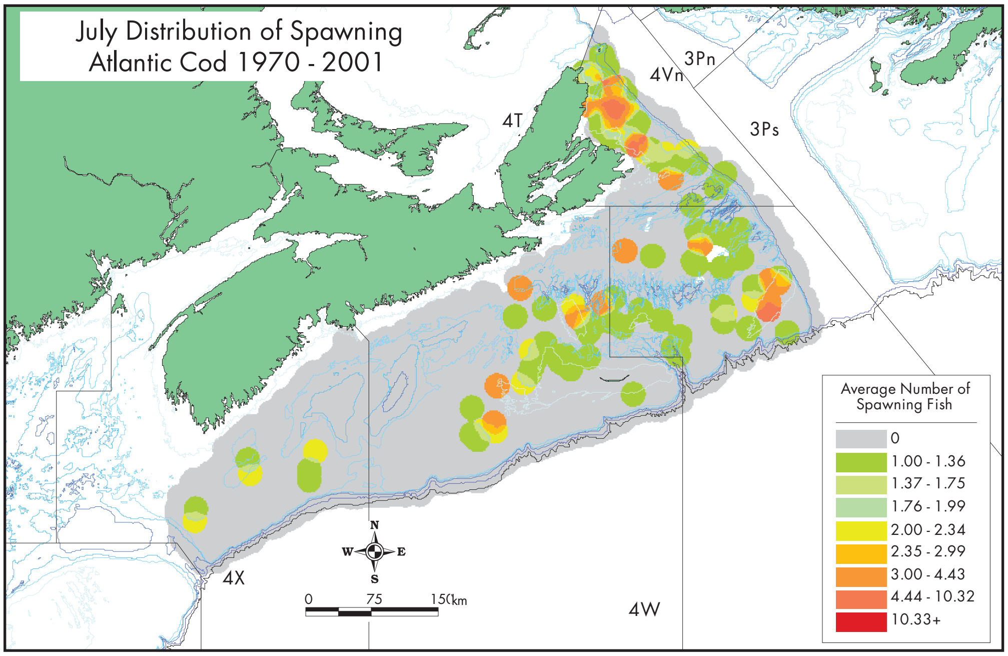

Figure 3 f.
August distribution of spawning Atlantic cod, 1973 - 1993. The 0 class represents survey sets where no fish were caught.

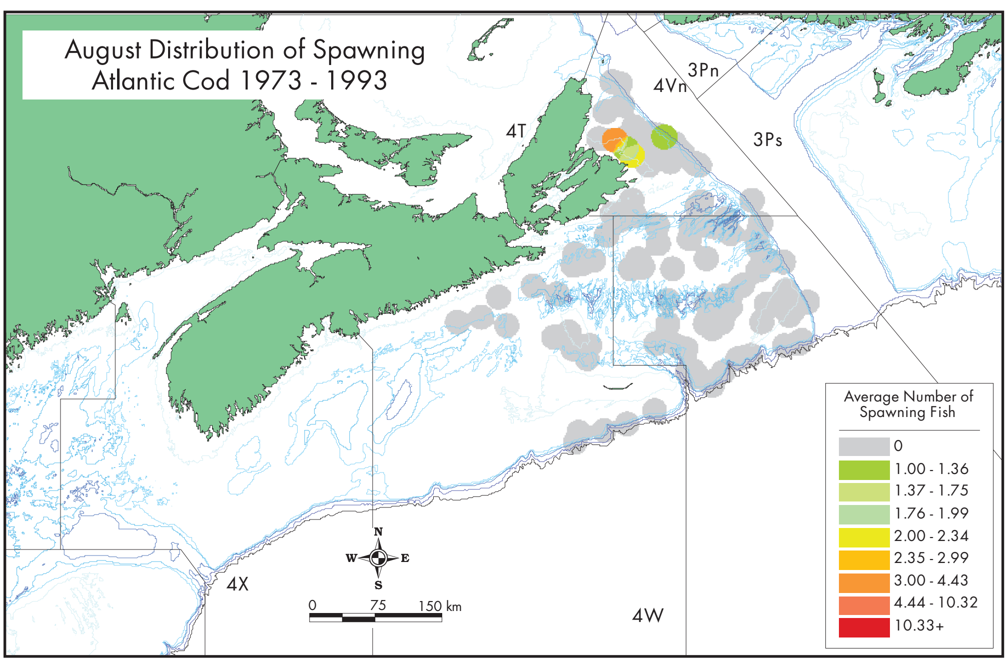

Figure 3 g.
September distribution of spawning Atlantic cod, 1982. The 0 class represents survey sets where no fish were caught.

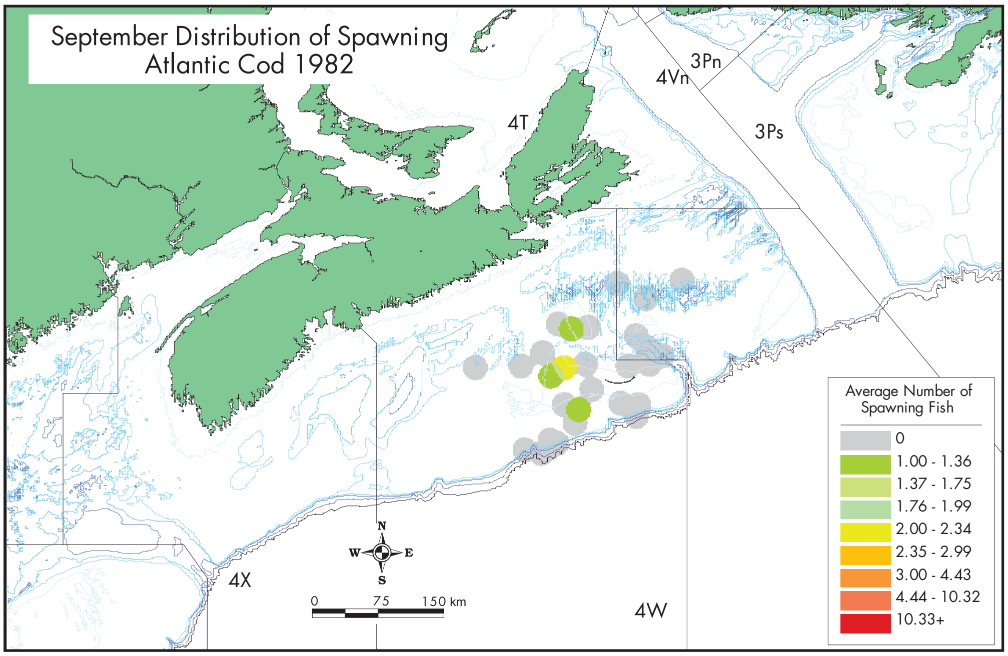

Figure 3 h.
October distribution of spawning Atlantic cod, 1979 - 1986. The 0 class represents survey sets where no fish were caught.

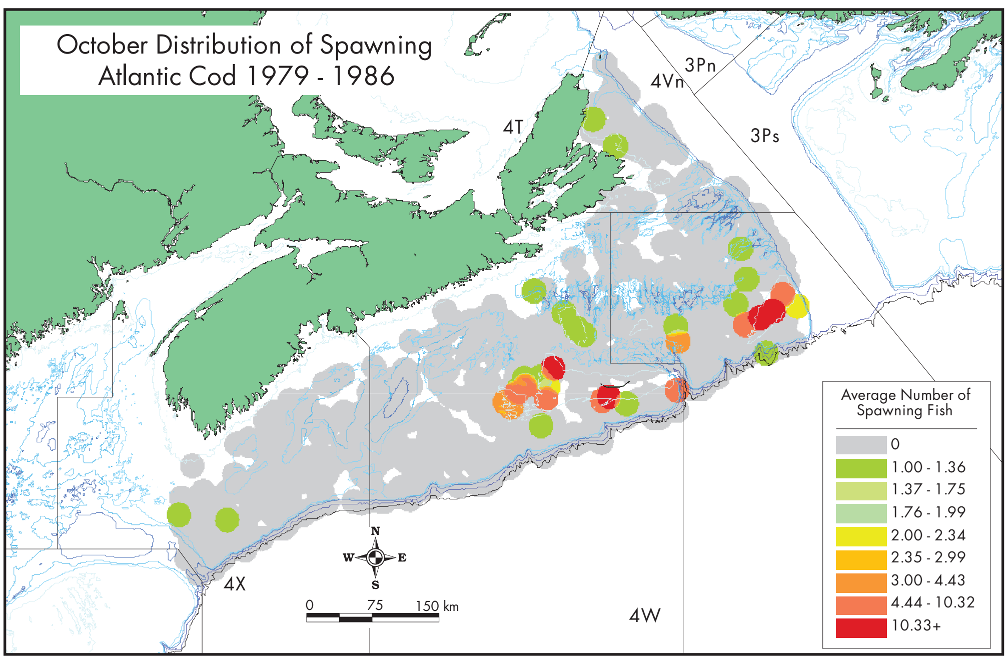

Figure 3 i.
November distribution of spawning Atlantic cod, 1978 - 1984. The 0 class represents survey sets where no fish were caught.

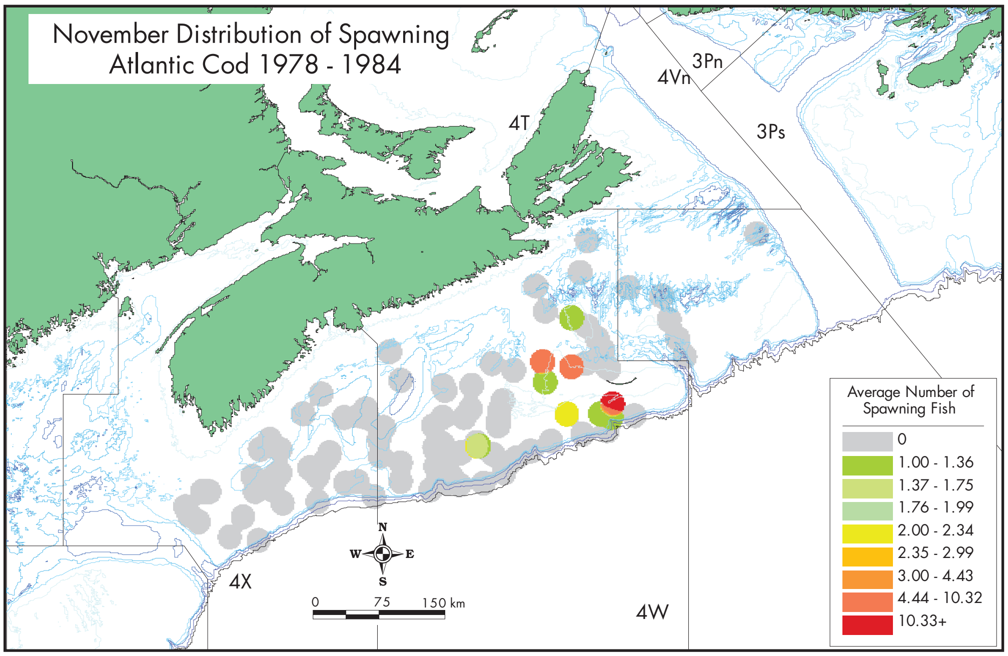

Figure 3 j.
December distribution of spawning Atlantic cod, 1978. The 0 class represents survey sets where no fish were caught.

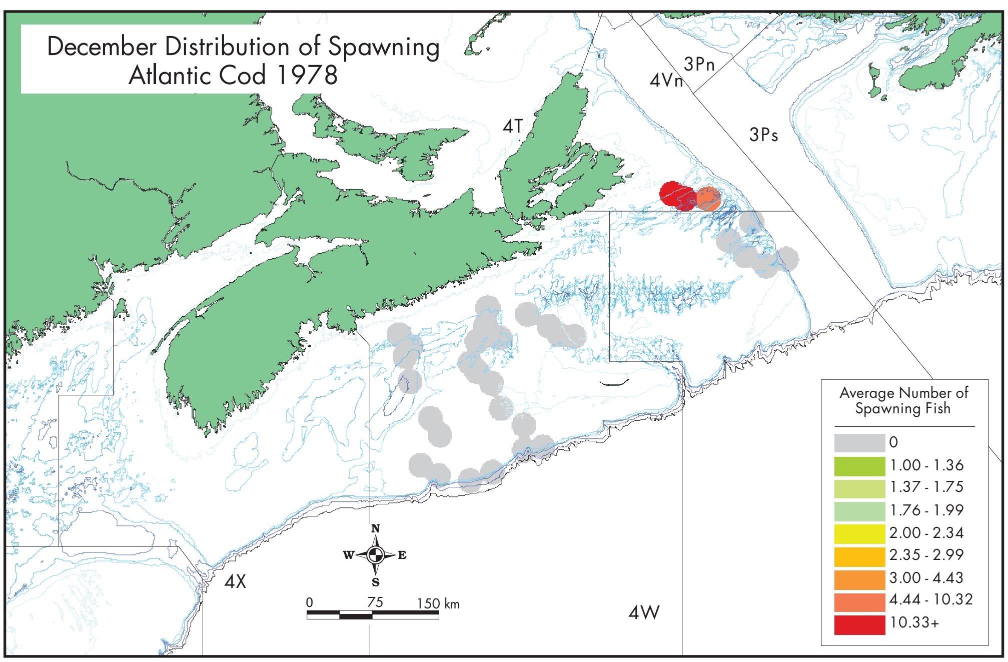

Figure 4 a.
February distribution of spawning Haddock, 1981 - 2001. The 0 class represents survey sets where no fish were caught.

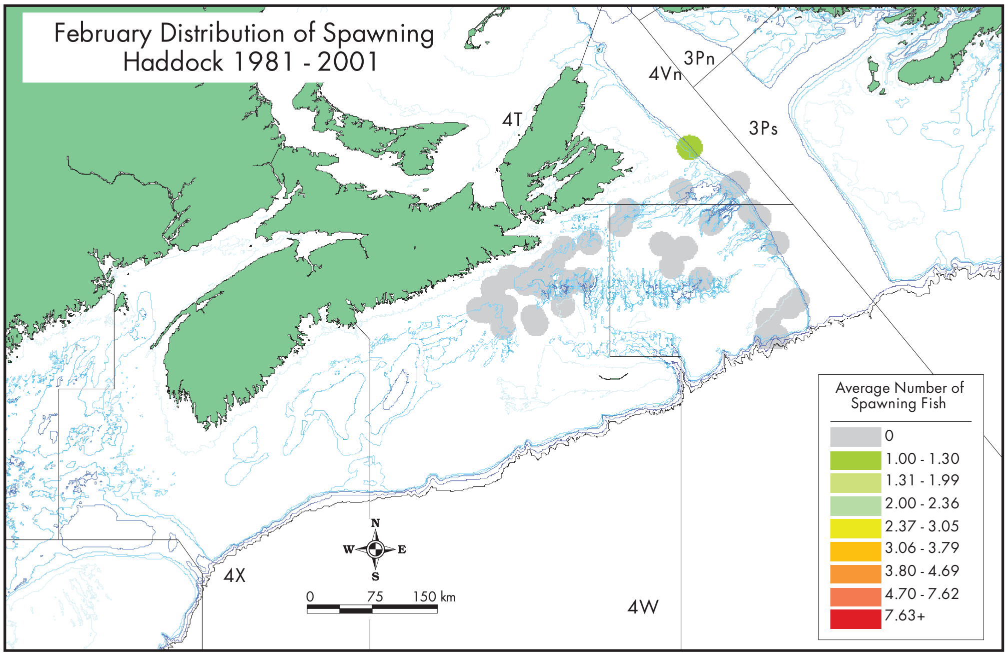

Figure 4 b.
March distribution of spawning Haddock, 1979 - 2005. The 0 class represents survey sets where no fish were caught.

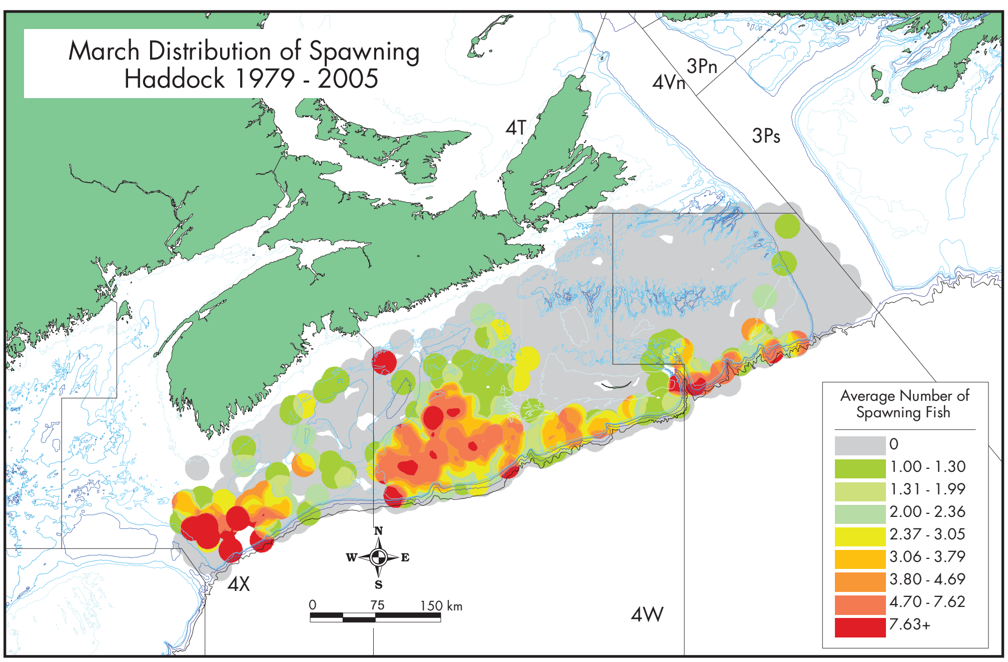

Figure 4 c.
April distribution of spawning Haddock, 1983 - 1987. The 0 class represents survey sets where no fish were caught.

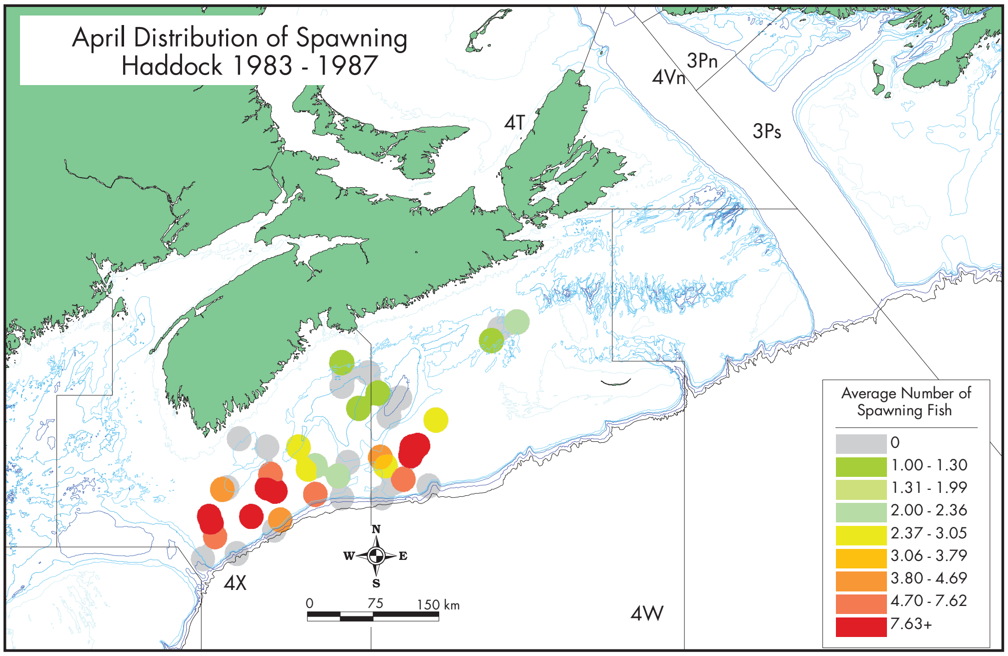

Figure 4 d.
June distribution of spawning Haddock, 1972. The 0 class represents survey sets where no fish were caught.

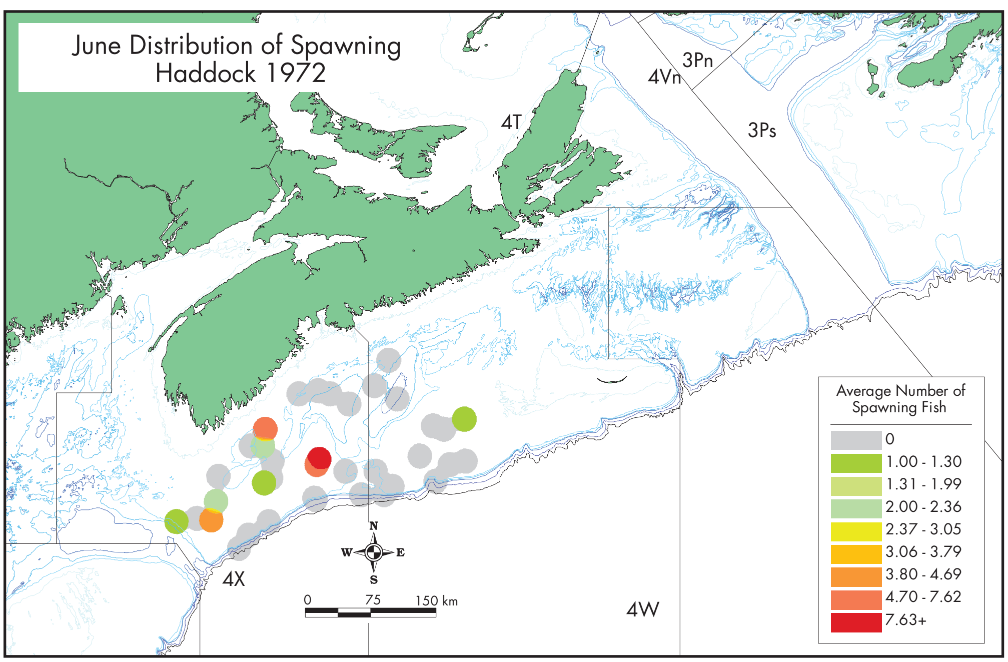

Figure 4 e.
July distribution of spawning Haddock, 1970 - 2001. The 0 class represents survey sets where no fish were caught.

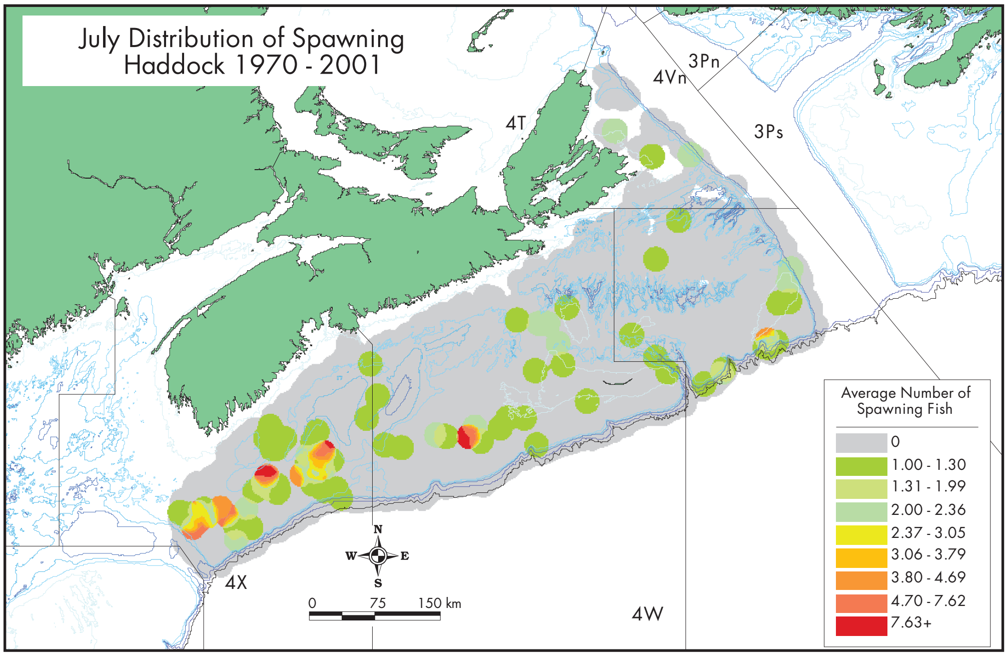

Figure 4 f.
August distribution of spawning Haddock, 1973 - 1993. The 0 class represents survey sets where no fish were caught.

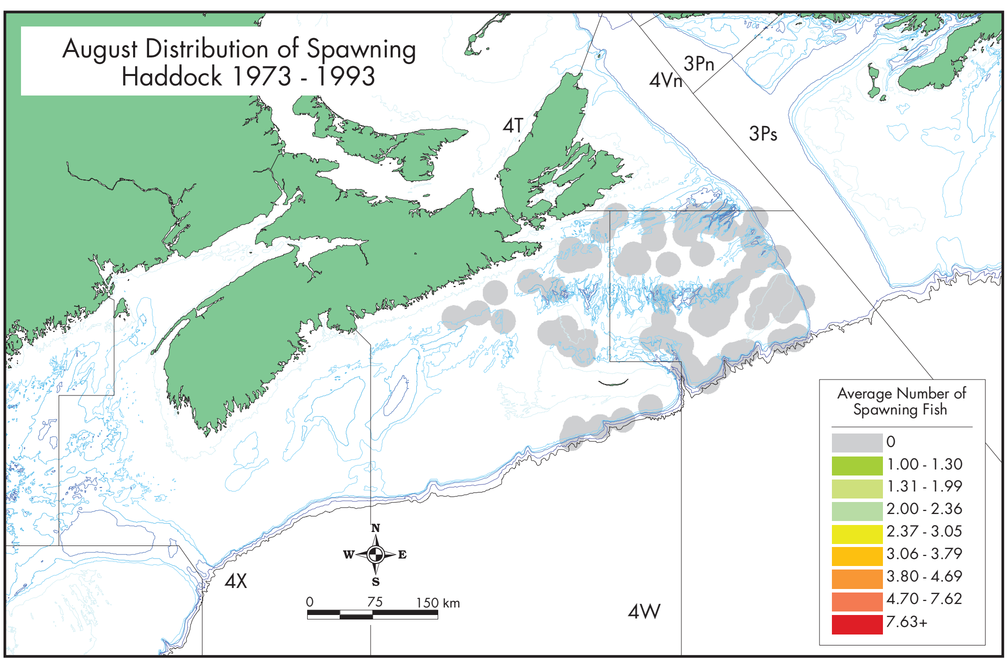

Figure 4 g.
September distribution of spawning Haddock, 1981 - 1982. The 0 class represents survey sets where no fish were caught.

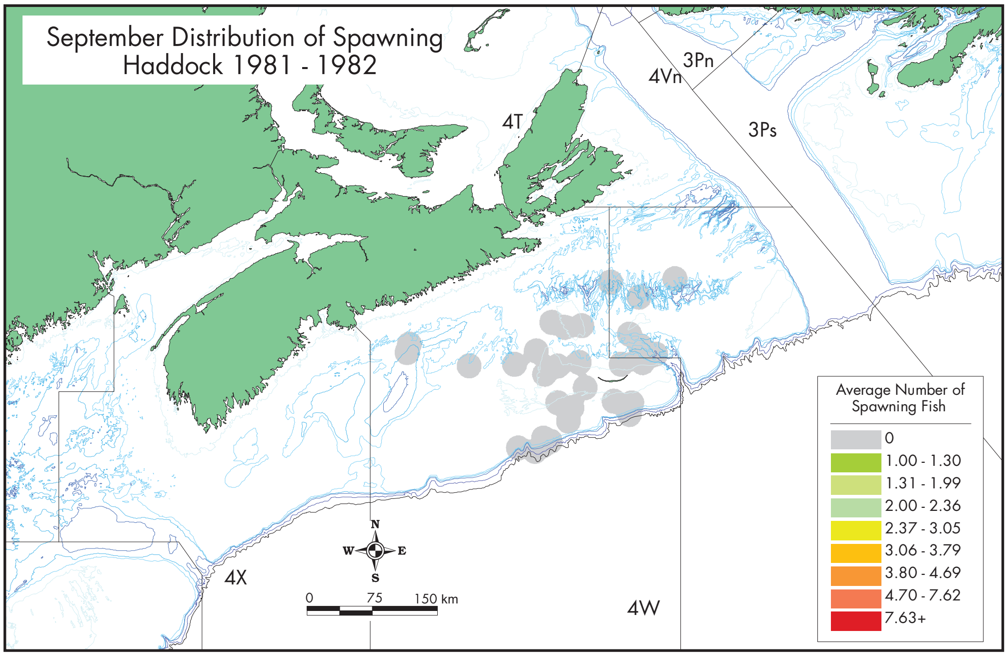

Figure 4 h.
October distribution of spawning Haddock, 1979 - 1986. The 0 class represents survey sets where no fish were caught.

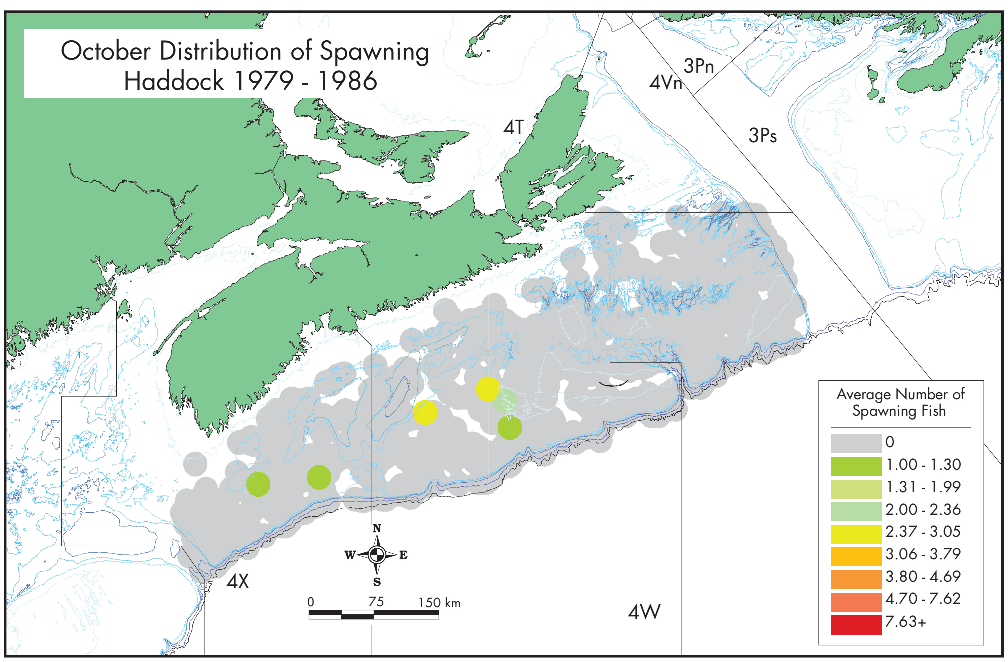

Figure 4 i.
November distribution of spawning Haddock, 1978 - 1984. The 0 class represents survey sets where no fish were caught.

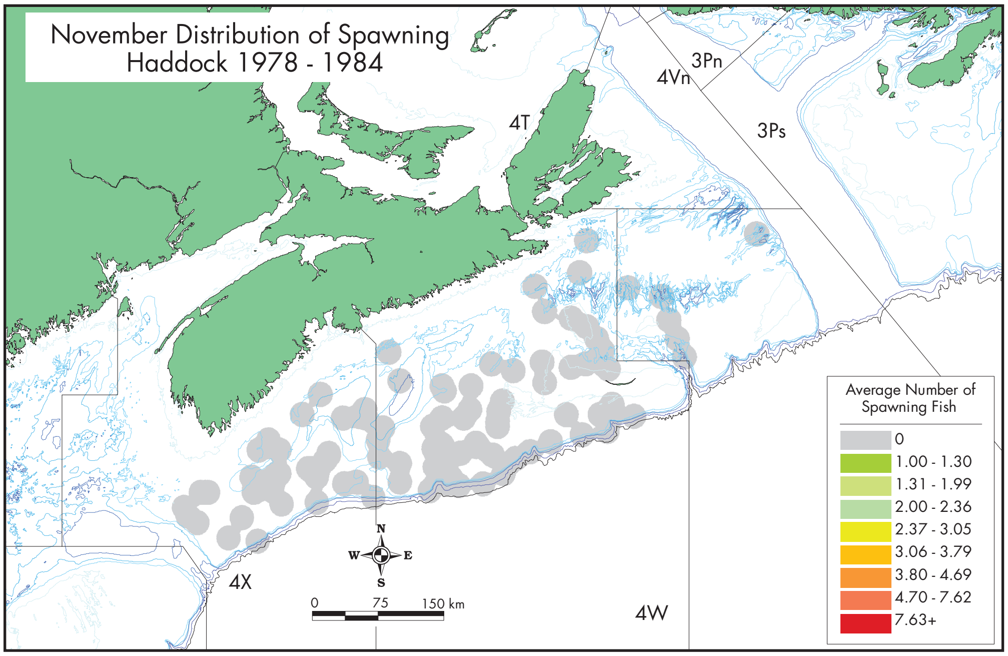

Figure 4 j.
December distribution of spawning Haddock, 1978. The 0 class represents survey sets where no fish were caught.

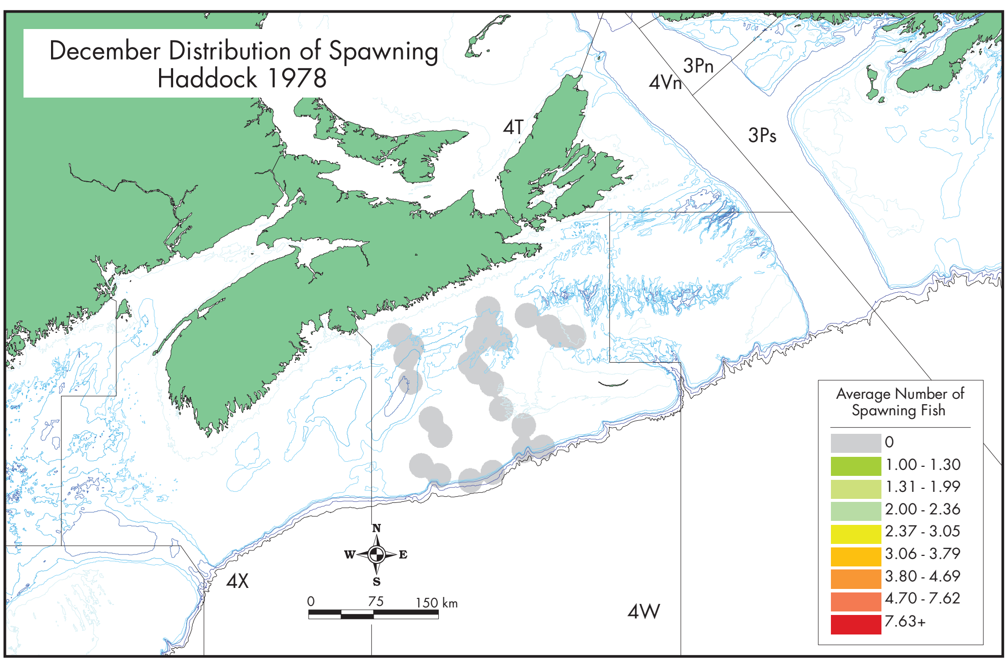

Figure 5 a.
February distribution of spawning Redfish, 1981. The 0 class represents survey sets where no fish were caught.

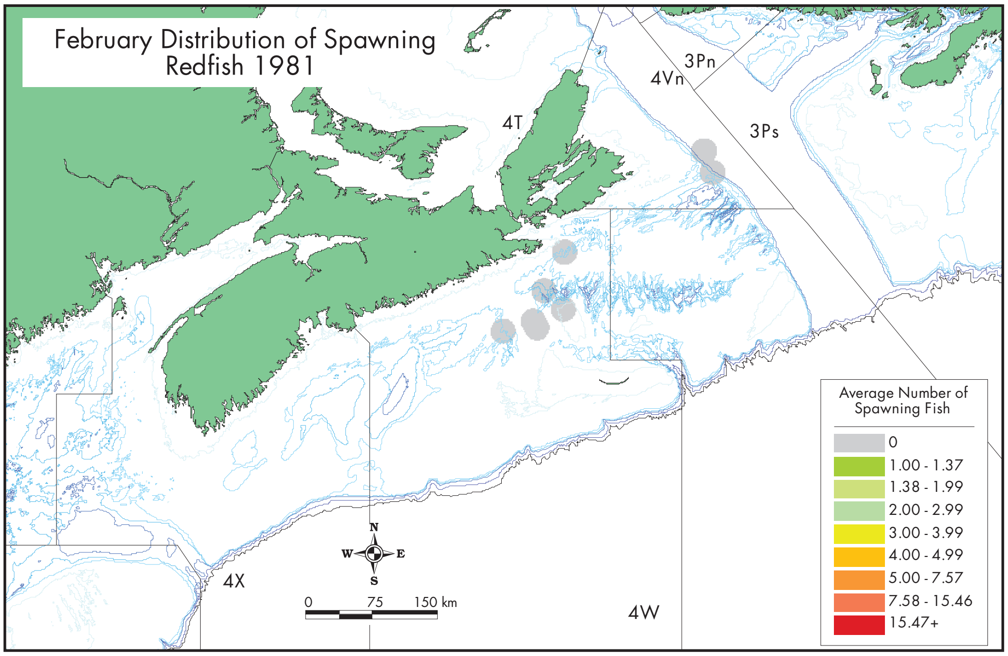

Figure 5 b.
March distribution of spawning Redfish, 1979 - 1997. The 0 class represents survey sets where no fish were caught.

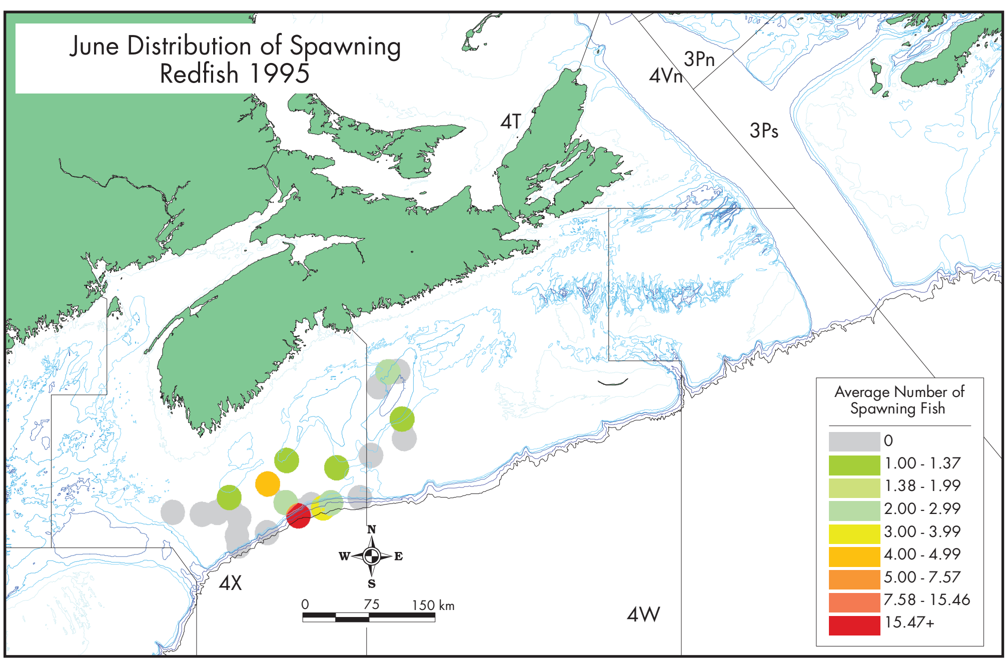

Figure 5 c.
April distribution of spawning Redfish, 1983. The 0 class represents survey sets where no fish were caught.

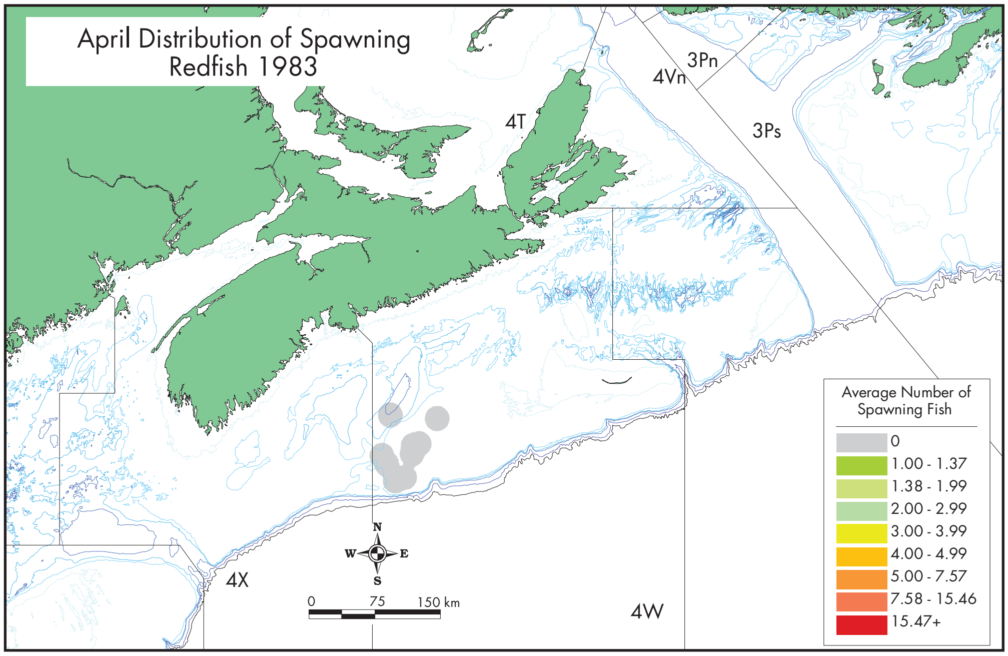

Figure 5 d.
June distribution of spawning Redfish, 1995. The 0 class represents survey sets where no fish were caught.

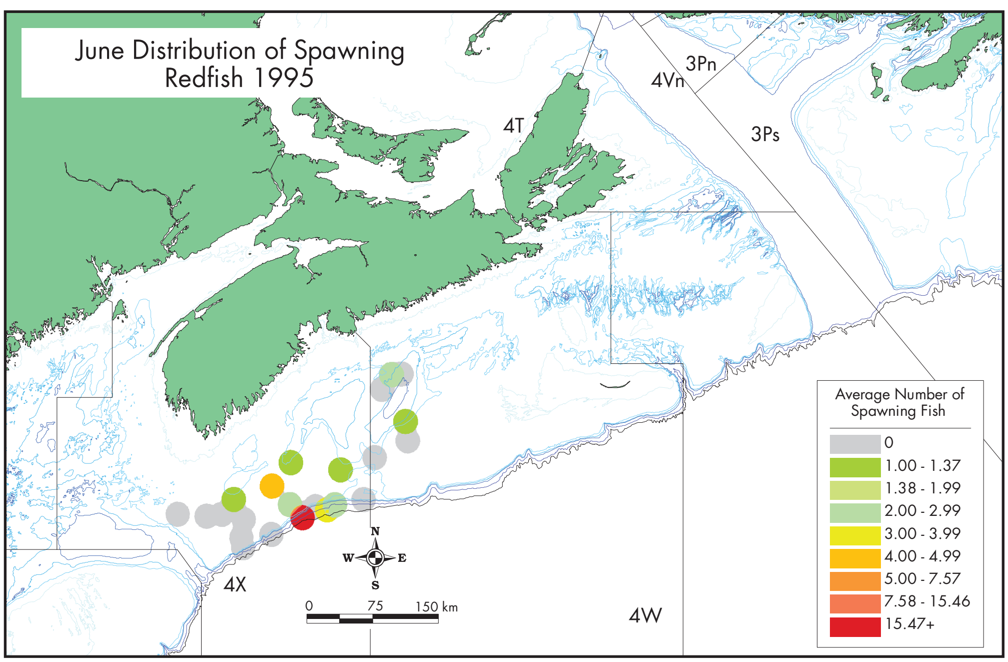

Figure 5 e.
July distribution of spawning Redfish, 1970 - 1997. The 0 class represents survey sets where no fish were caught.

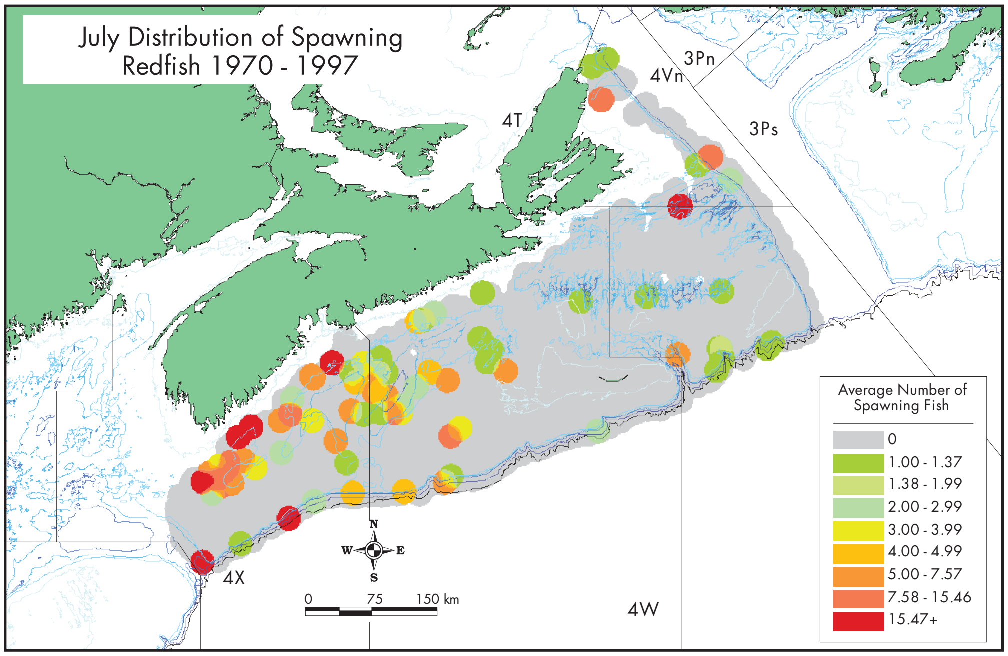

Figure 5 f.
August distribution of spawning Redfish, 1975 - 1976. The 0 class represents survey sets where no fish were caught.

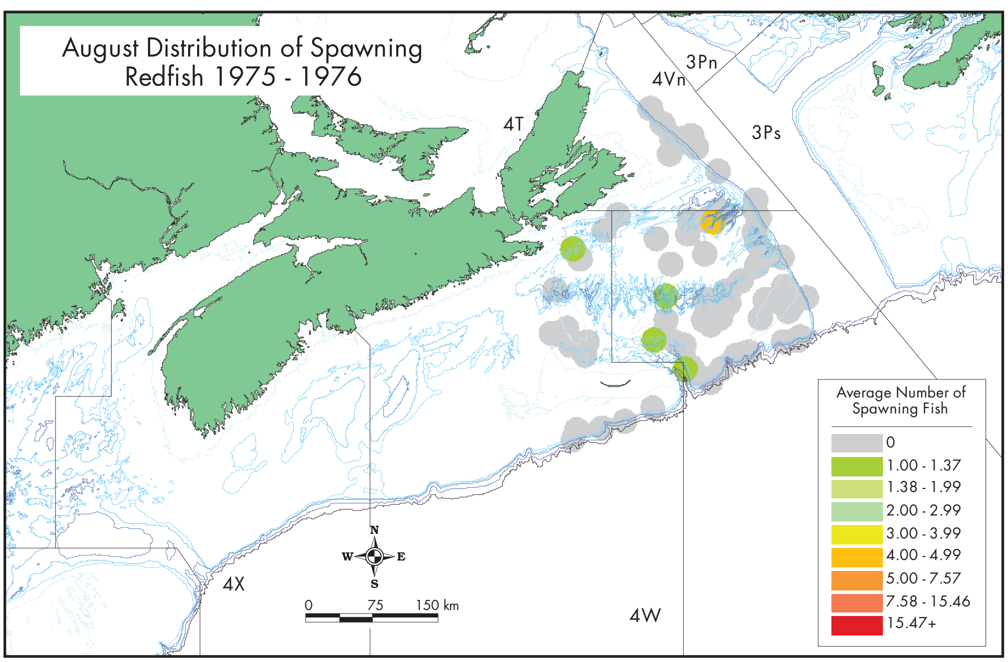

Figure 5 g.
September distribution of spawning Redfish, 1981 - 1982. The 0 class represents survey sets where no fish were caught.

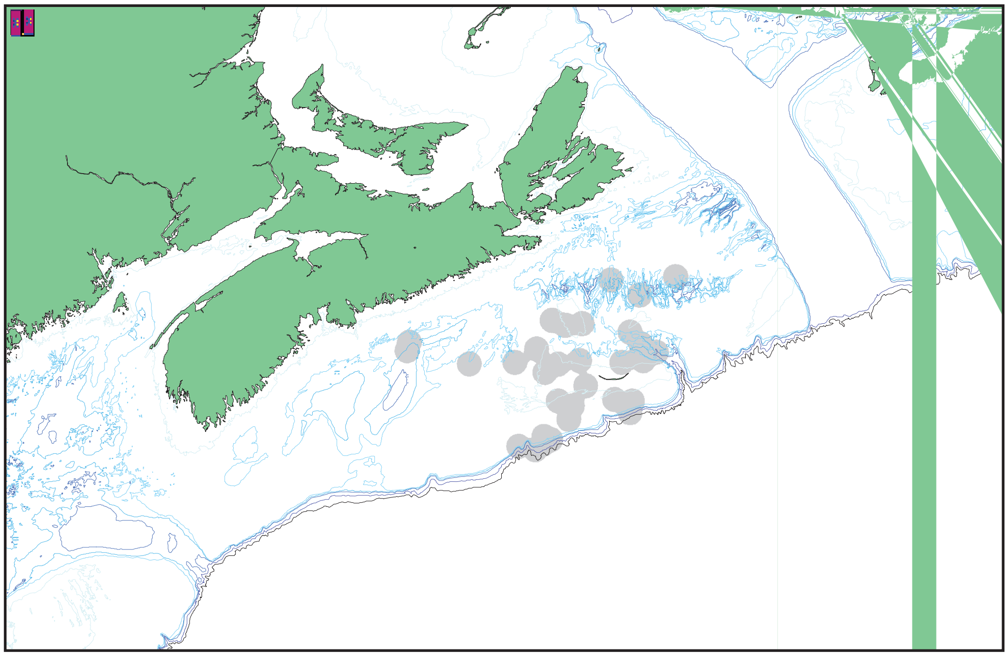

Figure 5 h.
October distribution of spawning Redfish, 1980 - 1984. The 0 class represents survey sets where no fish were caught.

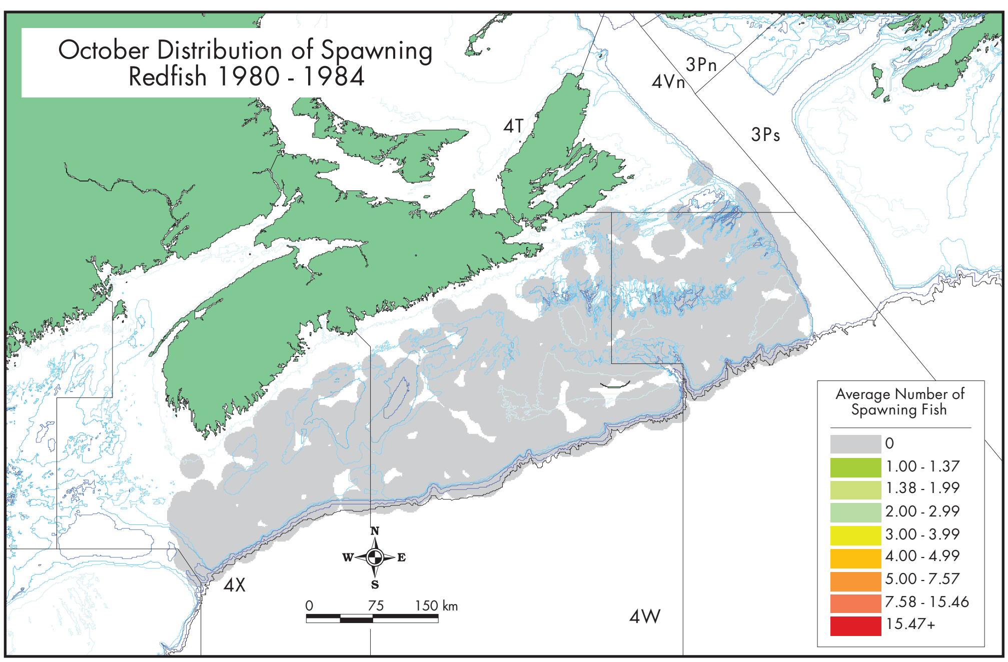

Figure 5 i.
November distribution of spawning Redfish, 1978 - 1979. The 0 class represents survey sets where no fish were caught.

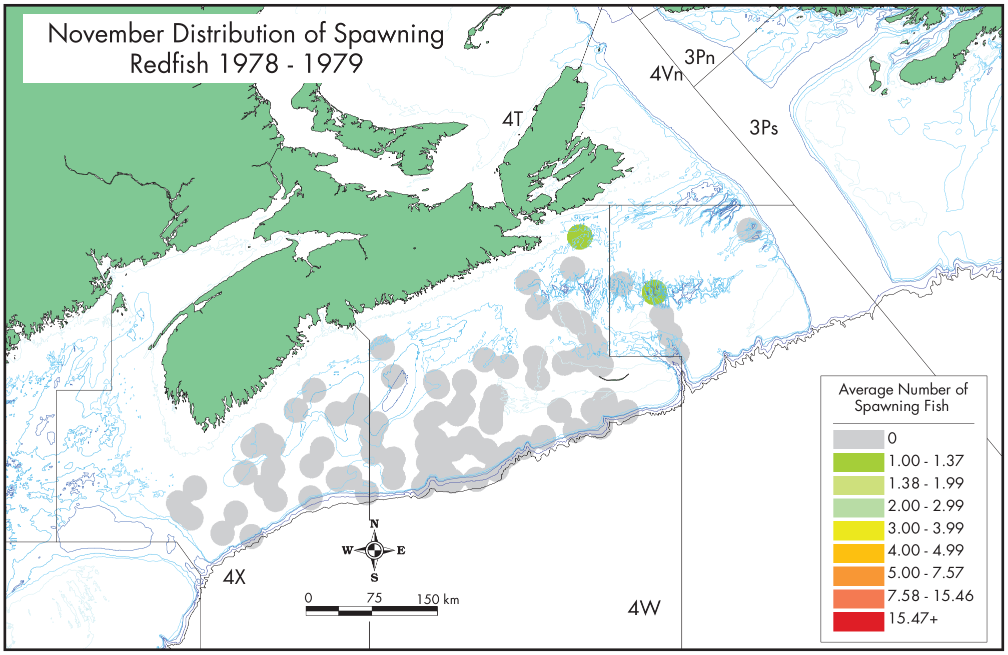

Figure 5 j.
December distribution of spawning Redfish, 1978. The 0 class represents survey sets where no fish were caught.

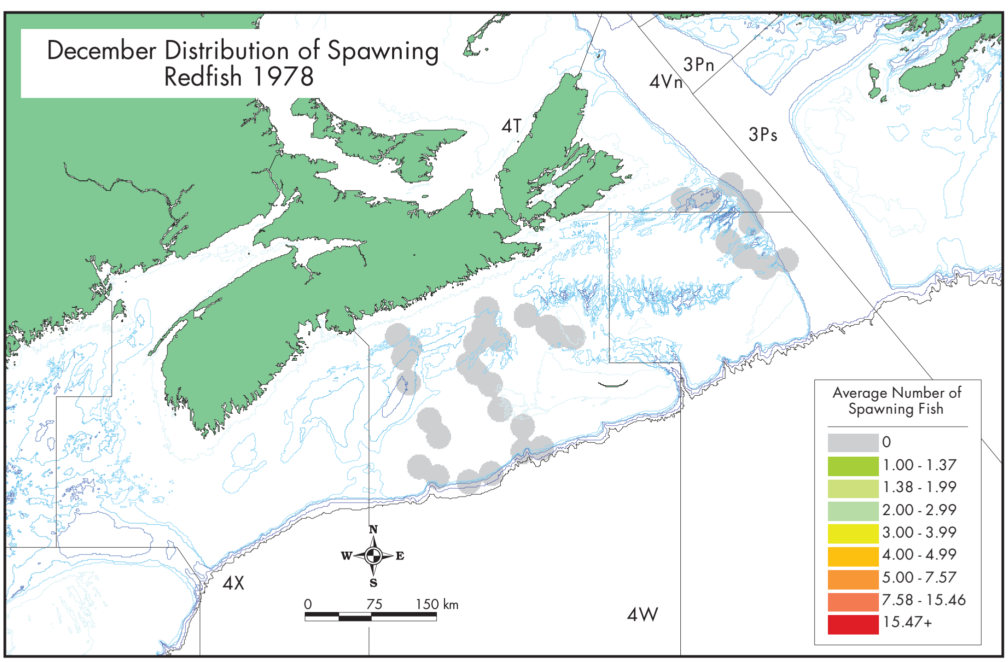

Figure 6 a.
February distribution of spawning Silver Hake, 1981 - 2001. The 0 class represents survey sets where no fish were caught.

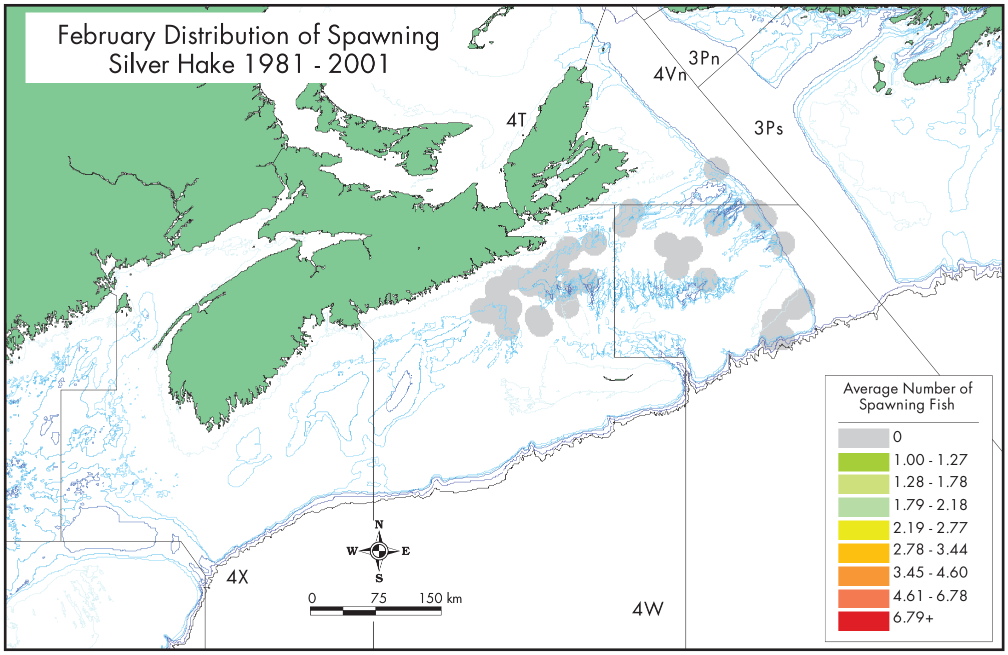

Figure 6 b.
March distribution of spawning Silver Hake, 1979 - 2001. The 0 class represents survey sets where no fish were caught.

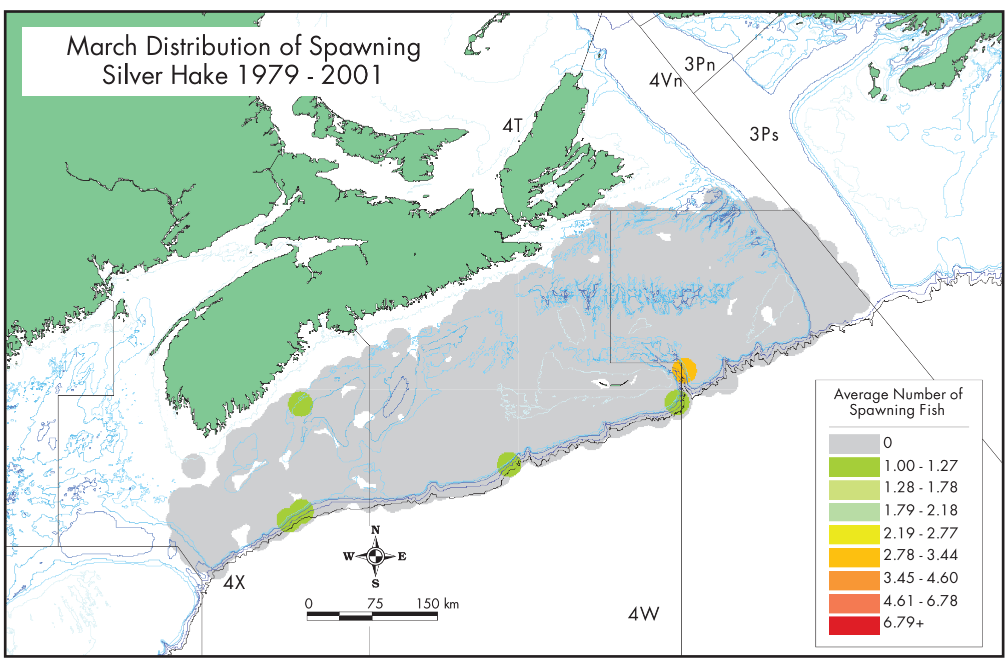

Figure 6 c.
April distribution of spawning Silver Hake, 1983. The 0 class represents survey sets where no fish were caught.

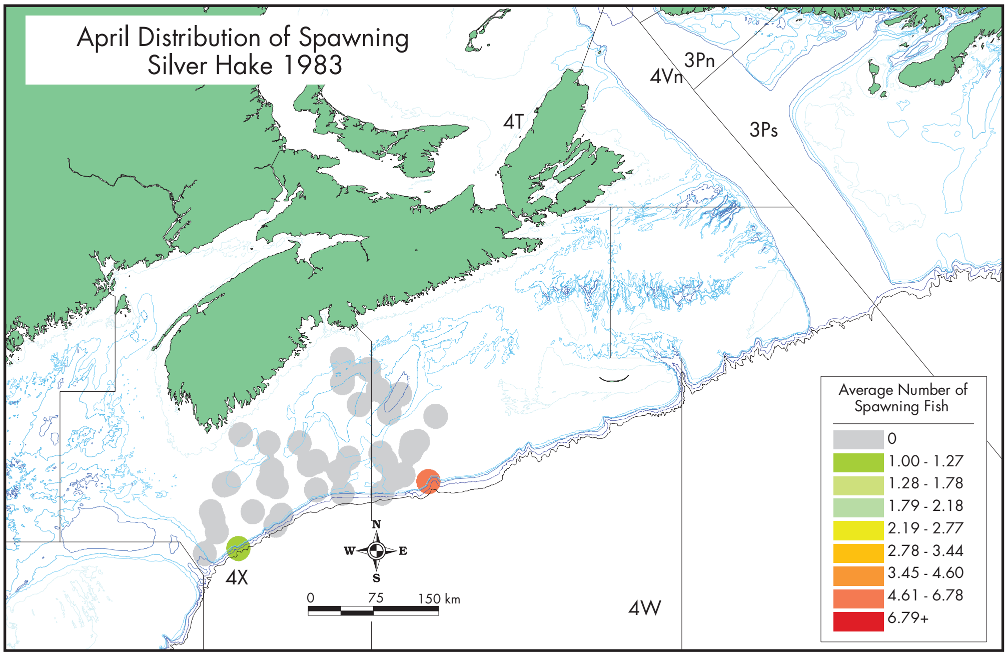

Figure 6 d.
June distribution of spawning Silver Hake, 1972 - 1995. The 0 class represents survey sets where no fish were caught.

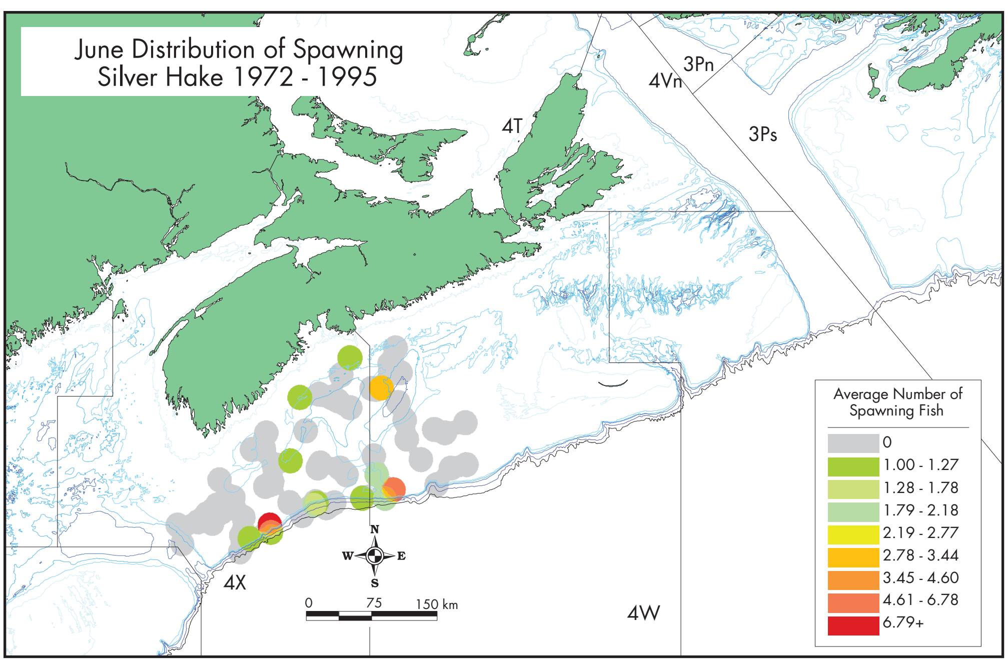

Figure 6 e.
July distribution of spawning Silver Hake, 1970 - 2004. The 0 class represents survey sets where no fish were caught.

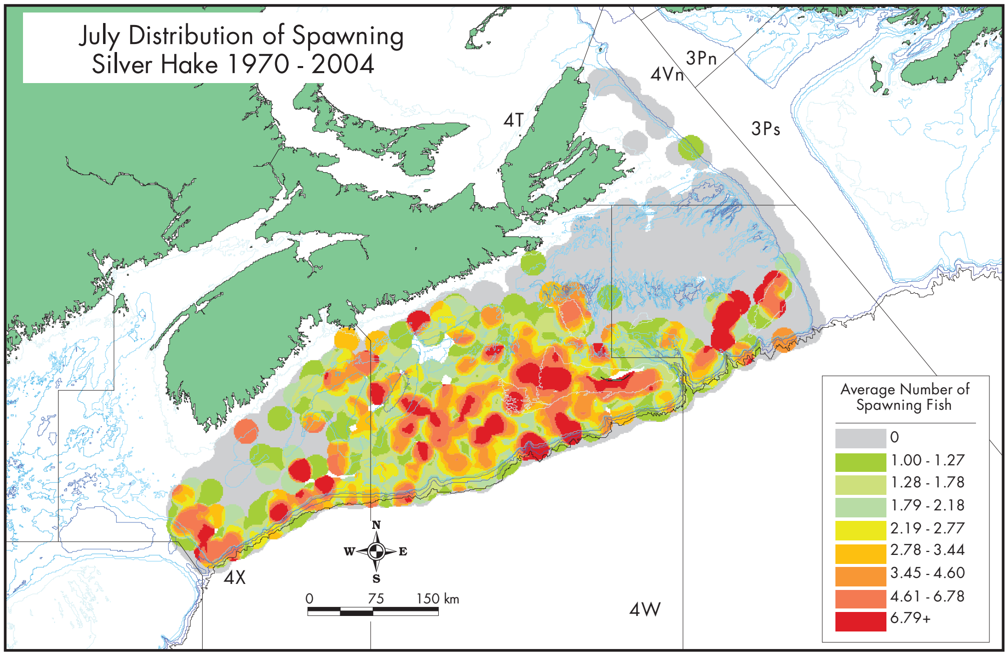

Figure 6 f.
August distribution of spawning Silver Hake, 1974 - 1984. The 0 class represents survey sets where no fish were caught.

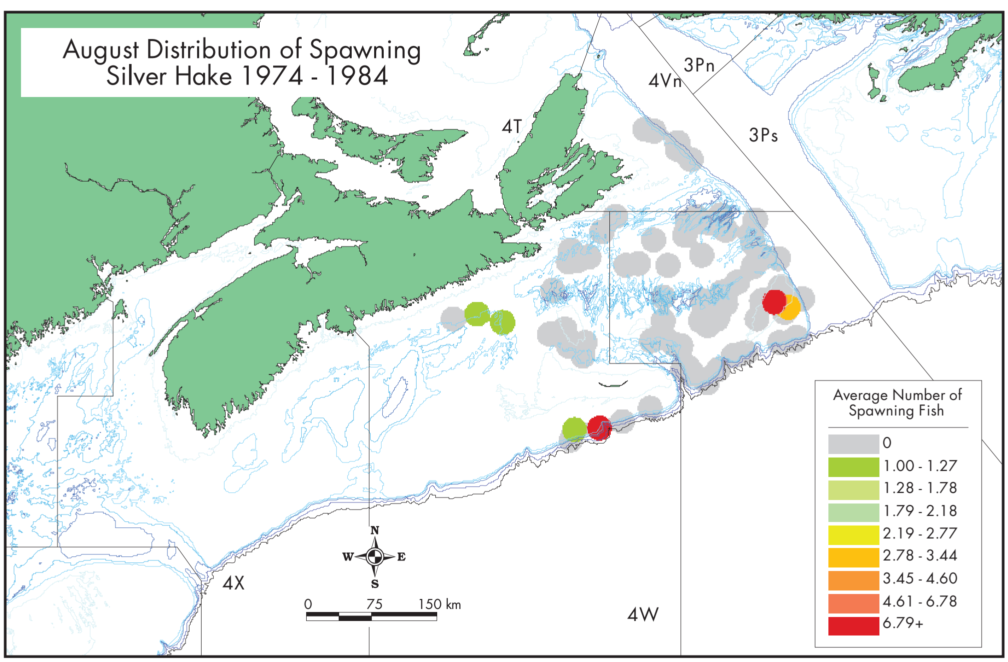

Figure 6 g.
September distribution of spawning Silver Hake, 1980 - 1982. The 0 class represents survey sets where no fish were caught.

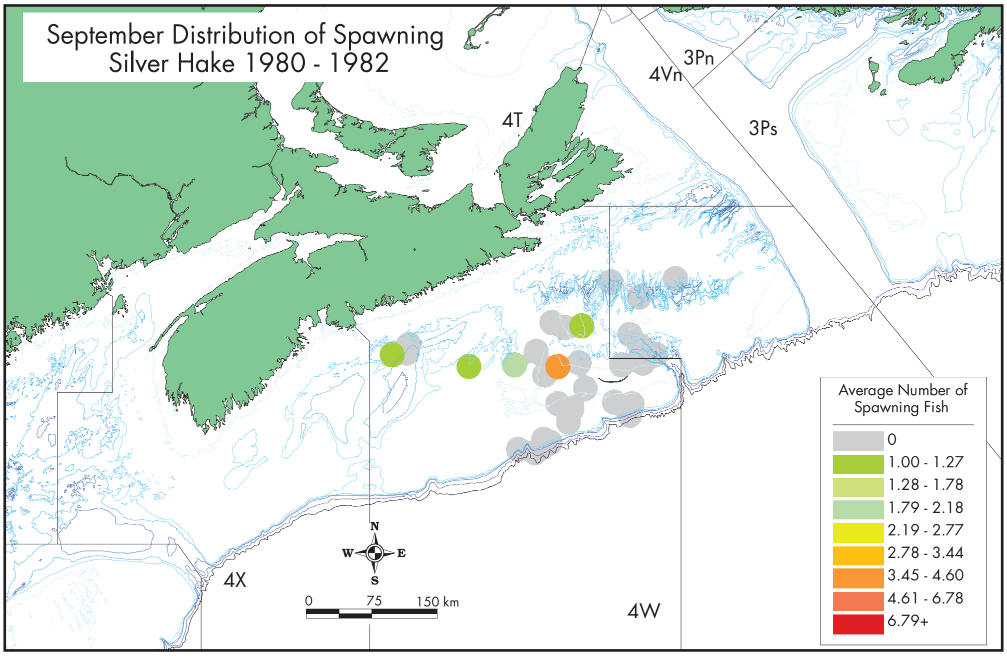

Figure 6 h.
October distribution of spawning Silver Hake, 1979 - 1984. The 0 class represents survey sets where no fish were caught.

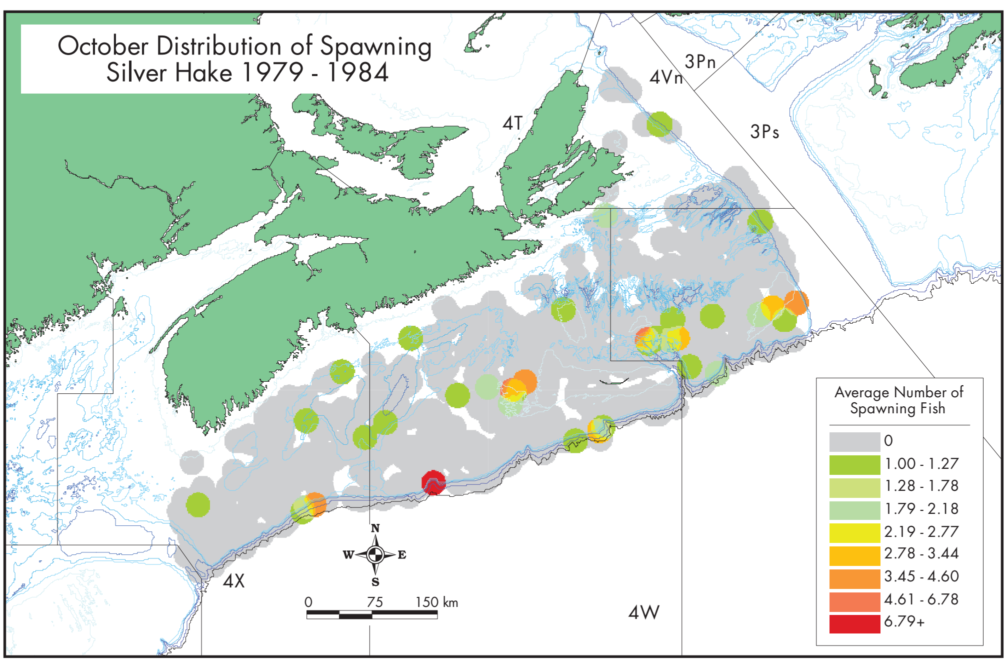

Figure 6 i.
November distribution of spawning Silver Hake, 1978 - 1984. The 0 class represents survey sets where no fish were caught.

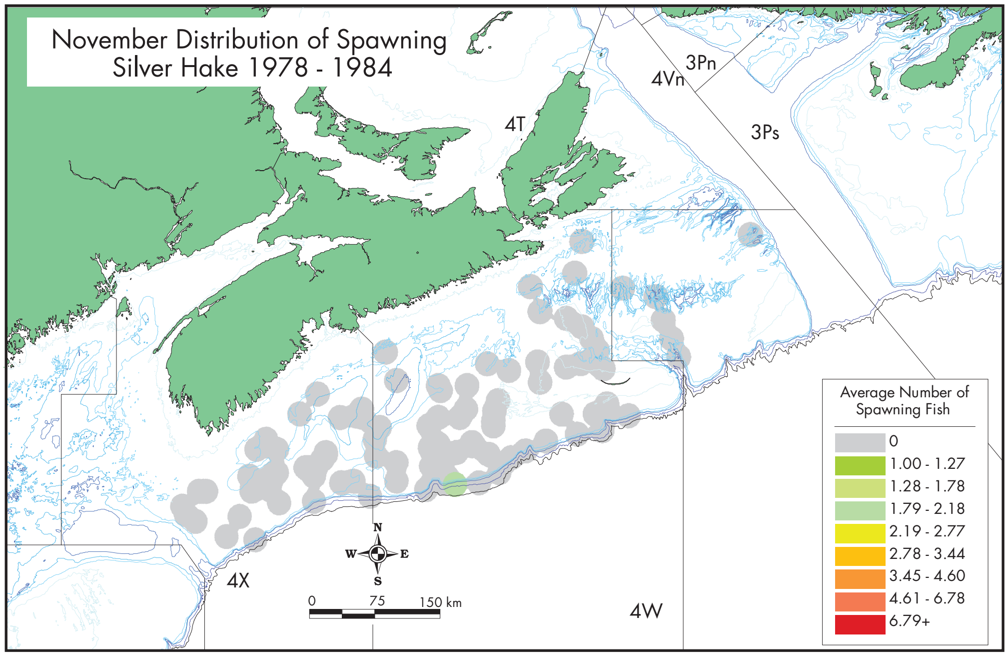

Figure 6 j.
December distribution of spawning Silver Hake, 1978. The 0 class represents survey sets where no fish were caught.

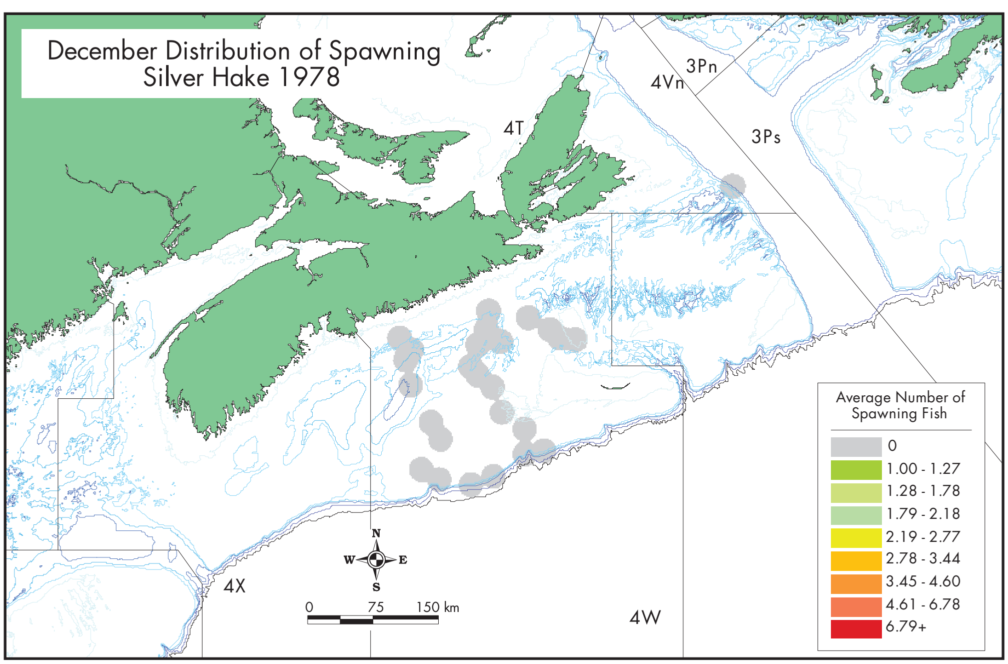

Figure 7 a.
February distribution of spawning White Hake, 1981. The 0 class represents survey sets where no fish were caught.

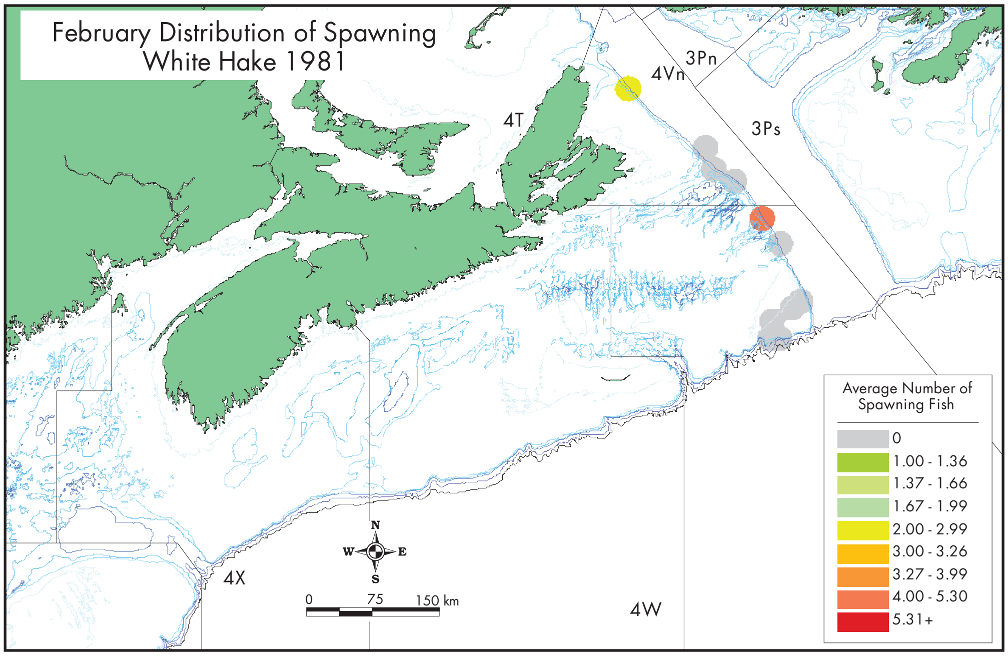

Figure 7 b.
March distribution of spawning White Hake, 1979 - 2005. The 0 class represents survey sets where no fish were caught.

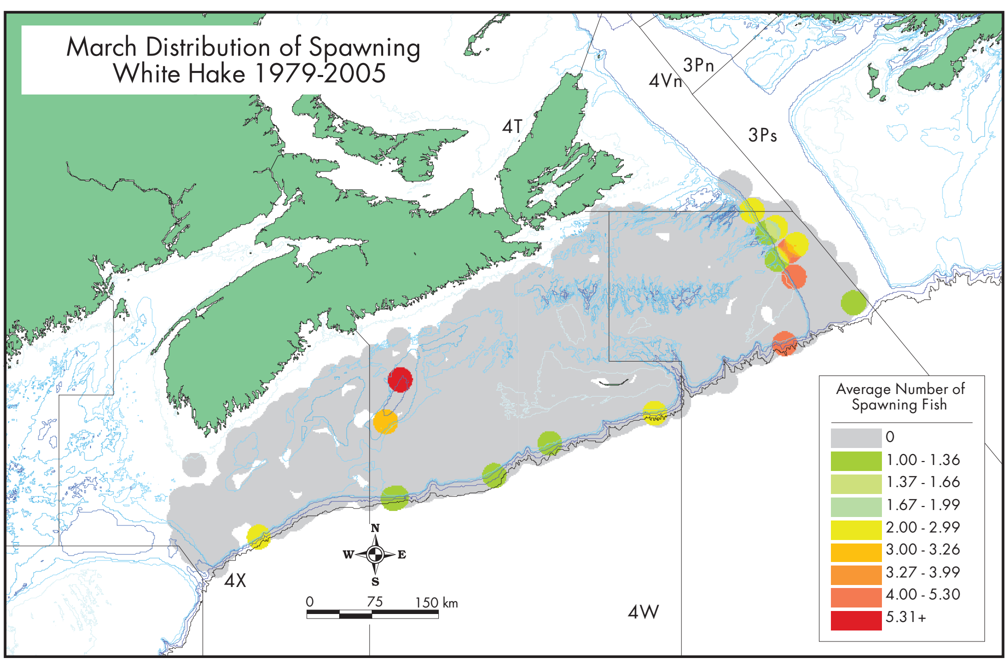

Figure 7 c.
April distribution of spawning White Hake, 1983. The 0 class represents survey sets where no fish were caught.

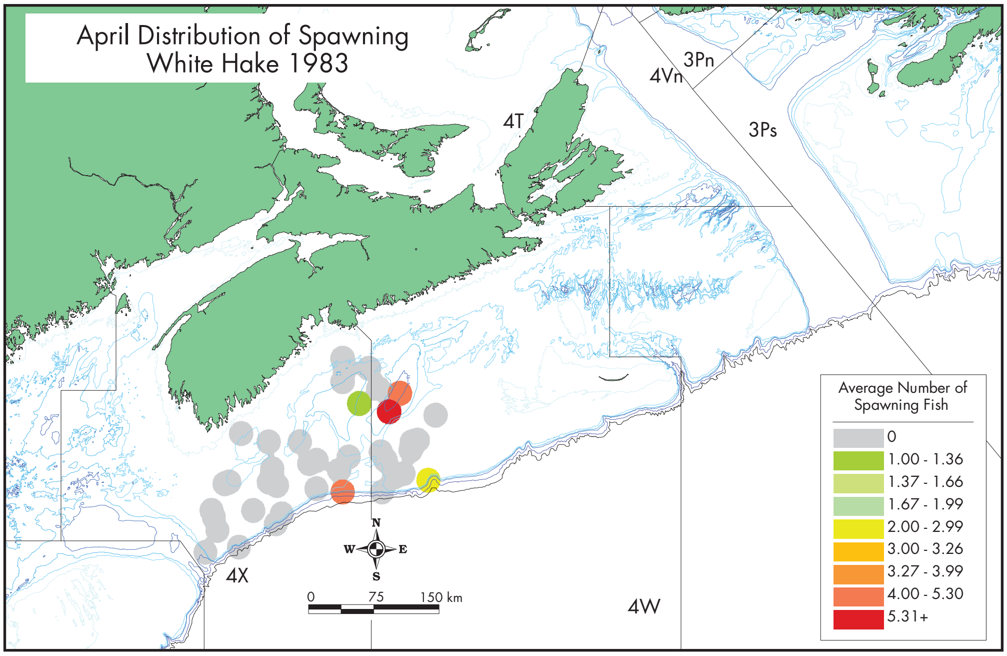

Figure 7 d.
July distribution of spawning White Hake, 1970 - 1985. The 0 class represents survey sets where no fish were caught.

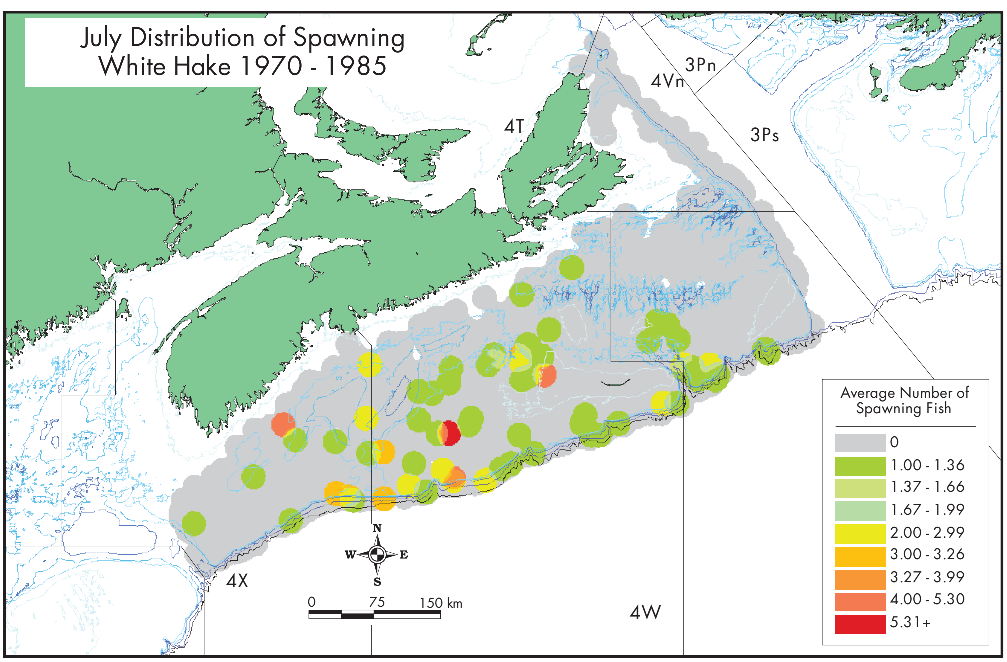

Figure 7 e.
August distribution of spawning White Hake, 1975 - 1984. The 0 class represents survey sets where no fish were caught.

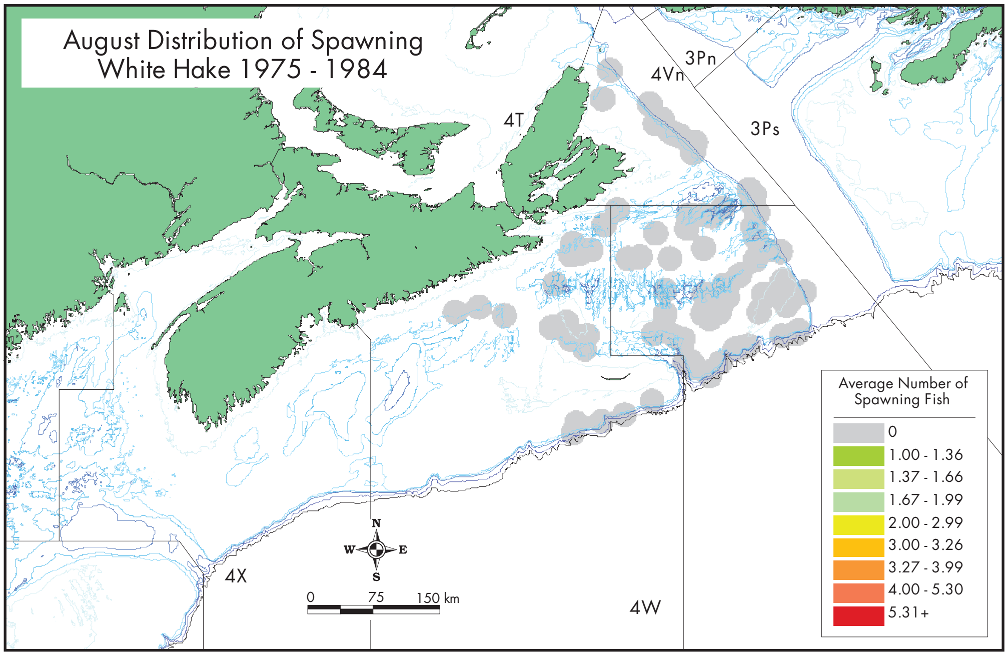

Figure 7 f.
September distribution of spawning White Hake, 1981 - 1982. The 0 class represents survey sets where no fish were caught.

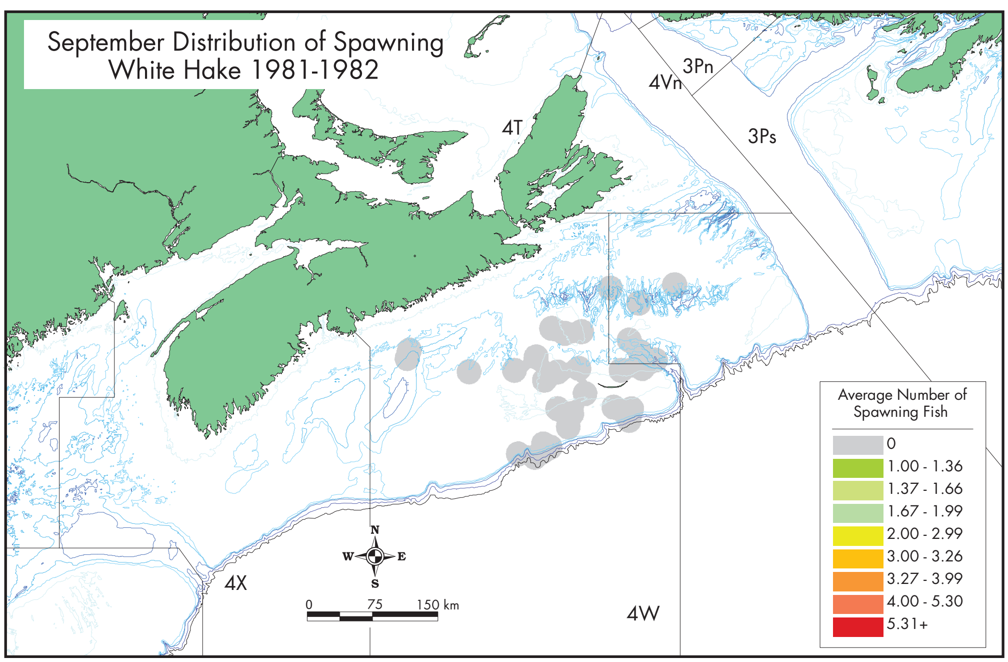

Figure 7 g.
October distribution of spawning White Hake, 1979 - 1984. The 0 class represents survey sets where no fish were caught.

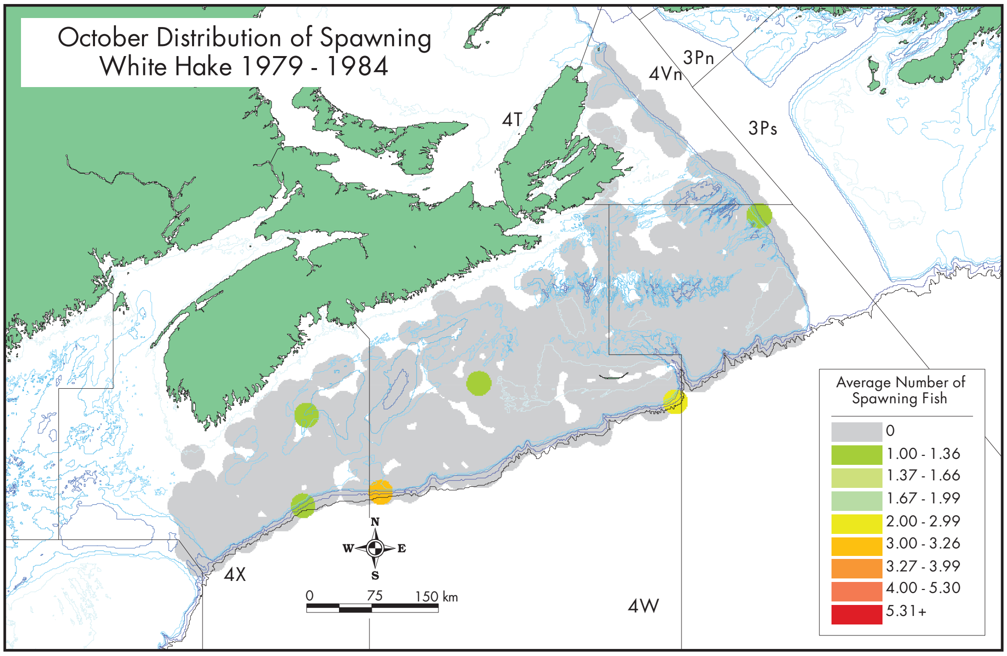

Figure 7 h.
November distribution of spawning White Hake, 1978 - 1984. The 0 class represents survey sets where no fish were caught.

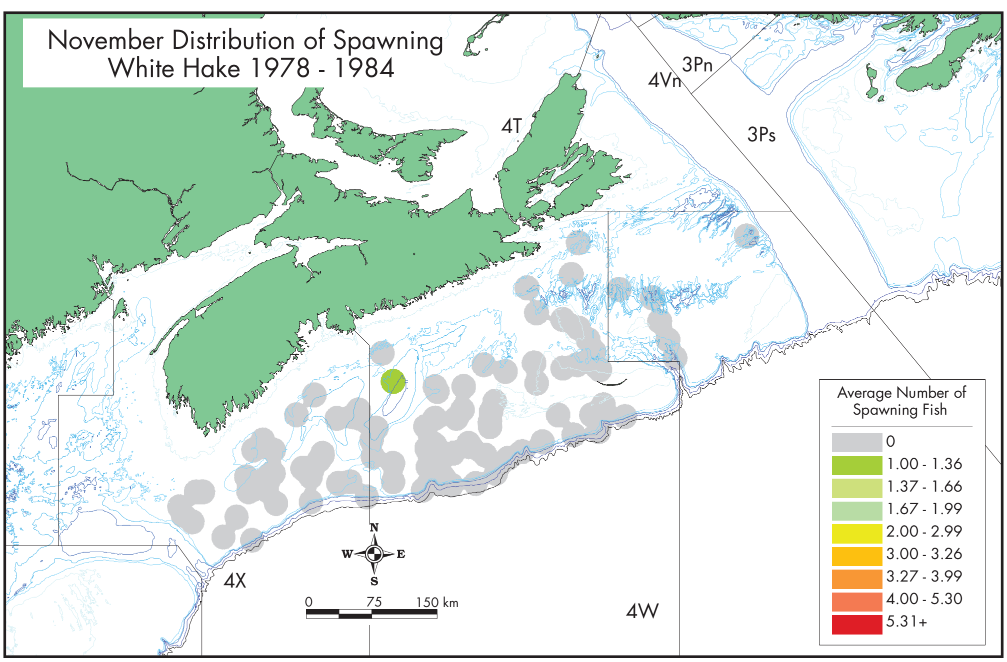

Figure 7 i.
December distribution of spawning White Hake, 1978. The 0 class represents survey sets where no fish were caught.

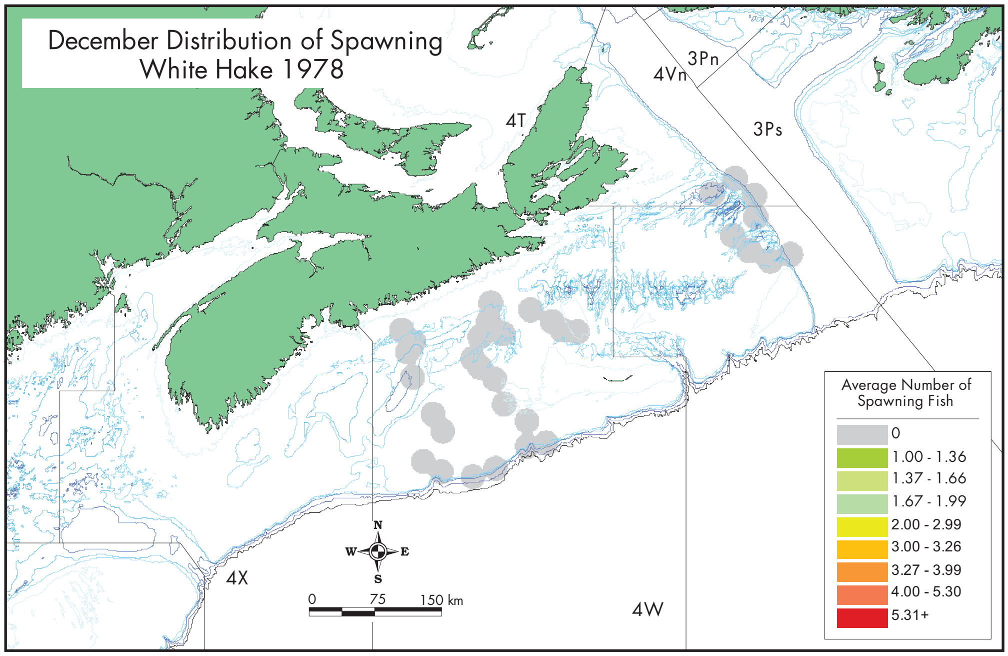

Figure 8 a.
February distribution of spawning Witch Flounder, 1981. The 0 class represents survey sets where no fish were caught.

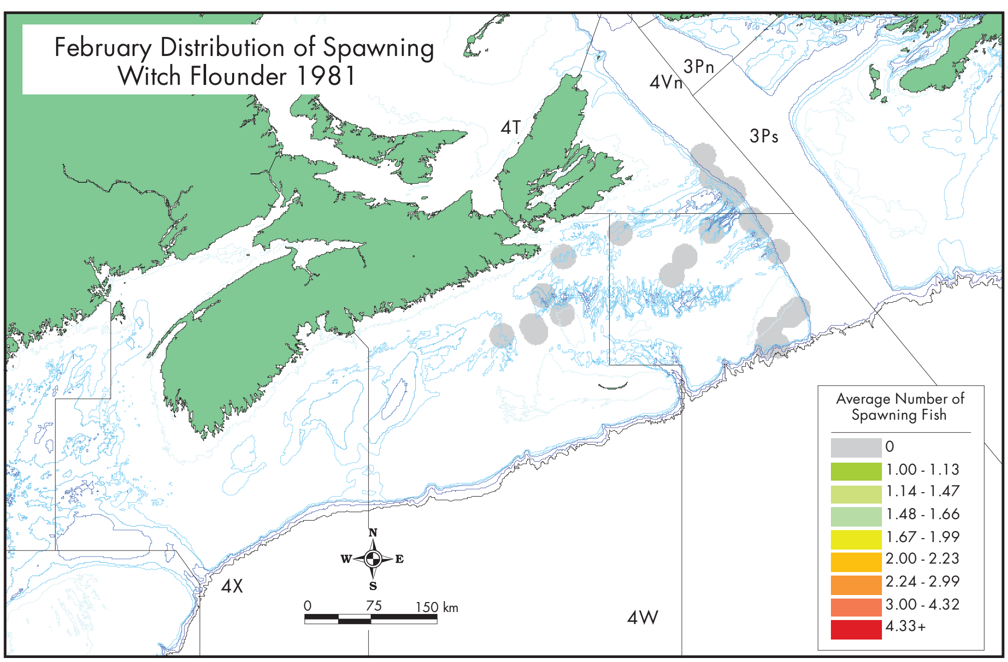

Figure 8 b.
March distribution of spawning Witch Flounder, 1979 - 1984. The 0 class represents survey sets where no fish were caught.

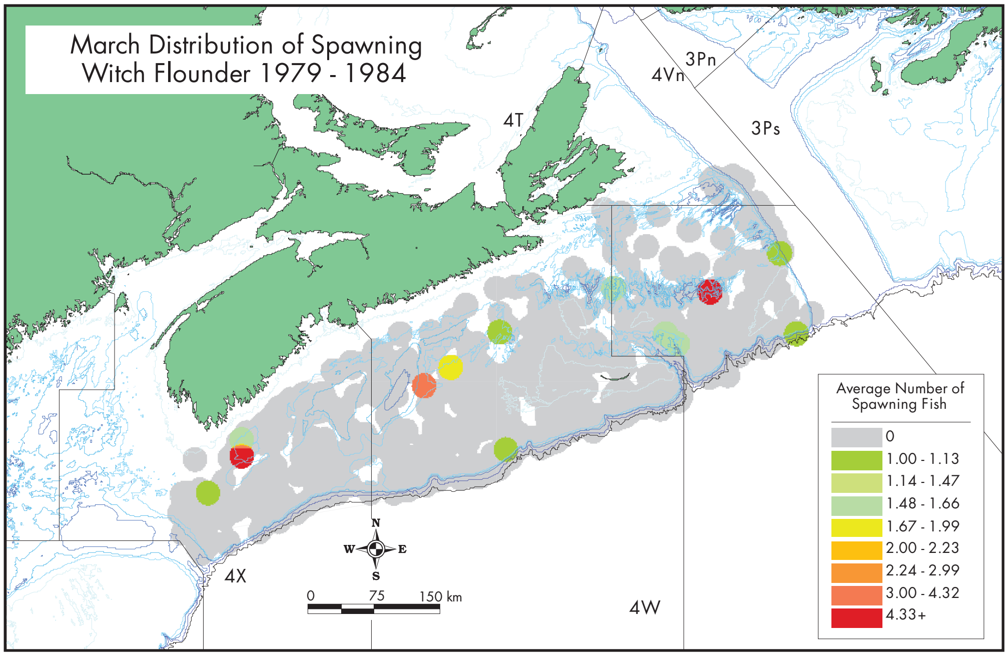

Figure 8 c.
April distribution of spawning Witch Flounder, 1983. The 0 class represents survey sets where no fish were caught.

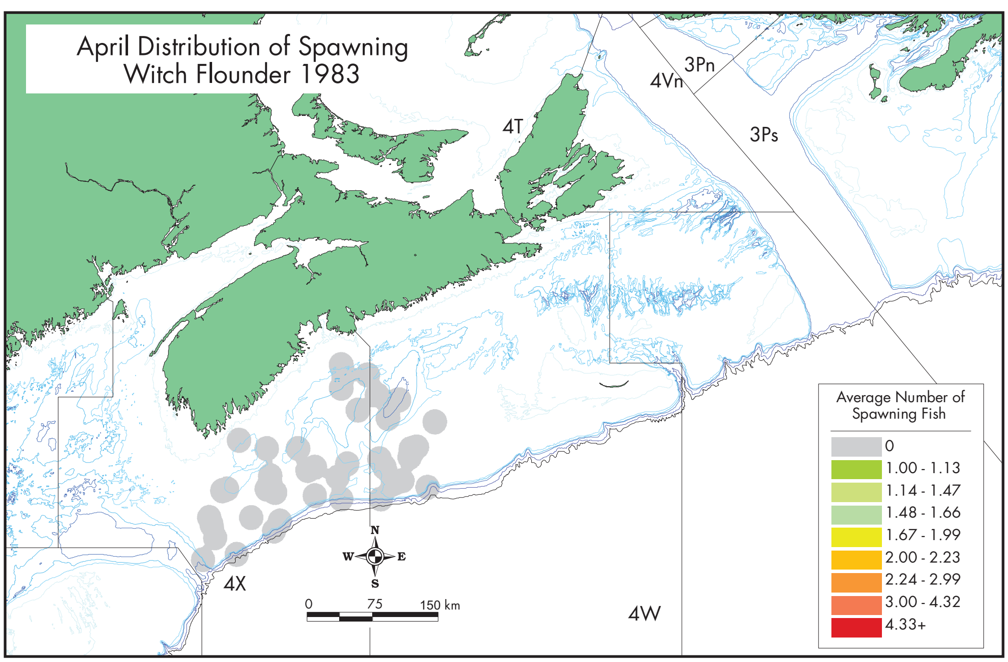

Figure 8 d.
June distribution of spawning Witch Flounder, 1972. The 0 class represents survey sets where no fish were caught.

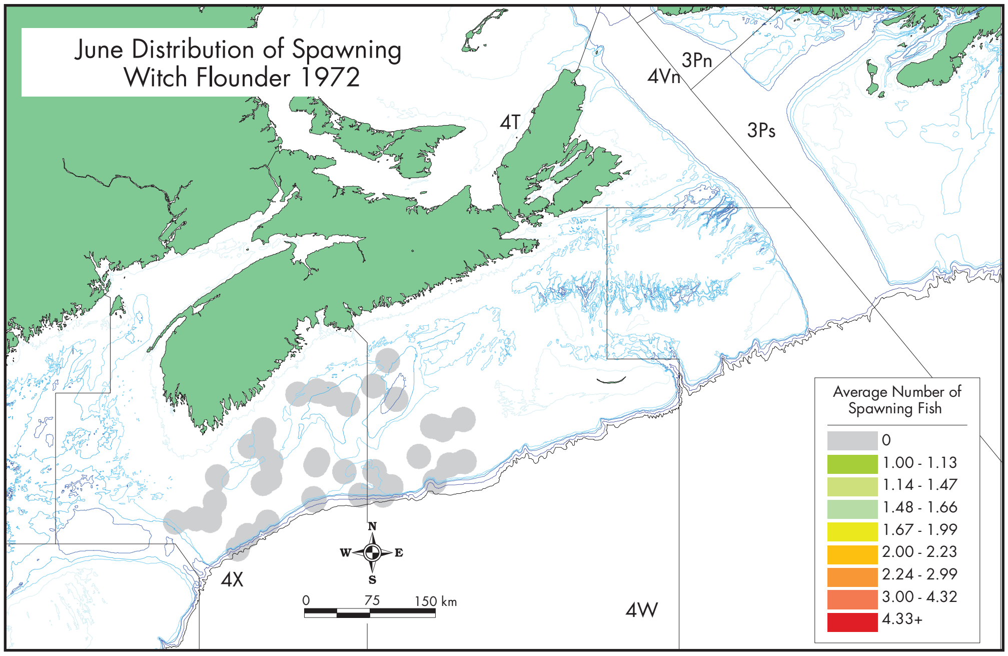

Figure 8 e.
July distribution of spawning Witch Flounder, 1970 - 1994. The 0 class represents survey sets where no fish were caught.

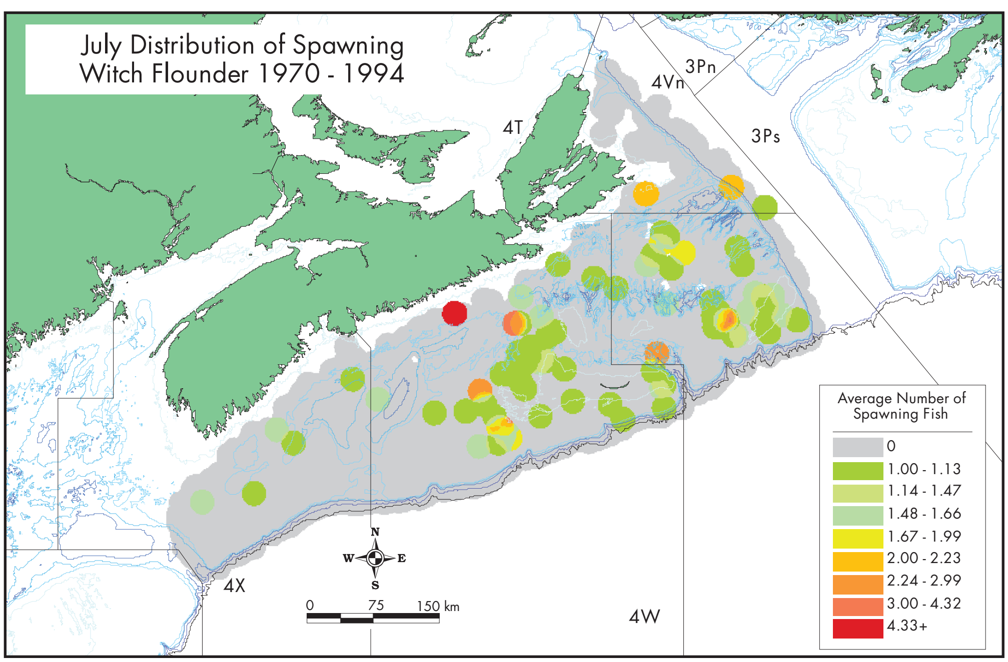

Figure 8 f.
August distribution of spawning Witch Flounder, 1973 - 1984. The 0 class represents survey sets where no fish were caught.

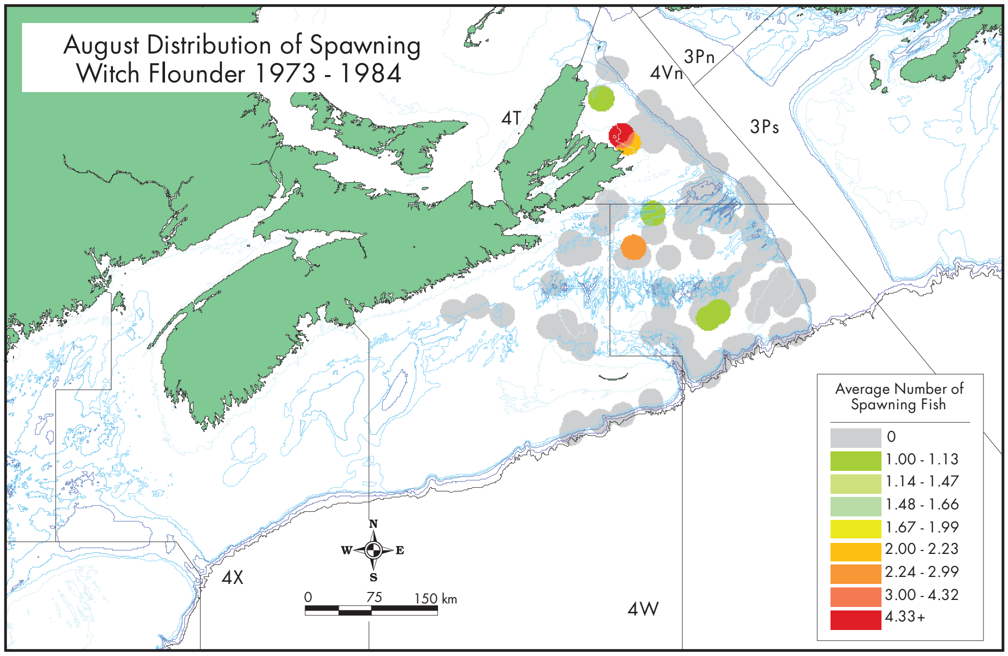

Figure 8 g.
September distribution of spawning Witch Flounder, 1980 - 1982. The 0 class represents survey sets where no fish were caught.

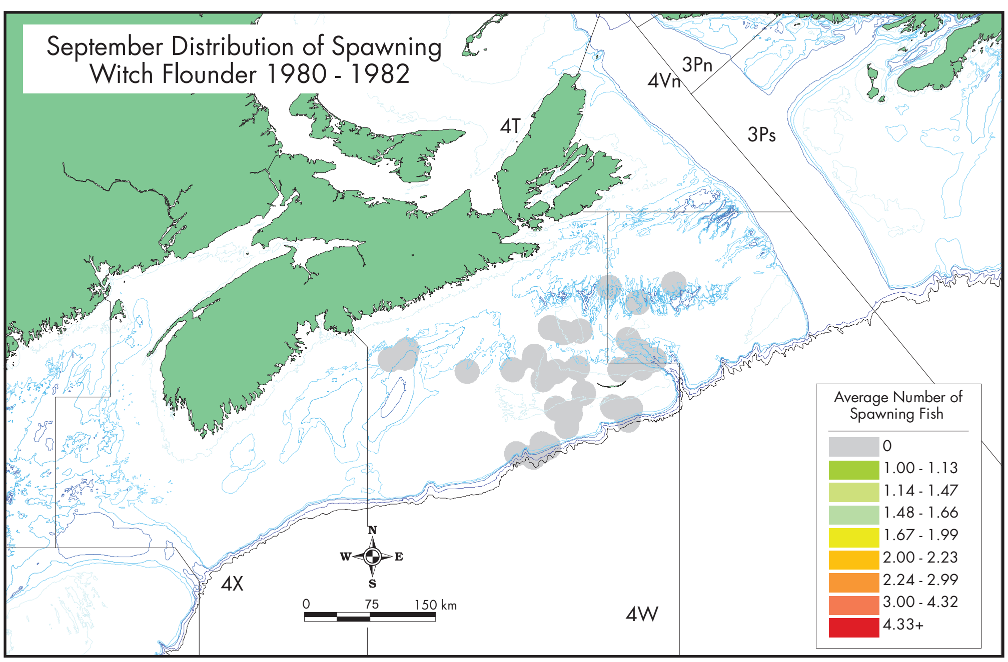

Figure 8 h.
October distribution of spawning Witch Flounder, 1979 - 1984. The 0 class represents survey sets where no fish were caught.

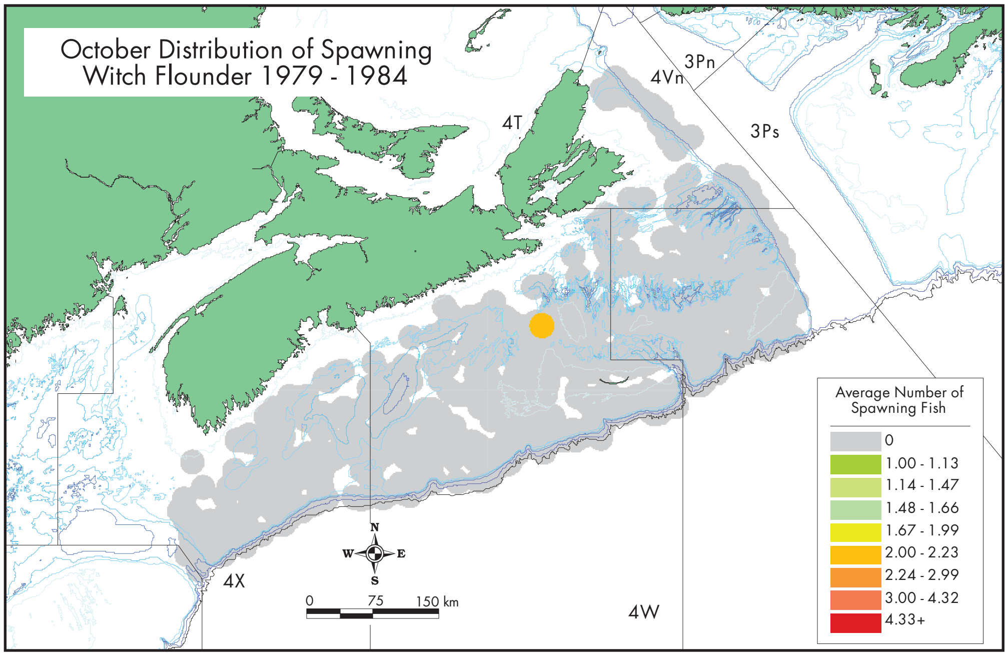

Figure 8 i.
November distribution of spawning Witch Flounder, 1978 - 1979. The 0 class represents survey sets where no fish were caught.

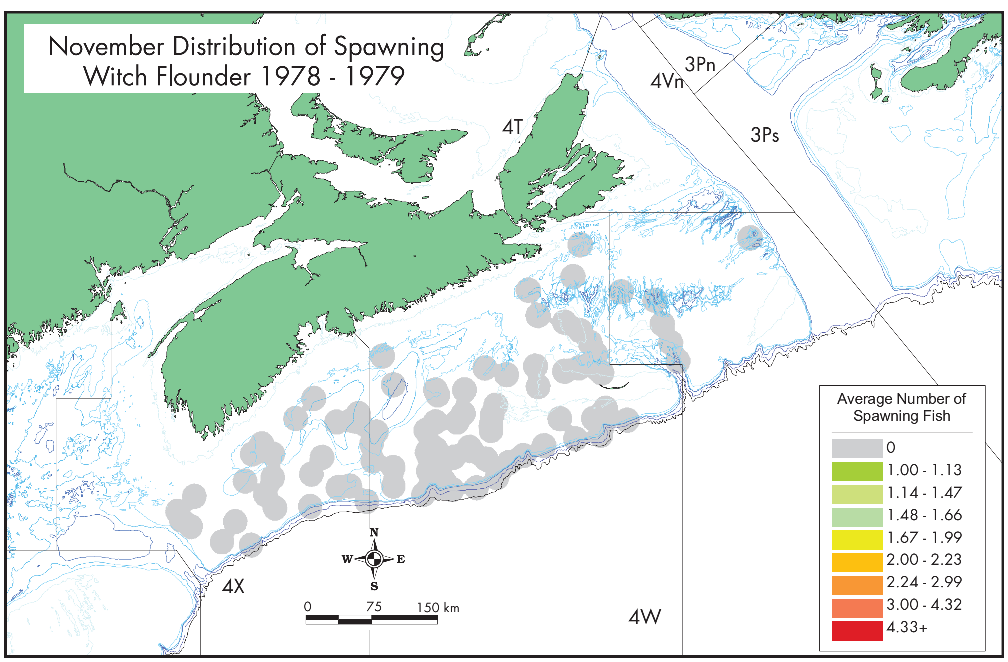

Figure 8 j.
December distribution of spawning Witch Flounder, 1978. The 0 class represents survey sets where no fish were caught.

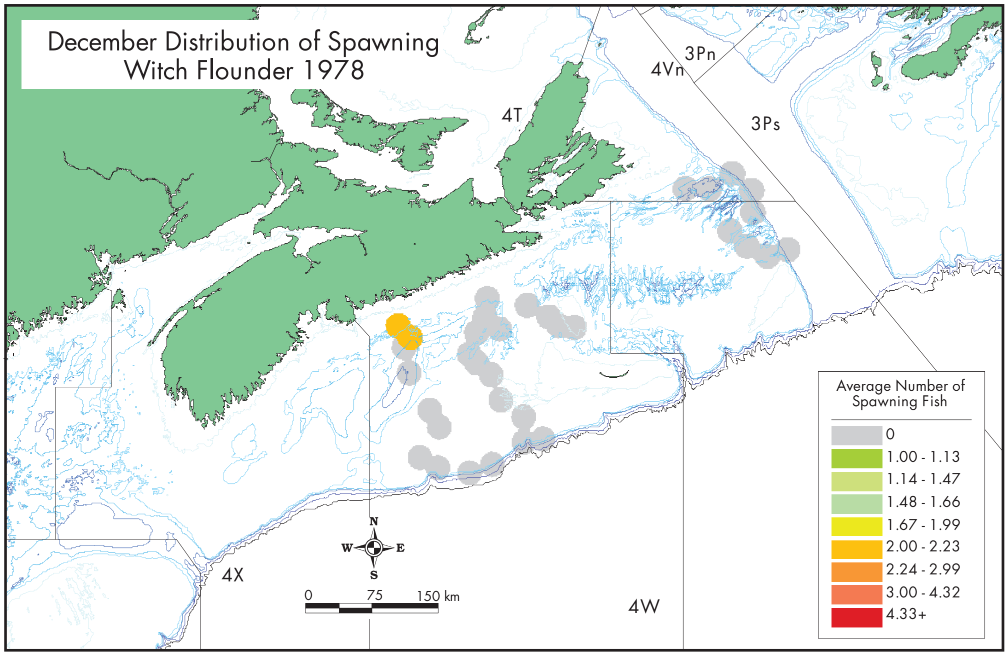

Figure 9 a.
February distribution of spawning Yellowtail Flounder, 1981. The 0 class represents survey sets where no fish were caught.

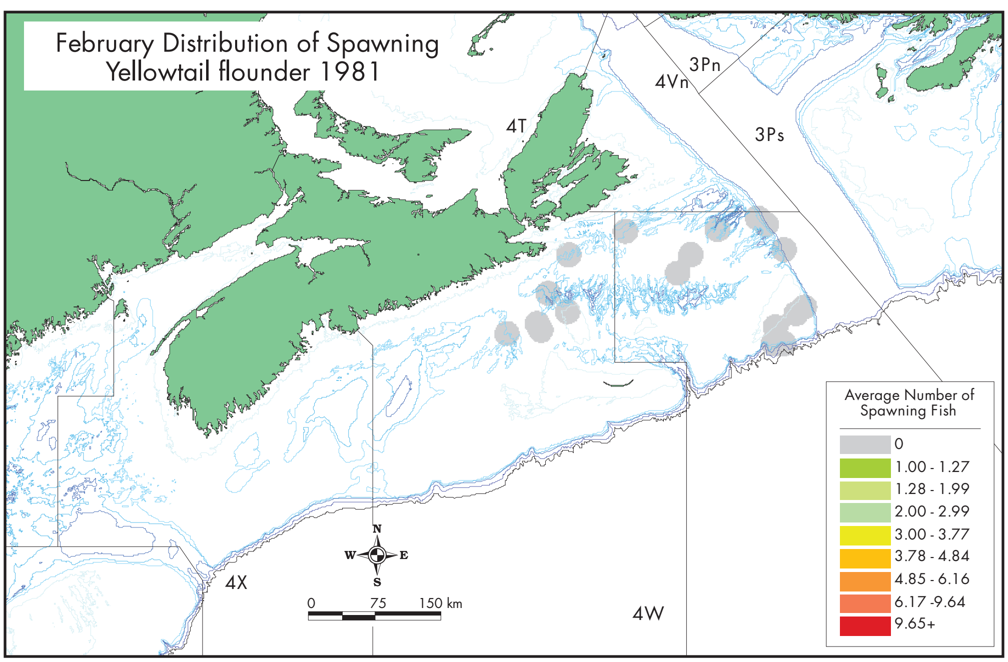

Figure 9 b.
March distribution of spawning Yellowtail Flounder, 1979 - 1987. The 0 class represents survey sets where no fish were caught.

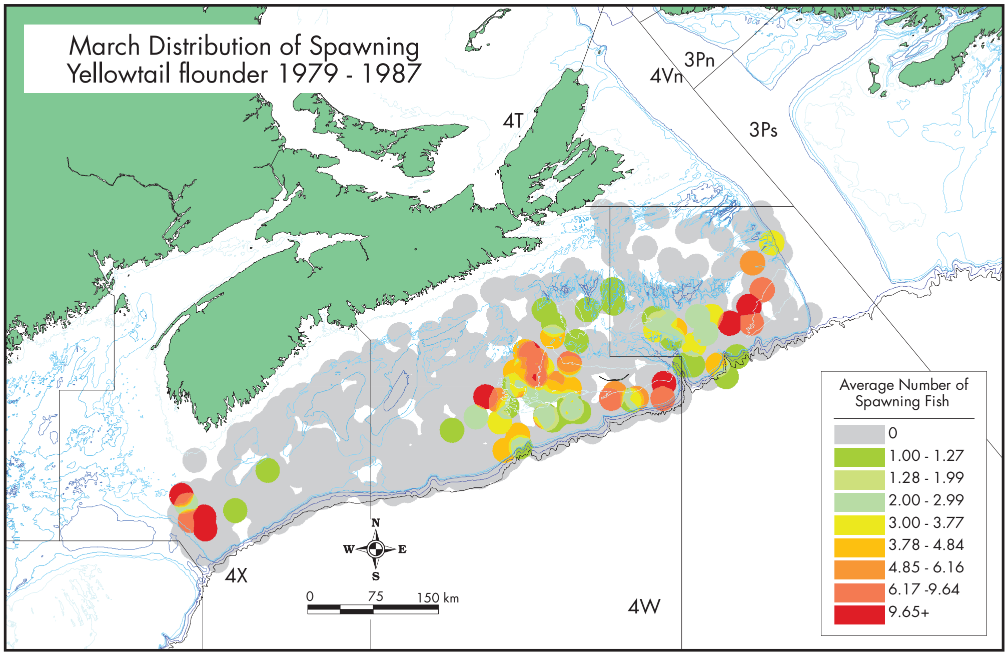

Figure 9 c.
April distribution of spawning Yellowtail Flounder, 1983. The 0 class represents survey sets where no fish were caught.

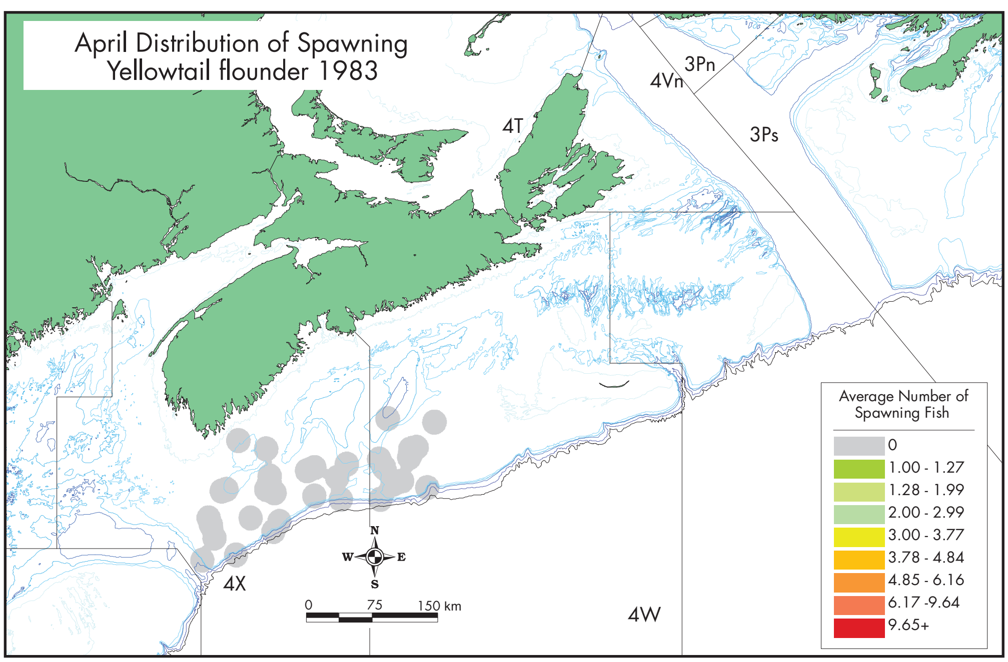

Figure 9 d.
June distribution of spawning Yellowtail Flounder, 1972. The 0 class represents survey sets where no fish were caught.

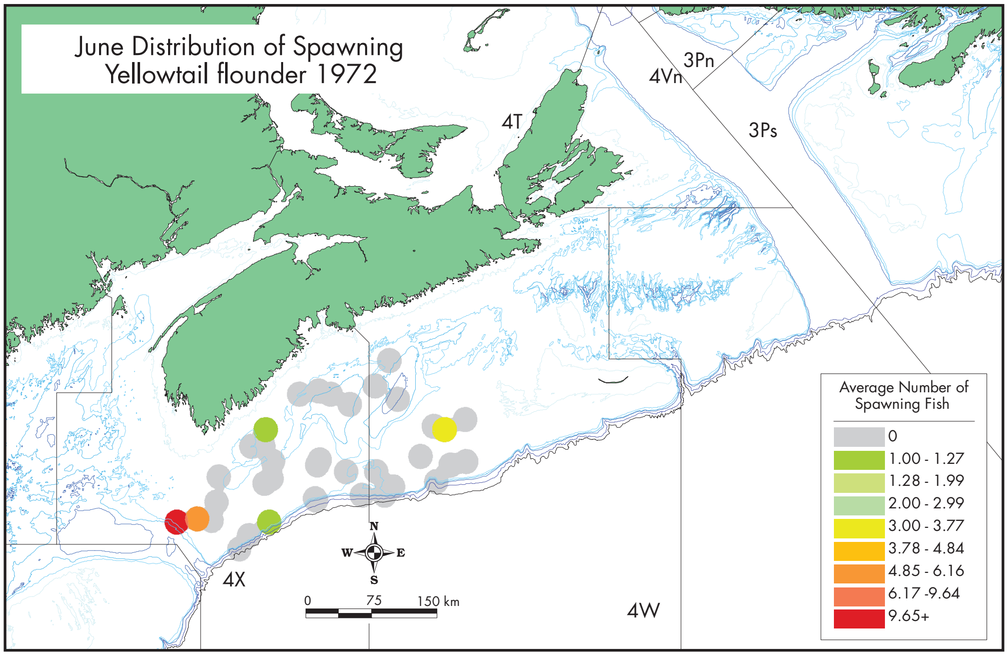

Figure 9 e.
July distribution of spawning Yellowtail Flounder, 1970 - 1999. The 0 class represents survey sets where no fish were caught.

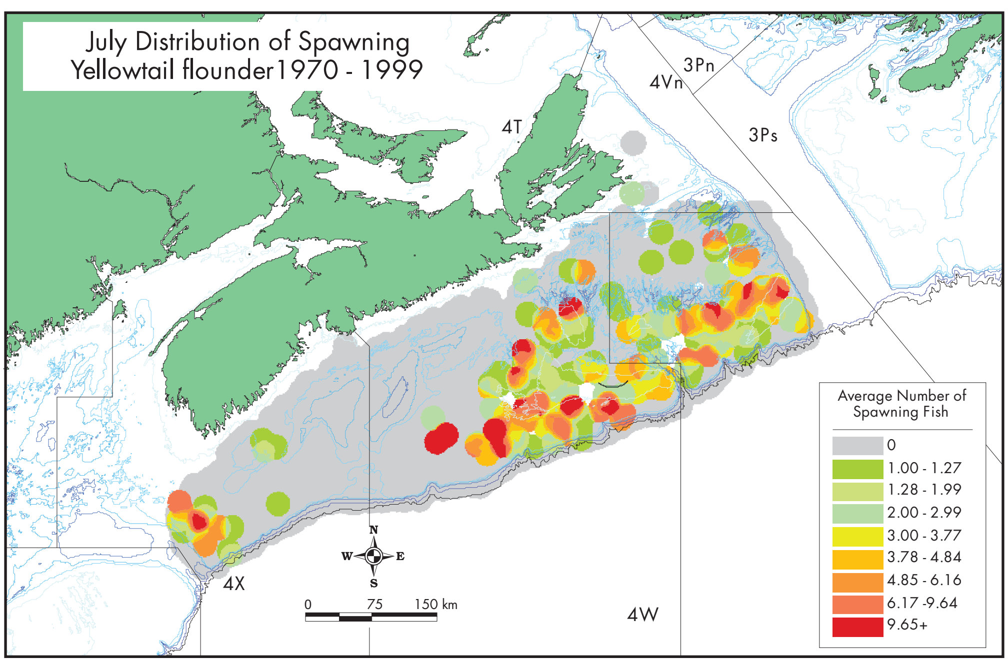

Figure 9 f.
August distribution of spawning Yellowtail Flounder, 1975 - 1976. The 0 class represents survey sets where no fish were caught.

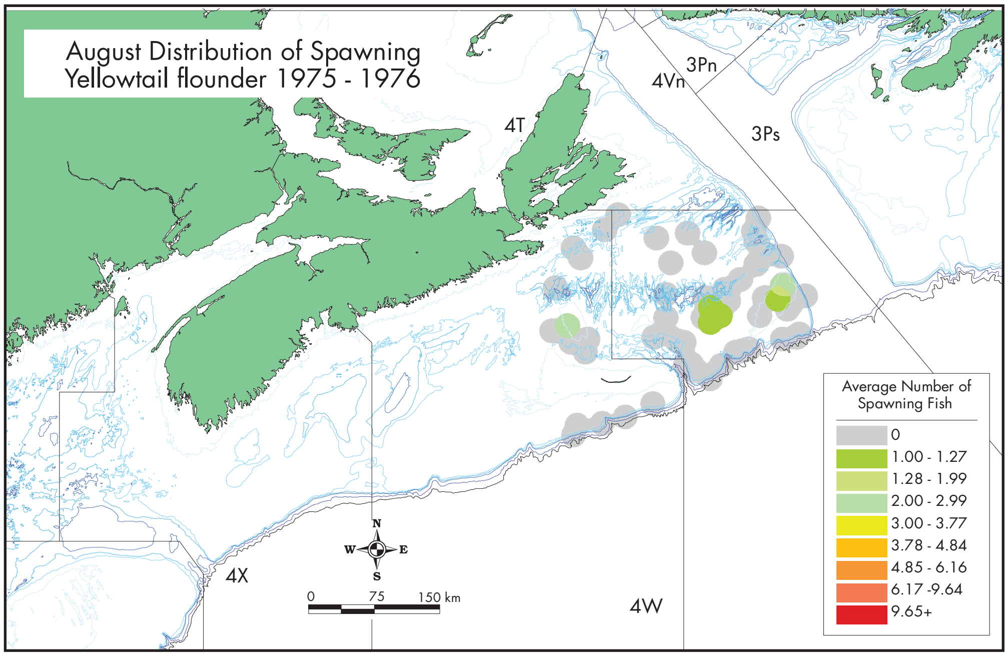

Figure 9 g.
September distribution of spawning Yellowtail Flounder, 1982. The 0 class represents survey sets where no fish were caught.

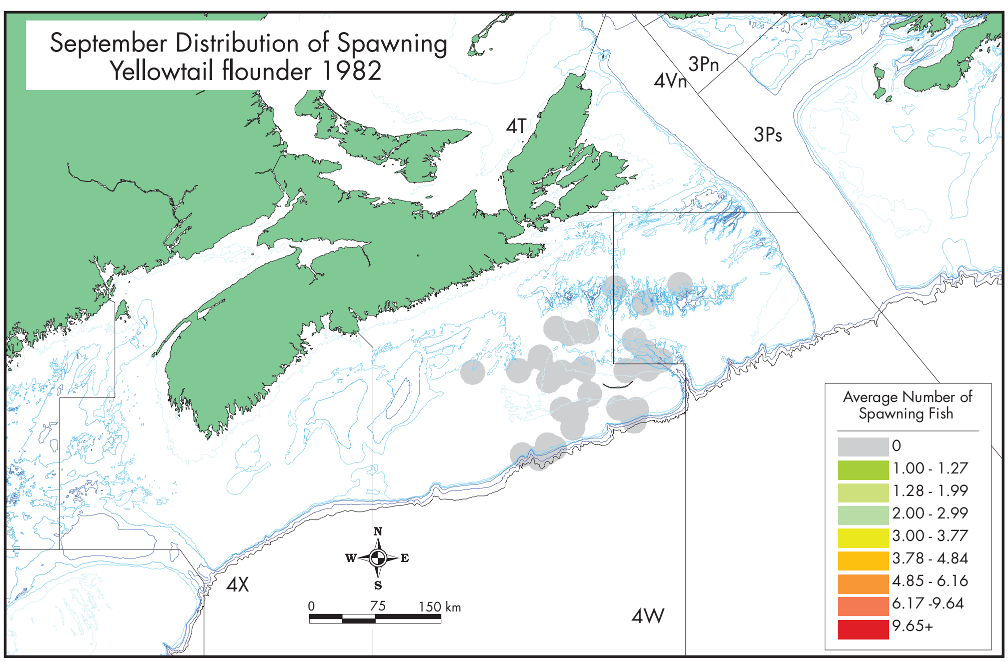

Figure 9 h.
October distribution of spawning Yellowtail Flounder, 1979 - 1984. The 0 class represents survey sets where no fish were caught.

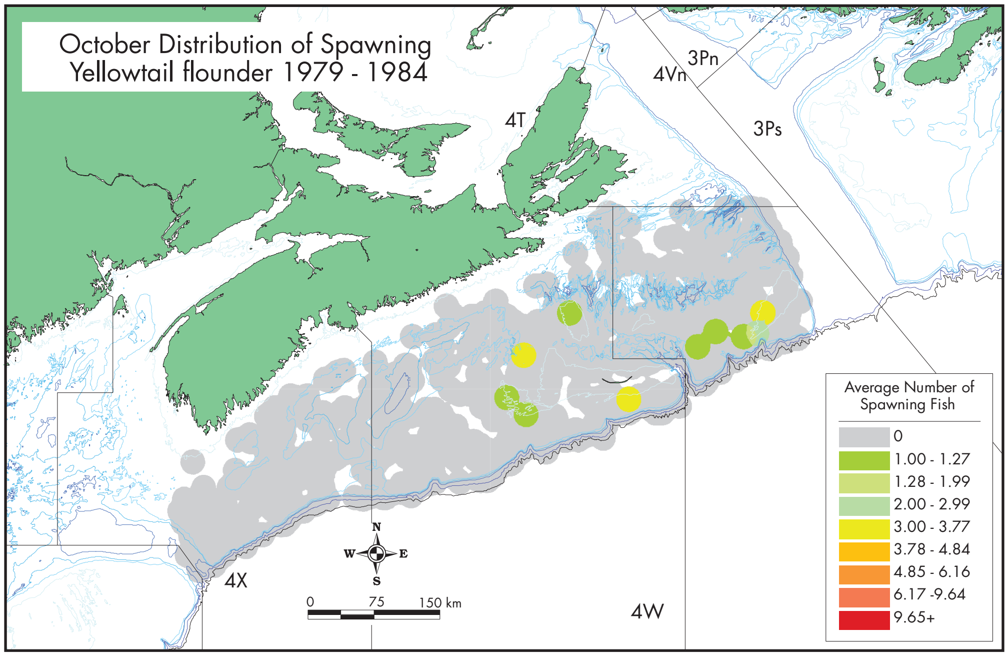

Figure 9 i.
November distribution of spawning Yellowtail Flounder, 1978 - 1984. The 0 class represents survey sets where no fish were caught.

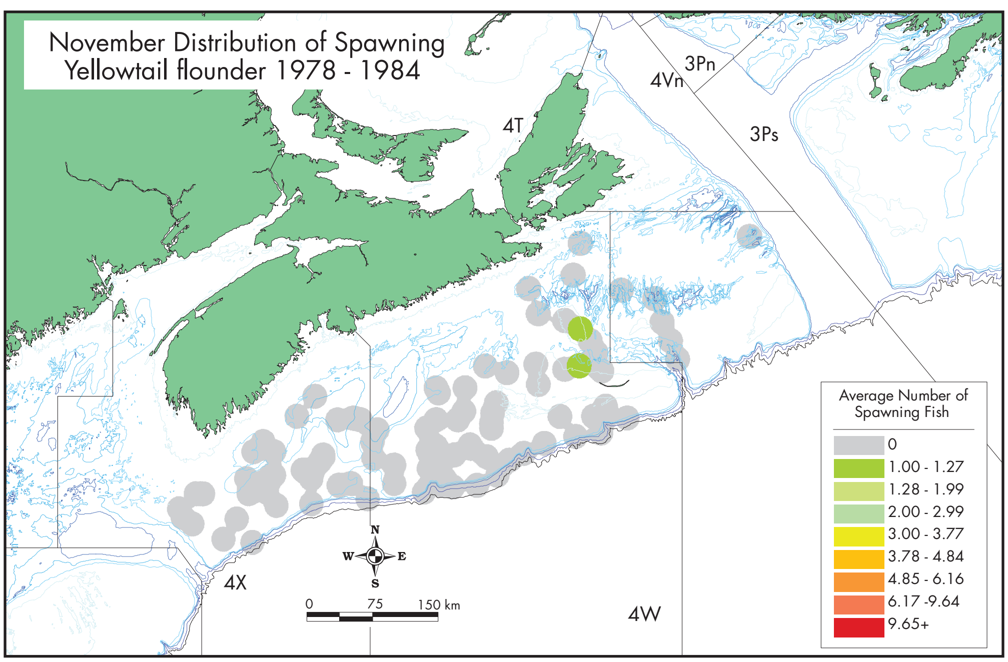

Figure 9 j.
December distribution of spawning Yellowtail Flounder, 1978. The 0 class represents survey sets where no fish were caught.

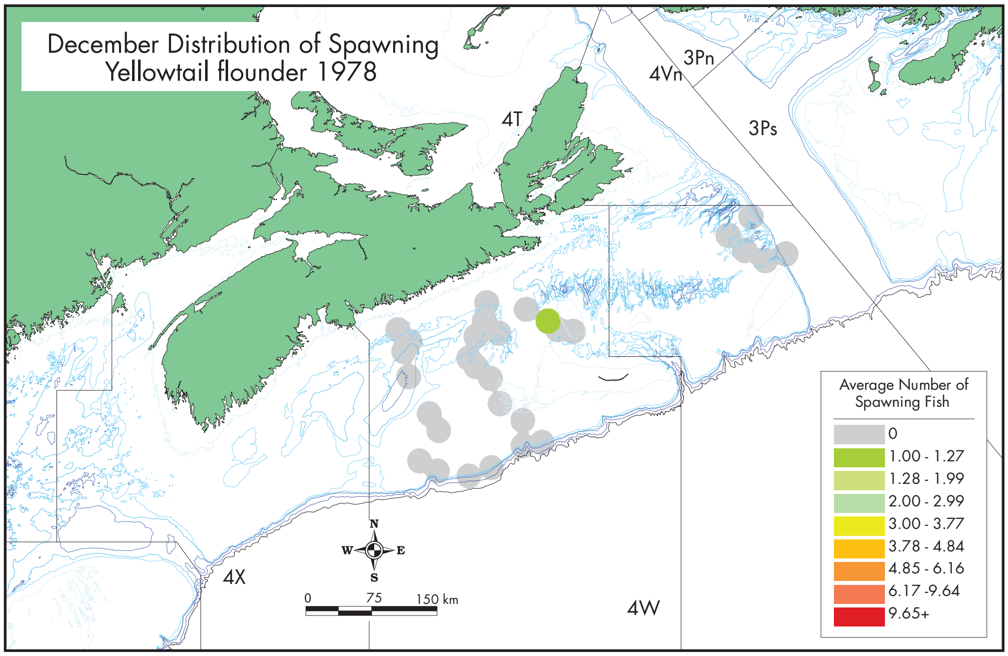

Figure 10 a.
February spawning distribution of all species combined, 1981 - 2001. The 0 class represents survey sets where no fish were caught.

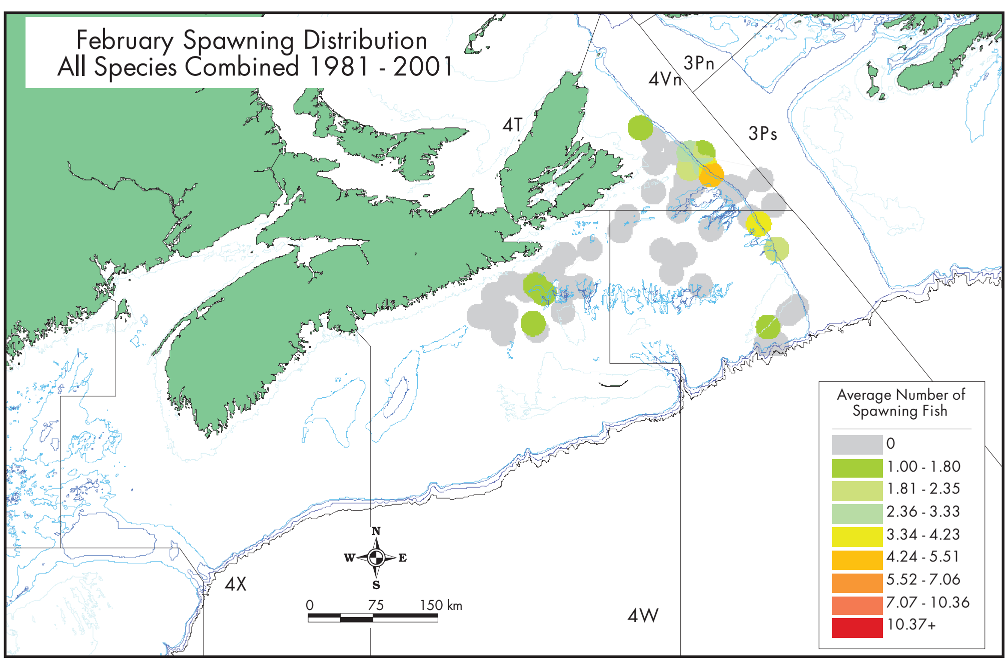

Figure 10 b.
March spawning distribution of all species combined, 1979 - 2005. The 0 class represents survey sets where no fish were caught.

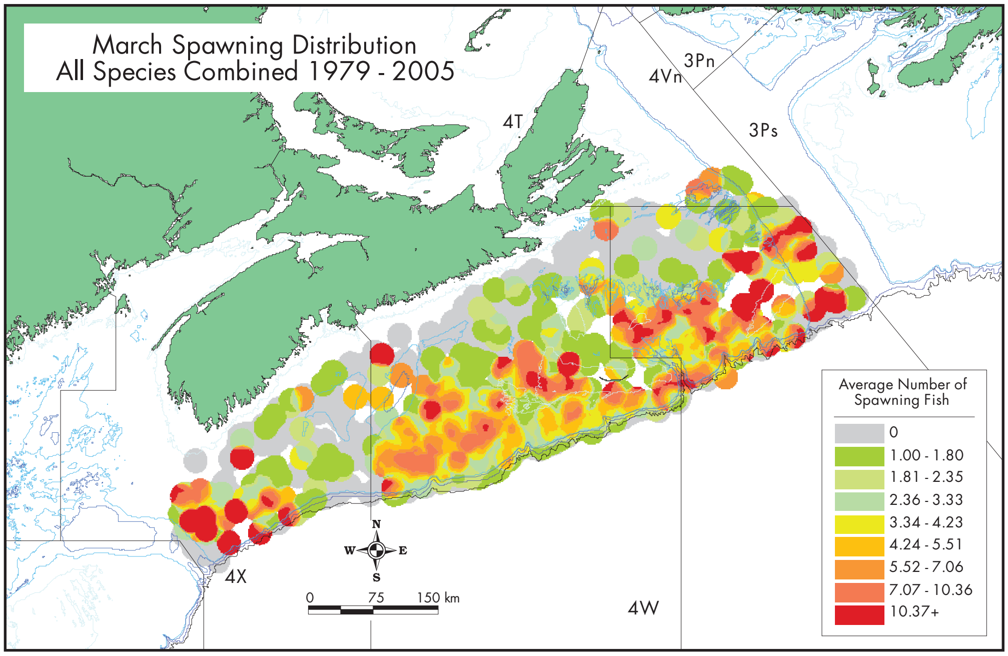

Figure 10 c.
April spawning distribution of all species combined, 1983 - 1987. The 0 class represents survey sets where no fish were caught.

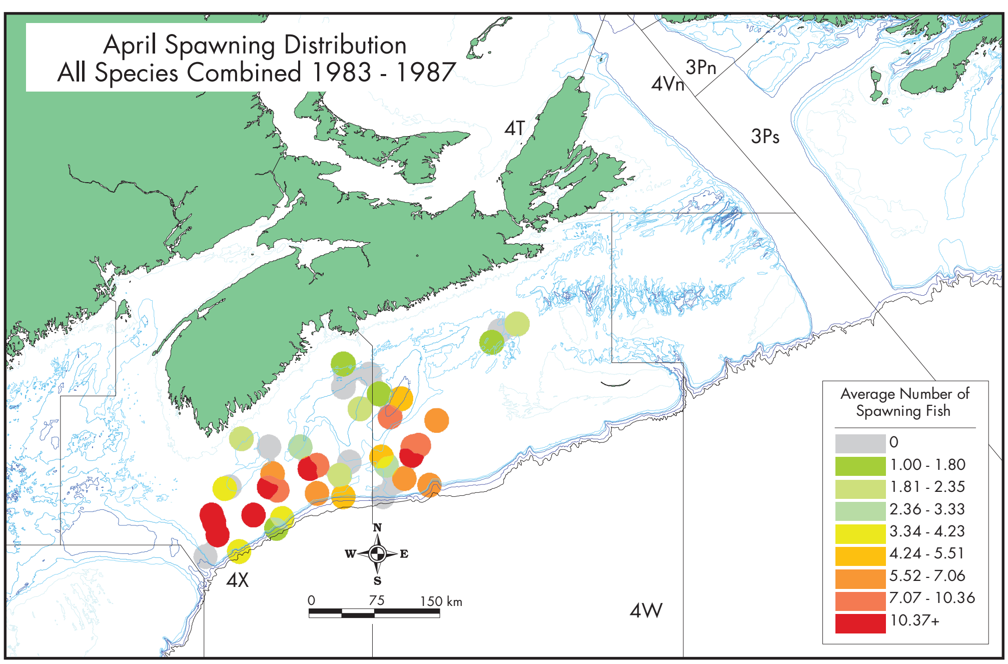

Figure 10 d.
June spawning distribution of all species combined, 1972 - 1995. The 0 class represents survey sets where no fish were caught.

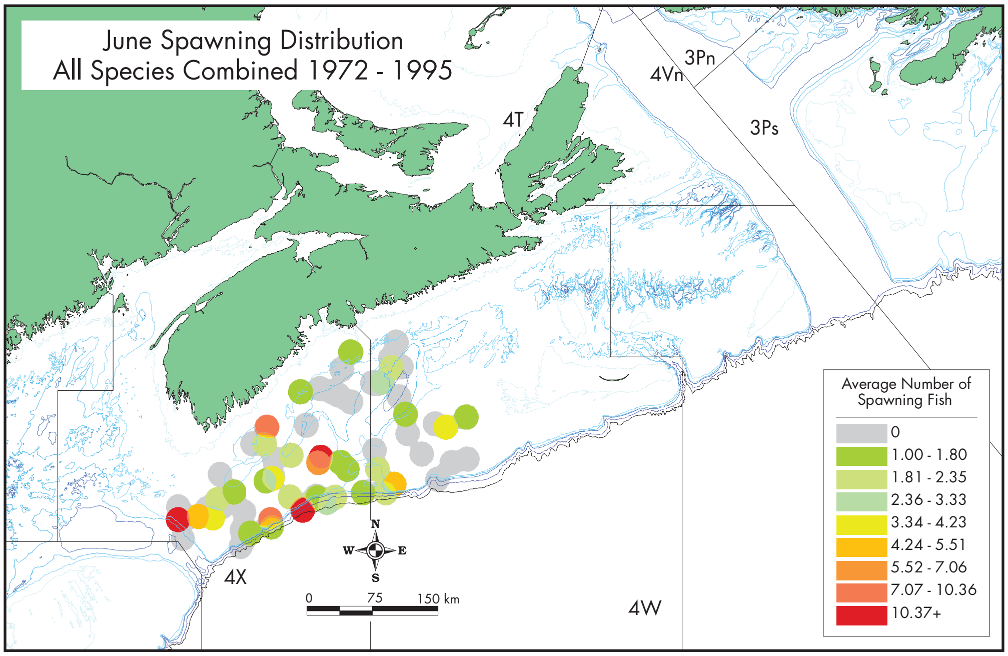

Figure 10 e.
July spawning distribution of all species combined, 1970 - 2004. The 0 class represents survey sets where no fish were caught.

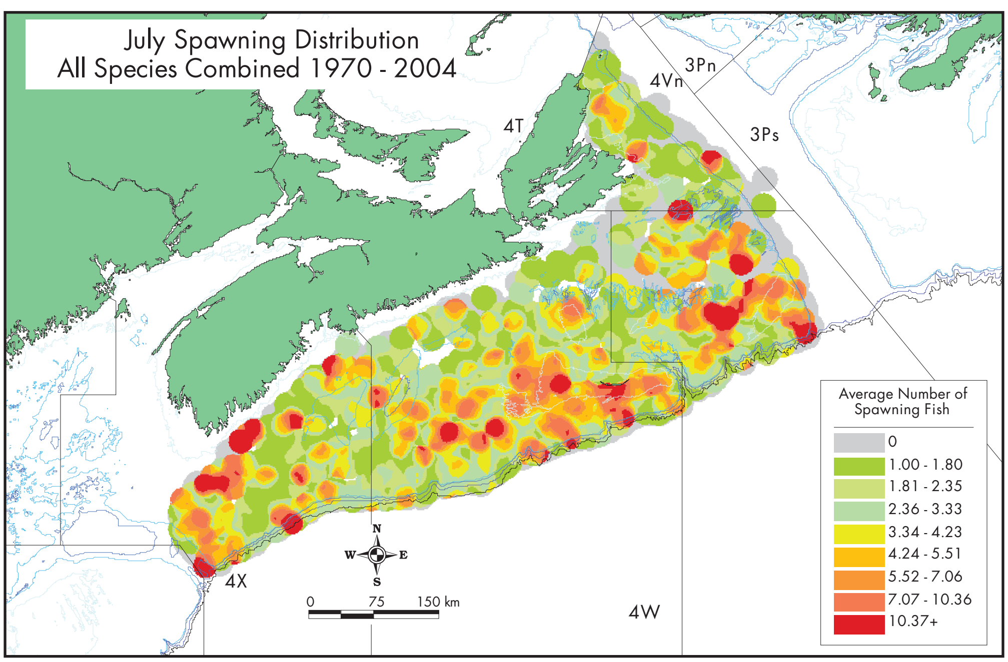

Figure 10 f.
August spawning distribution of all species combined, 1973 - 1993. The 0 class represents survey sets where no fish were caught.

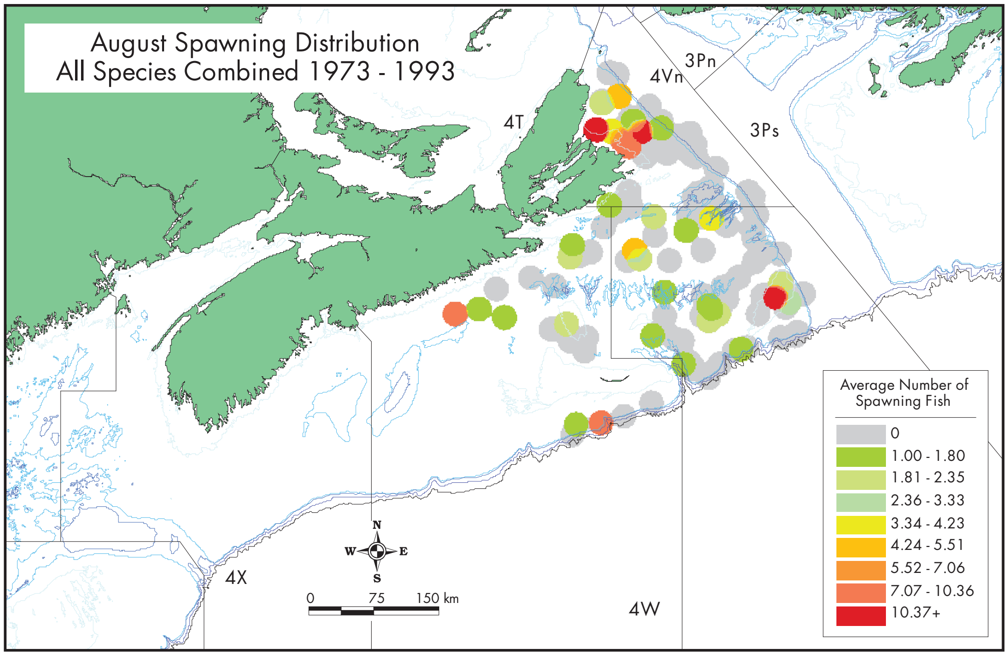

Figure 10 g.
September spawning distribution of all species combined, 1980 - 1982. The 0 class represents survey sets where no fish were caught.

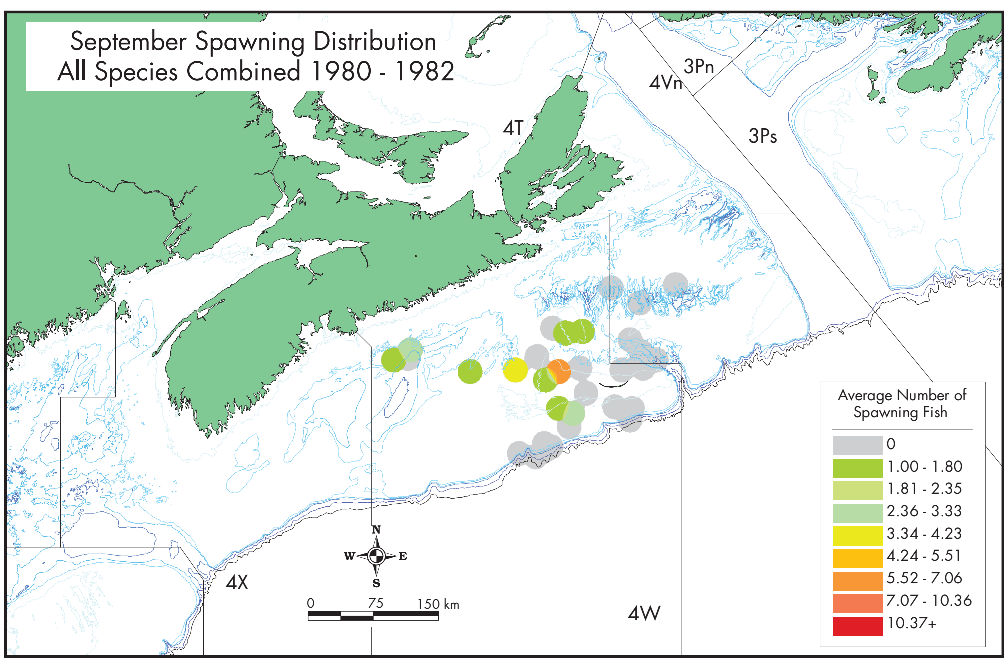

Figure 10 h.
October spawning distribution of all species combined, 1979 - 1986. The 0 class represents survey sets where no fish were caught.

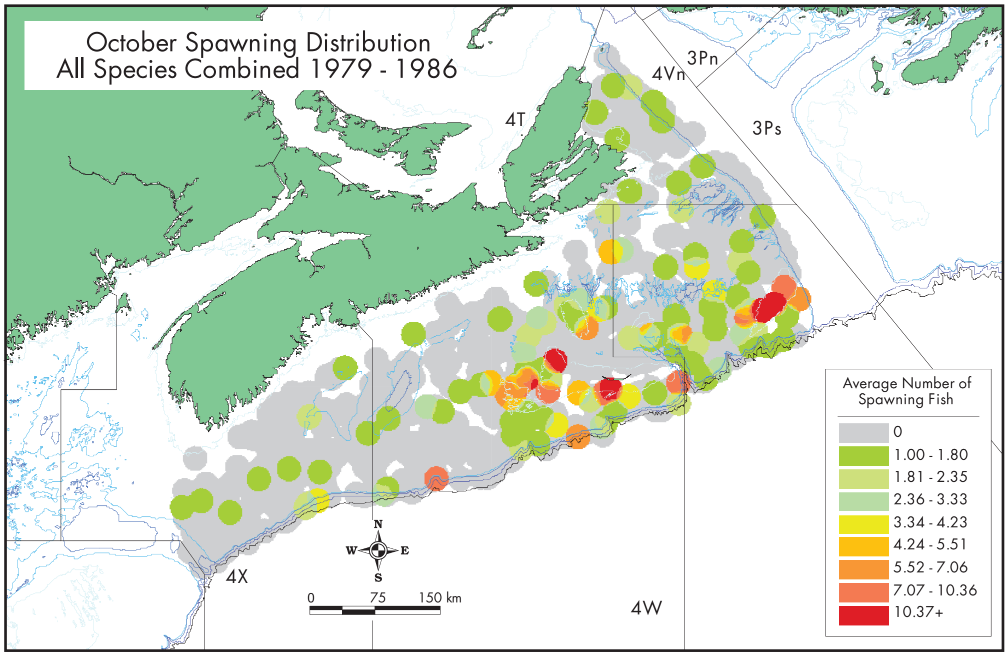

Figure 10 i.
November spawning distribution of all species combined, 1978 - 1984. The 0 class represents survey sets where no fish were caught.

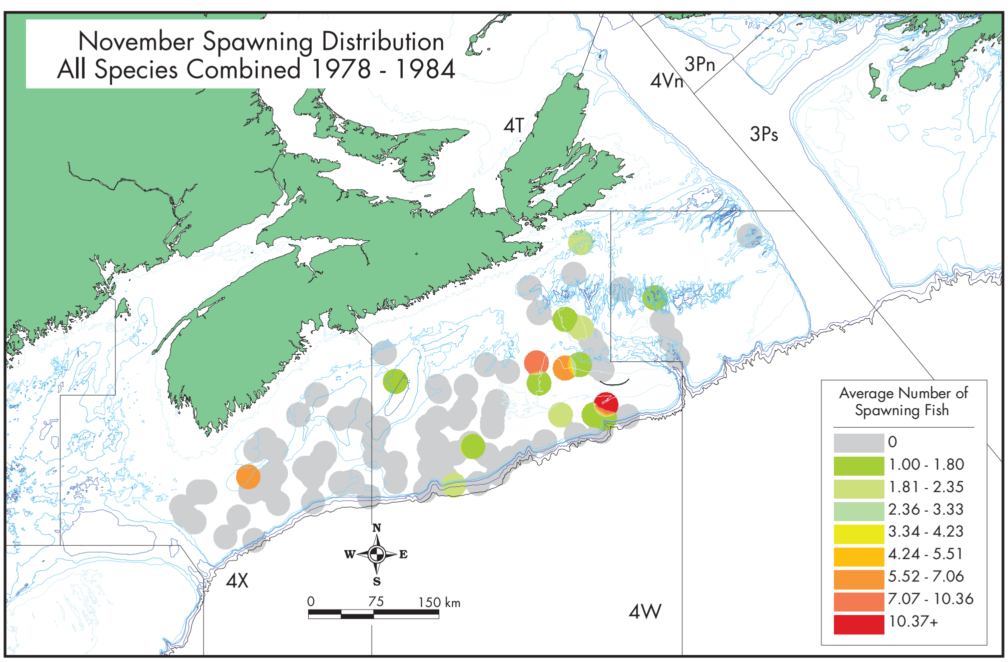

Figure 10 j.
December spawning distribution of all species combined, 1978. The 0 class represents survey sets where no fish were caught.