Spatial Analysis of 18 Demersal Species in Relation to Petroleum Licence Areas on the Grand Bank (1980-2000)

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2003

Canadian Technical Report of Fisheries and Aquatic Sciences 2473

Fisheries and Oceans Canada Pêches et Océans Canada

Canada

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Fisheries and Aquatic Sciences 2473

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Cat. No. Fs 97-6/2473E ISSN 1488-5379

Correct citation for this publication:

Kulka, D.W., Antle, N.C., and Simms, J.M. 2003. Spatial analysis of 18 demersal species in relation to petroleum licence areas on the Grand Bank (1980-2000). Can. Tech. Rep. Fish. Aquat. Sci. 2473: xix + 182 p.

Table of Contents

List of Tables

List of Figures

List of Abbreviations

bopd	barrels of oil per day
C-NOPB	Canada-Newfoundland Offshore Petroleum Board
DFO	Department of Fisheries and Oceans
GIS	Geographic Information System
MPA	Marine Protected Area
NAFO	Northwest Atlantic Fisheries Organization
SDL	Significant Discovery License
PL	Production Licence
EL	Exploration Licence
COSEWIC	Committee on the Status of Endangered Wildlife in Canada
NGBA	Northeast Grand Bank Area
SWBA	South Whale Bank Area

ABSTRACT

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Through the *Oceans Act,* the Government of Canada has expressed the necessity for an integrated approach in managing ocean activities. One of the legislated initiatives identified by the Act is the Marine Protected Areas (MPA) program. This program was designed to conserve and protect marine areas that require special protection for reasons specified under the *Act*. As listed in Section 35 (d), the Department of Fisheries and Oceans (DFO) is responsible for protecting commercial and non-commercial fishery resources including their habitats. One method of identifying such areas is to analyze species distribution. This study focuses on 18 commercial or common demersal species found throughout the Grand Bank area off Newfoundland and Labrador. Catch rates (weight/tow) collected by DFO scientific surveys conducted from 1980 to 2000 were used for the basis of this study. The point data were converted to a continuous surface representing species distribution using SPANS Potential Mapping procedure. Maps were generated to depict species abundance in relation to petroleum licence areas. In addition to the production of maps, proportion of biomass contained within these areas was calculated using the SPANdex method. The results of this study can be used by government, industry and other interested parties for planning and management of the Grand Bank marine ecosystem.

RÉSUMÉ

Kulka, D.W., Antle, N.C., and Simms, J.M. 2003. Spatial analysis of 18 demersal species in relation to petroleum licence areas on the Grand Bank (1980-2000). Can. Tech. Rep. Fish. Aquat. Sci. 2473: xix + 182 p.

Par l’entremise de la *Loi sur les océans,* le gouvernement du Canada a établi la nécessité d’adopter une approche intégrée dans la gestion des activités océaniques. Le programme des Zones de protection marines (ZPM) est une des initiatives prévues par la loi. Il a pour but de conserver et de protéger les zones marines qui nécessitent une protection particulière pour une des raisons décrites dans la loi. Tel qu’indiqué au paragraphe 35 d) de la loi, le ministère des Pêches et des Océans (MPO) est responsable de la protection des ressources halieutiques commerciales et non commerciales, ainsi que de leurs habitats. Un des moyens de déterminer quelles sont les zones à protéger consiste à analyser la distribution des espèces qu’on y trouve. La présente étude porte sur 18 espèces benthiques commerciales ou communes présentes sur l’ensemble du Grand Banc, au large de Terre-Neuve et du Labrador. Les taux de prises (poids/trait) obtenus lors des relevés scientifiques réalisés par le MPO de 1980 à 2000 ont servi de base à cette étude. Les données ponctuelles ont été converties et appliquées à une surface continue représentant la distribution des espèces, en suivant les modalités d’établissement de cartes de potentiels SPANS. Des cartes représentant l’abondance des espèces par rapport aux zones faisant l’objet de licences pétrolières ont été produites. De plus, on a calculé la biomasse présente dans ces zones au moyen de la méthode SPANdex. Les résultats de cette étude peuvent être utilisés par le gouvernement, l’industrie et les autres parties concernées pour planifier et gérer l’écosystème marin du Grand Banc.

INTRODUCTION

The Grand Bank (280,000 km^2) is an extension of the continental shelf located southeast of Newfoundland and Labrador that constitutes 26% of the entire Canadian Atlantic Shelf (Kulka 1991). It has a long history of commercial fishery exploitation reaching back to the 1400s, with fleets coming annually from many of the fishing nations of Europe (Lear 1998). A variety of fish, in particular Atlantic cod (*Gadus morhua*), have directly or indirectly been important contributors to the economy of Newfoundland and Labrador. In addition to Atlantic cod, the Bank contains a number of diverse habitats supporting many commercially valuable species. For this reason, the Grand Bank has long been recognized for its importance to the Newfoundland fishery and commercial fisheries of other countries under the Northwest Atlantic Fisheries Organization (NAFO).

In comparison to the long standing fishing interests, the oil and gas industry is a relatively new stakeholder in the area. In 1973, hydrocarbon deposits were discovered on the northeastern Grand Bank, which led to increased exploration and development. To date, 18 significant discoveries have been made on the Grand Bank, including Hibernia discovered in 1979 and Terra Nova in 1984 (Department of Mines and Energy 2002). With Hibernia producing at 175,000 barrels of oil per day (bopd) and Terra Nova producing at 125,000 bopd, the Grand Bank has moved from a purely exploration frontier to a significant production phase (Department of Mines and Energy 2002).

Since its commencement, the activities of the petroleum industry have continued to expand throughout Newfoundland and Labrador's offshore waters. Kulka (1991) first illustrated commercial fishing activity in relation to significant oil discovery areas on the northern part of the Grand Bank. The Canada-Newfoundland Offshore Petroleum Board (C-NOPB), a joint federal-provincial regulatory agency formed under the Atlantic Accord, manages the activities of the petroleum industry in Newfoundland and Labrador's offshore area. Currently, about 4.8 million hectares are held under licence in the province's offshore area of which about 4.0 million hectares are located on the Grand Bank (Figure 1, Department of Mines and Energy 2002).

The *Oceans Act,* passed in 1997*,* recognizes the need for integrated management of Canada's ocean resources (Government of Canada 2002). The Act calls for the Department of Fisheries and Oceans (DFO) to lead and facilitate the development of Canada's Ocean Strategy in order to achieve sustainable economic development. One initiative devised under this legislation, to enhance conservation efforts, is the Marine Protected Areas (MPA) program. This program was created to guide DFO in the establishment and management of MPAs (Department of Fisheries and Oceans 1999).

The *Oceans Act* defines a MPA as: *an area of the sea that forms part of the internal waters of Canada, the territorial sea of Canada or the exclusive economic zone of Canada and has been designated under this section for the special protection for one or more of the following reasons:*

- *the conservation and protection of commercial and non-commercial fishery resources, including marine mammals, and their habitats;*

- *the conservation and protection of endangered or threatened marine species, and their habitats;*
- *the conservation and protection of unique habitats;*
- *the conservation and protection of marine areas with high biodiversity or biological productivity; and*
- *the conservation and protection of any other marine resource or habitat as is necessary to fulfill the mandate of the Minster.*

The definition of species distribution, diversity and abundance is of paramount importance for the planning, management and conservation of fish resources (von Westernhagen et al. 2002; Sielfeld et al. 1995; Tremblay 1997). There have been several studies identifying demersal fish distributions on the continental shelf off Newfoundland and Labrador (Mahon et al. 1998; Mahon and Sandeman 1985; Gomes et al. 1992,1995; Guadalupe Villagarcia 1995; Kulka and Simpson 2002; Simon et al. 2002), but none except Kulka (1991) in relation to petroleum industry activities.

A number of commercially valuable species, namely Yellowtail flounder (*Limanda ferruginea*), Redfish (*Sebastes spp)*, Haddock *(Melanogrammus aeglefinus)*, Atlantic halibut *(Hippoglossus hippoglossus)*, Lumpfish *(Cyclopterus lumpus),* Monkfish *(Lophius americanus),* Pollock *(Pollachius virens),* Roughhead grenadier *(Macrourus berglax),* Roundnose grenadier *(Coryphaenoides rupestris),* Thorny skate *(Amblyraja radiata),* Greenland halibut *(Reinhardtius hippoglossoides),* White hake *(Urophycis tenuis)* and Witch flounder *(Glyptocephalus cynoglossus)* are found on the Grand Bank. American plaice *(Hippoglossoides platessoides)* and Atlantic cod, once key commercial species on the Grand Bank are currently under moratorium. Because of their value, or potential value, these species were chosen for the study. In addition to the commercially valuable species named above, several other fish species were chosen based on current or potential listing by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC); Cusk *(Brosme brosme)*, Spotted wolffish *(Anarhichas minor)* and Striped wolffish *(A. lupus)*.

Thus, the purpose of this study is to analyse the distribution of these 18 demersal fish species from 1980-2000 in relation to petroleum licence areas. The time series was extended back to 1980 because many of the species have undergone significant distributional changes. The historical data may be of use in predicting how some of the depleted species may recover. This analysis can also aid DFO in identifying potential MPAs in the Grand Bank area. Species concentrations can be an important indicator of key habitats such as spawning, feeding and rearing areas (e.g. biologically productive areas). This can be of particular importance if the species has been concentrated in the same area throughout the 21-year time frame. Historical DFO scientific surveys, conducted during spring and fall of each year, were used to map species distributions.

METHODS

For the purpose of this report, the study area includes the Grand Bank and Whale Bank extending to the edge of the continental shelf (the Grand Banks comprise Grand, Whale, and St. Pierre Bank). Distributions are also shown for the surrounding areas, the southern extent of the

Northeast Newfoundland Shelf to the north, the Flemish Pass and Cap to the east (the Cap was not sampled in all years), sections of the Northeast Newfoundland Shelf, and Laurentian Channel (Figure 2).

Each year during spring and fall, DFO conducts scientific surveys in the waters off Newfoundland and Labrador. Various data are collected including the location of each set and the associated catch rate (standardized weight/tow) for each species caught. Surveys conducted within the study area from 1980 to 2000 were used to generate distribution maps and indices of abundance for the 18 species (Table 1).

In the fall of 1995, the Campelen 1800 bottom trawl was introduced, replacing the Engels 145 that had been used during the previous surveys. As a result, the survey catch rates are not comparable between the two time series. As well, deeper sets were added to the surveys after 1993. Deeper distributed species, therefore, are better represented in the later years and apparent increases in extent of those species are in part or wholly due to the extended sampling area.

Simply mapping the catch rates, such as expanding symbol plots, can provide reasonable representation of local fish densities. However, to acquire reliable indices of abundance, a spatial element is required (Kulka 1998b). Thus, a continuous surface representing species abundance was interpolated from the point data using the Potential Mapping procedure, a Geographical Information System (GIS) technique in SPANS. This method also provides a better spatial visualization of the distribution of the species. The categorized survey data containing a catch per tow (kg) for each species were imported into SPANS using the latitude and longitude values of each set as the geo-reference.

Potential Mapping is a technique well suited to analyzing ratio point data representing a non-continuous phenomenon, such as catch rate (Kulka 1998a). The procedure creates a continuous surface from point data using an averaging technique in which circles are created around each point. Averaging occurs on values within each circle and again where circles intersect. The user can control the number of values included in the averaging through the Maximum Neighbours option in order to exclude points at the periphery. For this study, a value of 100 was used to ensure the inclusion of all values within each circle. The averaged values are then assigned to an underlying grid data structure of variable sized cells or rasters called a quadtree (Burke 1997). The value assigned to each individual quad cell depends on the value of each point whose sampling radius overlaps the center of that quad cell (Figure 3) (refer to Kulka 1998a for a description of quad cells).

On average, the survey sets are about 18 km apart. The aim in producing the distribution surfaces is to fully cover the survey area. Surface coverage depends upon the size of the circle sampling radius, defined by the users. The aim is to find the smallest possible radius (for best spatial definition of fish density) that will cover the surface (extend the surface to cover all the area between survey set locations). To determine the data set on which to base the circle size, comparisons were made on the quantity and distribution of sampling during each 3-year period. Containing an average number of sets in varying proximity to each other, fall survey data from 1980 to 1982 were selected to sample various radii. With varying distances between sampling points, it was possible to test for a scanning circle size that would be appropriate for both densely and sparsely sampled areas. A sample radius of 30 km was determined to be the lowest value creating a surface with minimal gaps.

The area of the circle placed around each data point (survey set) takes on the value of the point in kg per tow. Once the circles have been applied all the data points, the result are numerous crescents resulting from the intersection of the circles that have been imposed around each data point. Each crescent is the averaged values of the intersecting circles. The values of those crescents are then assigned to an underlying grid referred to as a quadtree. Quadding is a procedure that first splits the study area into four equal rectangles. If within a rectangle all values are equal then that rectangle or grid cell is assigned the value of the circle area. If there is more than one value (usually the case unless there are no data within that rectangle) then that rectangle is further divided into four rectangles. The quad level, indicating the number of times a cell can be subdivided, determines the resolution of the surface area. The higher the quad level the smaller the size of the smallest quad cell, thus the higher the resolution (Burke 1997). Therefore, the maximum quad level of 15, yielding the smallest quad cell size of .05 km^2, was used to achieve the highest resolution. As a result, each scanning circle is more than 55,000 times larger than the smallest quad cell size. According to Kulka (1998a), it is common for fisheries applications to use a scanning circle size that is much larger than the quad cell size.

When creating the species distribution maps, a user-defined legend was created to group the grid cells. These groups of cells show as different colours representing different values. A single legend is set for a baseline year for each species and is used across all years to show inter-annual variation (Kulka 1998a). Thus, 18 legends were created to represent each of the species throughout the 21-year period. All legends were devised using 15 equal area density strata, the same format to be used for SPANdex, the method used to estimate relative biomass for each species (see below). To smooth the surface transition from one density strata to another, a linear decay function was applied to the Potential Mapping process, effectively giving points on the periphery of the scanning circles less weight in the averaging function. This does not change patterns of distribution other than smoothing the result.

Using the method described above, maps depicting species distribution and abundance throughout the study area were generated separately for spring and fall. To reduce the volume of maps produced, the spring and fall surveys were grouped into intervals of three years, except the data collected in spring 1995 (introduction of Campelen trawl) which were grouped with other Campelen years. This grouping of years assumes similar distributions within those year groups. To maintain groups of data standardized to the same gear type, spring 1995 data were grouped with spring data from 1992 to 1994. Boundary lines defining areas held under petroleum licences, including Exploration Licences (EL), Production Licences (PL) and Significant Discovery Licences (SDL), were overlaid on the species distribution maps to define the spatial relationship between petroleum industry activities and species distribution.

After completion, each density surface, depicting areas of varying values of survey kg per tow, was overlaid on a map template showing the study area with bathymetry contours, and areas associated with petroleum activities (e.g. areas held under licence or areas represented by the C-NOPB 2001 Call for Bids) (Figure 4). Each map was then exported from SPANS as a Windows metafile and imported into Corel Draw to add a frame, species name and year. These metafiles were then converted to JPEG (.jpg) format to reduce the file size

Relative biomass estimates (Kulka et al. 2002) were calculated for each species and year combination using the SPANdex method (Kulka 1998a), an areal expansion method using Potential Mapping in SPANS. This method is well suited to survey data since using observed fish density as the strata potentially reduces within strata variability of density. The density strata are allowed to vary according to changes in species extent and distribution (post stratification of the data based on catch rates).

For each of the 15 density classes, the area and mean catch rate (in kg), based on all points within the stratum, were calculated and incorporated into Equation 1 to calculate biomass estimates.

Equation 1. SPANdex formula for biomass estimation (Kulka 1998a)

$$B = \sum_{n} \{(axc)/[(txw)/h]\}$$

Where B= biomass index (kg)
n= number of catch rate classes (strata)
a= area of catch rate class (km^2)
c= mean of catch rate class (kg/hr)
t= average tow length (km)
w= wingspread of net (km)
h= average number of hours per tow

Using Equation 1 above, biomass estimates were calculated for each species for the study area as a whole, and for any portion of a species residing within the petroleum licence areas.

In SPANS, a basemap can be used to limit the processing of information to a specified area of interest (Burke 1997). A basemap is a binary surface with only two classes, 1 and 0. Areas to be included in the processing are represented by class 1 and those to be excluded are defined by class 0. To restrict the extents of all surfaces to the same area, a basemap cut was used to allow processing to only occur between the land and the 2000-meter depth bathymetry line. The areas represented by the C-NOPB 2001 Call for Bids were used to define the boundary of areas currently held under licence by the petroleum industry (Figure 5). Due to the scale used in this study, the outline of the licence areas was used to create a boundary to represent areas of interest to the petroleum industry (Figure 5). This resulted in two main clusters, Northeast Grand Bank Area (NGBA) and South Whale Bank Area (SWBA).

To calculate biomass estimates for subsections of the study area (proportion biomass inside vs. outside the licence areas), different basemap cuts were applied. By using a basemap cut, it was possible to recalculate the area of each catch rate class based only on the surface residing within the defined sections. Two basemaps were created, one for the NGBA and another for the SWBA. To determine proportion of biomass occurring within the NGBA and SWBA versus the total area, a cookie cutting technique was applied to exclude biomass outside of these petroleum licence areas. The ratio of the species biomass within the petroleum licence areas compared to the full extent of the survey biomass illustrates species abundance within these areas.

RESULTS

SPATIAL ABUNDANCE

In total, 252 maps were produced from this study. They show the abundance and distribution of 18 different species throughout spring and fall from 1980 to 2000. Each map depicts a surface density based on the combined survey catch rates collected over a 3-year period.

SURVEY COVERAGE

Variation in the geographic location of sampling throughout the 21-year period should be noted when reading the analysis of each species. Differences occurred both within and between the spring and fall time frames.

SPRING SAMPLING

During spring, the geographic coverage of survey sampling was relatively consistent extending from the northern Grand Bank to the Tail, and from the Nose to the Laurentian Channel west of the study area boundary (Figure 2). During spring surveys, the Flemish Cap was excluded. It should also be noted that after 1992, both shallow and deep strata were added.

FALL SAMPLING

Throughout fall, areas sampled varied significantly in the 21-year study period. From 1980-82, sampling occurred from the Labrador Shelf to the Tail of the Grand Bank and included the Flemish Cap. For the 1983-85 interval, sampling occurred from the Labrador Shelf to just north of the Southeast Shoal of the Grand Bank, and included the Nose of the Bank and the Flemish Cap. During 1986-88, there was a similar coverage area but sampling excluded the Flemish Cap. From 1989-94, sampling extended from the Labrador Shelf to the Tail of the Bank, and included the Nose of the Bank, but excluded the Flemish Cap. During 1995-97, sampling extended from the Labrador Shelf to the Tail of the Bank, and from eastern St. Pierre Bank to the Flemish Cap. Similar survey coverage occurred in the 1998-2000 interval as in the 1995-97 interval, however, no sampling occurred on the Flemish Cap.

With the exception of limited sampling that occurred in 1981, regular sampling of the southern Grand Bank began in 1990 and continued throughout the remaining time frame of the study. The Flemish Cap was surveyed up to 1985 and again in 1996-97. In addition, sampling occurred in the Flemish Pass between the Nose of the Grand Bank and Flemish Cap from 1996 onwards. Also, after 1995, both shallow (nearshore) and deep strata were added.

SPECIES SUMMARIES

Atlantic cod (*Gadus morhua*)

Cod are widely distributed throughout the surveyed area during both spring and fall. The main areas of concentration are the northeast slope of the Grand Bank (fall), the central portion of the Grand Bank including the Virgin Rocks and the upper Southwest Slope of the Grand Bank (spring and fall). Both spring and fall surveys indicate a dramatic reduction in the density and extent of distribution of cod starting in the late 1980's and continuing until the late 1990's. The northeast Bank concentration is largely absent after the early 1990's. The remnant high density area is located along the Southwest Slope of the Grand Bank. A slight recovery from 1998-2000 can be noticed in both spring and fall maps. Throughout the late 1980's, cod appear to be highly concentrated along the northeast edge of the Bank and within the southern portion of the Bank during fall surveys. During spring, however, abundance is greatest along the Southwest Slope of the Bank. Refer to Figures 6a-d and 7a-d.

Cusk *(Brosme brosme)*

Cusk are rarely encountered within the study area and are located sporadically throughout the Flemish Cap, and around the Nose and Southwest Slope of the Grand Bank. There are no apparent distributional changes, Cusk being rare or absent in all years within the study area. Refer to Figures 8a-d and 9a-d.

Haddock *(Melanogrammus aeglefinus)*

Haddock are found primarily within the southern part of the Grand Bank along the Laurentian Channel slope, with high concentrations along the Southwest Slope of the Grand Bank. Spring catch rate values indicate a declining pattern in abundance beginning in the late 1980's and continuing until the late 1990's. Fall surveys also indicate a decrease in abundance throughout the early and mid 1990's. Both seasons show signs of recovery from 1998 to 2000. Overall, there is a greater presence of Haddock throughout spring. Refer to Figures 10a-d and 11a-d.

Atlantic halibut *(Hippoglossus hippoglossus)*

Atlantic halibut have a patchy distribution throughout the Grand Bank, Flemish Cap and Northeast Newfoundland Shelf, the main concentrations are along the Southwest Slope of the Grand Bank and along the Laurentian Channel slope during spring. This species also concentrates west of the Southeast Shoal on the centre of the Bank. A decreasing trend is apparent, starting in the mid 1980's and continuing until the late 1990's. From 1998 to 2000, there appears to be a slight increase in abundance. Similarly, fall surveys indicate a decreasing trend throughout the 1990's; however, there is no apparent recovery. The concentration west of the Southeast Shoal is absent in later years. Overall, Atlantic halibut are more prominent during spring within the study area. Refer to Figures 12a-d and 13a-d.

Lumpfish *(Cyclopterus lumpus)*

Lumpfish are distributed throughout the study area with sporadic catches mainly in the northern and southern sections of the Grand Bank. The greatest concentration occurs west of the study area on the St. Pierre Bank, particularly in spring. The greatest concentration in fall is on the northwest part of the Grand Bank, suggesting movements to the north between spring and fall. With the exception of a slight decline in abundance in the early 1990's, there is an increasing trend in the density of Lumpfish in fall. Up until the early 1990's, this increasing trend can be seen throughout the northern Grand Bank. After 1991, there is an apparent expansion of high concentrations south along the coastline of Newfoundland, but this may be due in part or entirely to the increased sampling in shallow waters during that period. Throughout spring, however, high concentrations appear along the Laurentian Channel slope extending eastwards toward the Whale Bank. Throughout the 1990's, there is a noticeable decrease in abundance followed by a slight increase from 1998-2000. Due to differences of survey coverage between spring and fall, the distribution of Lumpfish along the Laurentian Channel slope in fall and likewise, the distribution over the Northeast Newfoundland Shelf in spring, is unclear. Refer to Figures 14a-d and 15a-d.

Monkfish *(Lophius americanus)*

Monkfish are located almost exclusively along the Southwest Slope of the Grand Bank and within the Laurentian Channel. Abundance appears to fluctuate over time during spring and fall. The early 1990's indicate a decrease in catch rate values, which is followed by an increase during the mid 1990's, followed again by a decrease during 1998-2000. Overall, higher concentrations were noted in spring. Refer to Figures 16a-d and 17a-d.

American plaice *(Hippoglossoides platessoides)*

American plaice are distributed throughout the survey area with high concentrations throughout the northern and southern portions of the Grand Bank. They form some of the most dense and extensive concentrations within the study area in the earlier years. Both spring and fall maps indicate a drop in density during the late 1980's and early 1990's with a significant drop after 1991, although the area occupied by the species remained unchanged. As well, both spring and fall values indicate a continual increase in abundance after the Campelen trawl was introduced (fall 1995). An area of higher density appears to be returning to the Tail of the Bank since the mid to late 1990's. A similar recovery is not occurring elsewhere. Refer to Figures 18a-d and 19a-d.

Pollock *(Pollachius virens)*

During fall, Pollock are sparsely distributed along the southern edge of the Grand Bank with no apparent pattern. During spring, however, high concentrations are found along the southwest edge of the Bank and along the Laurentian Channel slope. A decreasing trend in abundance is apparent, starting in the early 1990's and continuing until the late 1990's (spring) with a noticeable drop after 1991. From 1998 to 2000, there is a slight increase in density and but not extent, apparent in spring to the west. Overall, concentrations and abundance are much higher during spring. Refer to Figures 20a-d and 21a-d.

Redfish *(Sebastes spp.)*

The maps indicate that Redfish are primarily located on the outer edge of the Northeast Newfoundland Shelf, the Flemish Cap and along the Laurentian Channel slope. As for other parts of the survey area, Redfish distribution is patchy and variable. Until the late 1990's, when a slight increase occurred (apparent in fall), there has been a continuing decline in the distribution of Redfish. Refer to Figures 22a-d and 23a-d.

Roughhead grenadier *(Macrourus berglax)*

Roughhead grenadier, a deepwater species, are located on the slope of the Northeast Newfoundland Shelf and along the edges of the Grand Bank and Flemish Cap. Roughhead grenadier are highly concentrated in the Flemish Pass between the Nose of the Bank and the Flemish Cap, and extend along the edges of the northeast portion of the Bank. Both the spring and fall maps show a decline in density and distribution through the late 1980's and early 1990's, especially on the slope of the Northeast Newfoundland Shelf in fall. After the Campelen trawl was introduced (fall 1995), an apparent continual increase in density is observed for both survey seasons. However, survey sampling was progressively deeper after 1993, resulting in a greater overlap with the species. Thus, these apparent increases are largely due to the increase in deepwater sampling where the survey area increasingly overlaps the distribution of this deepwater species. In fall, high concentrations are evident in the Flemish Pass after 1995 but due to changing survey coverage to deeper areas, patterns within this area are unclear. Overall, fall surveys appear to contain higher concentrations than spring. This is due to a greater proportion of deep sets prosecuted in fall rather than a movement into the surveyed area. Refer to Figures 24a-d and 25a-d.

Roundnose grenadier *(Coryphaenoides rupestris)*

Much like Roughhead grenadier, Roundnose grenadier are located on the edges of the Northeast Newfoundland Shelf, and throughout the 1980's, were sporadically located along the edges of the Grand Bank. From the late 1980's onward, there appears to be an increasing trend in abundance for both spring and fall. Starting in 1993, deep strata were incrementally added to survey. Thus, as for Roughhead grenadier, these apparent increases are largely due to the increase in deepwater sampling where the survey area overlaps the distribution of this deep water species over time. During fall, a major increase in abundance is present from 1995 onward. High concentrations first occur along the northeast slope and between the Flemish Cap and Nose of the Grand Bank due to the increasingly deeper sampling. Such high densities extend along the southeast and southwest slopes of the Bank. However, during spring, higher concentrations appear to be initially developing along the Southwest Slope of the Bank. Refer to Figures 26a-d and 27a-d.

Thorny skate *(Amblyraja radiata)*

Thorny skate are widely distributed throughout the survey area during both spring and fall. They tended to be distributed closer to the shelf edge eastward during spring and between the Southeast Shoal and Whale Bank during fall. Both spring and fall series indicate an increasing reduction in density of Thorny skate during the late 1980's and early 1990's in the northern part of their distribution. In recent surveys, the geographic concentrations of skate during spring and fall surveys vary slightly, with spring concentrations primarily along the Southwest Slope and edges of the Grand Bank, and fall concentrations throughout the Tail of the Grand Bank, especially over the Southeast Shoal. Refer to Figures 28a-d and 29a-d.

Spotted wolffish *(Anarhichas minor)*

Spotted wolffish are located primarily on the Northeast Newfoundland Shelf, the Flemish Cap and along the north and east edges of the Grand Bank with sporadic catches along the Southwest Slope. Starting in the late 1980's and continuing into the mid 1990's, the Spotted wolffish underwent a decline in abundance reflected in both spring and fall distributions. Since the mid 1990's, there has been an apparent increase in abundance during spring and fall. Refer to Figures 30a-d and 31a-d.

Striped wolffish *(Anarchichas lupus)*

Striped wolffish are generally located throughout the northern and southern portions of the survey area with high concentrations occurring on the Northeast Newfoundland Shelf, and extending along the northern edge of the Grand Bank. The densest concentration of Striped wolffish occurred on the south central part of the Grand Bank (unlike Spotted wolffish). Striped wolffish, like many other species, began to decline in the late 1980's and continued to do so into the late 1990's at which point catch rate values started to increase. High concentrations of Striped wolffish occurred over the Flemish Cap from 1995 to 1997, as identified from fall surveys, but due to the differences in survey coverage of this area, the pattern of distribution is unclear. Refer to Figures 32a-d and 33a-d.

Greenland halibut *(Reinhardtius hippoglossoides)*

Greenland halibut are concentrated mainly along the northeast edge of the Grand Bank and the slope of the Northeast Newfoundland Shelf. However, the distribution of Greenland halibut also extends into the Flemish Pass area and along the southeast and southwest slopes of the Grand Bank, and continuing into the Laurentian Channel. Both spring and fall surveys identify a drop in abundance during the late 1980's and early 1990's with an increase after the introduction of the Campelen trawl (Fall 1995). Refer to Figures 34a-d and 35a-d.

White hake *(Urophycis tenuis)*

Spring and fall research surveys indicate that White hake were primarily caught along the Southwest Slope of the Grand Bank and along the Laurentian Channel slope. After the Campelen trawl was introduced in fall of 1995, there appears to be an increase in abundance in an easterly direction over the Tail of the Grand Bank. This expansion, although noticeable during spring and fall, is most identifiable in fall from 1995 onwards. In addition, the presence of White hake in the spring appears to be slightly higher than in fall. Refer to Figures 36a-d and 37a-d.

Witch flounder *(Glyptocephalus cynoglossus)*

Witch flounder are distributed mainly on the periphery of the Grand Bank with some distribution towards the inner portion of the Bank to the southwest in fall. Concentrations are found along the northeast edge of the Grand Bank extending to the south and along the Southwest Slope of the Grand Bank and extending into the Laurentian Channel. Witch flounder experienced a decline in abundance in the late 1980's and early 1990's with the most noticeable decline occurring in fall on the Southwest Slope. Since the introduction of the Campelen trawl (Fall 1995), there has been a slight increase in abundance of Witch flounder (possibly a gear affect) and spring surveys show an increase in abundance eastwards of the Laurentian Channel. Refer to Figures 38a-d and 39a-d.

Yellowtail flounder *(Limanda ferruginea)*

This is the most shallowly distributed of all the species examined and are largely found at depths < 100 m in the middle of the Grand Bank. There are two main concentrations of Yellowtail flounder, along the Laurentian Channel slope and the Tail of the Grand Bank extending northwards, the latter being the greater of the two. There appears to be little difference in distribution between the seasons. The spring surveys identify a decreasing trend in abundance during the late 1980's and early 1990's followed by an increasing trend thereafter. Due to differences in survey coverage throughout fall, the pattern of Yellowtail flounder throughout the 1980's is unclear. However, fall surveys do identify an increasing trend in abundance starting in the early 1990's and continuing forward. Refer to Figures 40a-d and 41a-d.

BIOMASS PROPORTIONS

The graphs (and associated tables) displayed in Figures 42 - 59 show trends in proportion of biomass of the 18 species analyzed in relation to the petroleum licence areas NGBA and SWBA. Values are based on 3-year averages. Extreme high or low values (large differences from one year to the next) do not necessarily mean large shifts in or out of the licence areas. They are more likely due to anomalously large catches occurring inside or outside these areas. No sampling occurred from 1980-88 during fall surveys in the SWBA for any species.

Atlantic cod *(Gadus morhua)*

In fall, proportion of Atlantic cod biomass found within the SWBA increased from near zero in the late 1980's, to about 2% in 1998-2000. A much larger proportion of biomass was observed in that area in spring, ranging from 1% in 1980-1982 to about 6% in 1998-2000. The large value observed in spring in the SWBA was due to a single large capture. On the other hand, proportion of cod biomass found within the NGBA declined over time from about 2-5% in the early 1980's to a low of less than 1% in 1995-97. Thus, neither area contained a large proportion of the total biomass of cod within the study area at any time, although high densities of cod were found within the SWBA in some years. Proportion of biomass within the area was small because cod are widespread (Figure 42).

Cusk *(Brosme brosme)*

Cusk, a species that is at the northern fringe of its range on the Grand Bank, was found only in very small amounts and proportions in the licence areas. During the period 1980-91, survey results did not reveal any trace of Cusk on the NGBA or in the SWBA. Small amounts were recorded in the SWBA after 1994. A large value observed in fall 1995(6)-97 was due to a single large capture (Figure 43).

Haddock *(Melanogrammus aeglefinus)*

A significant proportion of the Haddock biomass was present in the SWBA during spring surveys for the entire 21-year period, showing a general increase over time. Biomass estimates ranged from approximately 19-48%. During fall surveys in the SWBA, proportion of Haddock biomass ranged from 28-88%, peaking at ~88% in 1998-2000. Haddock were virtually absent from the NGBA during both fall and spring surveys (Figure 44).

Atlantic halibut *(Hippoglossus hippoglossus)*

The presence of Atlantic halibut is fairly consistent in the SWBA during spring and fall surveys for the 21-year period. Biomass estimates peak at 40% during fall throughout the 1995(6)-97 year interval, and at about 24% during spring throughout the 1989-91 year interval. In the NGBA, the presence of halibut is low, less than 3% during fall and spring throughout the 21-year period (Figure 45).

Lumpfish *(Cyclopterus lumpus)*

Lumpfish biomass estimates are greatest in the NGBA during fall surveys. Aside from an anomolously high value in 1983-85, proportion of biomass in the NGBA peaked at almost 4% in 1992-95 falling to near zero in 1998-2000. A large value observed in the NGBA in fall 1983-85 was due to single large capture. After 1986, estimates remain below 5%. During spring surveys on the NGBA, biomass estimates never increase above 0.4%. Fall survey results in the SWBA range from 0.3-0.5%. Lumpfish biomass peaks at 3.9% during the 1992-94(5) interval and drops to 0% from 1995 onward (Figure 46).

Monkfish *(Lophius americanus)*

During the 21-year period, Monkfish are consistently present in the SWBA and surrounding areas. However, Monkfish do not occur in the NGBA during spring or fall surveys. A greater proportion of the biomass occurred in SWBA during fall. Fall survey results show biomass estimates peaking at approximately 54% during the 1995(6)-97 interval. Spring survey results peak at about 32% during the 1983-85 interval (Figure 47).

American plaice *(Hippoglossoides platessoides)*

American plaice are widely distributed throughout the study area, which includes the northern and southern portions of the Grand Bank. Consistently high concentrations of American plaice occur in spring and fall throughout the northern portion of the Grand Bank, with proportion of biomass within the NGBA ranging from 3.5-8.8% during fall surveys and 4-7% during spring surveys. In fall, proportions were slightly lower in recent years. Spring survey results showed a steady increase in American plaice from 1980 up to the mid 1990's in the SWBA. As well, for years in which the SWBA was sampled during fall surveys, a consistent proportion of American plaice was present (Figure 48).

Pollock *(Pollachius virens)*

Pollock are virtually nonexistent in the NGBA during spring and fall surveys. However, they occurred sporadically in SWBA. During spring, biomass values in SWBA ranged from approximately 0.1-16%. A value of approximately 39% was observed in SWBA in fall 1992-94(5). There are some instances where Pollock occur just north of the Tail of the Grand Bank, however, the most predominant habitat for Pollock within the study area is along the Southwest Slope of the Grand Bank and along the Laurentian Channel, and within the SWBA. Their presence in these areas is much greater and more consistent in spring than fall (Figure 49).

Redfish *(Sebastes spp.)*

Redfish are concentrated along the eastern sections of the NGBA, on the Flemish Cap and along the Southwest Slope of the Grand Bank. However, Redfish are semi-pelagic and undergo substantial movement causing significant inter-annual variation in proportion of biomass inside the petroleum licence areas. For the NGBA, proportion of biomass reached 7.2% during fall for the period 1992-94(5) but remained below 1% for all other years. Biomass estimations on the Grand Bank during spring surveys were sporadic throughout the 21-year period, ranging from 0-31%. Redfish were viturally absent from the SWBA during spring and fall surveys for the 21-year study period, with much of the biomass falling just outside the area (Figure 50).

Roughhead grenadier *(Macrourus berglax)*

The presence of Roughhead grenadier is very minor in the SWBA throughout the 21-year period. Proportion of biomass within the SWBA did not rise above 0.9% during spring surveys and never above 0.4% during fall surveys. Roughhead grenadier are consistently present during fall and spring surveys in the NGBA. Proportion of biomass for fall surveys range from approximately 6-22% while spring survey estimates range from about 9-23%. Nearly all of the biomass occurred in the deeper parts of the Flemish Pass (Figure 51).

Roundnose grenadier *(Coryphaenoides rupestris)*

Aside from one value, approximately 65% in 1983-85, proportion of Roundnose grenadier biomass within the NGBA did not exceed 12%. However, proportion within that area increased from the mid 1980's. During spring surveys, Roundnose grenadier are found mainly along the Tail of the Grand Bank and within the SWBA. The proportion within the SWBA increased after the mid-1980's as well (Figure 52).

Thorny skate *(Amblyraja radiata)*

Thorny skate became increasingly less dense on the northern part of the Grand Bank and increasingly more dense to the south. The NGBA has experienced a steady decline in proportion of Thorny skate biomass during both spring and fall, with highs of 13% (1983-85) in fall and 9% (1980-82) in spring, and lows of approximately 2.5% in fall (1995-97) and spring (1998-2000). Proportion of Thorny skate biomass increased after 1988 in the SWBA as observed in spring and fall and began declining starting in the mid 1990s (Figure 53).

Spotted wolffish *(Anarhichas minor)*

Proportion of Spotted wolffish biomass within the NGBA has shown a general increase over the 21-year period, from approximately 4% in the 1989-91 interval to about 16% in 1998-2000 during spring surveys. Spotted wolffish are virtually non-existent during fall surveys in the SWBA. Proportion of biomass in the SWBA was much lower than in the NGBA. In spring, Spotted wolffish reached nearly 2% (highest in 21-year study period) in the 1989-91 year interval but have decreased to 0.4% in 1998-2000 (Figure 54).

Striped wolffish *(Anarchichas lupus)*

Proportion of Striped wolffish biomass within both petroleum licence areas was more variable over time than for Spotted wolffish. Proportion of biomass in the NGBA has decreased since the early and mid-1980s. Spring survey results decreased from 9% in 1980-82 to 0.2% in 1992-94(5), with a slight increase to 1.3% in the 1995(6)-97 interval. Fall survey results indicate an increase from 1980 to 1988, from 0.7% to 5.4% respectively, and an overall decrease from 1988 to 2000, declining from 5.4% in 1986-88 to 2.1% in 1998-2000. Proportion of biomass for Striped wolffish in the SWBA ranges from 0.9-3.2% during fall surveys and 1.3-9.9% during spring surveys, with biomass increasing steadily from 1992-94(5) up to 2000 (Figure 55).

Greenland halibut *(Reinhardtius hippoglossoides)*

Proportion of Greenland halibut biomass has been consistently greater in the NGBA (adjacent areas near the Nose of the Bank) and the Flemish Cap than in the southern section and the SWBA. Proportion of biomass in the NGBA during spring surveys ranges from approximately 6-19% and 0.8-3% during fall surveys. The SWBA has consistently lower proportions of Greenland halibut biomass ranging from 0.1-0.6% during fall surveys and 0.0-1.7% during spring surveys. Greater concentrations of Greenland halibut exist in the northern sections of the Grand Bank and along the northeast coast of Newfoundland with smaller concentrations along the Southeast Shoal (Figure 56).

White hake *(Urophycis tenuis)*

White hake are virtually non-existent in the central and northern sections of the Grand Bank, including the NGBA during both spring and fall surveys. The greatest concentrations of White hake exist in the SWBA and the Tail of the Bank during fall, and the SWBA and the Laurentian Channel during spring. During fall, proportion of biomass in the SWBA ranges from 16.4-33.7%, while spring biomass estimates range from approximately 8-25% (Figure 57).

Witch flounder *(Glyptocephalus cynoglossus)*

Proportion of Witch flounder biomass is variable within the two petroleum licence areas but the proportion is consistently higher in the SWBA. There has been a consistent but smaller presence of Witch flounder within the NGBA. Fall survey results show a downward trend in proportion of biomass in the NGBA after the 1992-94(5) interval. This decline continues to the end of the study period. Biomass starts to decrease during spring surveys in NGBA after 1985. Biomass estimates range from 0.9-8% in fall and from 0.8-7% in spring for the NGBA. The Witch flounder biomass is somewhat more stable in the SWBA areas throughout the entire period. There is a strong consistent presence of Witch flounder during spring surveys in the SWBA, the Tail of the Bank and the Laurentian Channel. Proportion of biomass ranged from approximately 4-20% in fall and approximately 6-18% in spring (Figure 58).

Yellowtail flounder *(Limanda ferruginea)*

Proportion of Yellowtail flounder biomass is low within both petroleum licence areas. It has shown a steady decline in the NGBA since 1983-85 during both spring and fall. Fall survey results show that the biomass decreased to 0% in the 1989-91 interval and has remained non-existent up to 2000. Spring results were 0.1% from 1986-91 and have remained at 0% since 1992. Greater concentrations exist south of the NGBA and northeast of the SWBA. The proportion of Yellowtail flounder in SWBA (spring) has been increasing from 1989-97 with a slight decrease from 1997-2000. In fall, biomass proportions have decreased since 1989 (Figure 59).

SUMMARY

For most species, proportion of biomass inside the petroleum licence areas tended to vary the between species and areas. Those species that consistently occupied the licence areas (proportion within the area exceeded 15% in most years during spring or fall) were as follows:

Species	Area
Haddock	South Whale Bank Area
Atlantic halibut	South Whale Bank Area
Monkfish	South Whale Bank Area
White hake	South Whale Bank Area
Witch flounder	South Whale Bank Area
Roughhead grenadier	Northeast Grand Bank Area

Haddock and Monkfish had the largest proportions of their biomass occupying a petroleum licence area, namely the SWBA. For Haddock, proportion of biomass was consistently higher than 18% in the SWBA during both spring and fall. Proportions of Monkfish biomass were greatest in the fall in the SWBA, ranging from approximately 35-53% throughout the study period. To a lesser extent, Thorny skate and Pollock (SWBA) and Greenland halibut, American plaice, and Spotted and Striped wolffish (NGBA) were also found in significant amounts within the licence areas. Some other species were densely concentrated within one or both of the licence areas but the proportion of biomass within was low because they were also extensively distributed over the whole study area (e.g. Atlantic cod and American plaice). During both spring and fall on the southern and northern portions of the Grand Bank, values for American plaice indicate a continual increase in abundance after the mid-1990's. An area of higher density appears to be returning to the Tail of the Bank. As well, for years in which the SWBA was sampled during fall surveys, a consistent proportion of biomass of American plaice was present.

The presence of Atlantic halibut is fairly constant in the SWBA throughout spring and fall surveys for the 21-year period. Biomass estimates for halibut were at about 25% for the spring survey during the 1989-91 year interval and peaked at 40% for the fall survey during the 1995(6)-97 year interval. Proportion of Spotted wolffish biomass within the NGBA has shown a general increase over the 21-year period, from approximately 5% in the 1989-91 interval to almost 16% in 1998-2000 during spring surveys. Roughhead grenadier are consistently present during fall and spring surveys in the NGBA. The Witch flounder biomass is somewhat more stable in the SWBA areas throughout the entire period.

Thus, the SWBA supported a greater diversity and relative proportion of the total biomass of fish species than the NGBA. The SWBA is located on the Southwest Slope of the Grand Bank where bottom temperatures are considerably higher than to the north. The bottom temperatures there are similar to those on the Scotian Shelf, much warmer than the remainder of the Grand Bank (Colbourne and Fitzpatrick 2002). In contrast, the NGBA is located just east of an area of very cold bottom temperatures, the coldest in the Northwest Atlantic.

DISCUSSION

This mapping project has identified the spatial and temporal distribution of 18 species throughout the Grand Bank, Flemish Cap and St. Pierre Bank in relation to two petroleum licence areas. It should be noted that although the density maps produced from this study provide a general overview on the distribution and species abundance, denser sampling would be required to fully account for subtle distributional changes and small scale patterns. Currently, fall survey sets have a range of approximately 20-70 km annually (Kulka 1998a), which may be inefficient for sampling schools of fish that are smaller in width than 20 km. It should also be noted that the grouping of data into 3-year intervals is based on the assumption of little annual variation during that time.

The study revealed that the SWBA, located along the Southwest Slope of the Grand Bank, contains a greater number of species and a greater proportion of the biomass of most species. Species that had the largest proportion of their biomass occupying a licence area were Haddock and Monkfish, while other species such as Atlantic halibut, White hake, Witch flounder and Roughhead grenadier consistently occupied the two licence areas in significant numbers.

The 18 demersal fish species examined tended to fall into three general categories: widespread on the Bank (Yellowtail flounder, American plaice, Atlantic cod, Thorny skate), concentrated on the warm Southwest Slope (Monkfish, White hake, Atlantic halibut, Haddock and Pollock) and distributed along slope waters (Roundnose and Roughhead grenadier, Greenland halibut, Redfish and Spotted wolffish). Striped wolffish were distributed along the shelf edge but also formed concentrations on the Bank. American plaice, Atlantic cod, Yellowtail flounder and Thorny skate tended to cover a widespread area of the Bank in the 1980's but have a more restricted distribution on the southern part of the Bank in recent years. Lumpfish were distributed quite differently from other species, tending to be found in the western extent of the study area right up to the coast and particularly on the St. Pierre Bank. Cusk were rarely observed. Its distribution is restricted to warmer waters to the south of the Grand Bank on the Scotian Shelf.

The *Oceans Act* has given DFO the mandate to establish a national network of MPAs. Identifying the spatial and temporal distribution of the 18 demersal fish species has satisfied two requirements for consideration for the designation of MPAs under Canada's *Oceans Act*. As stated in Section 35 (d), two of the reasons for designating a MPA are for "…the conservation and protection of 1) commercial and non-commercial fishery resources, including marine mammals, and their habitats, and 2) endangered or threatened marine species, and their habitats".

In addition, this mapping project has identified the spatial distribution of species that are listed by COSEWIC as threatened (Spotted wolffish) and special concern (Striped wolffish, Atlantic cod) (Simpson and Kulka 2002). The designation of these species indicates that the Spotted and Striped wolffish populations are thought to be sufficiently reduced as to be threatened with extinction (COSEWIC Criteria, http://www.cosewic.gc.ca). Special consideration will be required when planning any activity that may harm these species and/or their critical habitat. The study also looks at species that are currently under commercial fishing moratoria in the area (American plaice and Atlantic cod within NAFO Divisions 3LNO).

CONCLUSION

The Grand Bank represents an area that is highly biologically productive, supporting a diverse commercial fishery. Now, it is also the location of a growing petroleum industry. This study illustrates how GIS techniques can be used to study the spatial relationships between species distribution and petroleum industry activities. Documentation of the spatial and temporal distribution of species and species biomass proportions within petroleum licence areas on the Grand Bank is an important step in developing a systematic planning approach to oceans conservation in Newfoundland and Labrador. Along with the results of this report, further analysis can be achieved by adding other layers of information such as temperature, salinity, commercial fishery catch, and seismic surveys. This information, combined with data on oceanography, spawning sites, critical habitats, areas of high biological productivity, can be used to identify, develop and implement MPAs under the *Oceans Act*. The results can be used by internal groups, e.g. Science, Oceans and Environment Branch, Marine Environment and Habitat Management and Fisheries Management, as well as external organizations, e.g. fishing industry, C-NOPB, to protect species and their habitats in planning for sustainable economic development on the Grand Bank.

ACKNOWLEDGMENTS

The authors wish to thank the staff of DFO, Science, Oceans and Environment who collected the data used in this report during research surveys. We would also like to thank the reviewers Neil Ollerhead, Dave Orr and Jim Meade. Special thanks to Helen Griffiths for the final preparation of the report.

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Table 1. Species selected for study (Scott and Scott 1988).

COMMON NAME	SCIENTIFIC NAME
Atlantic halibut	*Hippoglossus hippoglossus*
Atlantic cod	*Gadus morhua*
Cusk	*Brosme brosme*
Greenland halibut	*Reinhardtius hippoglossoides*
Haddock	*Melanogrammus aeglefinus*
Lumpfish	*Cyclopterus lumpus*
Monkfish	*Lophius americanus*
American plaice	*Hippoglossoides platessoides*
Pollock	*Pollachius virens*
Redfish	*Sebastes spp.*
Roughhead grenadier	*Macrourus berglax*
Roundnose grenadier	*Coryphaenoides rupestris*
Thorny skate	*Raja radiata*
White hake	*Urophsis tenuis*
Witch flounder	*Glyptocephalus cynoglossus*
Striped wolffish	*Anarhichas lupus*
Spotted wolffish	*Anarhichas minor*
Yellowtail flounder	*Limanda ferruginea*

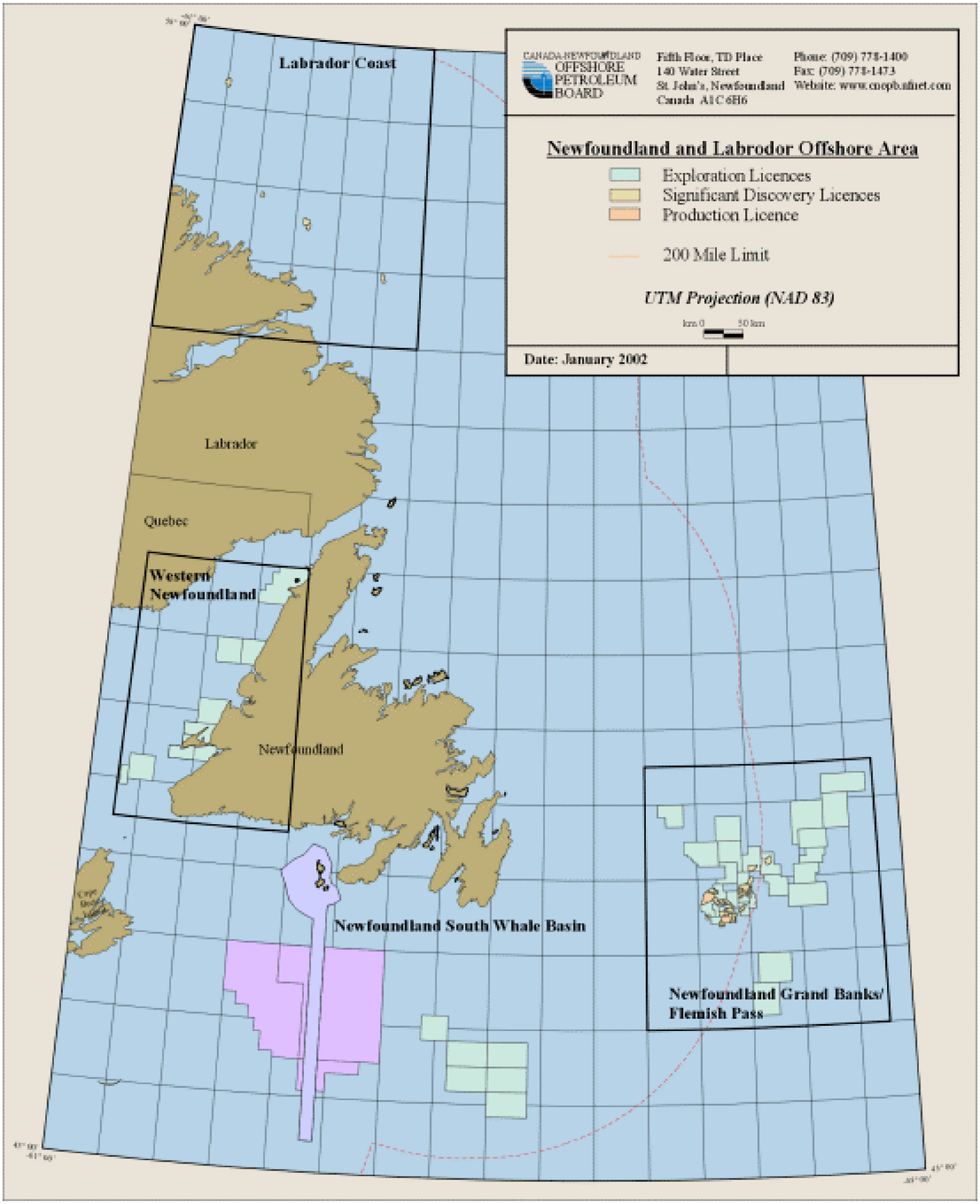


Figure 1. Petroleum Rights Offshore Newfoundland. (C-NOPB 2002)

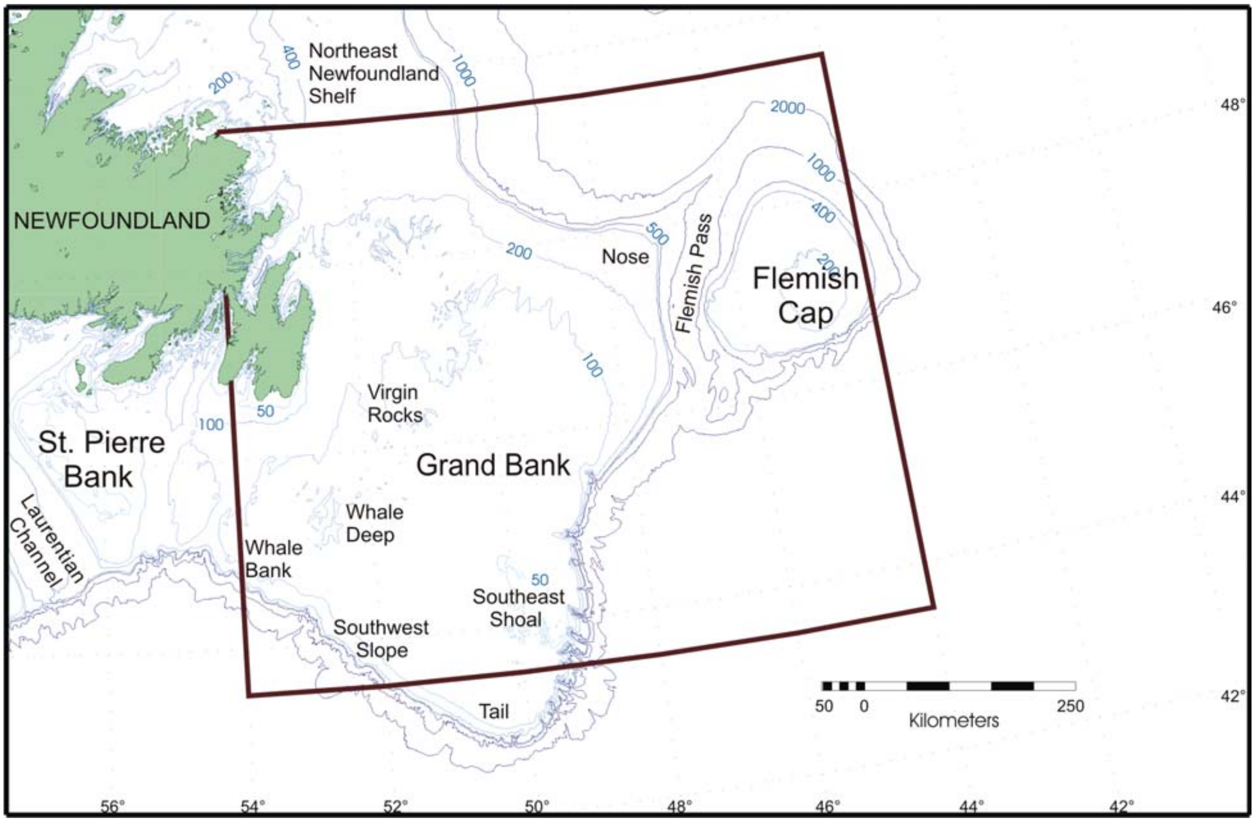


Figure 2. Study Area Location. Locations shown on map correspond to those described in the text.

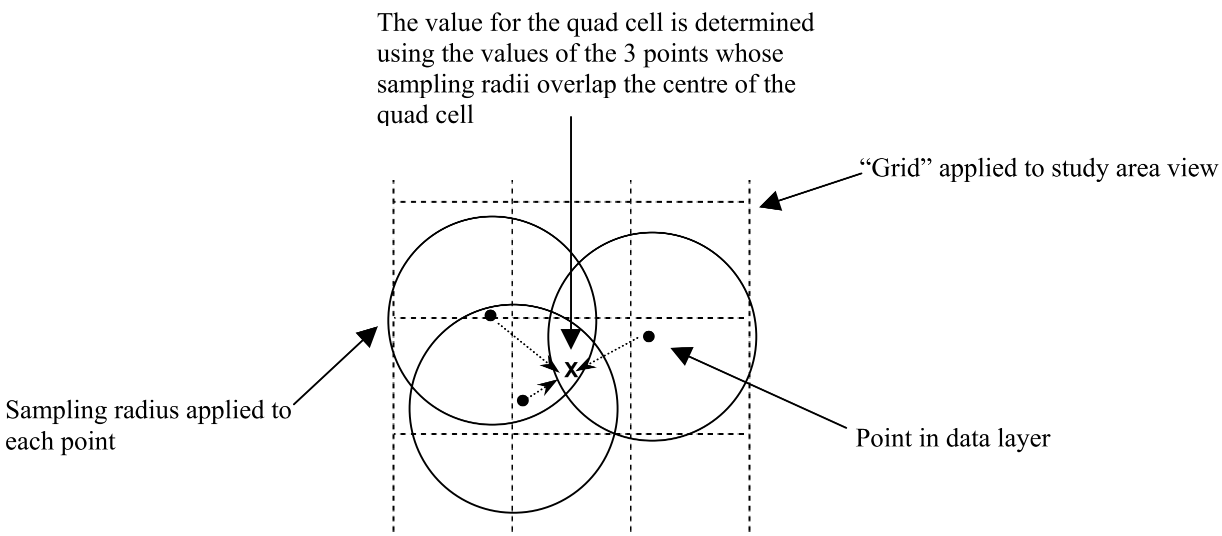


Figure 3. Sampling radius applied to each point (fishing set kg per tow) (after Kulka 1998).

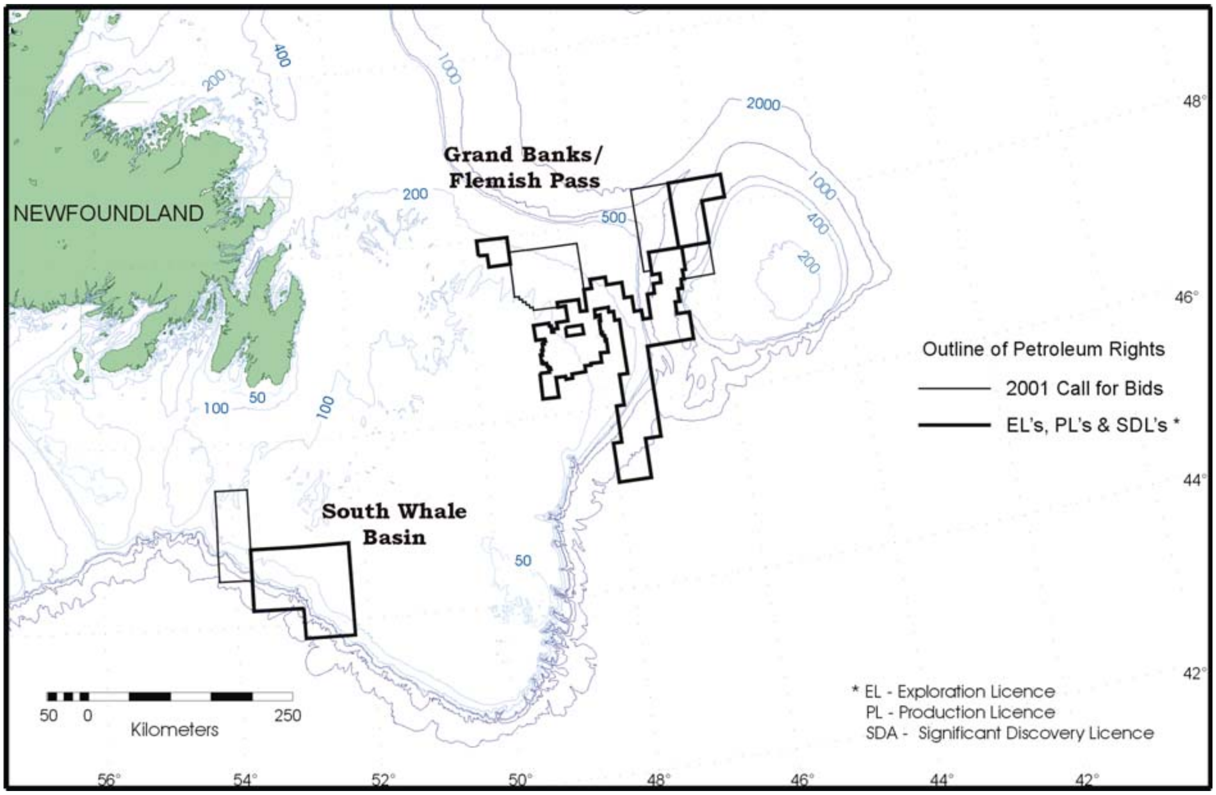


Figure 4. Map Template.

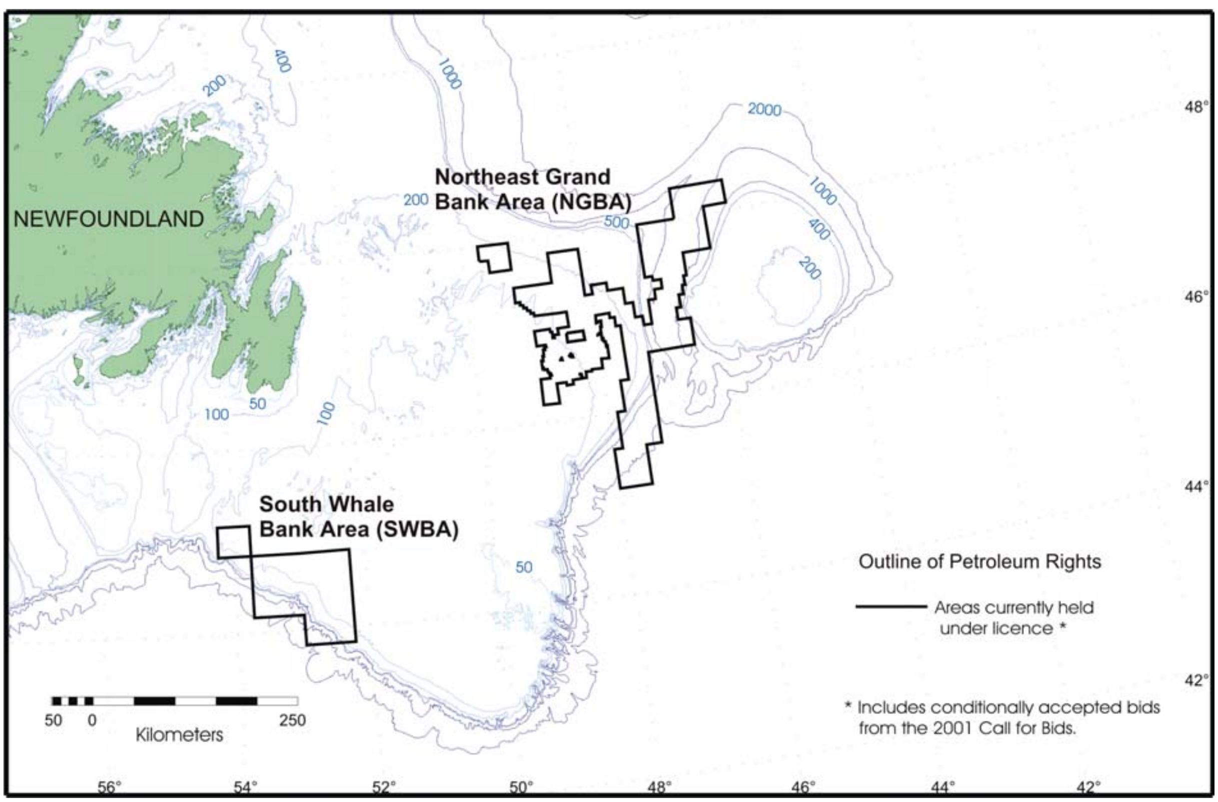


Figure 5. Areas used to define basemap cuts to calculate biomass proportions.

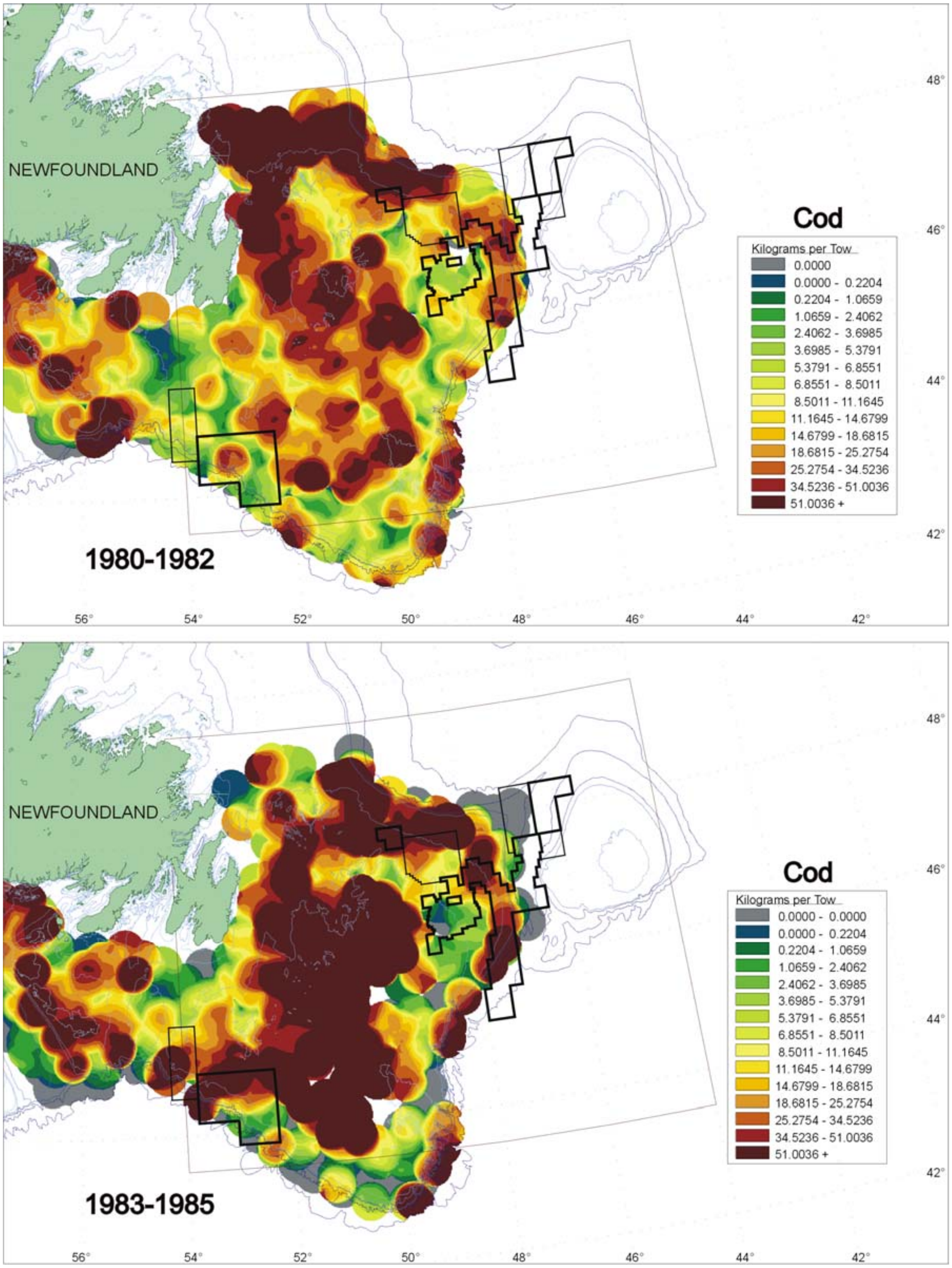
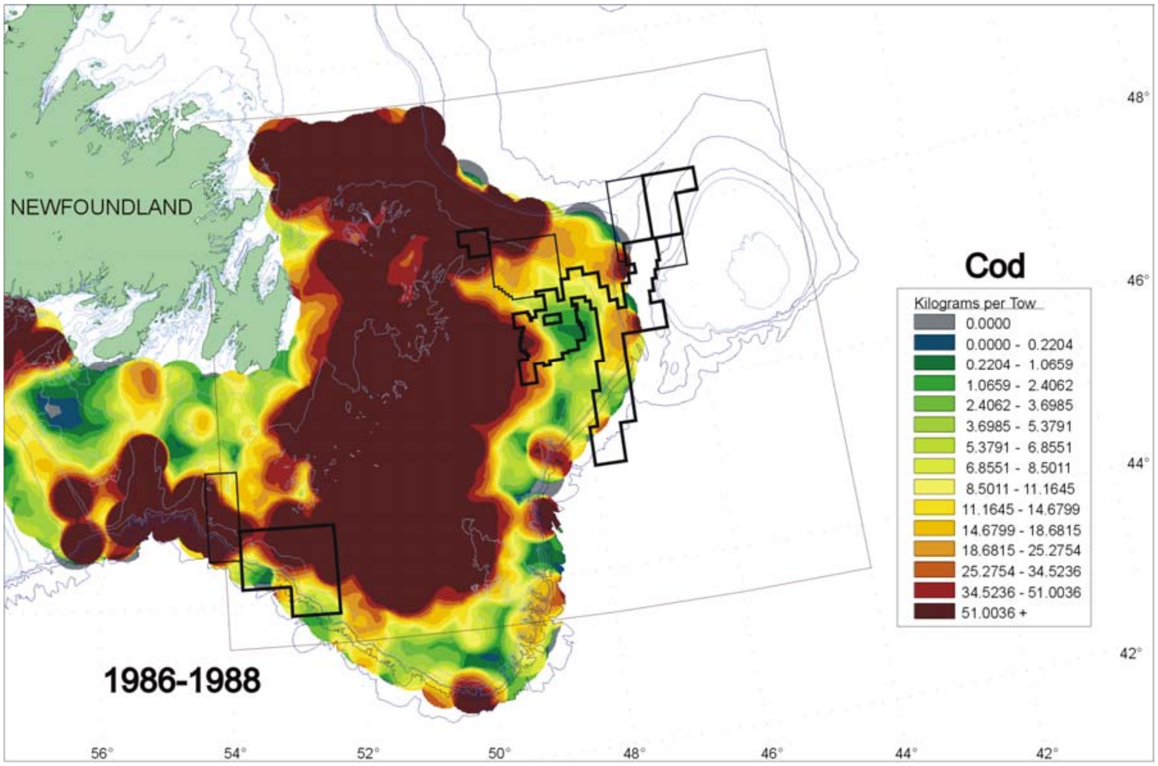


Figure 6a. Atlantic cod distribution based on spring research surveys from 1980-82 & 1983-85. Gray sections represent areas sampled with no catch rate values. (Cod on map refers to Atlantic cod).



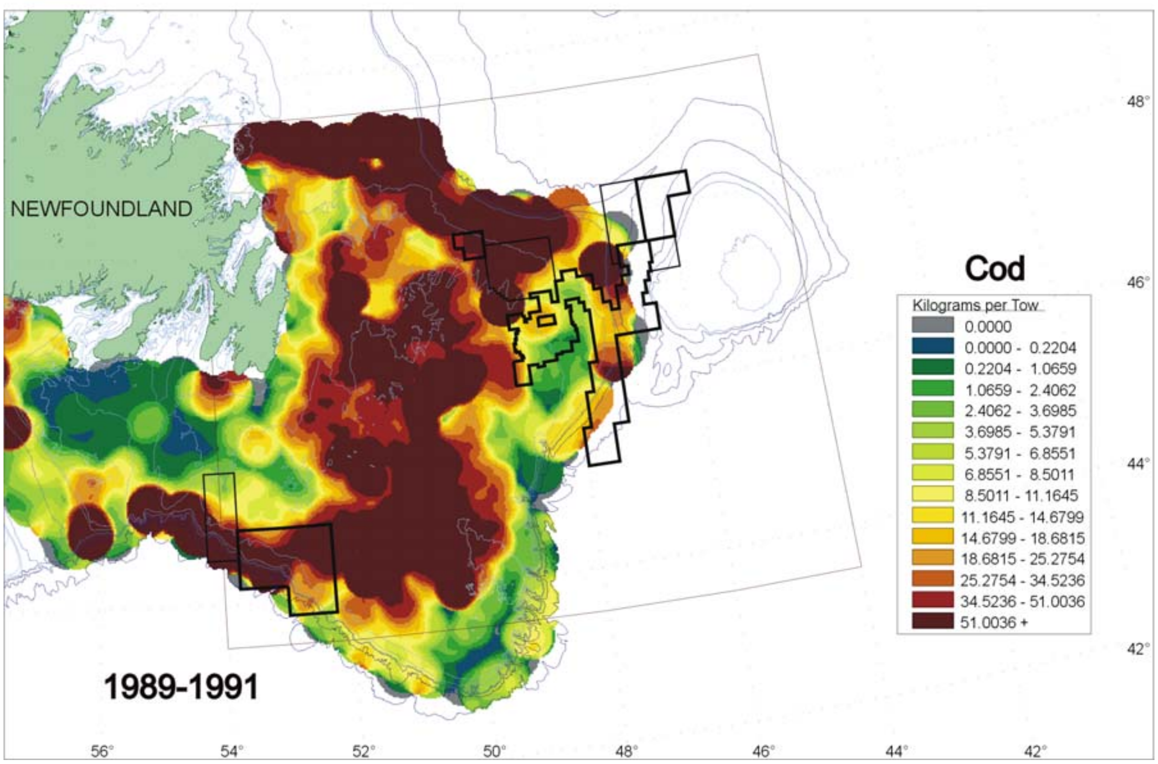
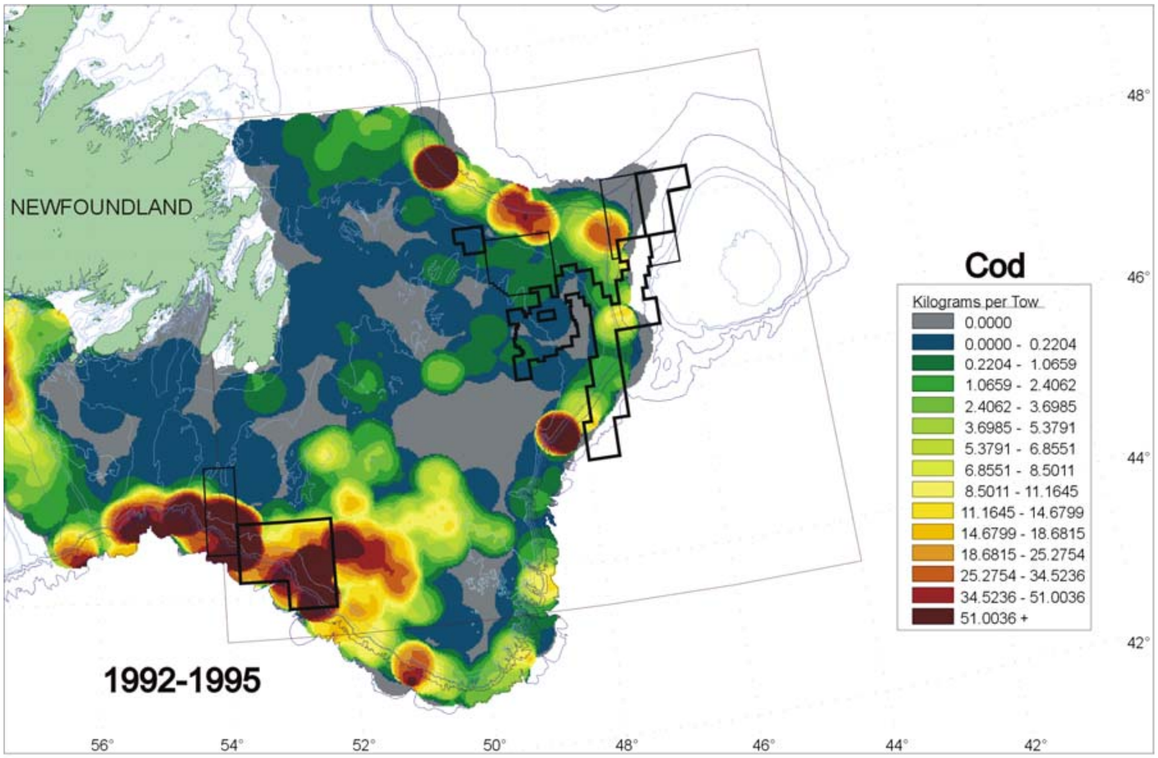


Figure 6b. Atlantic cod distribution based on spring research surveys from 1986-88 & 1989-91. Gray sections represent areas sampled with no catch rate values. (Cod on map refers to Atlantic cod).



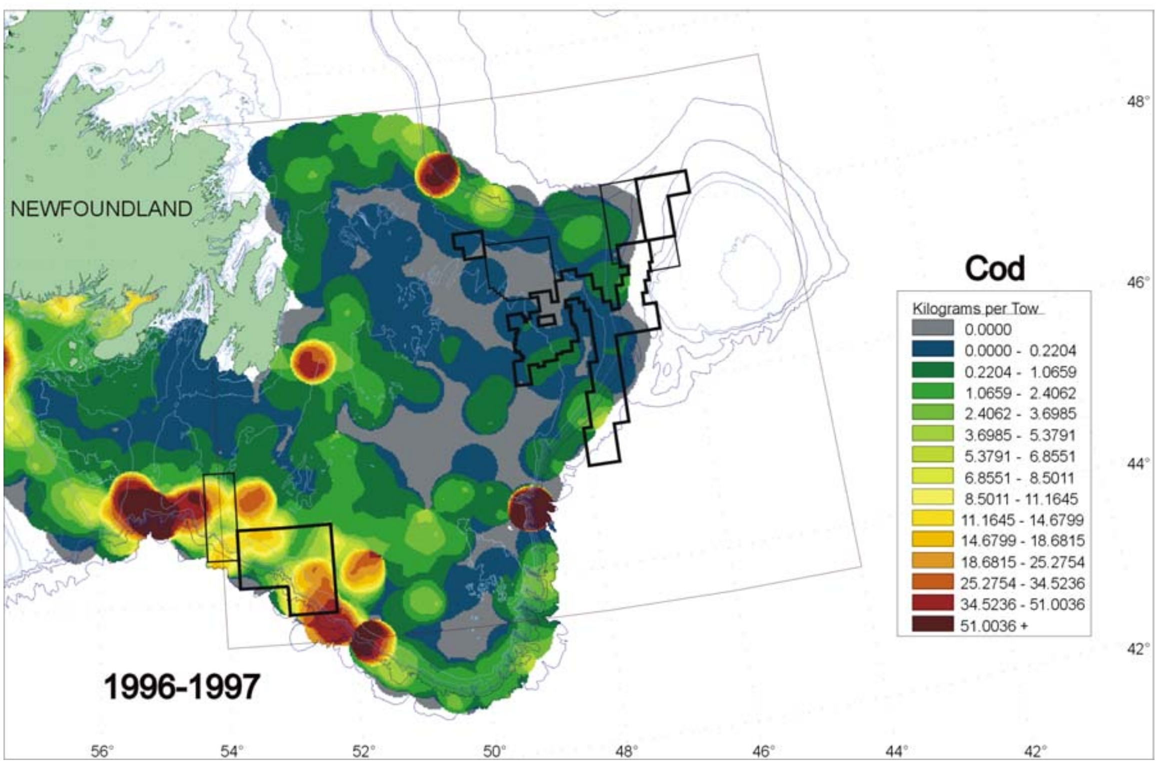


Figure 6c. Atlantic cod distribution based on spring research surveys from 1992-95 & 1996-97. Gray sections represent areas sampled with no catch rate values. (Cod on map refers to Atlantic cod).

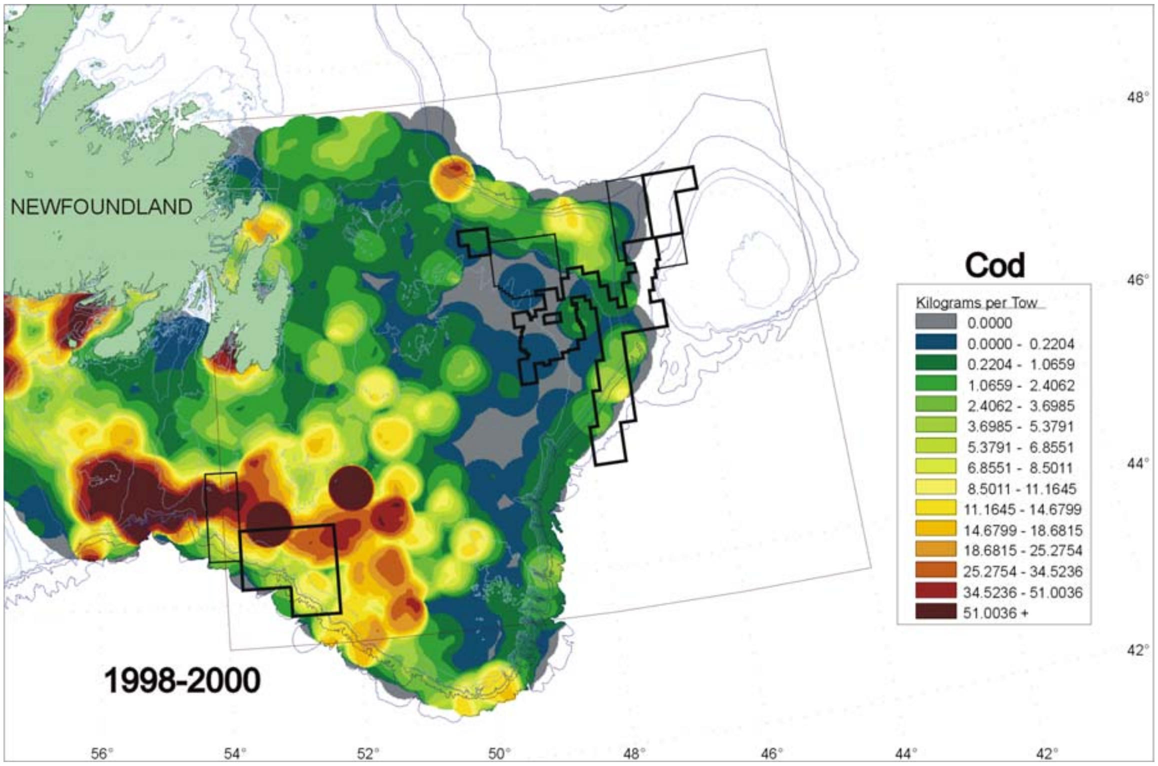
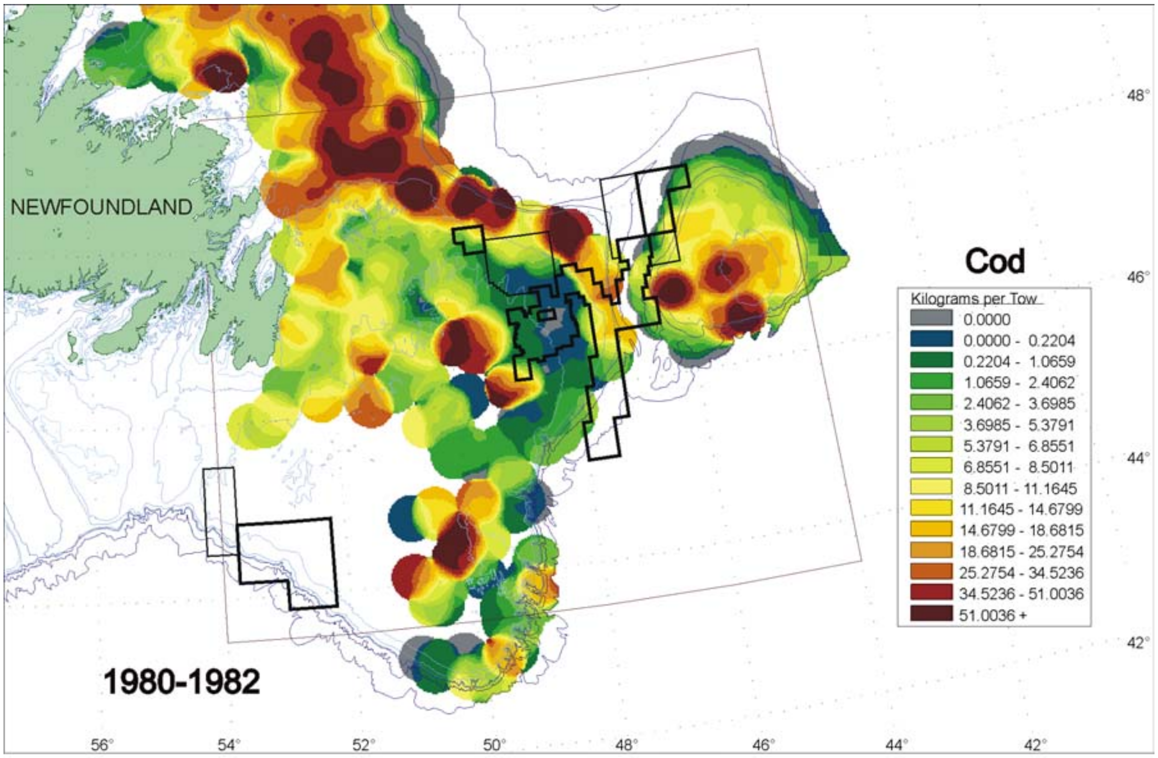


Figure 6d. Atlantic cod distribution based on spring research surveys from 1998-2000. Gray sections represent areas sampled with no catch rate values. (Cod on map refers to Atlantic cod).



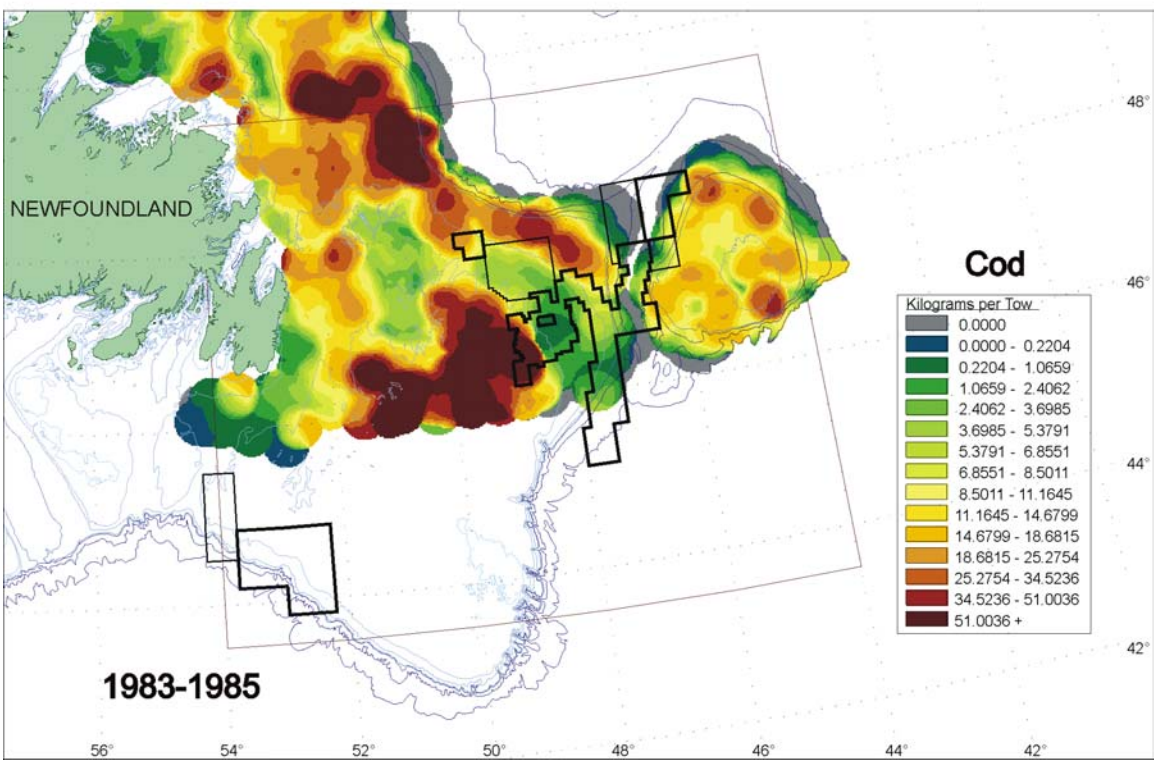


Figure 7a. Atlantic cod distribution based on fall research surveys from 1980-82 & 1983-85. Gray sections represent areas sampled with no catch rate values. (Cod on map refers to Atlantic cod).

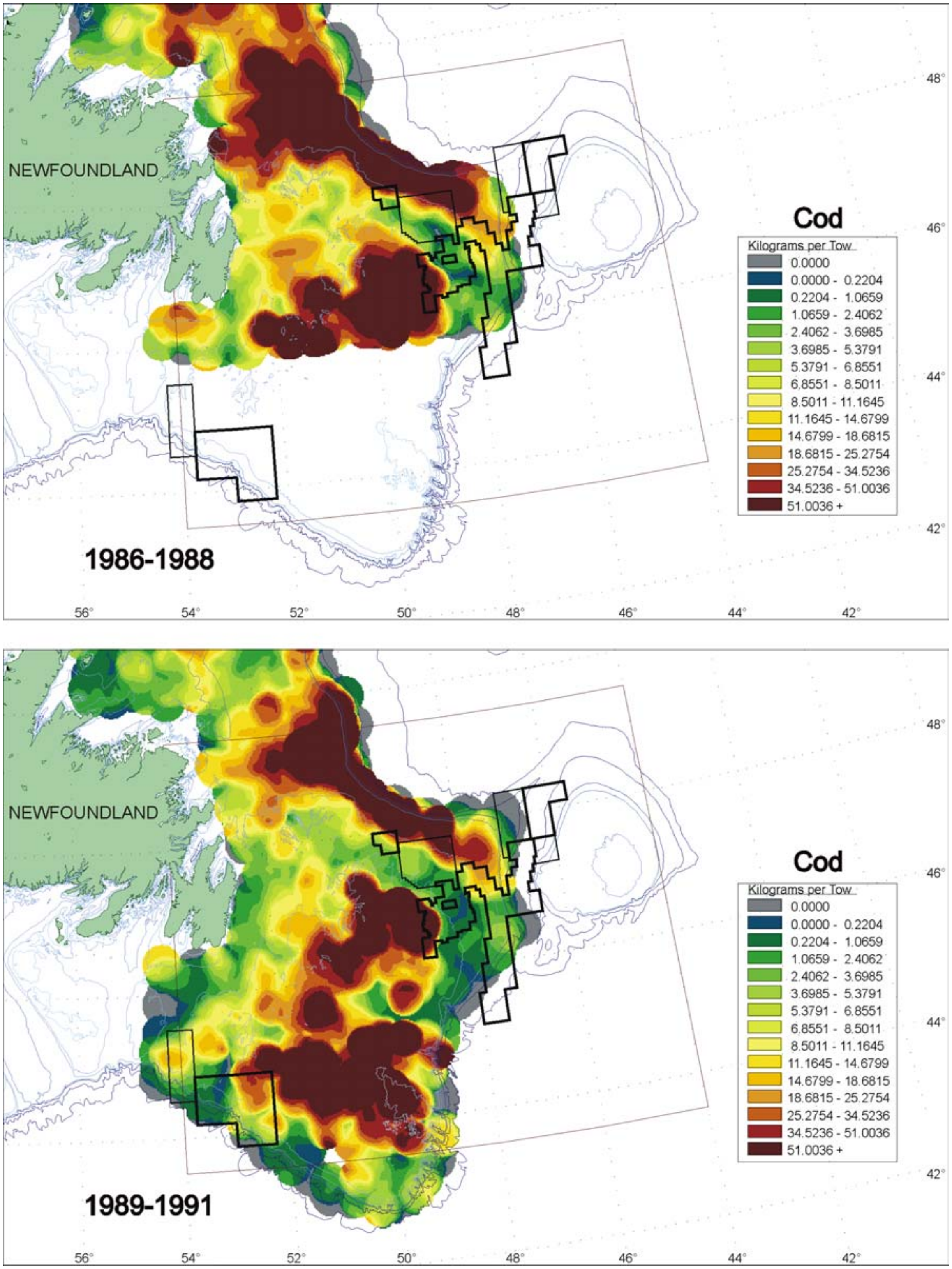
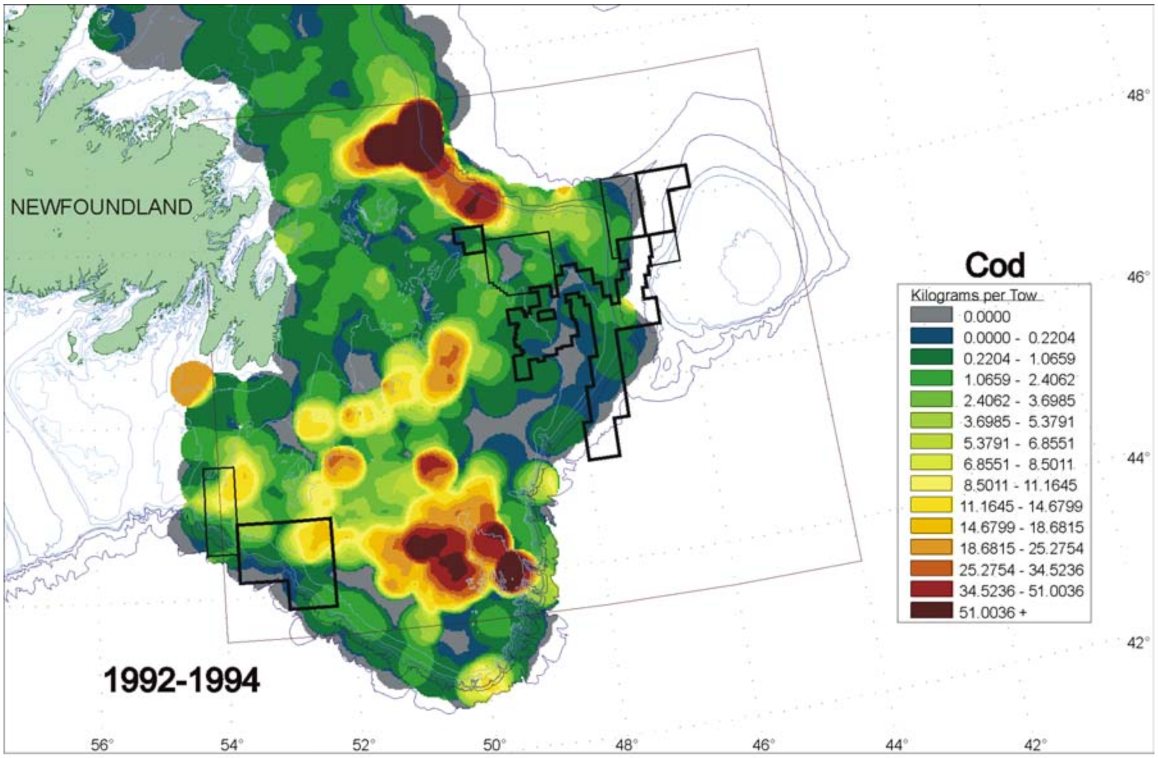


Figure 7b. Atlantic cod distribution based on fall research surveys from 1986-88 & 1989-91. Gray sections represent areas sampled with no catch rate values. (Cod on map refers to Atlantic cod).



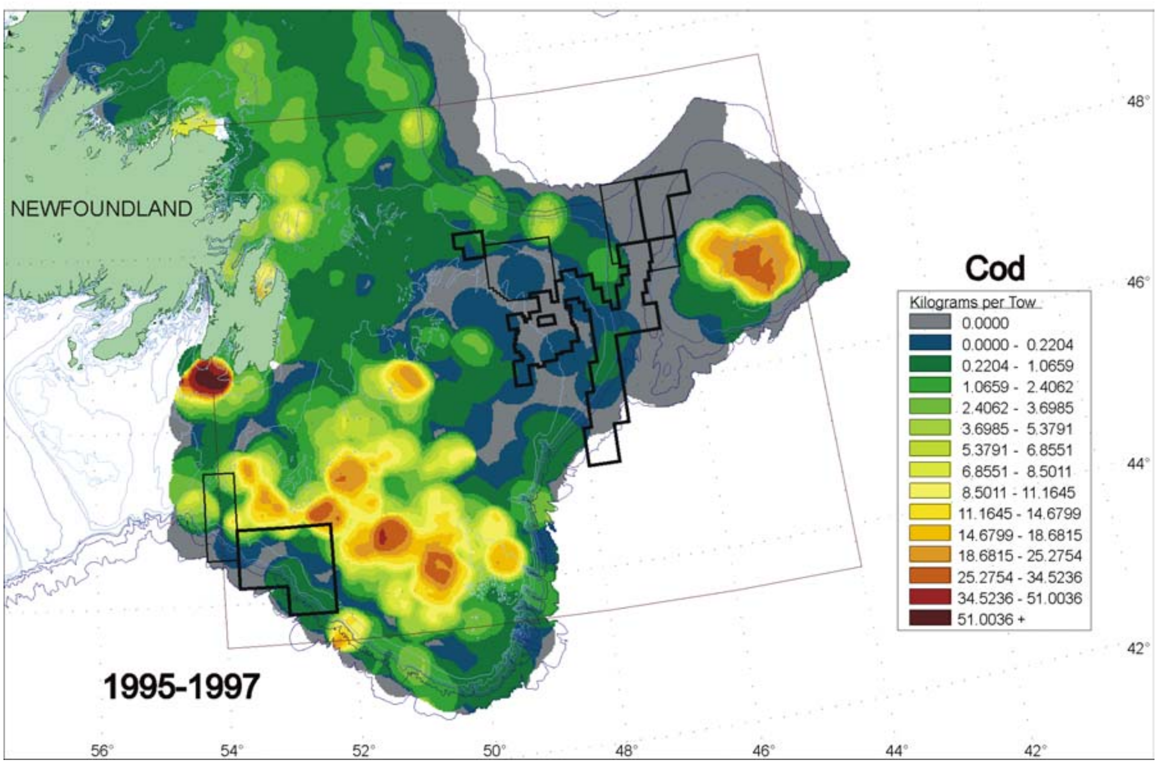


Figure 7c. Atlantic cod distribution based on fall research surveys from 1992-94 & 1995-97. Gray sections represent areas sampled with no catch rate values. (Cod on map refers to Atlantic cod).

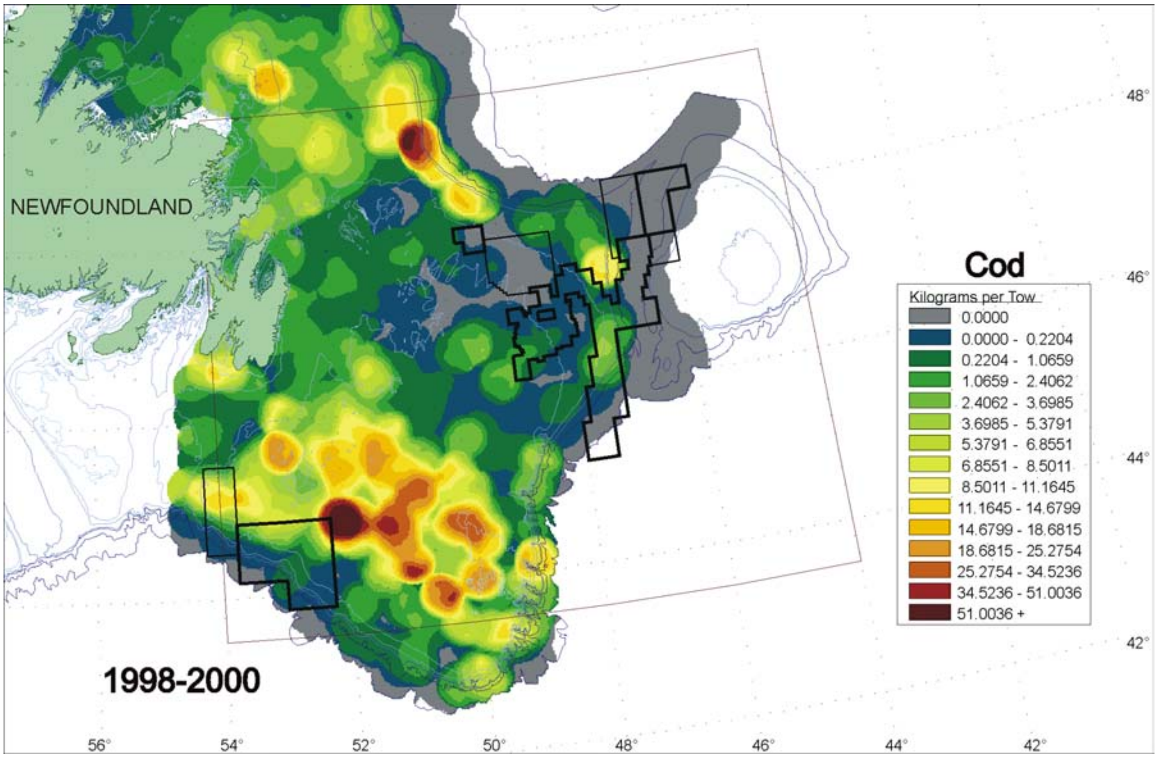
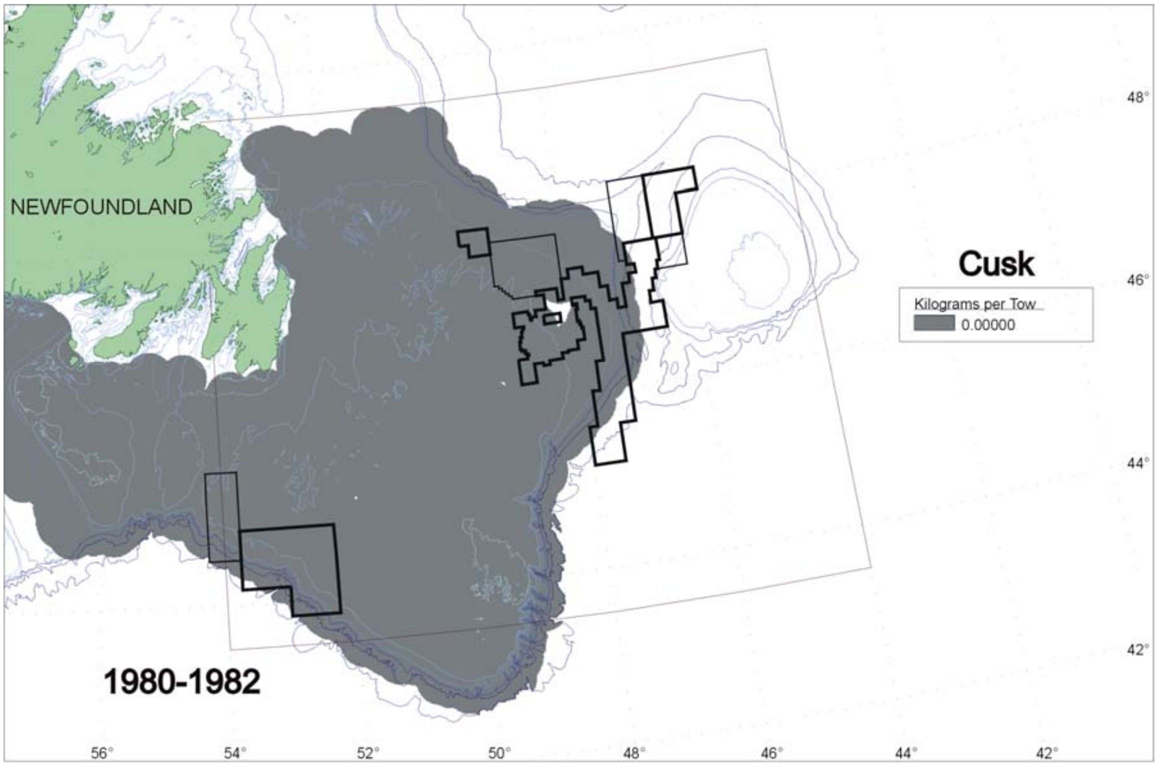


Figure 7d. Atlantic cod distribution based on fall research surveys from 1998-2000. Gray sections represent areas sampled with no catch rate values. (Cod on map refers to Atlantic cod).



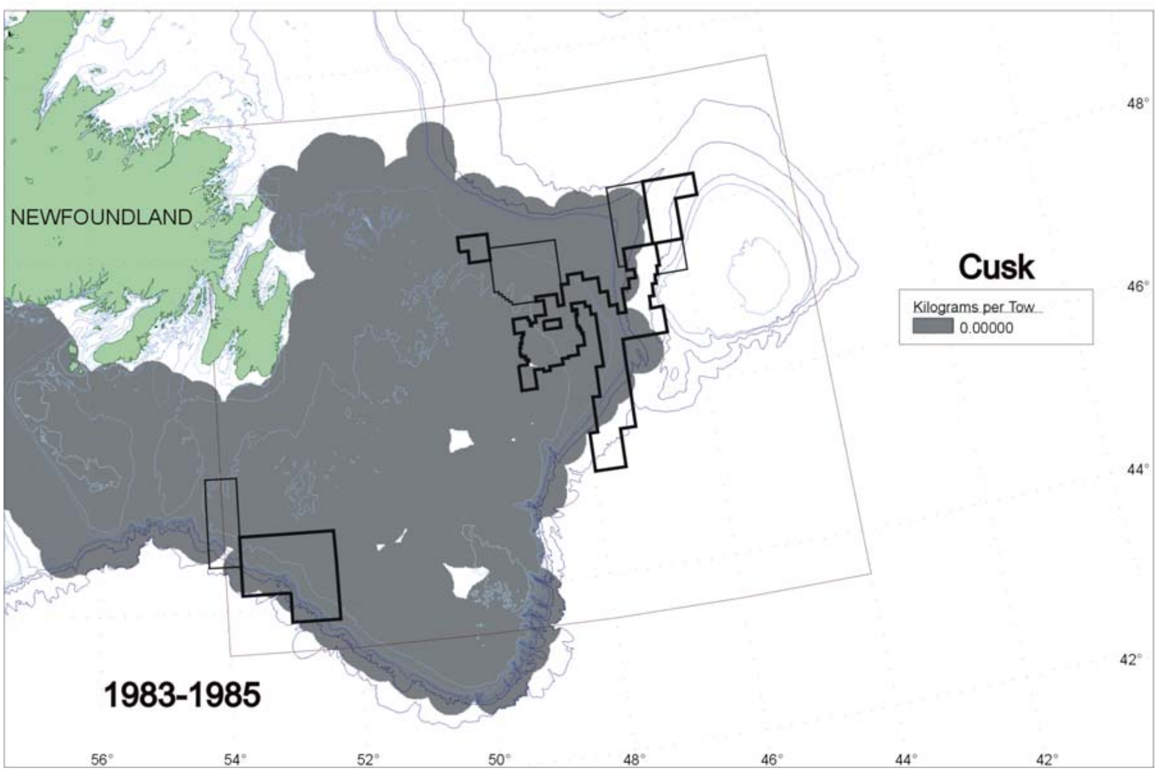
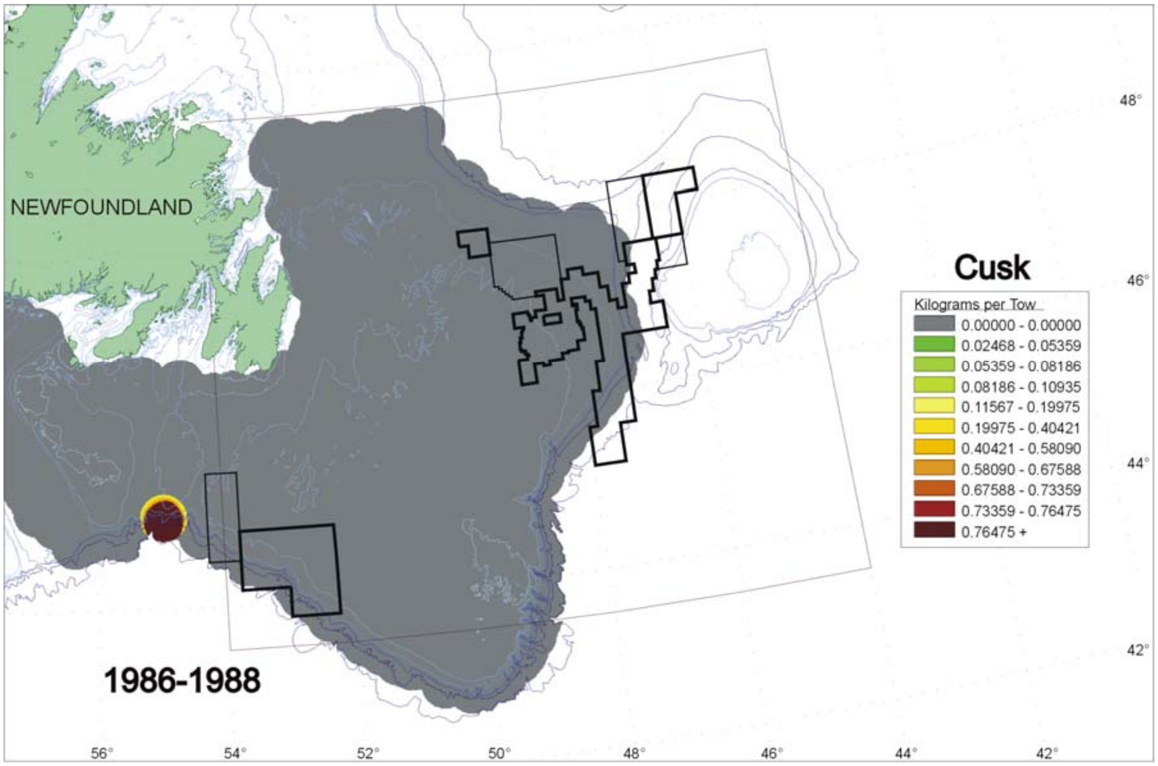


Figure 8a. Cusk distribution based on spring research surveys from 1980-82 & 1983-85. Gray sections represent areas sampled with no catch rate values.



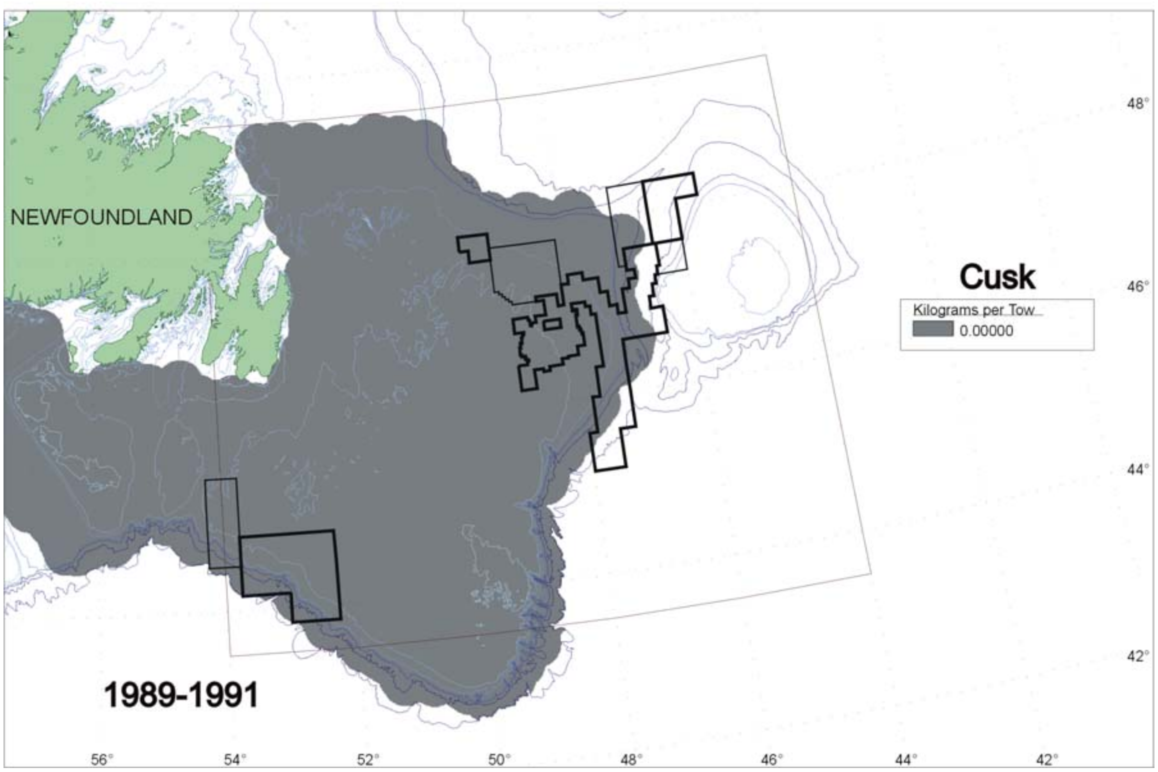
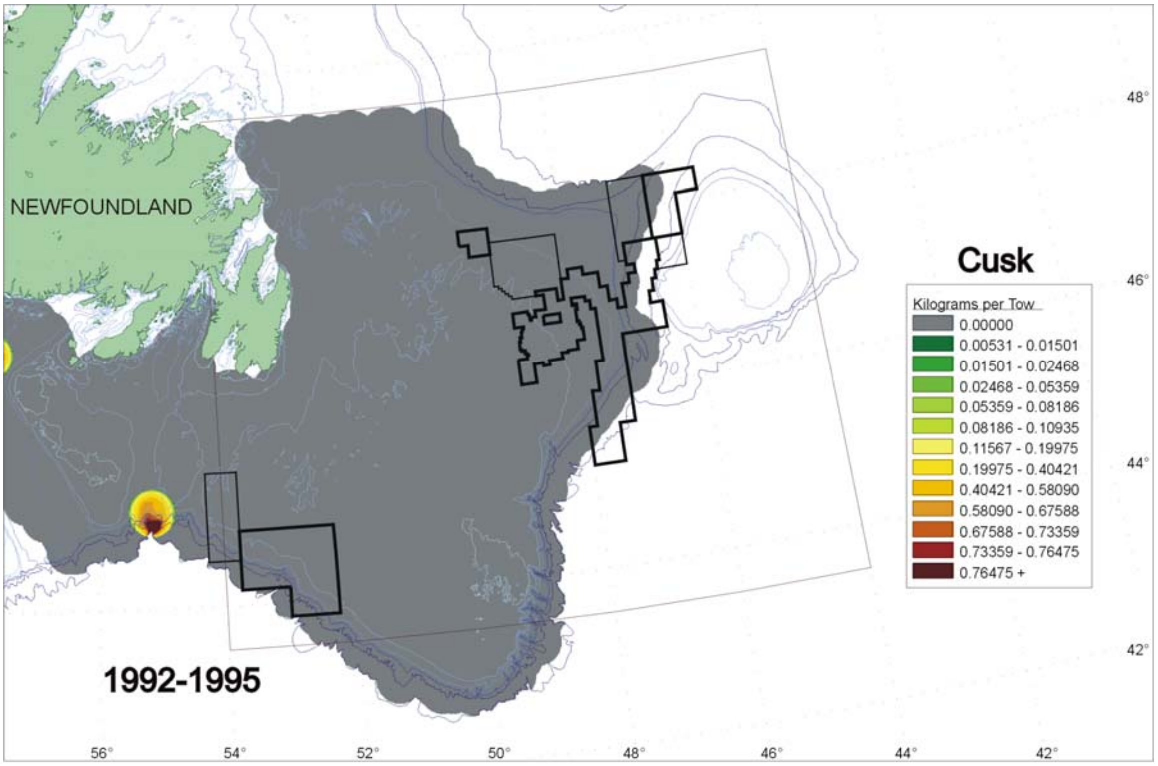


Figure 8b. Cusk distribution based on spring research surveys from 1986-88 & 1989-91. Gray sections represent areas sampled with no catch rate values.



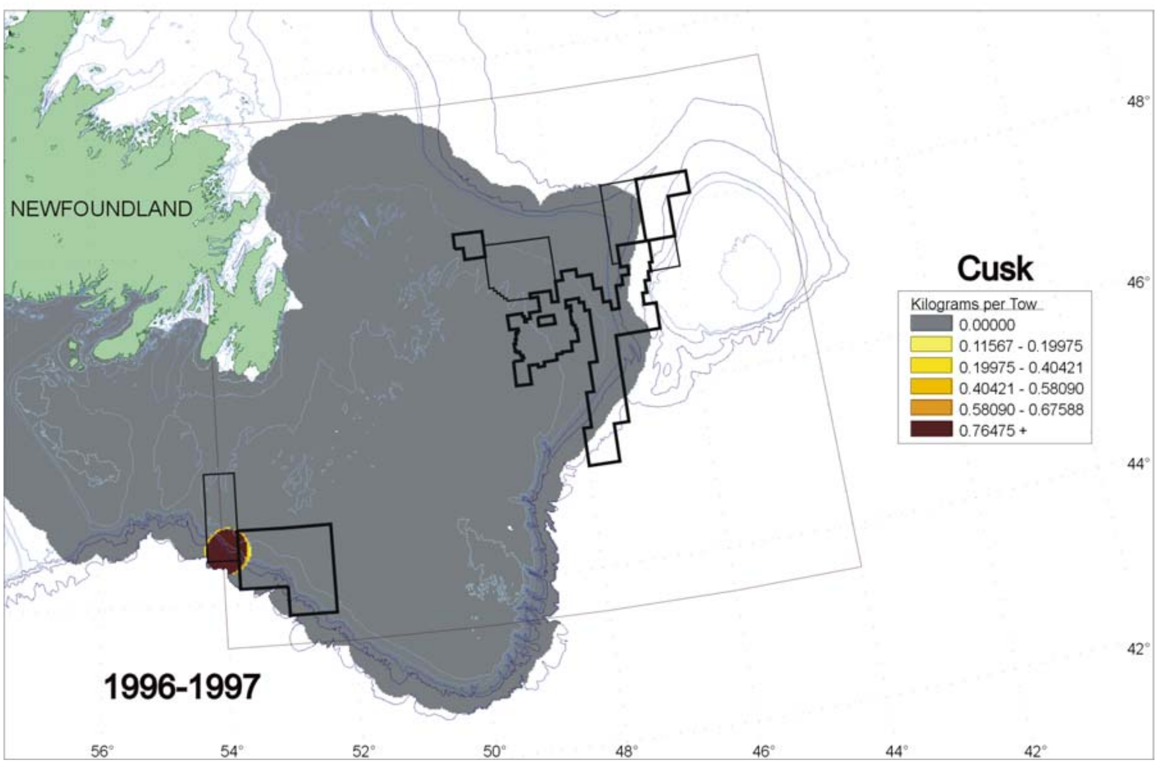


Figure 8c. Cusk distribution based on spring research surveys from 1992-95 & 1996-97. Gray sections represent areas sampled with no catch rate values.

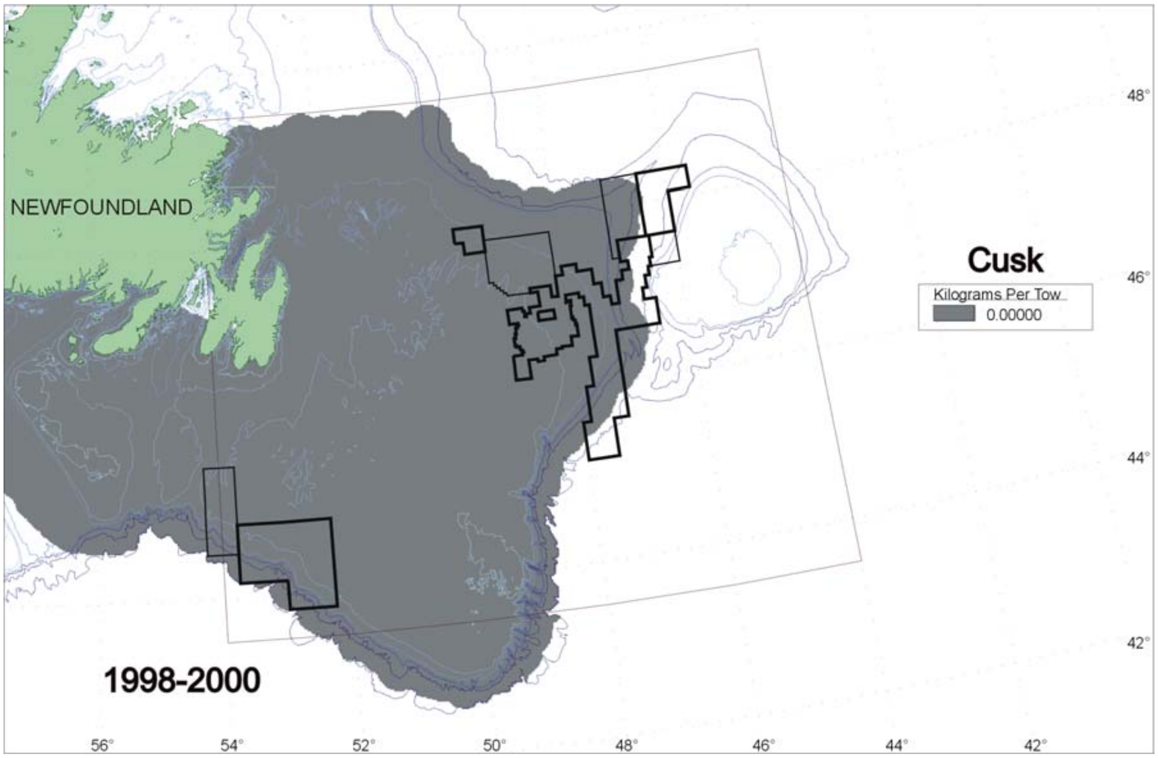
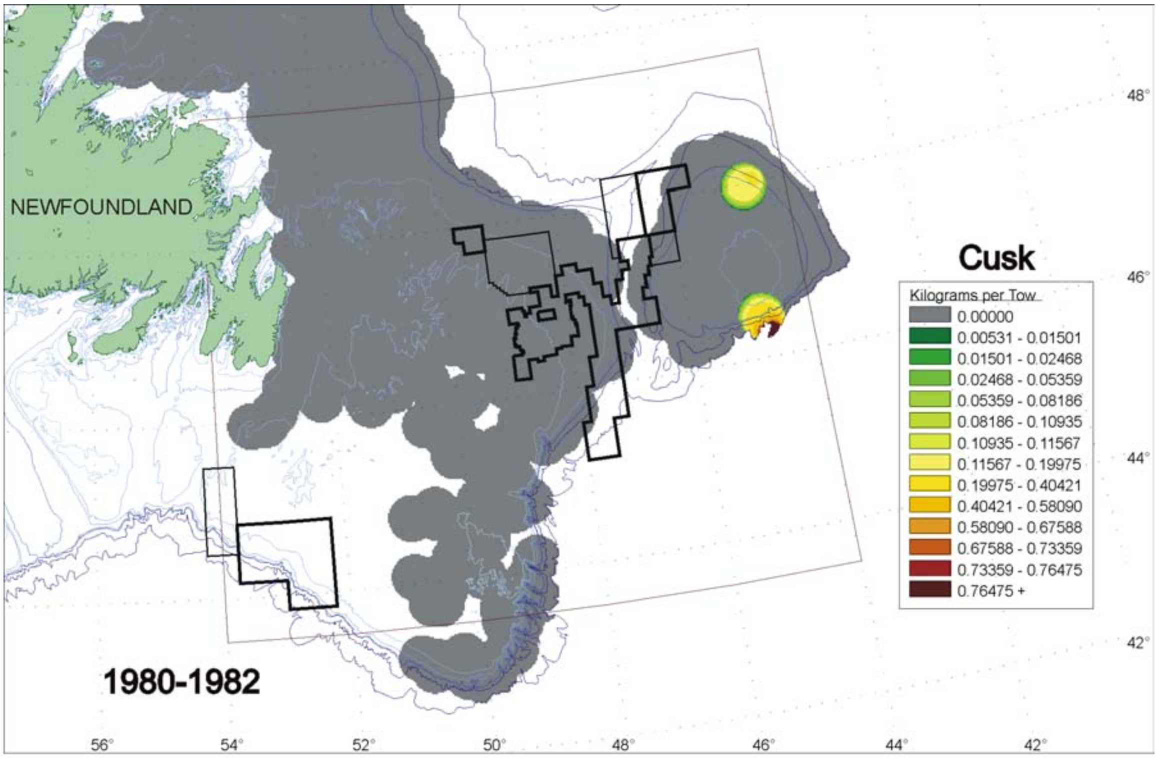


Figure 8d. Cusk distribution based on spring research surveys from 1998-2000. Gray sections represent areas sampled with no catch rate values.



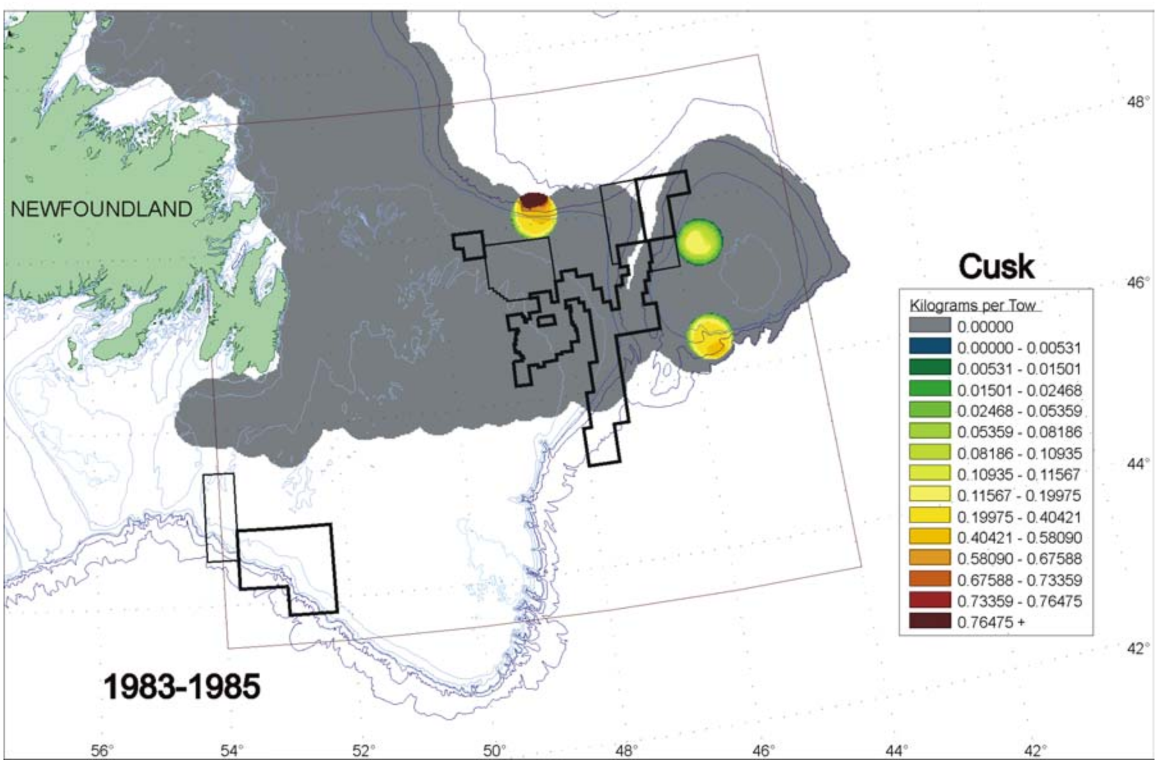


Figure 9a. Cusk distribution based on fall research surveys from 1980-82 & 1983-85. Gray sections represent areas sampled with no catch rate values.

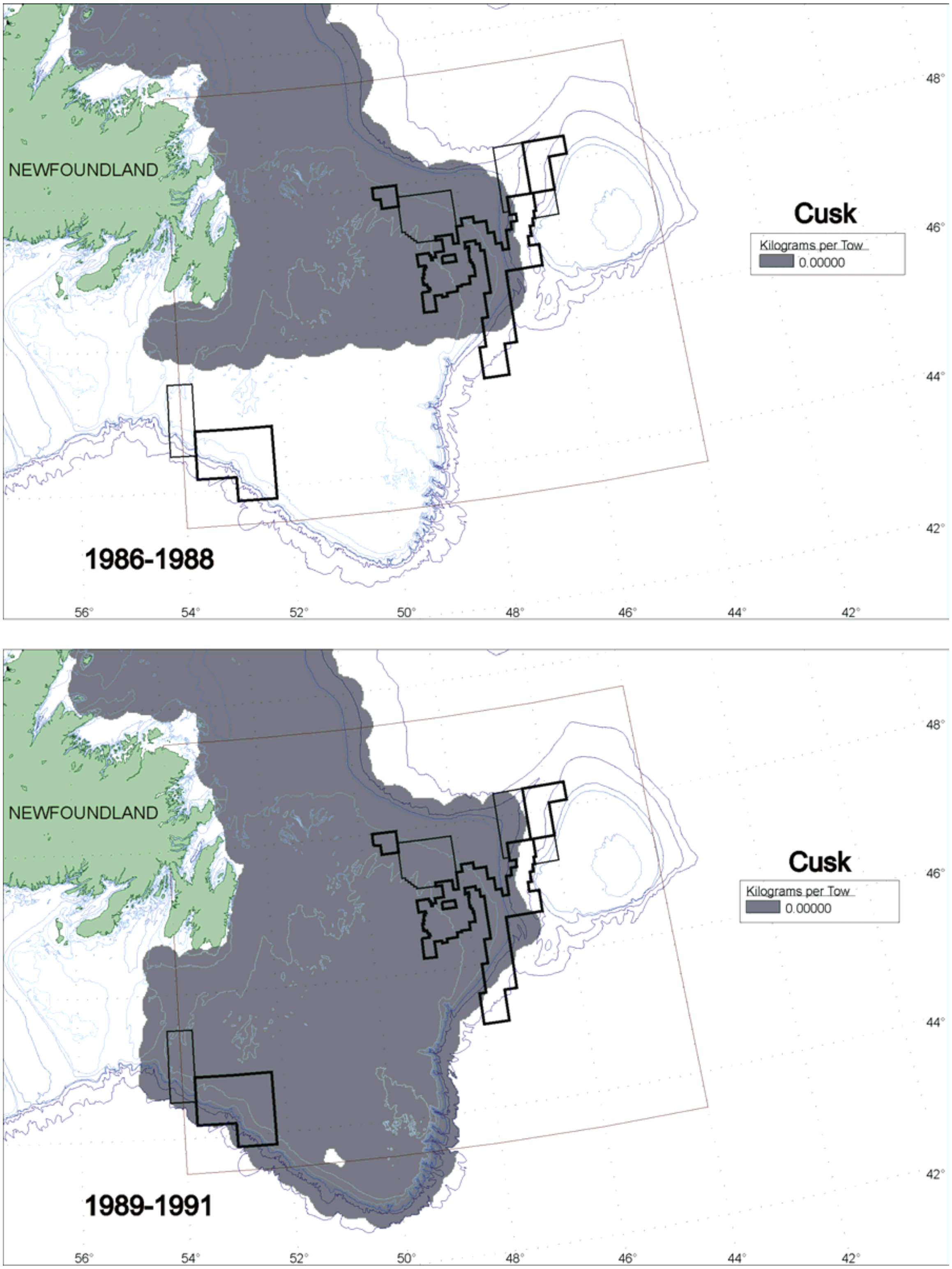


Figure 9b. Cusk distribution based on fall research surveys from 1986-88 & 1989-91. Gray sections represent areas sampled with no catch rate values.

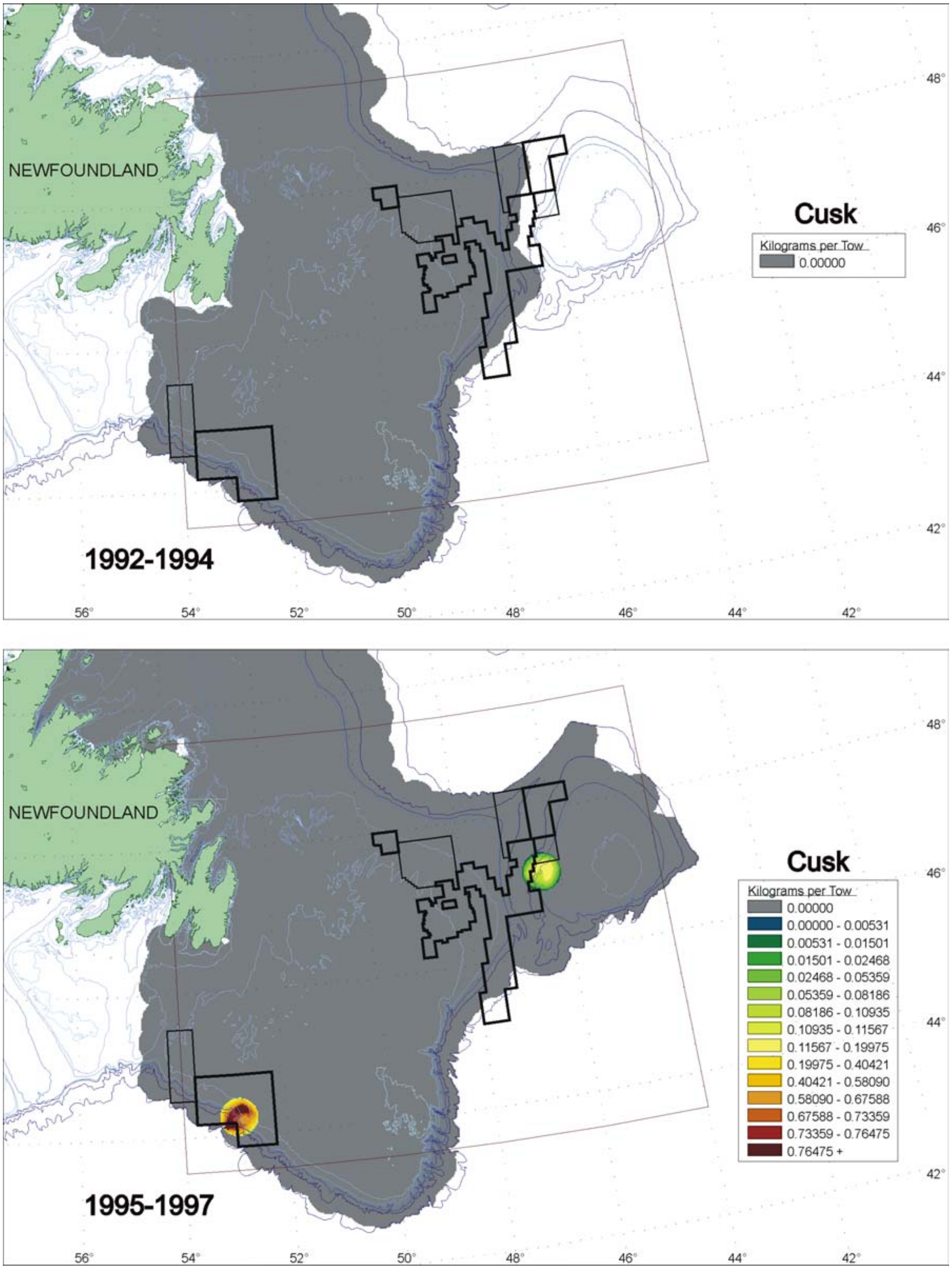


Figure 9c. Cusk distribution based on fall research surveys from 1992-94 & 1995-97. Gray sections represent areas sampled with no catch rate values.

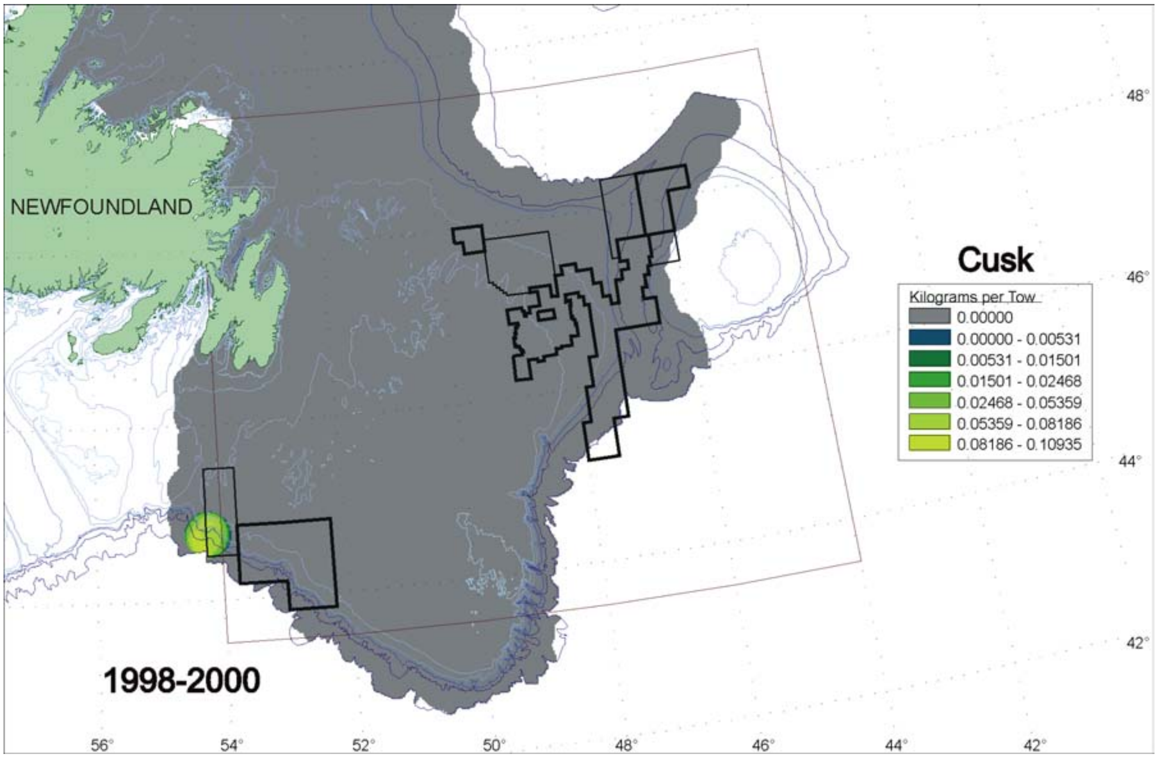
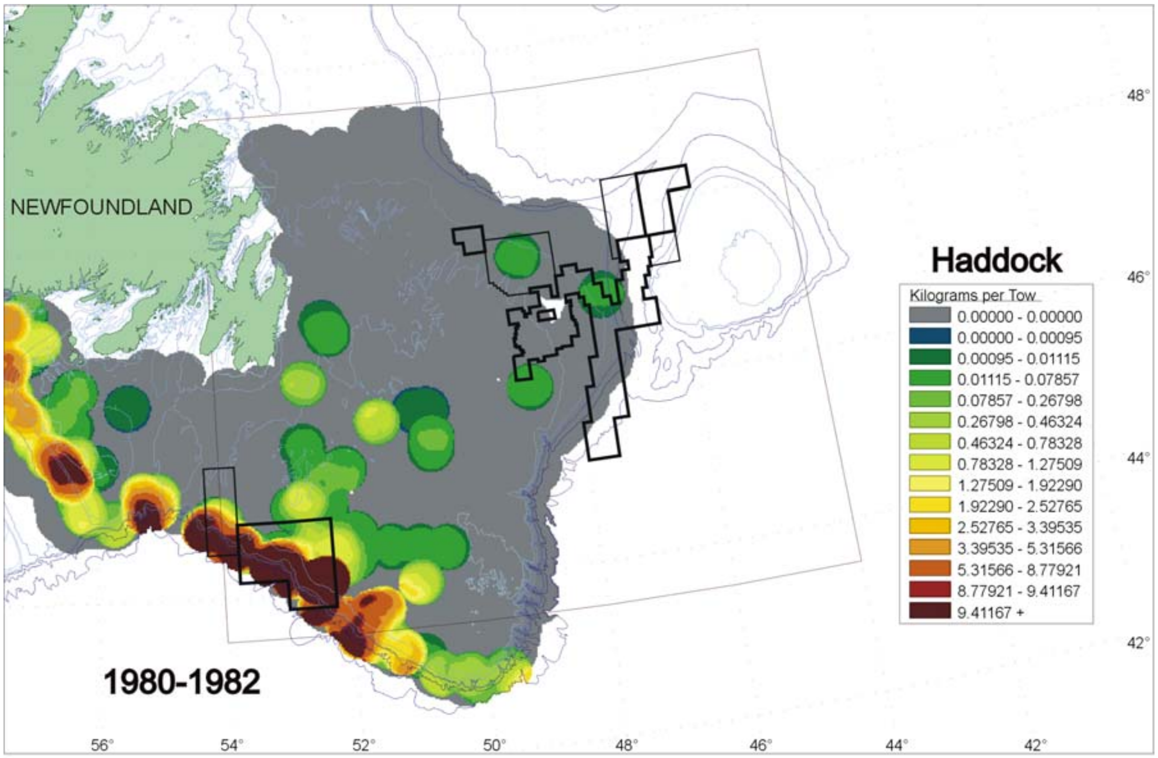


Figure 9d. Cusk distribution based on fall research surveys from 1998-2000. Gray sections represent areas sampled with no catch rate values.



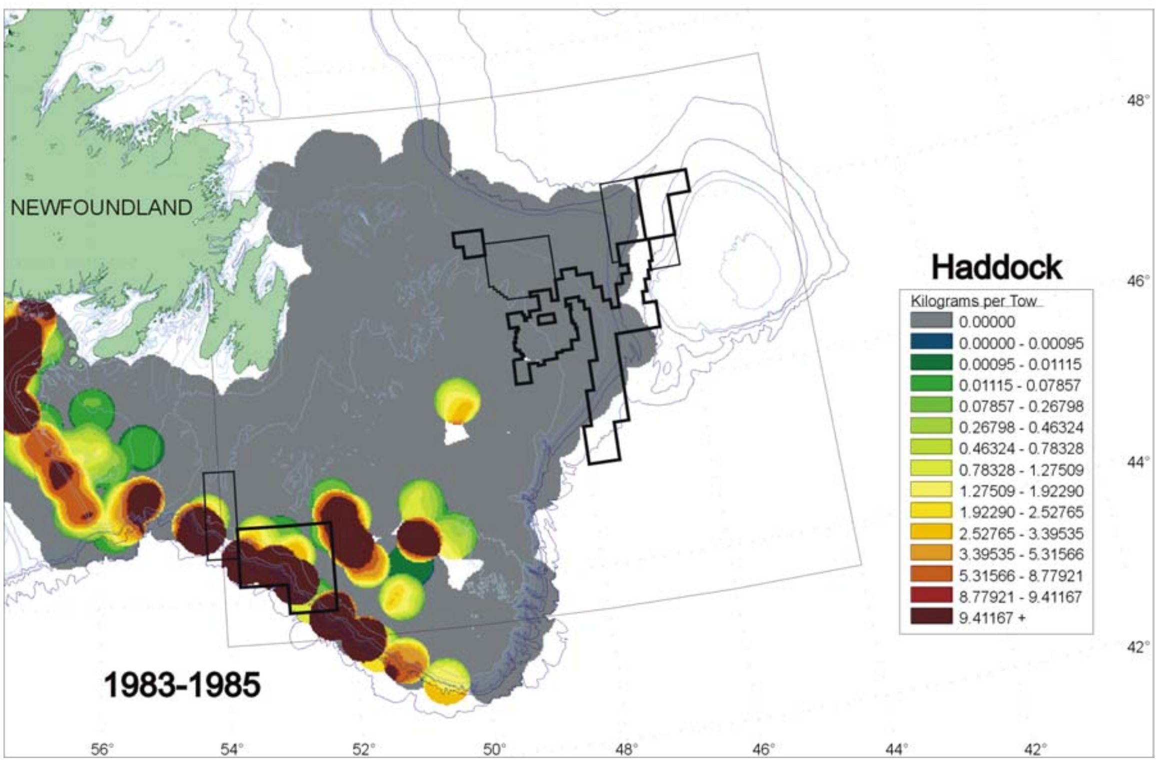
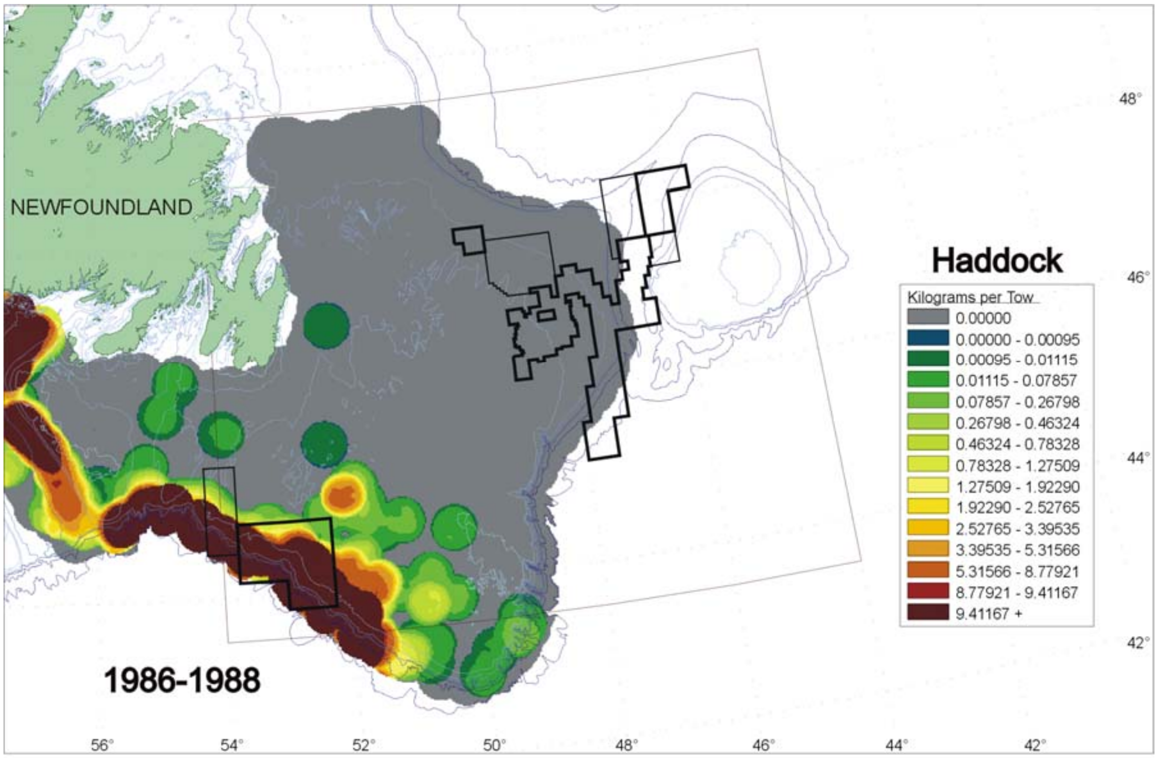


Figure 10a. Haddock distribution based on spring research surveys from 1980-82 & 1983-85. Gray sections represent areas sampled with no catch rate values.



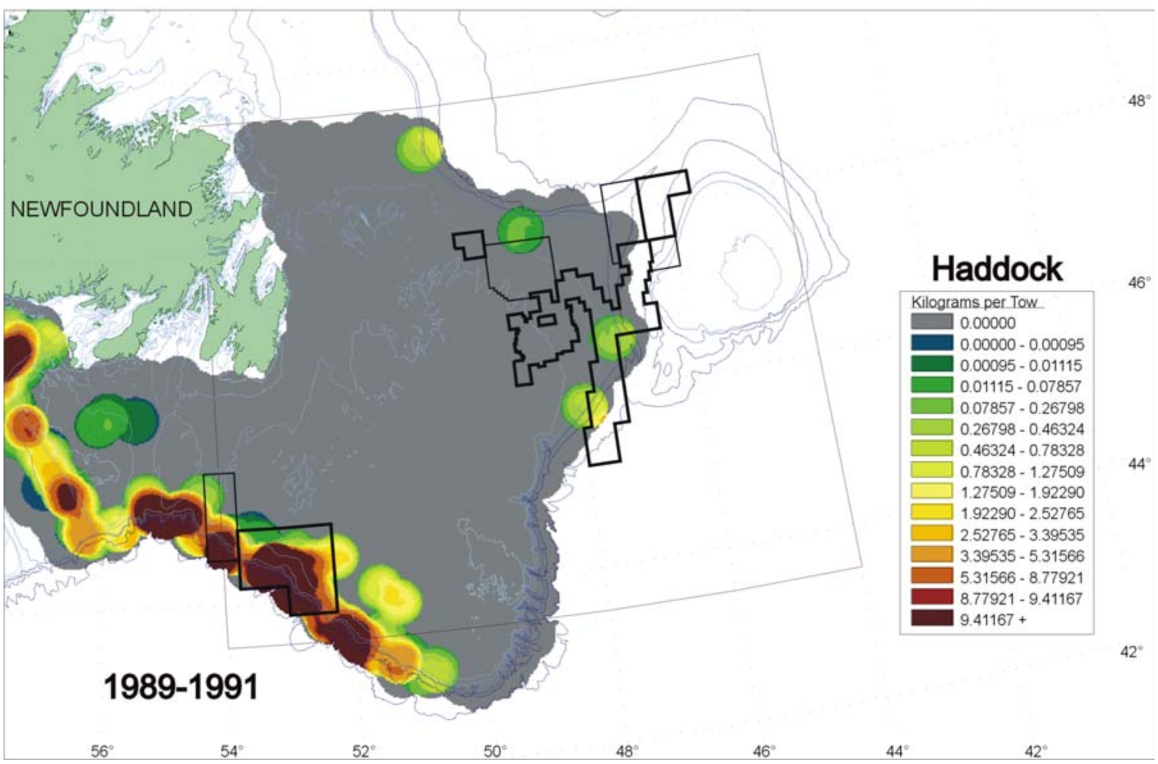
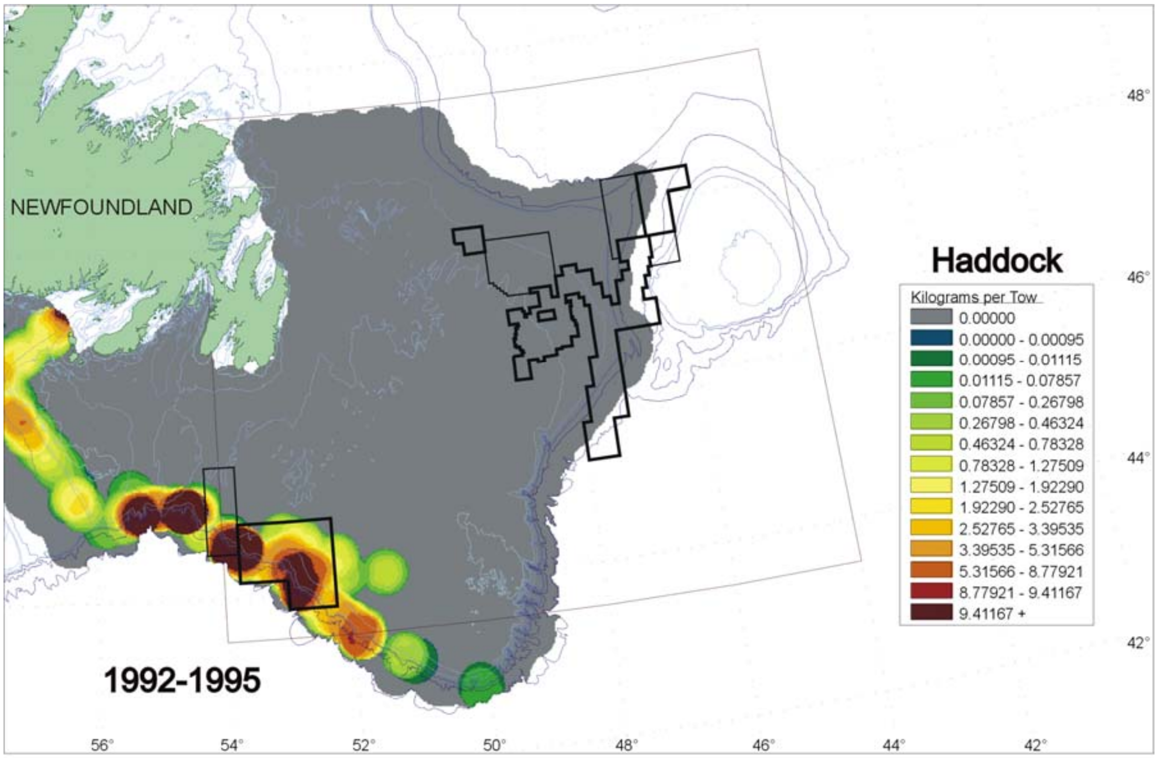


Figure 10b. Haddock distribution based on spring research surveys from 1986-88 & 1989-91. Gray sections represent areas sampled with no catch rate values.



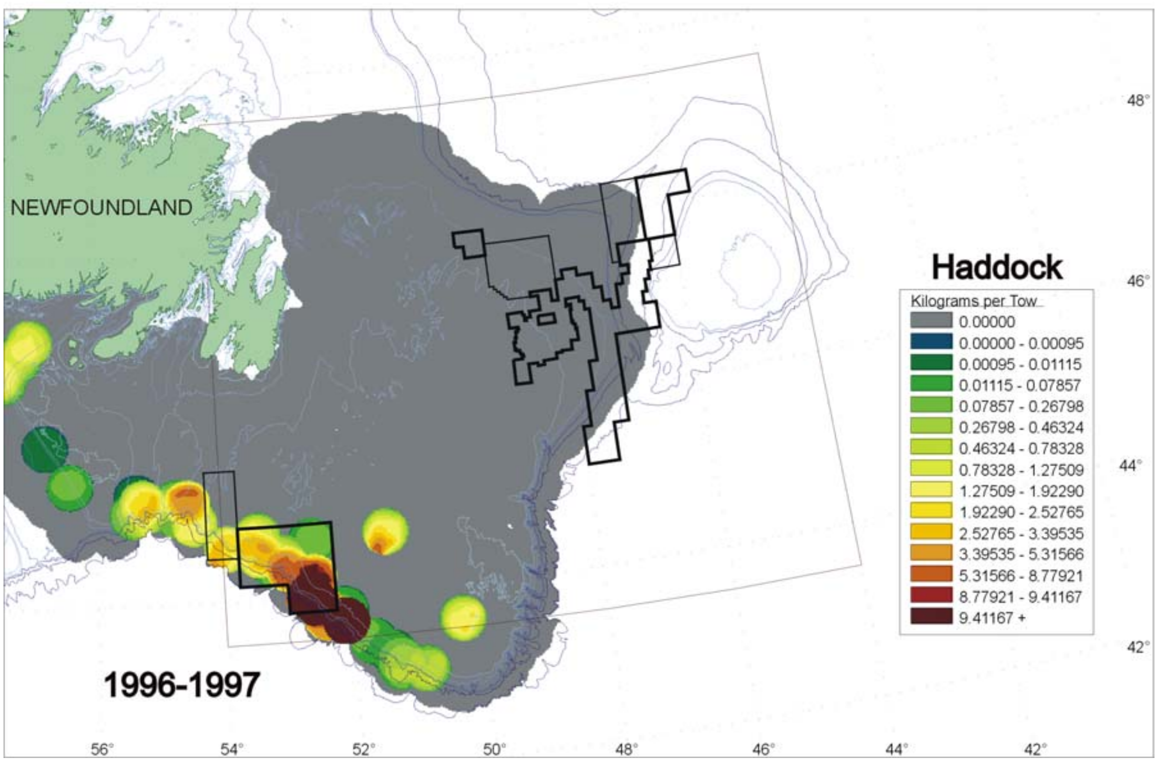


Figure 10c. Haddock distribution based on spring research surveys from 1992-95 & 1996-97. Gray sections represent areas sampled with no catch rate values.

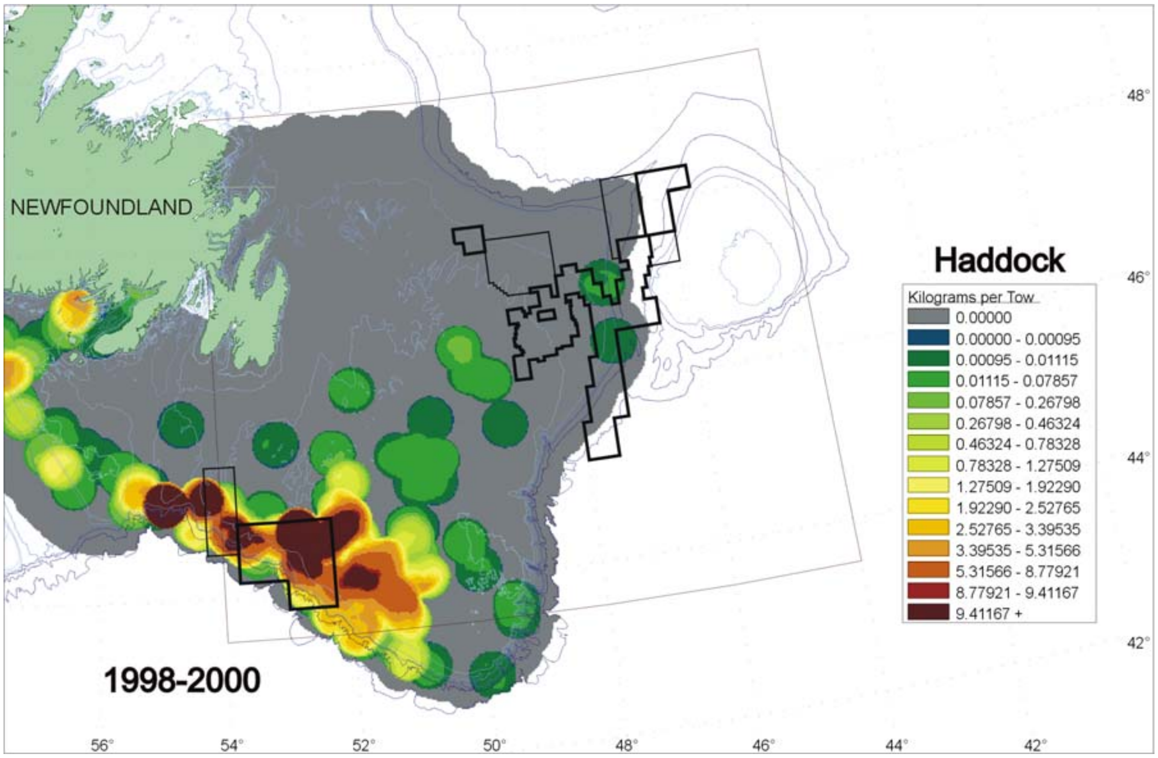
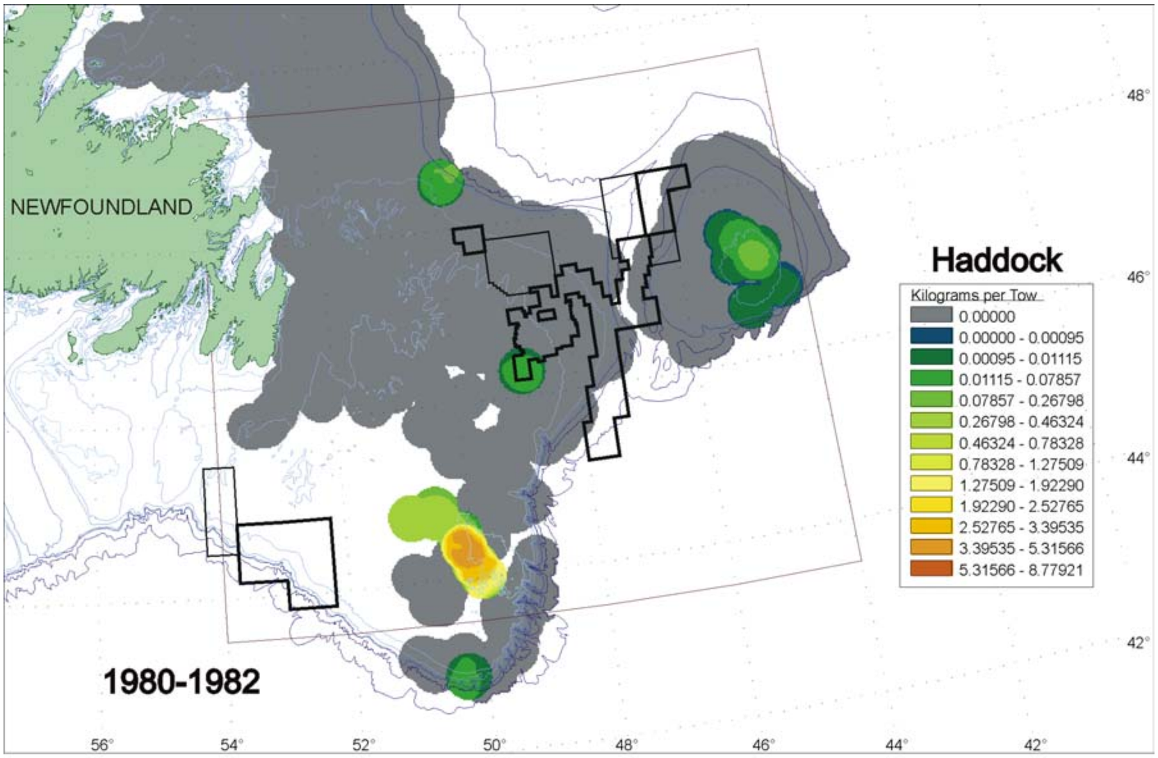


Figure 10d. Haddock distribution based on spring research surveys from 1998-2000. Gray sections represent areas sampled with no catch rate values.



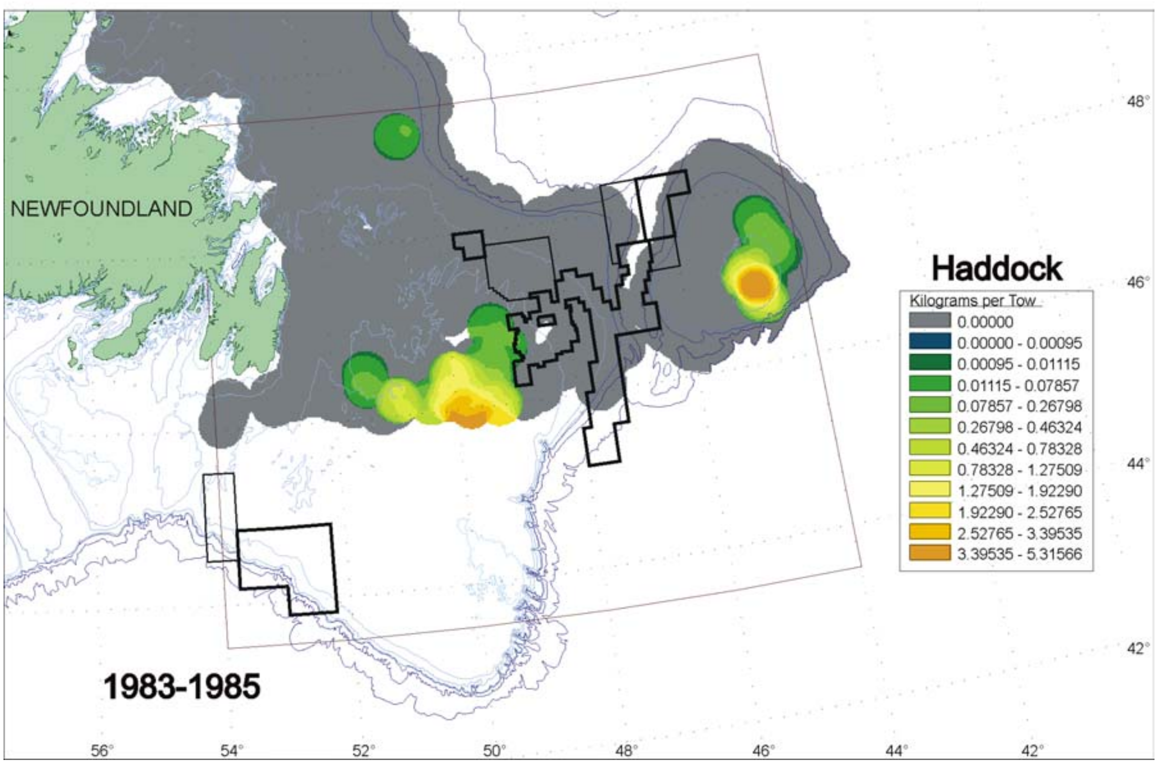
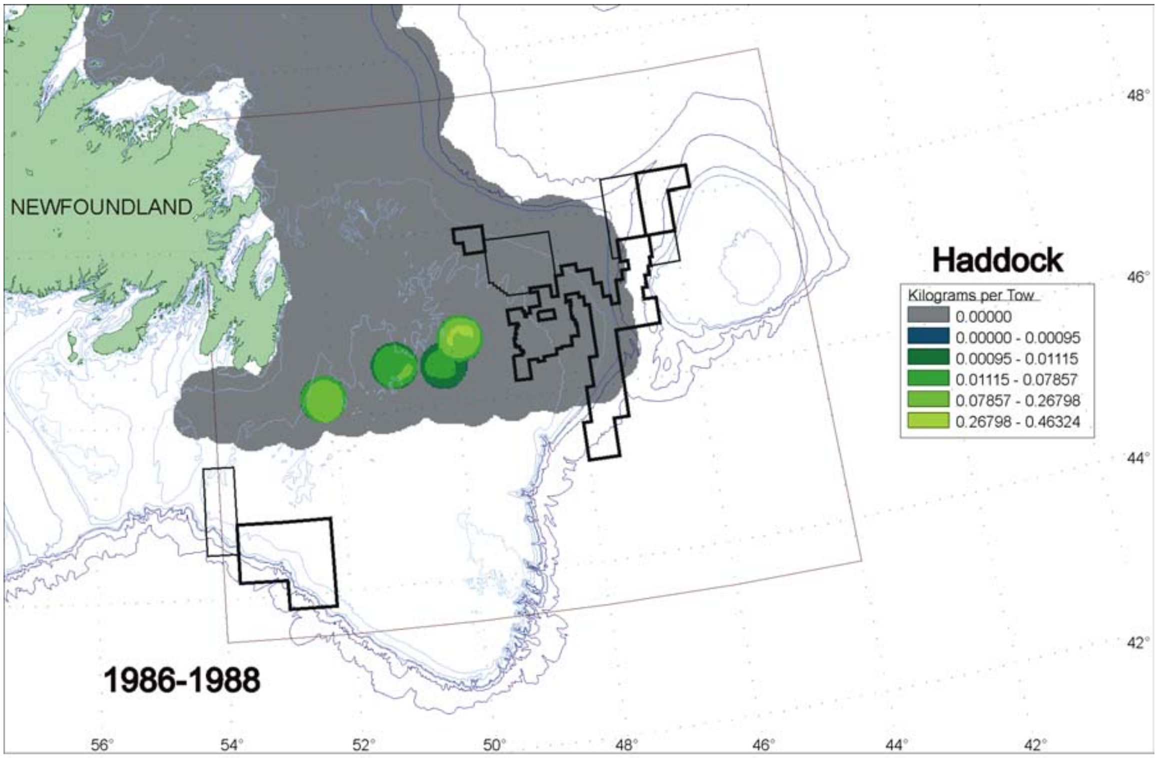


Figure 11a. Haddock distribution based on fall research surveys from 1980-82 & 1983-85. Gray sections represent areas sampled with no catch rate values.



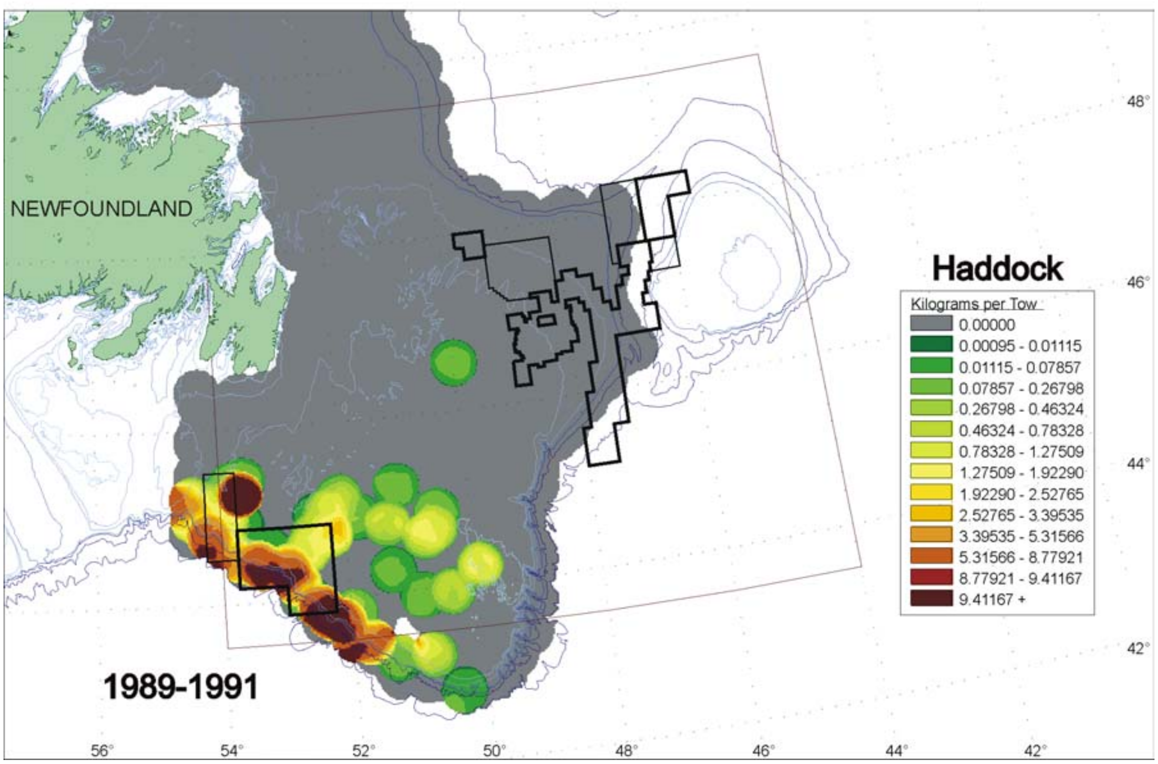
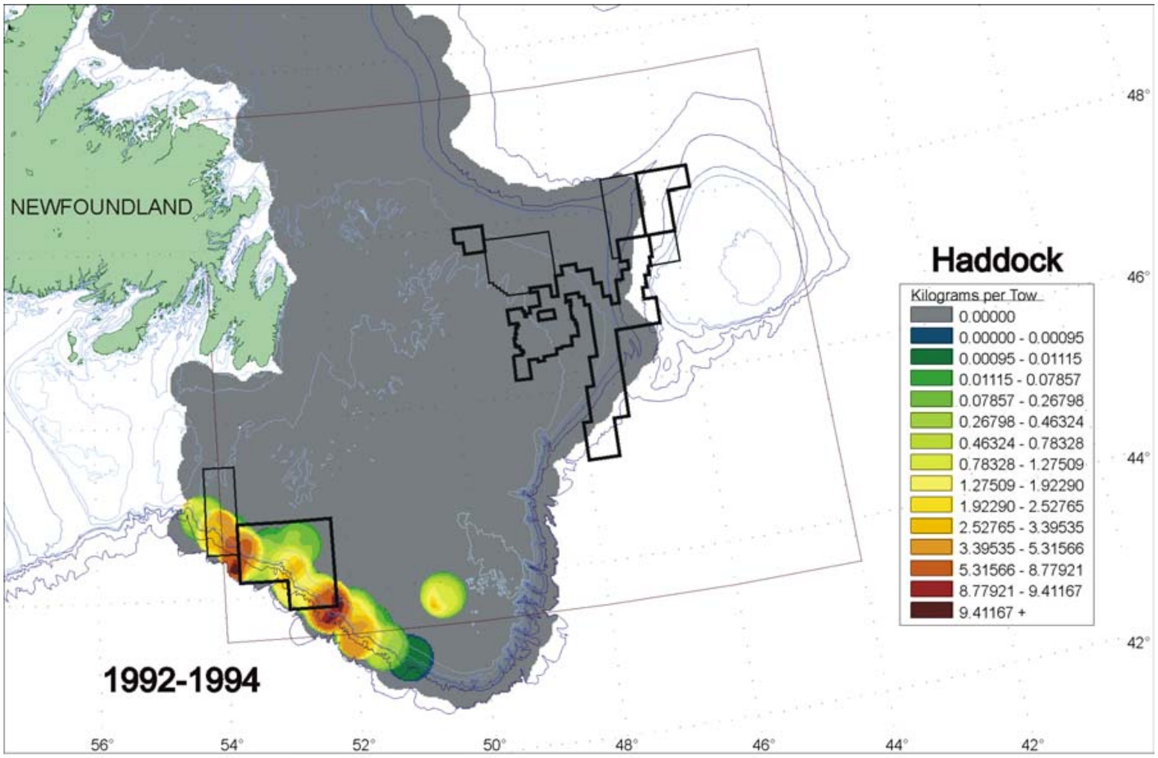


Figure 11b. Haddock distribution based on fall research surveys from 1986-88 & 1989-91. Gray sections represent areas sampled with no catch rate values.



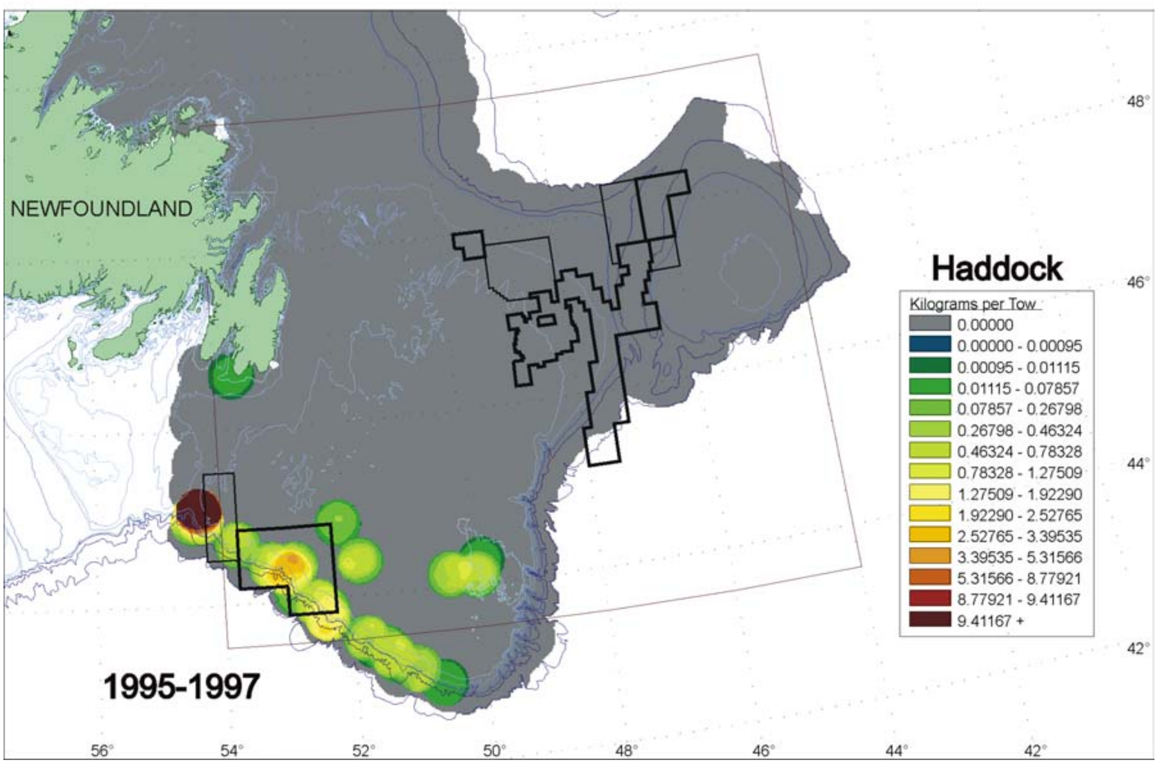


Figure 11c. Haddock distribution based on fall research surveys from 1992-94 & 1995-97. Gray sections represent areas sampled with no catch rate values.

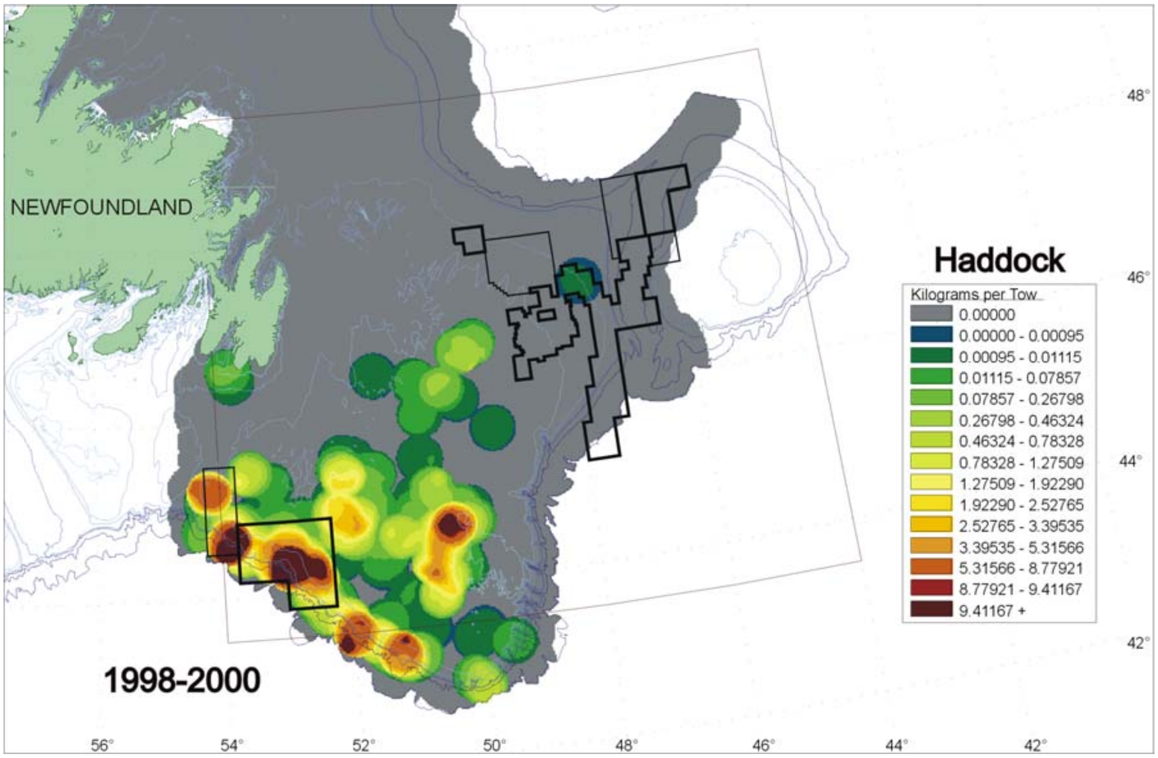


Figure 11d. Haddock distribution based on fall research surveys from 1998-2000. Gray sections represent areas sampled with no catch rate values.

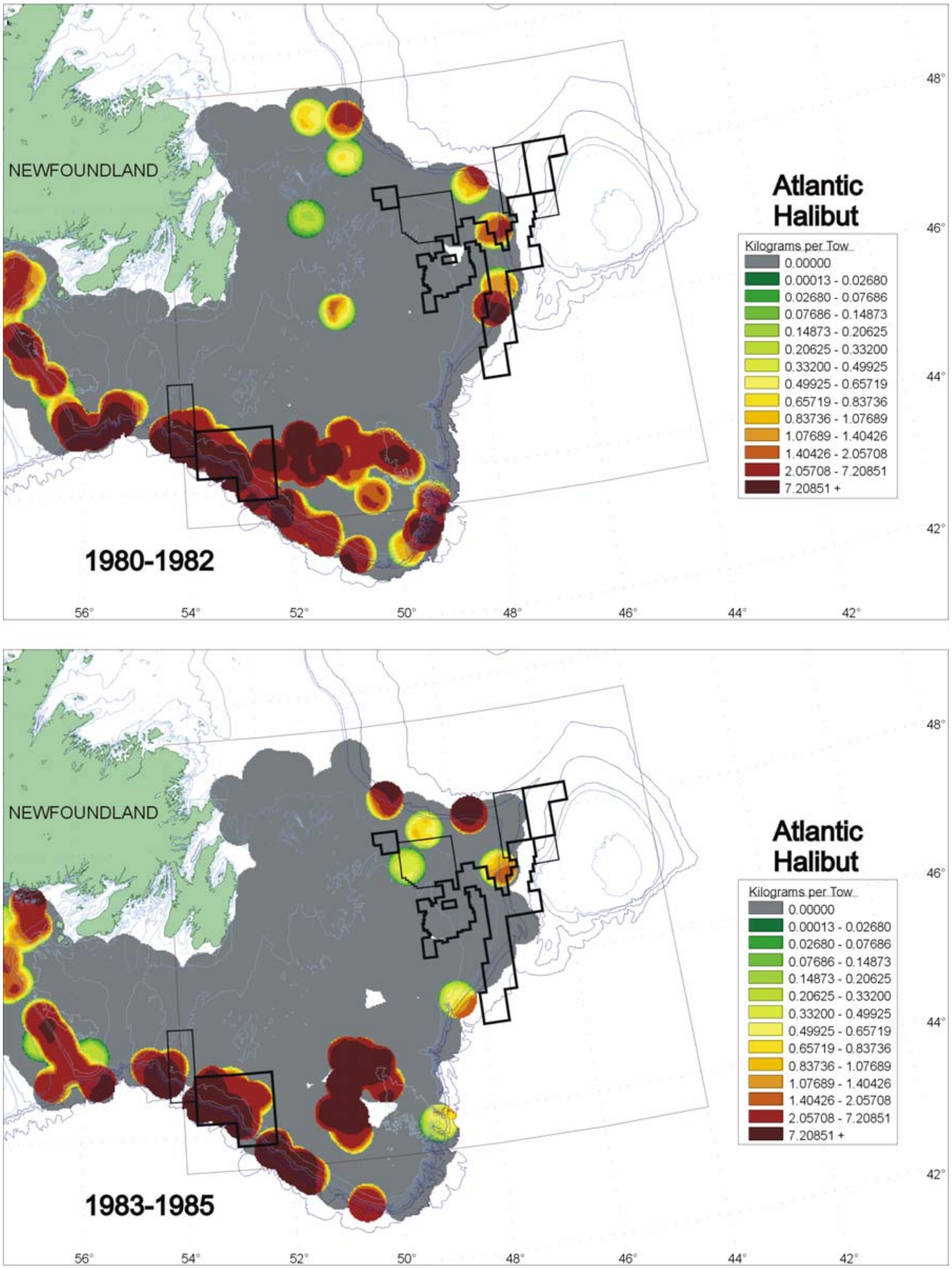
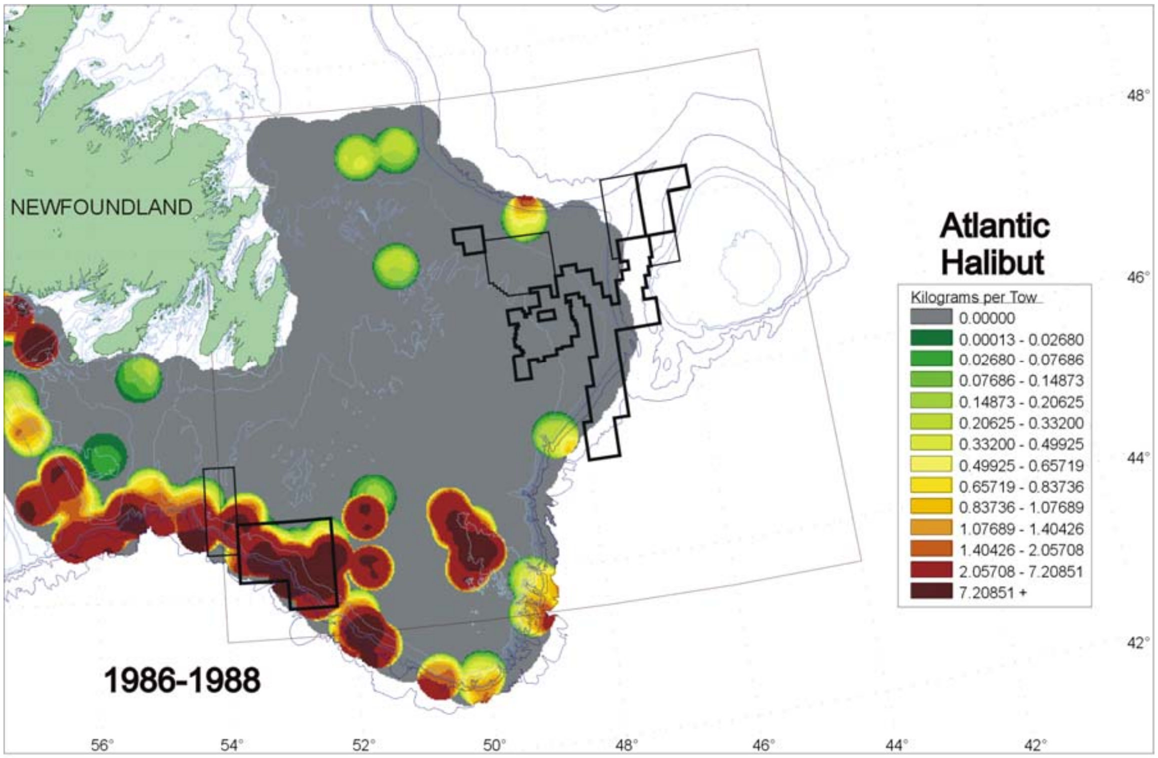


Figure 12a. Atlantic Halibut distribution based on spring research surveys from 1980-82 & 1983-85. Gray sections represent areas sampled with no catch rate values.



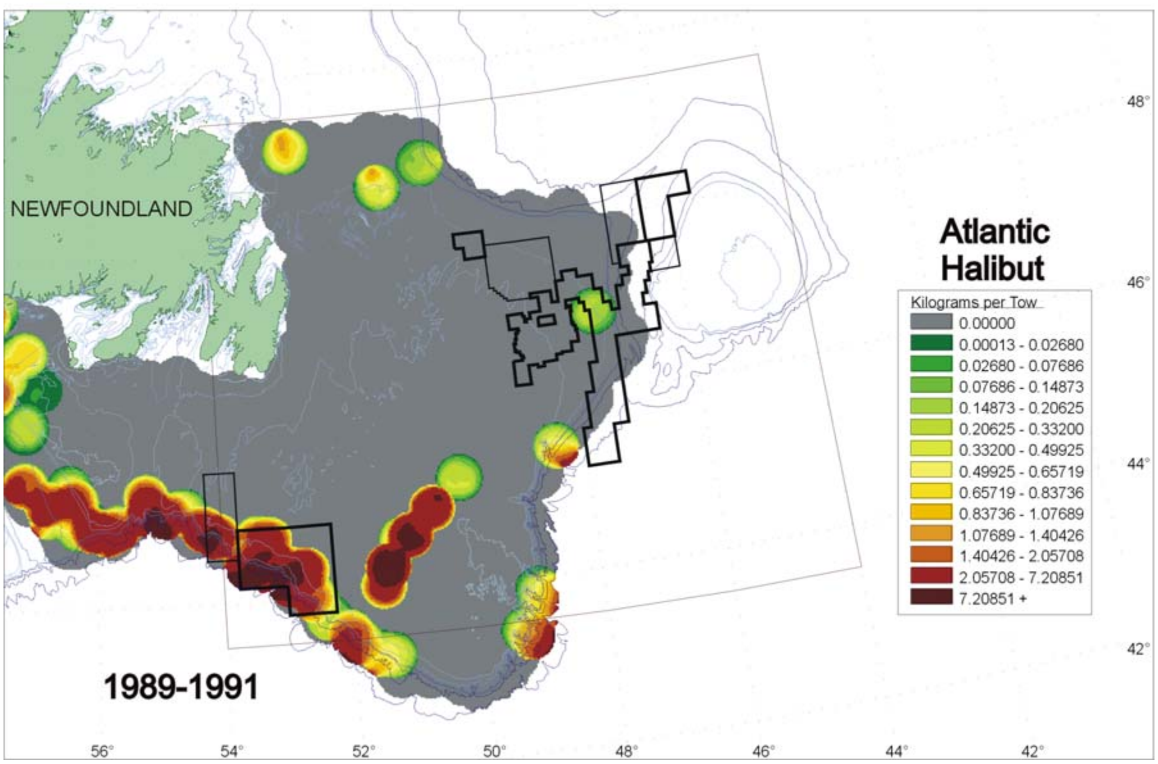


Figure 12b. Atlantic Halibut distribution based on spring research surveys from 1986-88 & 1989-91. Gray sections represent areas sampled with no catch rate values.

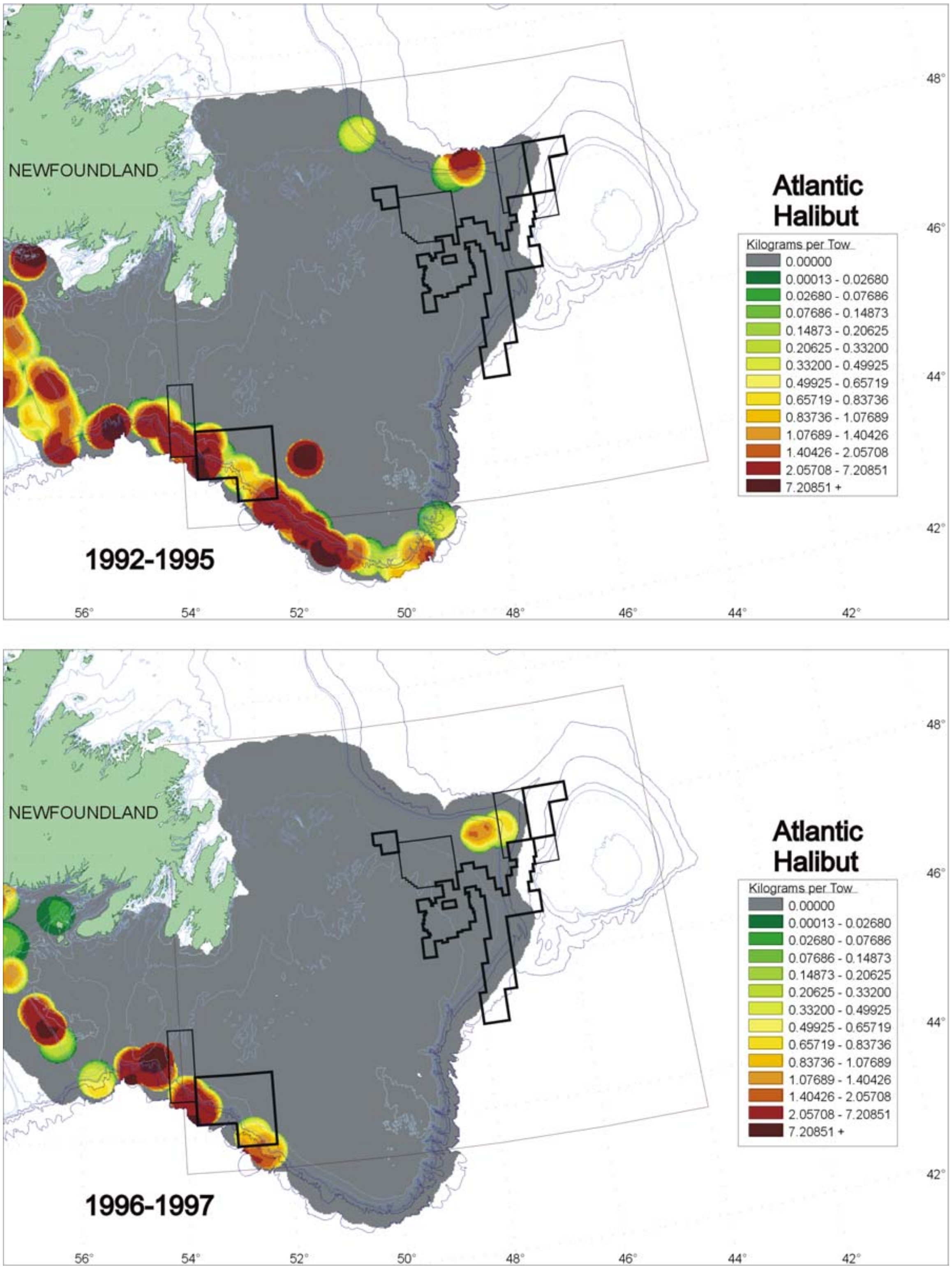


Figure 12c. Atlantic Halibut distribution based on spring research surveys from 1992-95 & 1996-97. Gray sections represent areas sampled with no catch rate values.

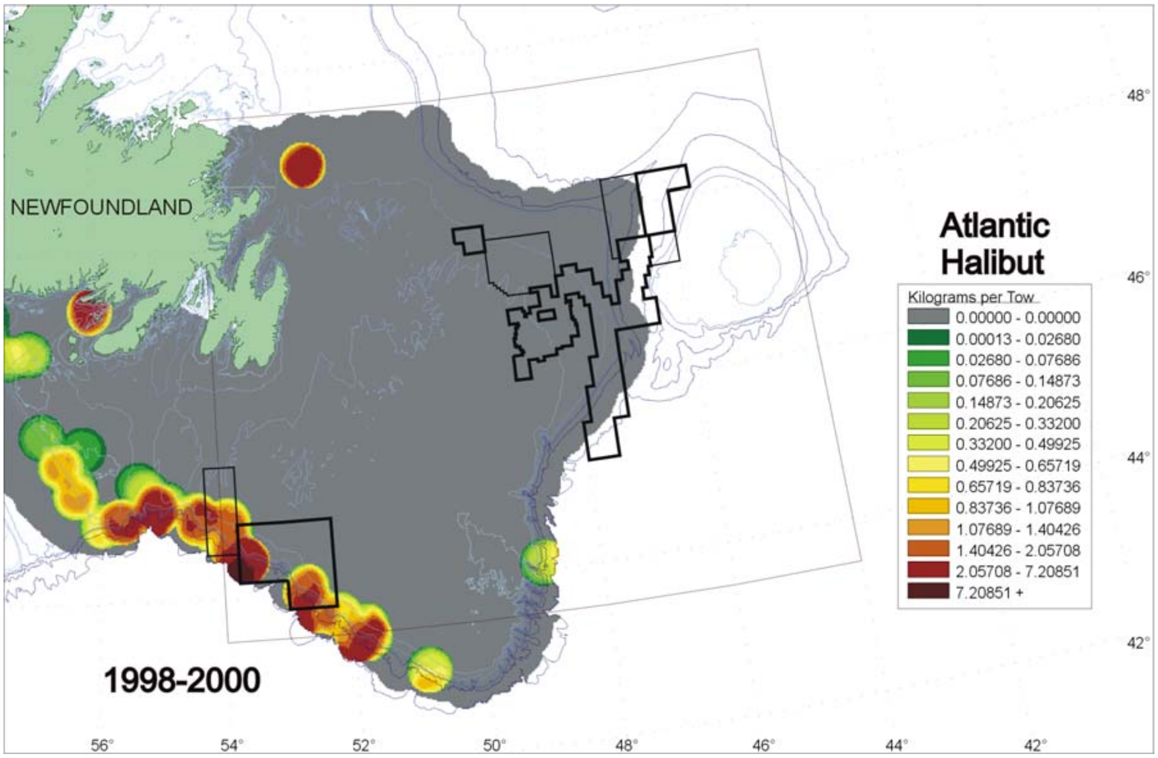


Figure 12d. Atlantic Halibut distribution based on spring research surveys from 1998-2000. Gray sections represent areas sampled with no catch rate values.

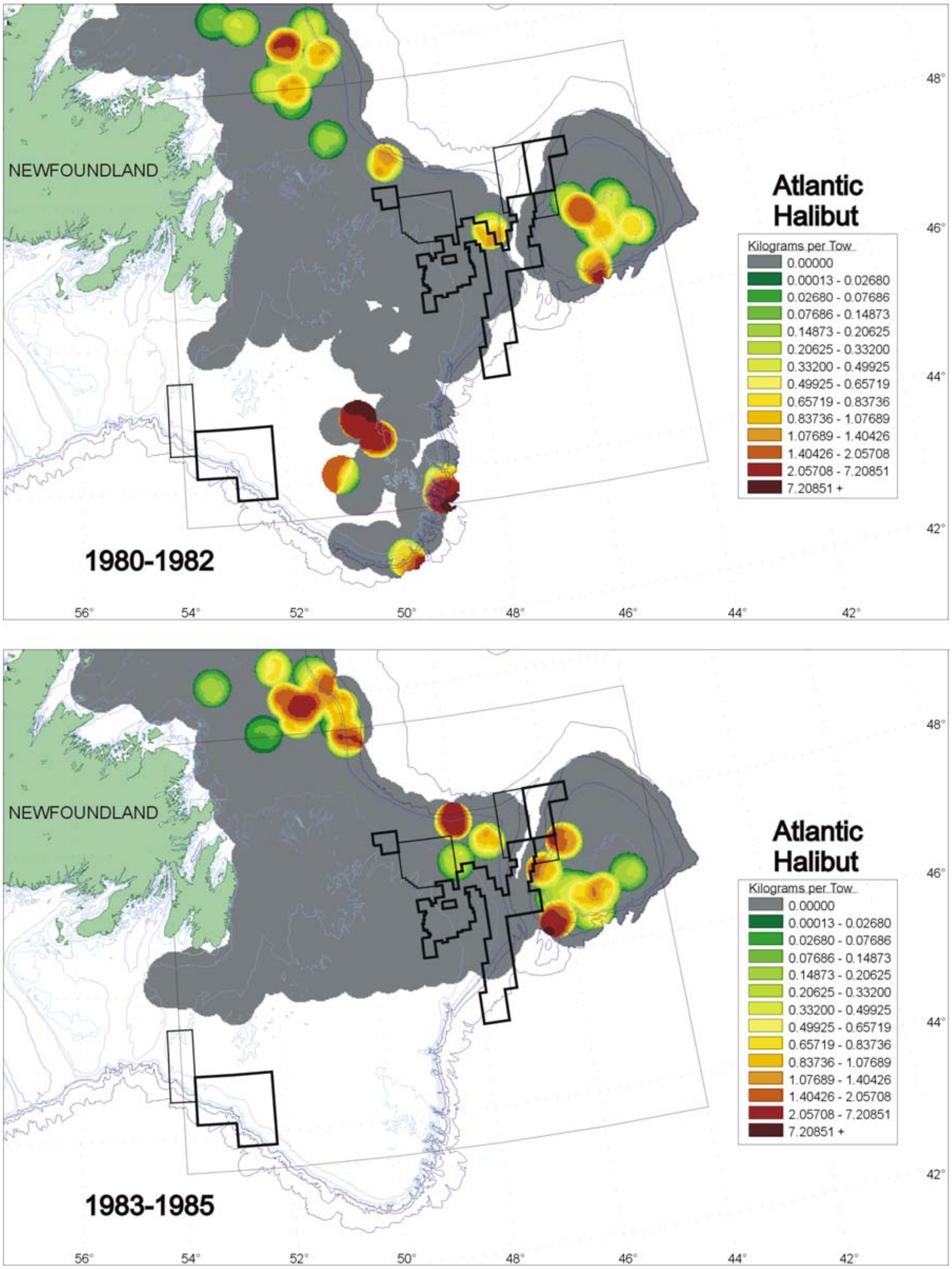
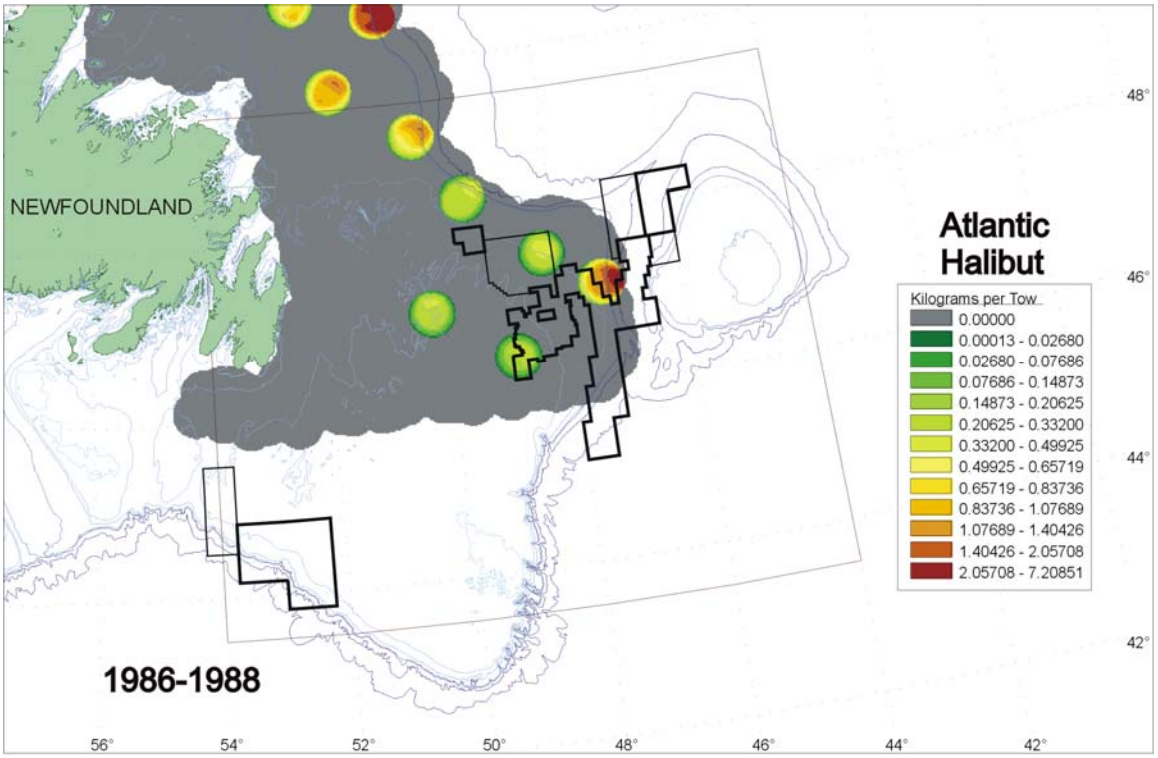


Figure 13a. Atlantic Halibut distribution based on fall research surveys from 1980-82 & 1983-85. Gray sections represent areas sampled with no catch rate values.



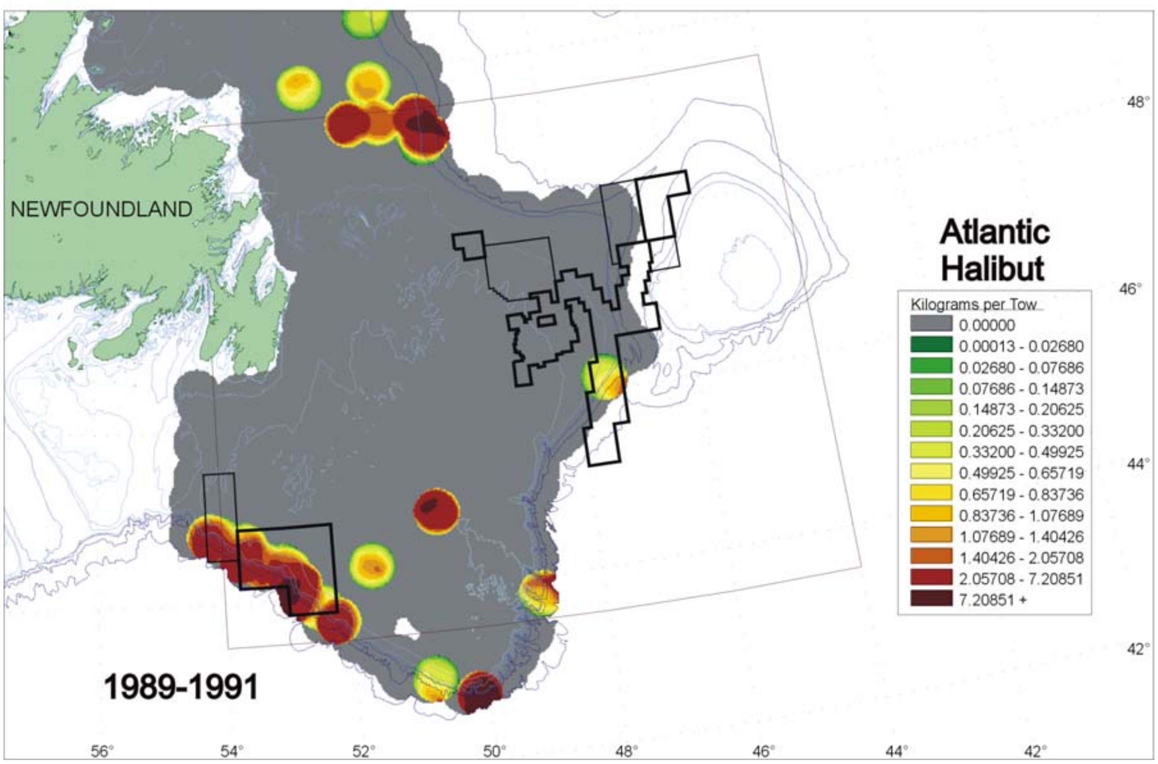


Figure 13b. Atlantic Halibut distribution based on fall research surveys from 1986-88 & 1989-91. Gray sections represent areas sampled with no catch rate values.

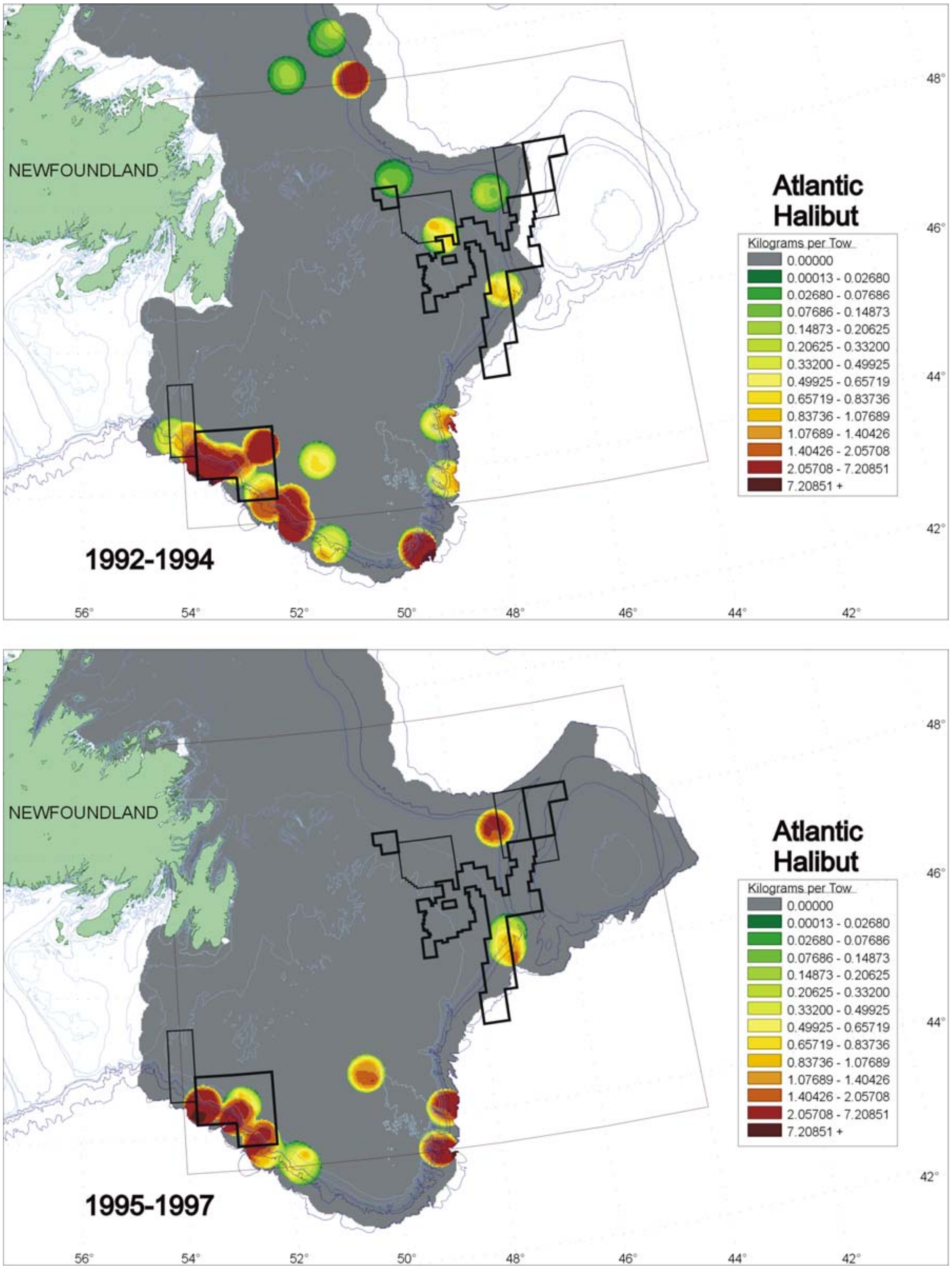


Figure 13c. Atlantic Halibut distribution based on fall research surveys from 1992-94 & 1995-97. Gray sections represent areas sampled with no catch rate values.

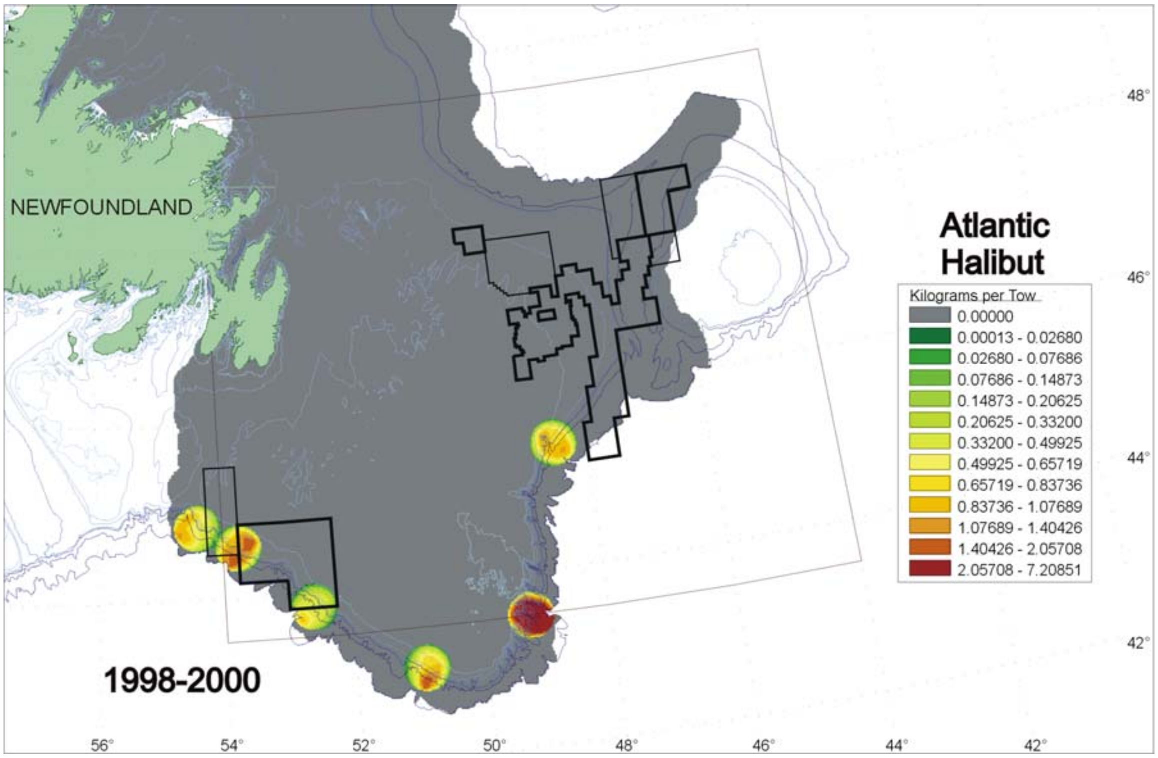
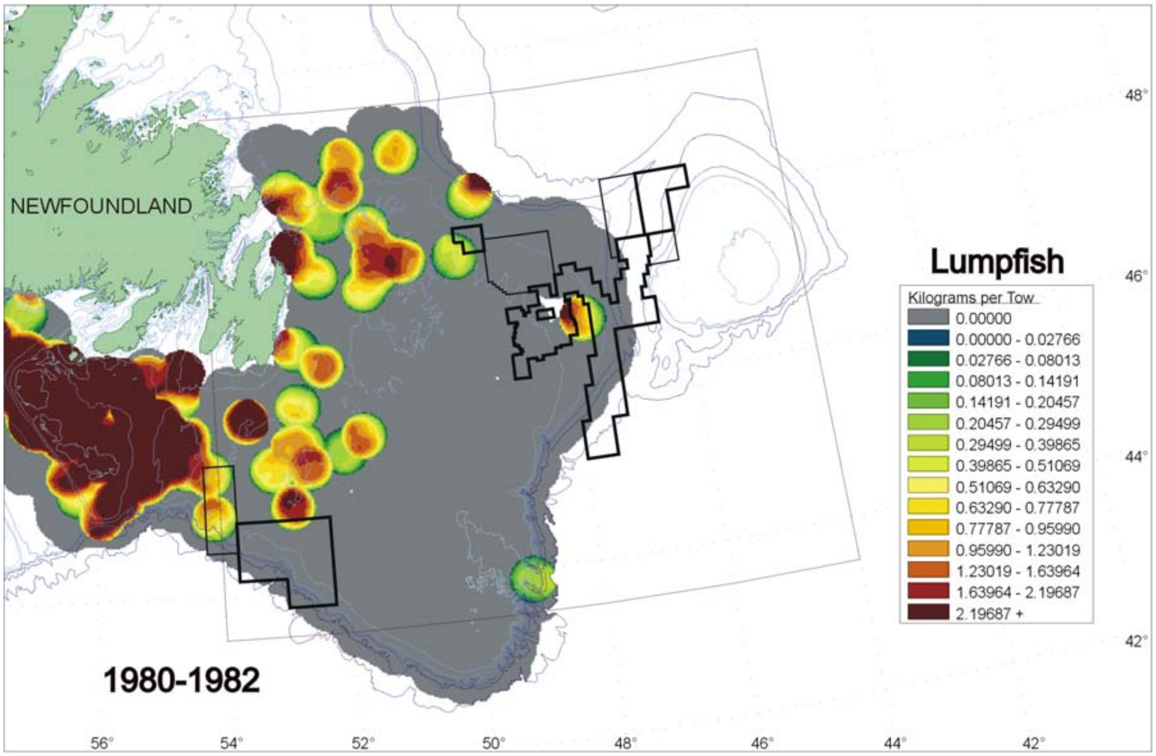


Figure 13d. Atlantic Halibut distribution based on fall research surveys from 1998-2000. Gray sections represent areas sampled with no catch rate values.



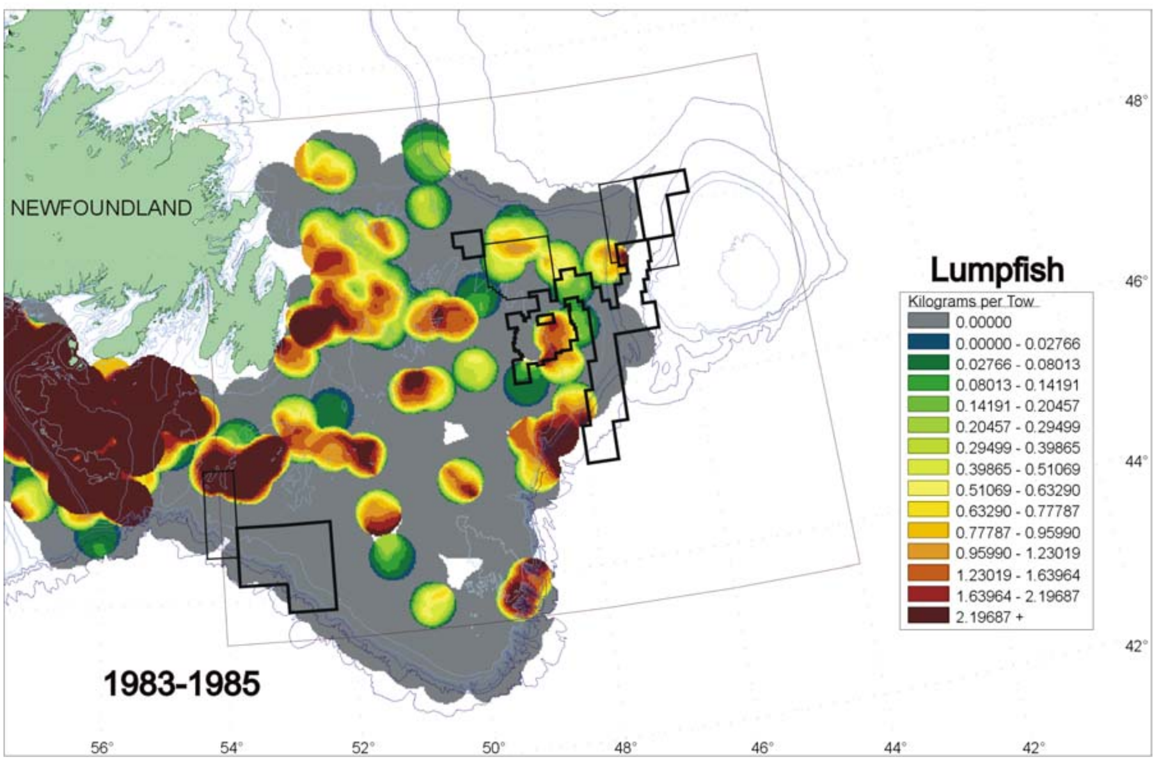
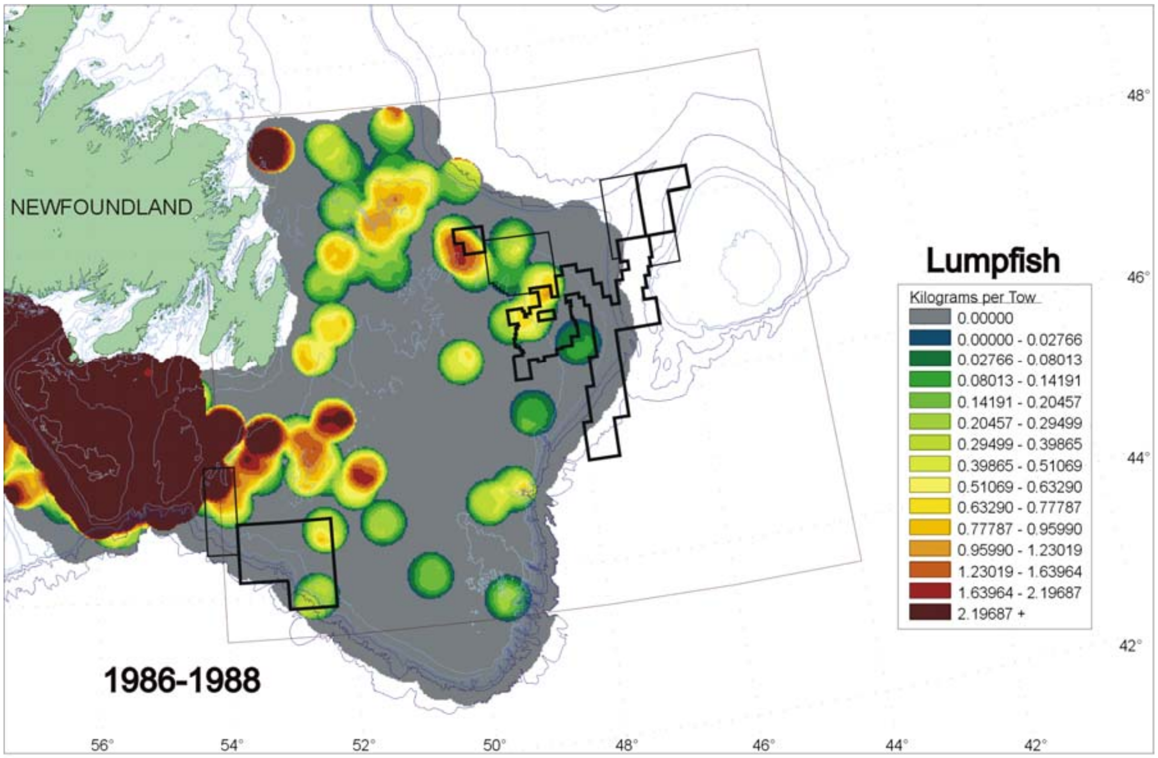


Figure 14a. Lumpfish distribution based on spring research surveys from 1980-82 & 1983-85. Gray sections represent areas sampled with no catch rate values.



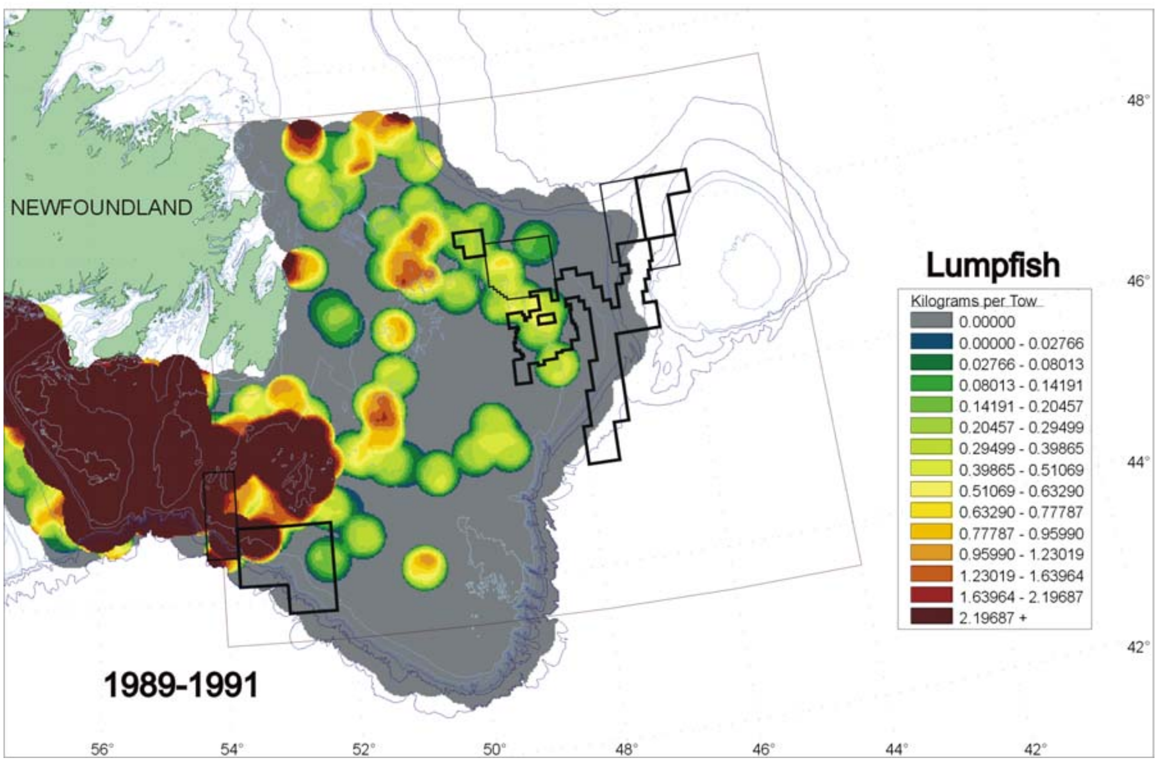


Figure 14b. Lumpfish distribution based on spring research surveys from 1986-88 & 1989-91. Gray sections represent areas sampled with no catch rate values.

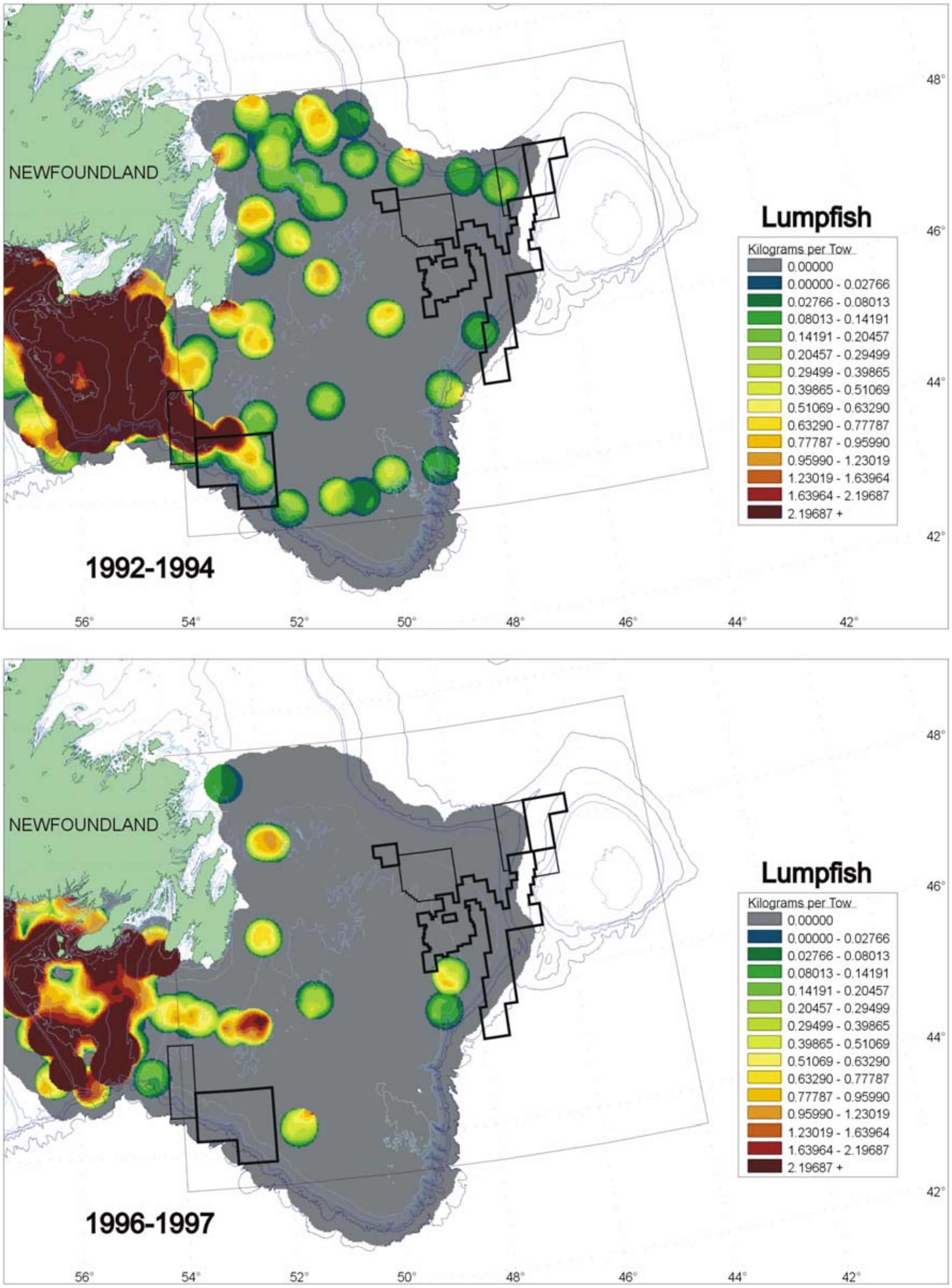


Figure 14c. Lumpfish distribution based on spring research surveys from 1992-95 & 1996-97. Gray sections represent areas sampled with no catch rate values.

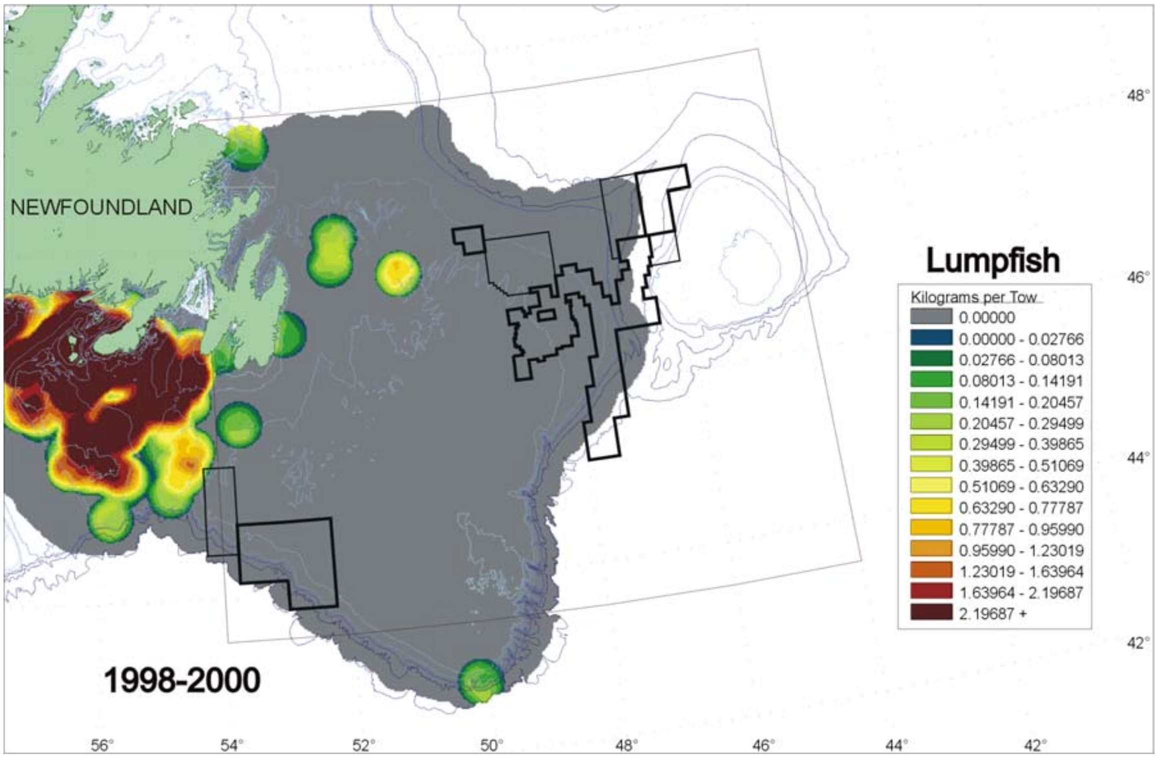


Figure 14d. Lumpfish distribution based on spring research surveys from 1998-2000. Gray sections represent areas sampled with no catch rate values.

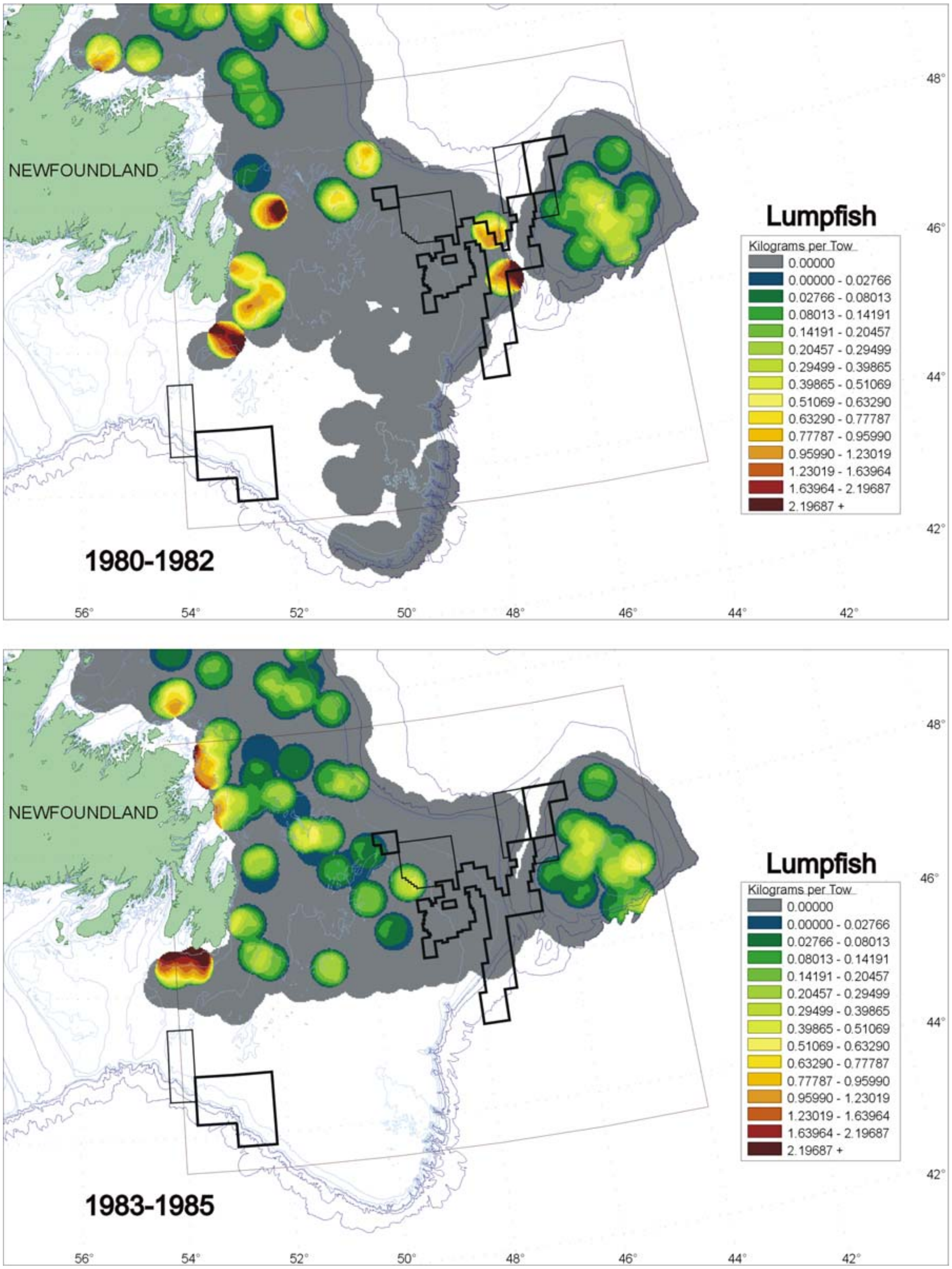


Figure 15a. Lumpfish distribution based on fall research surveys from 1980-82 & 1983-85. Gray sections represent areas sampled with no catch rate values.

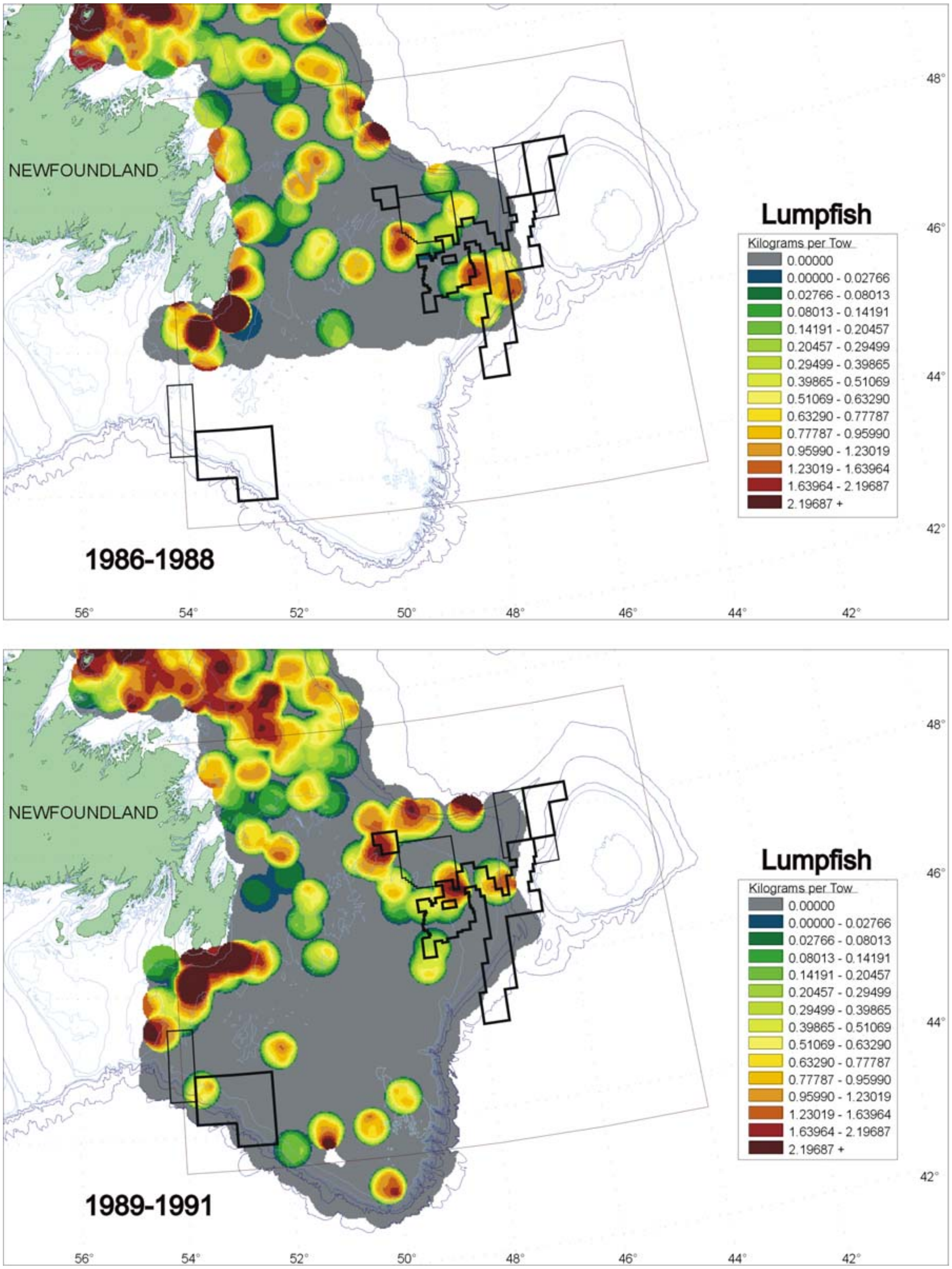


Figure 15b. Lumpfish distribution based on fall research surveys from 1986-88 & 1989-91. Gray sections represent areas sampled with no catch rate values.

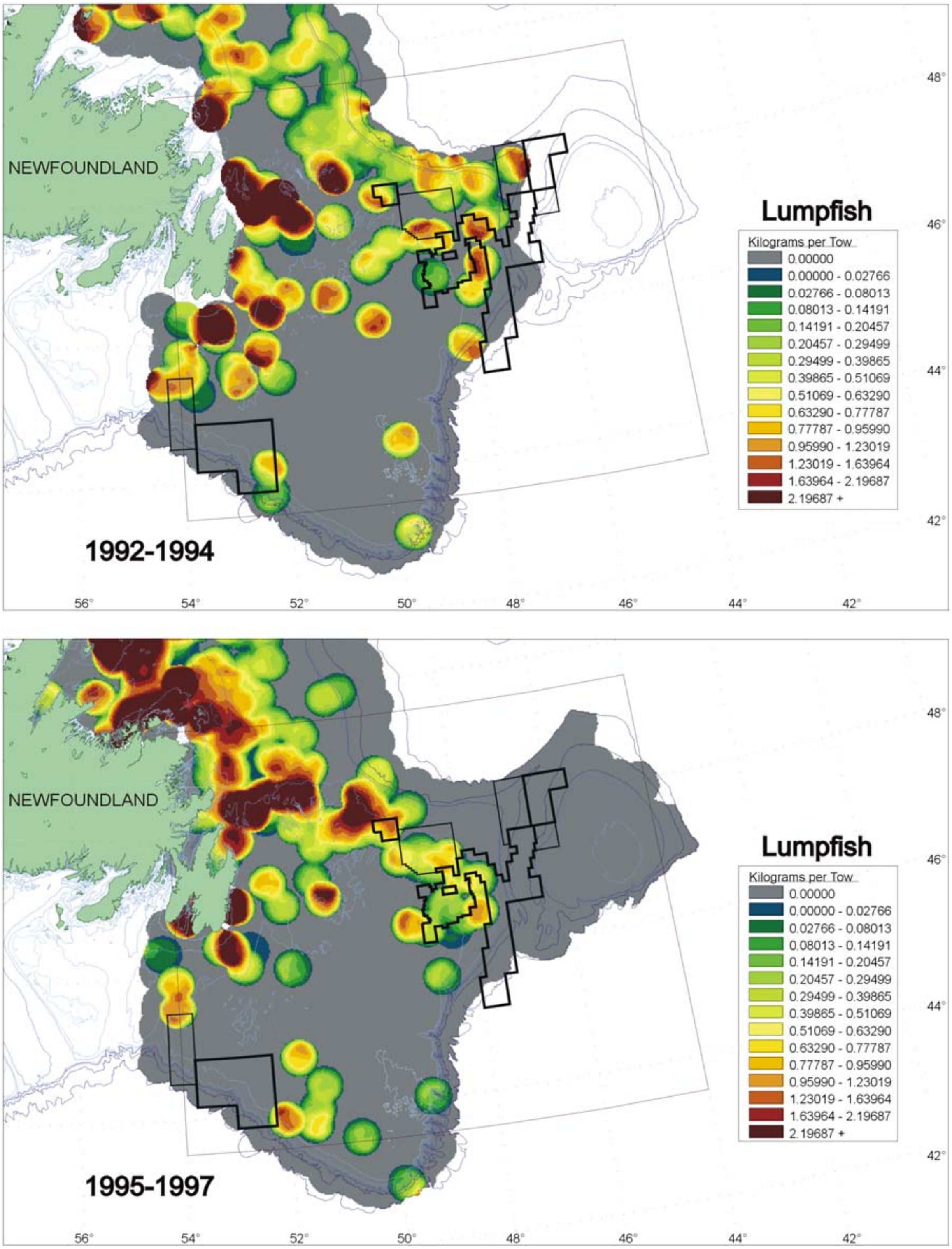


Figure 15c. Lumpfish distribution based on fall research surveys from 1992-94 & 1995-97. Gray sections represent areas sampled with no catch rate values.

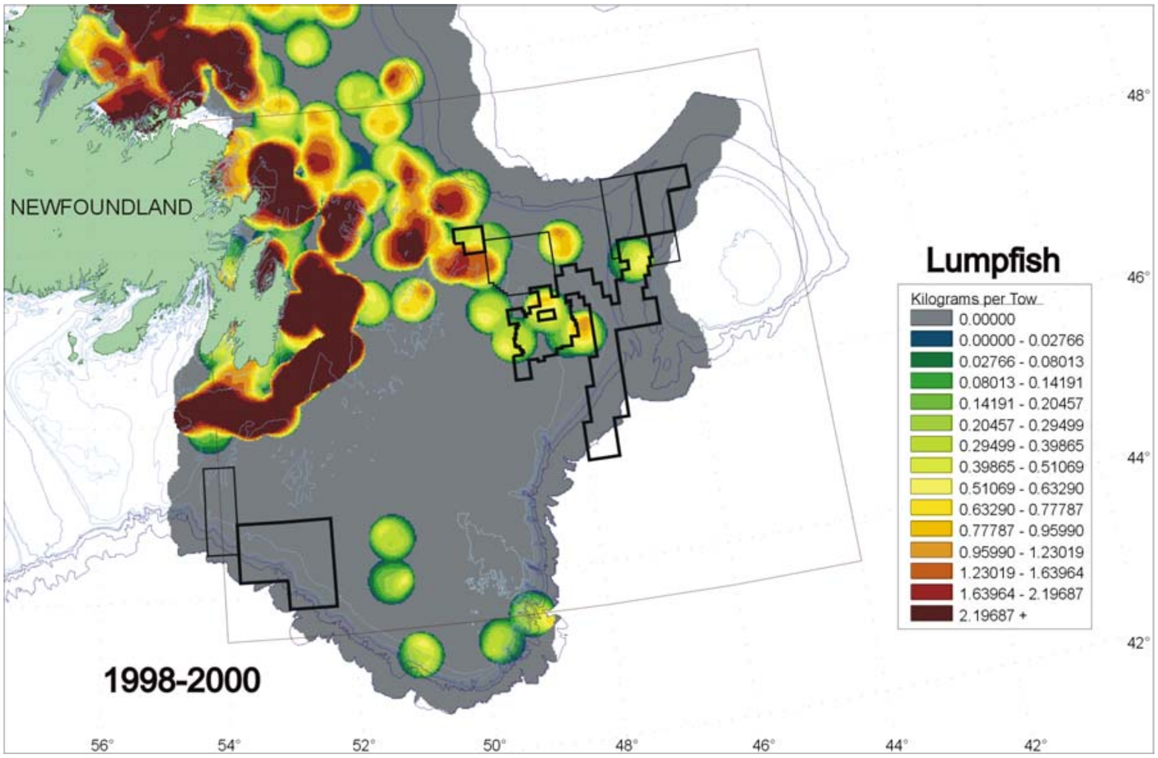


Figure 15d. Lumpfish distribution based on fall research surveys from 1998-2000. Gray sections represent areas sampled with no catch rate values.

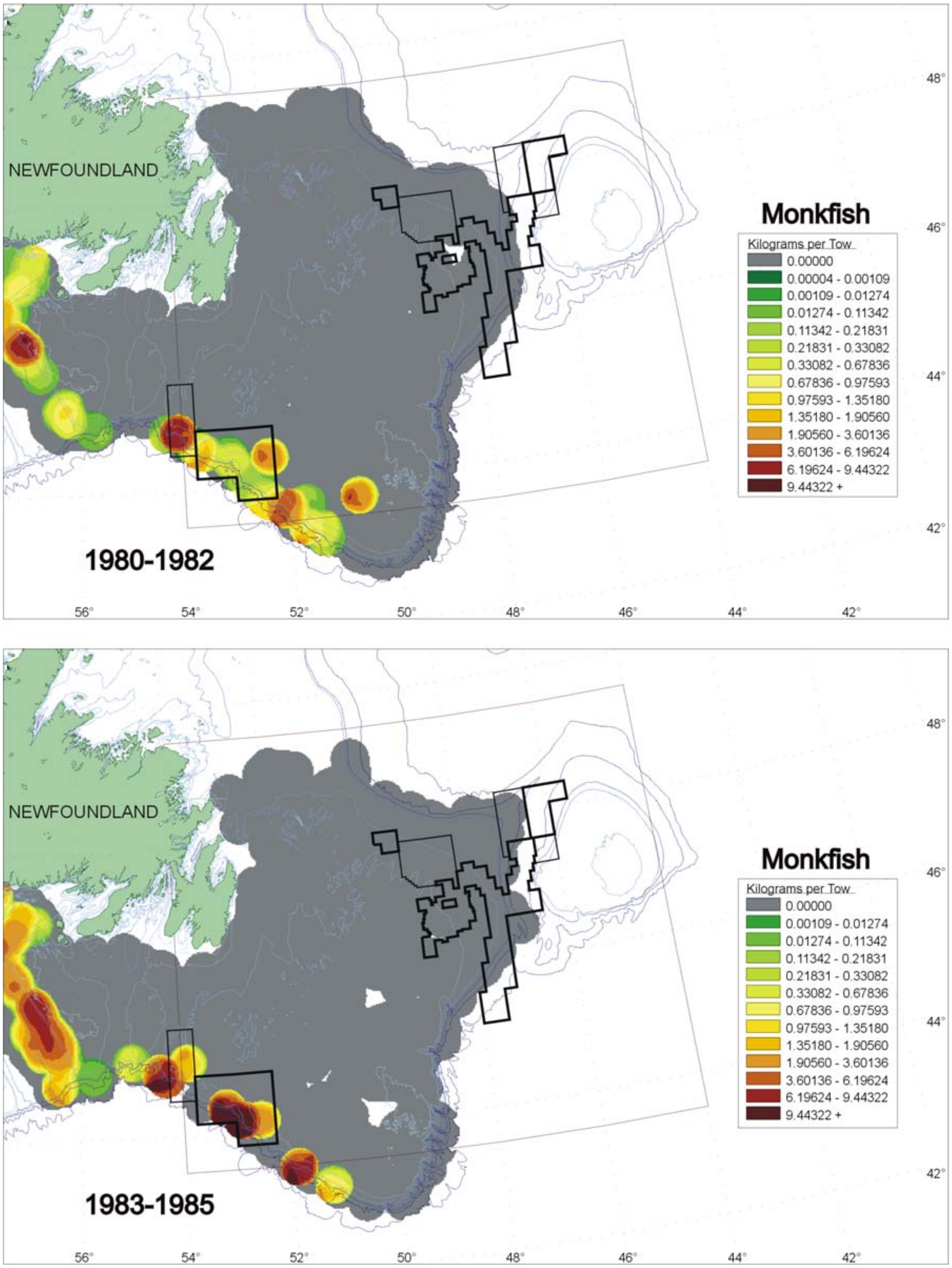
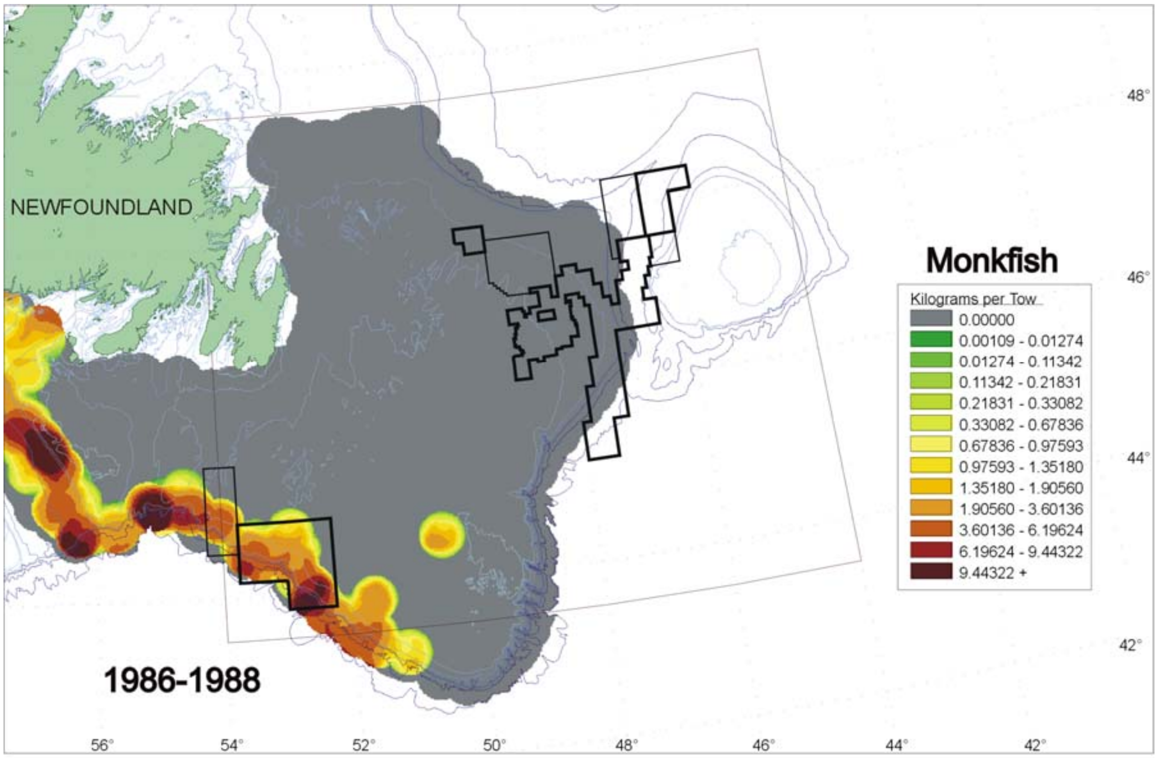


Figure 16a. Monkfish distribution based on spring research surveys from 1980-82 & 1983-85. Gray sections represent areas sampled with no catch rate values.



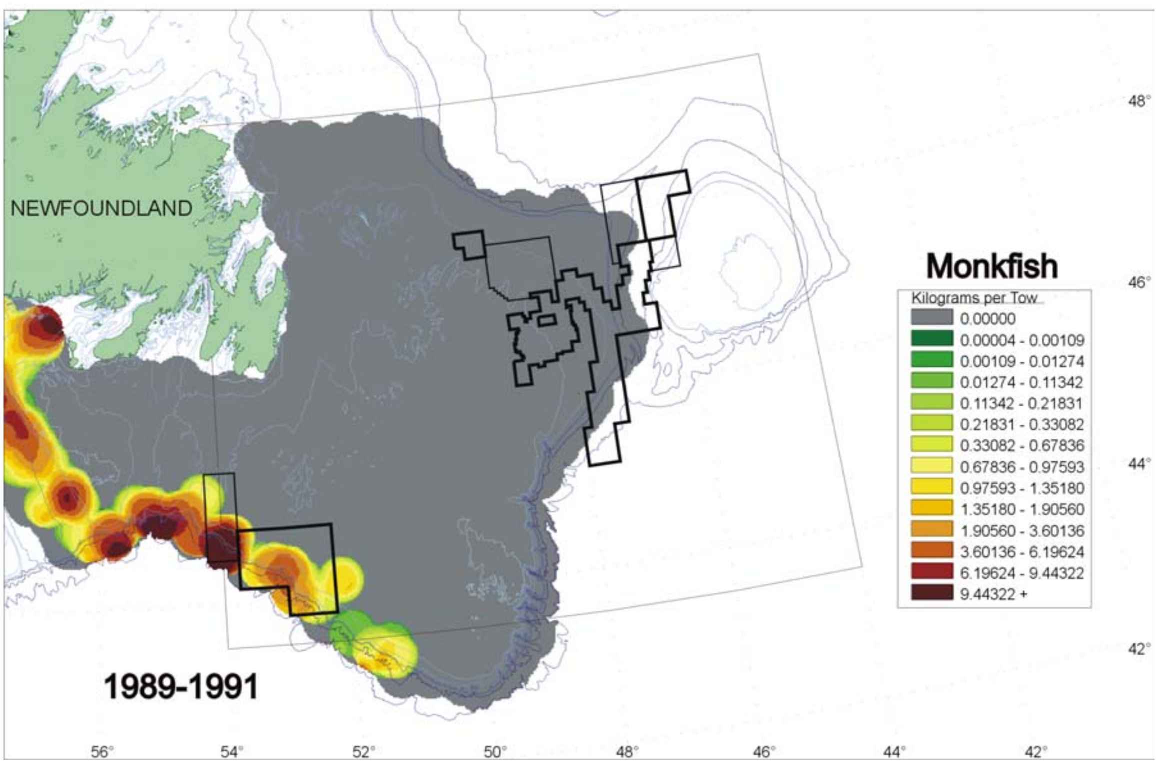
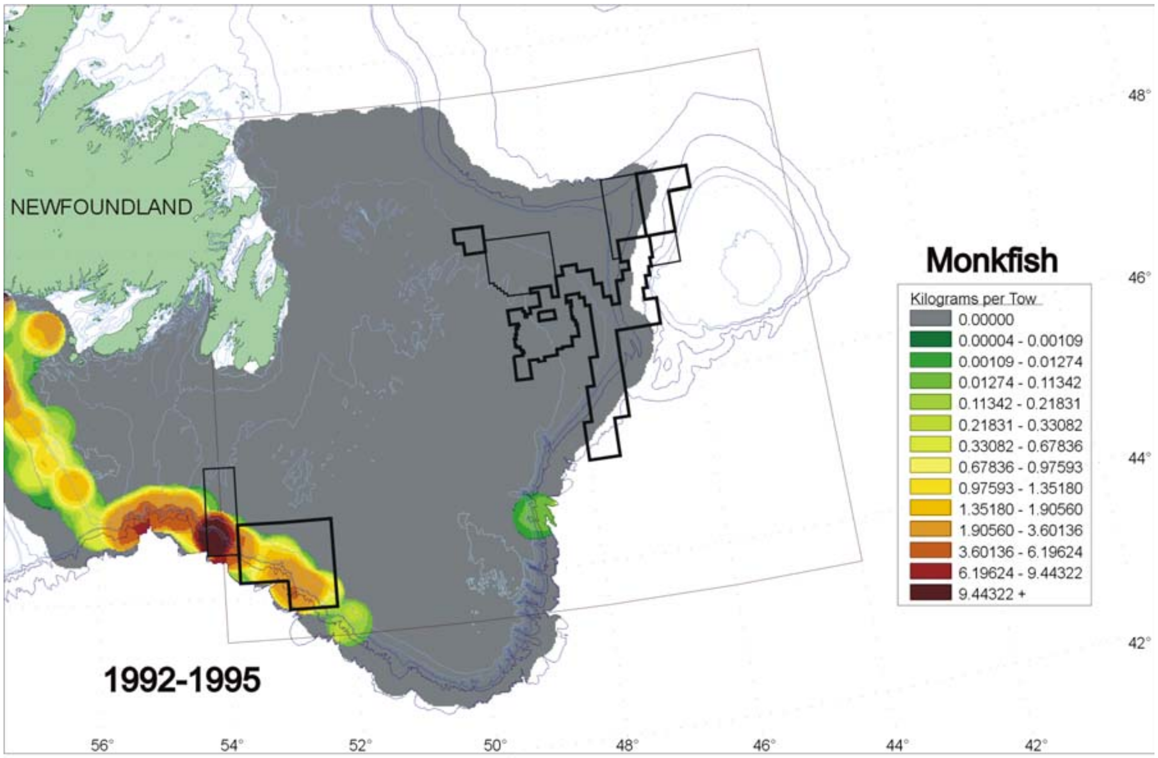


Figure 16b. Monkfish distribution based on spring research surveys from 1986-88 & 1989-91. Gray sections represent areas sampled with no catch rate values.



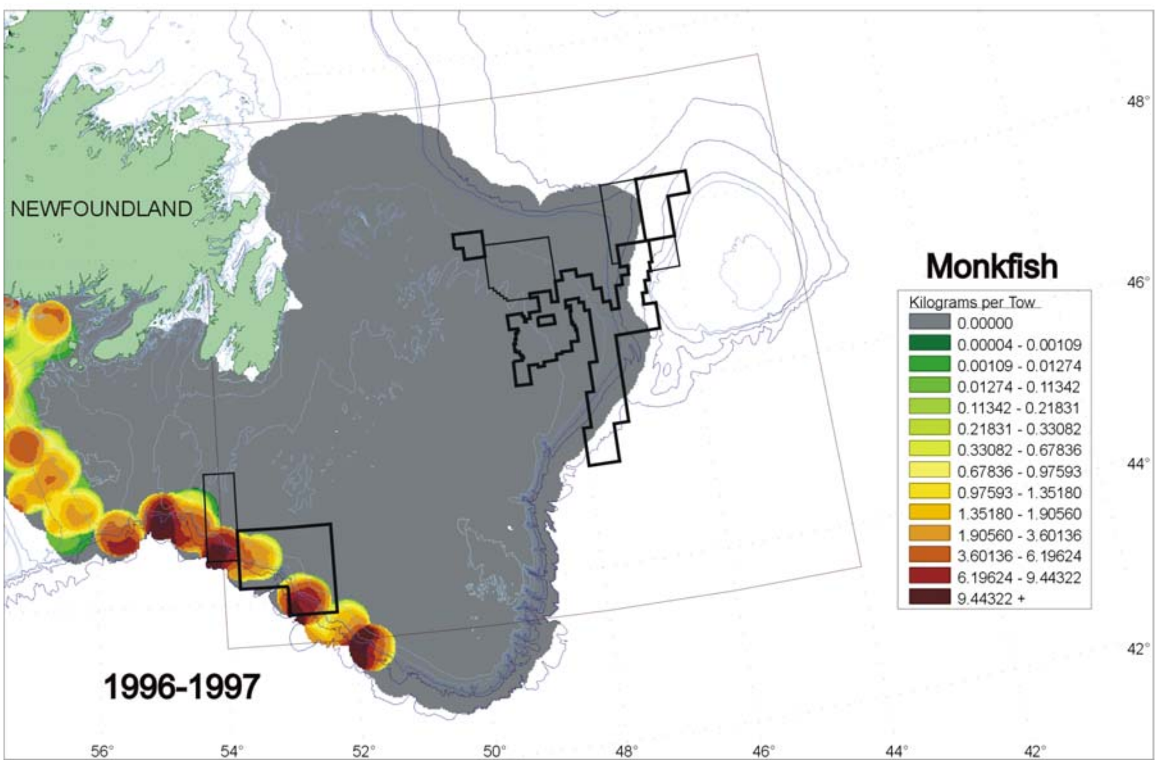


Figure 16c. Monkfish distribution based on spring research surveys from 1992-95 & 1996-97. Gray sections represent areas sampled with no catch rate values.

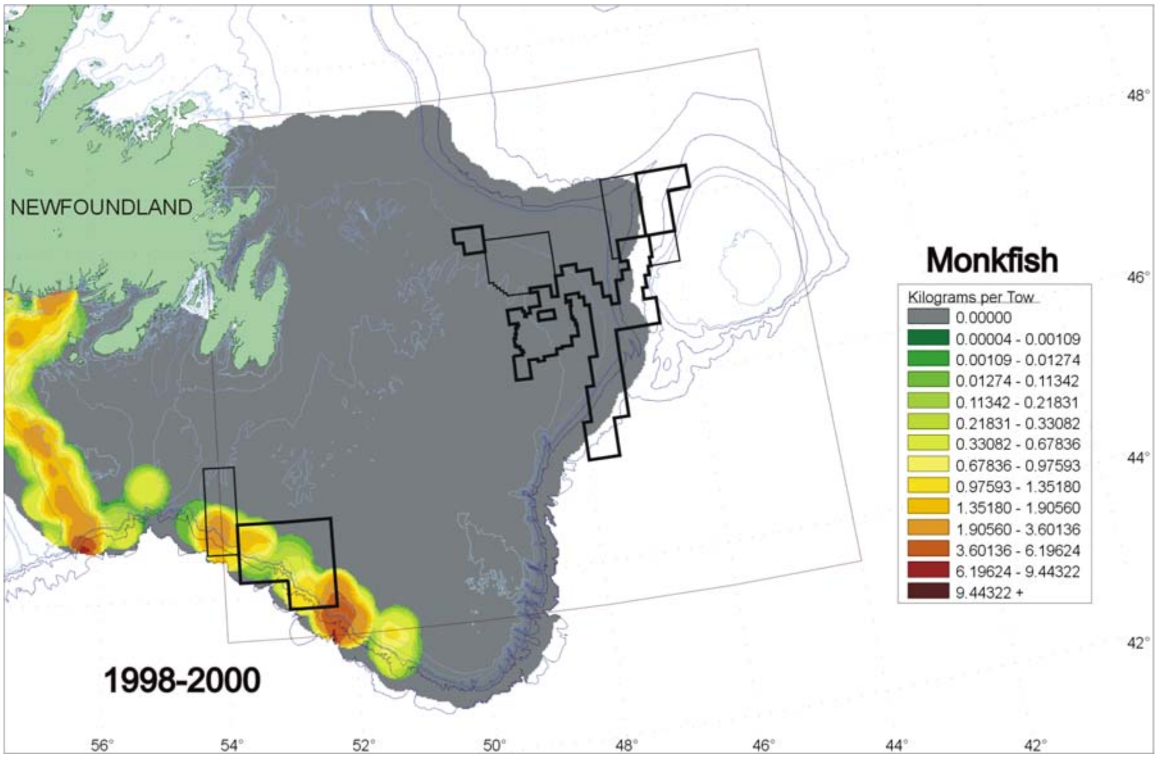
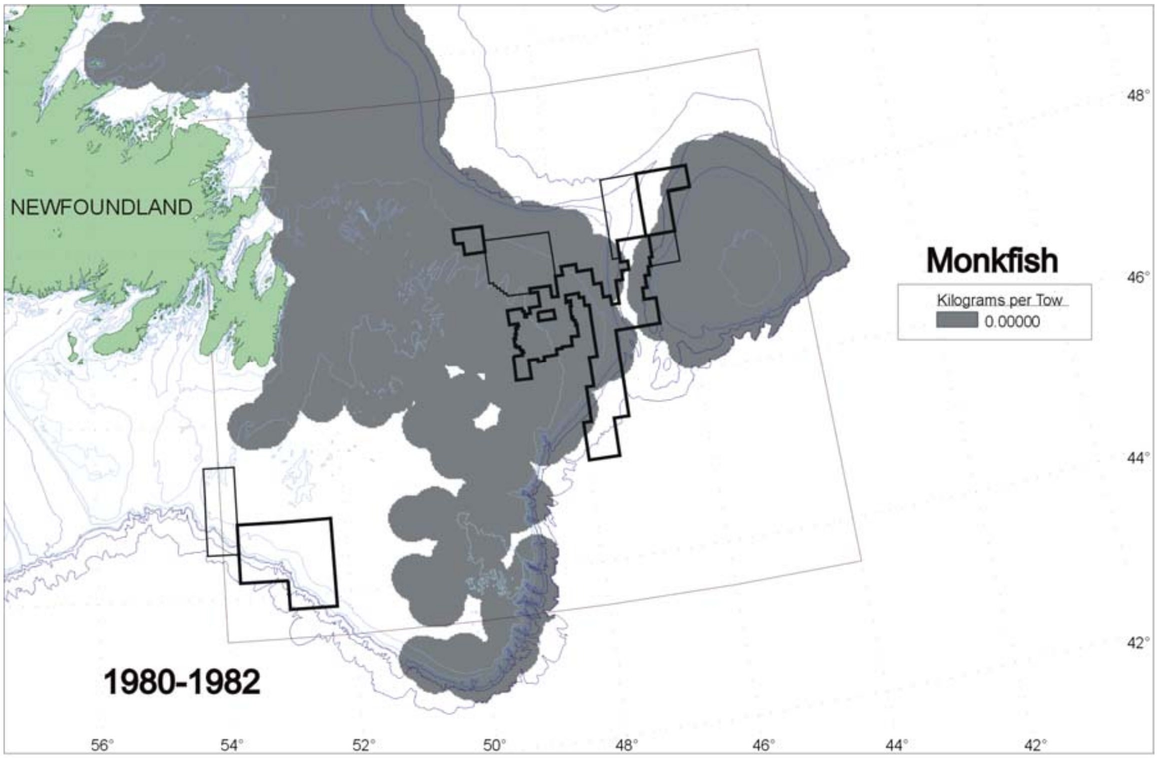


Figure 16d. Monkfish distribution based on spring research surveys from 1998-2000. Gray sections represent areas sampled with no catch rate values.



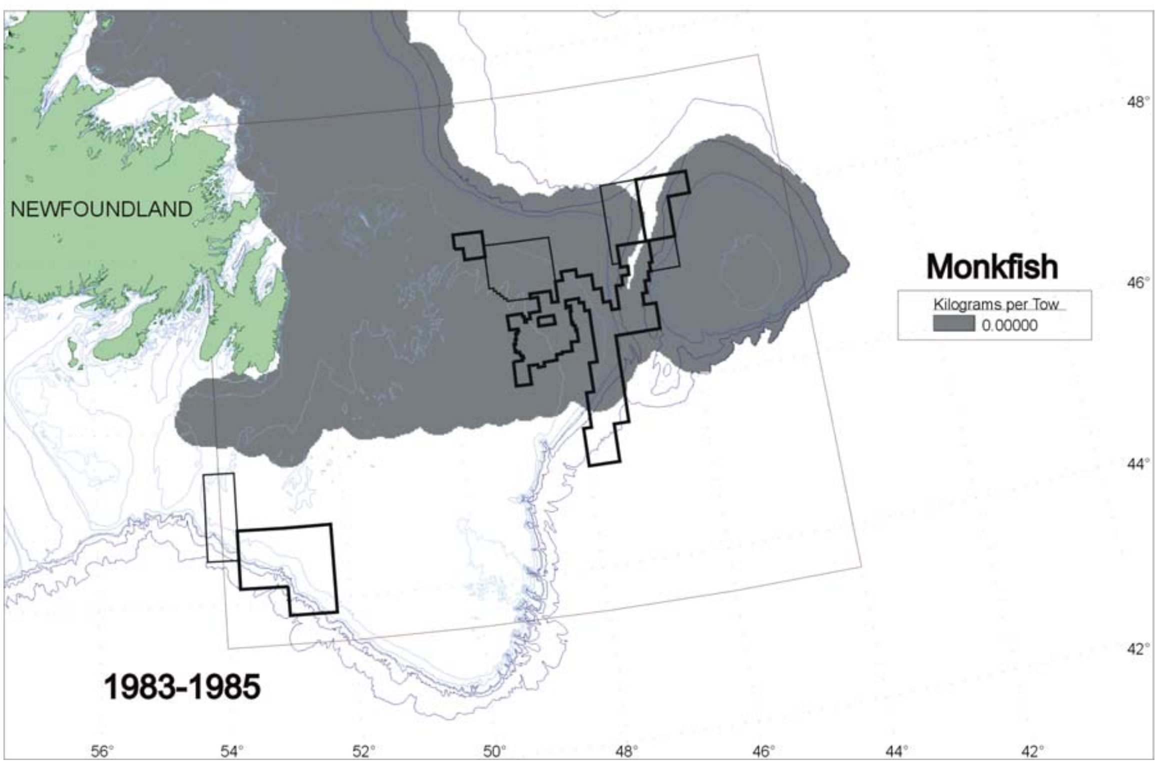
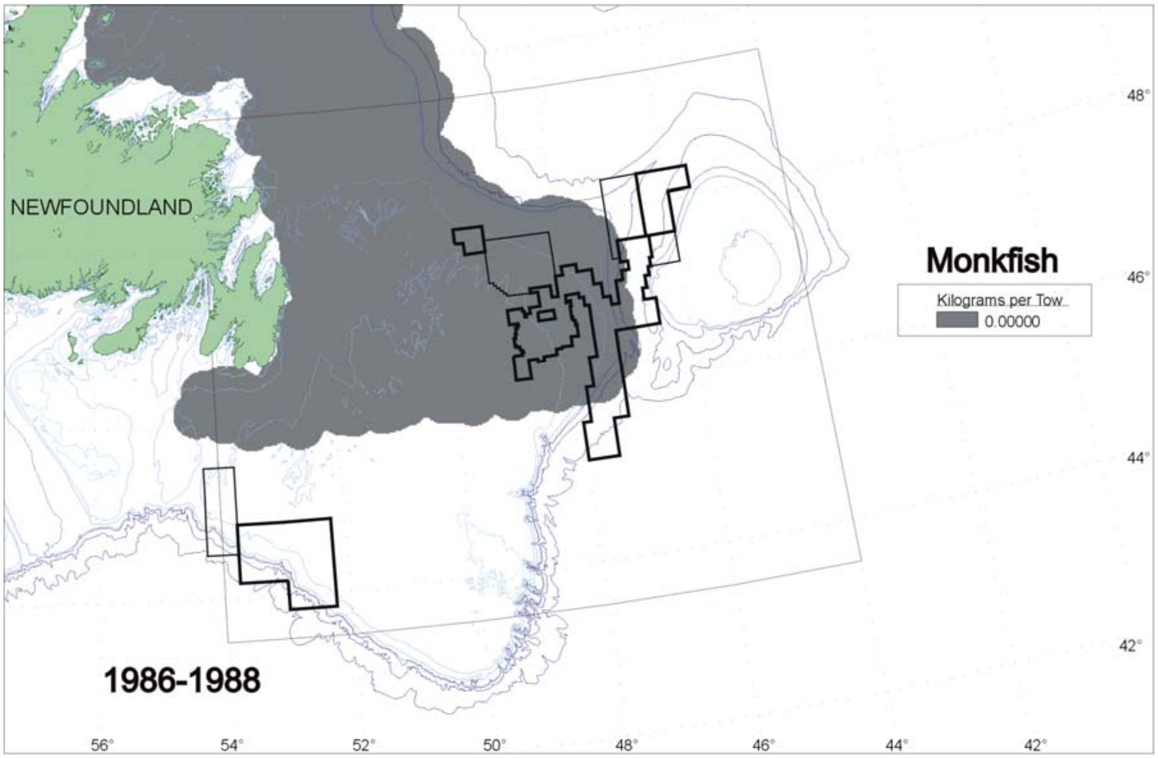


Figure 17a. Monkfish distribution based on fall research surveys from 1980-82 & 1983-85. Gray sections represent areas sampled with no catch rate values.



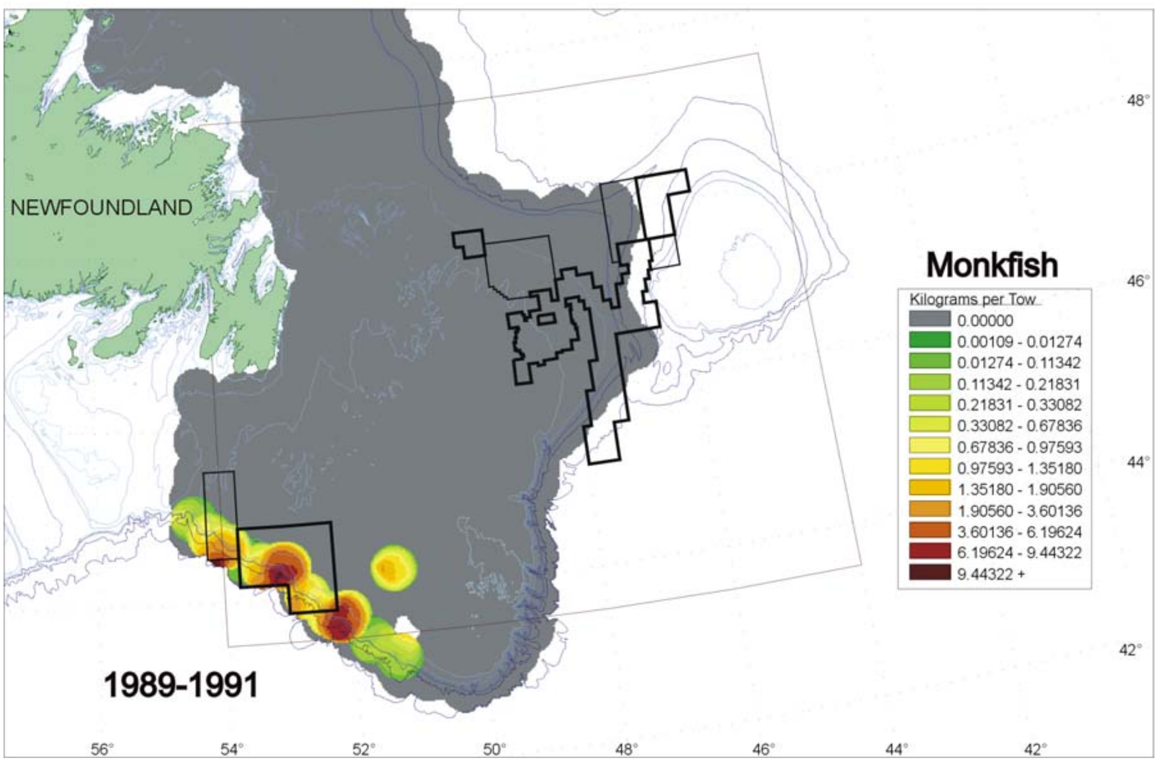
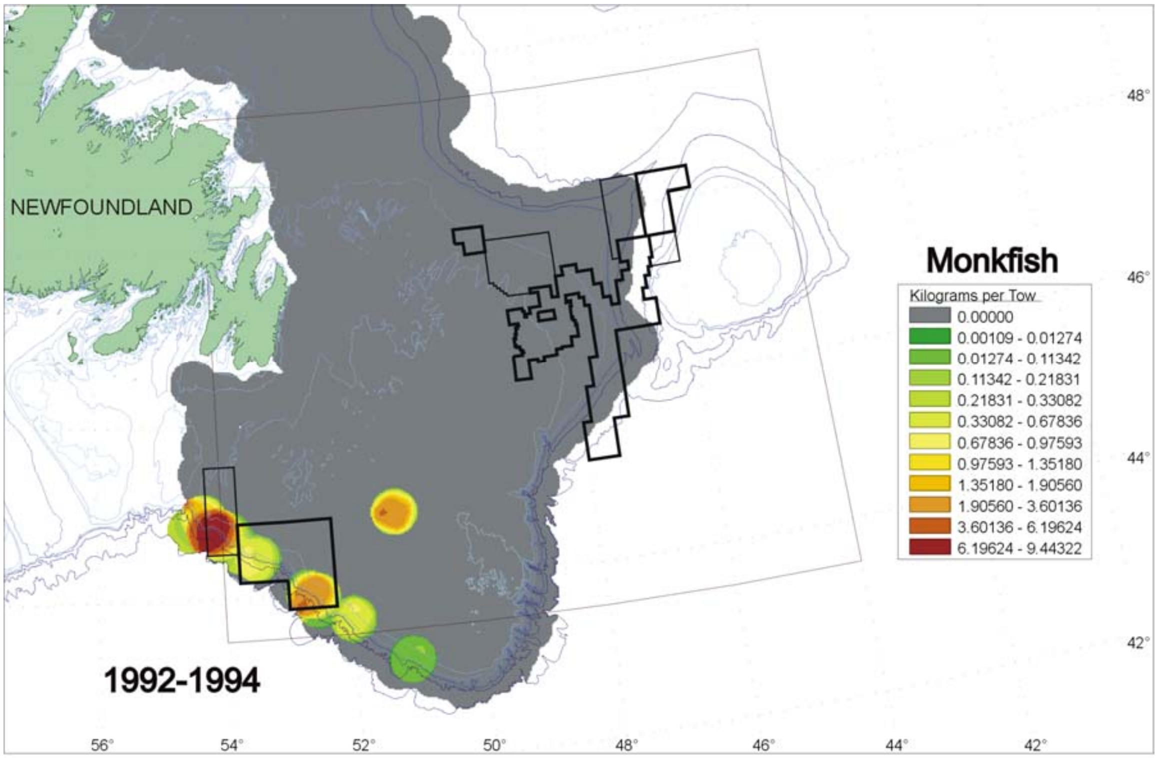


Figure 17b. Monkfish distribution based on fall research surveys from 1986-88 & 1989-91. Gray sections represent areas sampled with no catch rate values.



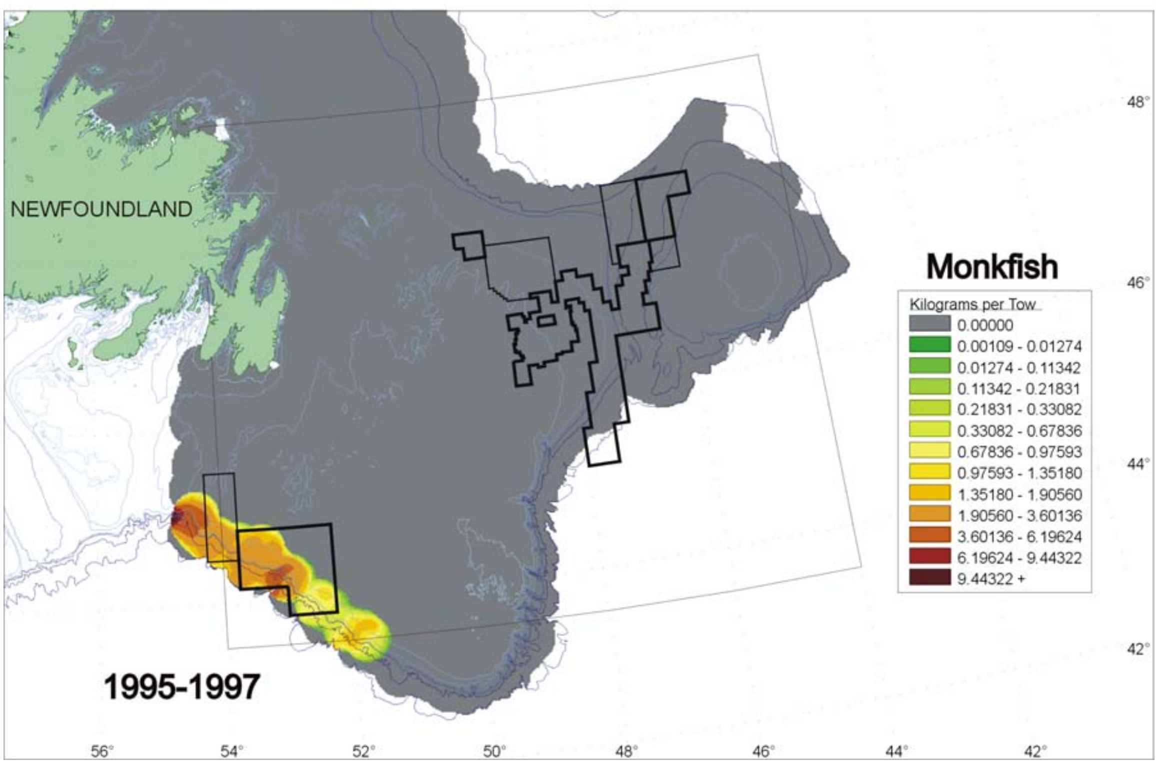


Figure 17c. Monkfish distribution based on fall research surveys from 1992-94 & 1995-97. Gray sections represent areas sampled with no catch rate values.

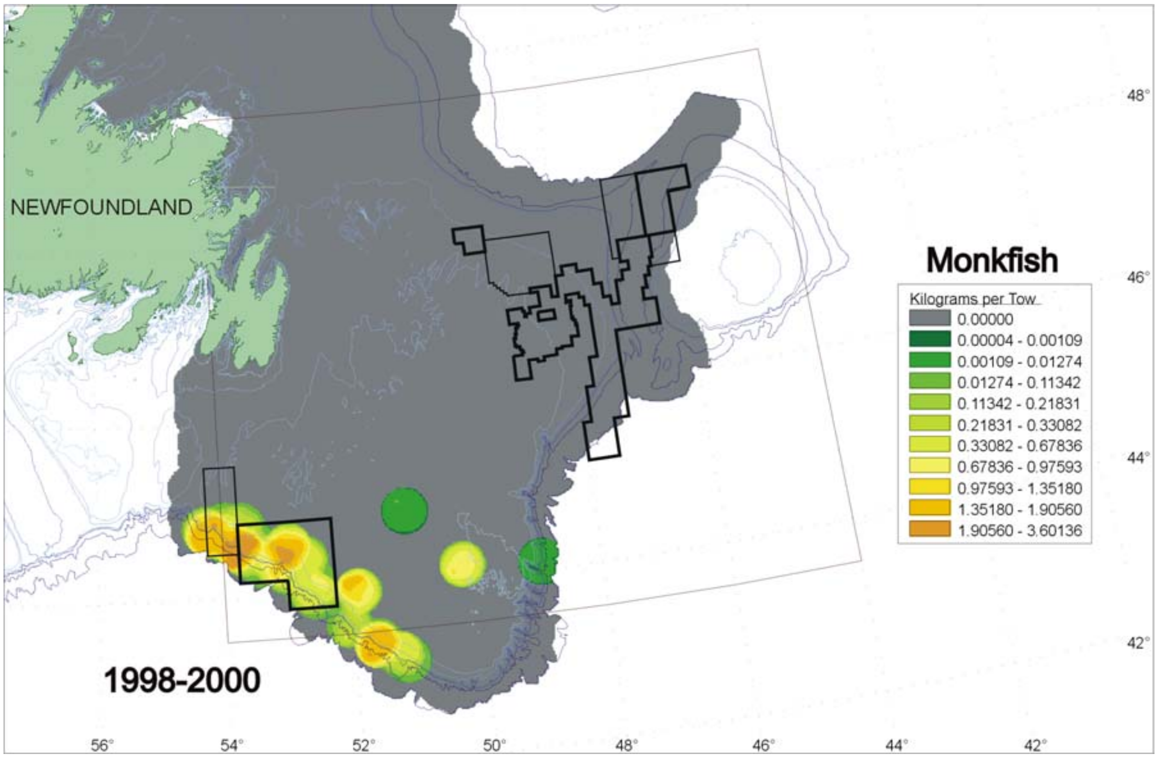
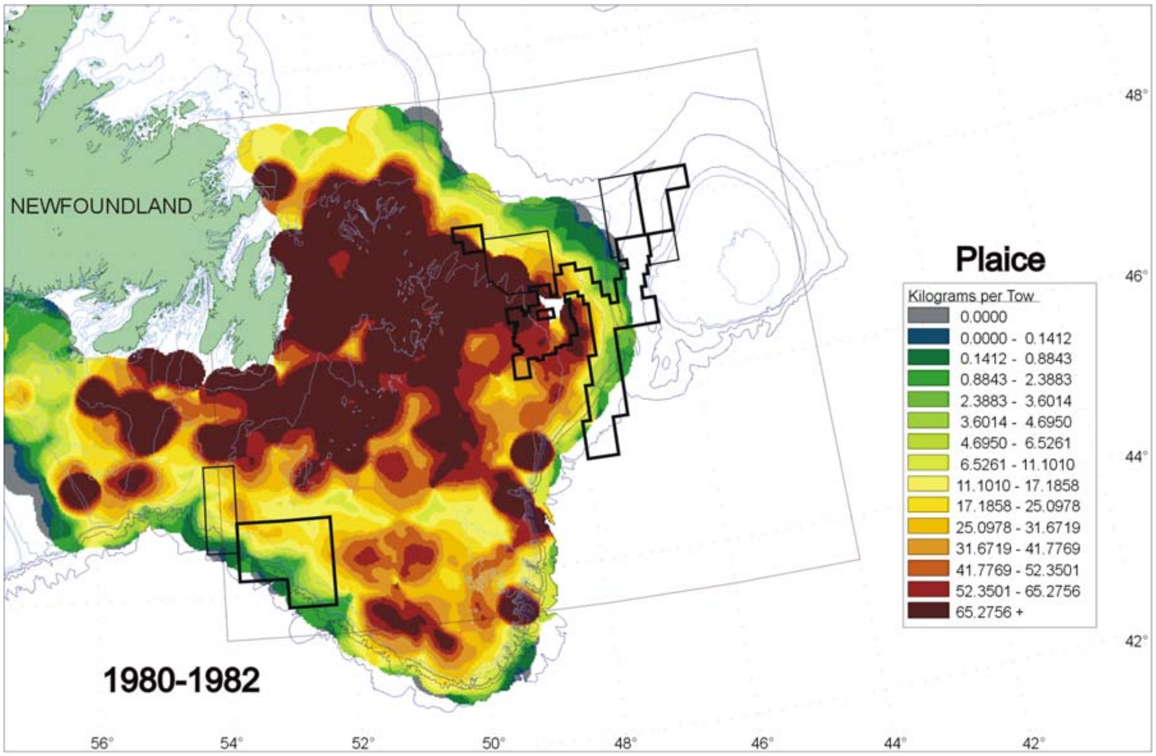


Figure 17d. Monkfish distribution based on fall research surveys from 1998-2000. Gray sections represent areas sampled with no catch rate values.



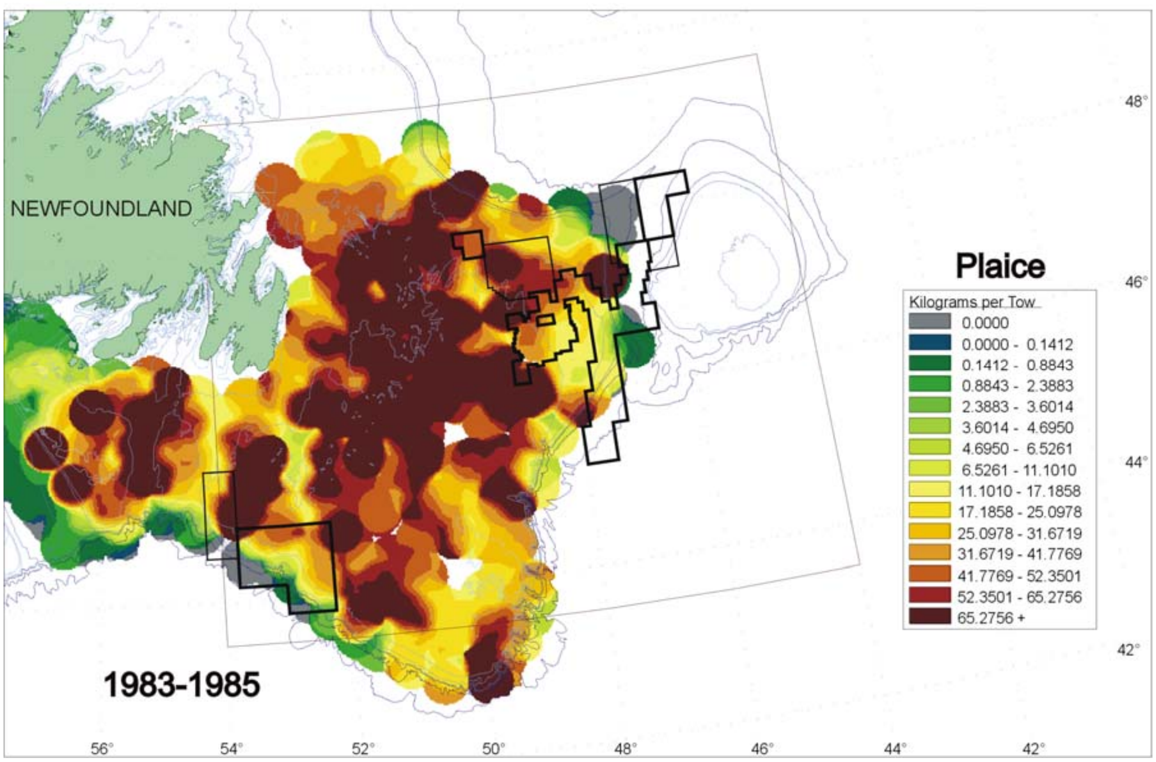
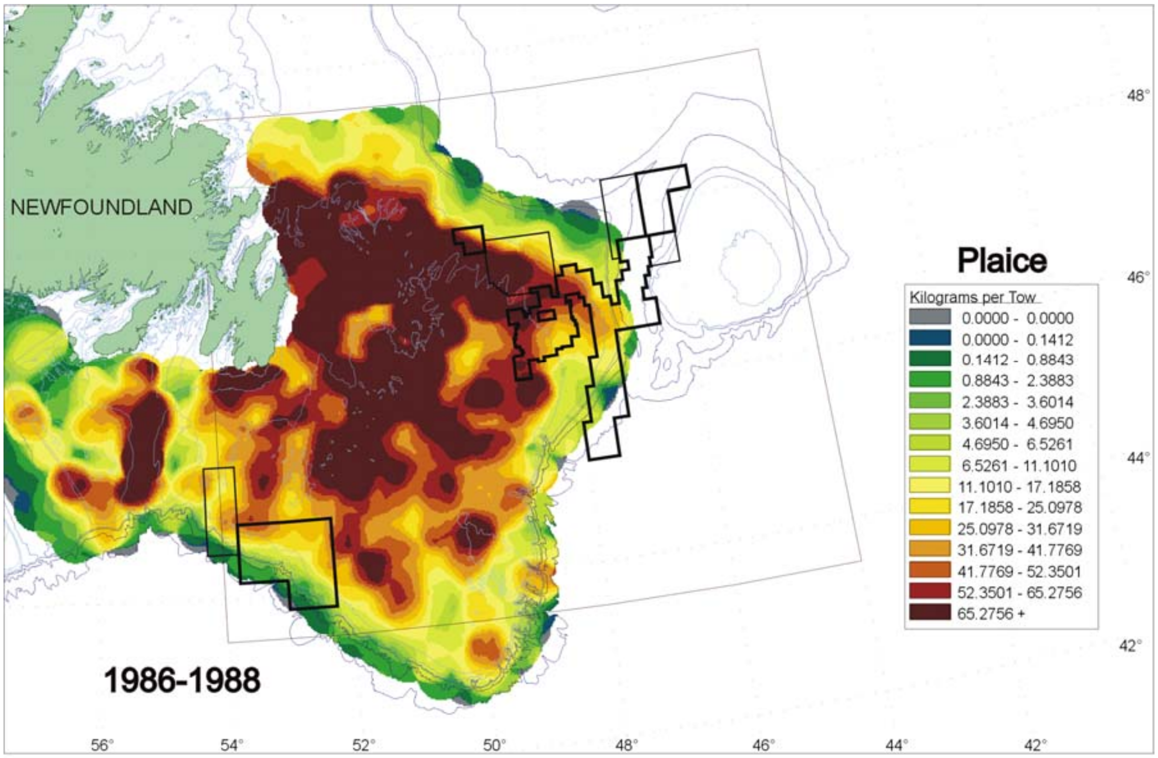


Figure 18a. American plaice distribution based on spring research surveys from 1980-82 & 1983-85. Gray sections represent areas sampled with no catch rate values. (Plaice on map refers to American plaice).



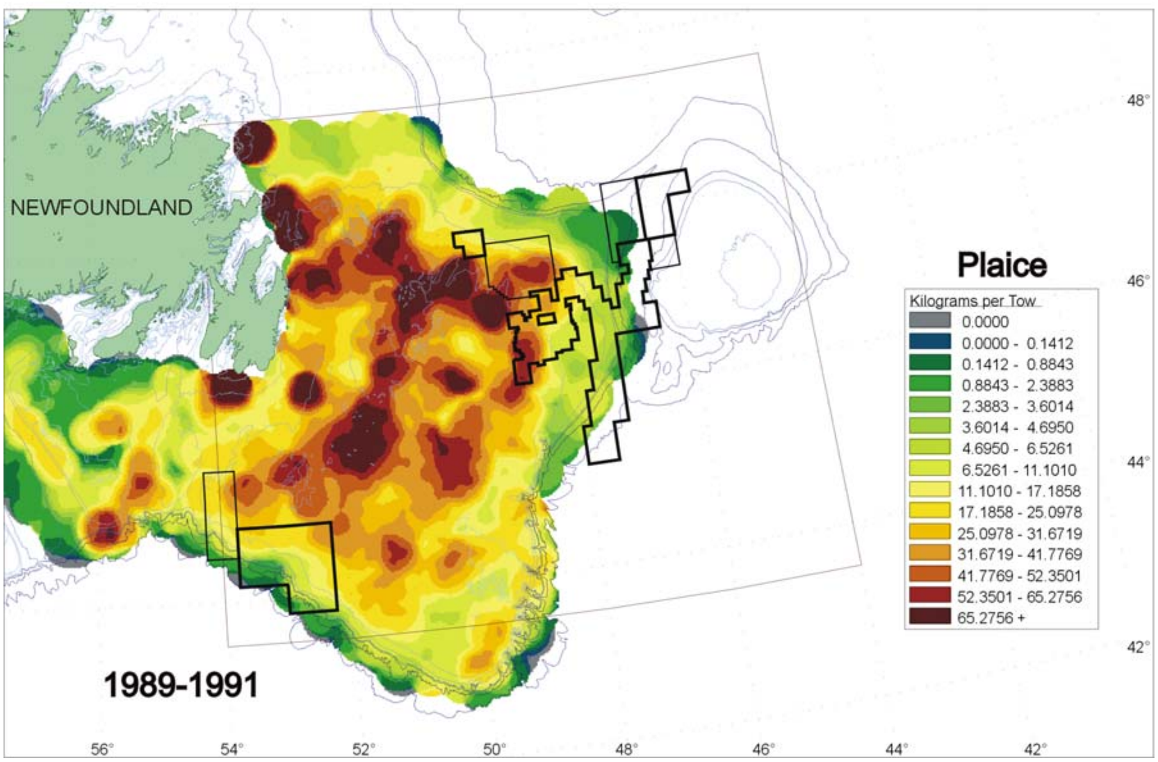
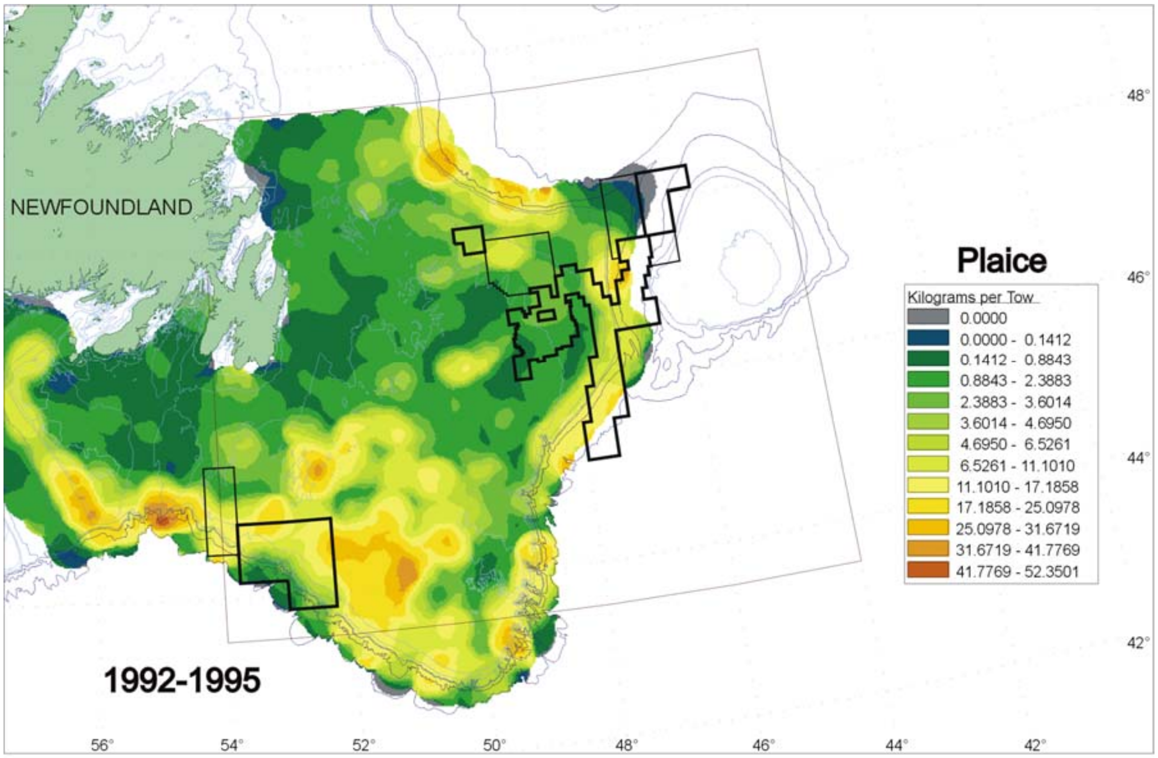


Figure 18b. American plaice distribution based on spring research surveys from 1986-88 & 1989-91. Gray sections represent areas sampled with no catch rate values. (Plaice on map refers to American plaice).



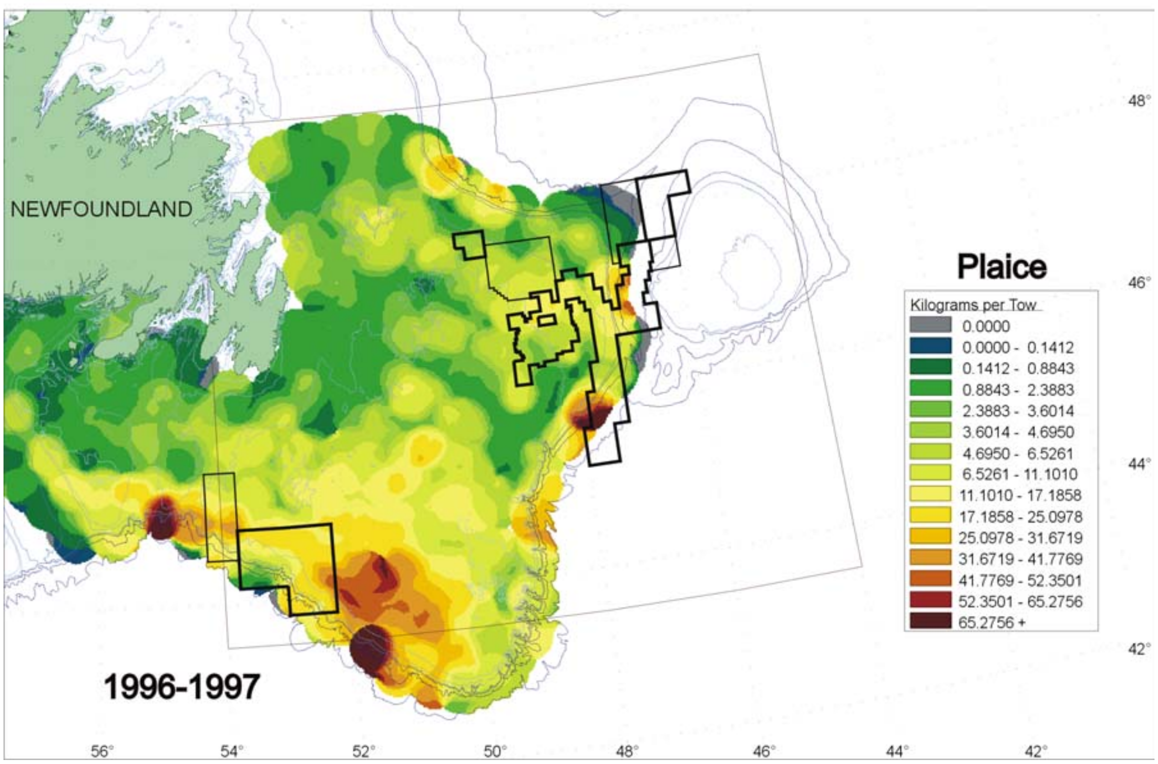


Figure 18c. American plaice distribution based on spring research surveys from 1992-95 & 1996-97. Gray sections represent areas sampled with no catch rate values. (Plaice on map refers to American plaice).

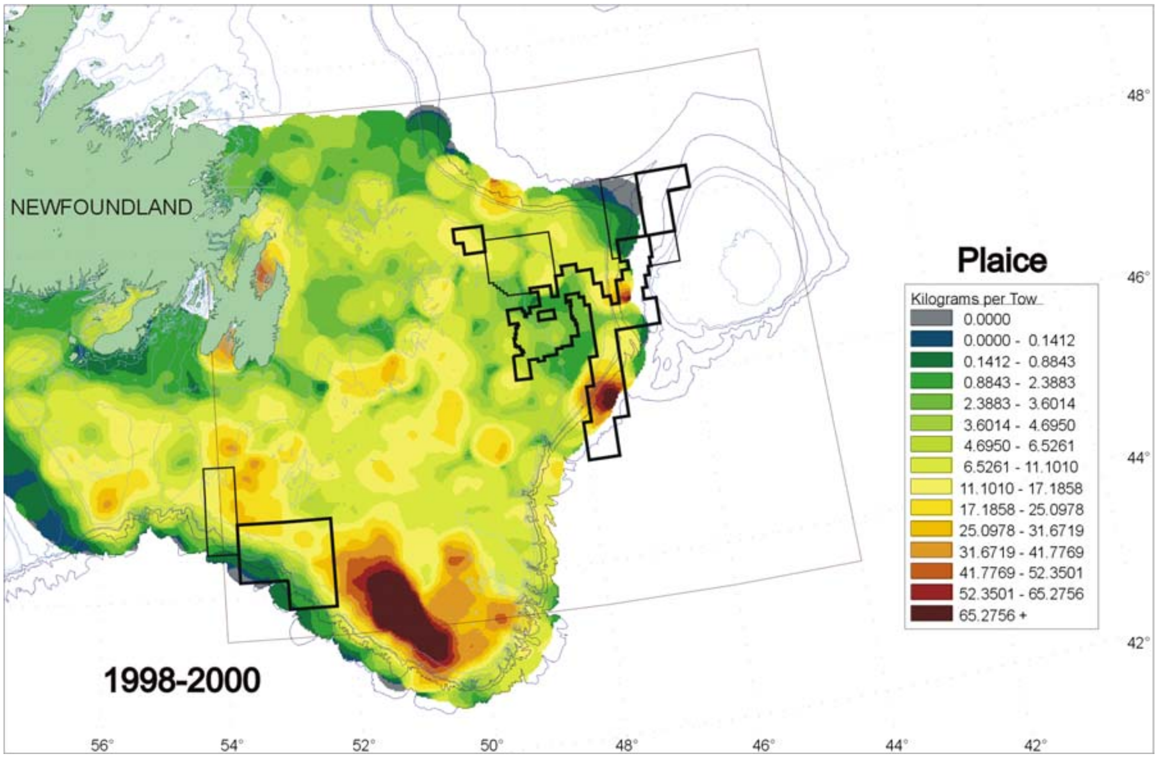
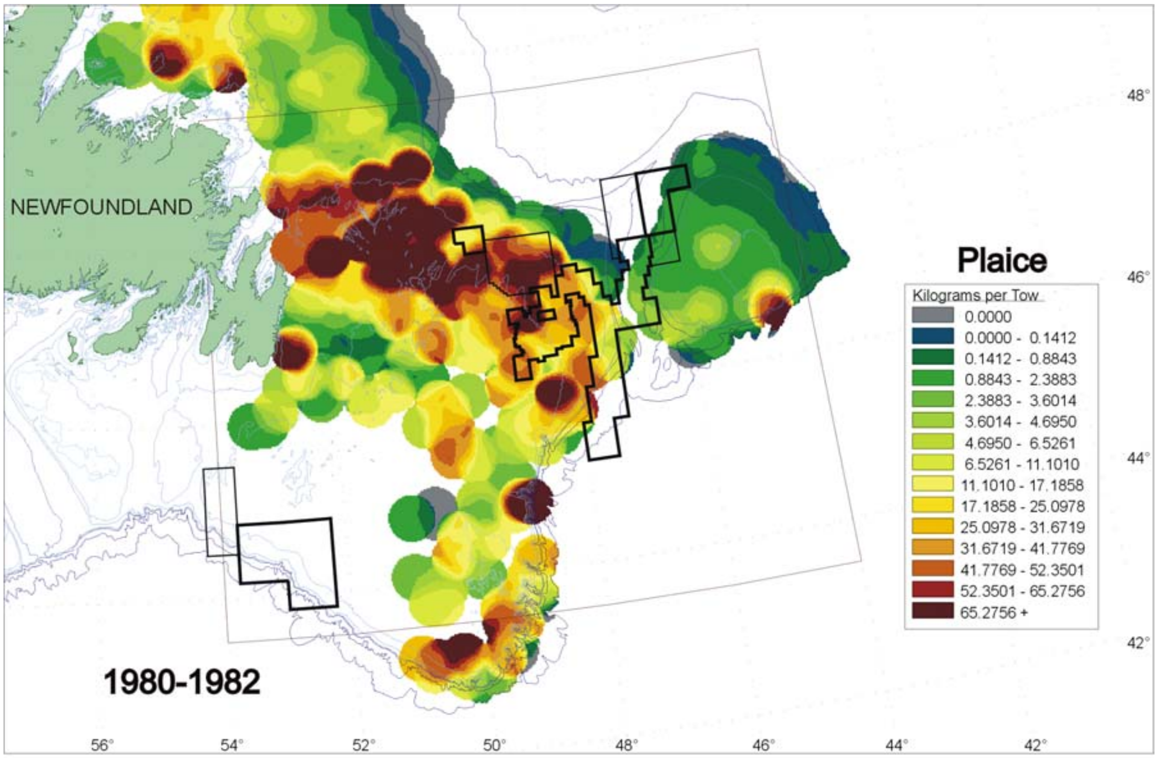


Figure 18d. American plaice distribution based on spring research surveys from 1998-2000. Gray sections represent areas sampled with no catch rate values. (Plaice on map refers to American plaice).



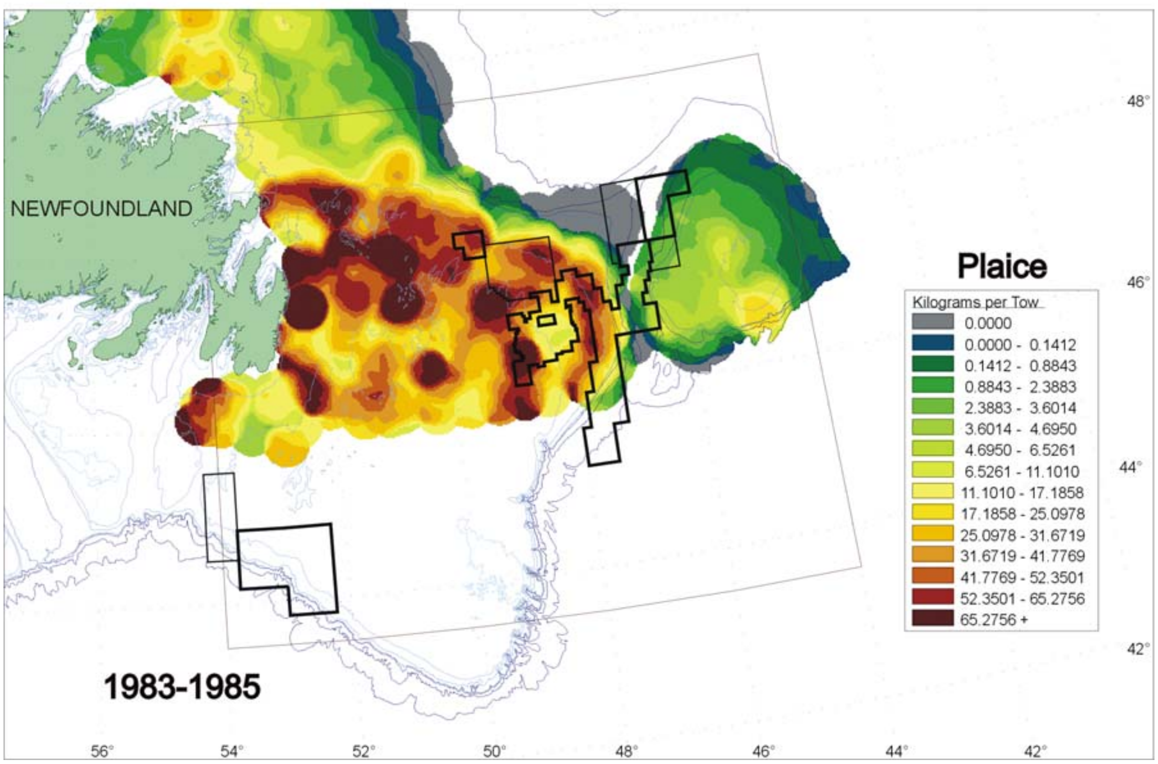
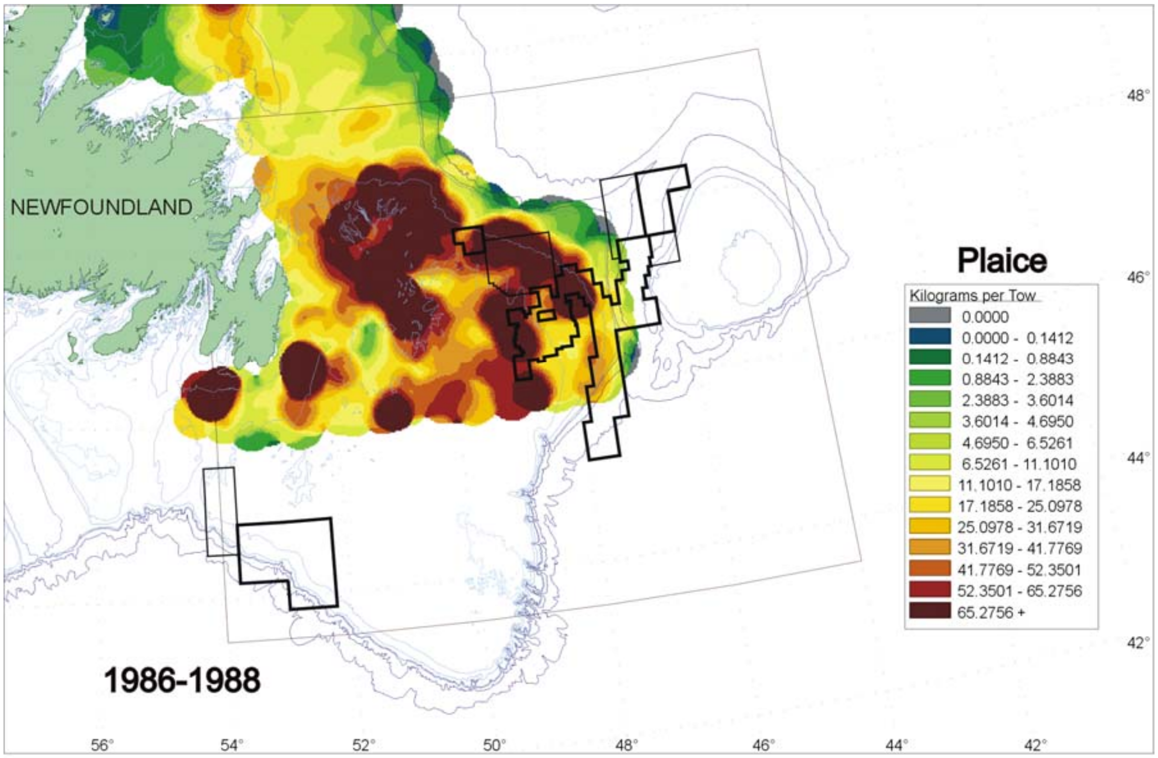


Figure 19a. American plaice distribution based on fall research surveys from 1980-82 & 1983-85. Gray sections represent areas sampled with no catch rate values. (Plaice on map refers to American plaice).



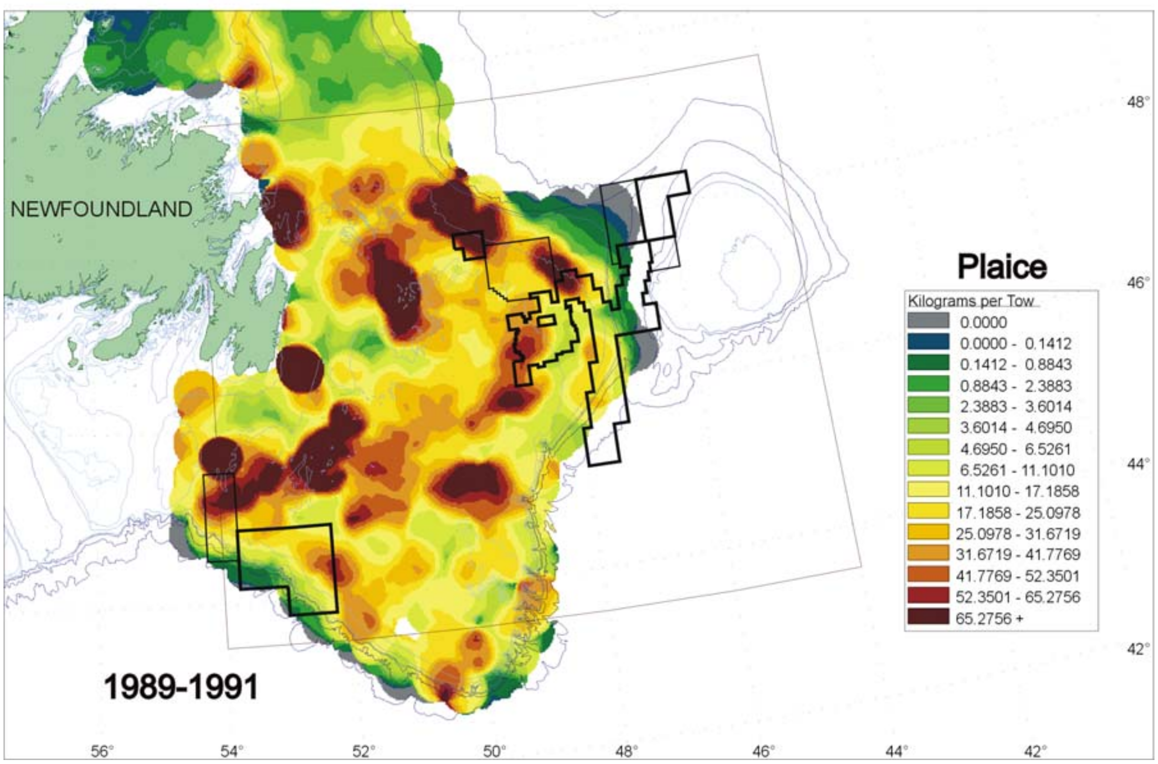
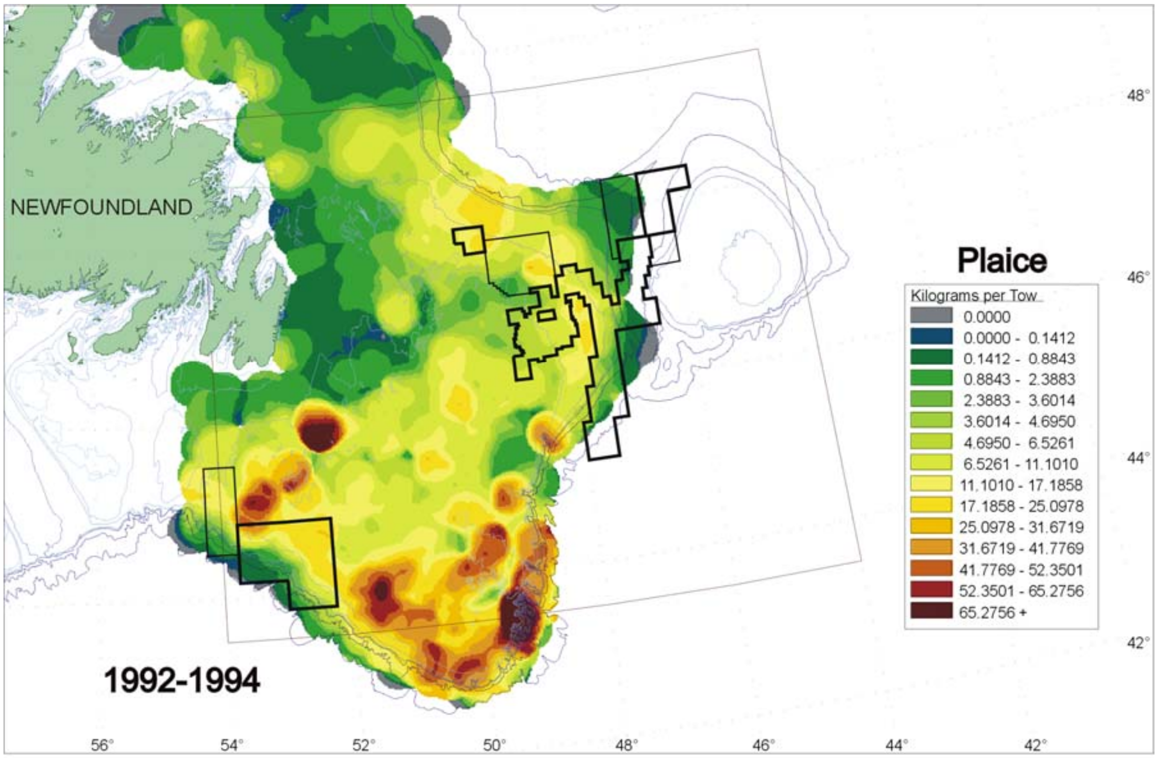


Figure 19b. American plaice distribution based on fall research surveys from 1986-88 & 1989-91. Gray sections represent areas sampled with no catch rate values. (Plaice on map refers to American plaice).



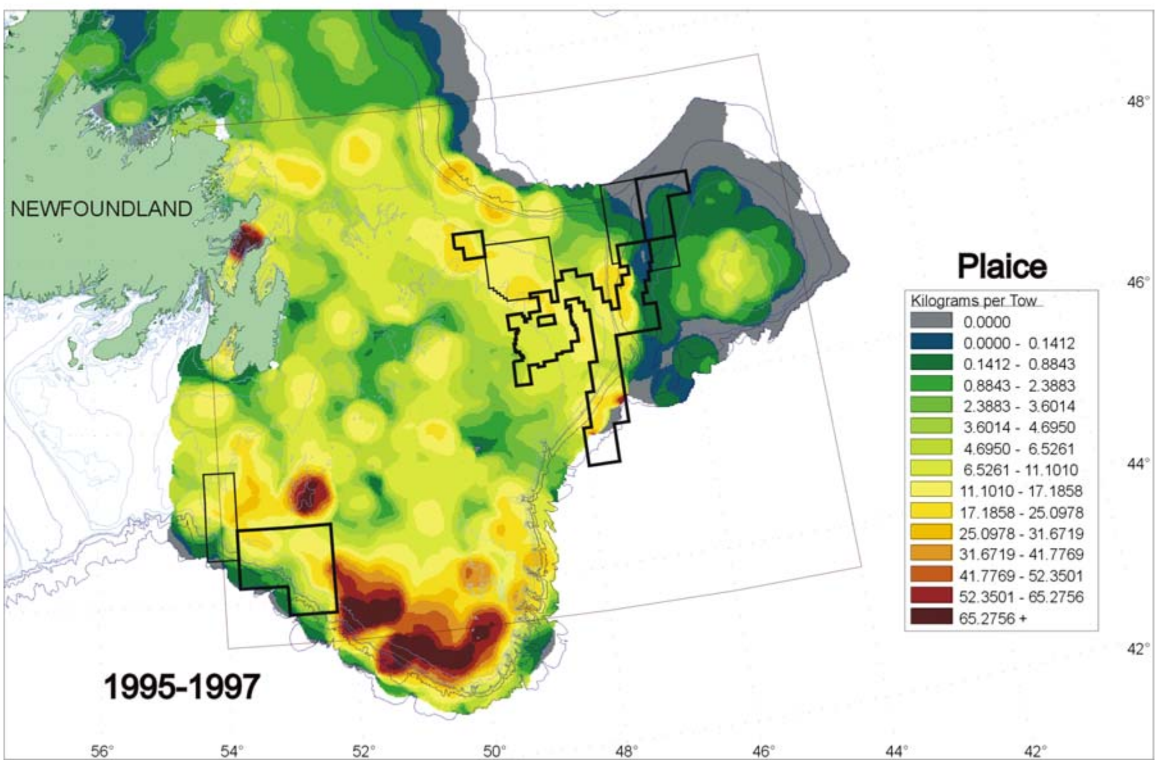


Figure 19c. American plaice distribution based on fall research surveys from 1992-94 & 1995-97. Gray sections represent areas sampled with no catch rate values. (Plaice on map refers to American plaice).

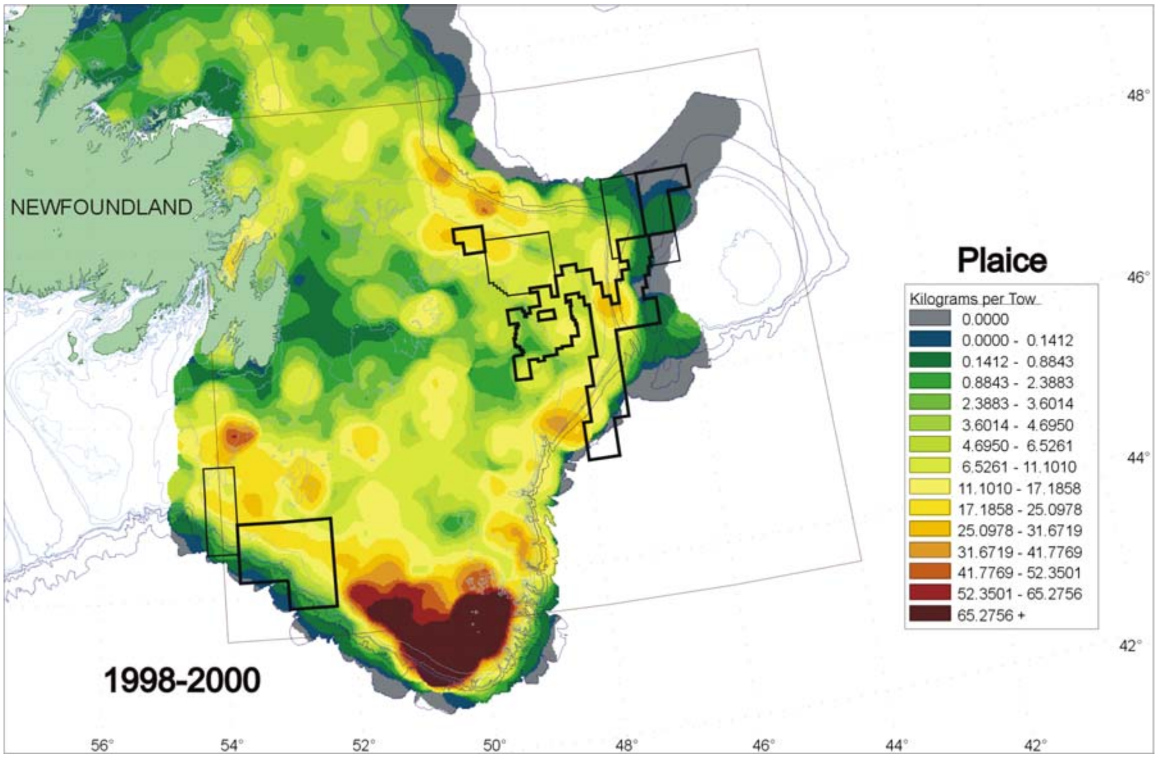


Figure 19d. American plaice distribution based on fall research surveys from 1998-2000. Gray sections represent areas sampled with no catch rate values. (Plaice on map refers to American plaice).

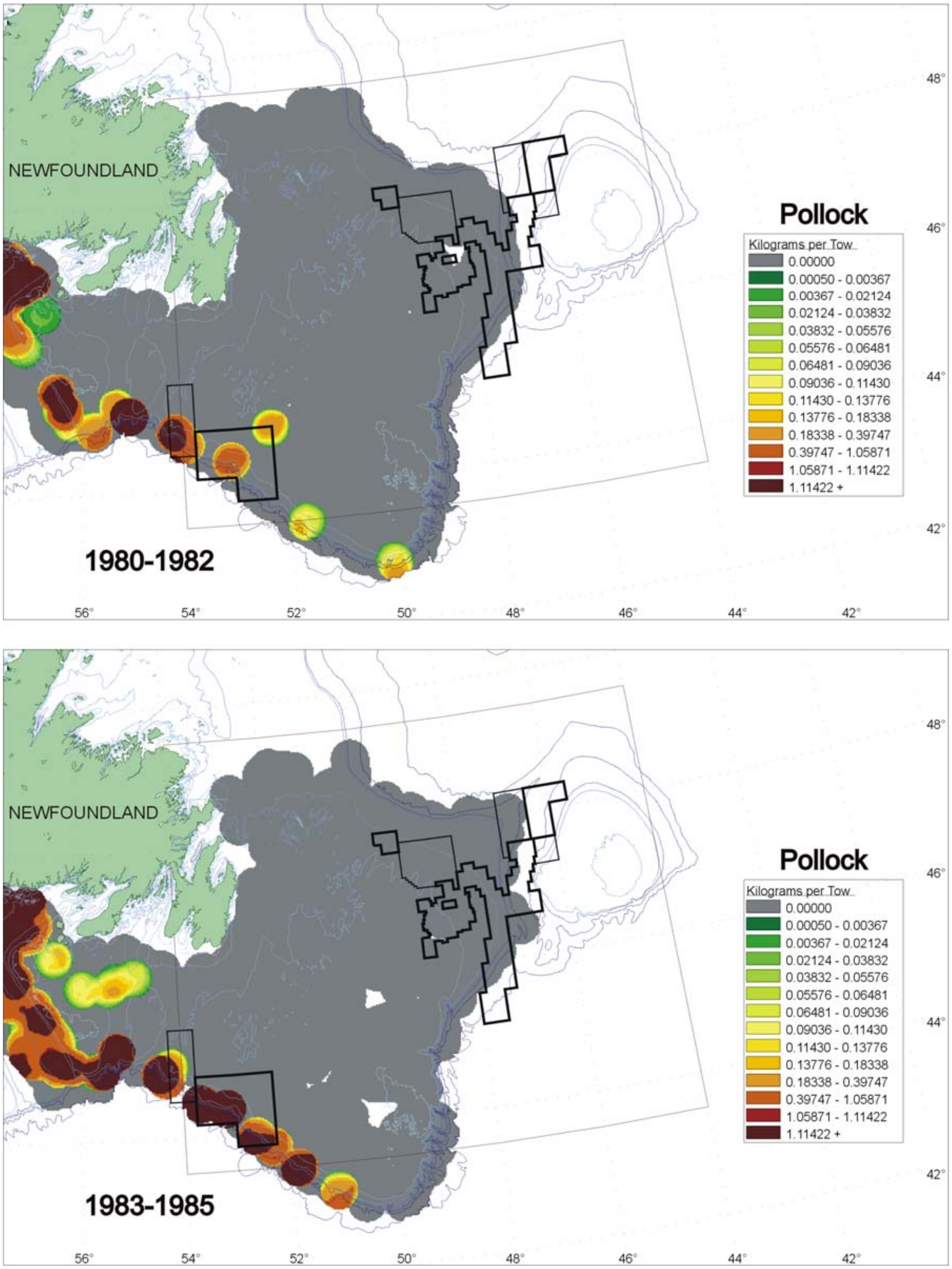


Figure 20a. Pollock distribution based on spring research surveys from 1980-82 & 1983-85. Gray sections represent areas sampled with no catch rate values.

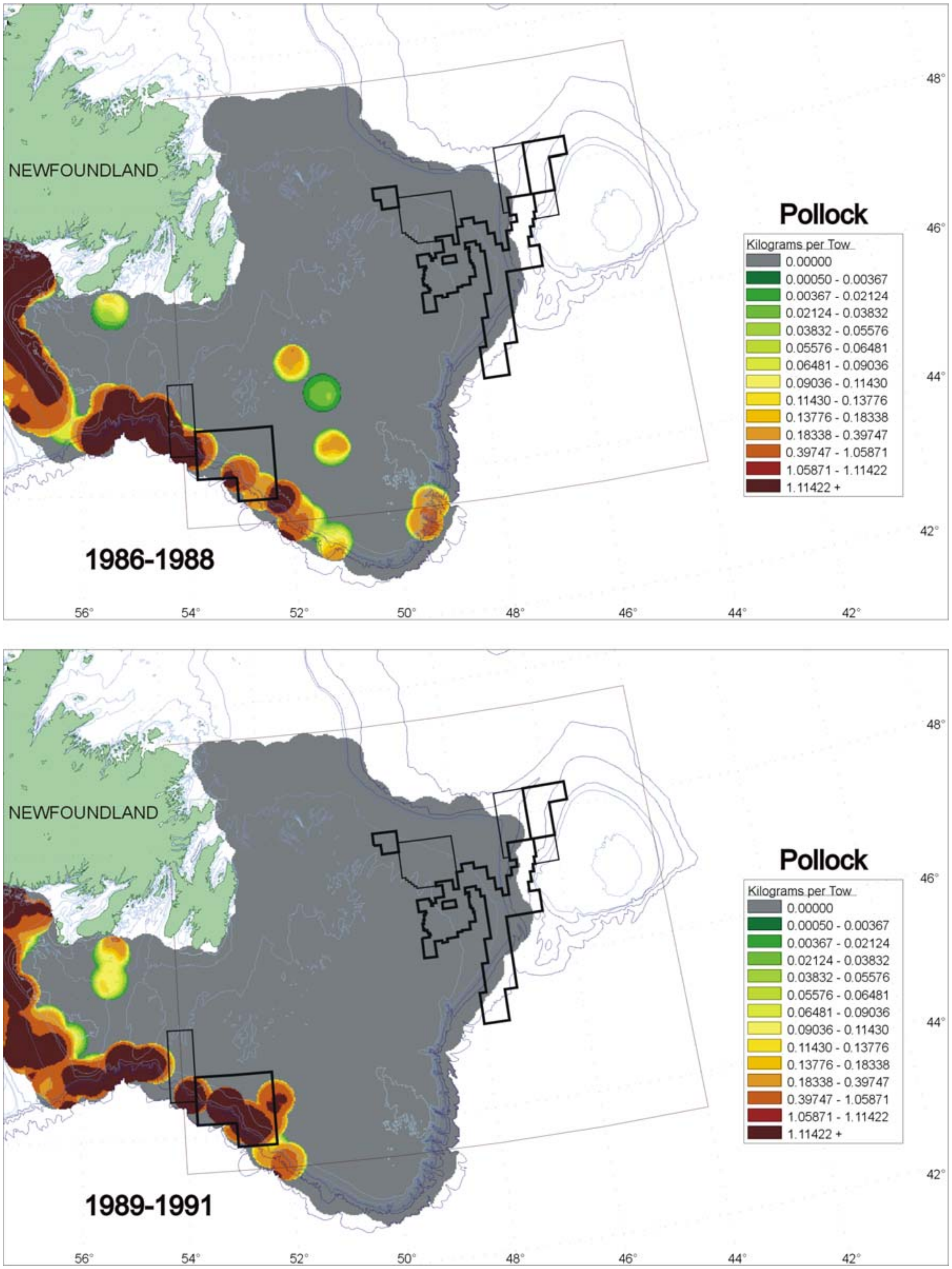
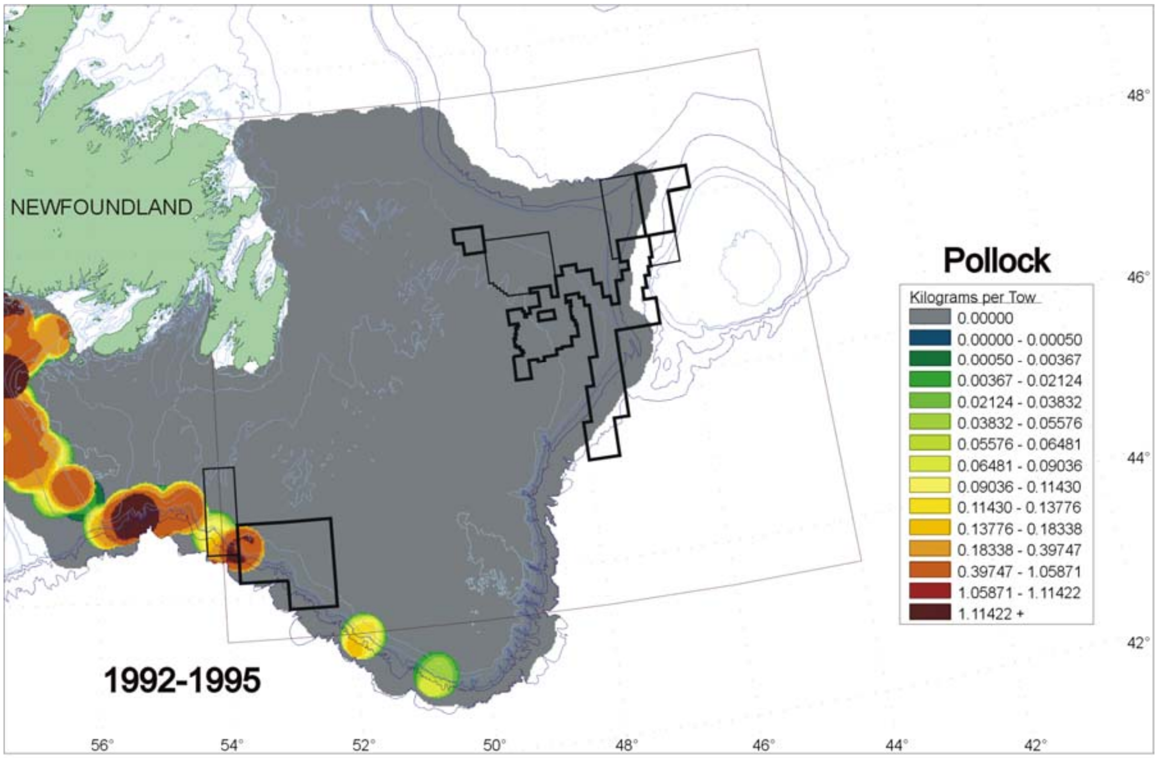


Figure 20b. Pollock distribution based on spring research surveys from 1986-88 & 1989-91. Gray sections represent areas sampled with no catch rate values.



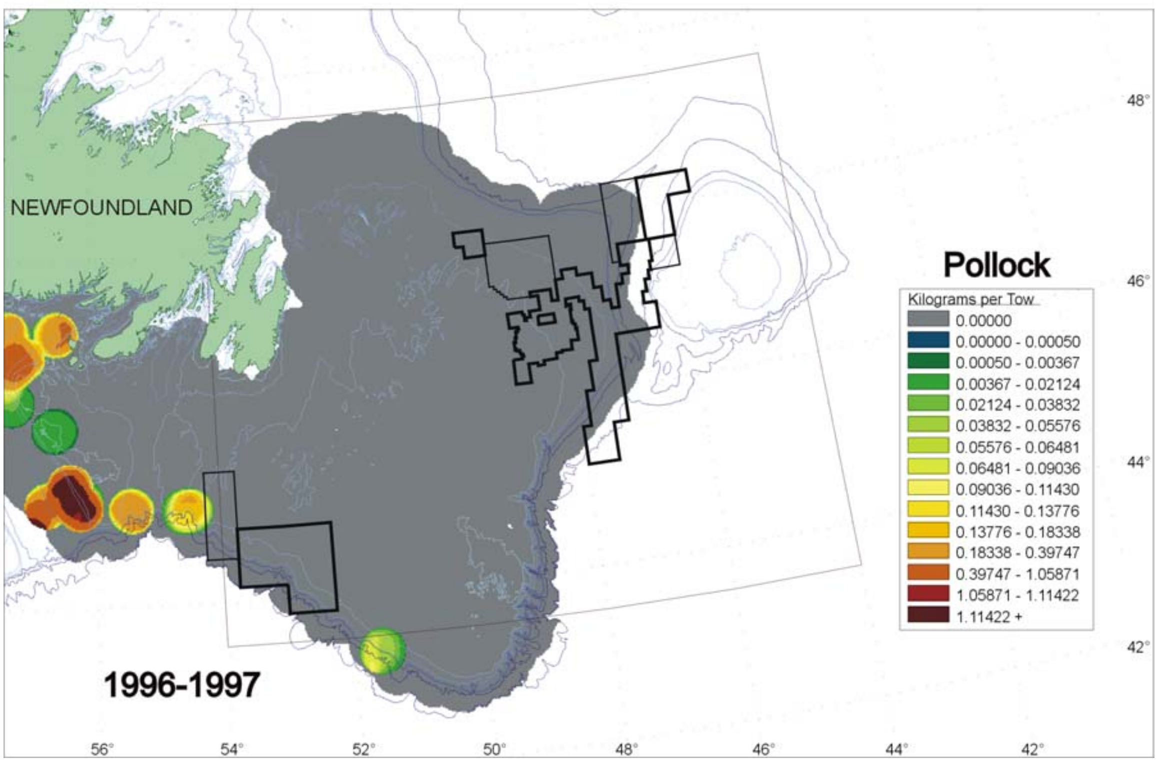


Figure 20c. Pollock distribution based on spring research surveys from 1992-95 & 1996-97. Gray sections represent areas sampled with no catch rate values.

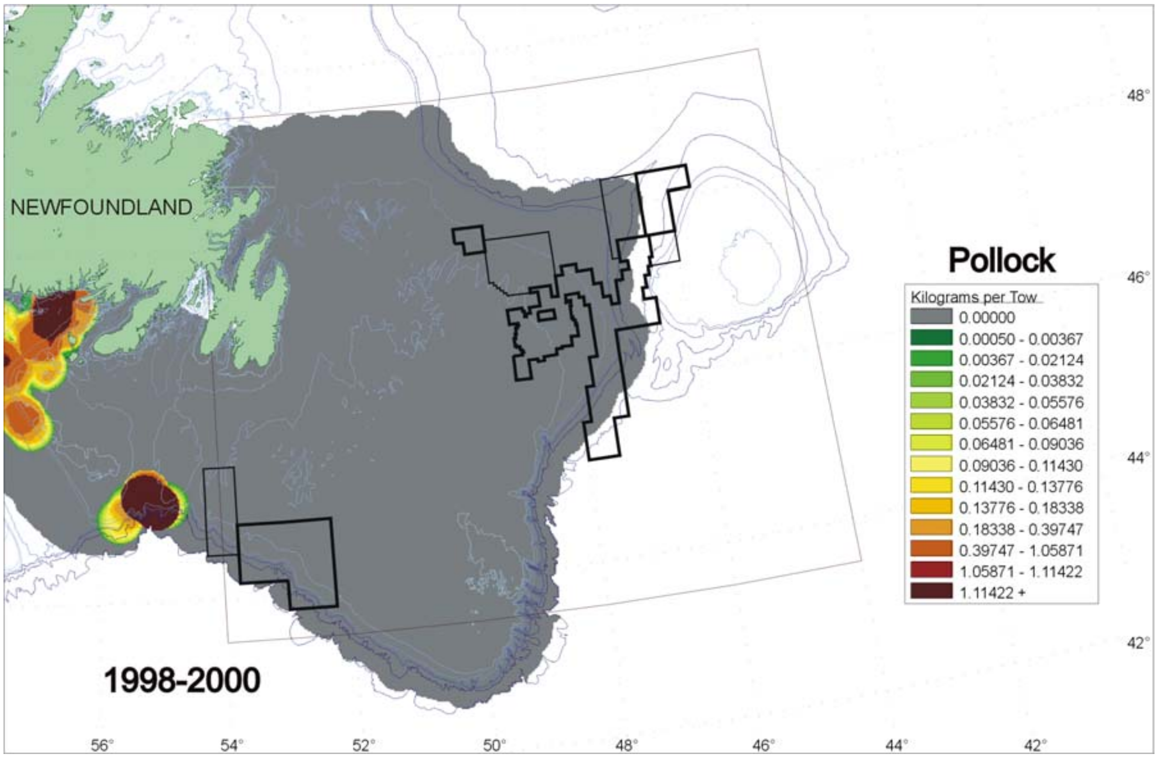
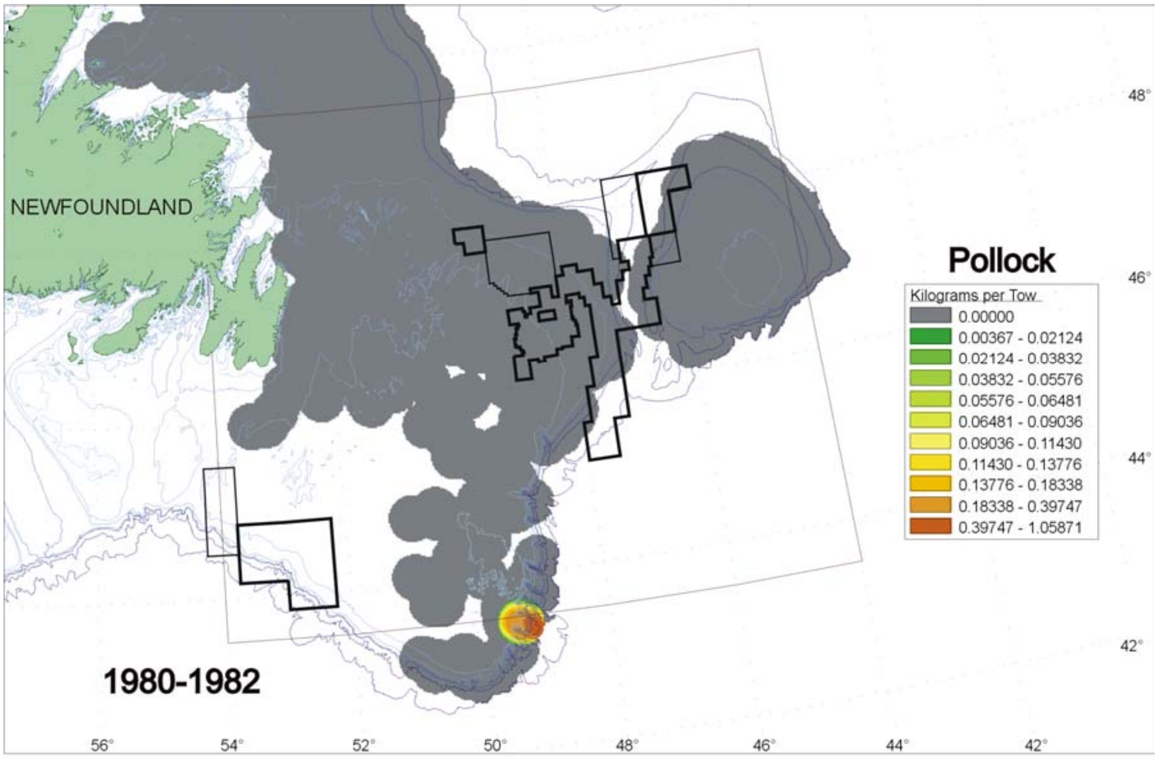


Figure 20d. Pollock distribution based on spring research surveys from 1998-2000. Gray sections represent areas sampled with no catch rate values.



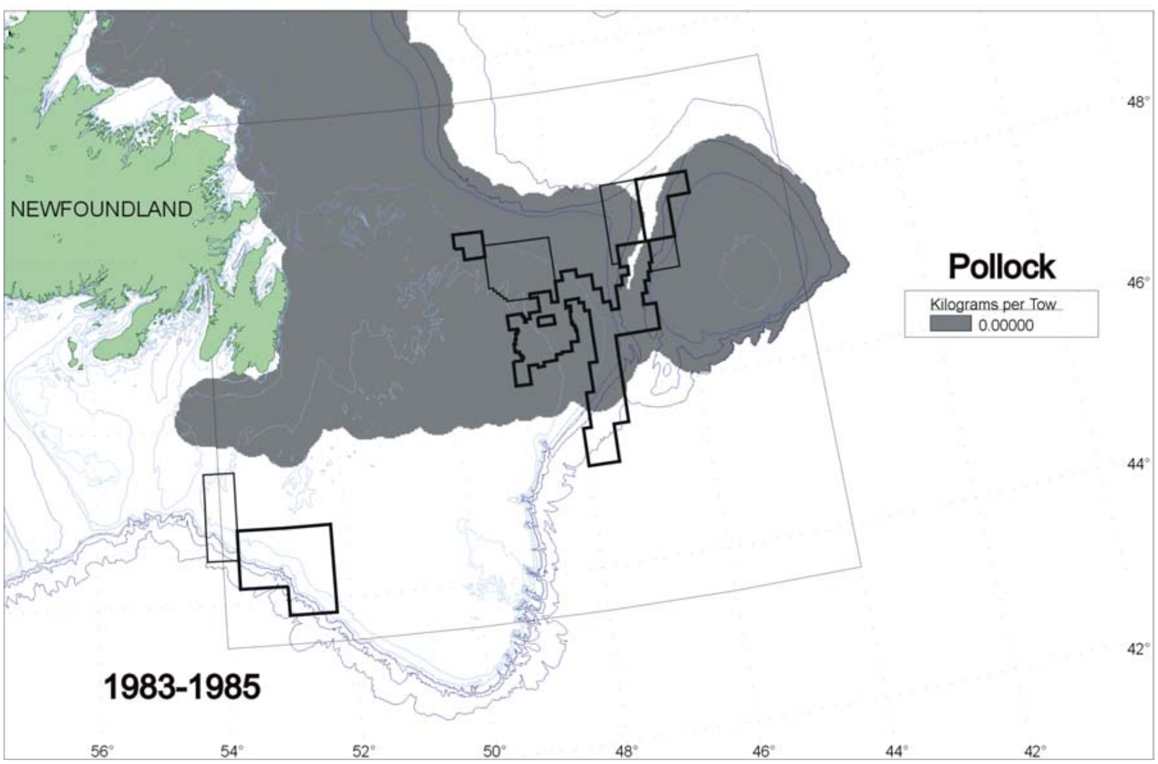
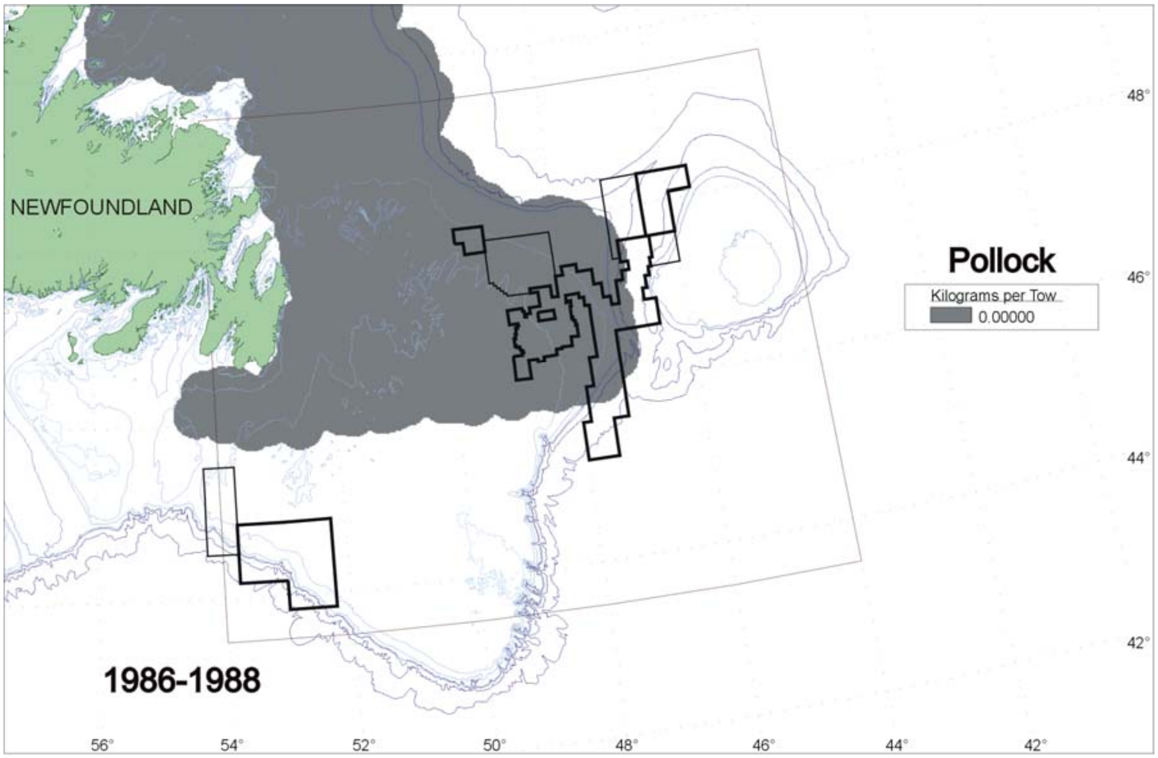


Figure 21a. Pollock distribution based on fall research surveys from 1980-82 & 1983-85. Gray sections represent areas sampled with no catch rate values.



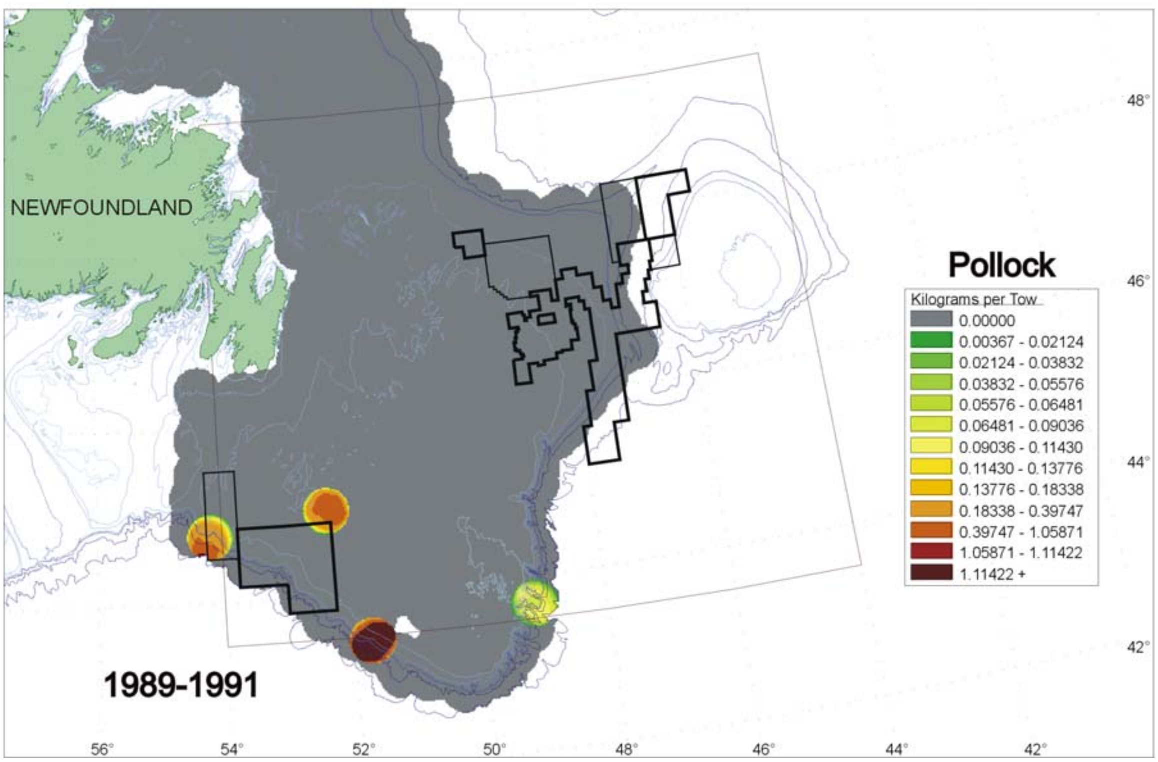
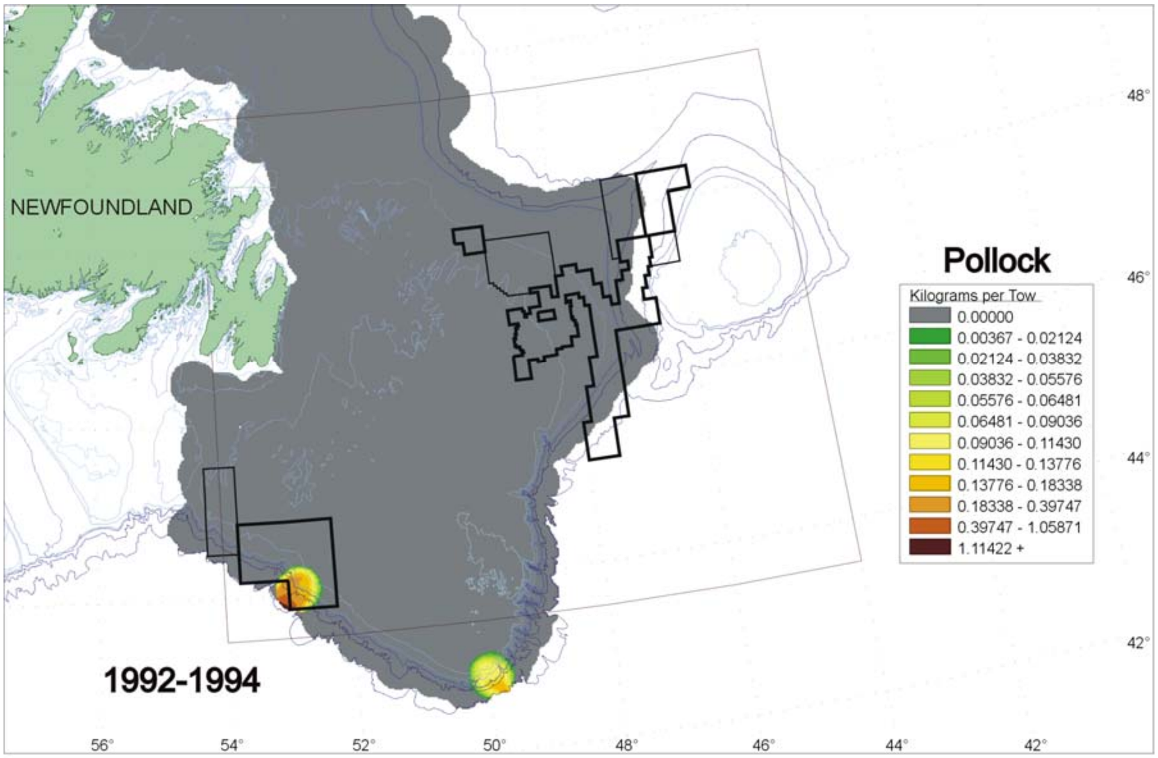


Figure 21b. Pollock distribution based on fall research surveys from 1986-88 & 1989-91. Gray sections represent areas sampled with no catch rate values.



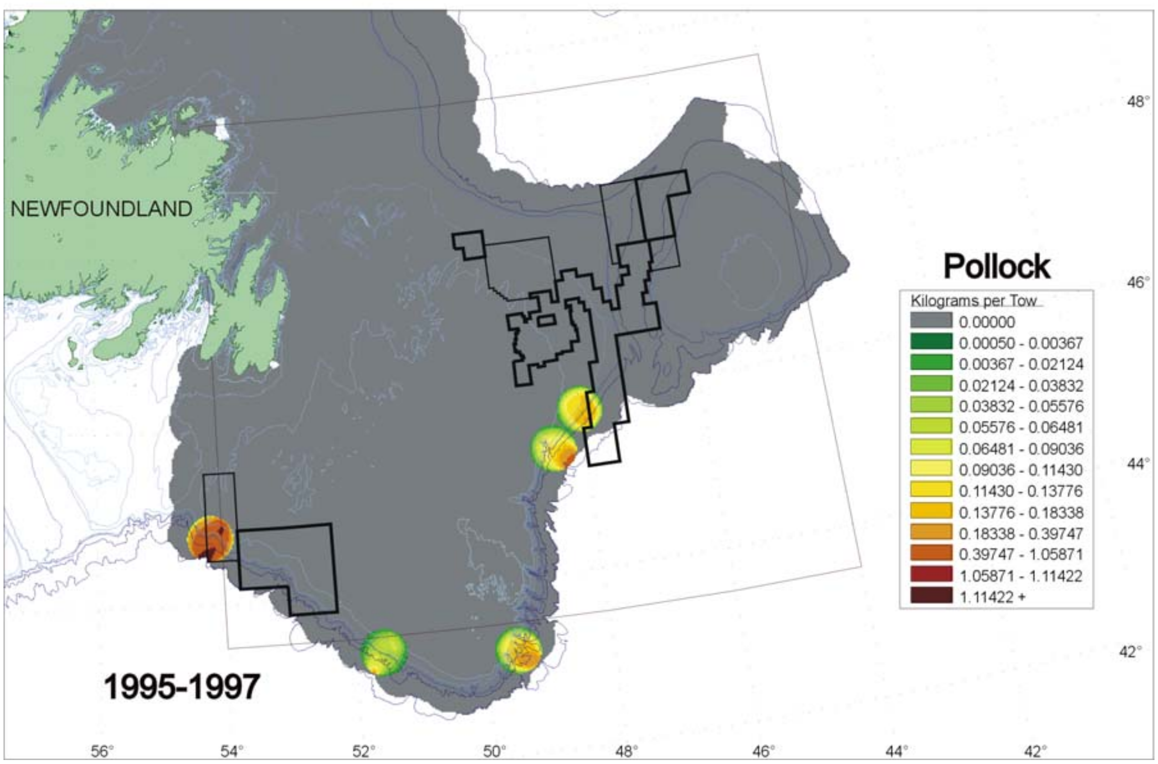


Figure 21c. Pollock distribution based on fall research surveys from 1992-94 & 1995-97. Gray sections represent areas sampled with no catch rate values.

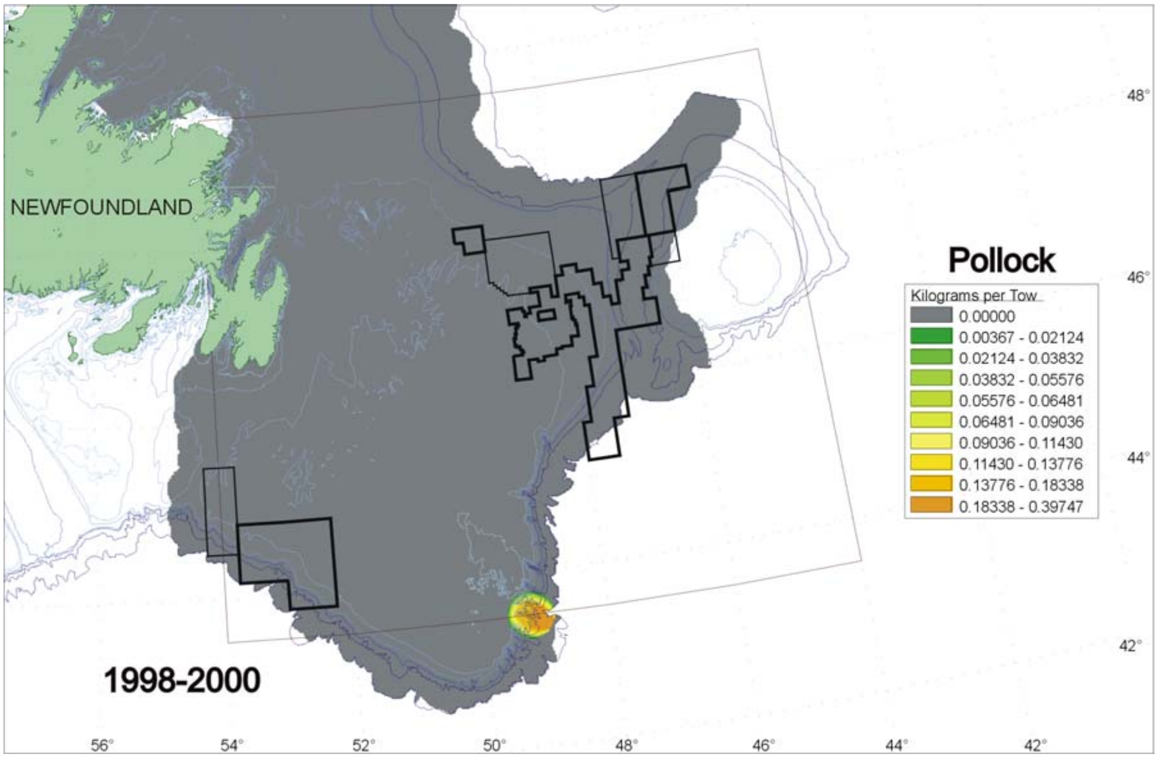
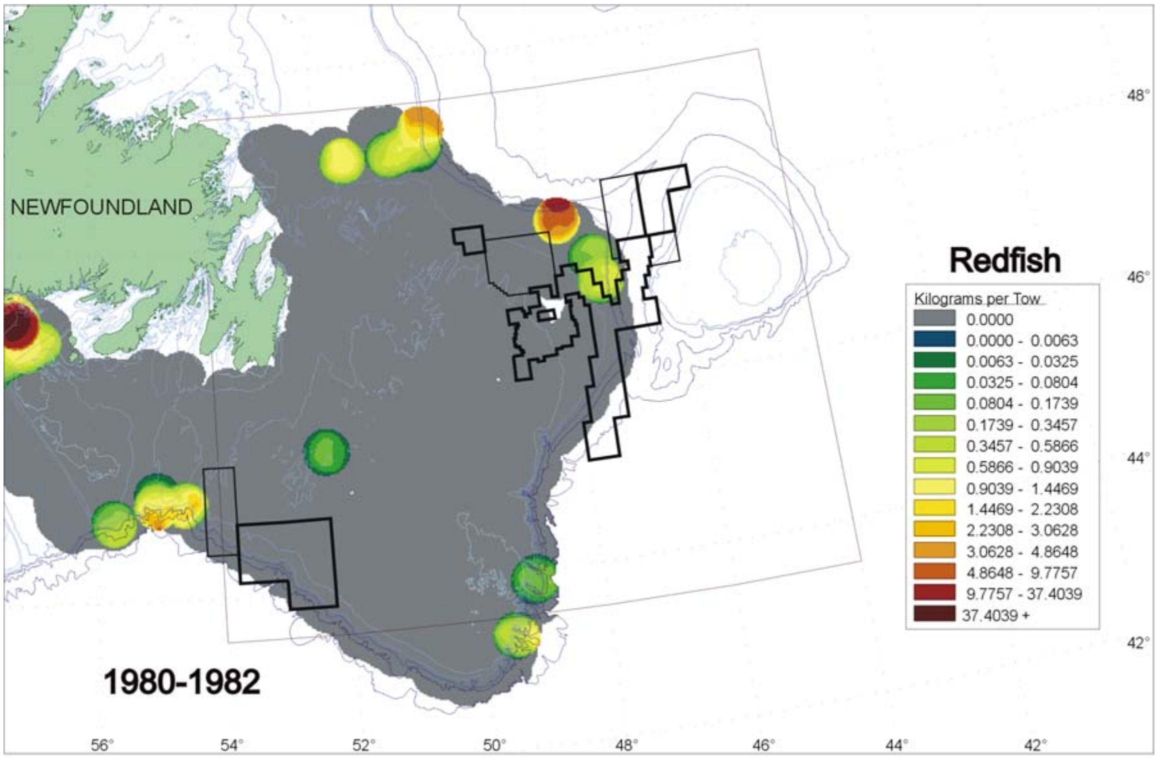


Figure 21d. Pollock distribution based on fall research surveys from 1998-2000. Gray sections represent areas sampled with no catch rate values.



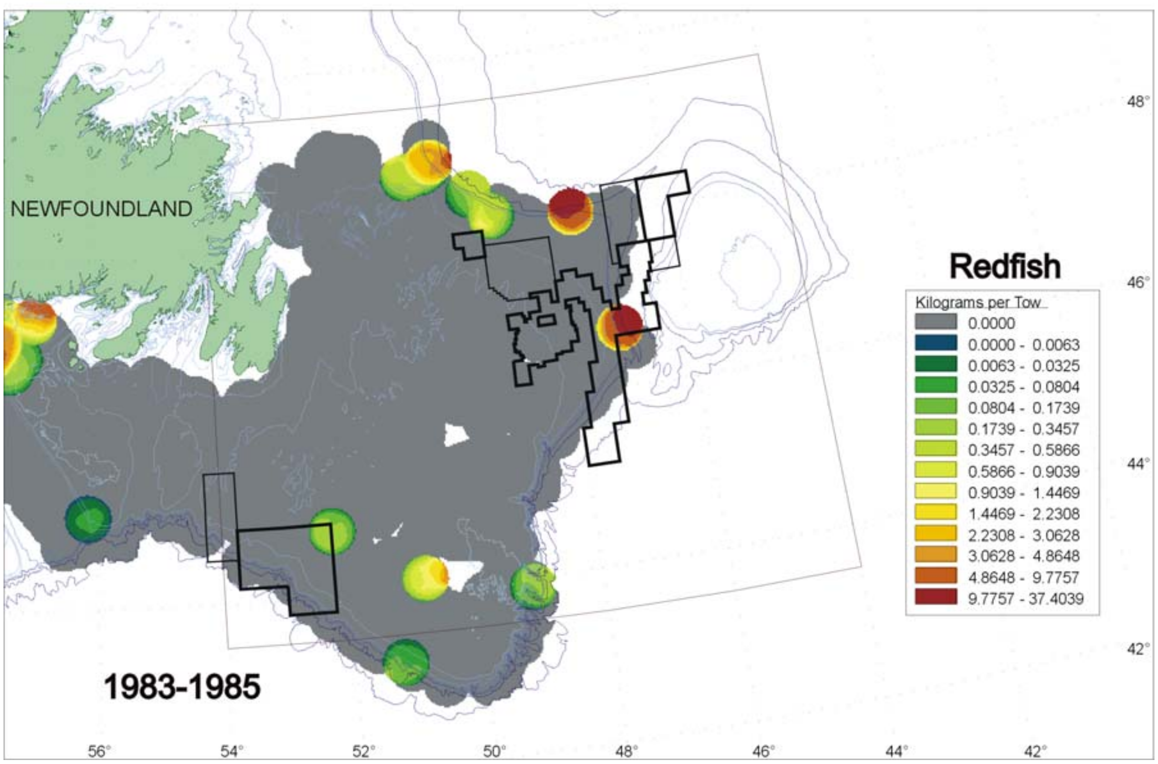


Figure 22a. Redfish distribution based on spring research surveys from 1980-82 & 1983-85. Gray sections represent areas sampled with no catch rate values.

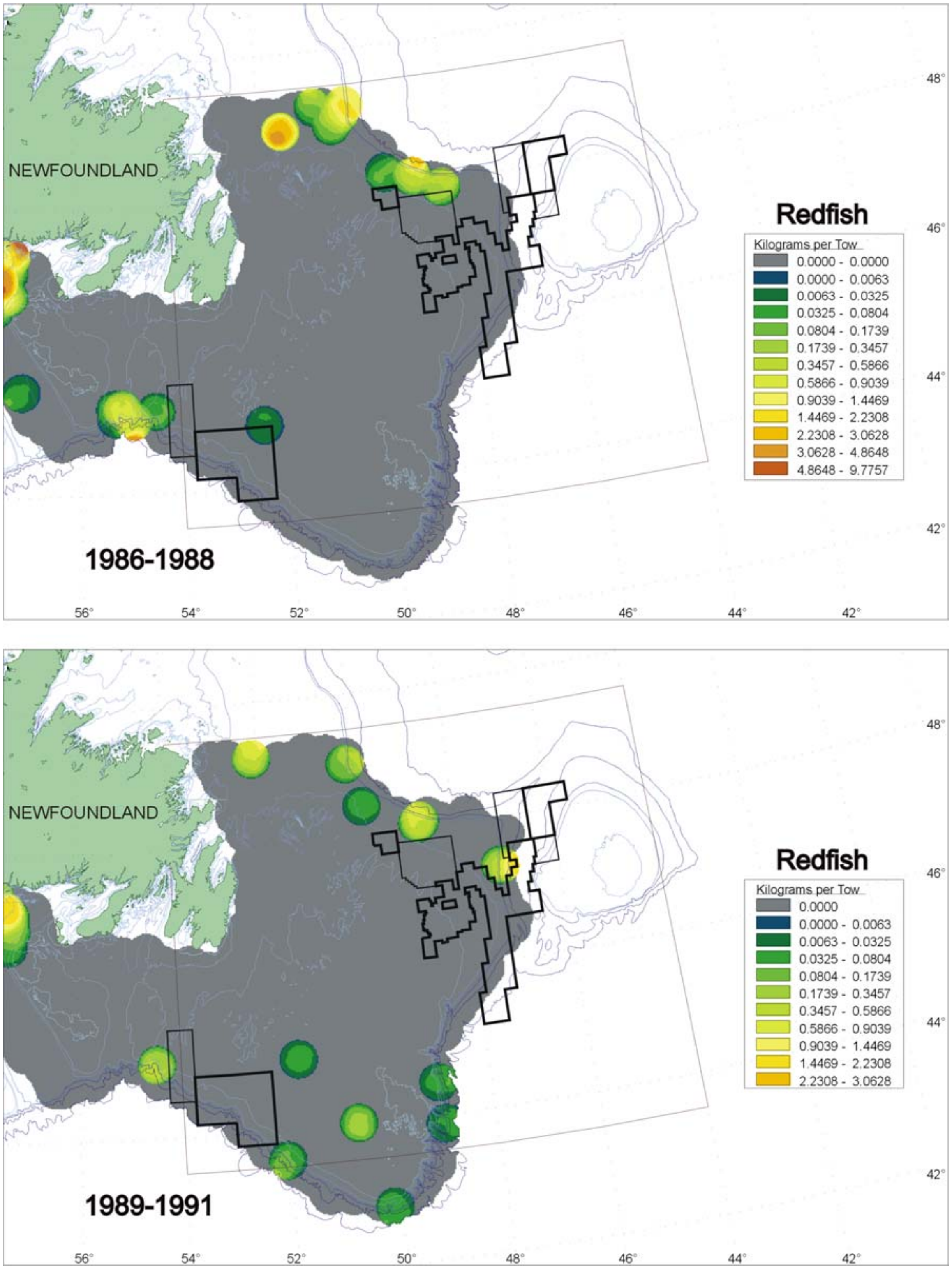
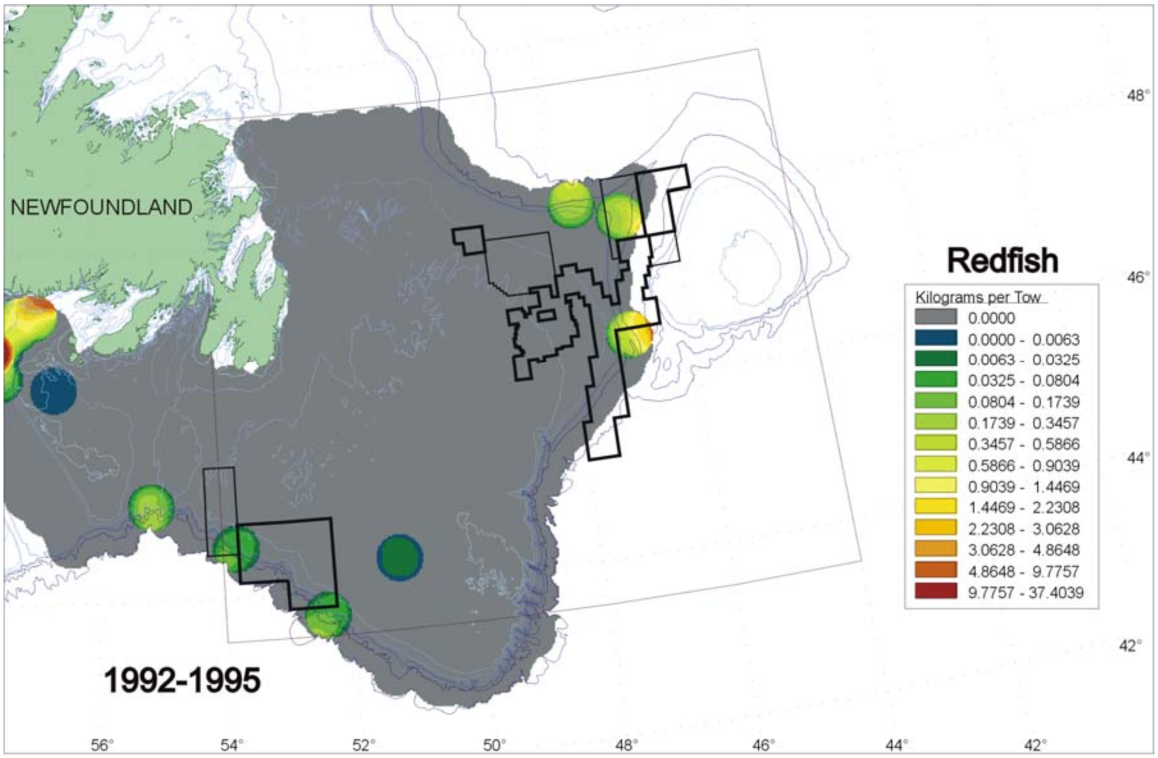


Figure 22b. Redfish distribution based on spring research surveys from 1986-88 & 1989-91. Gray sections represent areas sampled with no catch rate values.



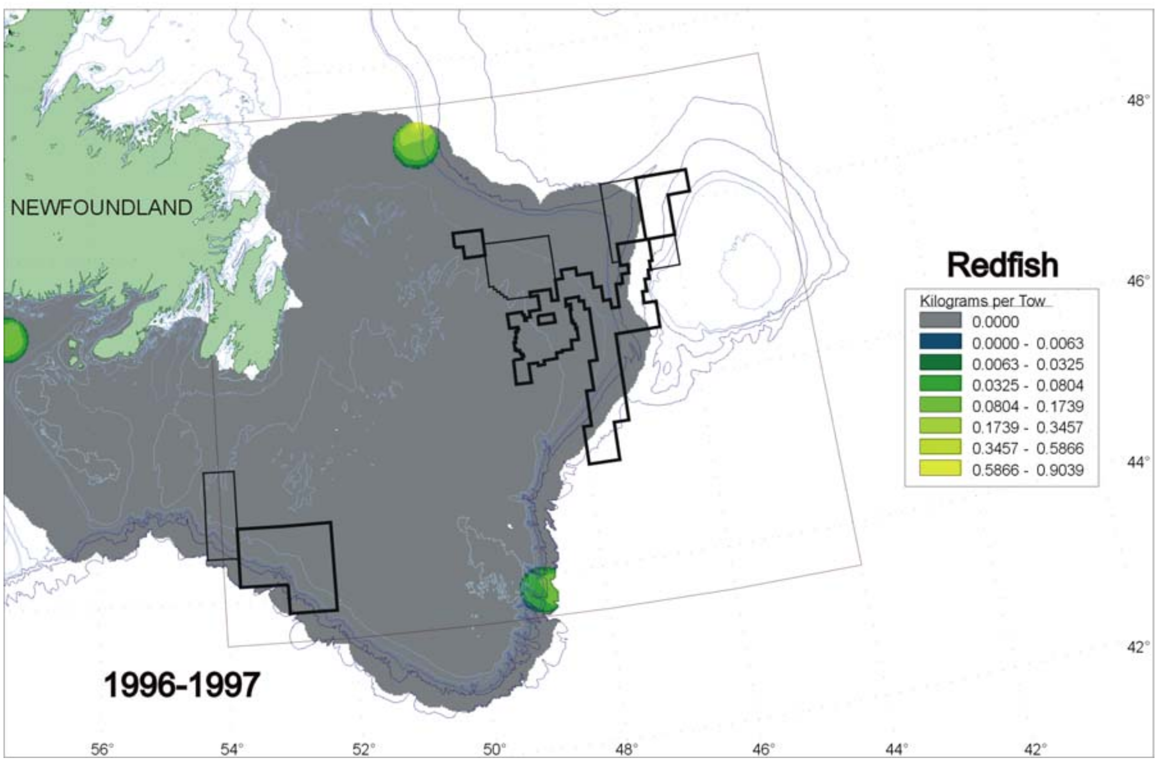


Figure 22c. Redfish distribution based on spring research surveys from 1992-95 & 1996-97. Gray sections represent areas sampled with no catch rate values.

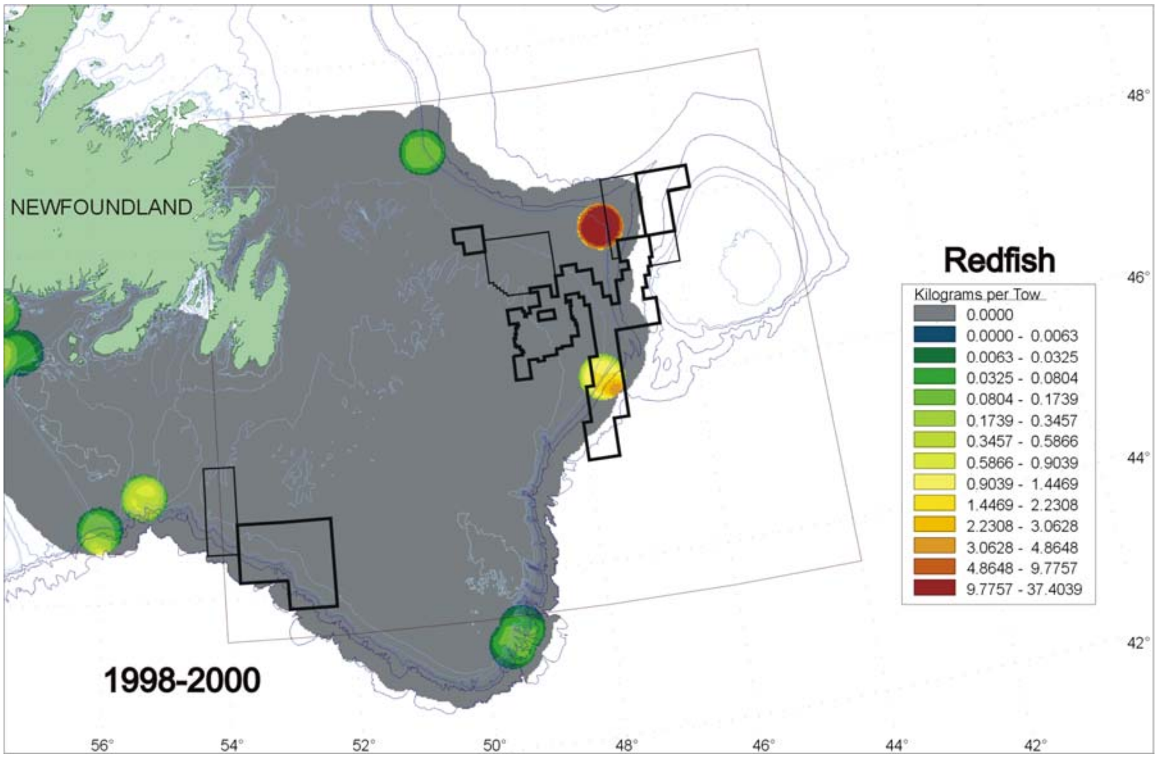
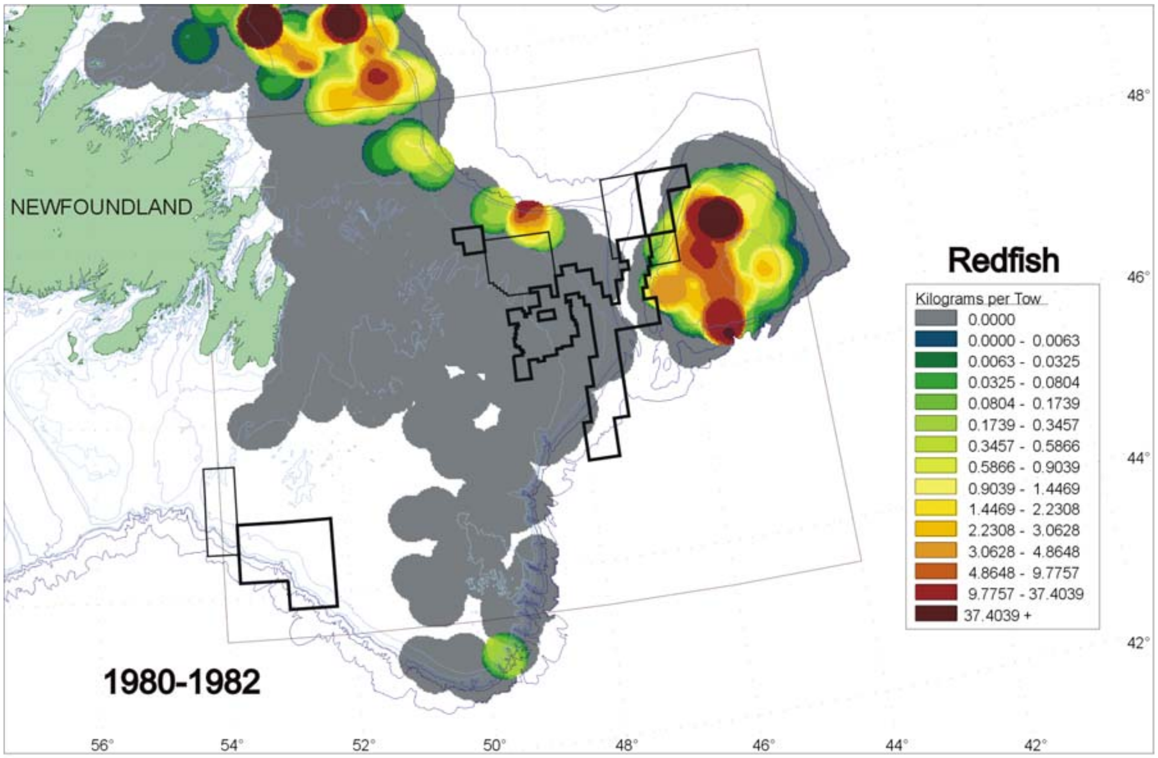


Figure 22d. Redfish distribution based on spring research surveys from 1998-2000. Gray sections represent areas sampled with no catch rate values.



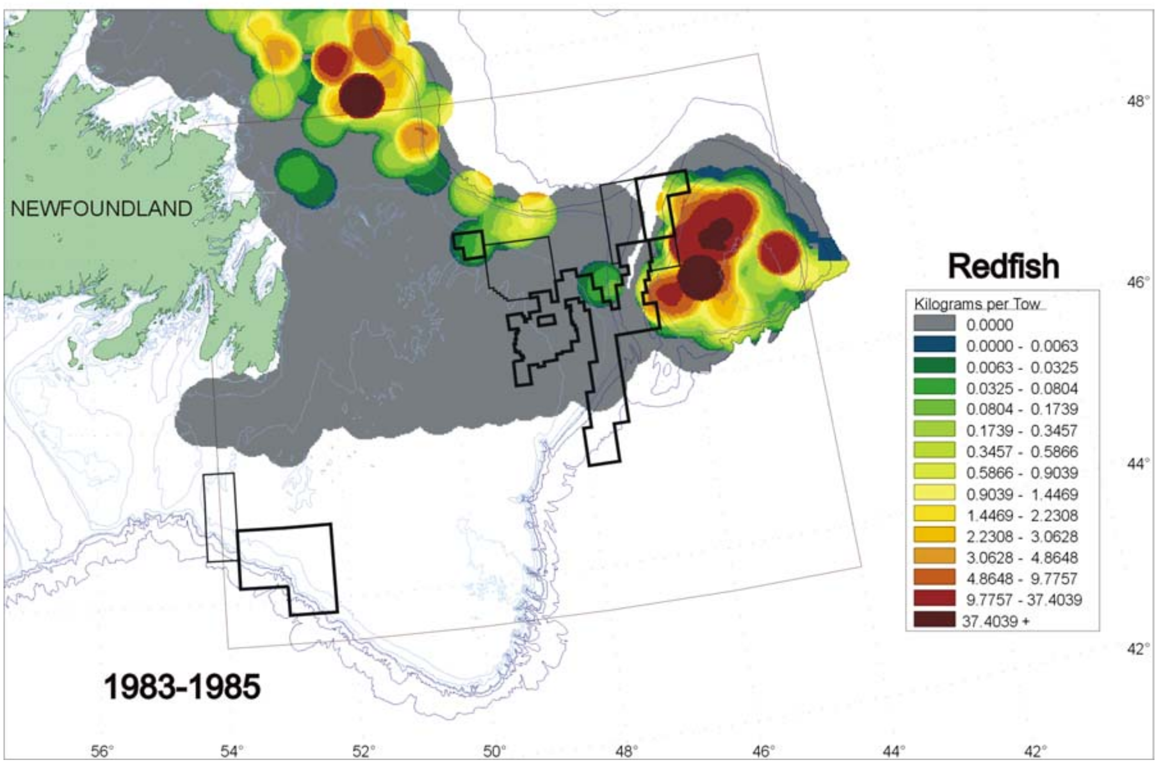


Figure 23a. Redfish distribution based on fall research surveys from 1980-82 & 1983-85. Gray sections represent areas sampled with no catch rate values.

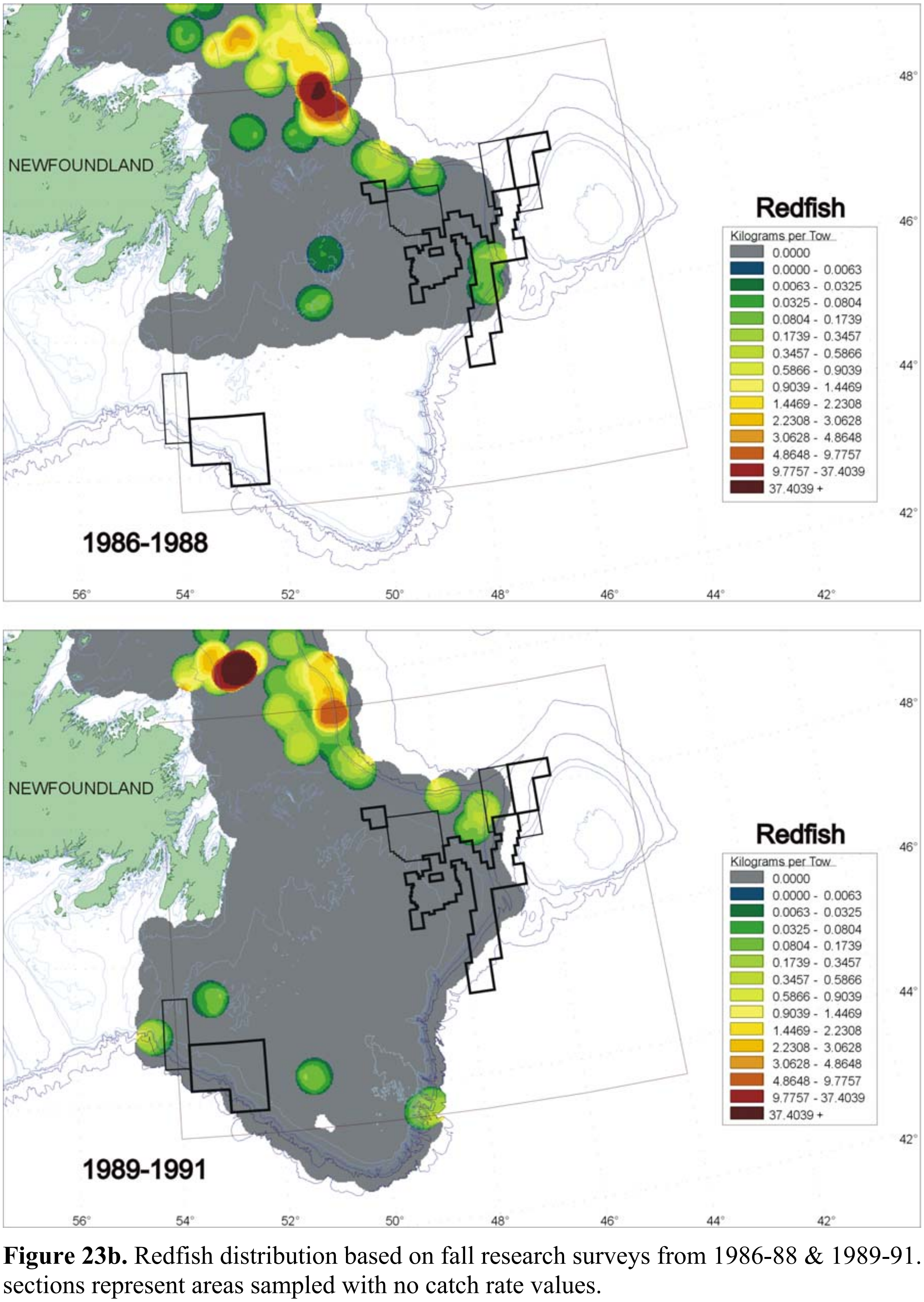


Figure 23b. Redfish distribution based on fall research surveys from 1986-88 & 1989-91. Gray sections represent areas sampled with no catch rate values.

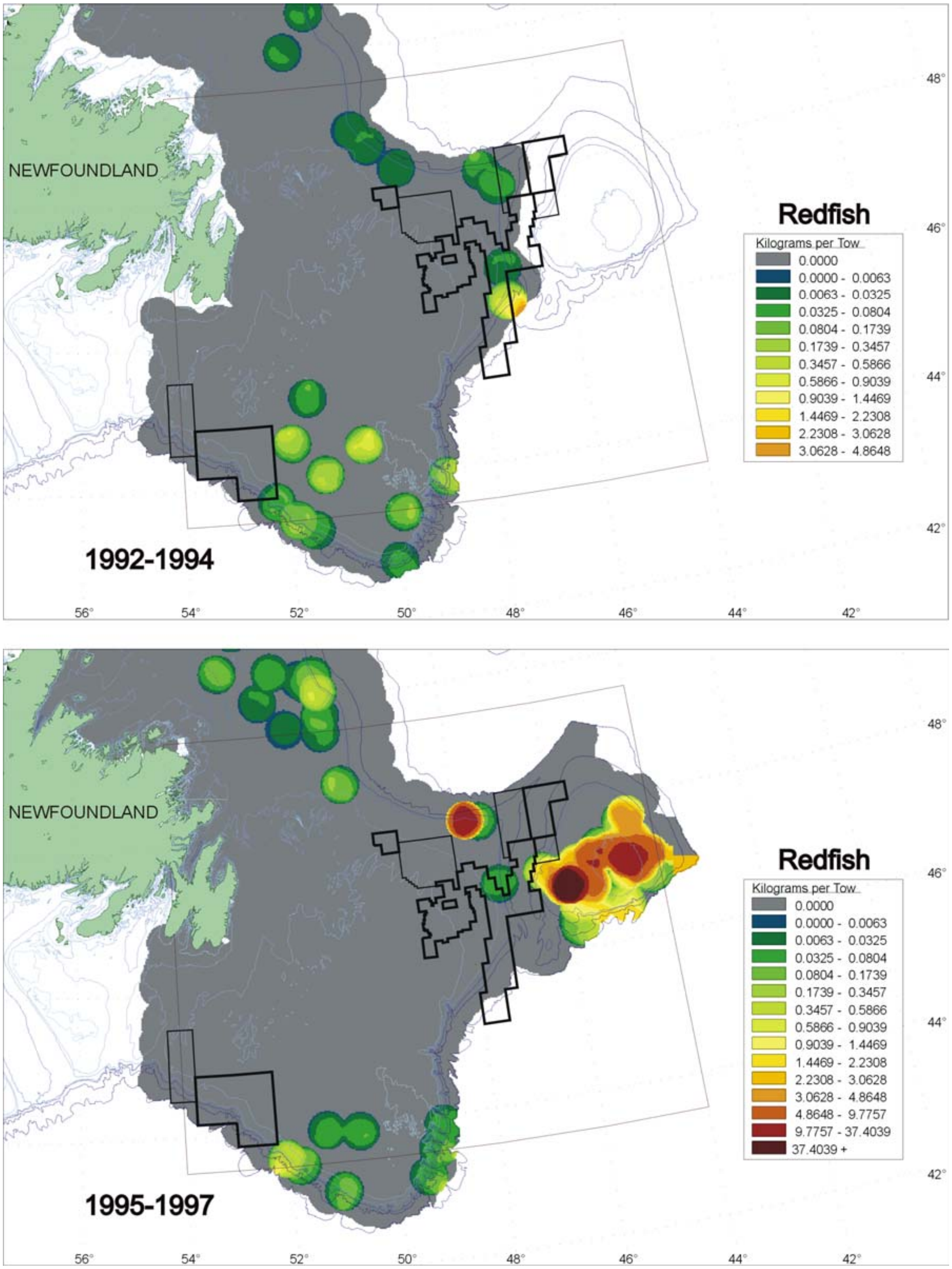


Figure 23c. Redfish distribution based on fall research surveys from 1992-94 & 1995-97. Gray sections represent areas sampled with no catch rate values.

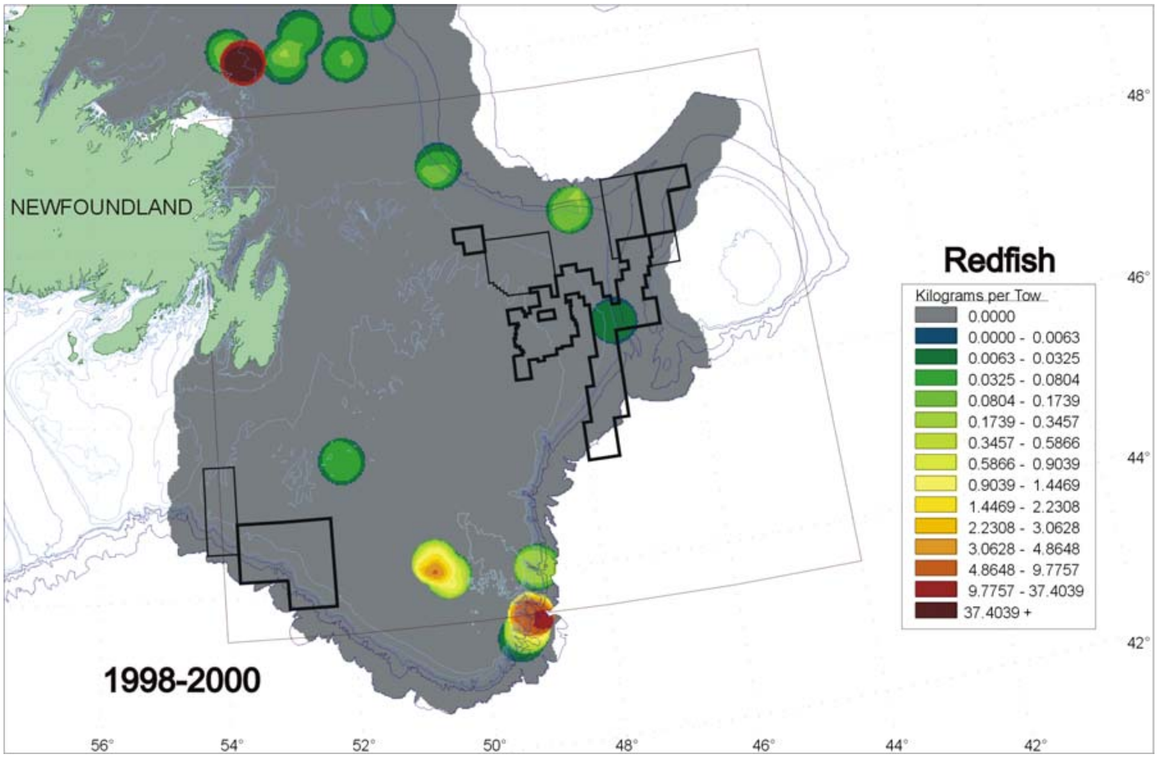


Figure 23d. Redfish distribution based on fall research surveys from 1998-2000. Gray sections represent areas sampled with no catch rate values.

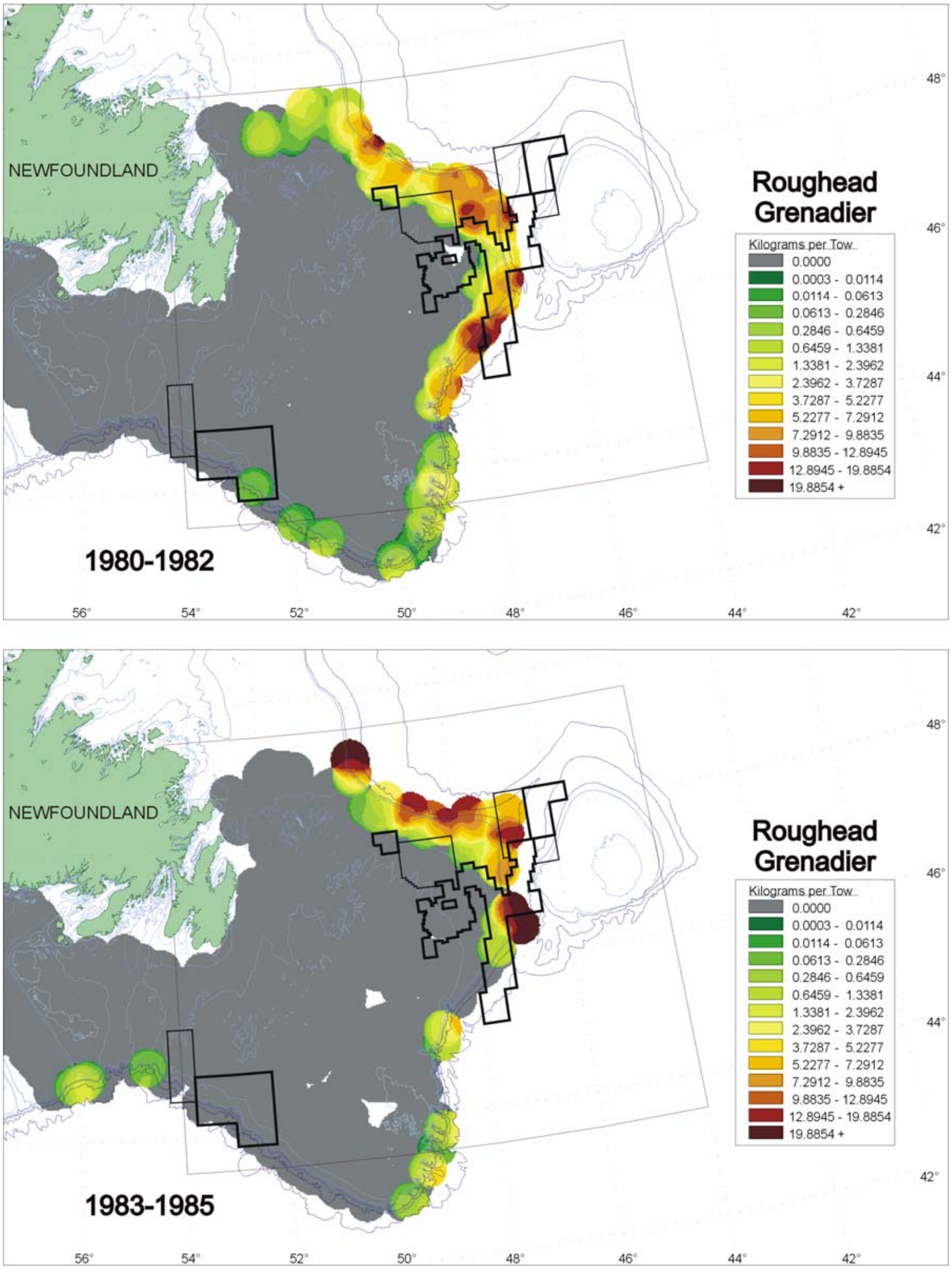
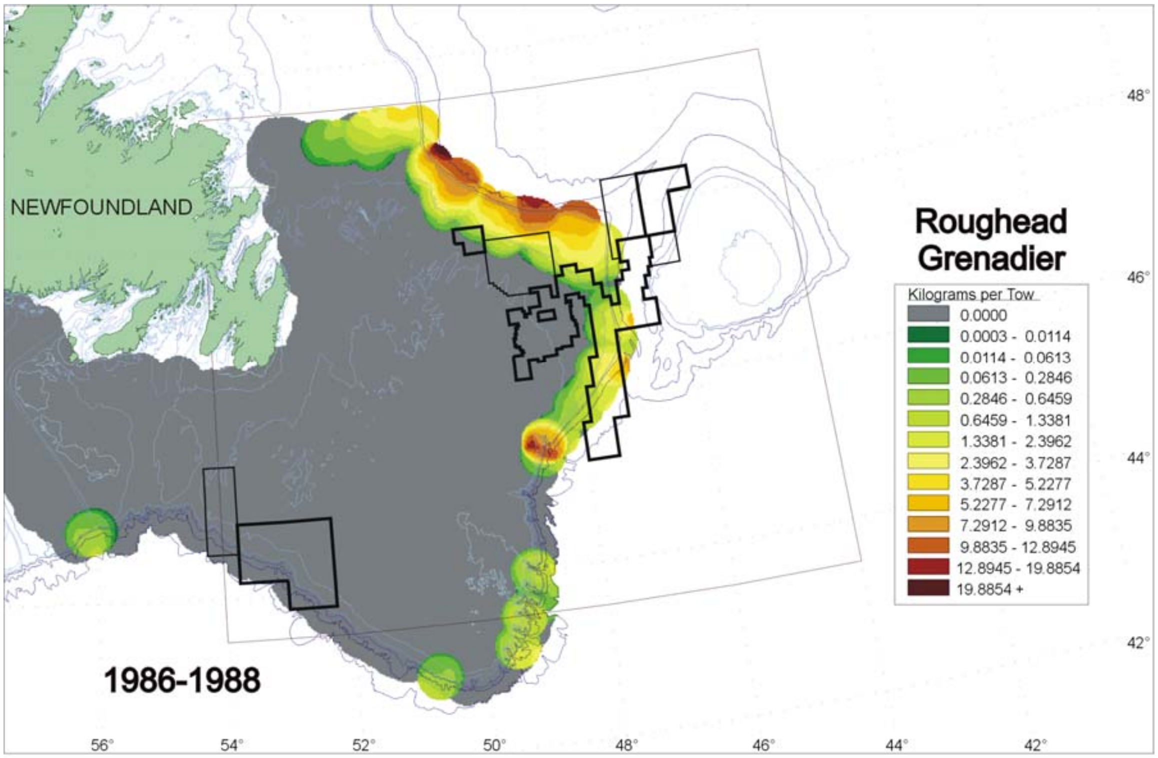


Figure 24a. Roughead grenadier distribution based on spring research surveys from 1980-82 & 1983-85. Gray sections represent areas sampled with no catch rate values.



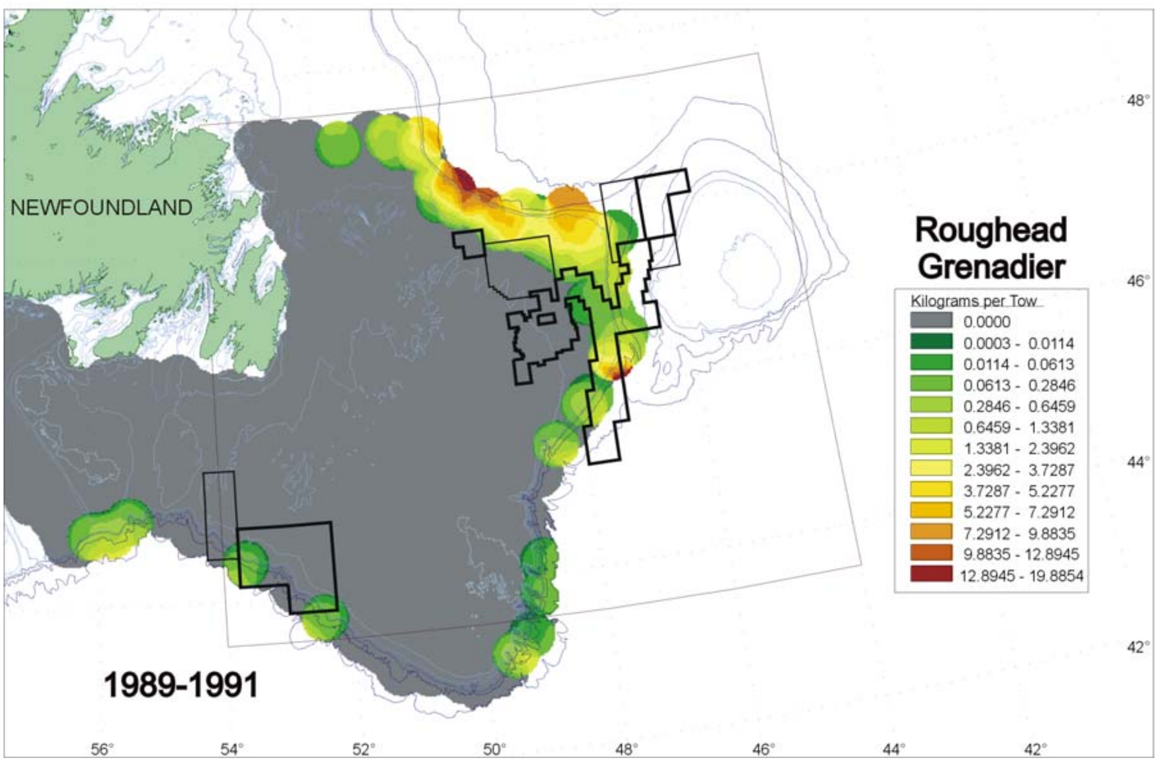


Figure 24b. Roughead grenadier distribution based on spring research surveys from 1986-88 & 1989-91. Gray sections represent areas sampled with no catch rate values.

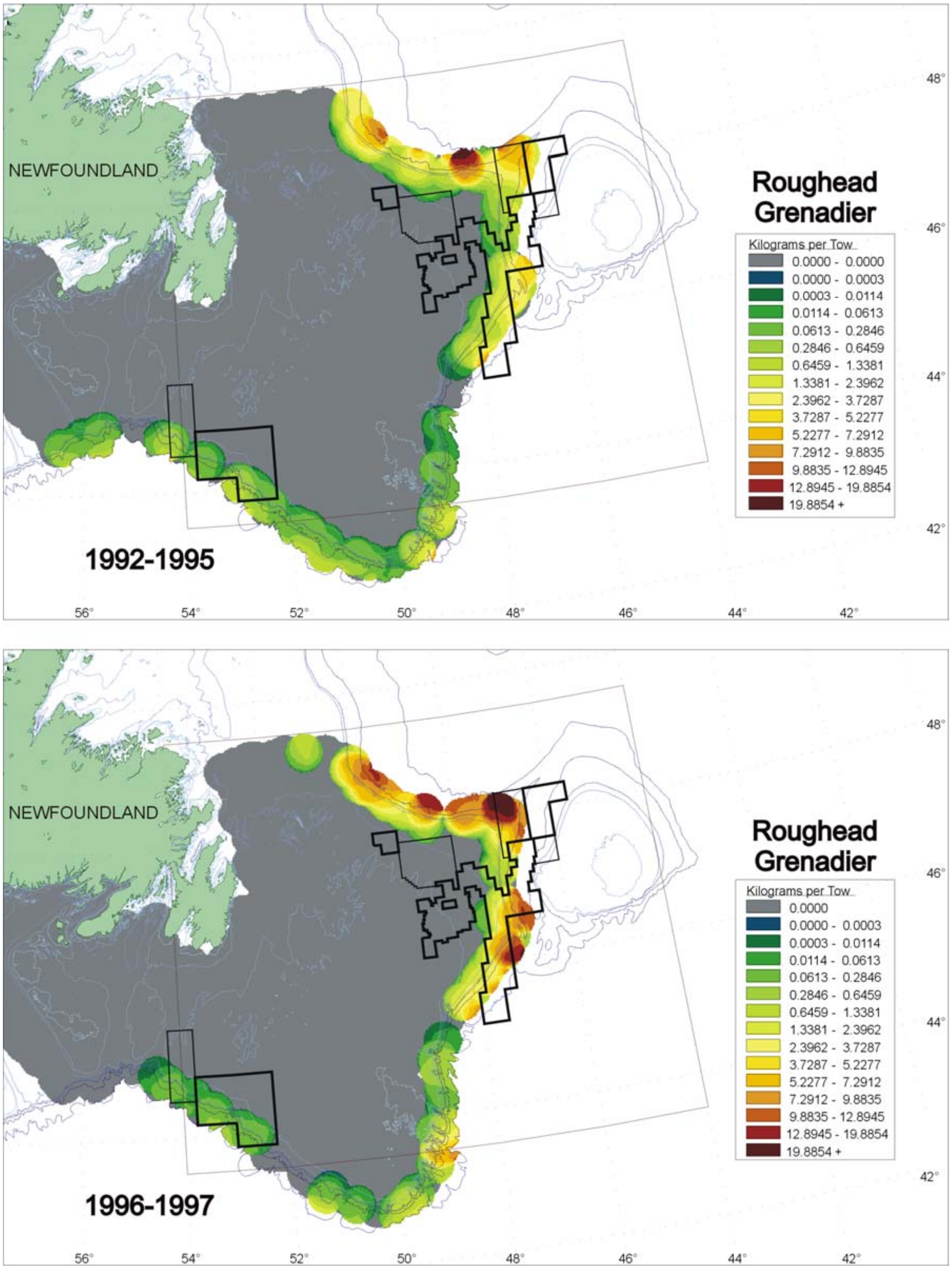


Figure 24c. Roughead grenadier distribution based on spring research surveys from 1992-95 & 1996-97. Gray sections represent areas sampled with no catch rate values.

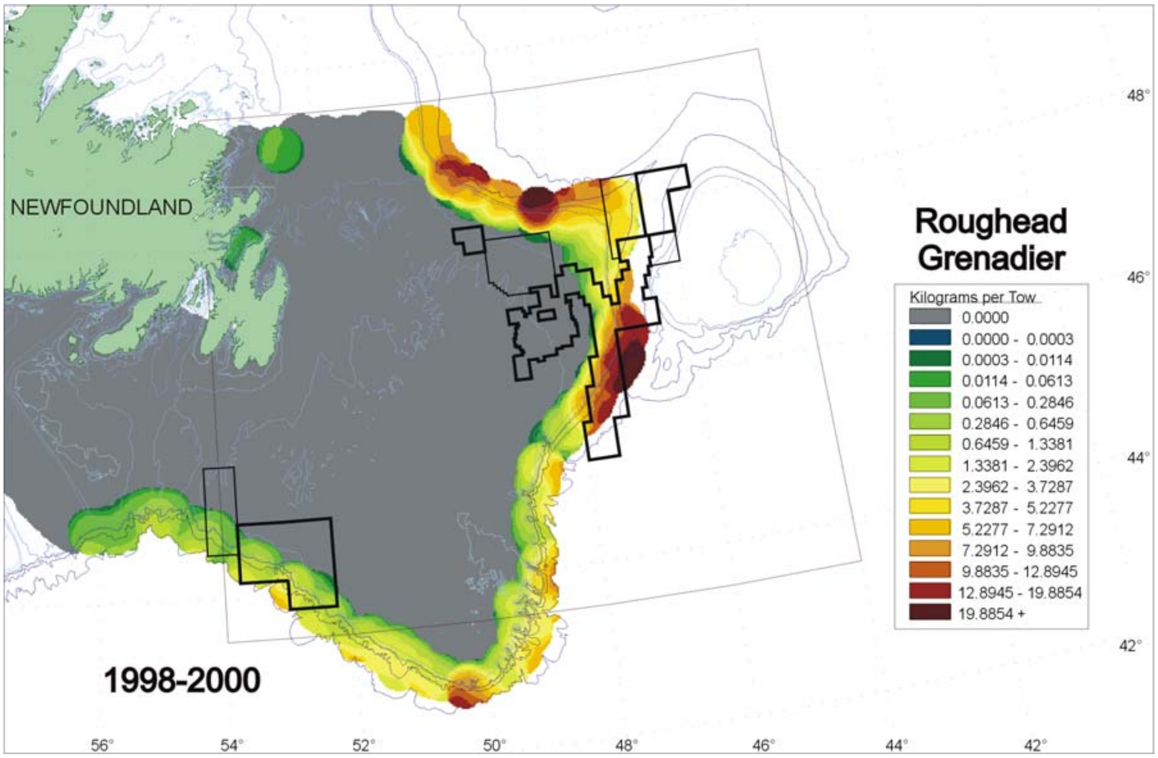
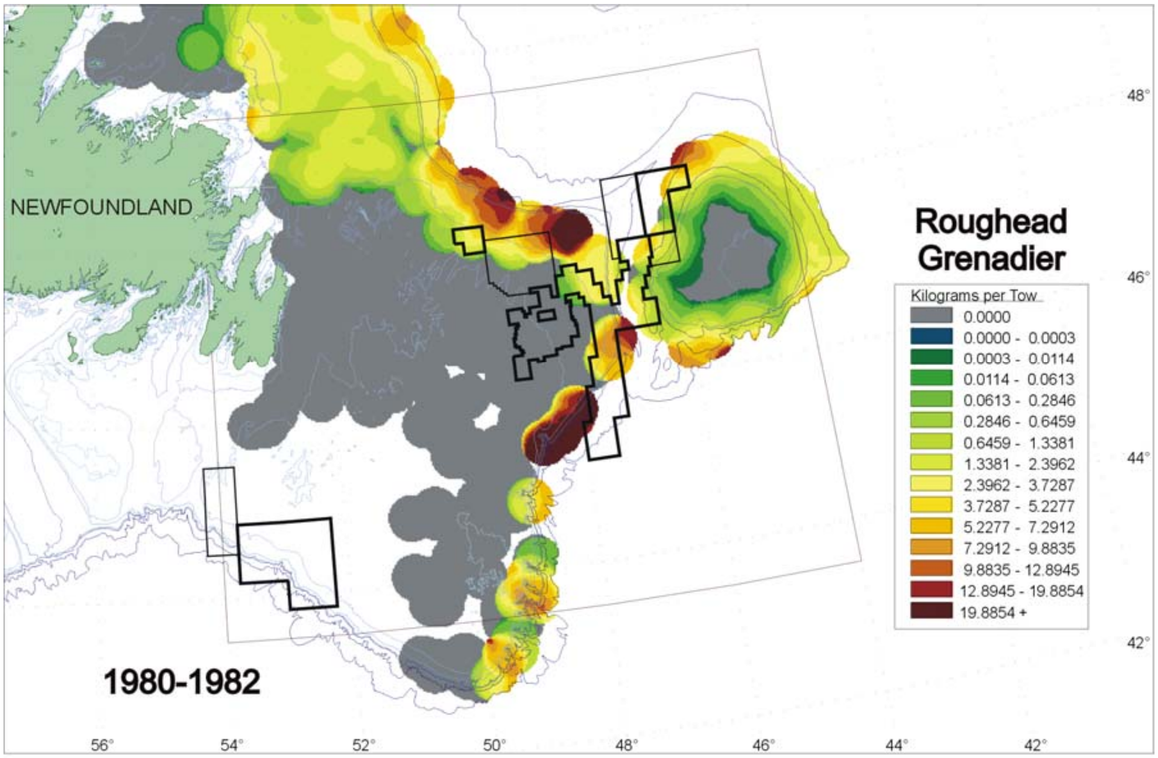


Figure 24d. Roughead grenadier distribution based on spring research surveys from 1998-2000. Gray sections represent areas sampled with no catch rate values.



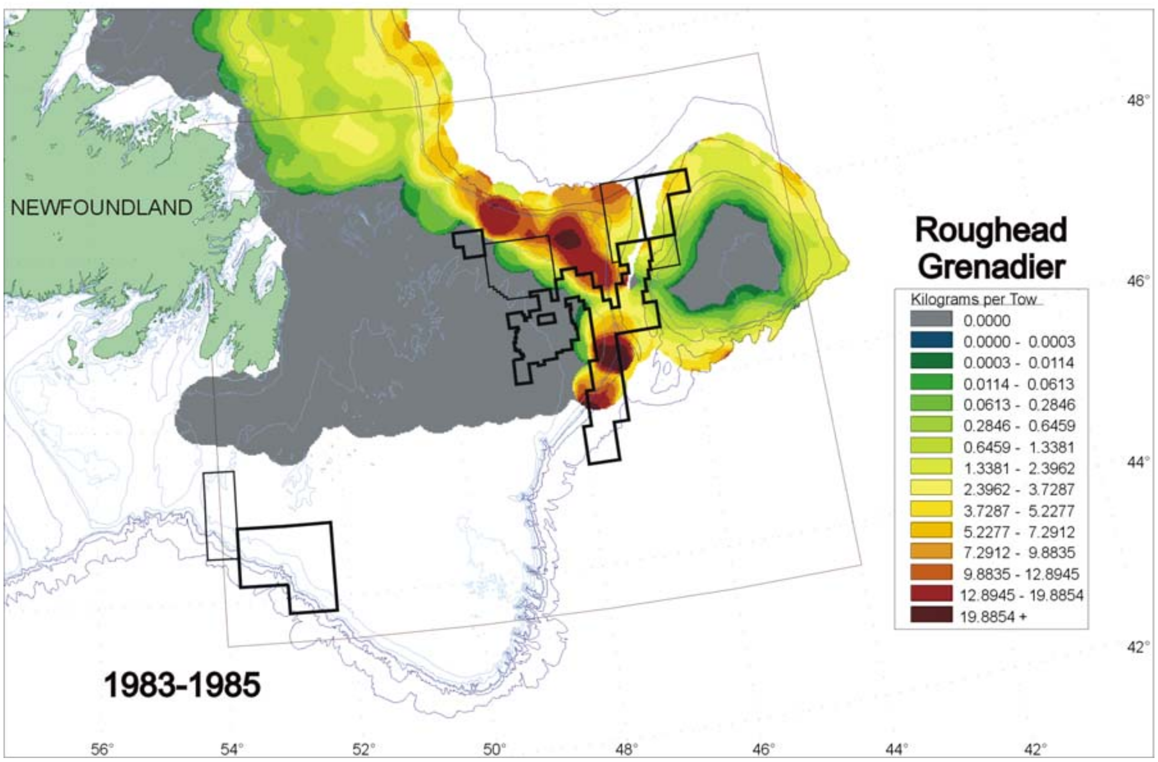


Figure 25a. Roughead grenadier distribution based on fall research surveys from 1980-82 & 1983-85. Gray sections represent areas sampled with no catch rate values.

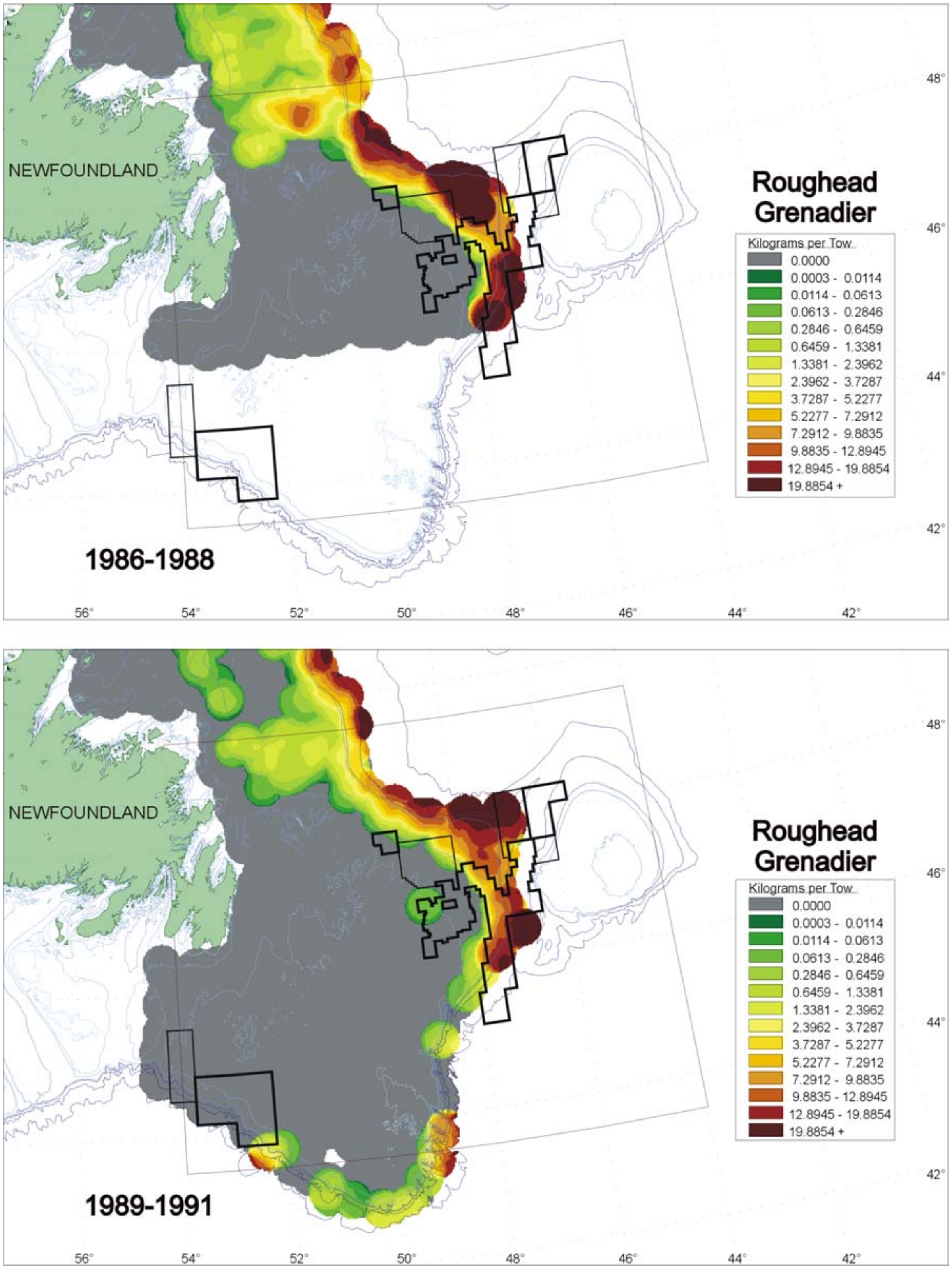


Figure 25b. Roughead grenadier distribution based on fall research surveys from 1986-88 & 1989-91. Gray sections represent areas sampled with no catch rate values.

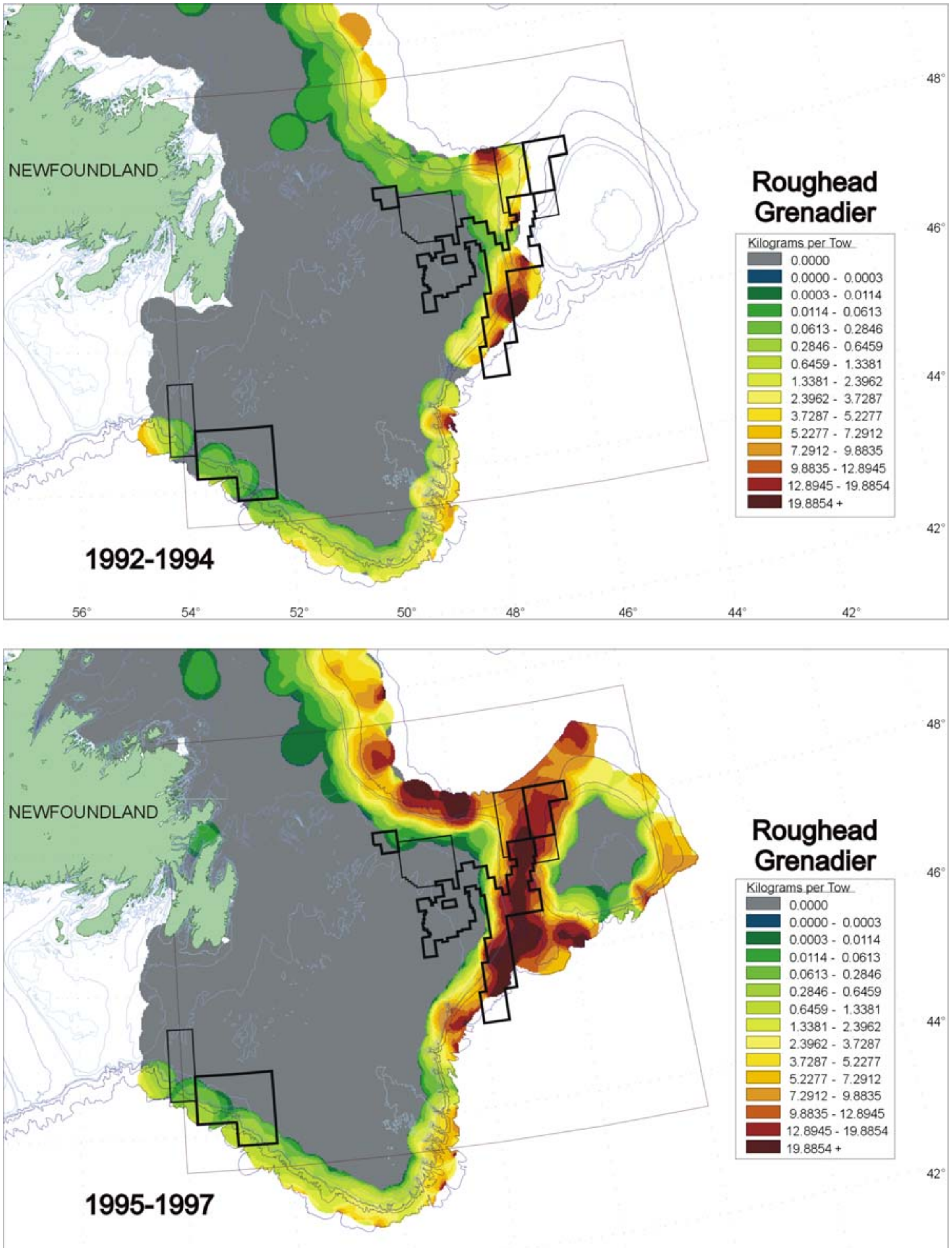


Figure 25c. Roughead grenadier distribution based on fall research surveys from 1992-94 & 1995-97. Gray sections represent areas sampled with no catch rate values.

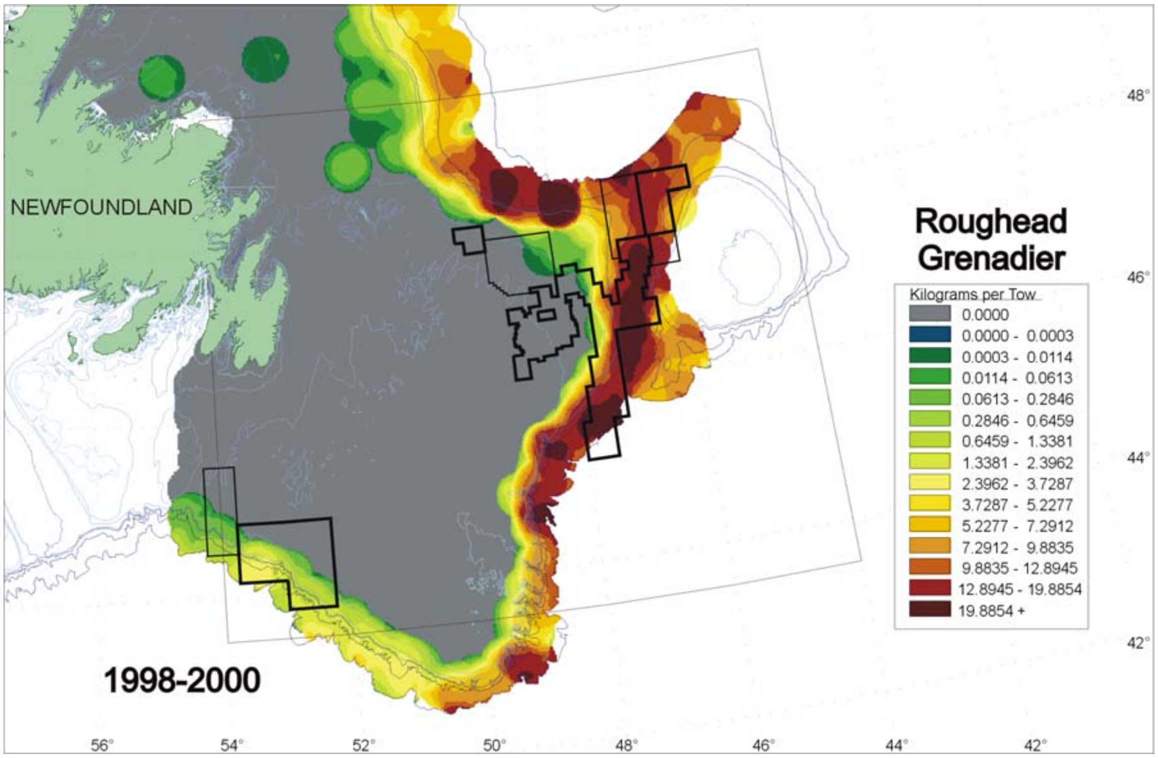


Figure 25d. Roughead grenadier distribution based on fall research surveys from 1998-2000. Gray sections represent areas sampled with no catch rate values.

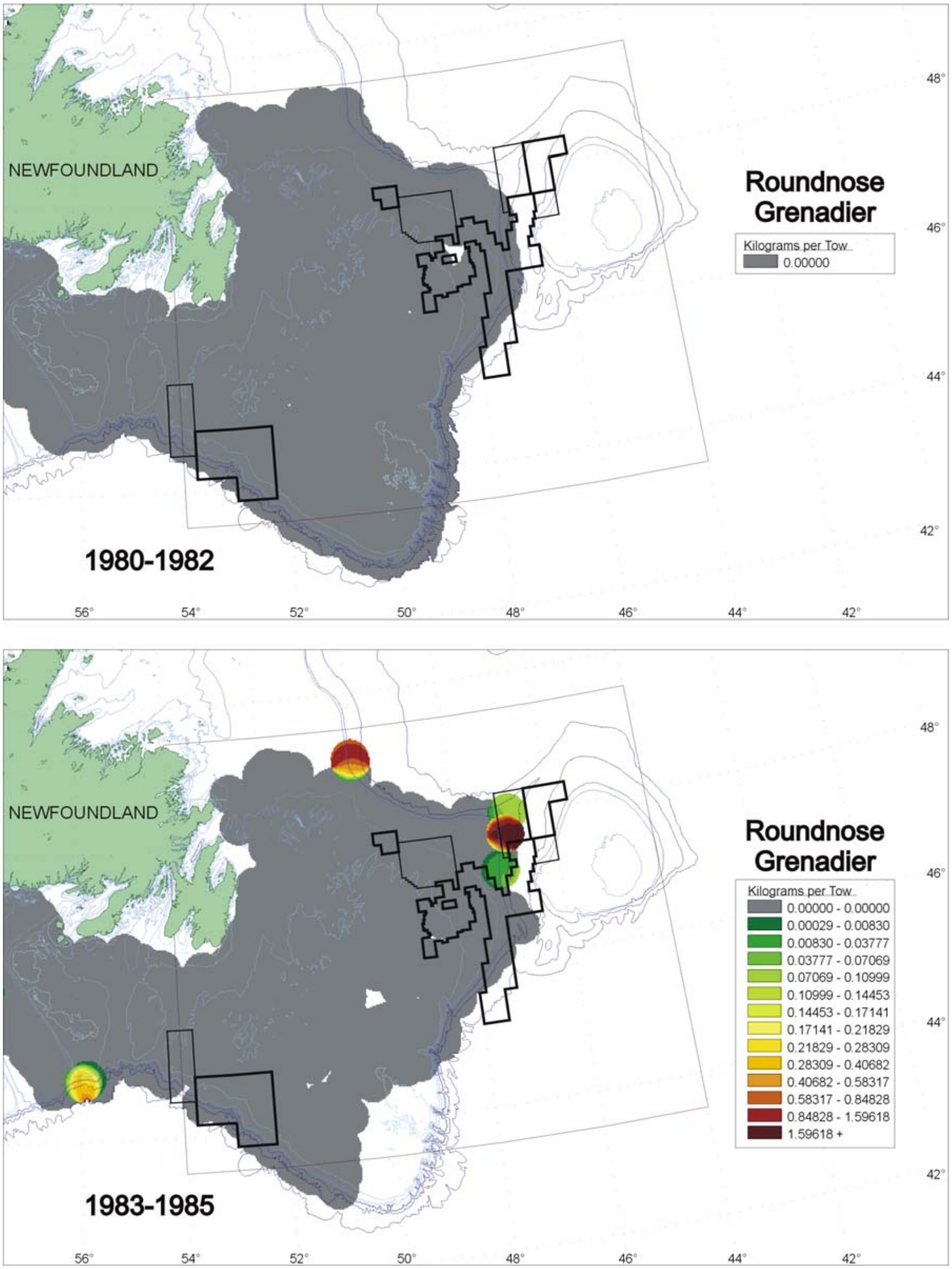
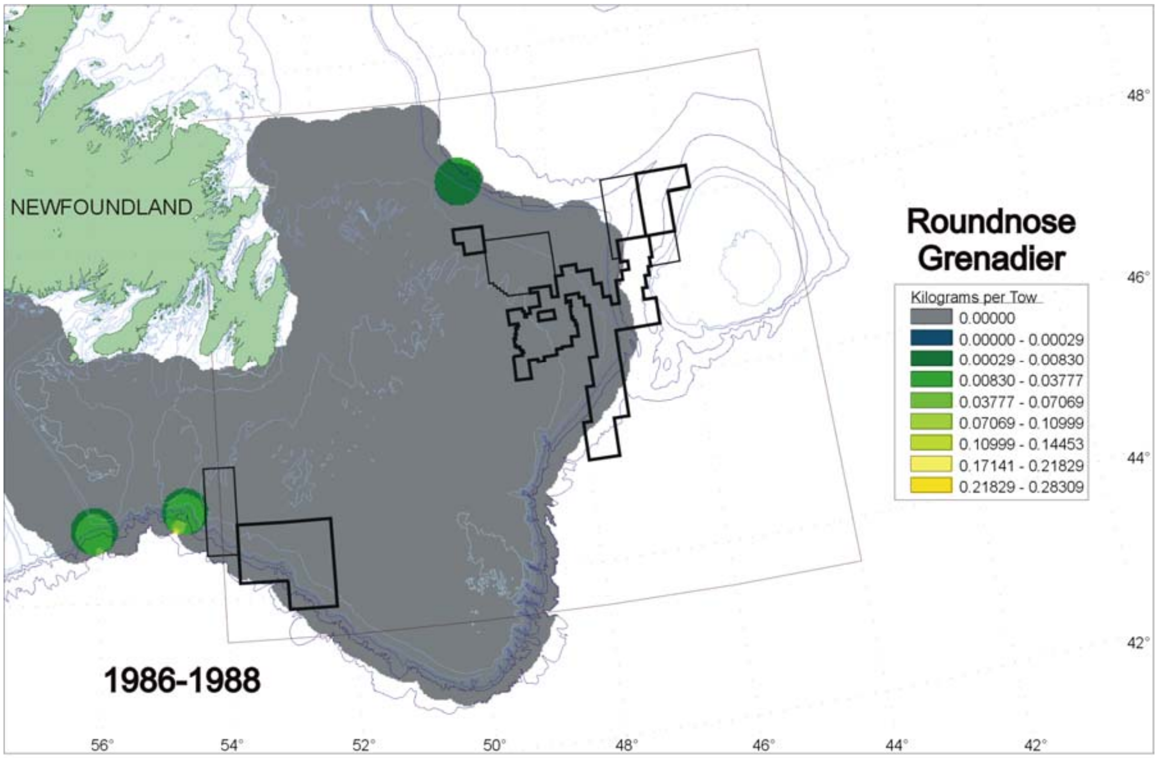


Figure 26a. Roundnose grenadier distribution based on spring research surveys from 1980-82 & 1983-85. Gray sections represent areas sampled with no catch rate values.



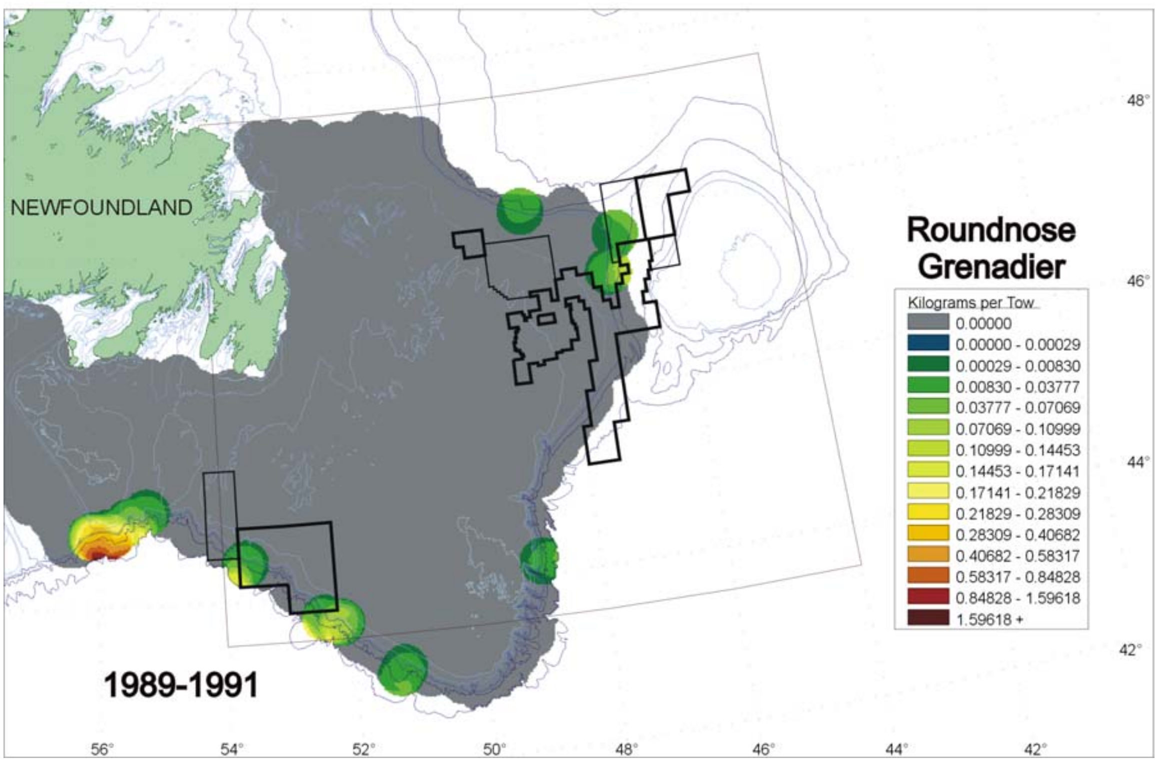


Figure 26b. Roundnose grenadier distribution based on spring research surveys from 1986-88 & 1989-91. Gray sections represent areas sampled with no catch rate values.

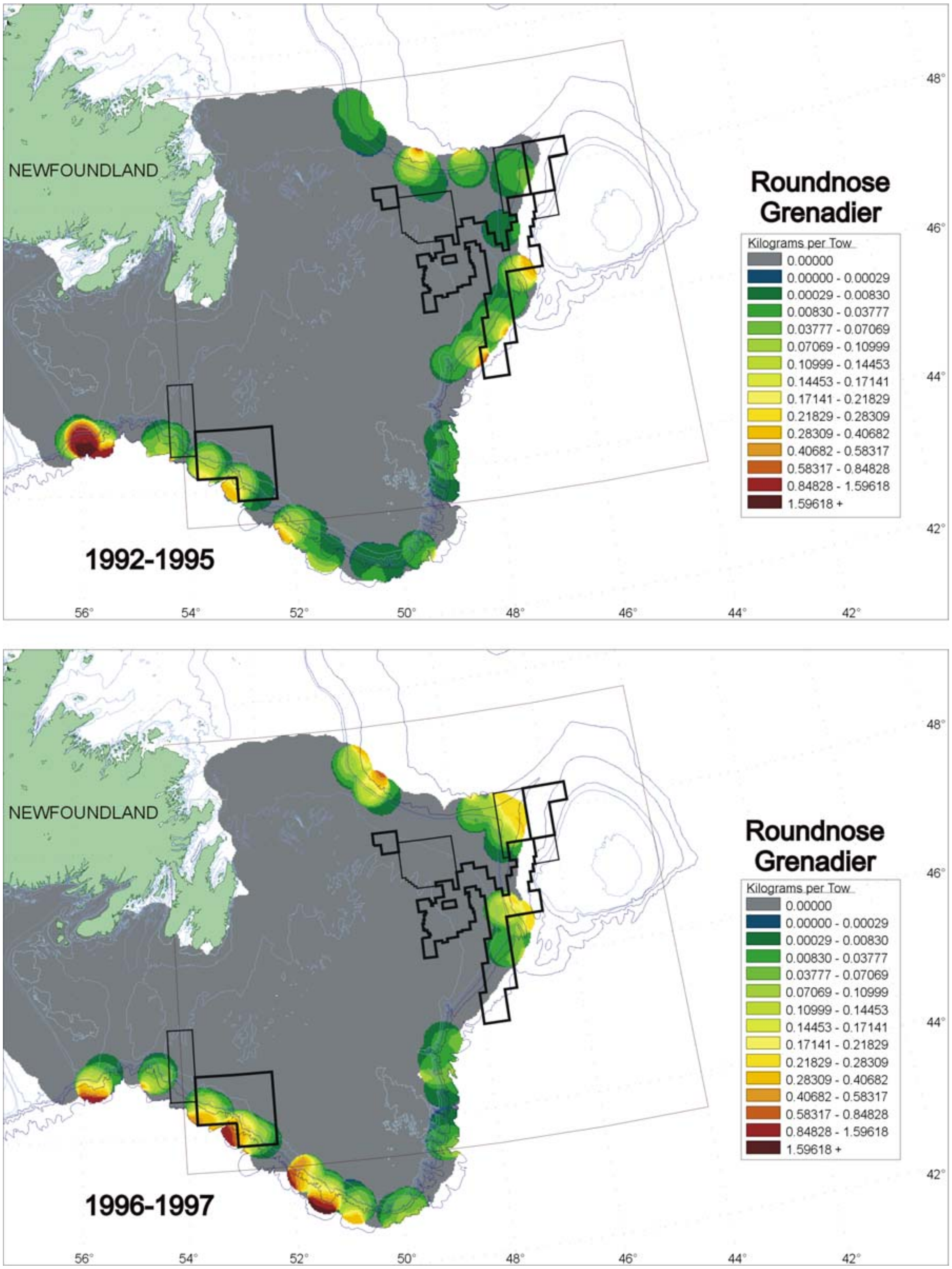


Figure 26c. Roundnose grenadier distribution based on spring research surveys from 1992-95 & 1996-97. Gray sections represent areas sampled with no catch rate values.

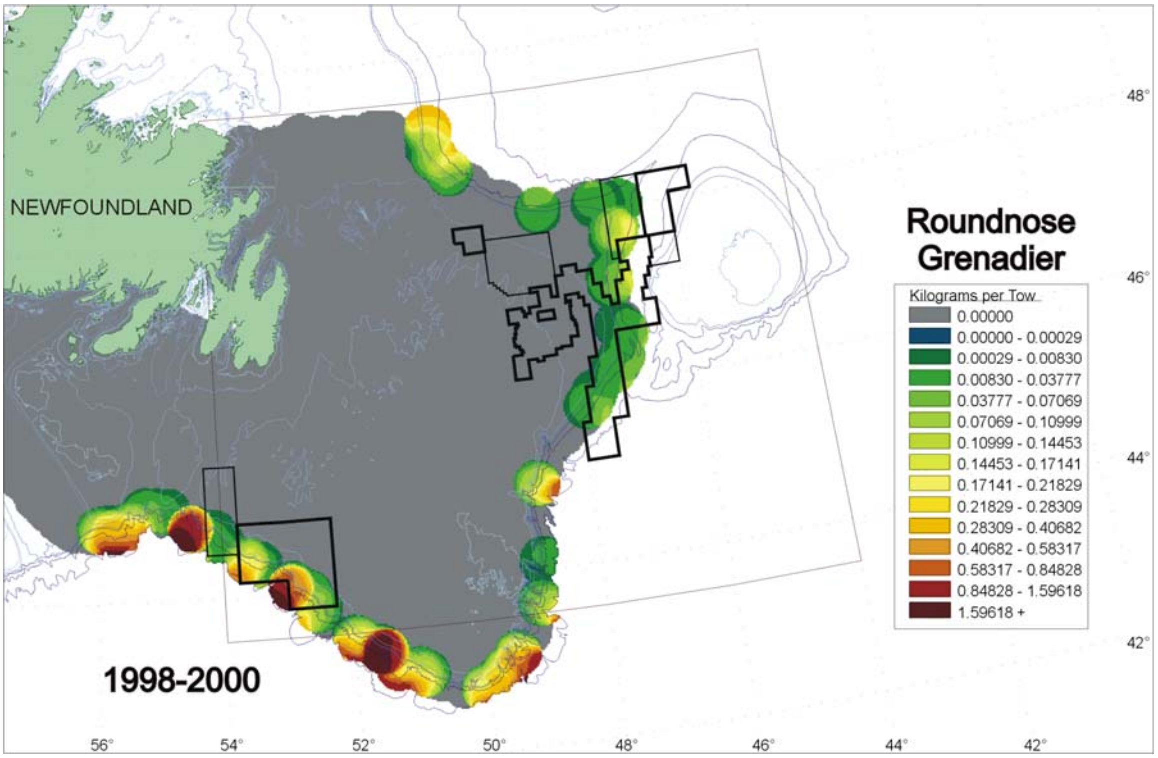
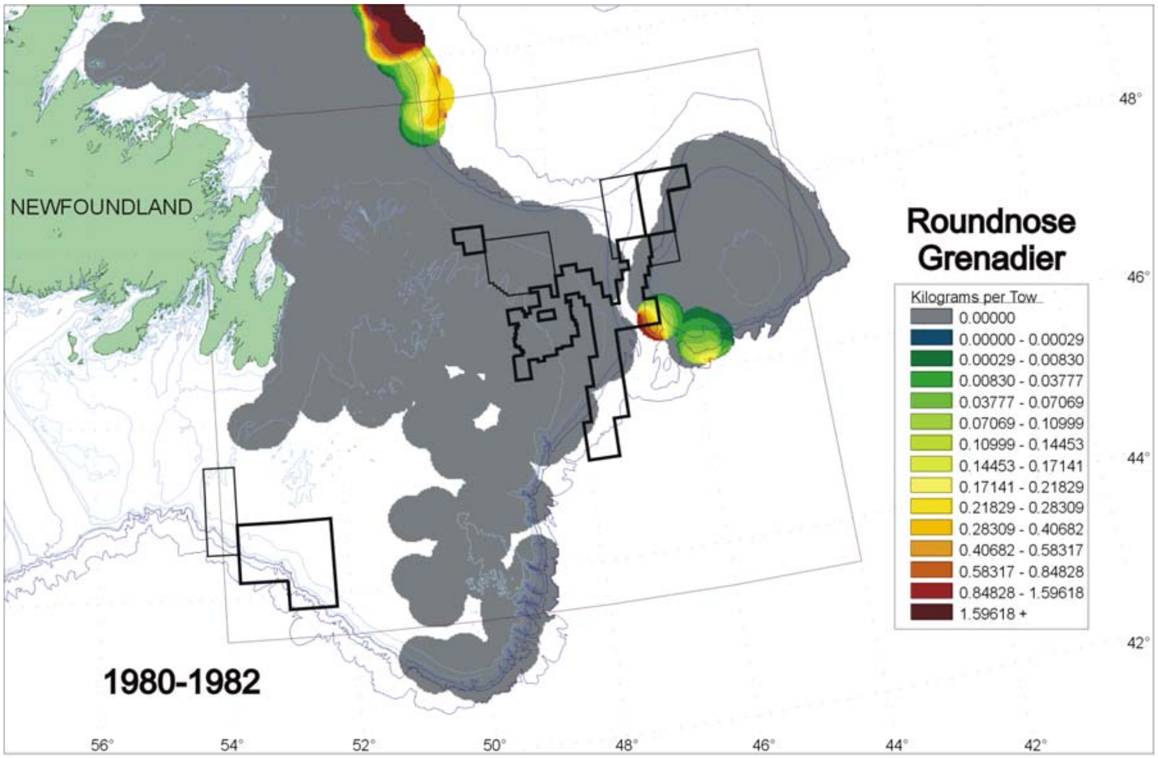


Figure 26d. Roundnose grenadier distribution based on spring research surveys from 1998-2000. Gray sections represent areas sampled with no catch rate values.



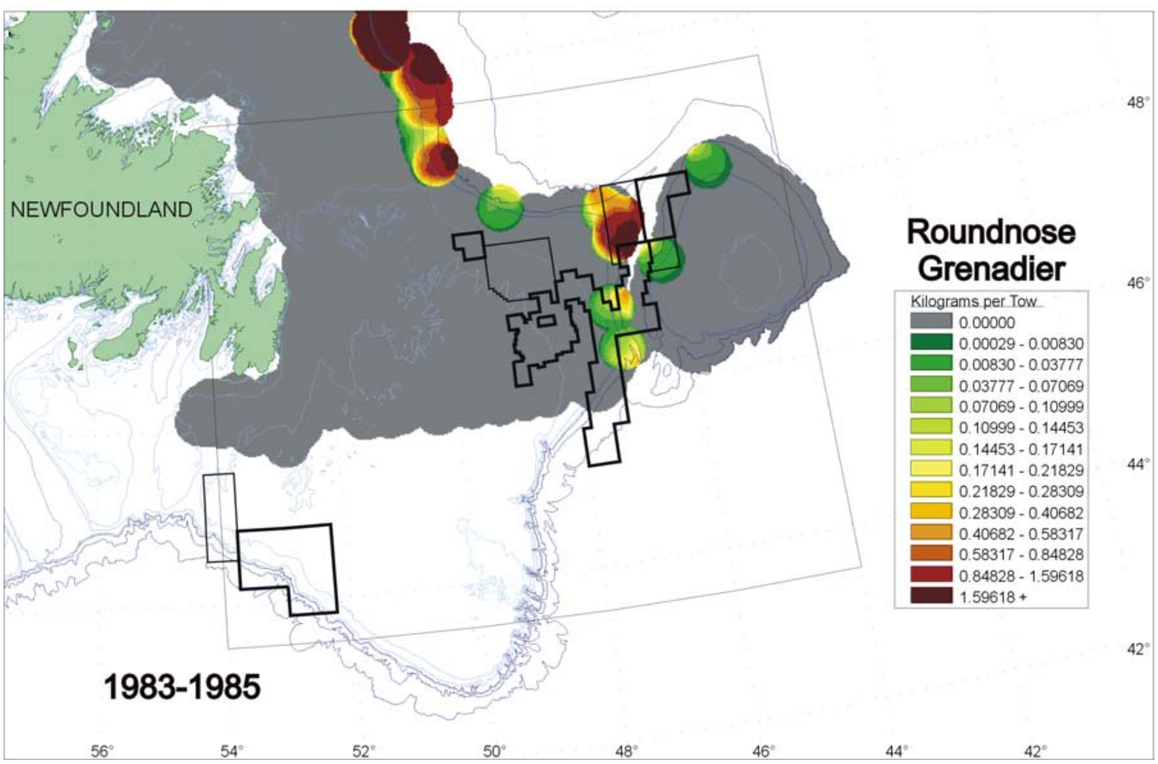
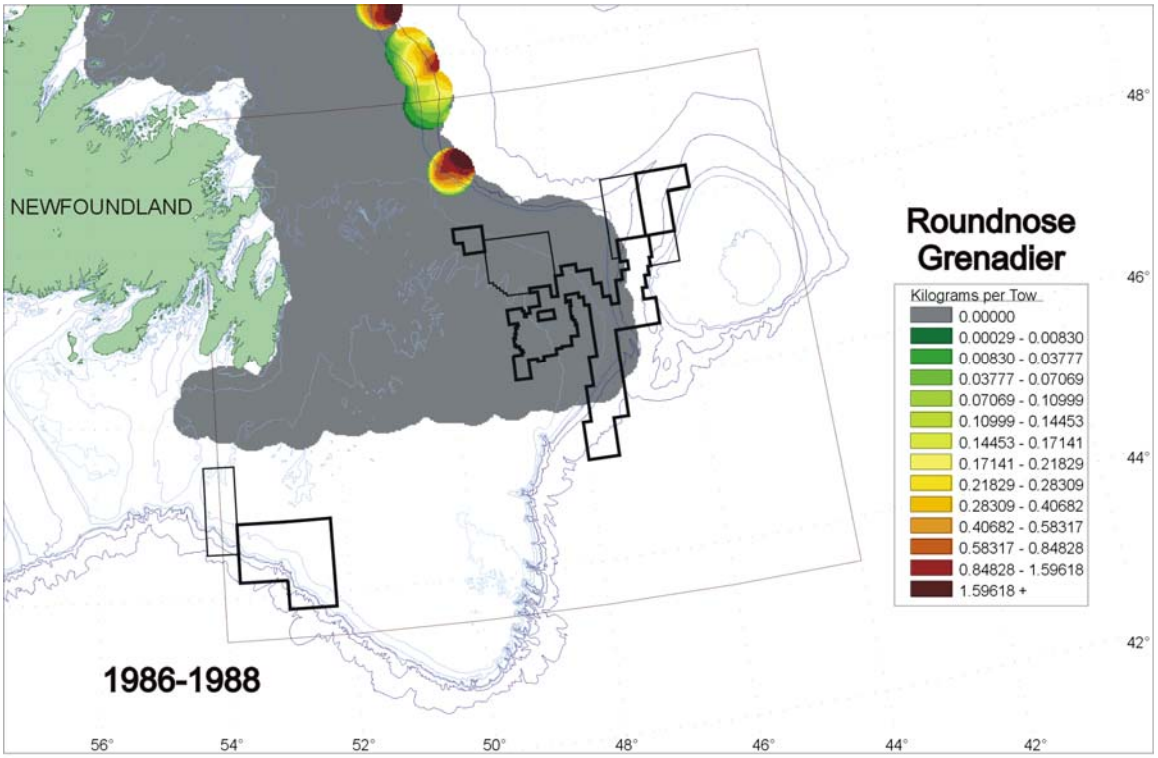


Figure 27a. Roundnose grenadier distribution based on fall research surveys from 1980-82 & 1983-85. Gray sections represent areas sampled with no catch rate values.



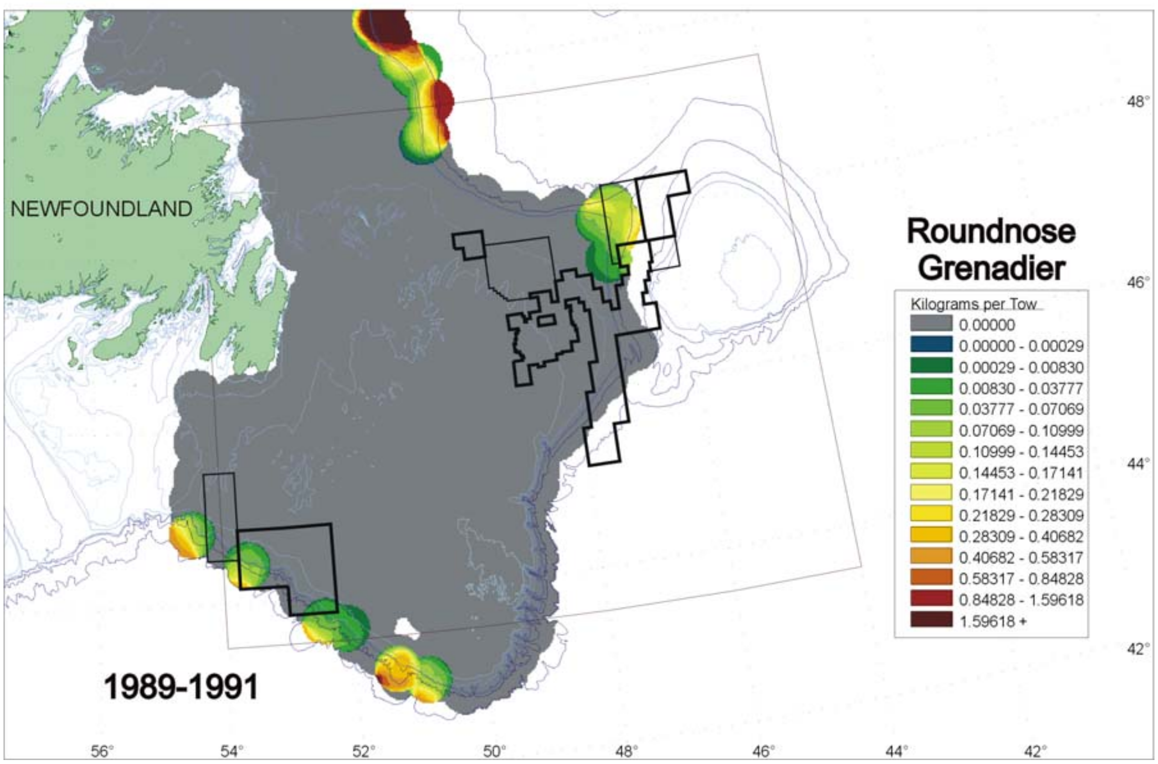


Figure 27b. Roundnose grenadier distribution based on fall research surveys from 1986-88 & 1989-91. Gray sections represent areas sampled with no catch rate values.

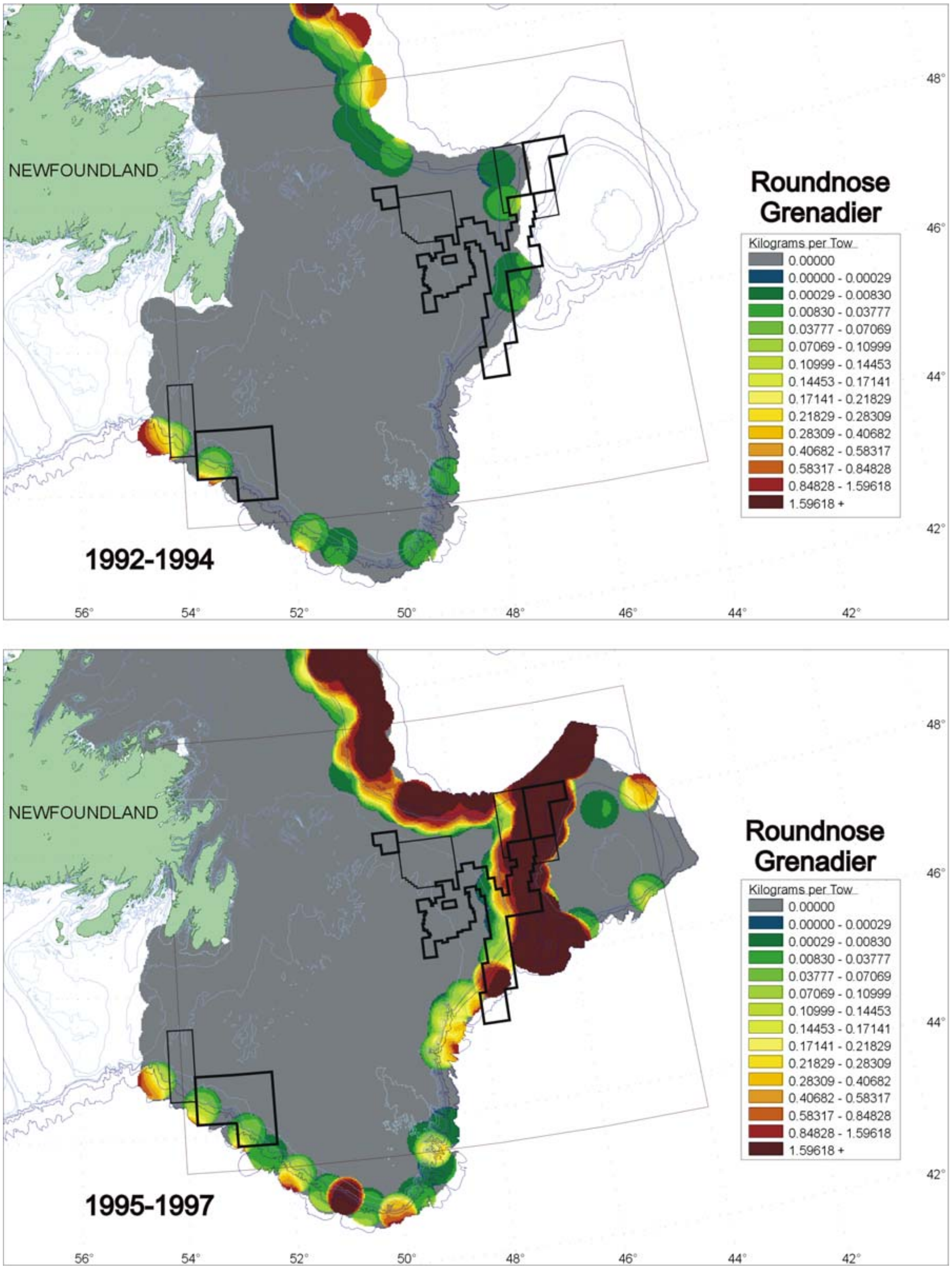


Figure 27c. Roundnose grenadier distribution based on fall research surveys from 1992-94 & 1995-97. Gray sections represent areas sampled with no catch rate values.

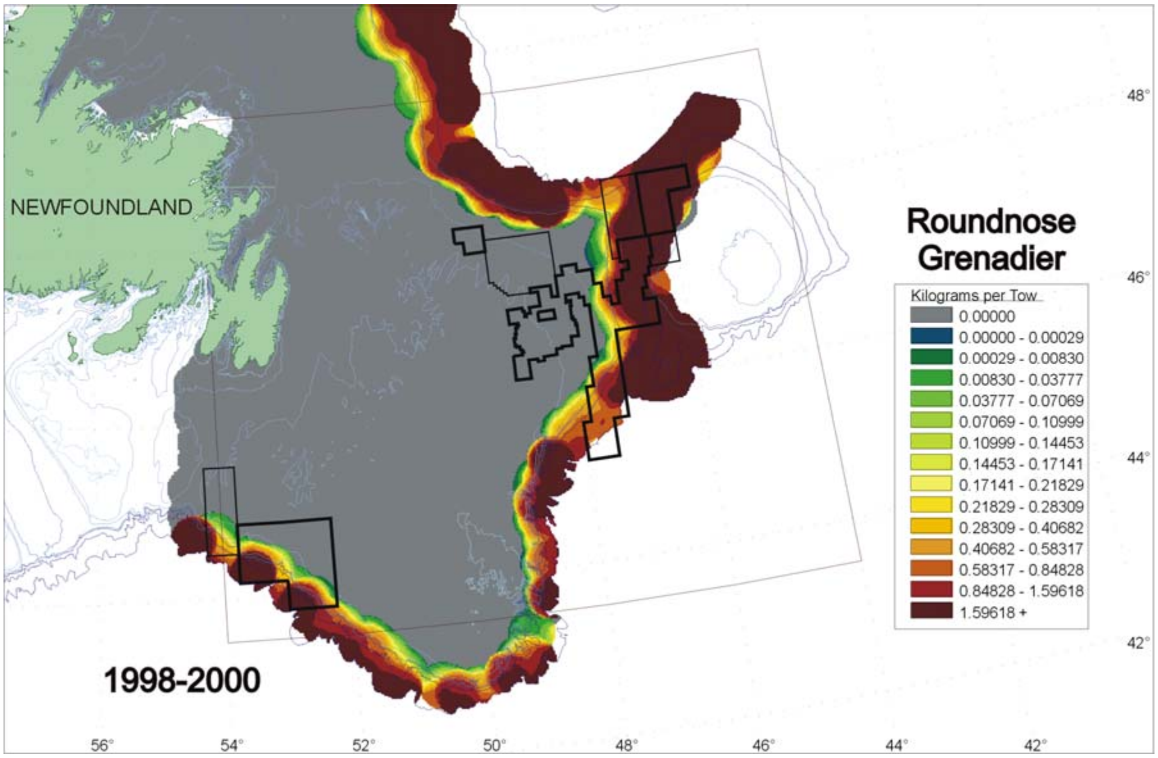


Figure 27d. Roundnose grenadier distribution based on fall research surveys from 1998-2000. Gray sections represent areas sampled with no catch rate values.

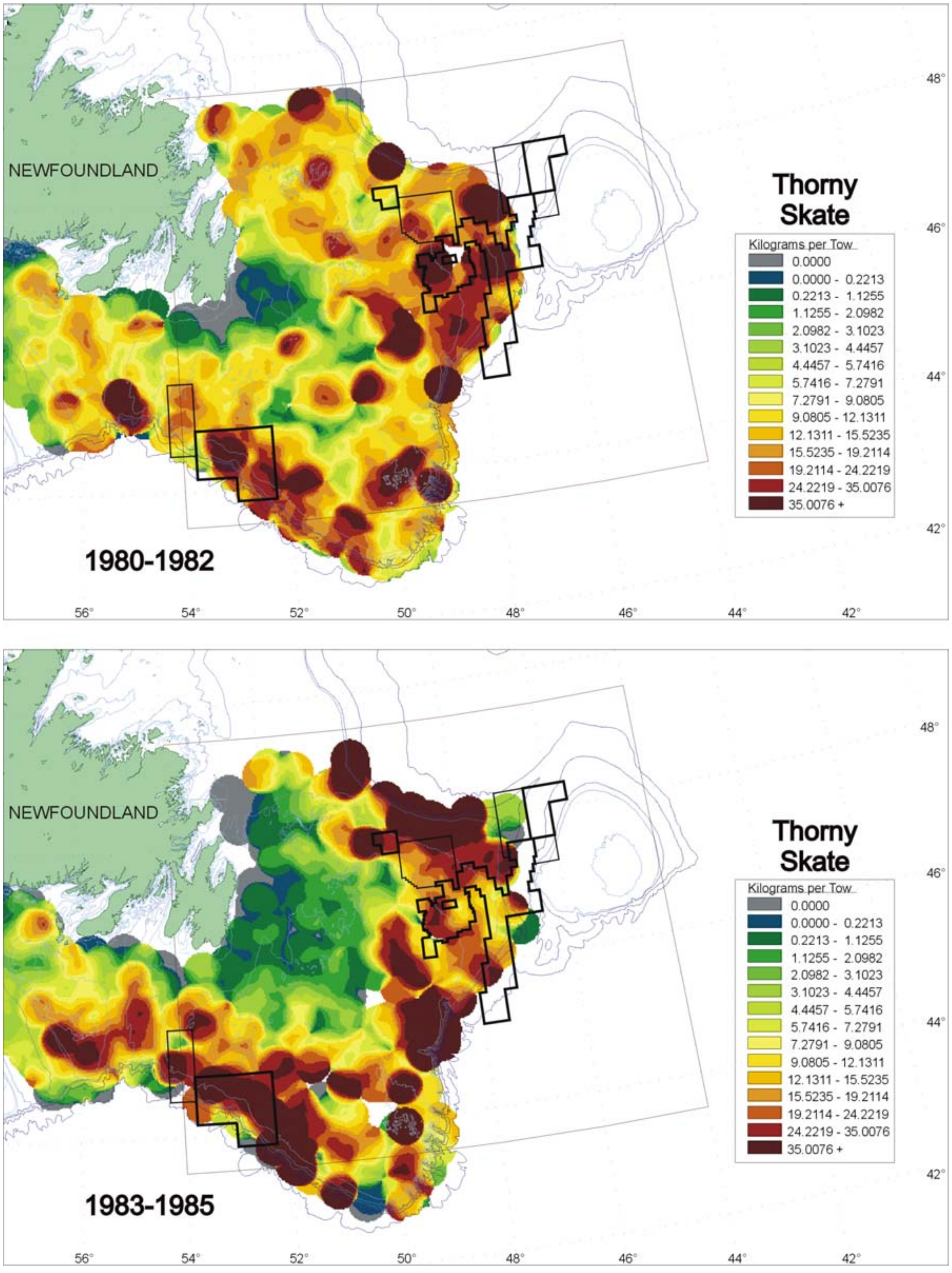
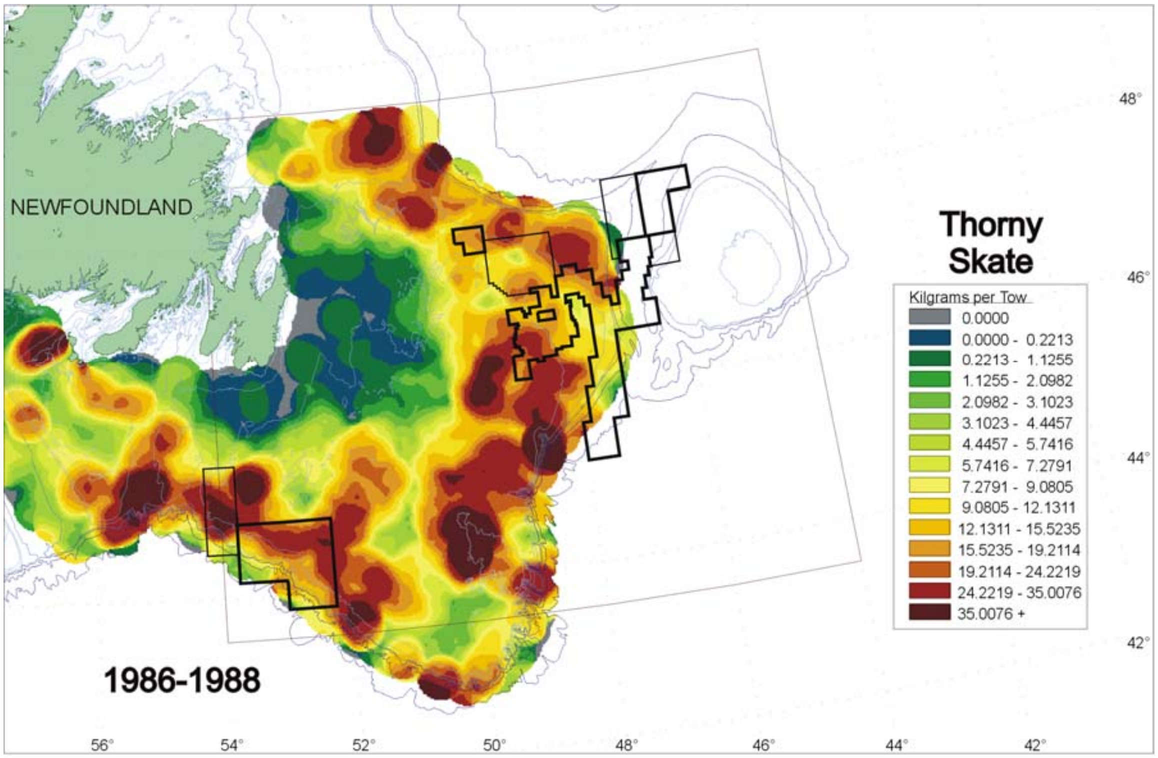


Figure 28a. Thorny skate distribution based on spring research surveys from 1980-82 & 1983-85. Gray sections represent areas sampled with no catch rate values.



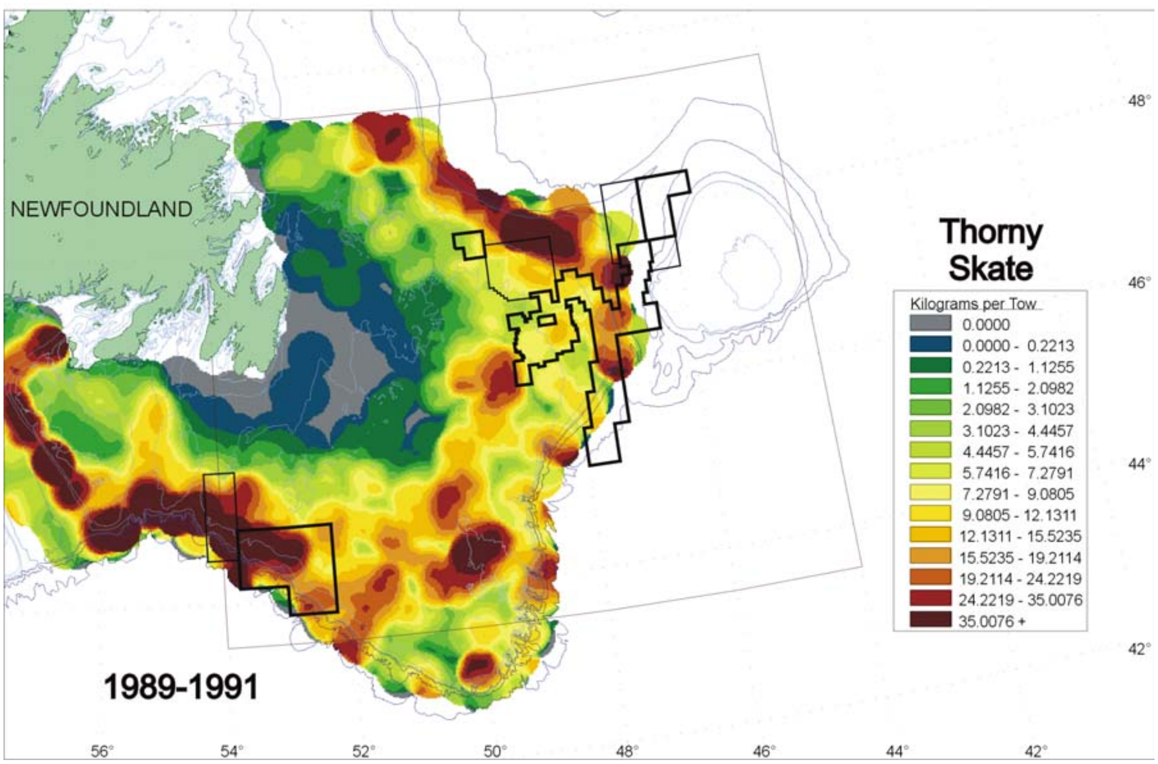


Figure 28b. Thorny skate distribution based on spring research surveys from 1986-88 & 1989-91. Gray sections represent areas sampled with no catch rate values.

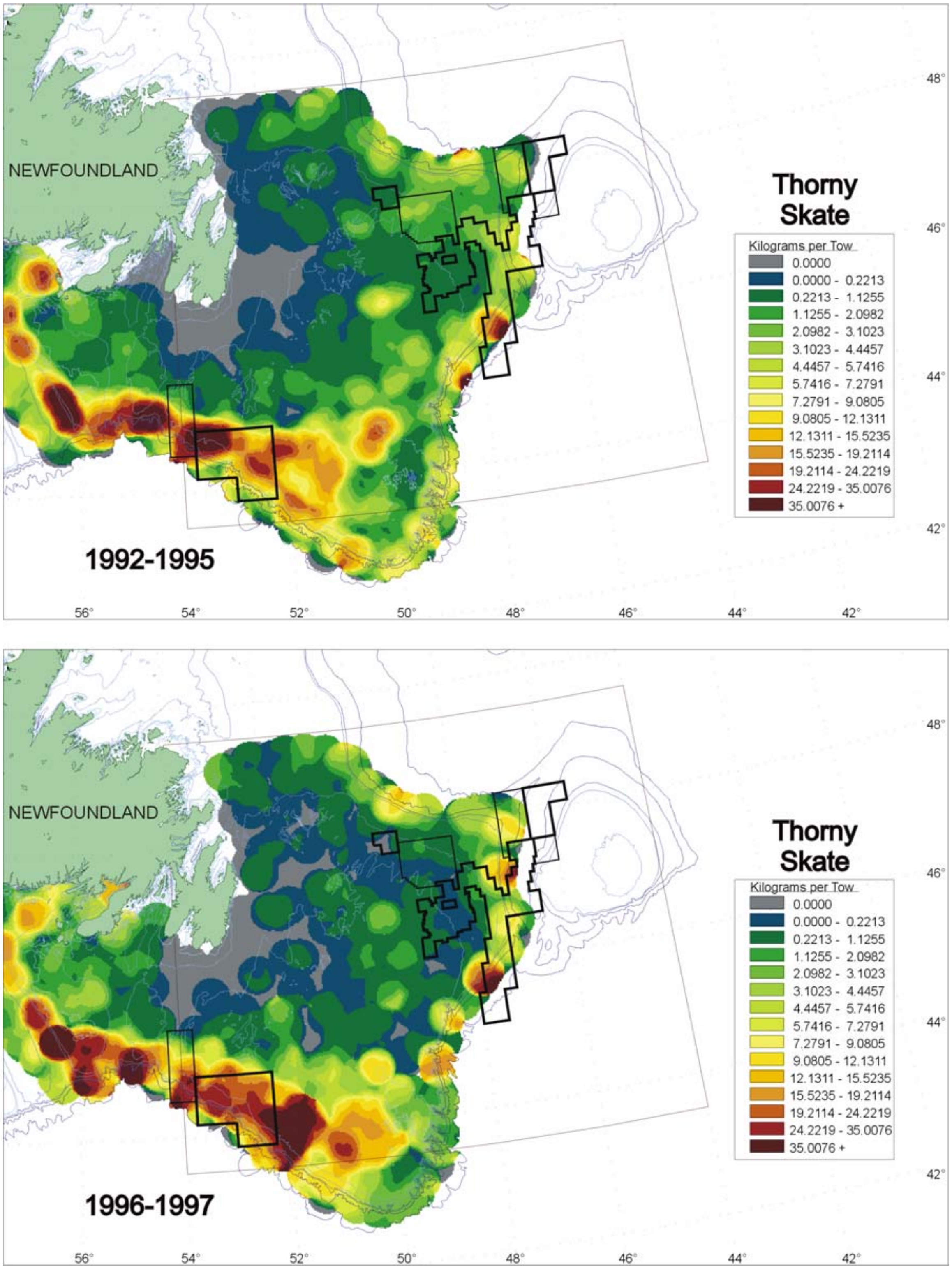


Figure 28c. Thorny skate distribution based on spring research surveys from 1992-95 & 1996-97. Gray sections represent areas sampled with no catch rate values.

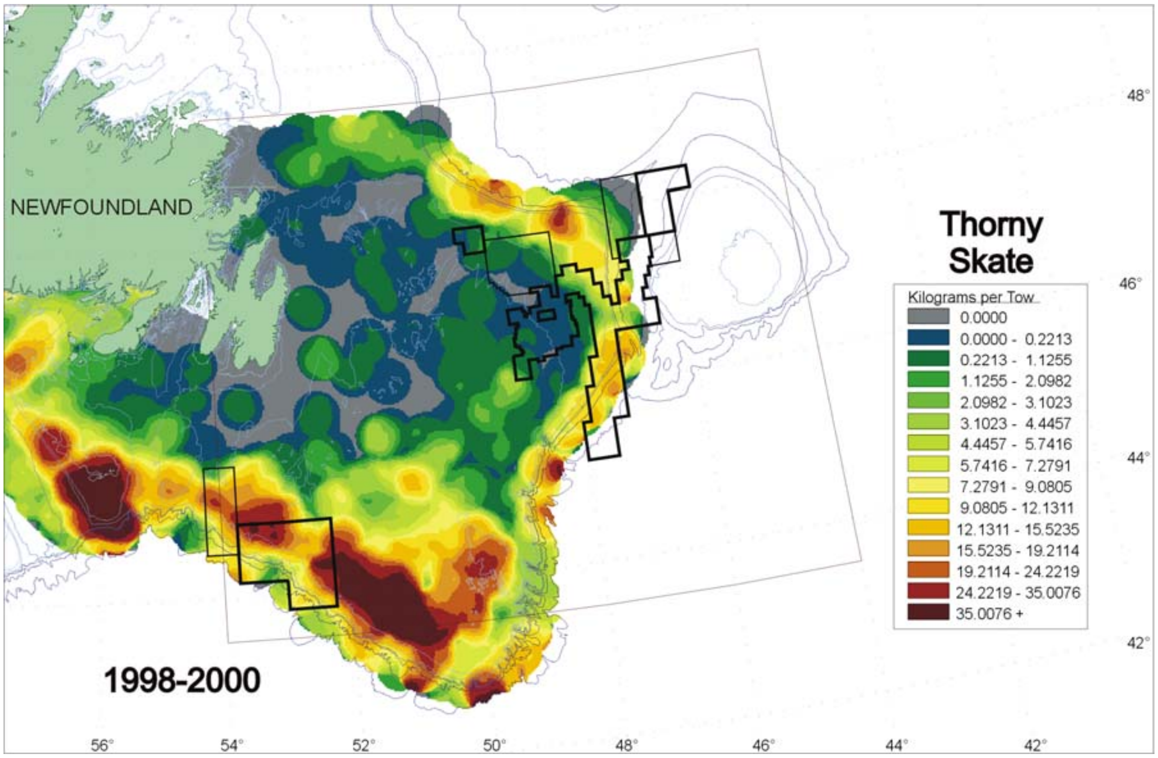


Figure 28d. Thorny skate distribution based on spring research surveys from 1998-2000. Gray sections represent areas sampled with no catch rate values.

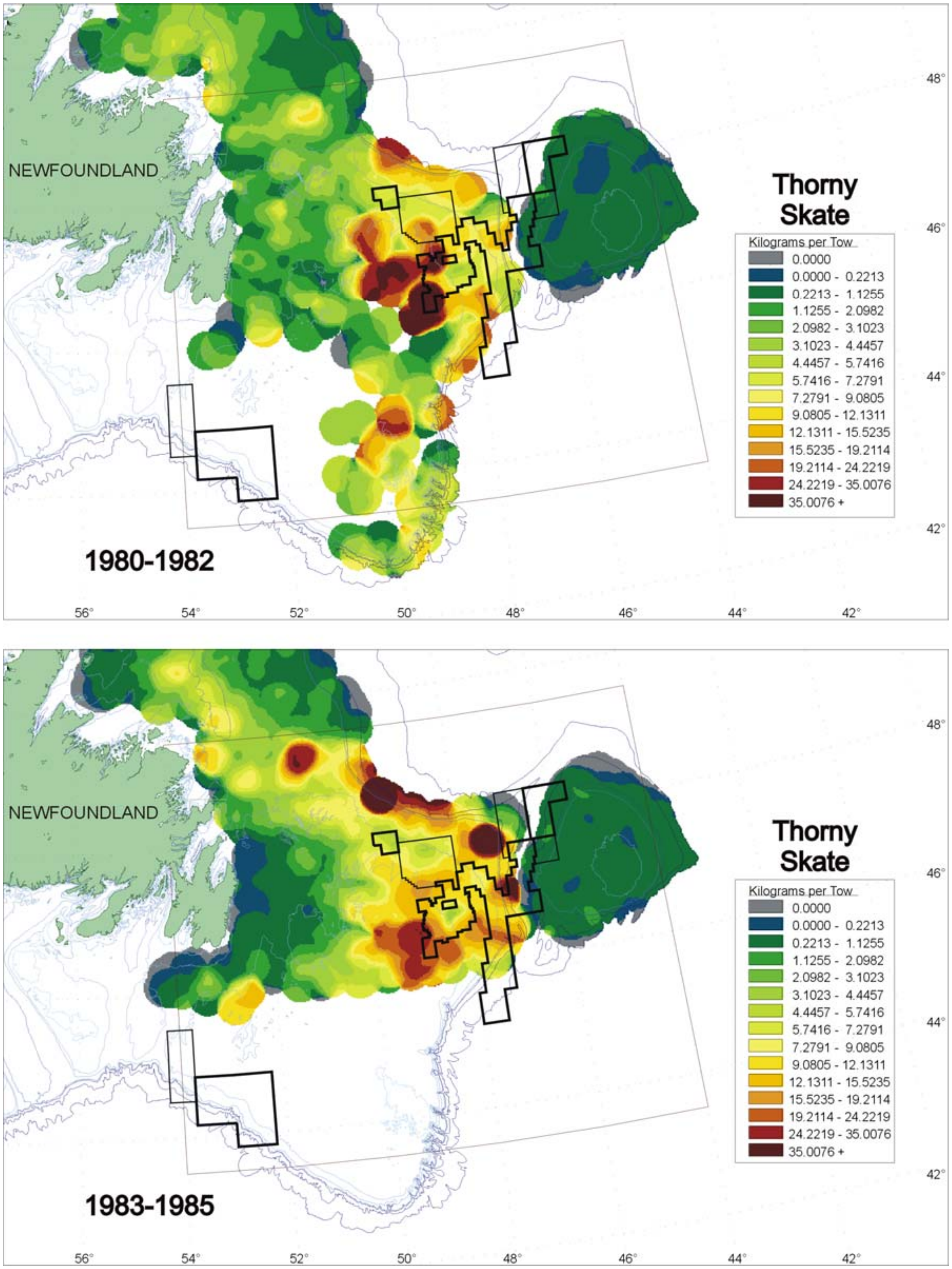


Figure 29a. Thorny skate distribution based on fall research surveys from 1980-82 & 1983-85. Gray sections represent areas sampled with no catch rate values.

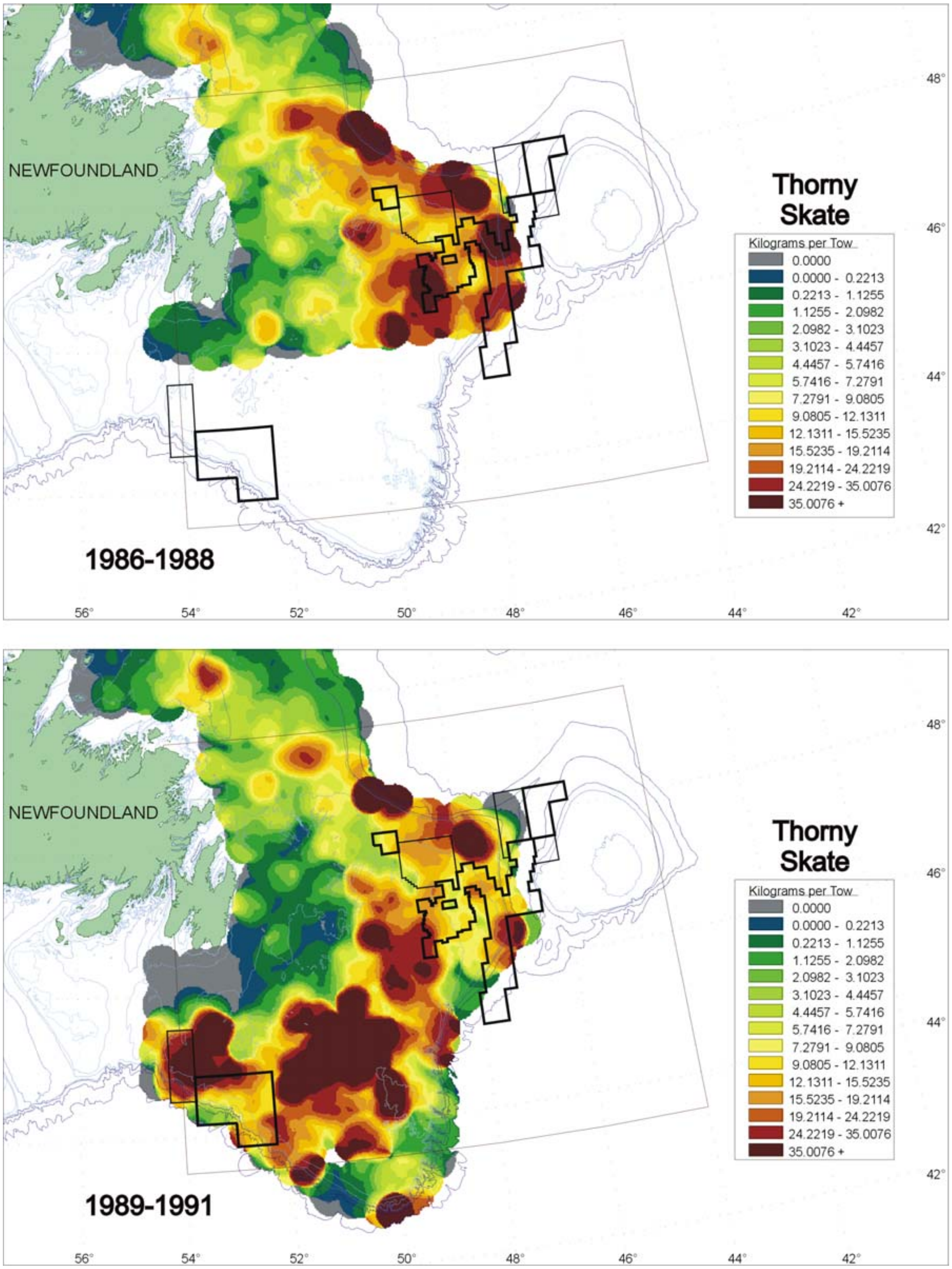


Figure 29b. Thorny skate distribution based on fall research surveys from 1986-88 & 1989-91. Gray sections represent areas sampled with no catch rate values.

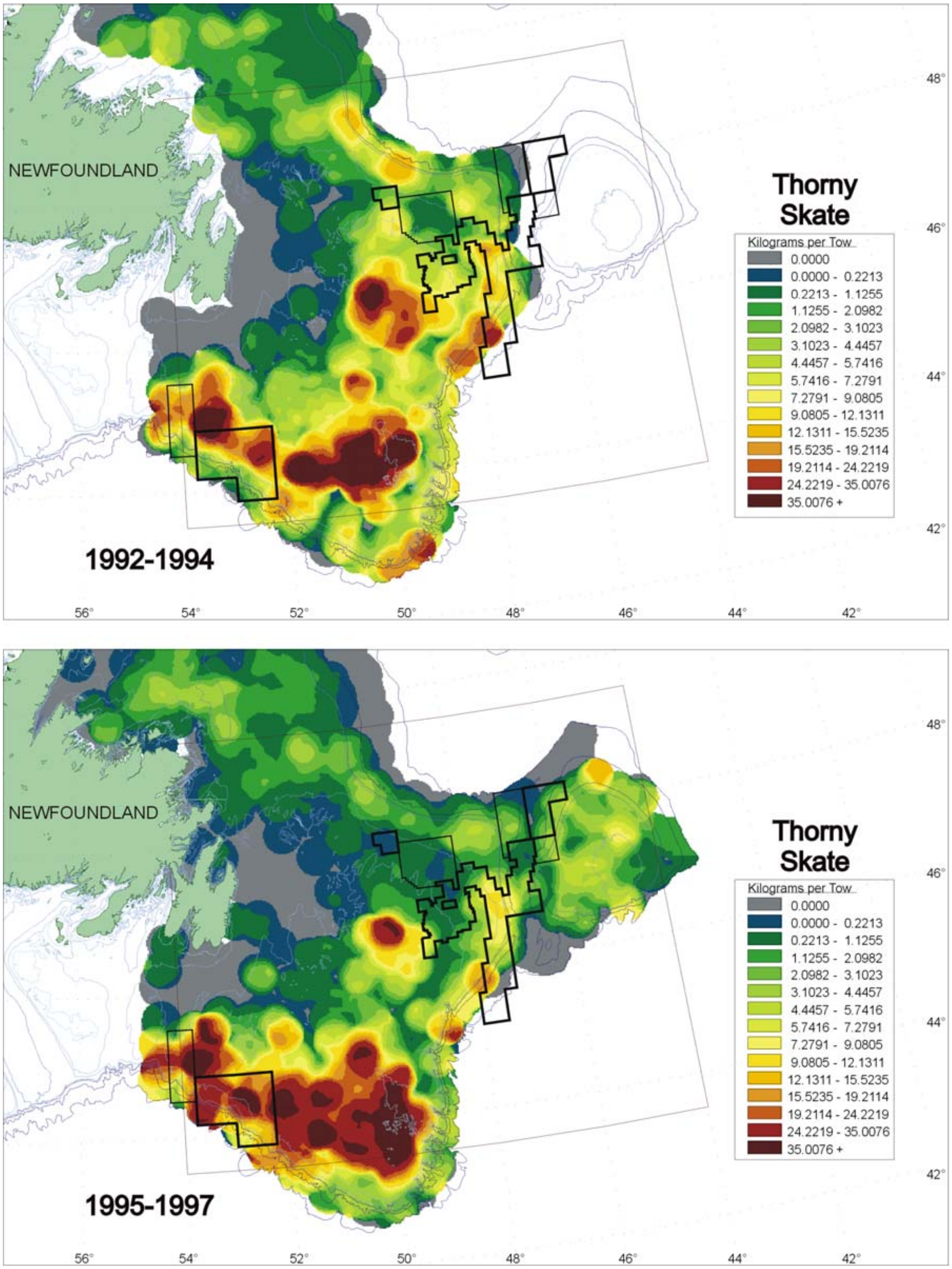


Figure 29c. Thorny skate distribution based on fall research surveys from 1992-94 & 1995-97. Gray sections represent areas sampled with no catch rate values.

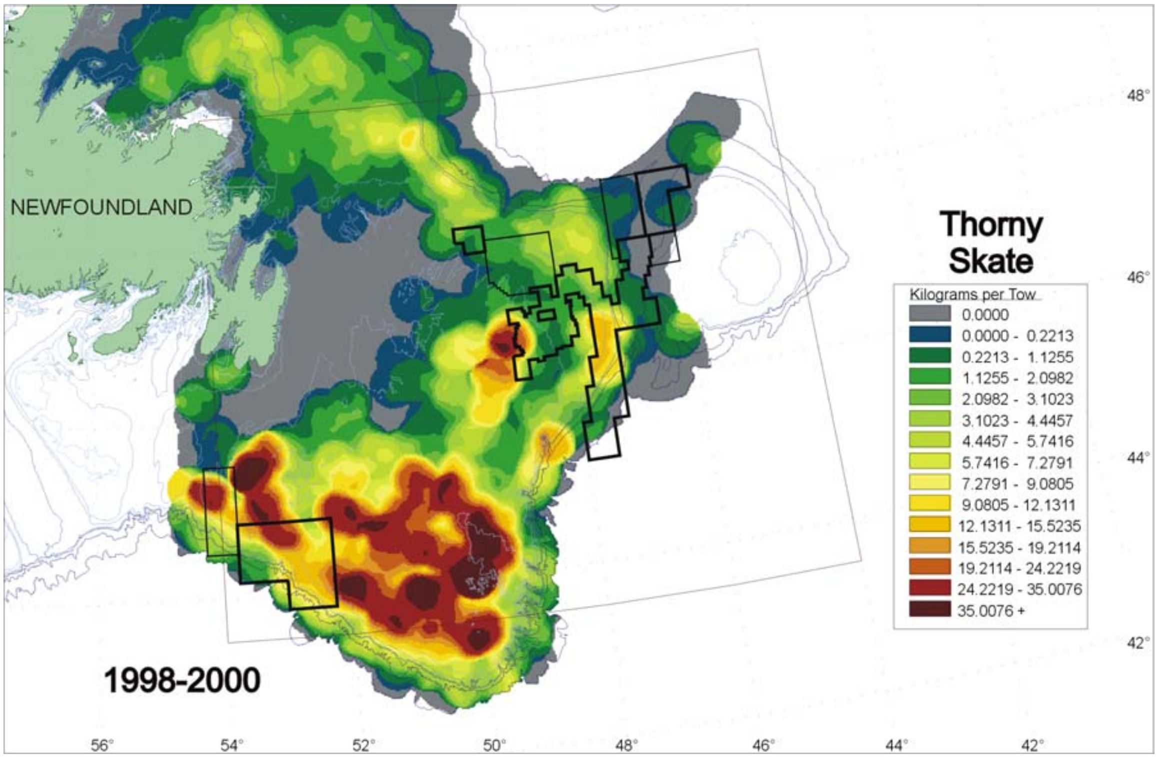


Figure 29d. Thorny skate distribution based on fall research surveys from 1998-2000. Gray sections represent areas sampled with no catch rate values.

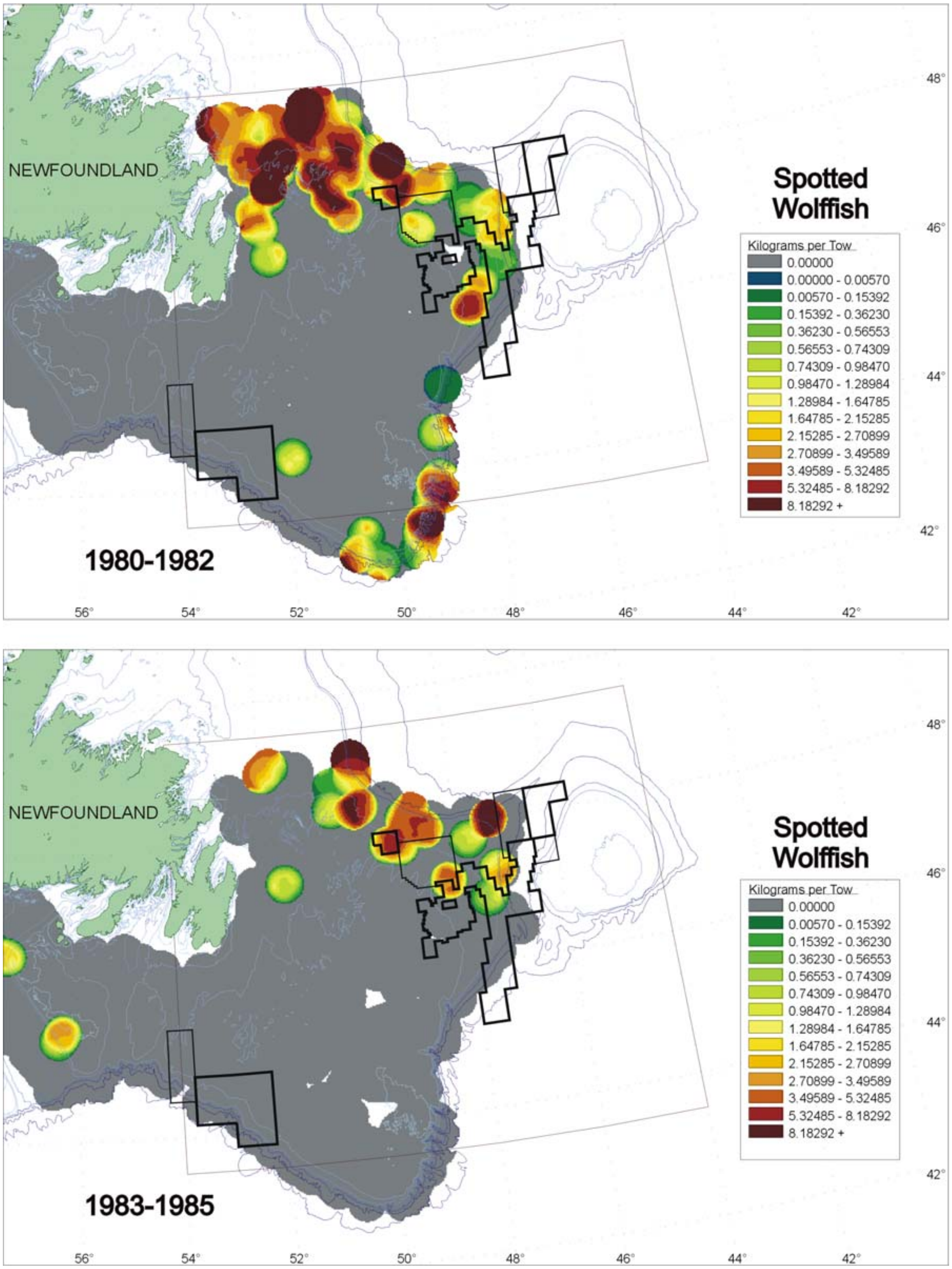
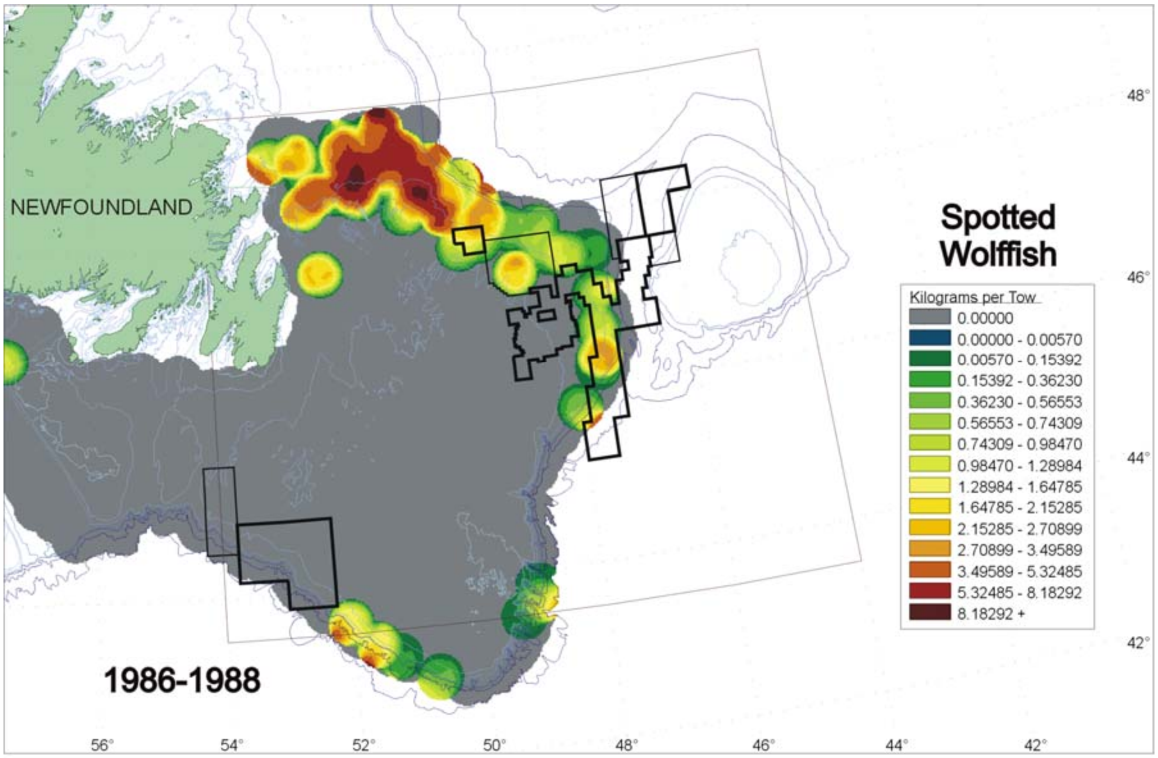


Figure 30a. Spotted wolffish distribution based on spring research surveys from 1980-82 & 1983-85. Gray sections represent areas sampled with no catch rate values.



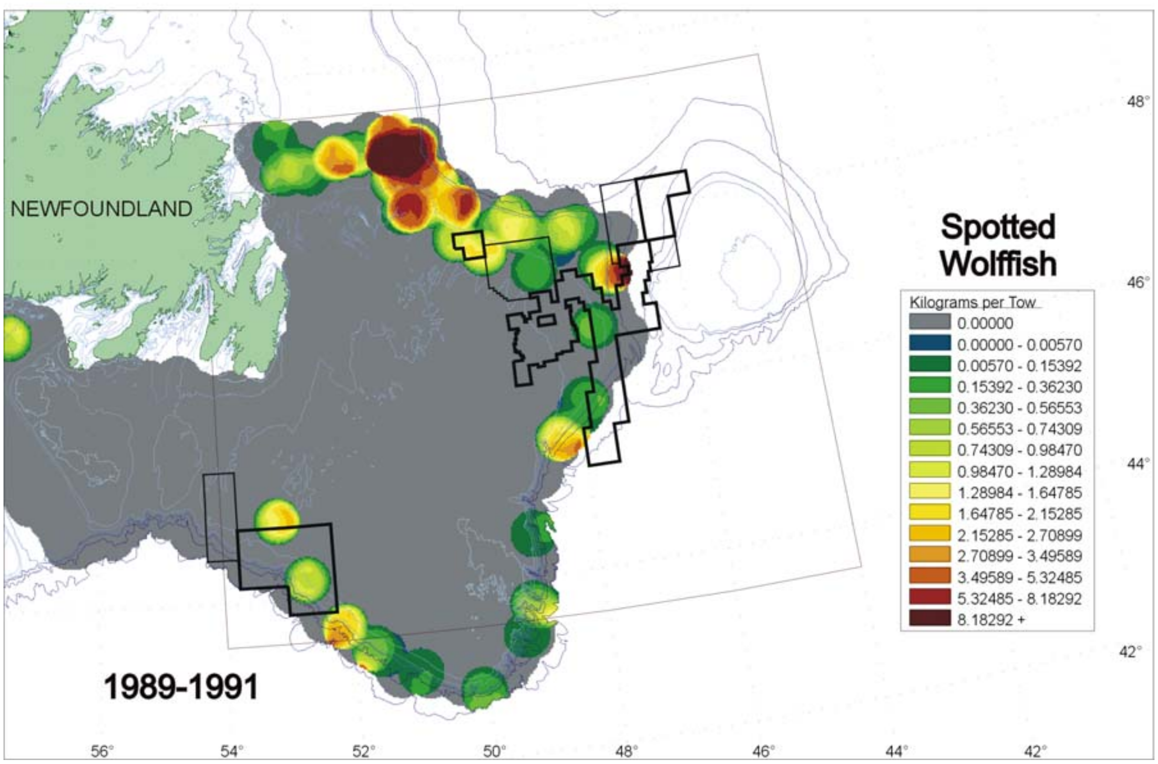
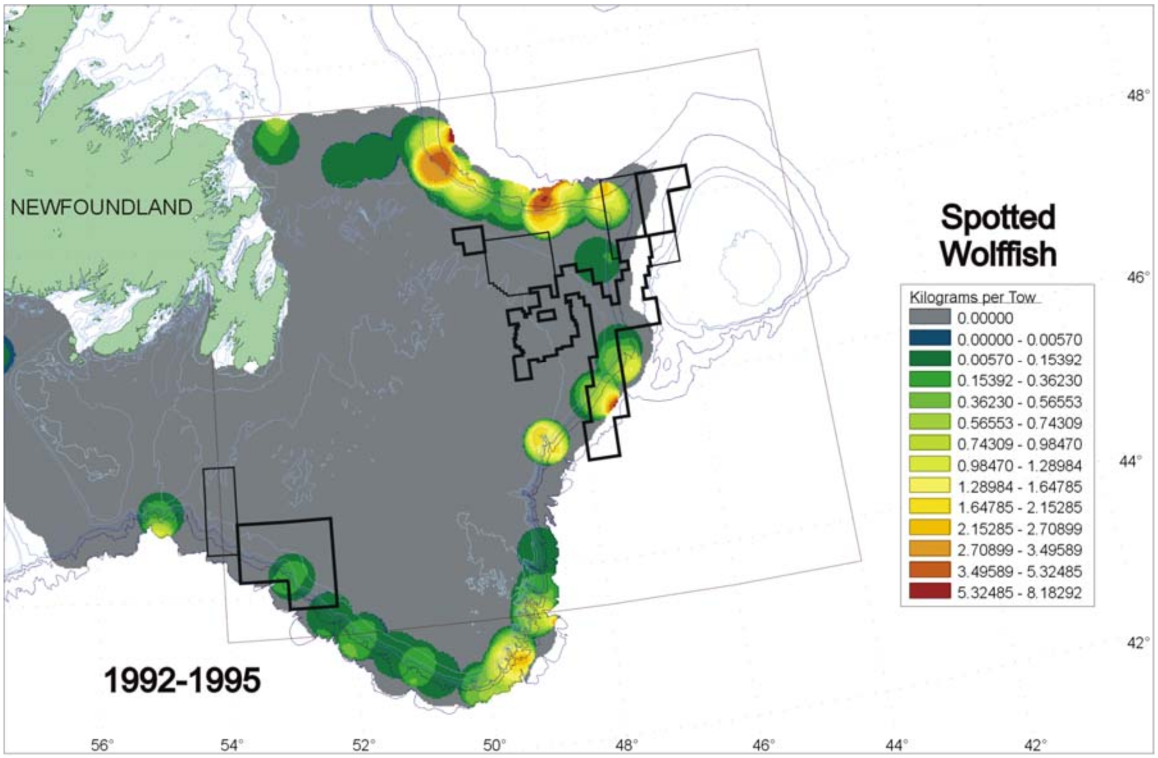


Figure 30b. Spotted wolffish distribution based on spring research surveys from 1986-88 & 1989-91. Gray sections represent areas sampled with no catch rate values.



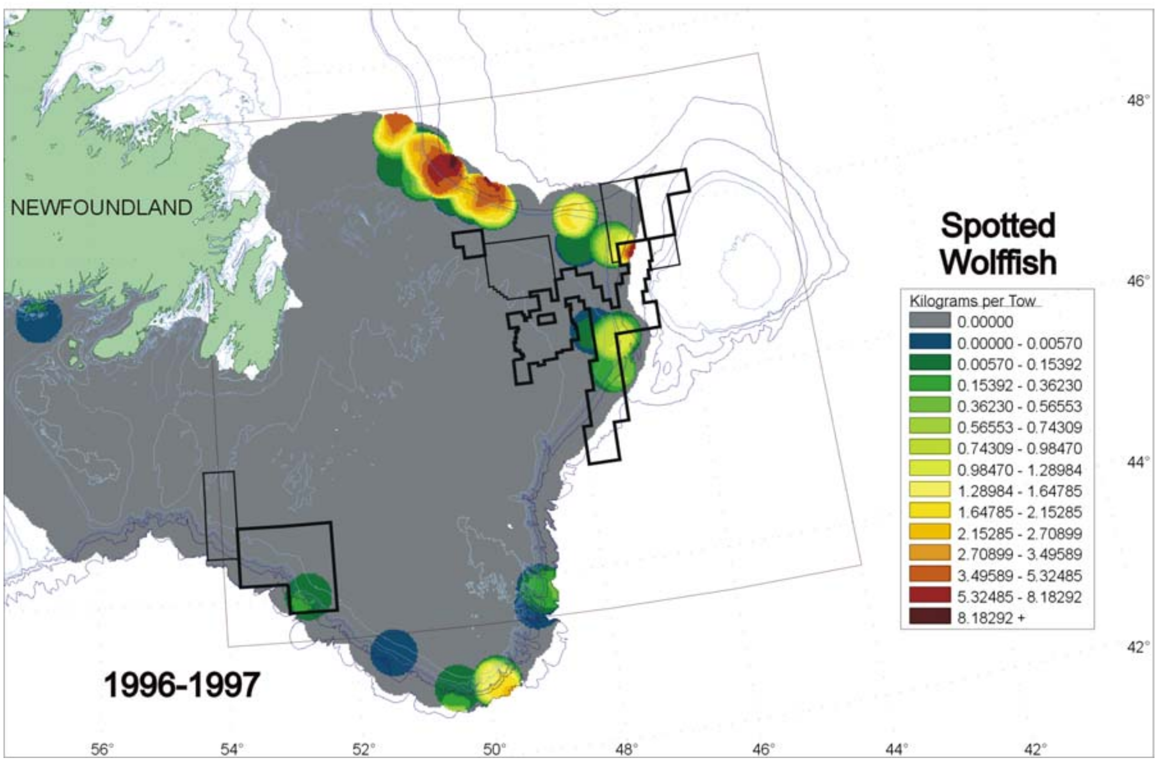


Figure 30c. Spotted wolffish distribution based on spring research surveys from 1992-95 & 1996-97. Gray sections represent areas sampled with no catch rate values.

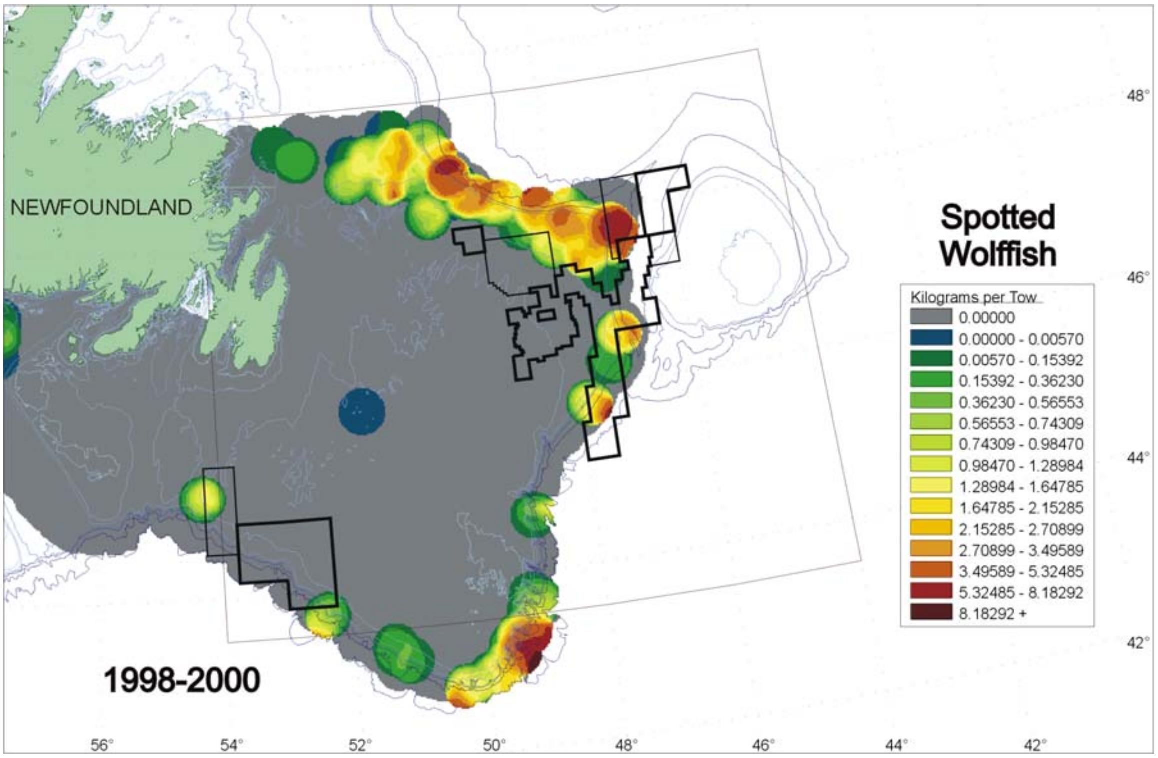
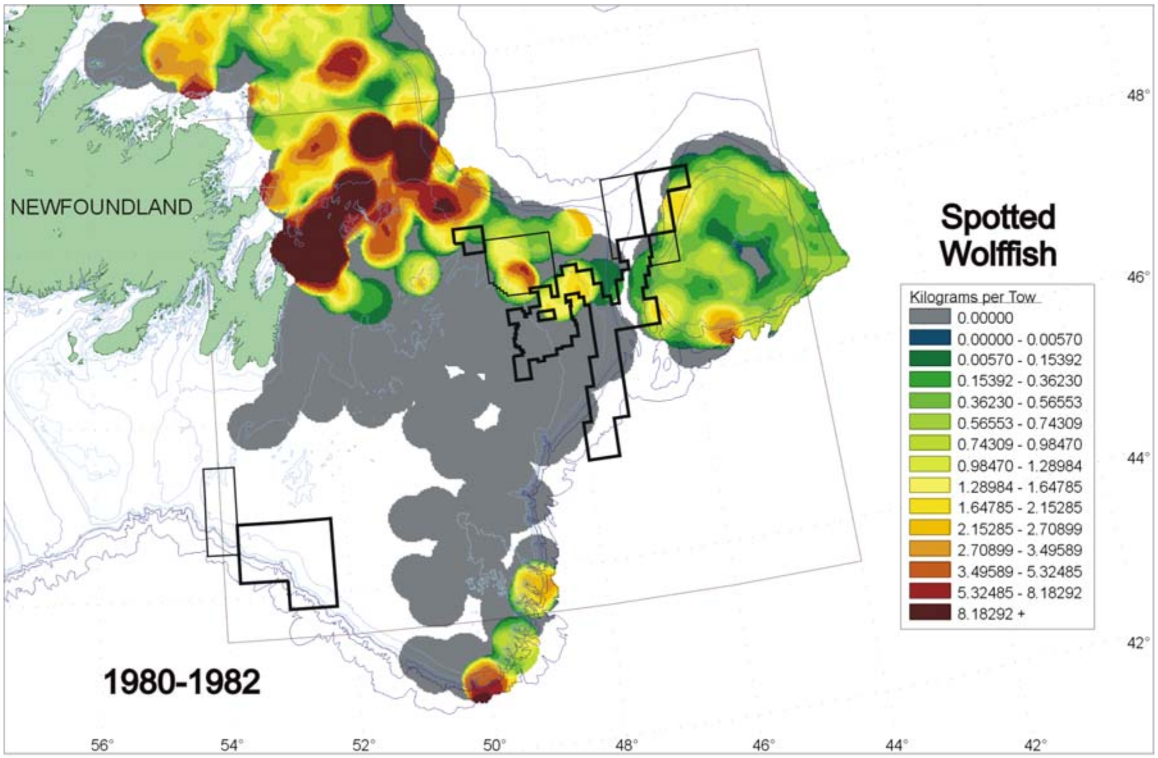


Figure 30d. Spotted wolffish distribution based on spring research surveys from 1998-2000. Gray sections represent areas sampled with no catch rate values.



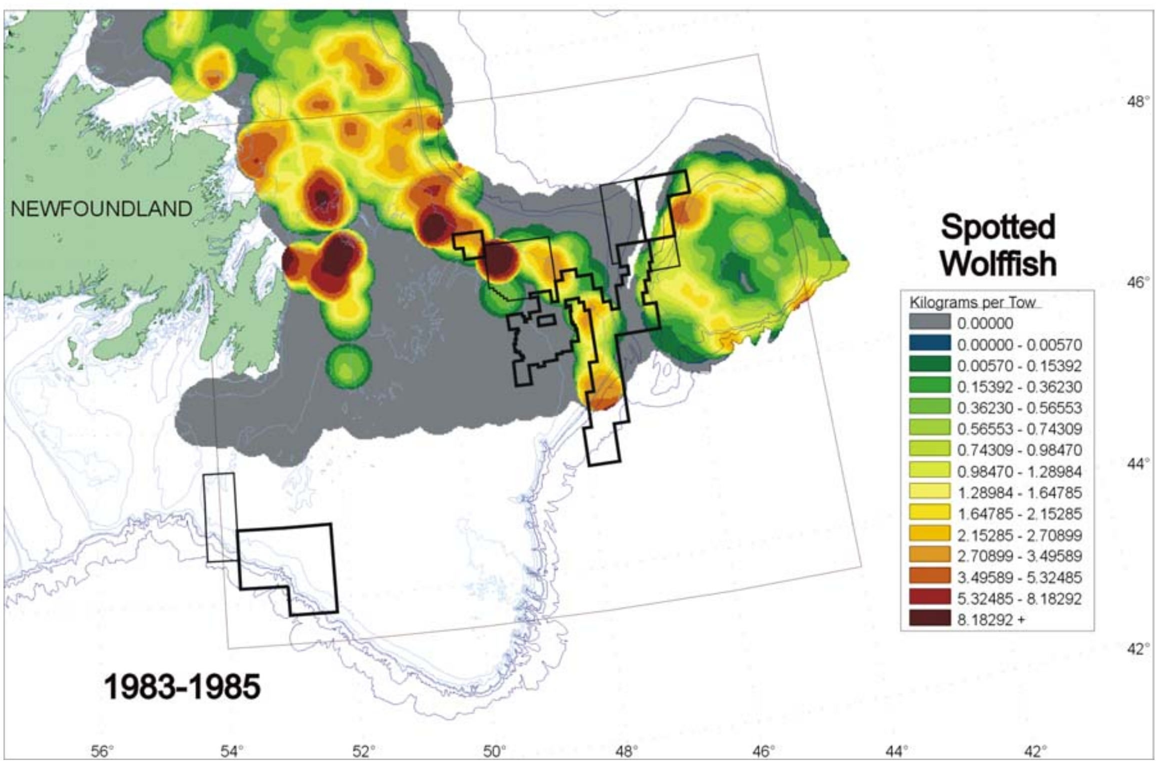


Figure 31a. Spotted wolffish distribution based on fall research surveys from 1980-82 & 1983-85. Gray sections represent areas sampled with no catch rate values.

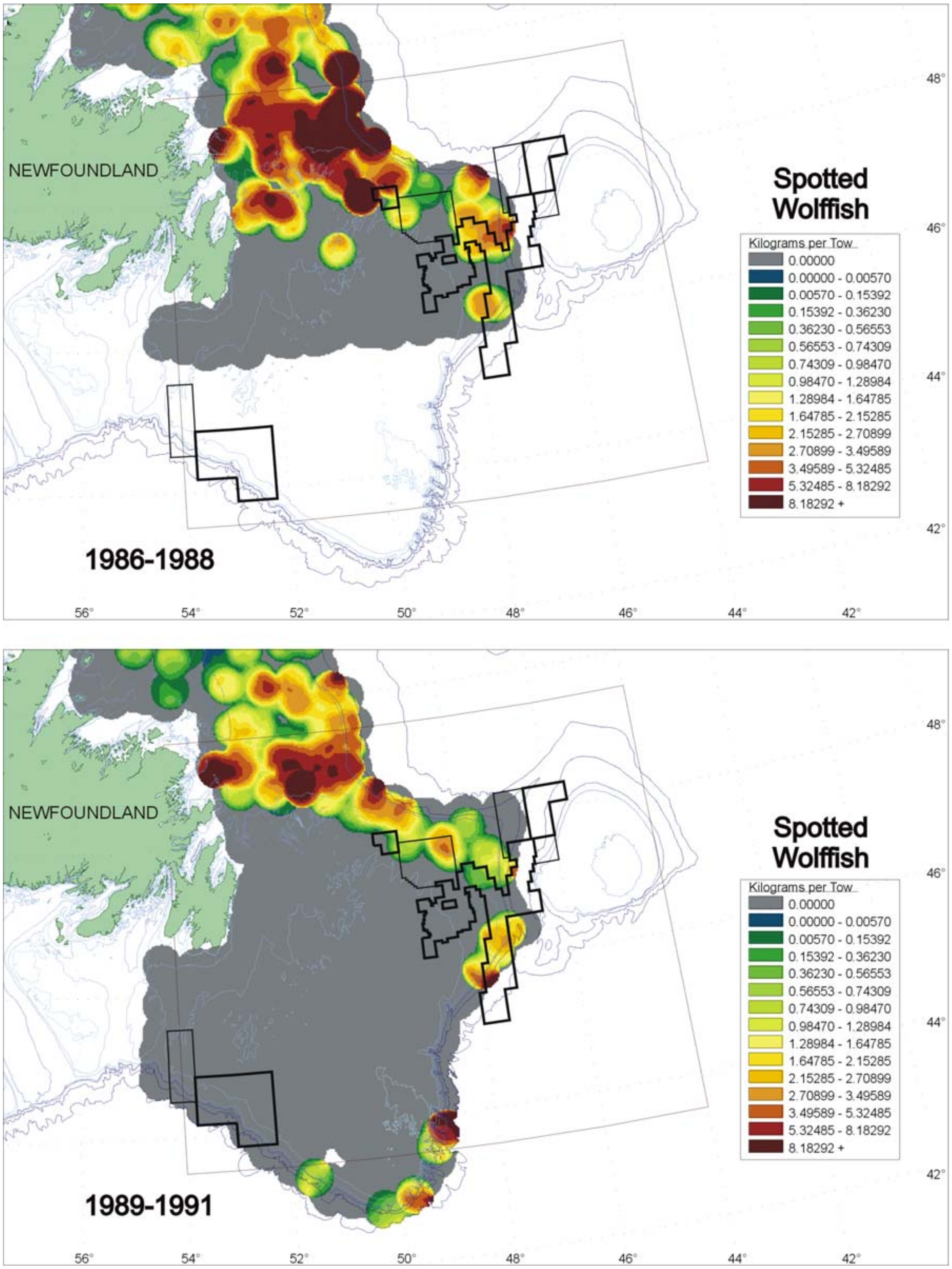


Figure 31b. Spotted wolffish distribution based on fall research surveys from 1986-88 & 1989-91. Gray sections represent areas sampled with no catch rate values.

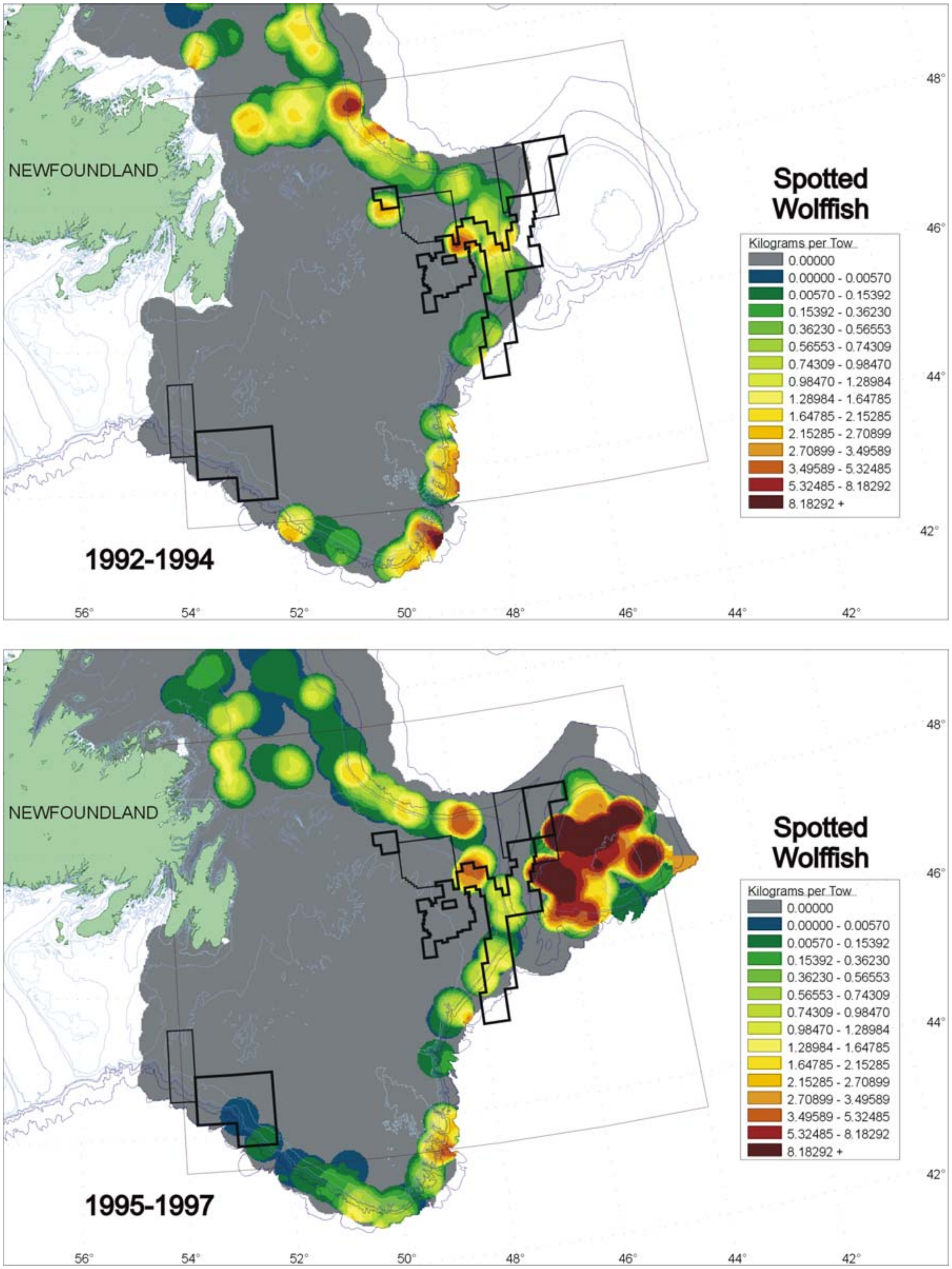


Figure 31c. Spotted wolffish distribution based on fall research surveys from 1992-94 & 1995-97. Gray sections represent areas sampled with no catch rate values.

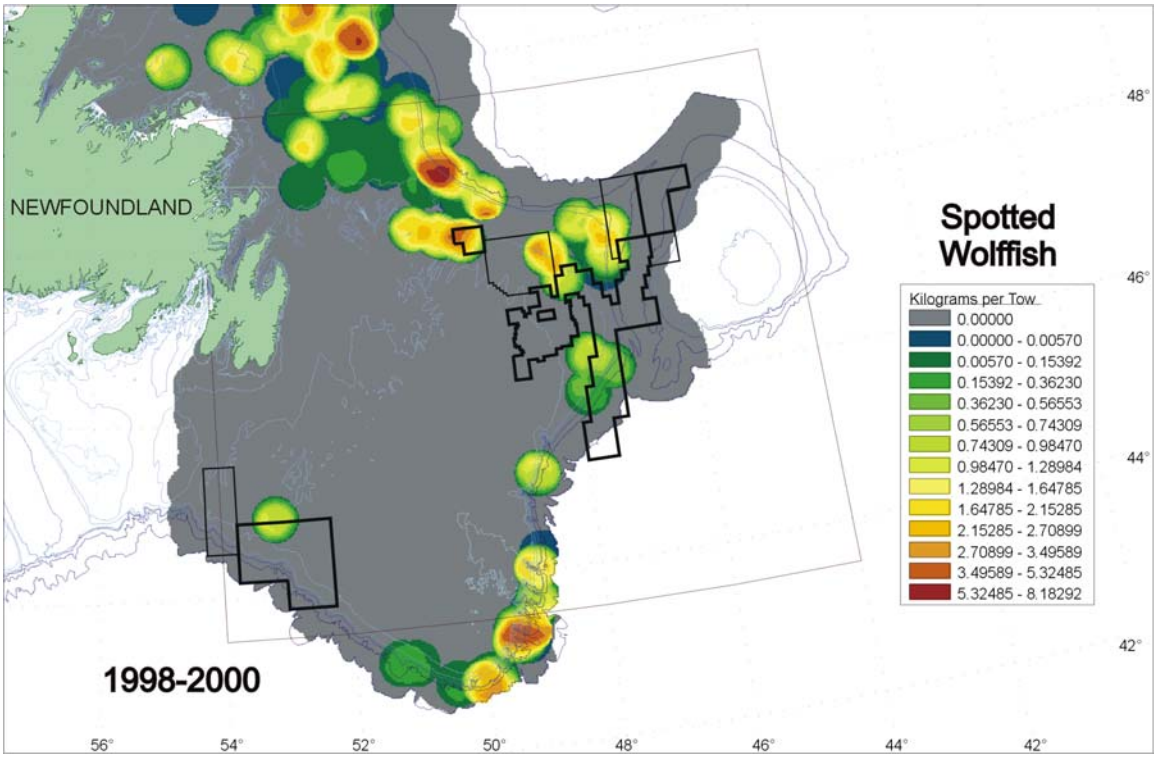
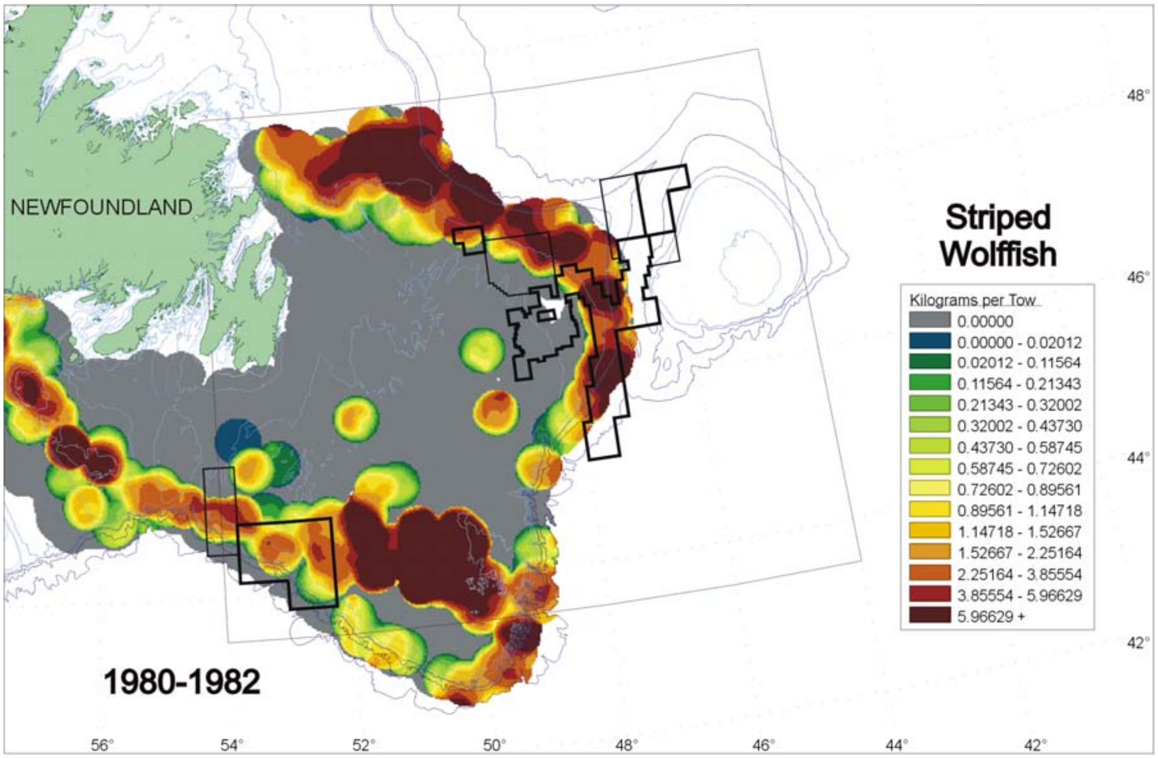


Figure 31d. Spotted wolffish distribution based on fall research surveys from 1998-2000. Gray sections represent areas sampled with no catch rate values.



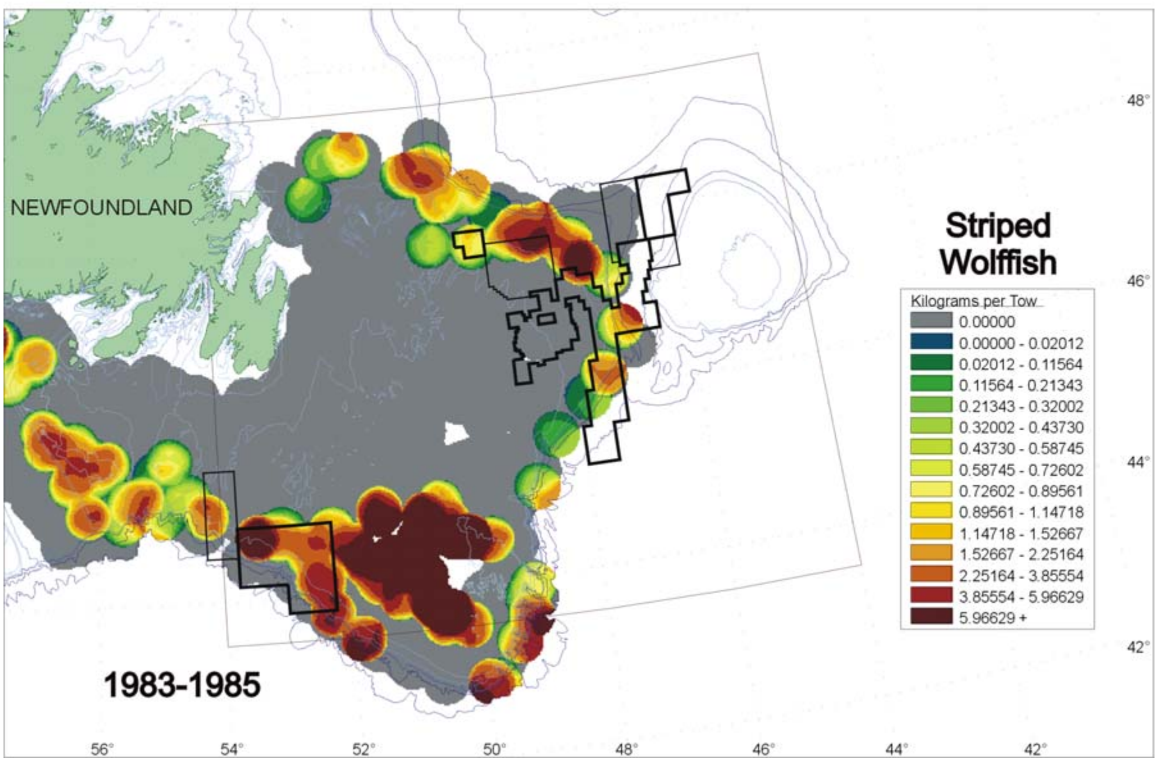
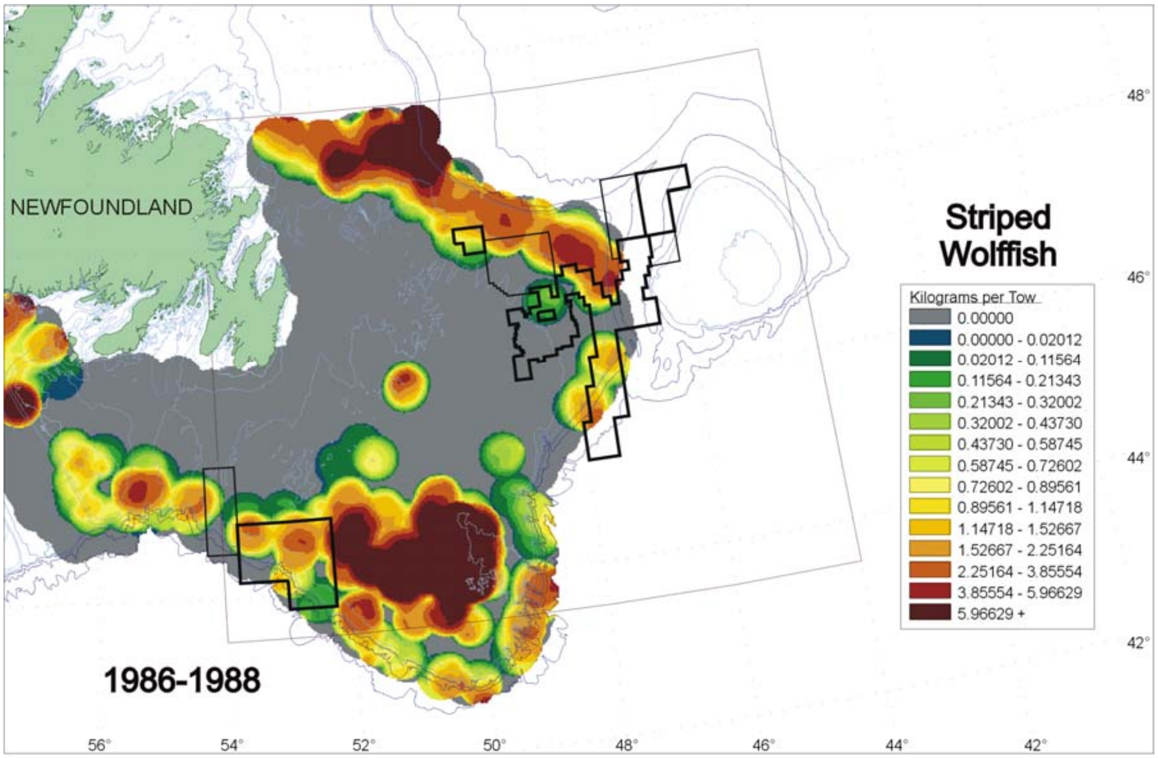


Figure 32a. Striped wolffish distribution based on spring research surveys from 1980-82 & 1983-85. Gray sections represent areas sampled with no catch rate values.



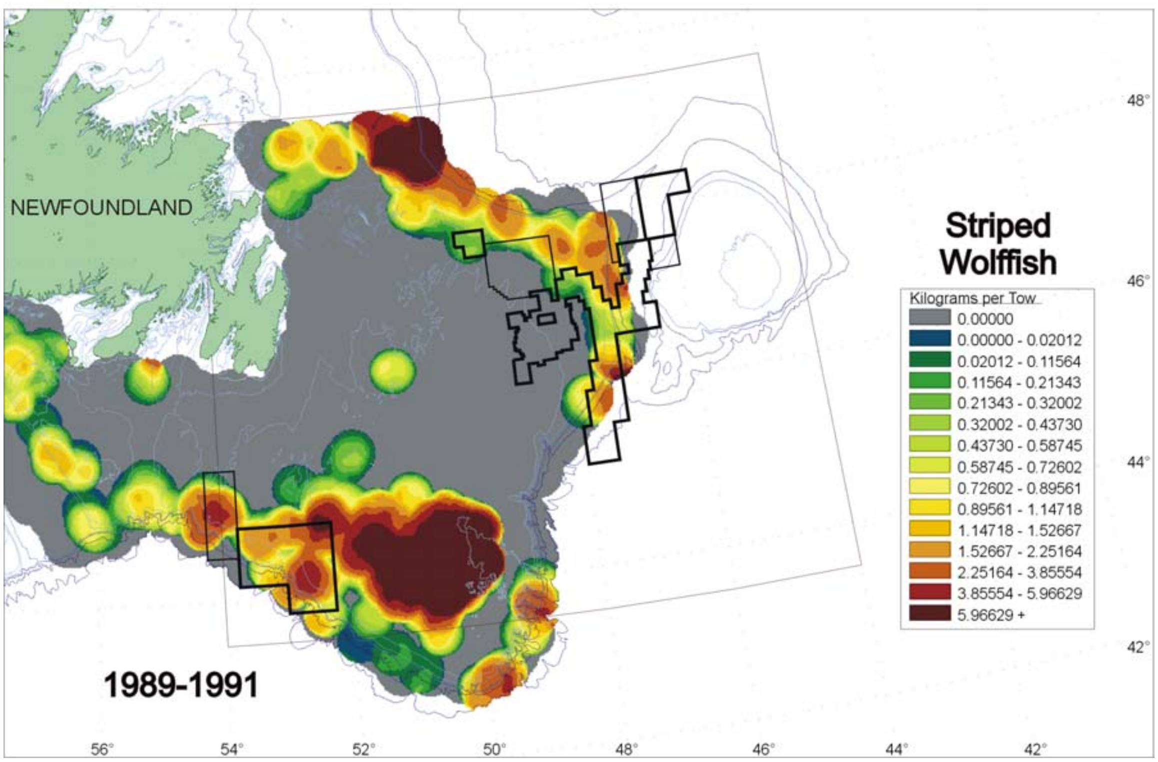


Figure 32b. Striped wolffish distribution based on spring research surveys from 1986-88 & 1989-91. Gray sections represent areas sampled with no catch rate values.

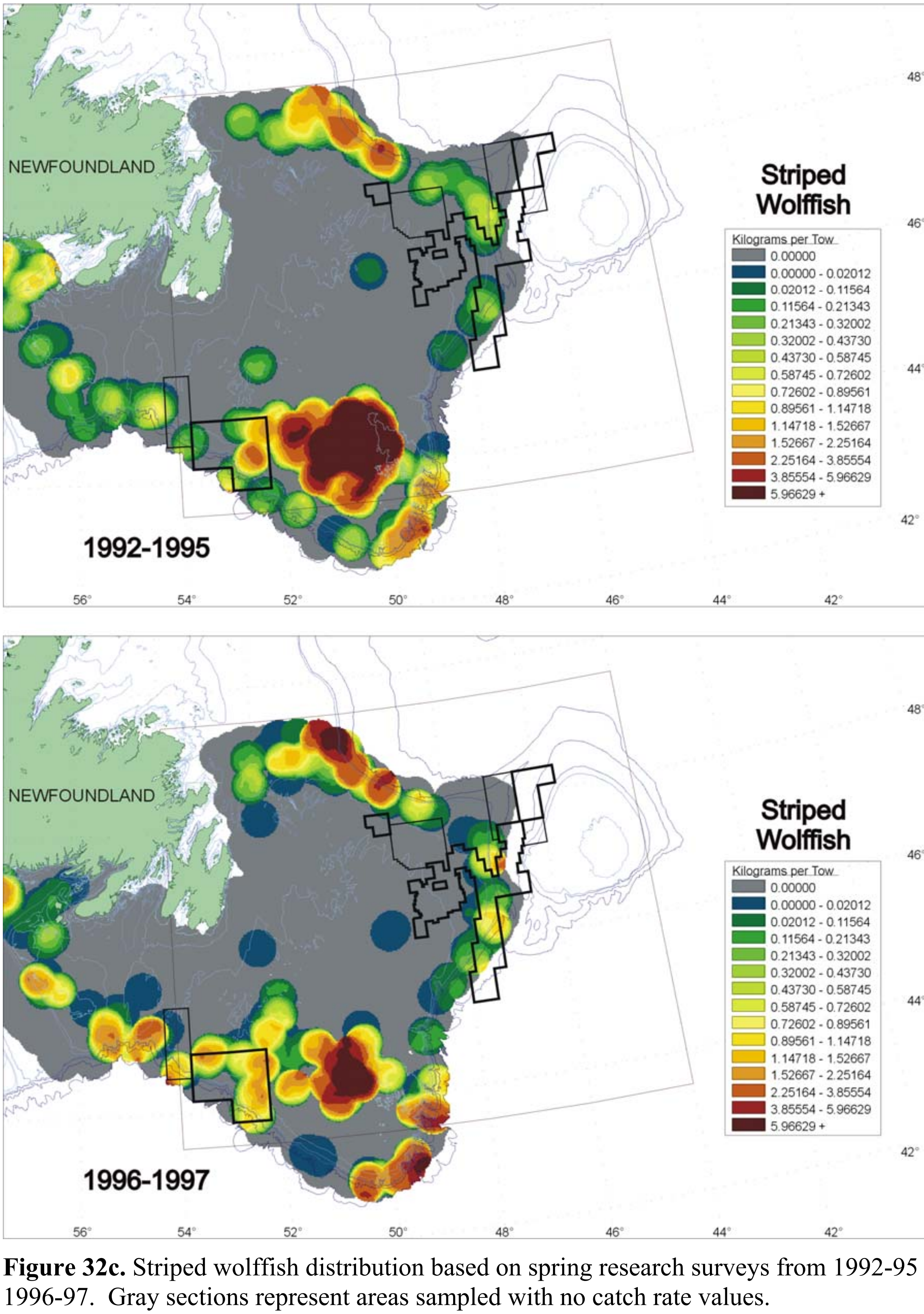


Figure 32c. Striped wolffish distribution based on spring research surveys from 1992-95 & 1996-97. Gray sections represent areas sampled with no catch rate values.

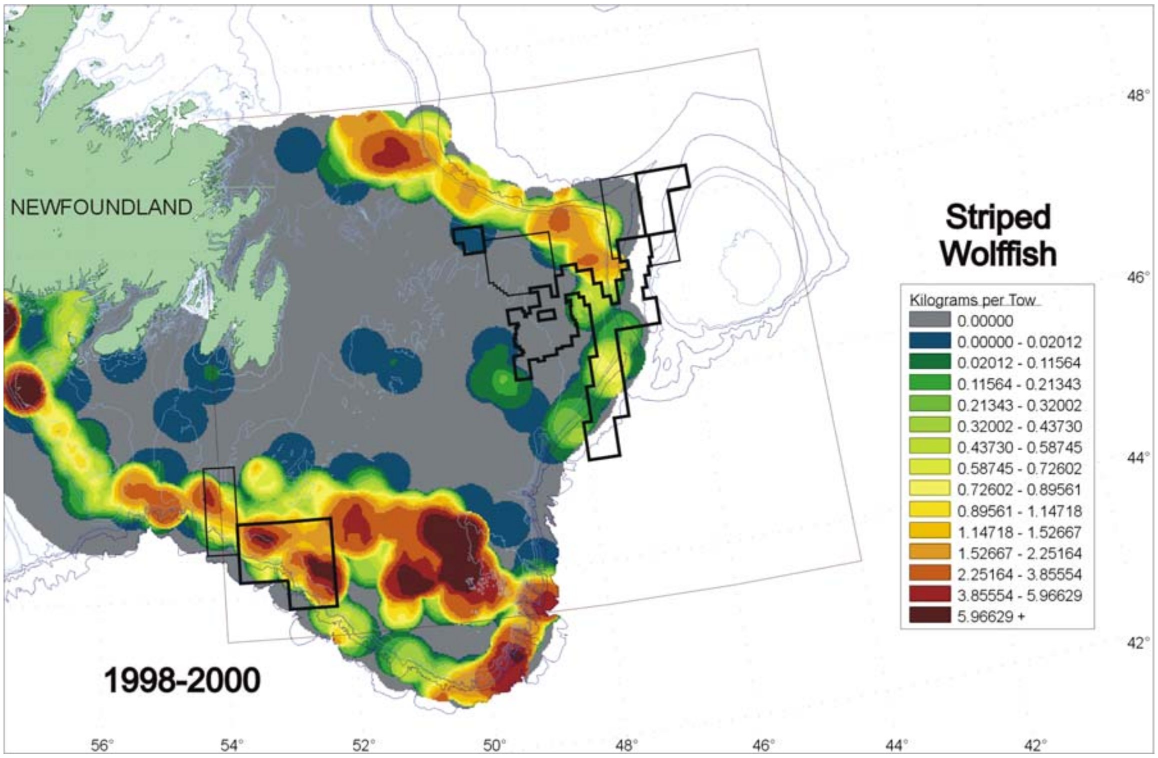


Figure 32d. Striped wolffish distribution based on spring research surveys from 1998-2000. Gray sections represent areas sampled with no catch rate values.

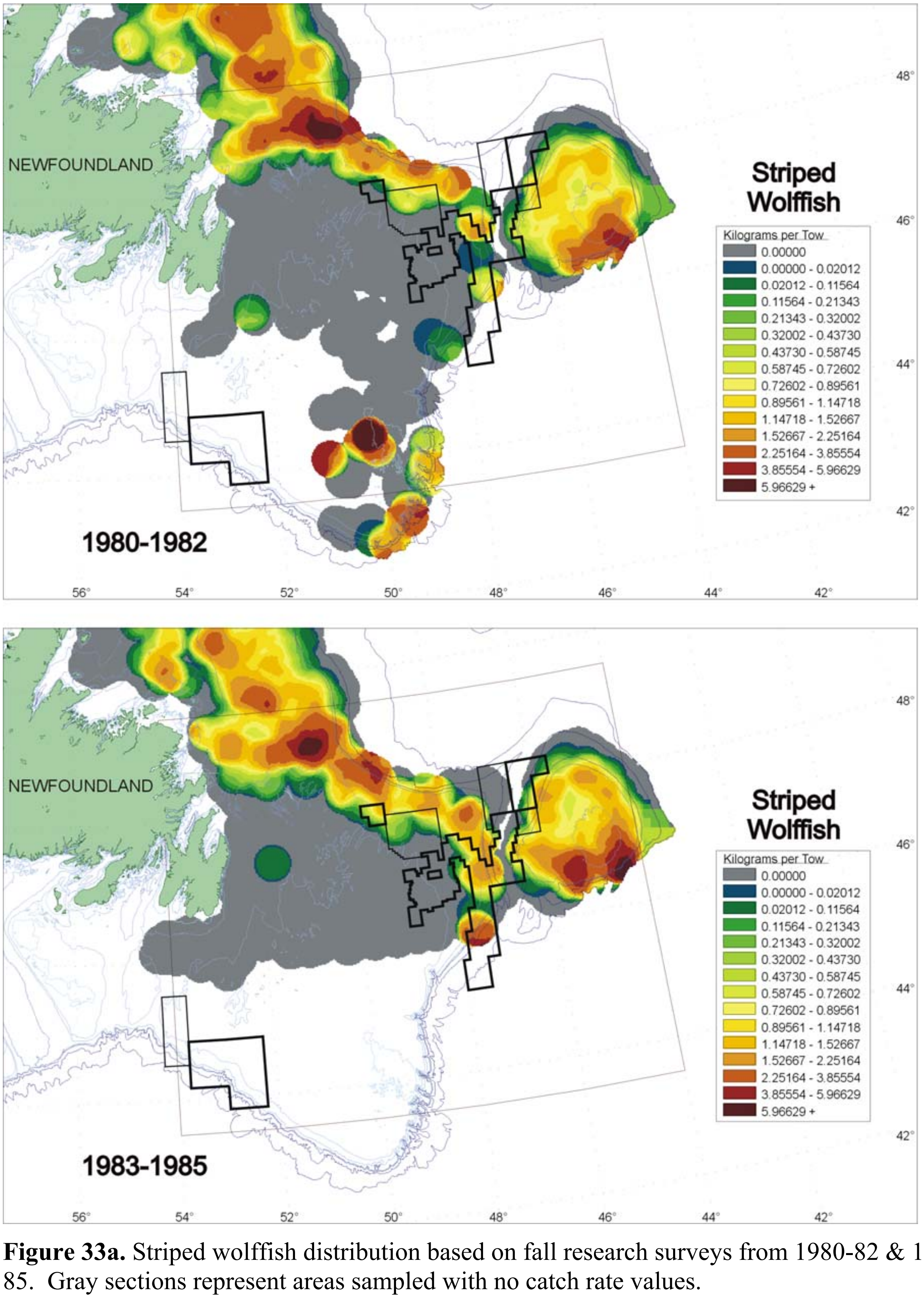


Figure 33a. Striped wolffish distribution based on fall research surveys from 1980-82 & 1983-85. Gray sections represent areas sampled with no catch rate values.

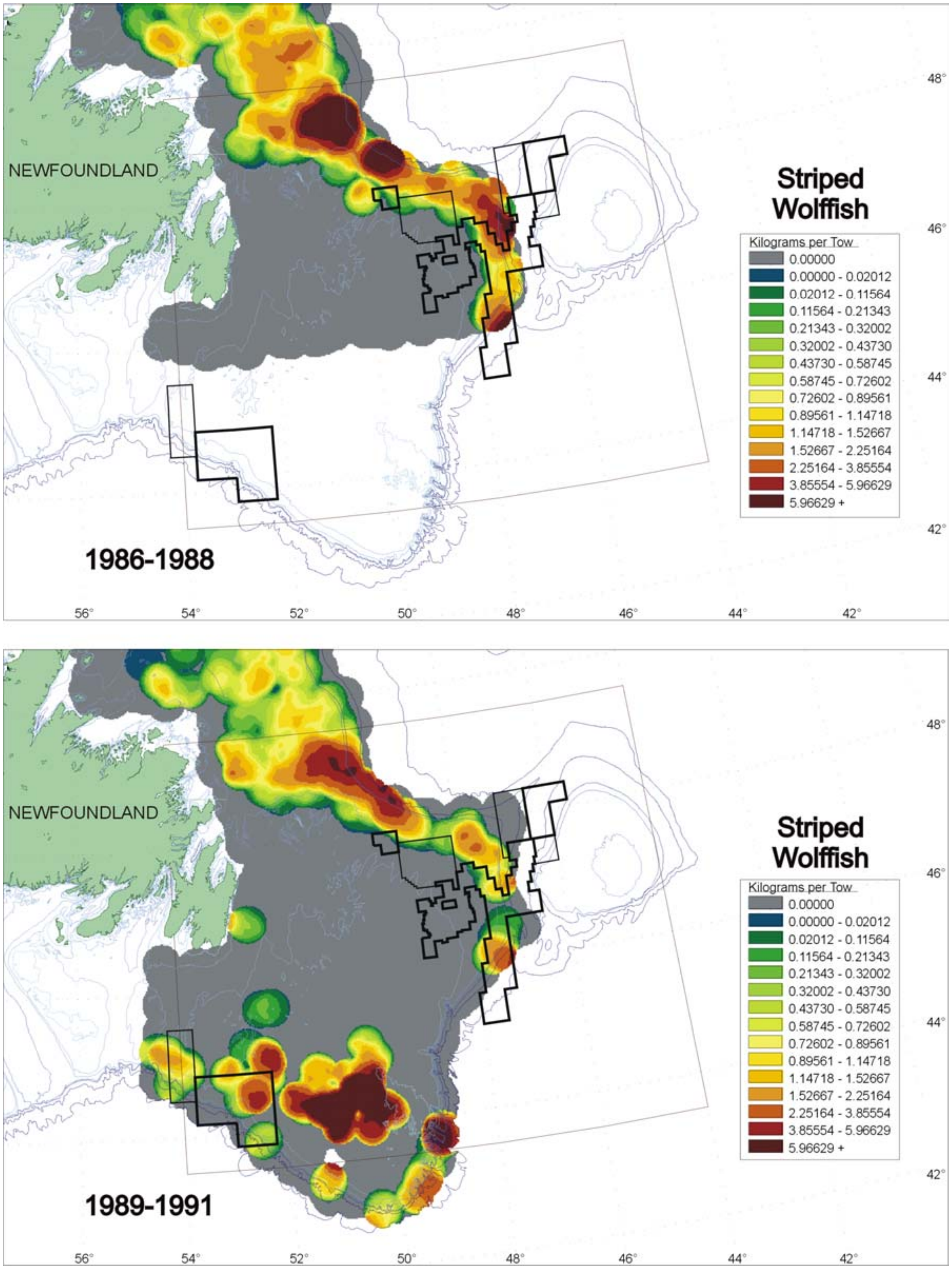


Figure 33b. Striped wolffish distribution based on fall research surveys from 1986-88 & 1989-91. Gray sections represent areas sampled with no catch rate values.

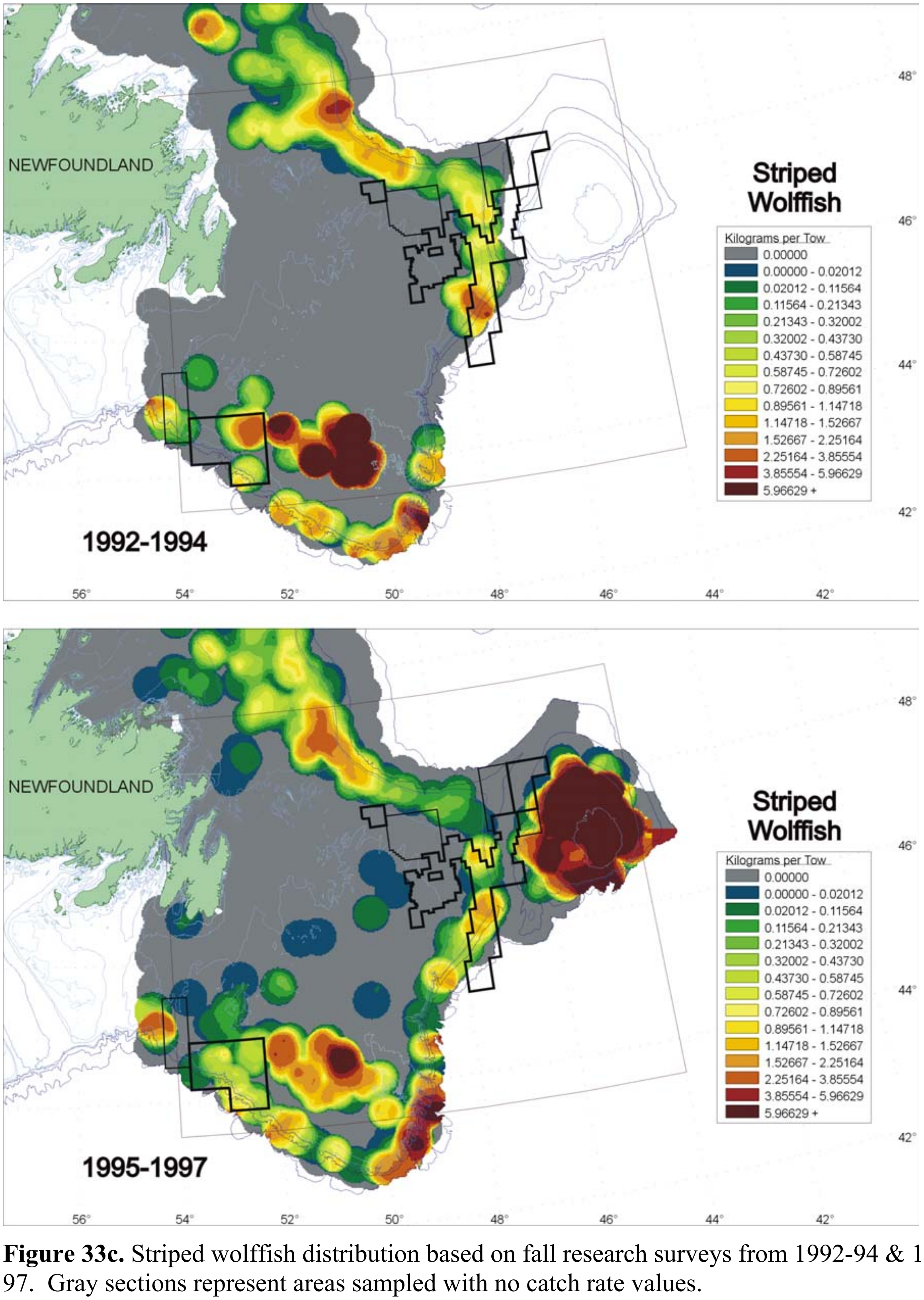


Figure 33c. Striped wolffish distribution based on fall research surveys from 1992-94 & 1995-97. Gray sections represent areas sampled with no catch rate values.

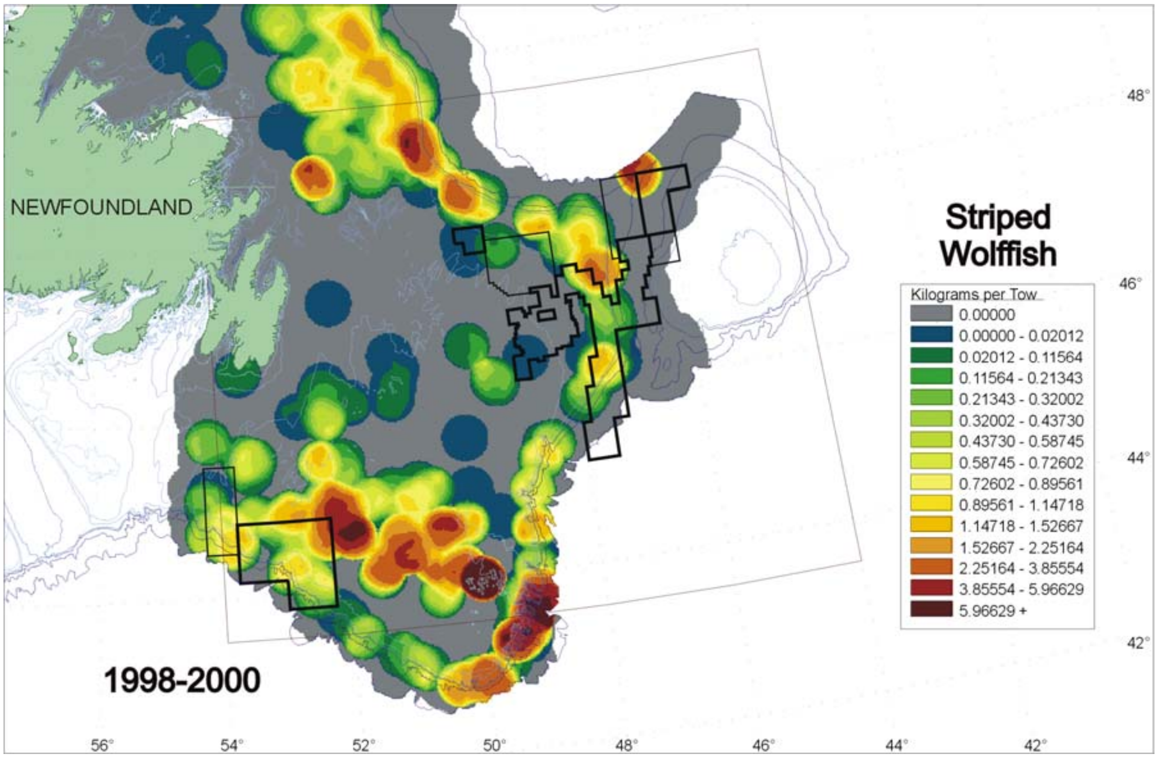


Figure 33d. Striped wolffish distribution based on fall research surveys from 1998-2000. Gray sections represent areas sampled with no catch rate values.

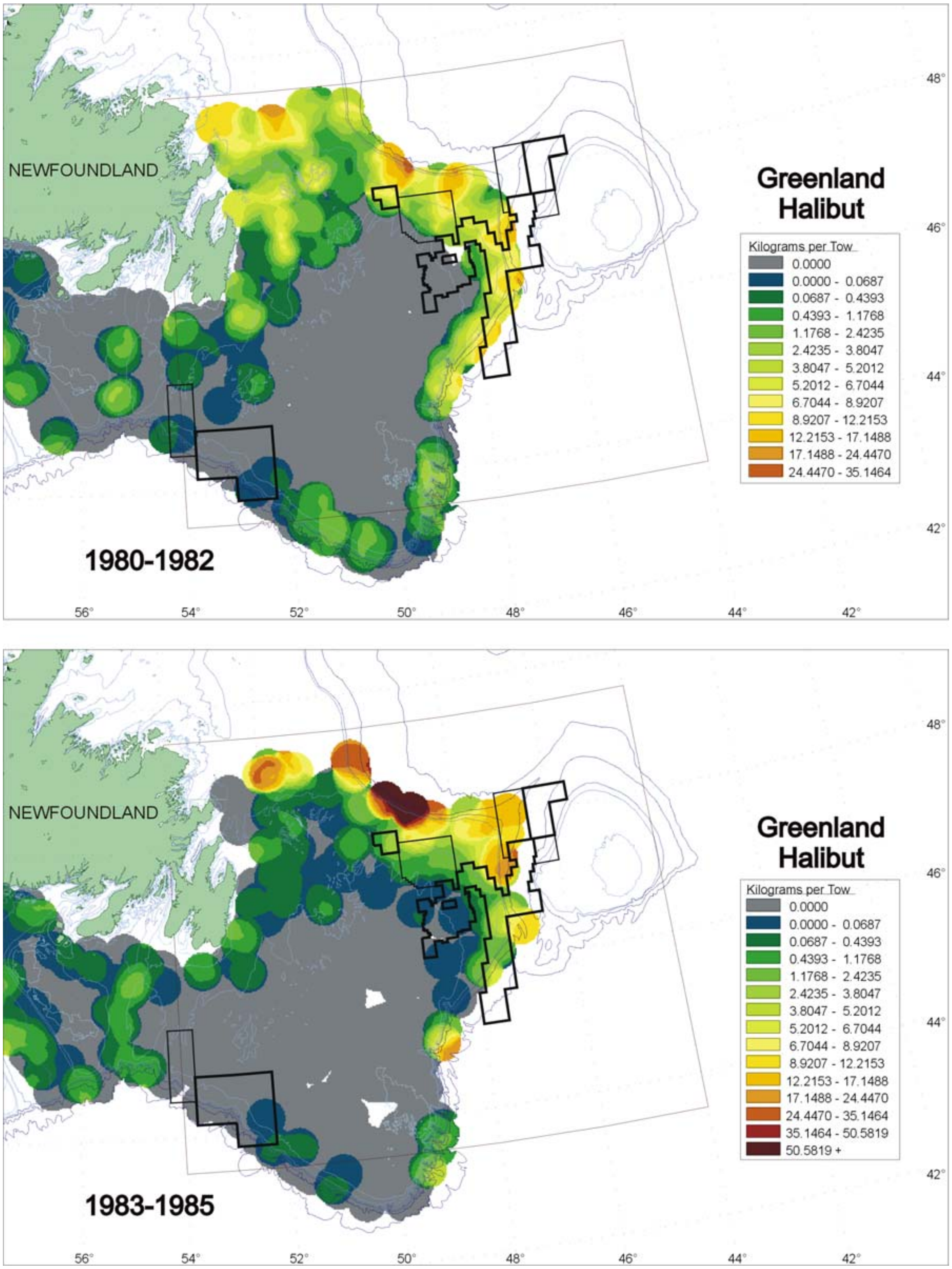
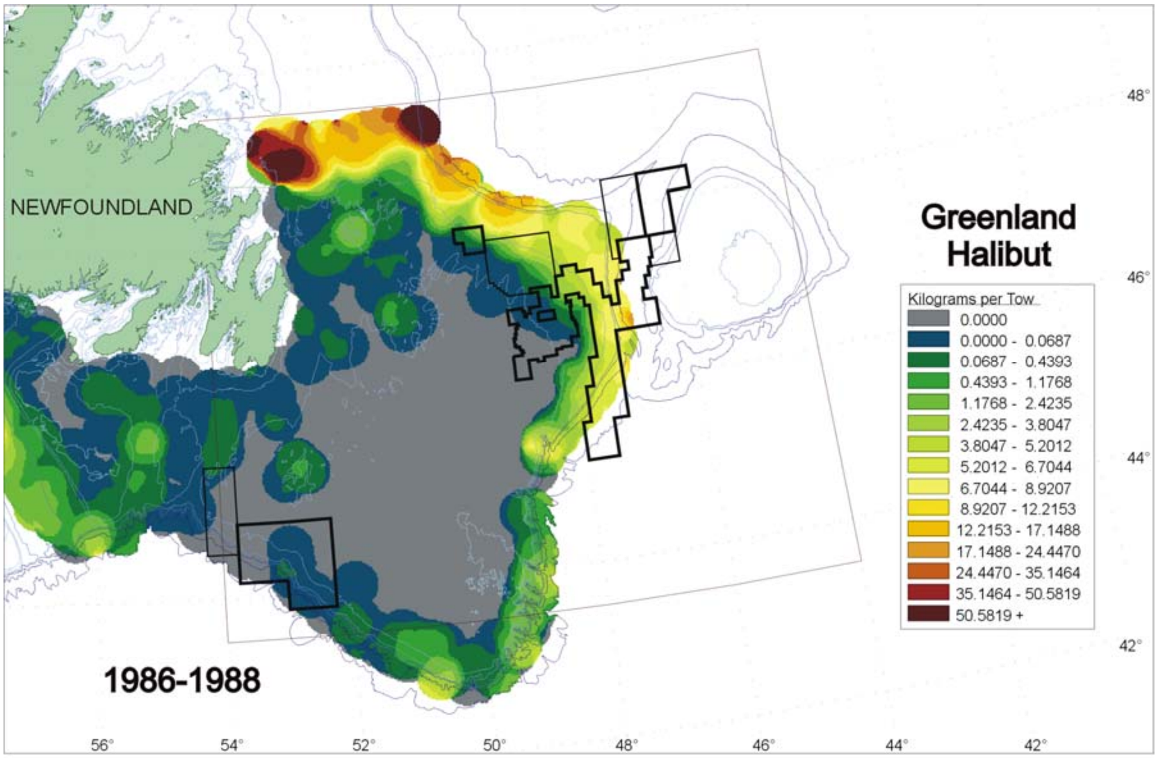


Figure 34a. Greenland Halibut distribution based on spring research surveys from 1980-82 & 1983-85. Gray sections represent areas sampled with no catch rate values.



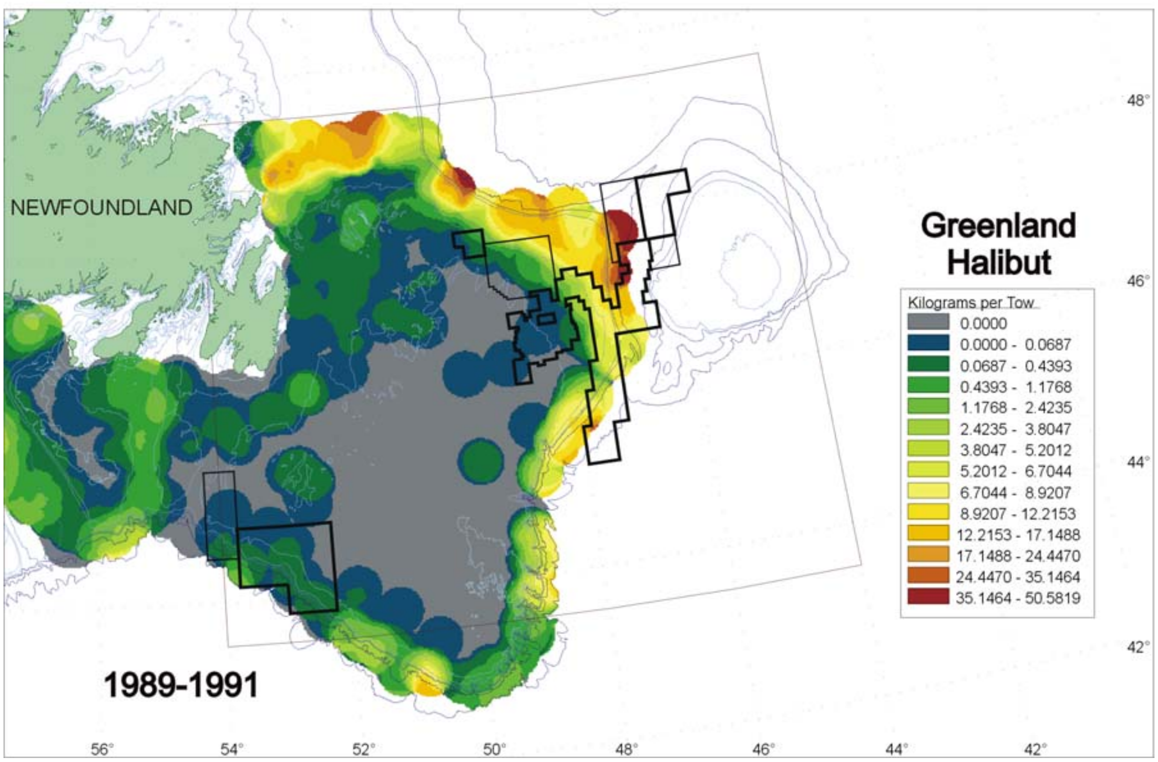
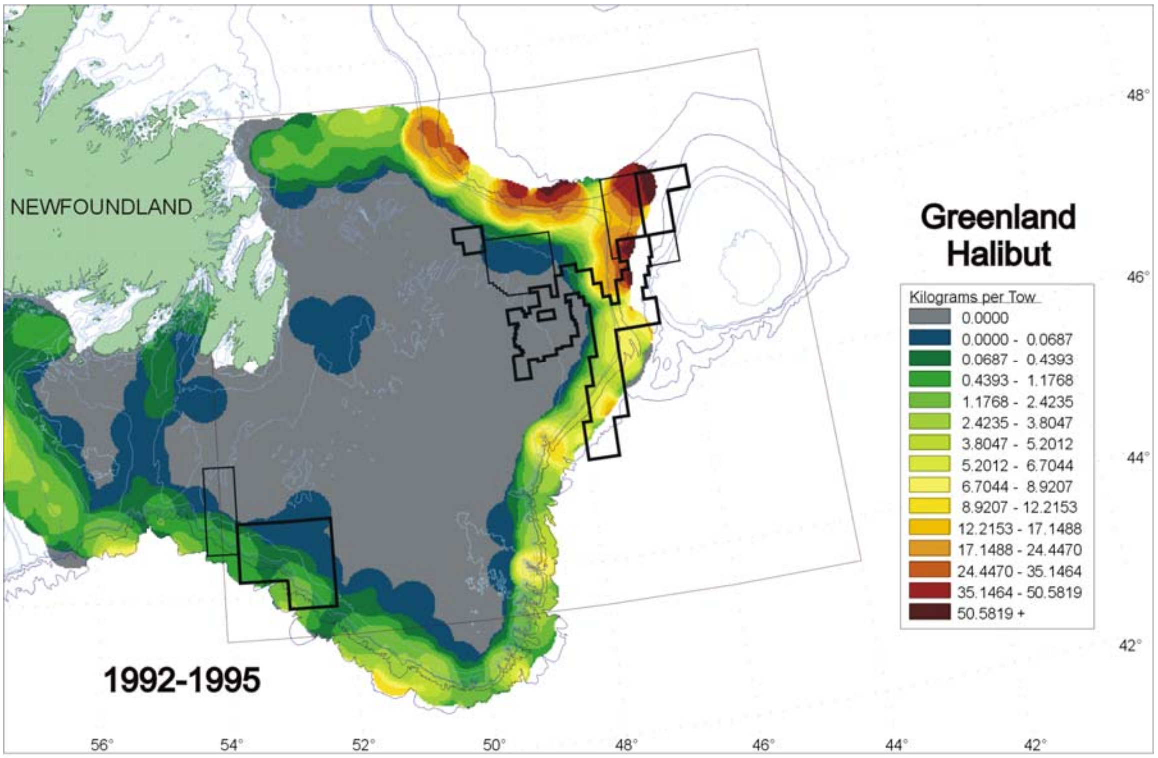


Figure 34b. Greenland Halibut distribution based on spring research surveys from 1986-88 & 1989-91. Gray sections represent areas sampled with no catch rate values.



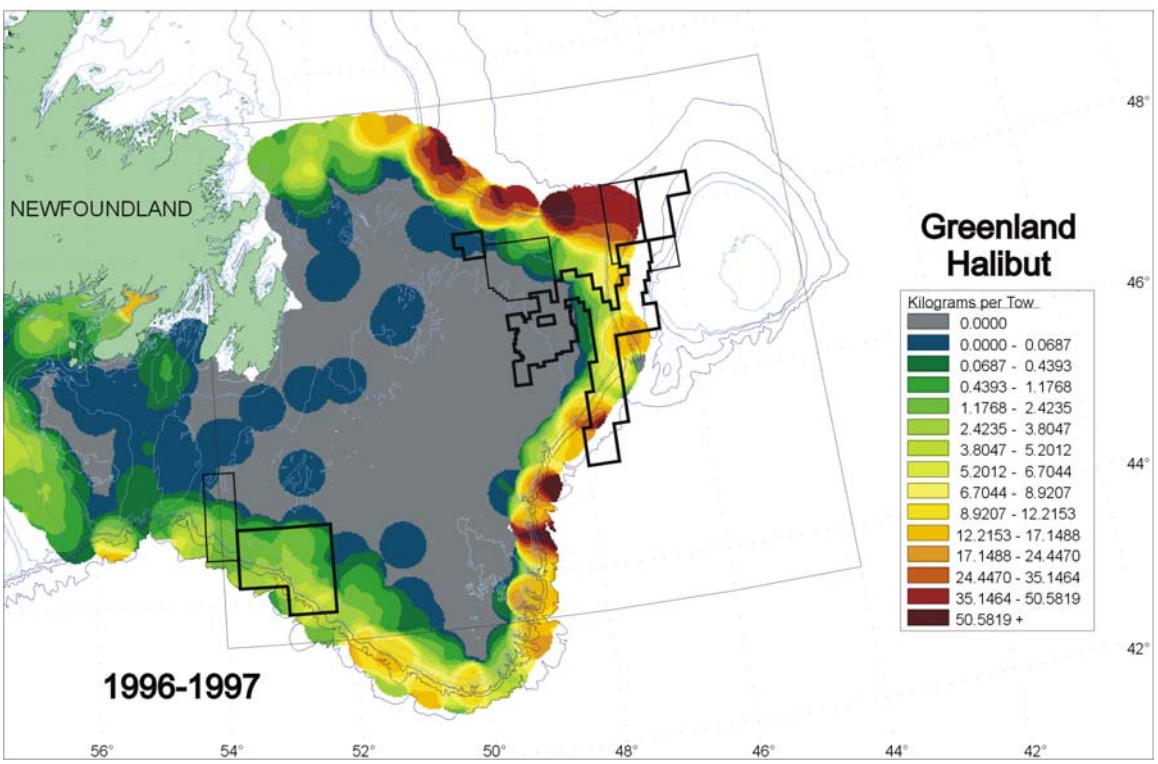


Figure 34c. Greenland Halibut distribution based on spring research surveys from 1992-95 & 1996-97. Gray sections represent areas sampled with no catch rate values.

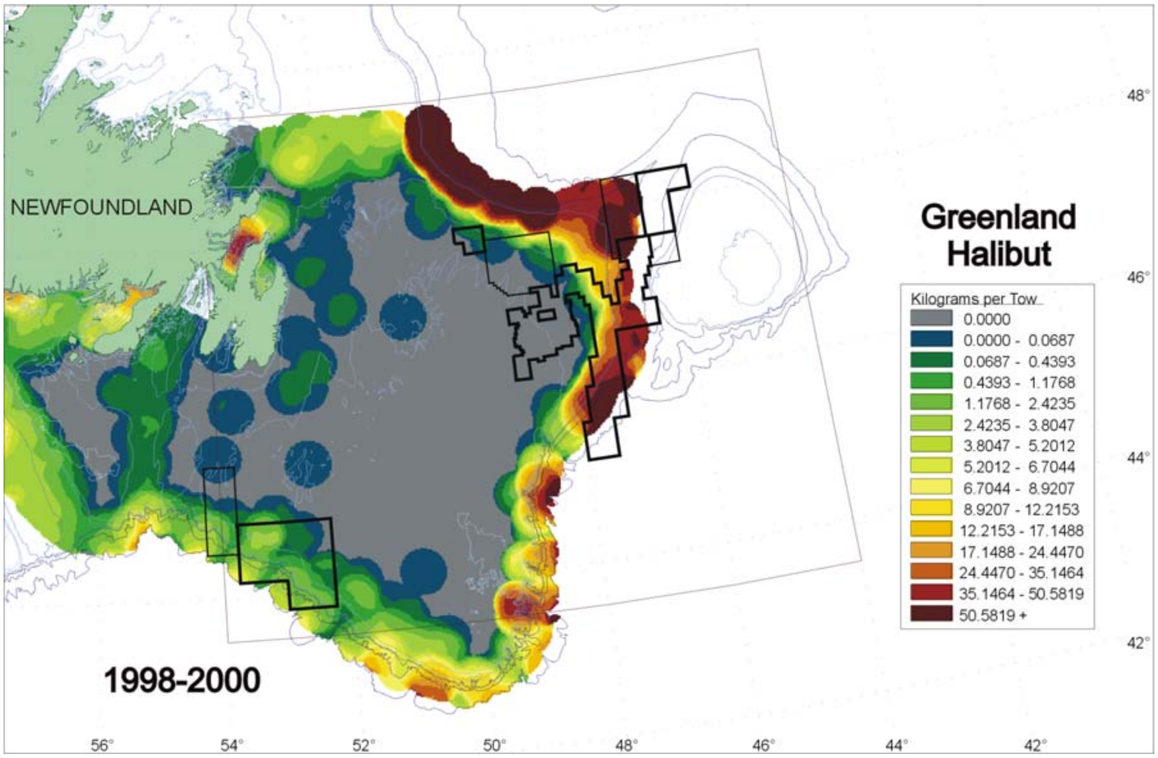


Figure 34d. Greenland Halibut distribution based on spring research surveys from 1998-2000. Gray sections represent areas sampled with no catch rate values.

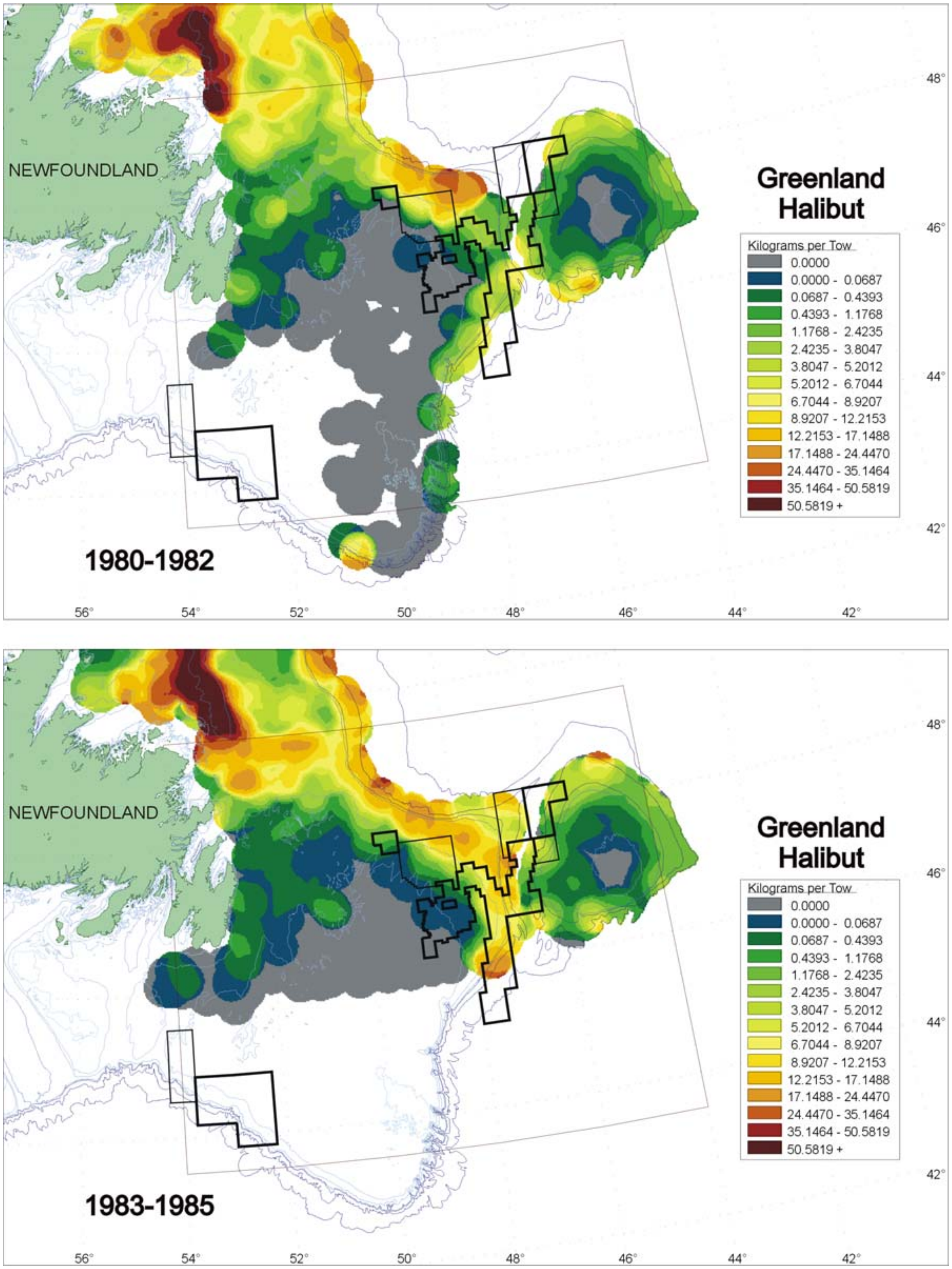
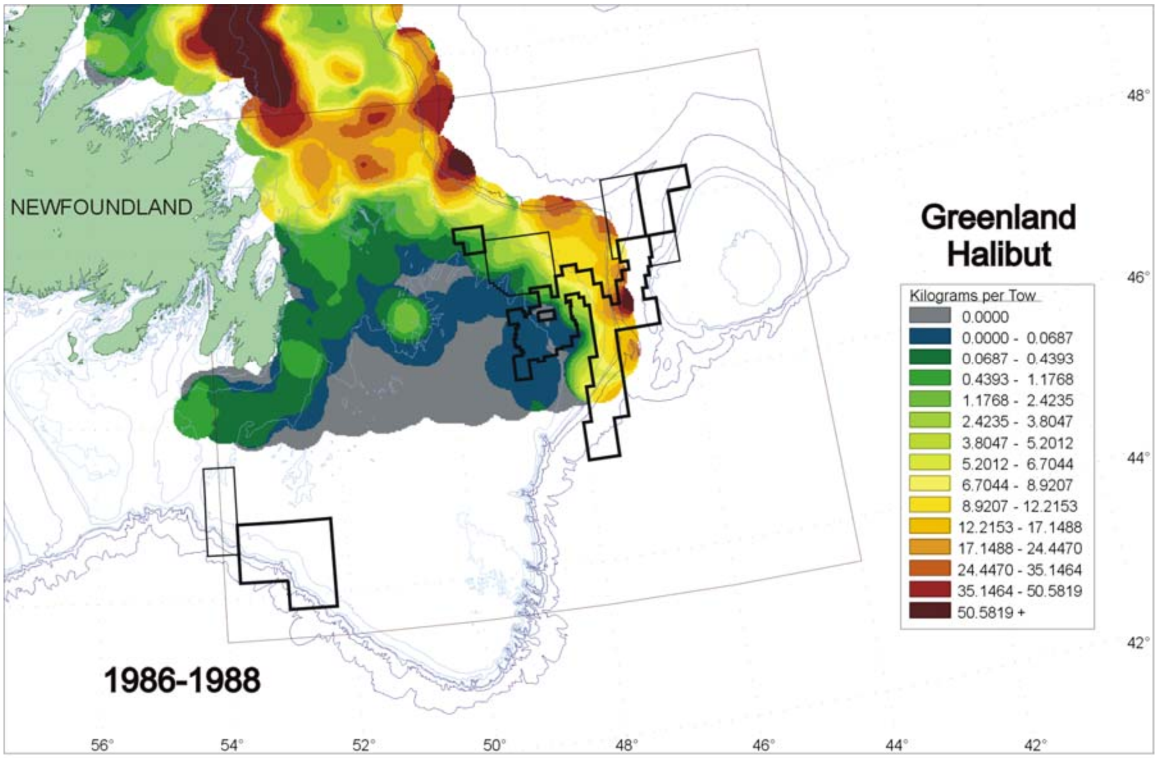


Figure 35a. Greenland Halibut distribution based on fall research surveys from 1980-82 & 1983-85. Gray sections represent areas sampled with no catch rate values.



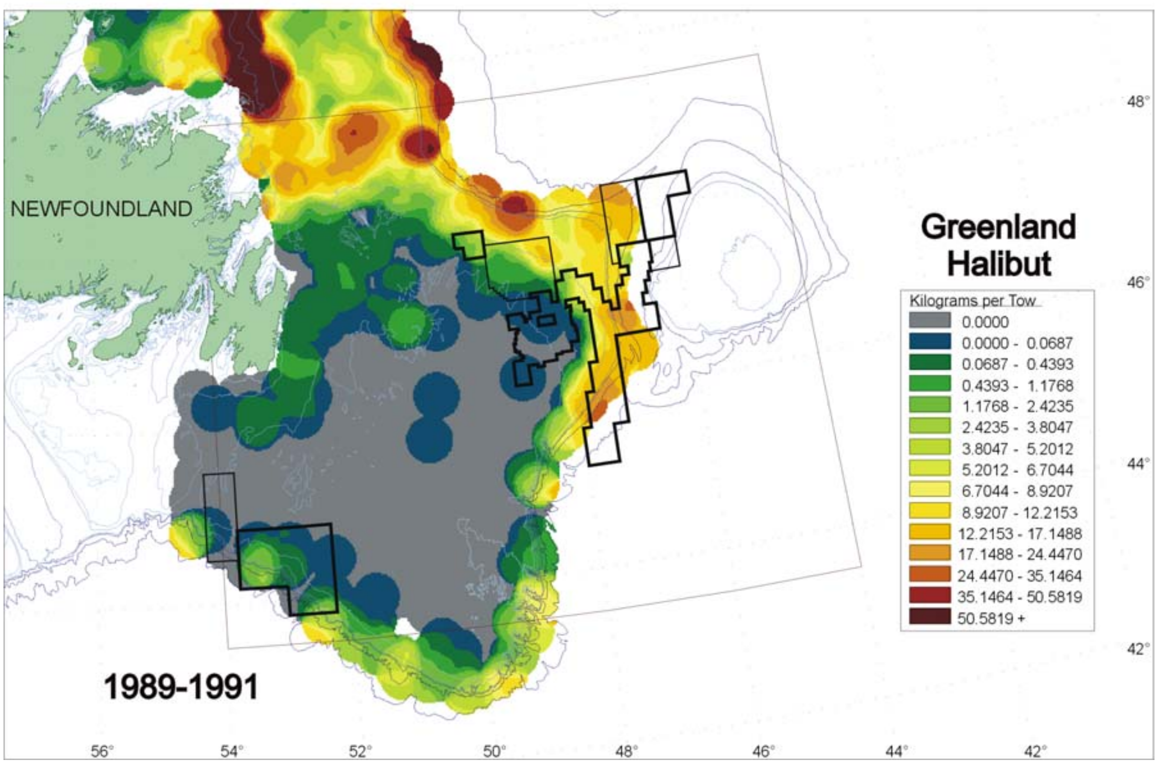


Figure 35b. Greenland Halibut distribution based on fall research surveys from 1986-88 & 1989-91. Gray sections represent areas sampled with no catch rate values.

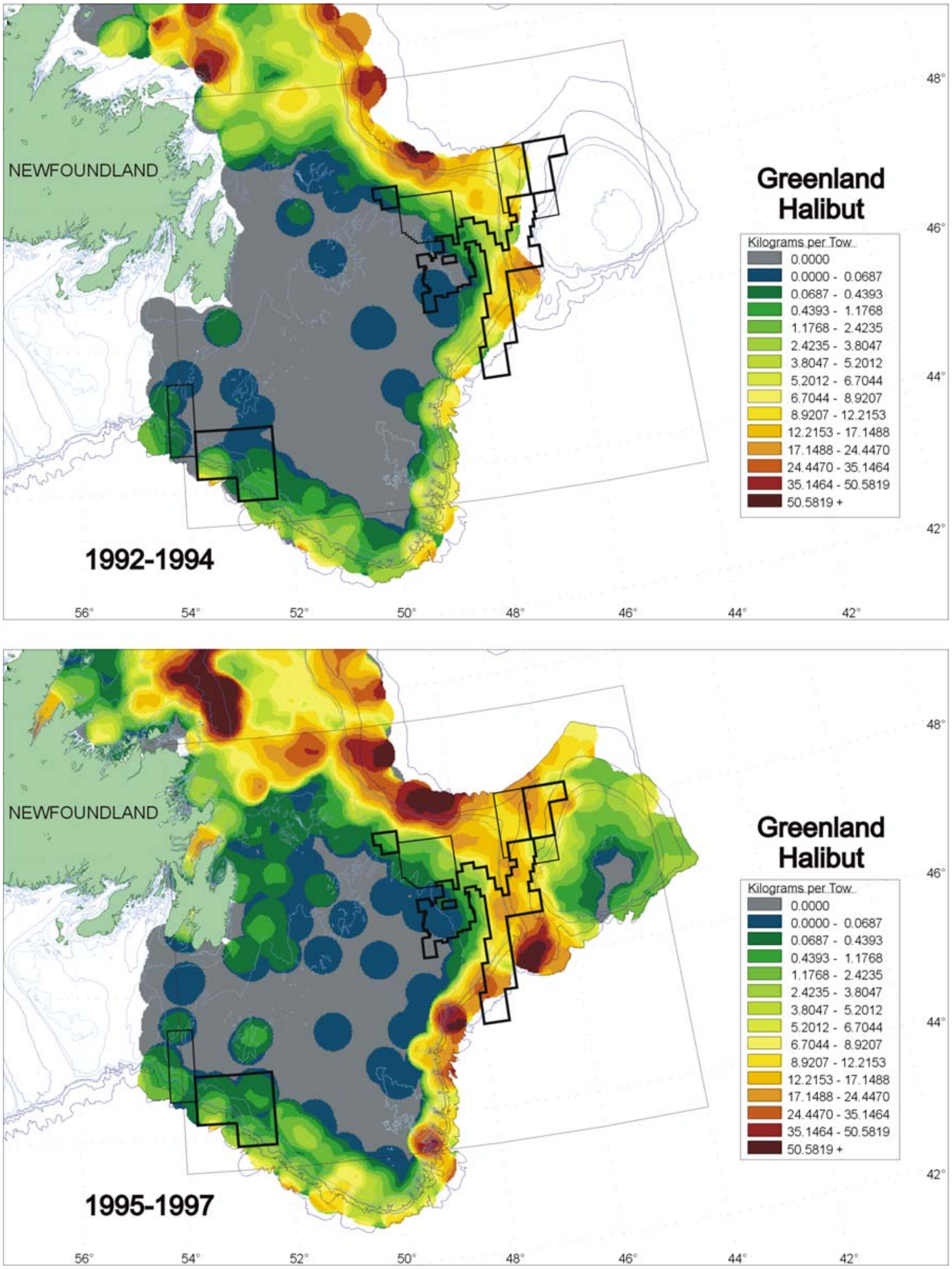


Figure 35c. Greenland Halibut distribution based on fall research surveys from 1992-94 & 1995-97. Gray sections represent areas sampled with no catch rate values.

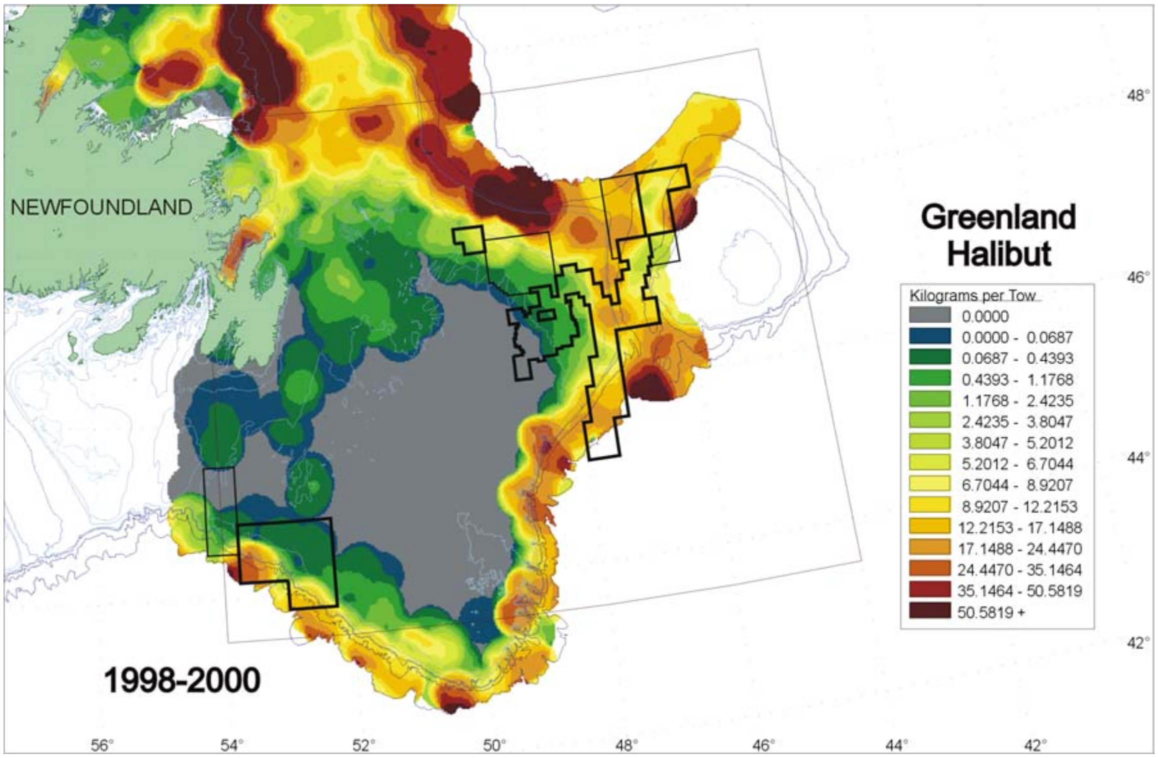
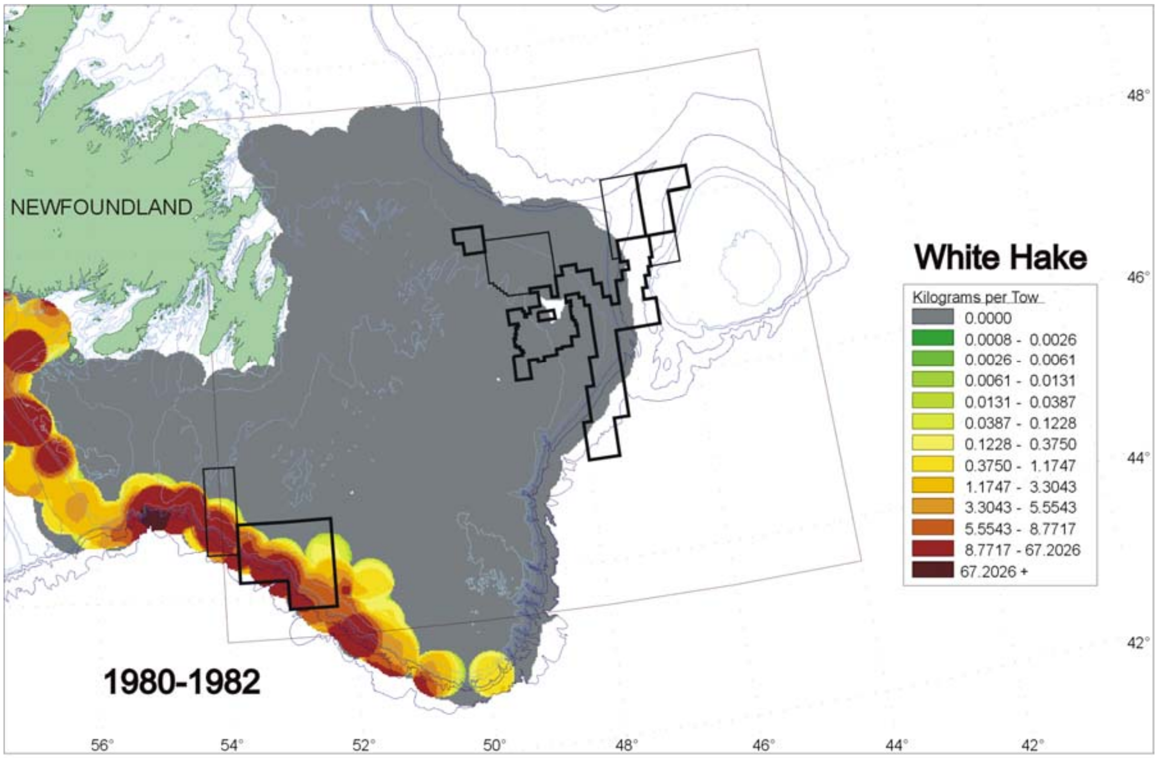


Figure 35d. Greenland Halibut distribution based on fall research surveys from 1998-2000. Gray sections represent areas sampled with no catch rate values.



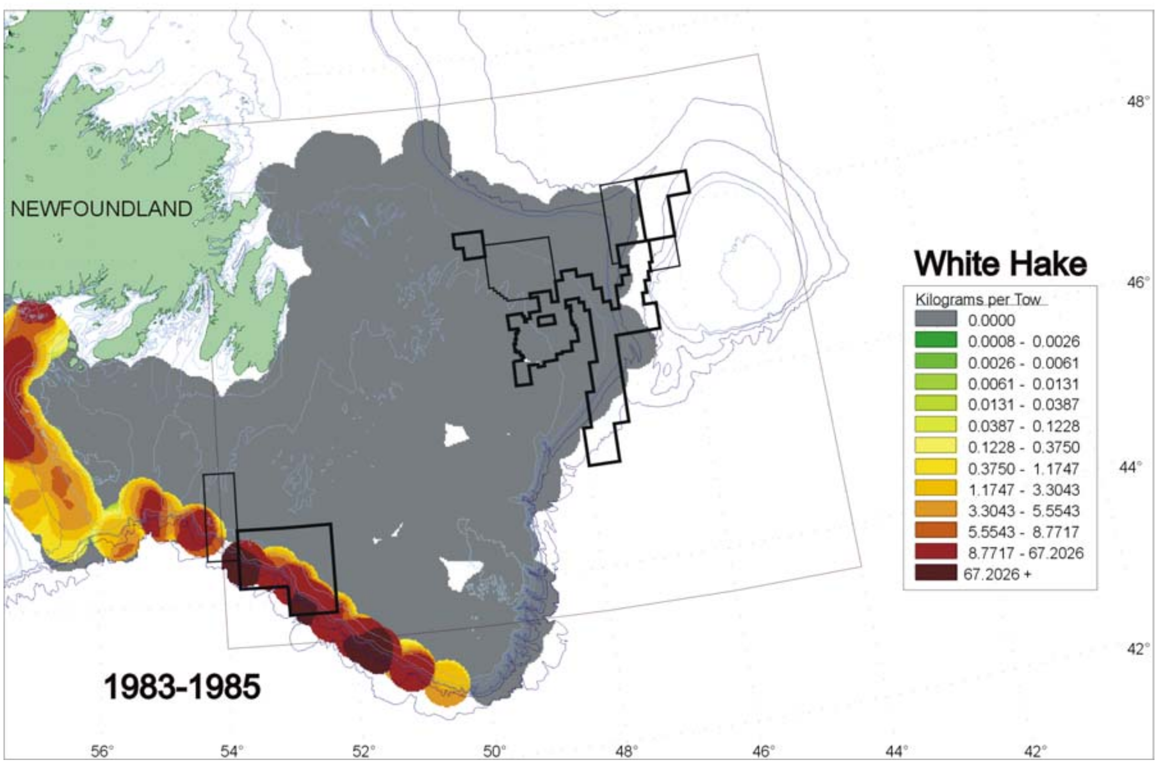
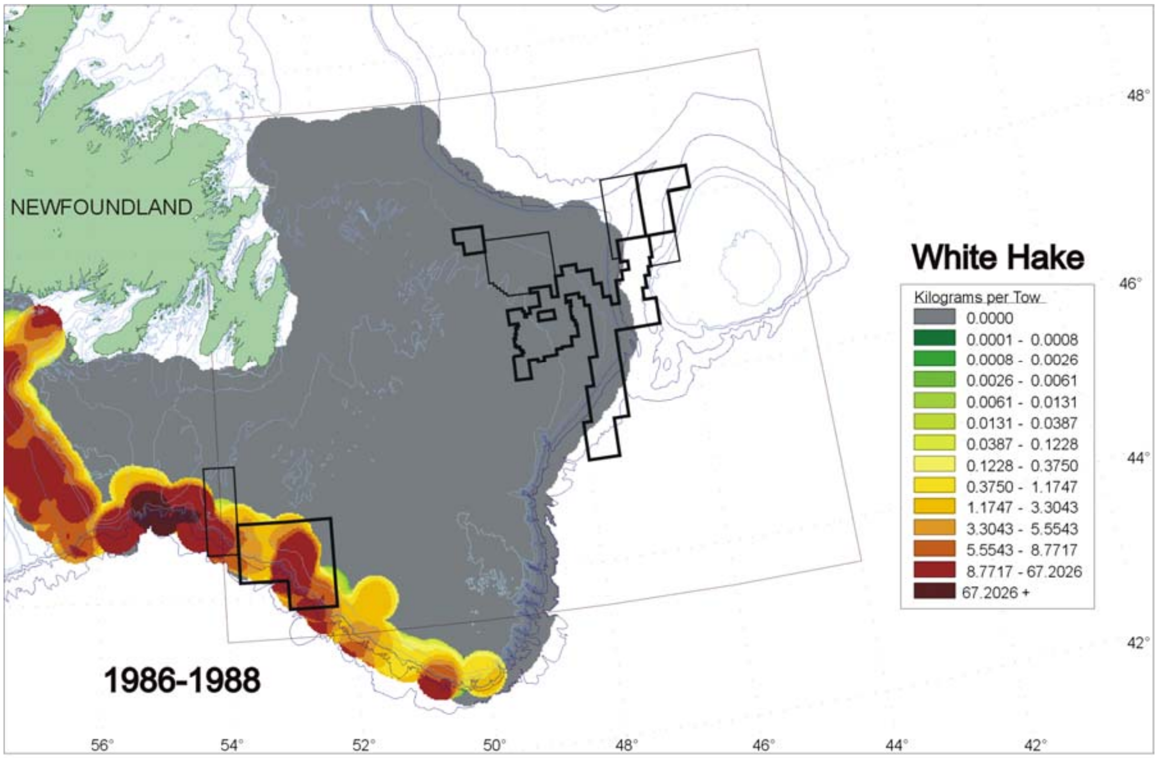


Figure 36a. White hake distribution based on spring research surveys from 1980-82 & 1983-85. Gray sections represent areas sampled with no catch rate values.



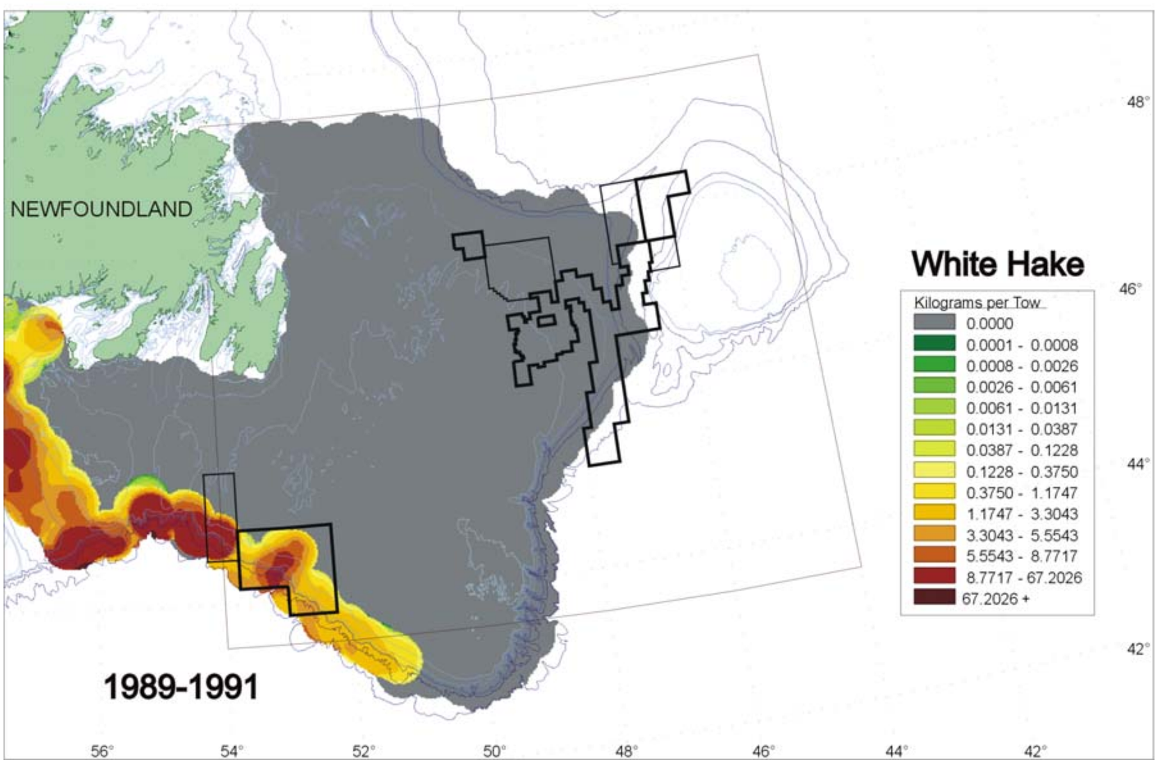


Figure 36b. White hake distribution based on spring research surveys from 1986-88 & 1989-91. Gray sections represent areas sampled with no catch rate values.

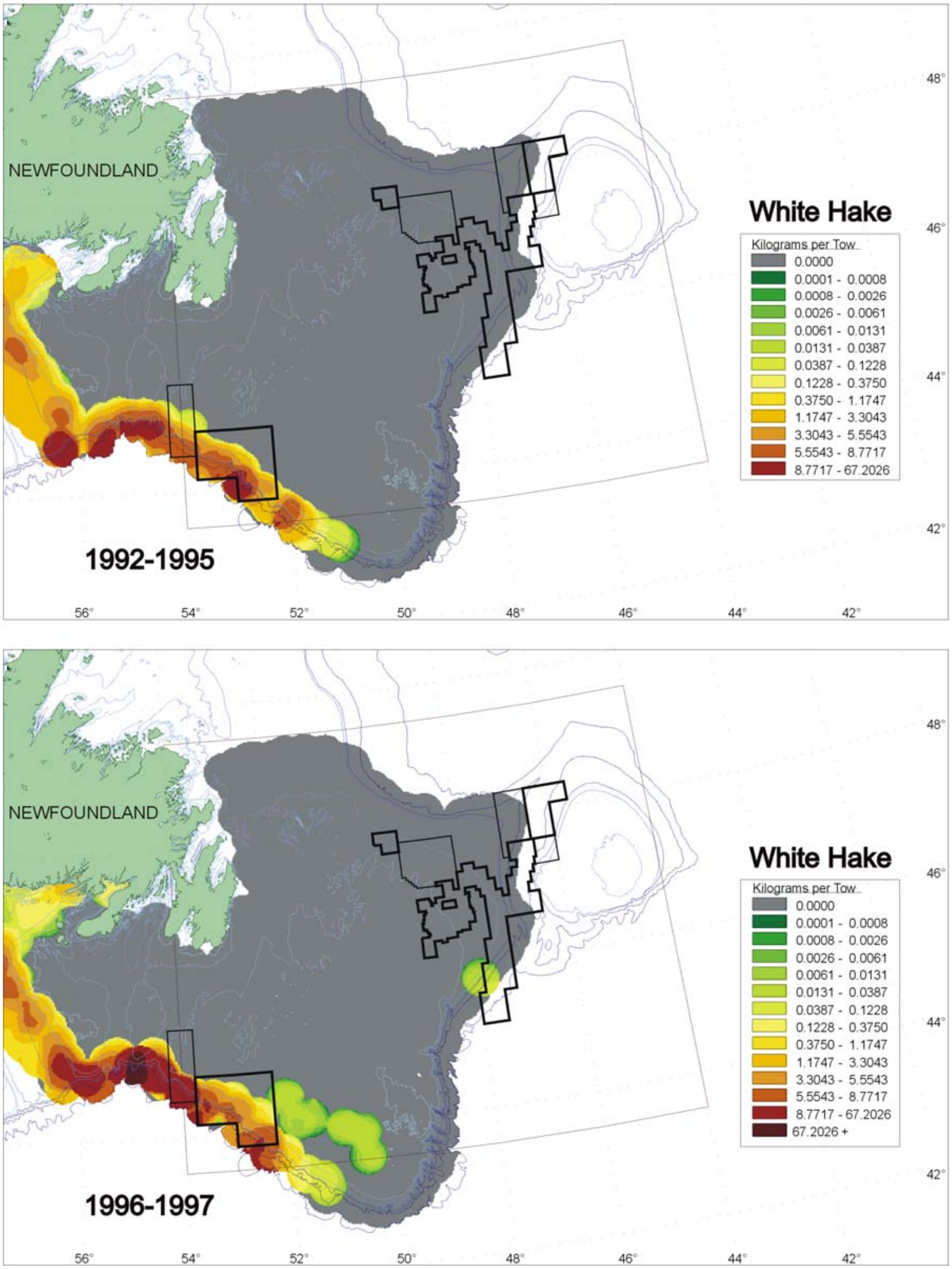


Figure 36c. White hake distribution based on spring research surveys from 1992-95 & 1996-97. Gray sections represent areas sampled with no catch rate values.

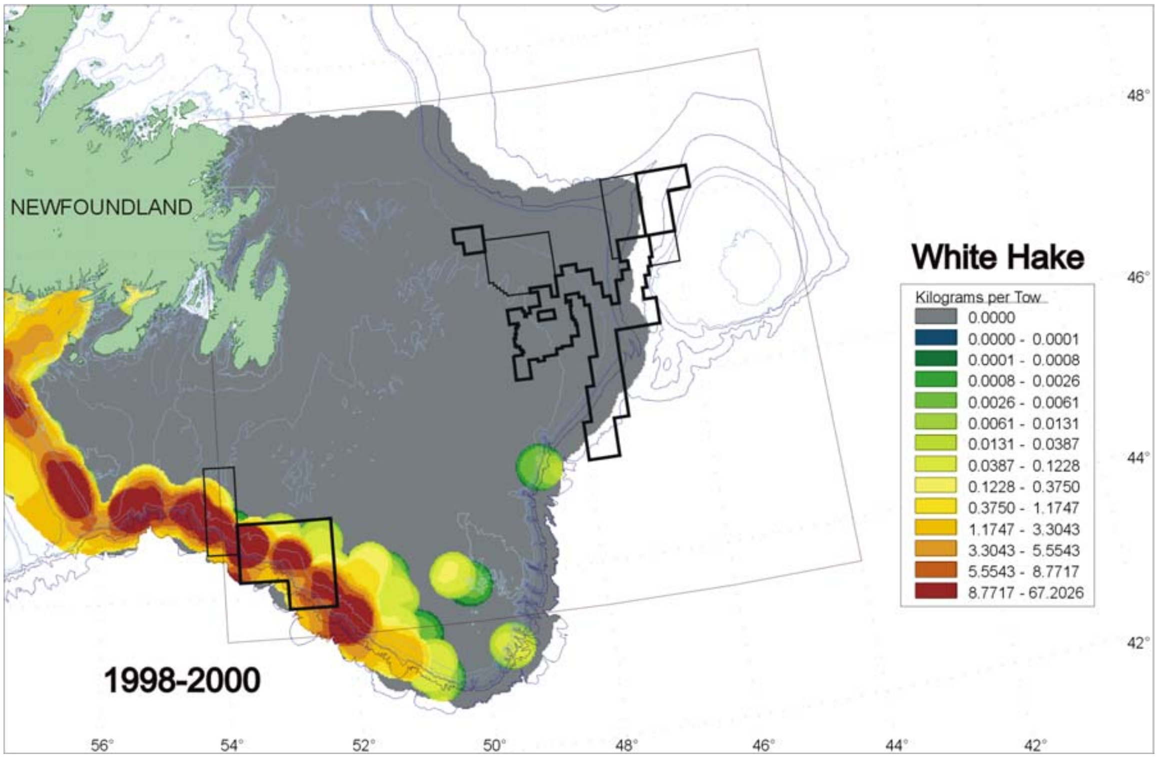
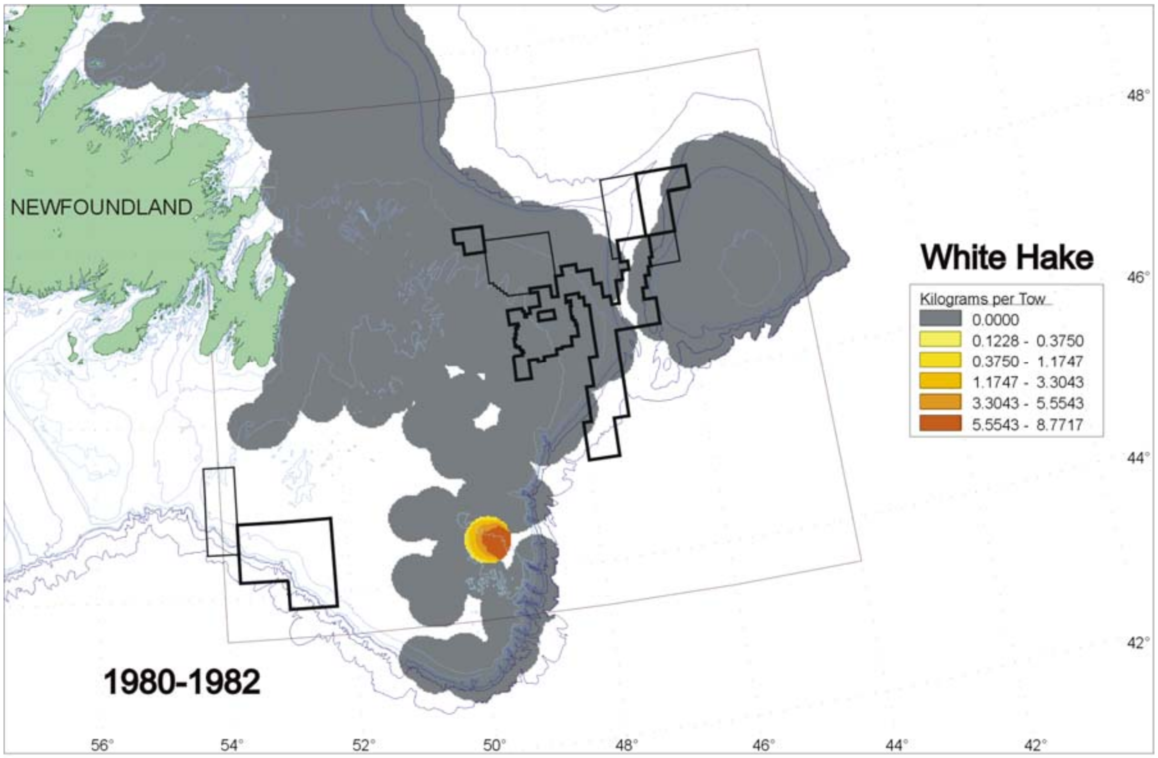


Figure 36d. White hake distribution based on spring research surveys from 1998-2000. Gray sections represent areas sampled with no catch rate values.



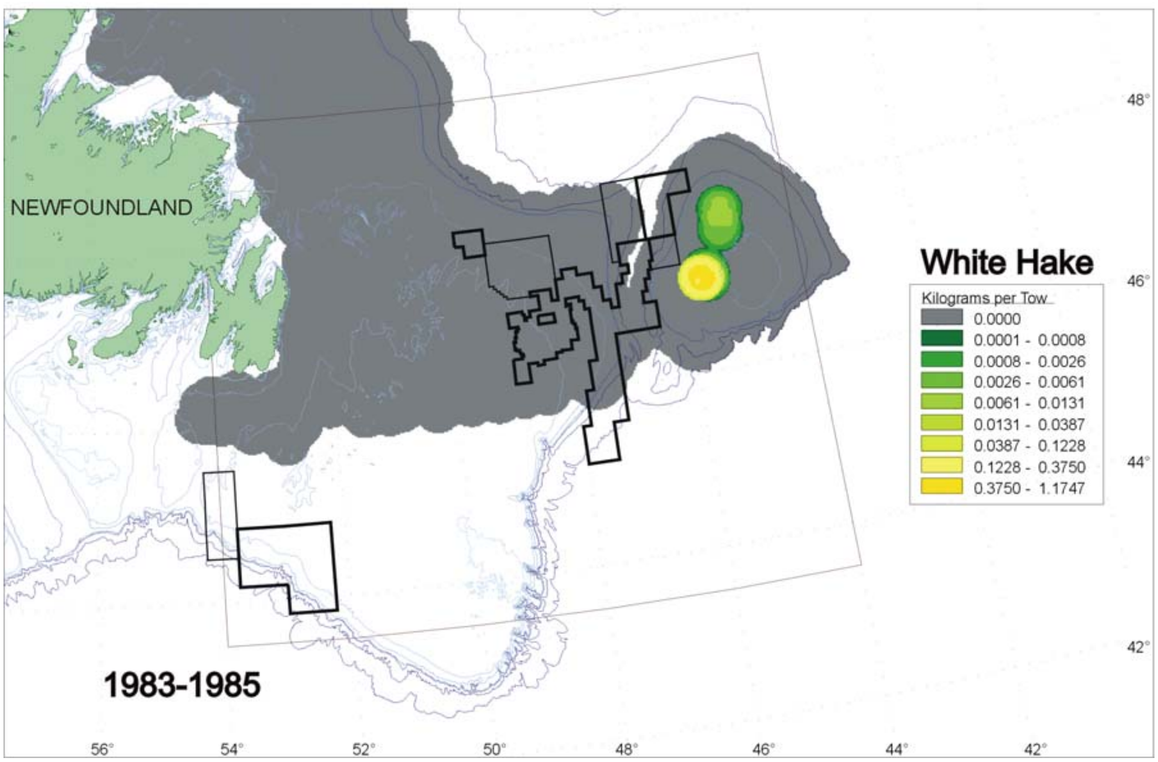
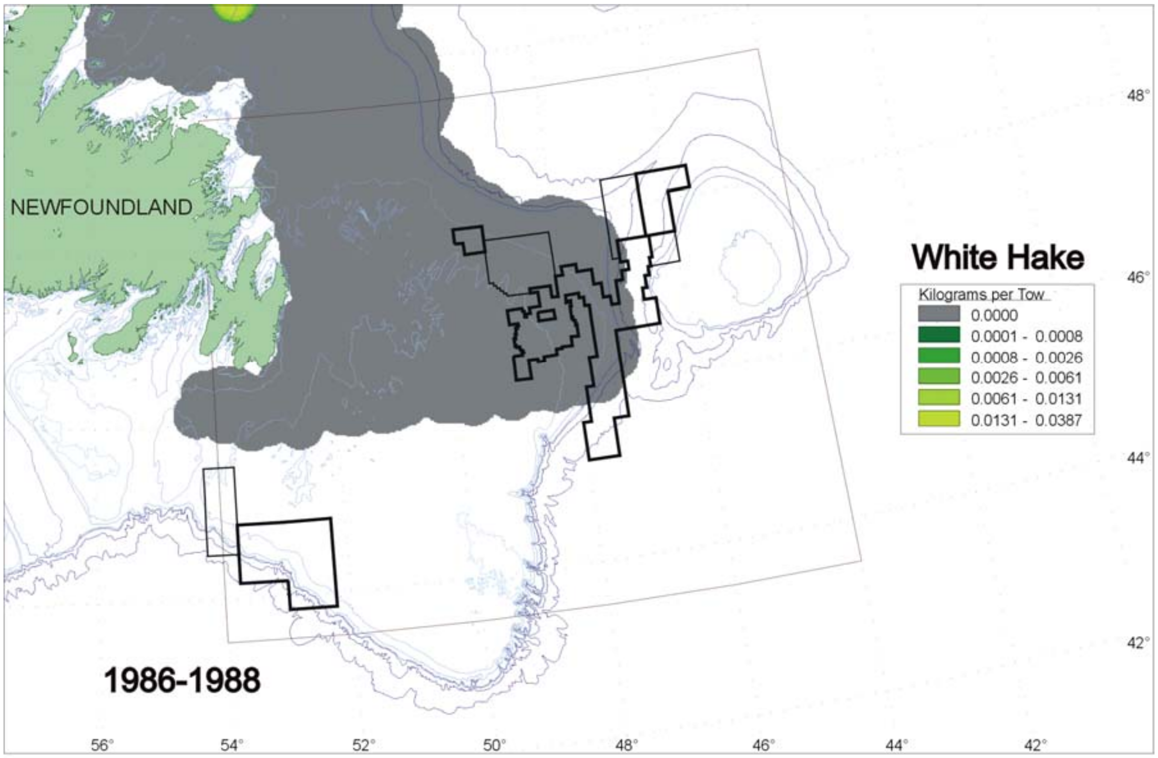


Figure 37a. White hake distribution based on fall research surveys from 1980-82 & 1983-85. Gray sections represent areas sampled with no catch rate values.



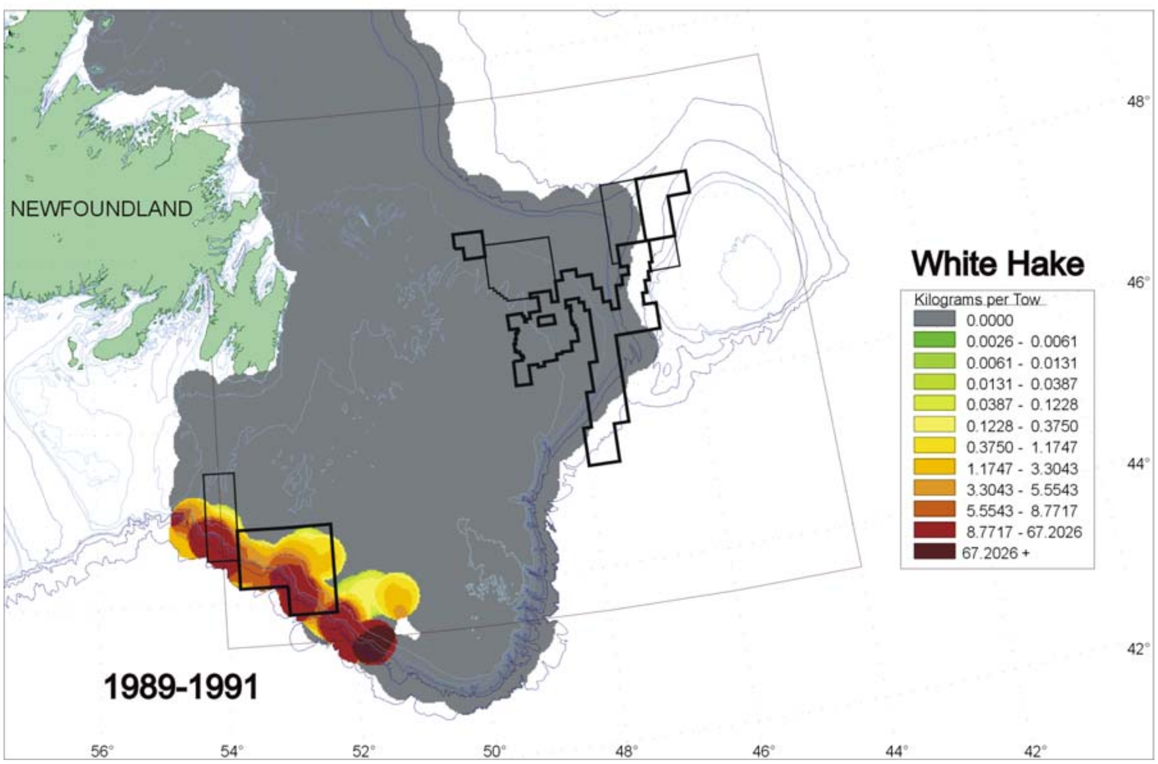
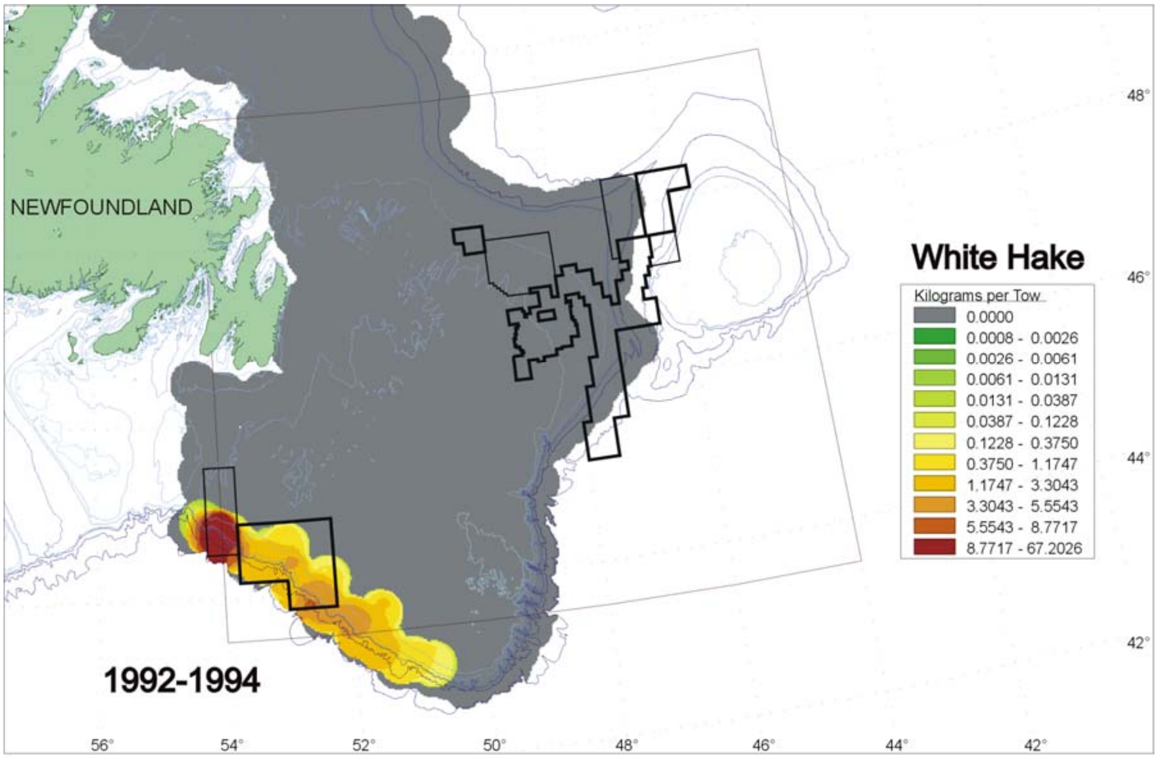


Figure 37b. White hake distribution based on fall research surveys from 1986-88 & 1989-91. Gray sections represent areas sampled with no catch rate values.



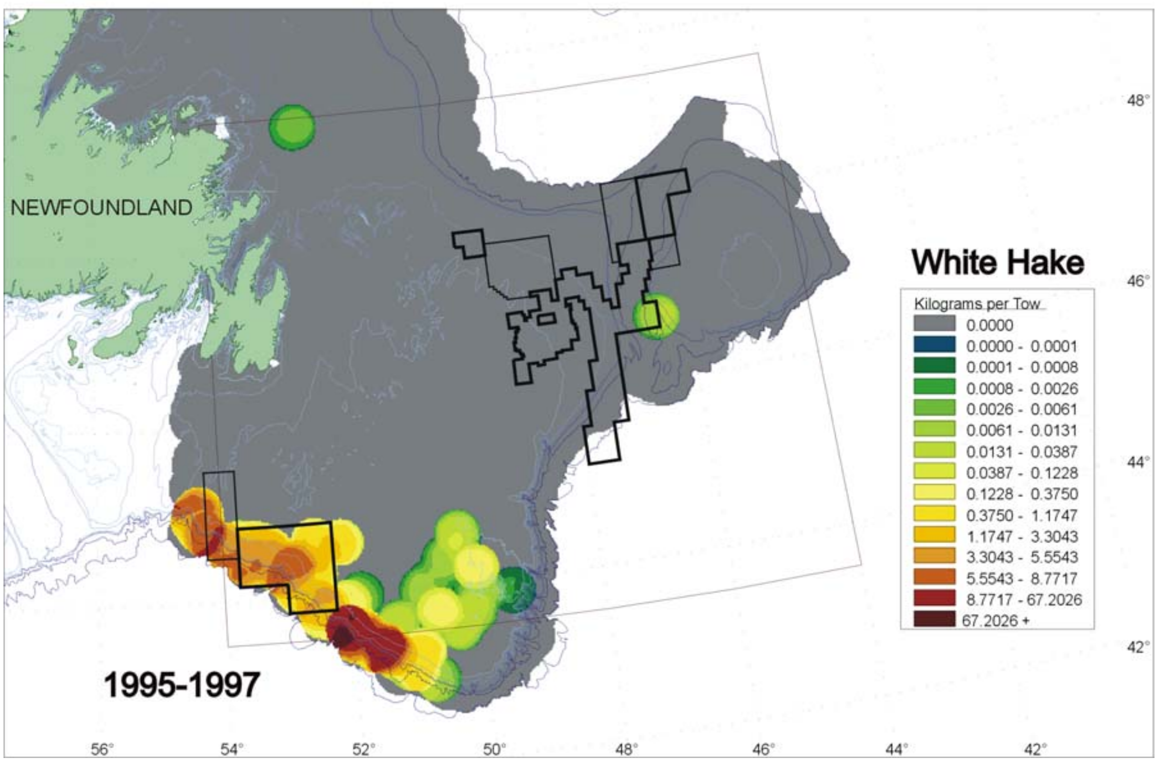


Figure 37c. White hake distribution based on fall research surveys from 1992-94 & 1995-97. Gray sections represent areas sampled with no catch rate values.

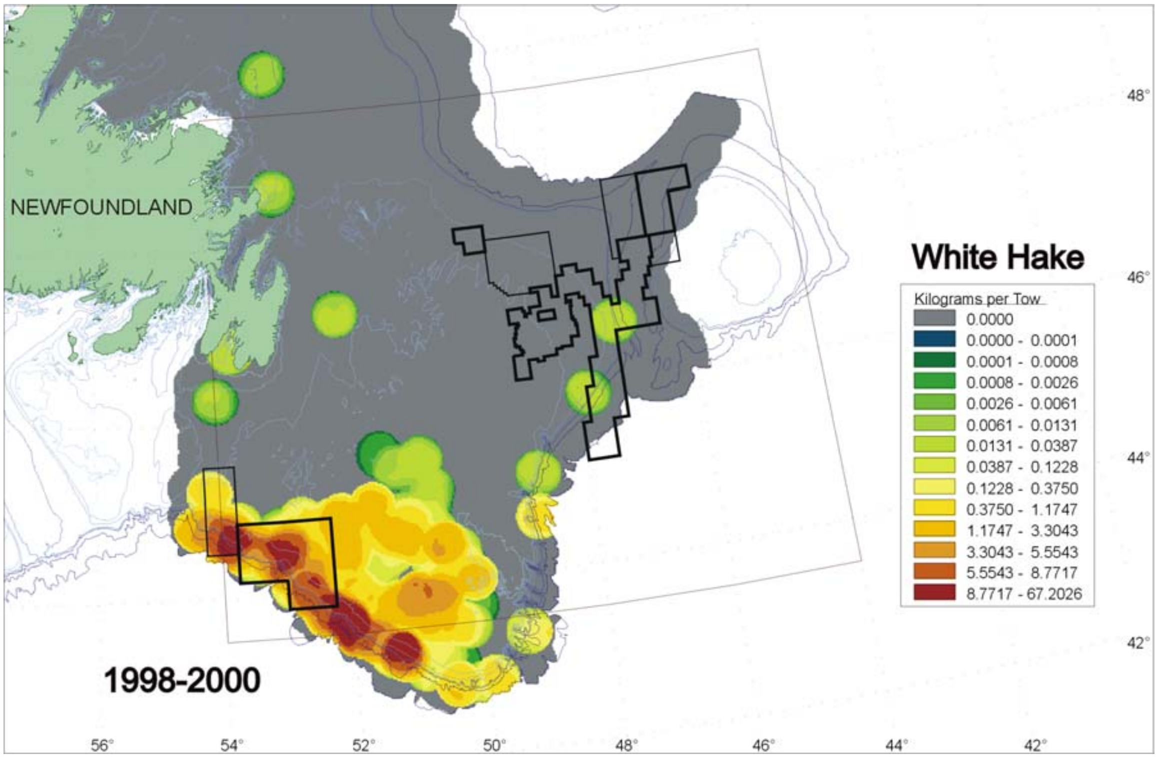


Figure 37d. White hake distribution based on fall research surveys from 1998-2000. Gray sections represent areas sampled with no catch rate values.

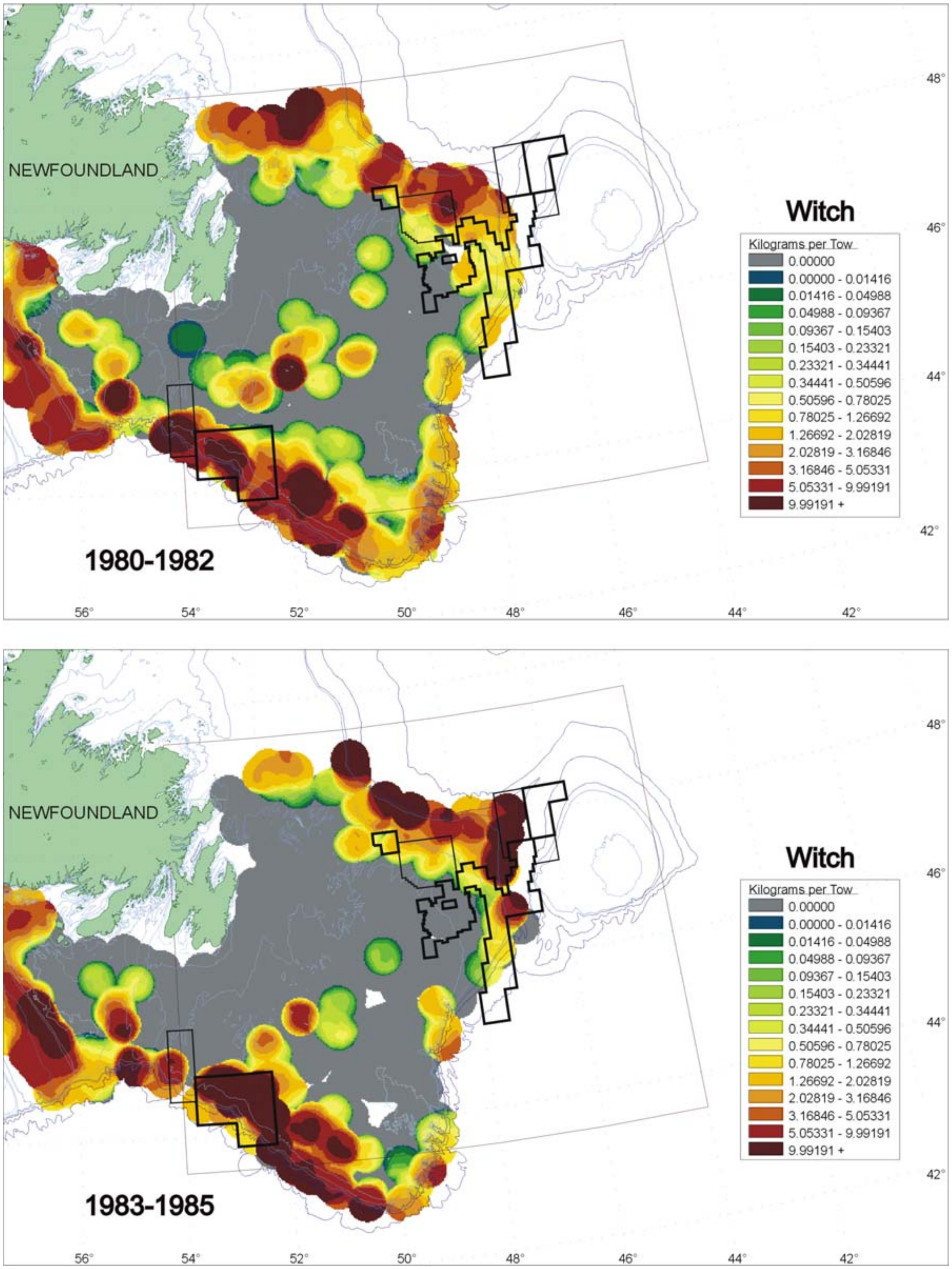
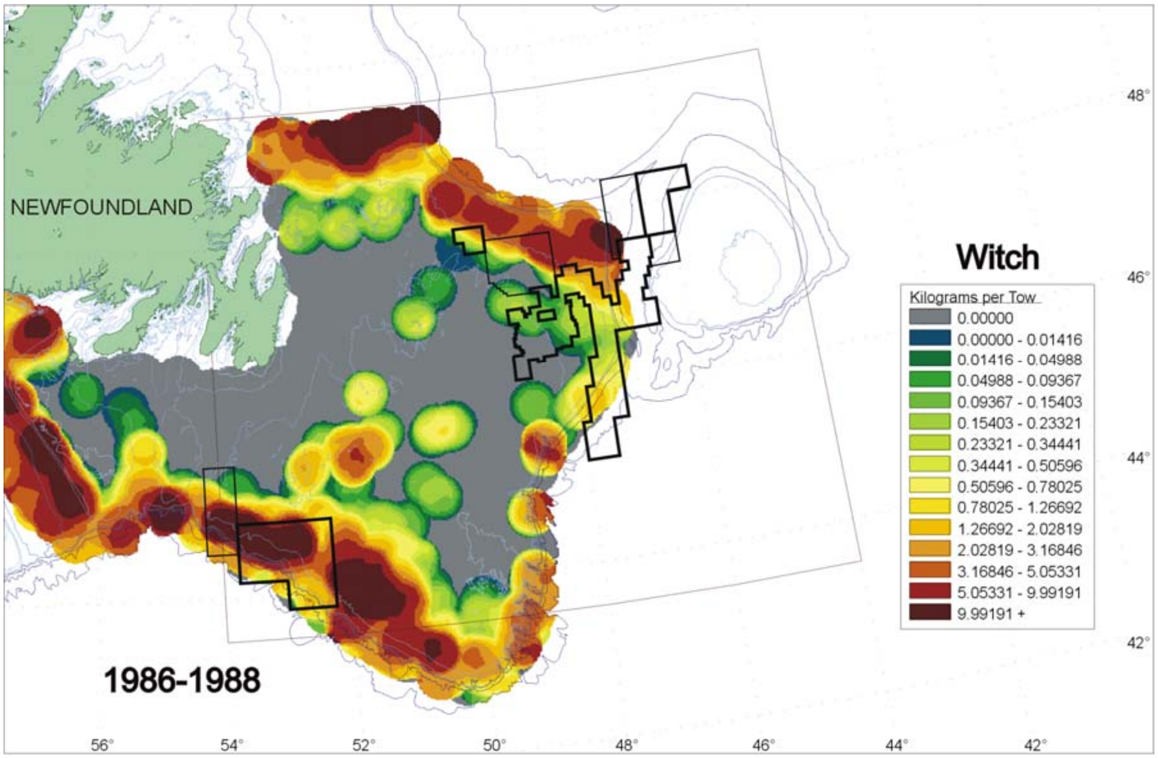


Figure 38a. Witch flounder distribution based on spring research surveys from 1980-82 & 1983-85. Gray sections represent areas sampled with no catch rate values. (Witch on map refers to witch flounder).



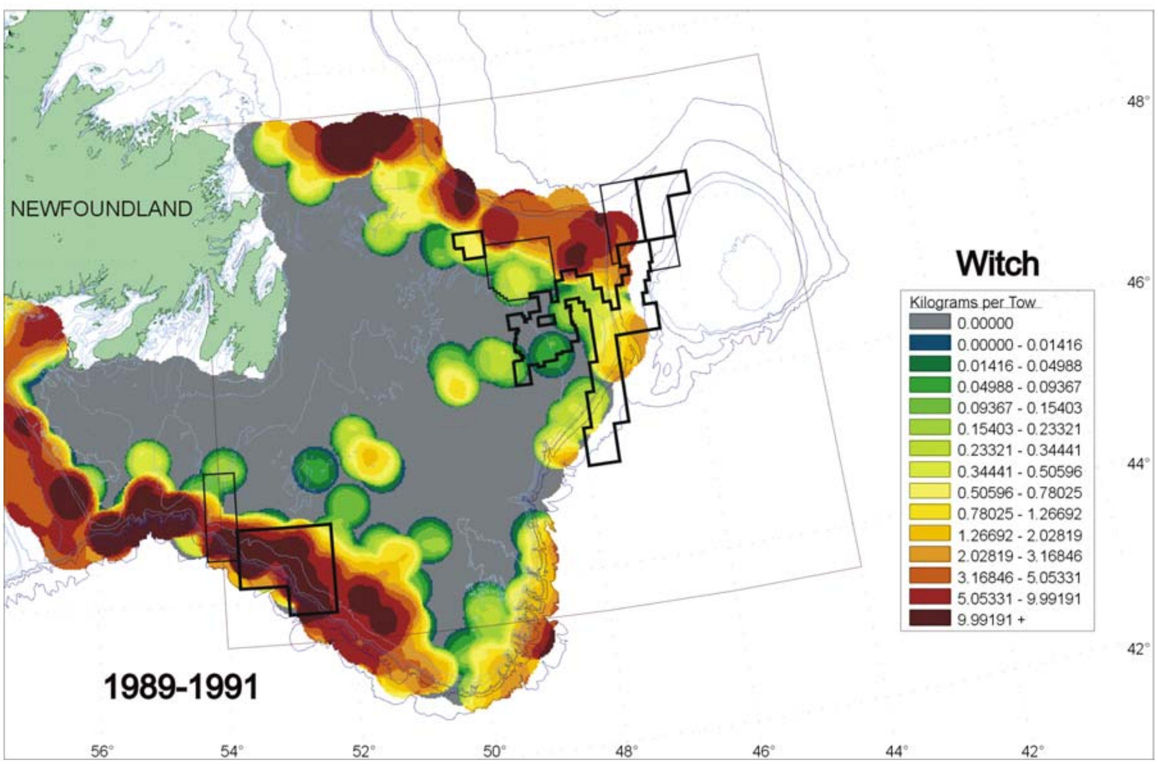


Figure 38b. Witch flounder distribution based on spring research surveys from 1986-88 & 1989-91. Gray sections represent areas sampled with no catch rate values. (Witch on map refers to witch flounder).

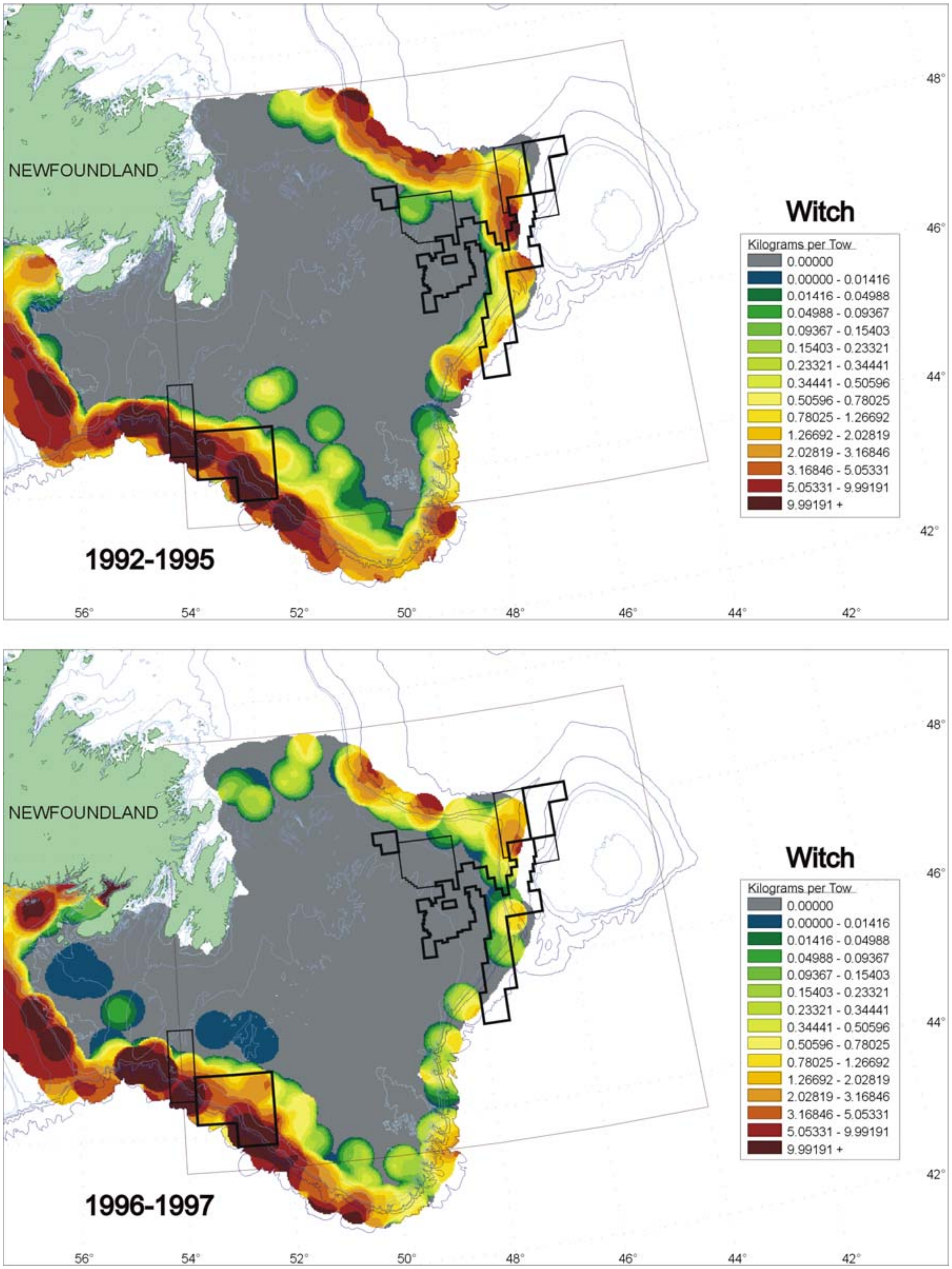


Figure 38c. Witch flounder distribution based on spring research surveys from 1992-95 & 1996-97. Gray sections represent areas sampled with no catch rate values. (Witch on map refers to witch flounder).

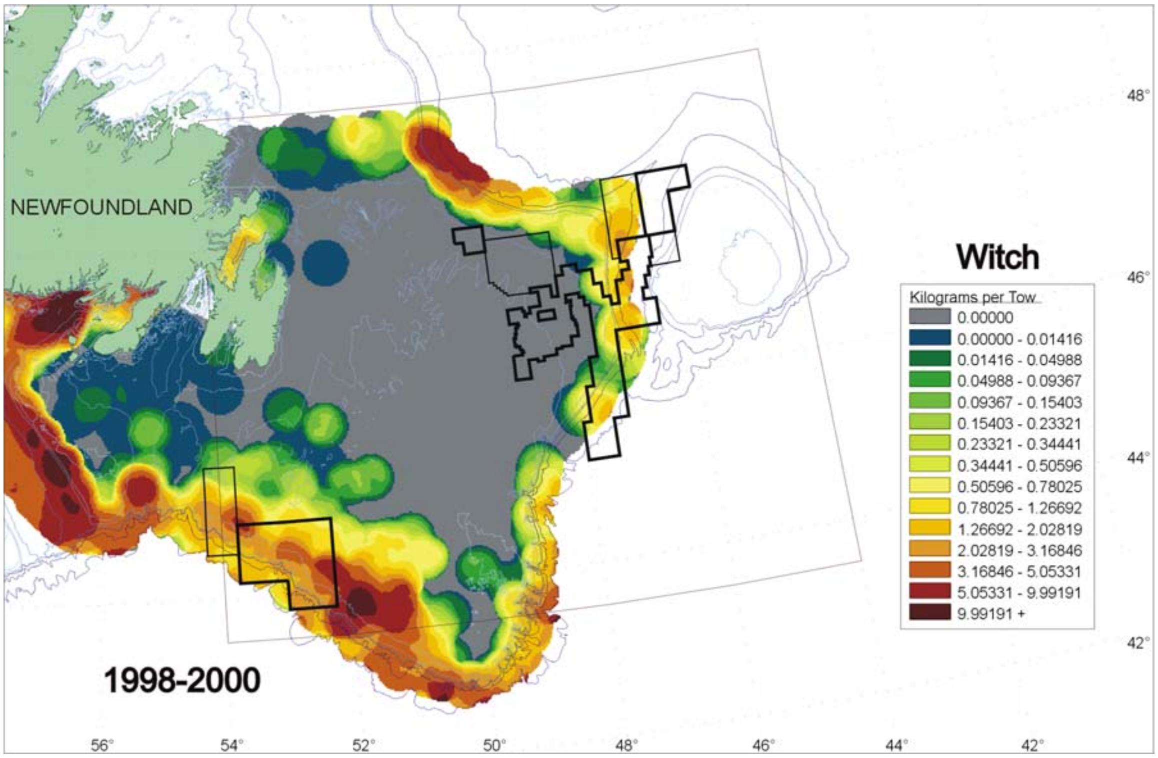


Figure 38d. Witch flounder distribution based on spring research surveys from 1998-2000. Gray sections represent areas sampled with no catch rate values. (Witch on map refers to witch flounder).

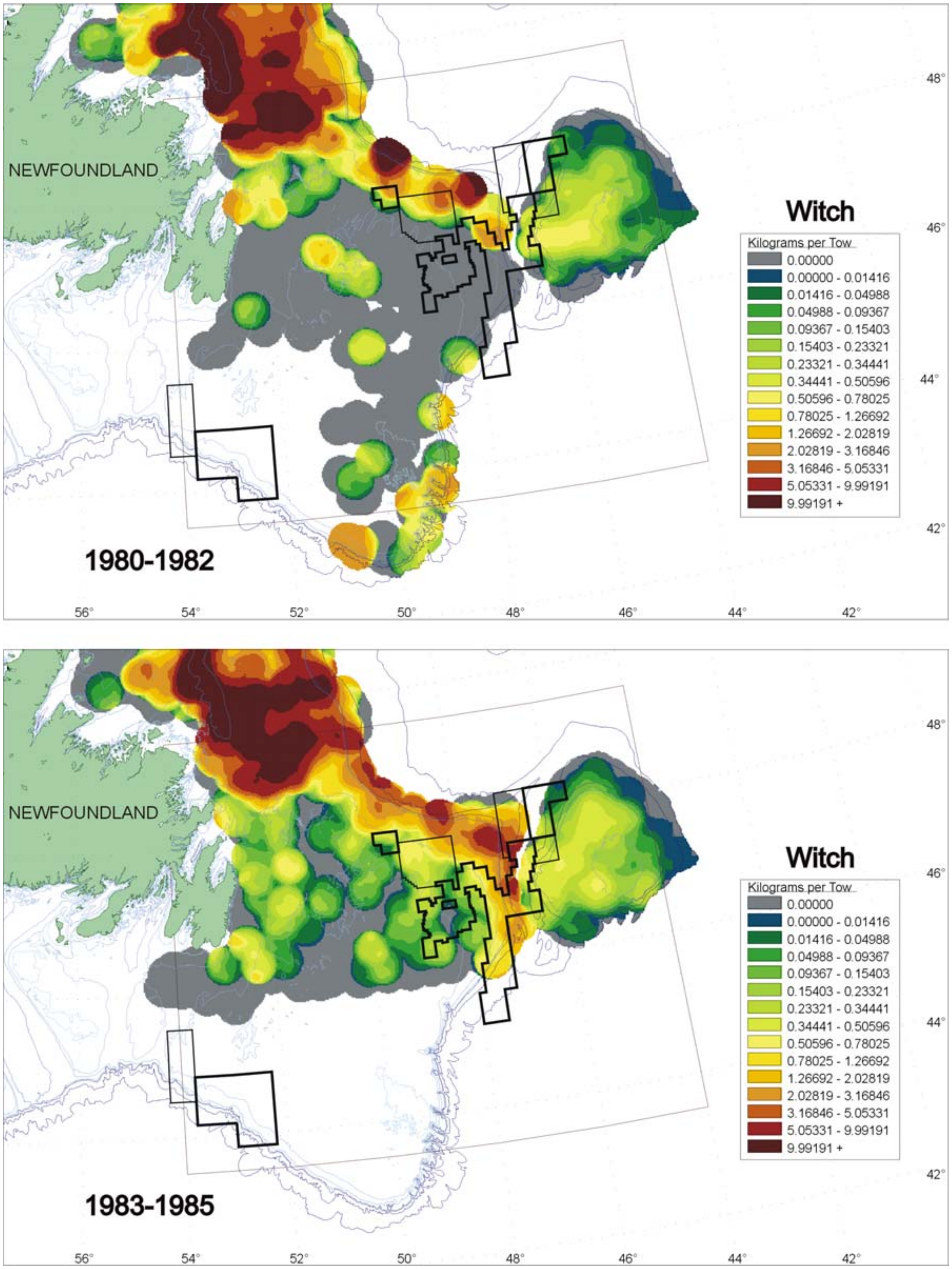


Figure 39a. Witch flounder distribution based on fall research surveys from 1980-82 & 1983-85. Gray sections represent areas sampled with no catch rate values. (Witch on map refers to witch flounder).

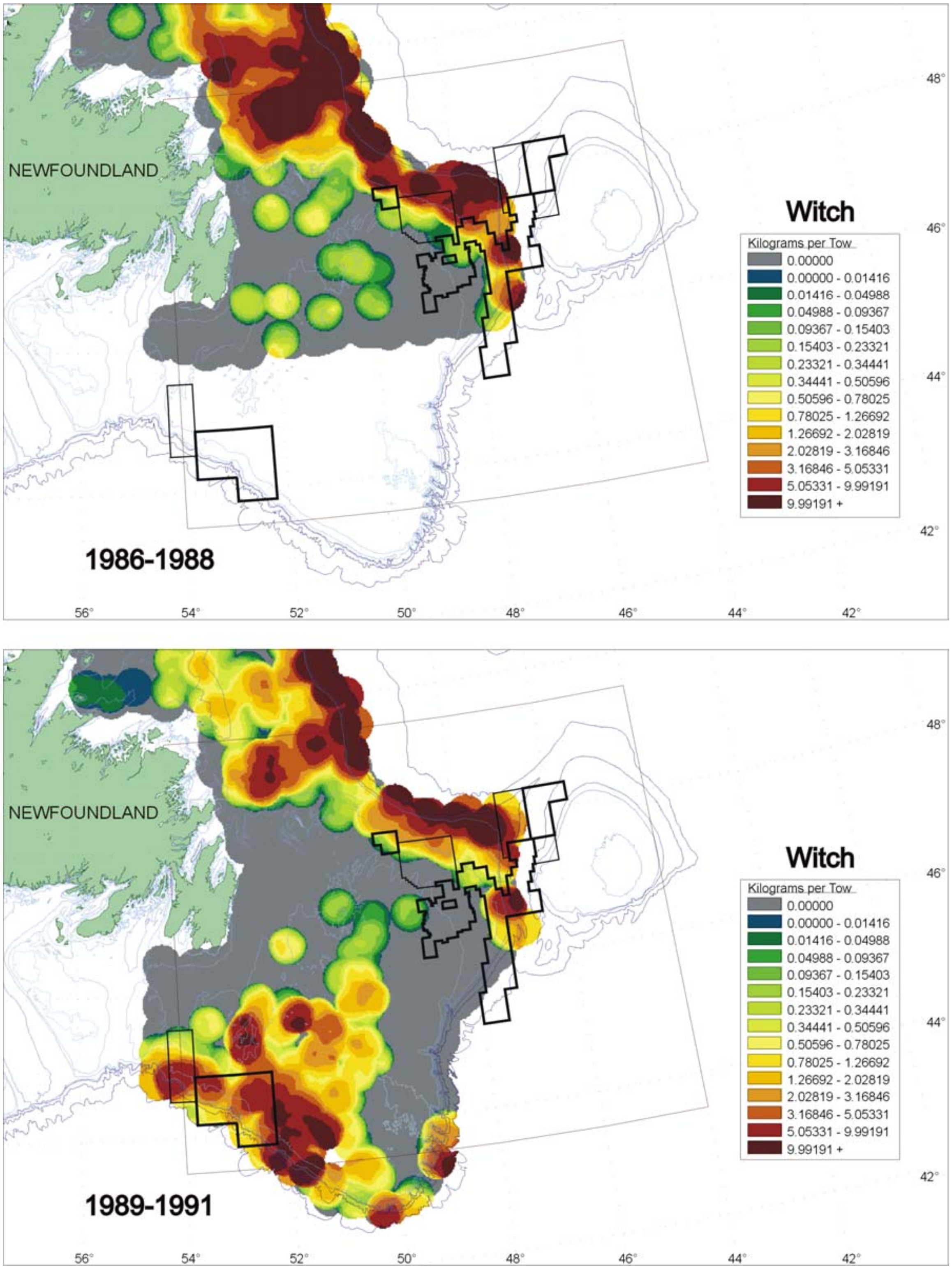
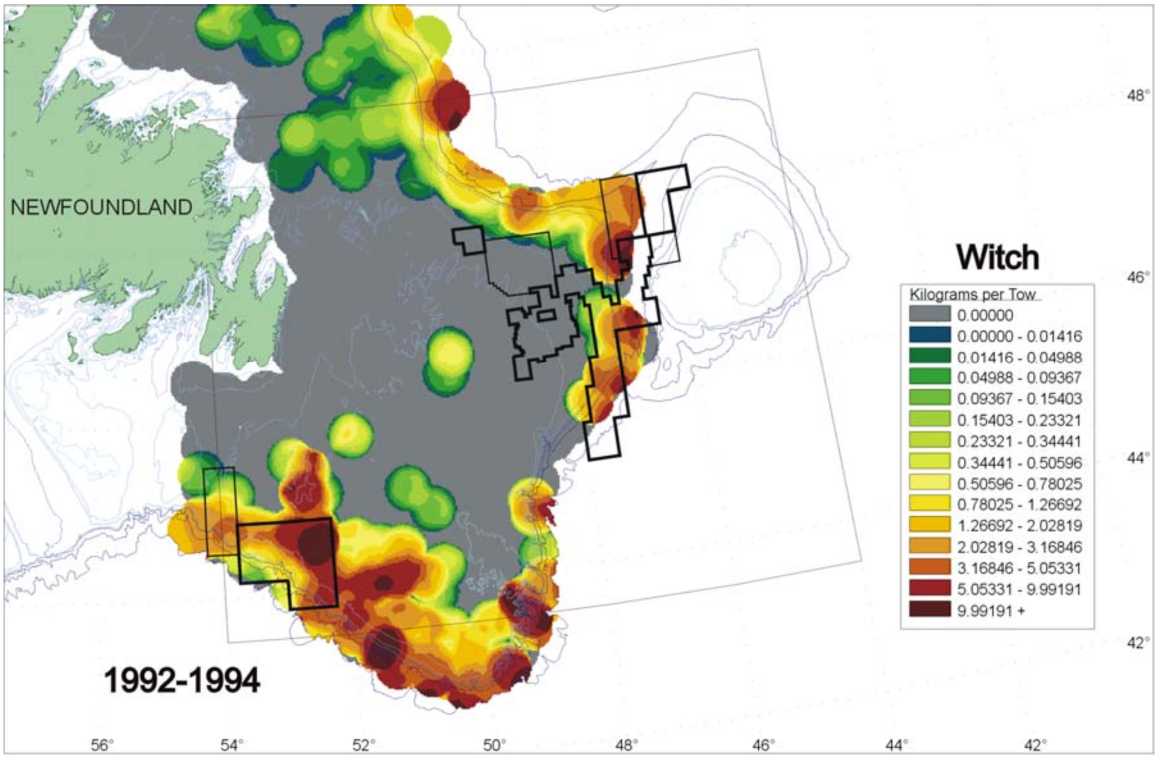


Figure 39b. Witch flounder distribution based on fall research surveys from 1986-88 & 1989-91. Gray sections represent areas sampled with no catch rate values. (Witch on map refers to witch flounder).



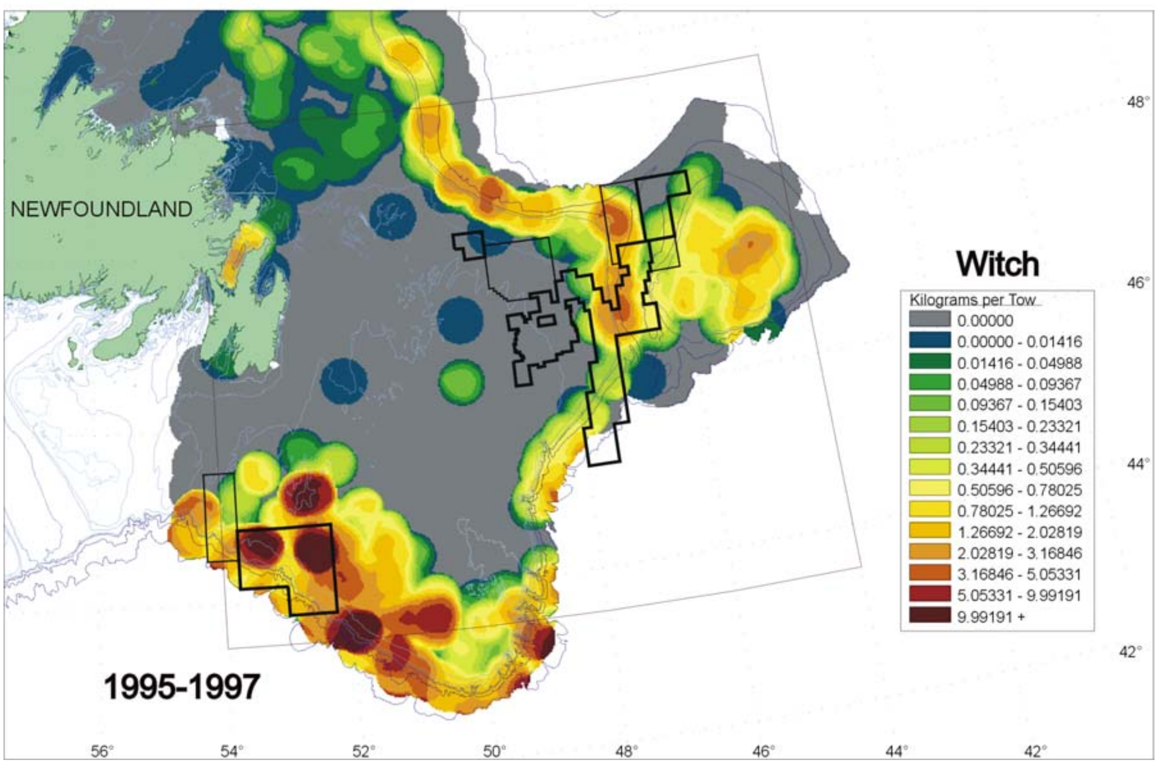


Figure 39c. Witch flounder distribution based on fall research surveys from 1992-94 & 1995-97. Gray sections represent areas sampled with no catch rate values. (Witch on map refers to witch flounder).

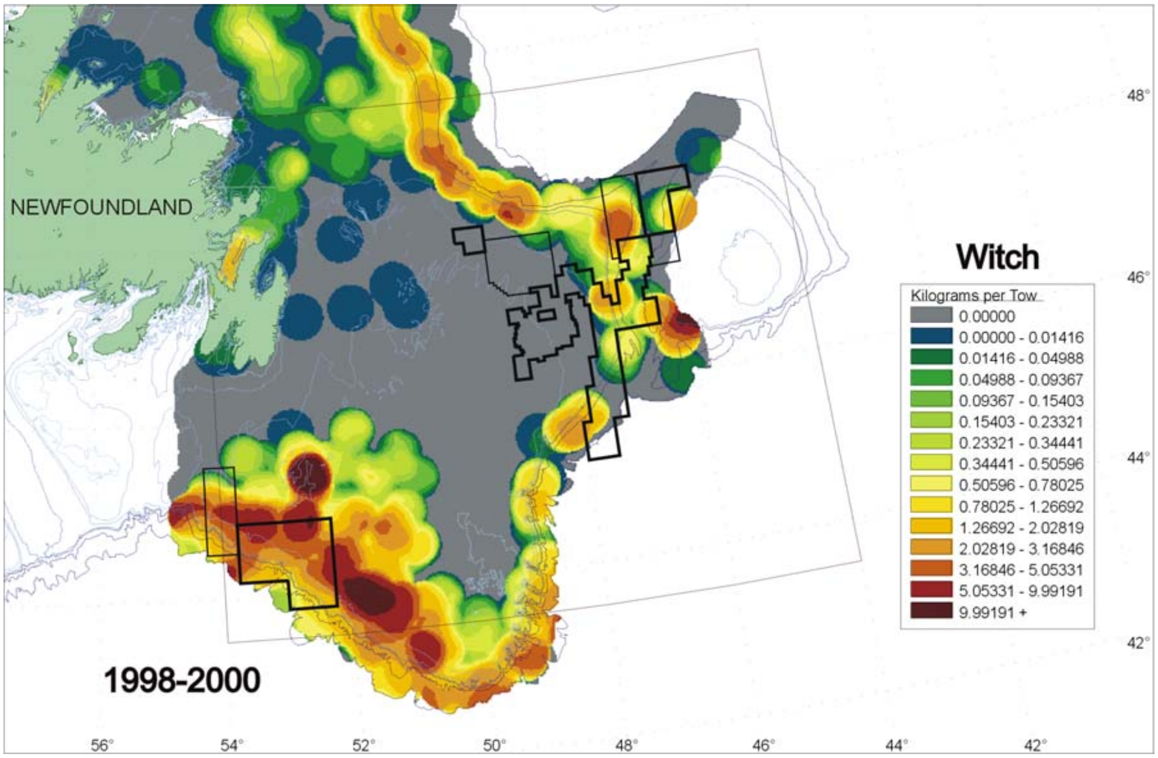


Figure 39d. Witch flounder distribution based on fall research surveys from 1998-2000. Gray sections represent areas sampled with no catch rate values. (Witch on map refers to witch flounder).

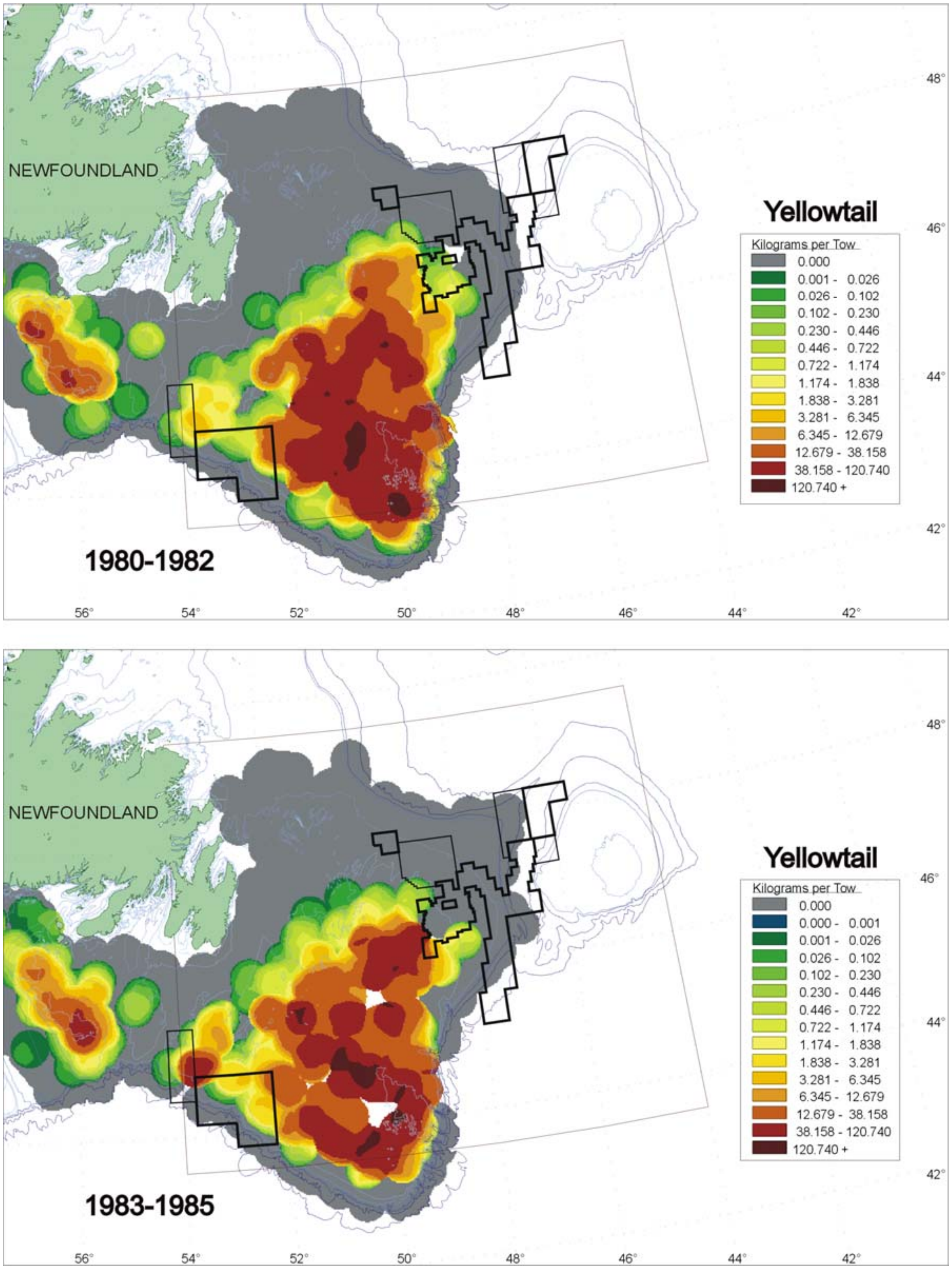
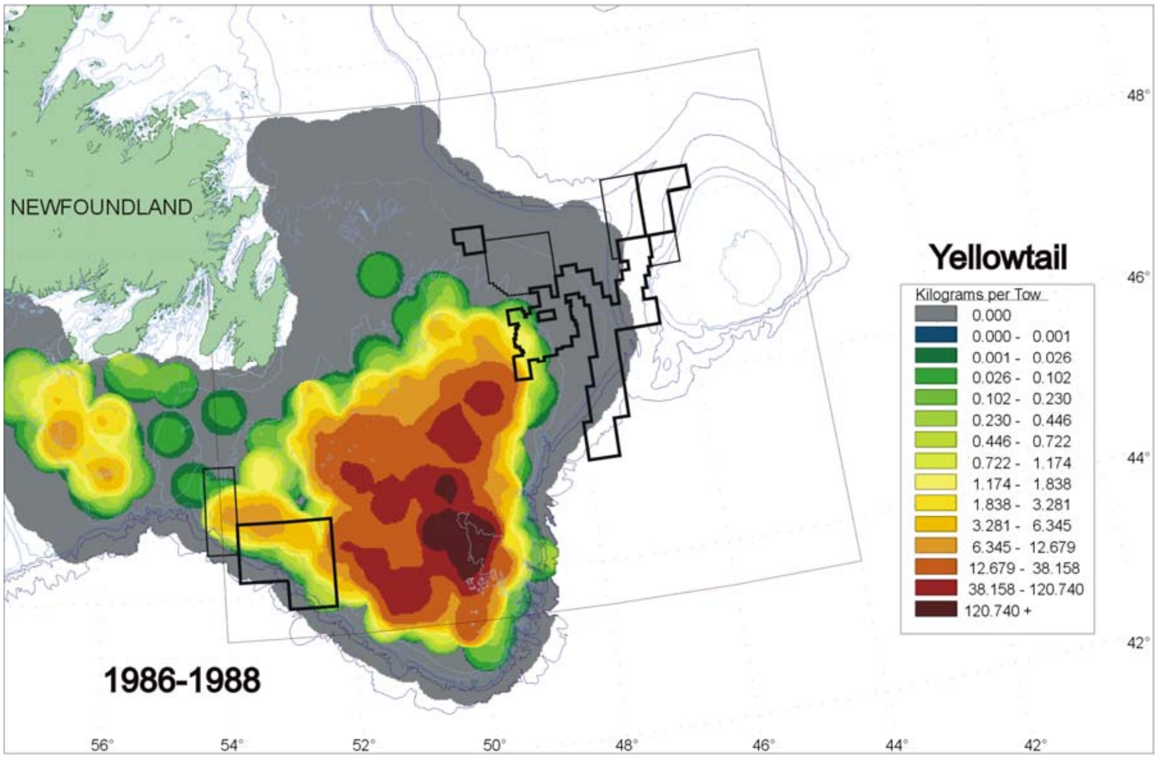


Figure 40a. Yellowtail flounder distribution based on spring research surveys from 1980-82 & 1983-85. Gray sections represent areas sampled with no catch rate values. (Yellowtail on map refers to yellowtail flounder).



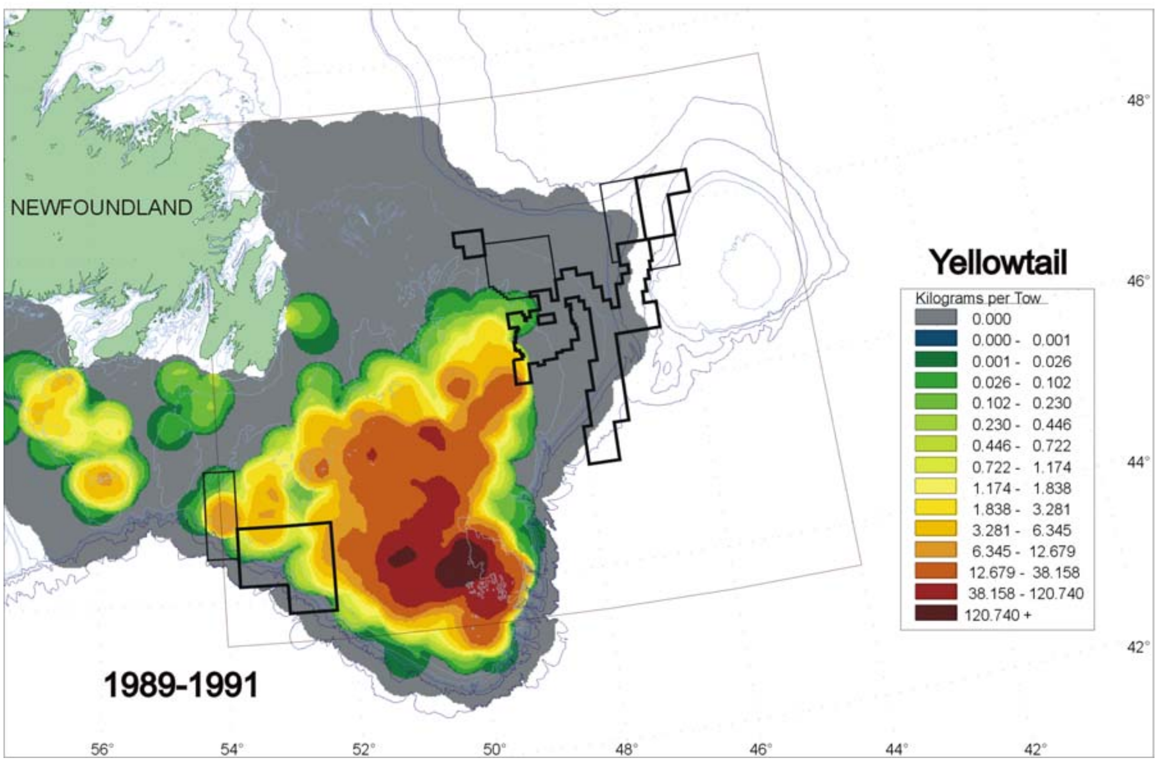


Figure 40b. Yellowtail flounder distribution based on spring research surveys from 1986-88 & 1989-91. Gray sections represent areas sampled with no catch rate values. (Yellowtail on map refers to yellowtail flounder).

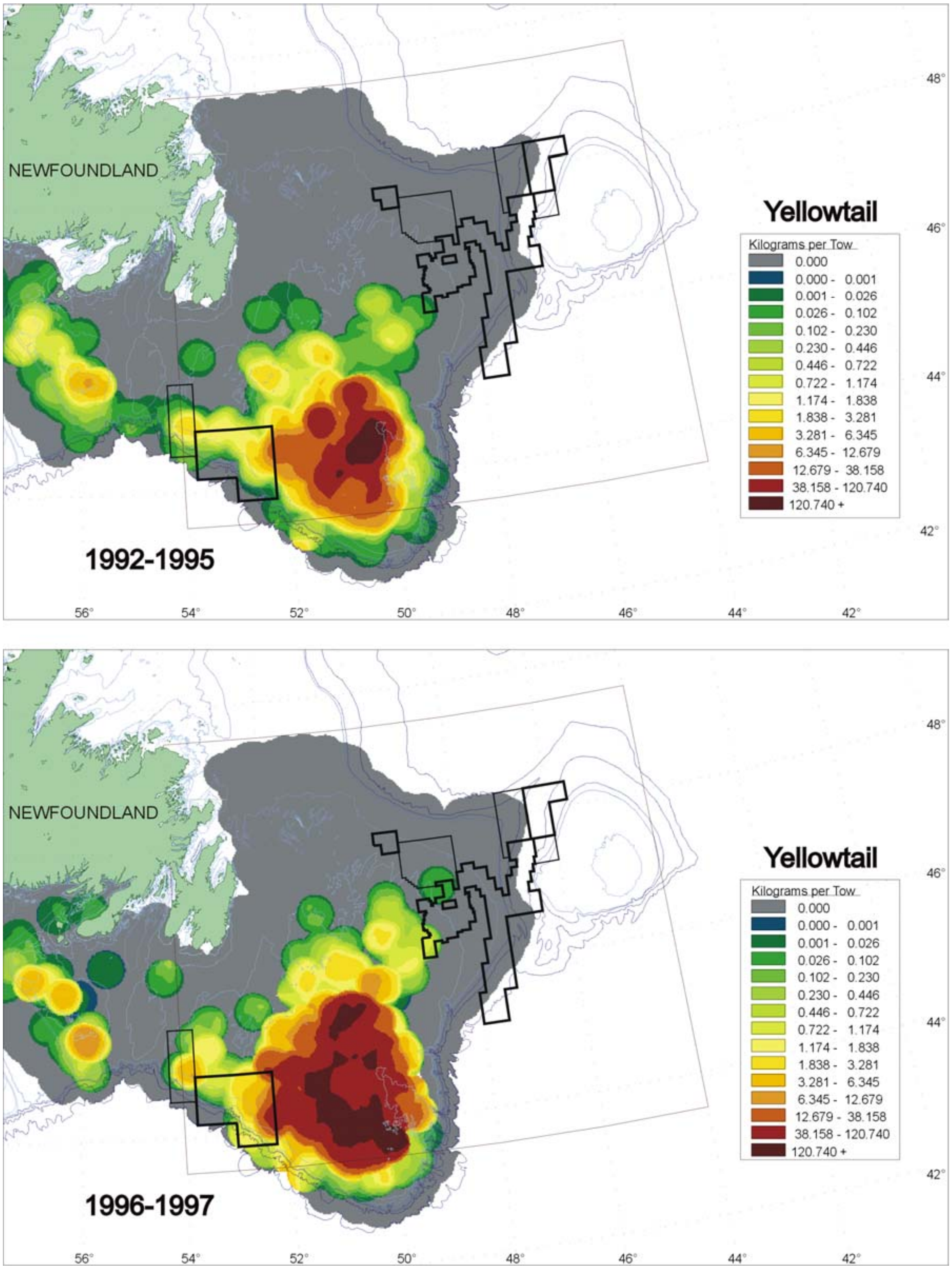


Figure 40c. Yellowtail flounder distribution based on spring research surveys from 1992-95 & 1996-97. Gray sections represent areas sampled with no catch rate values. (Yellowtail on map refers to yellowtail flounder).

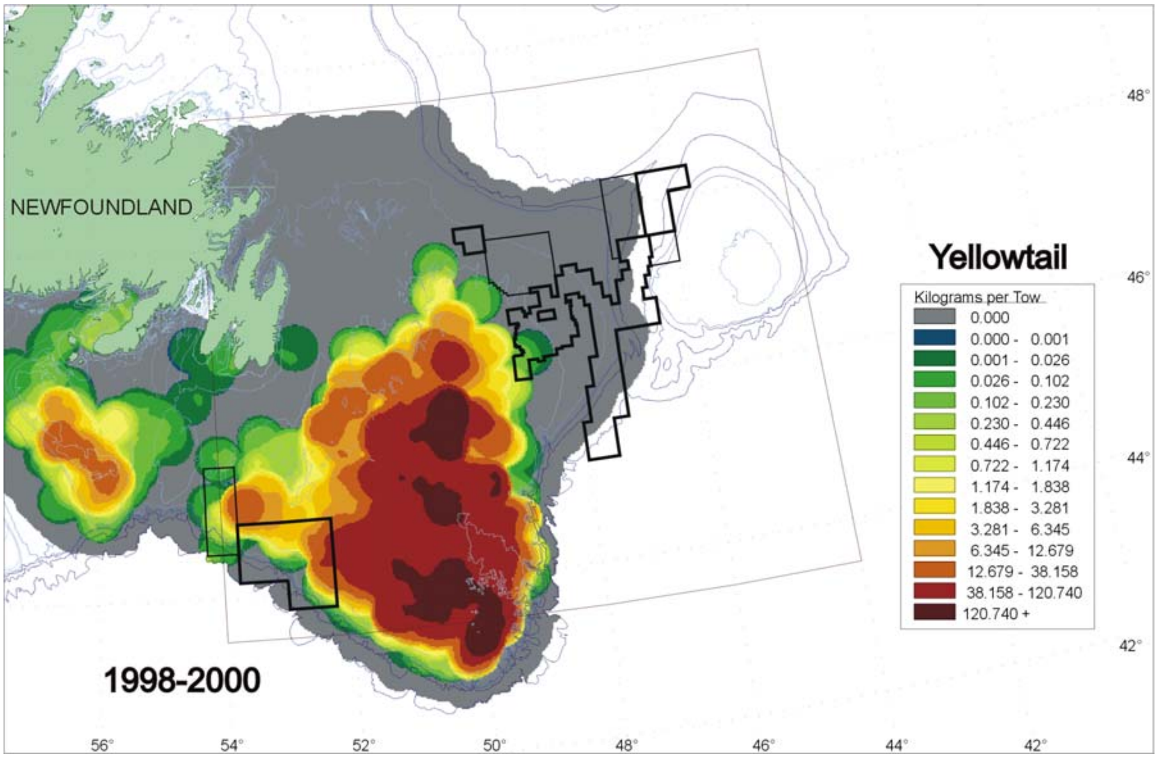
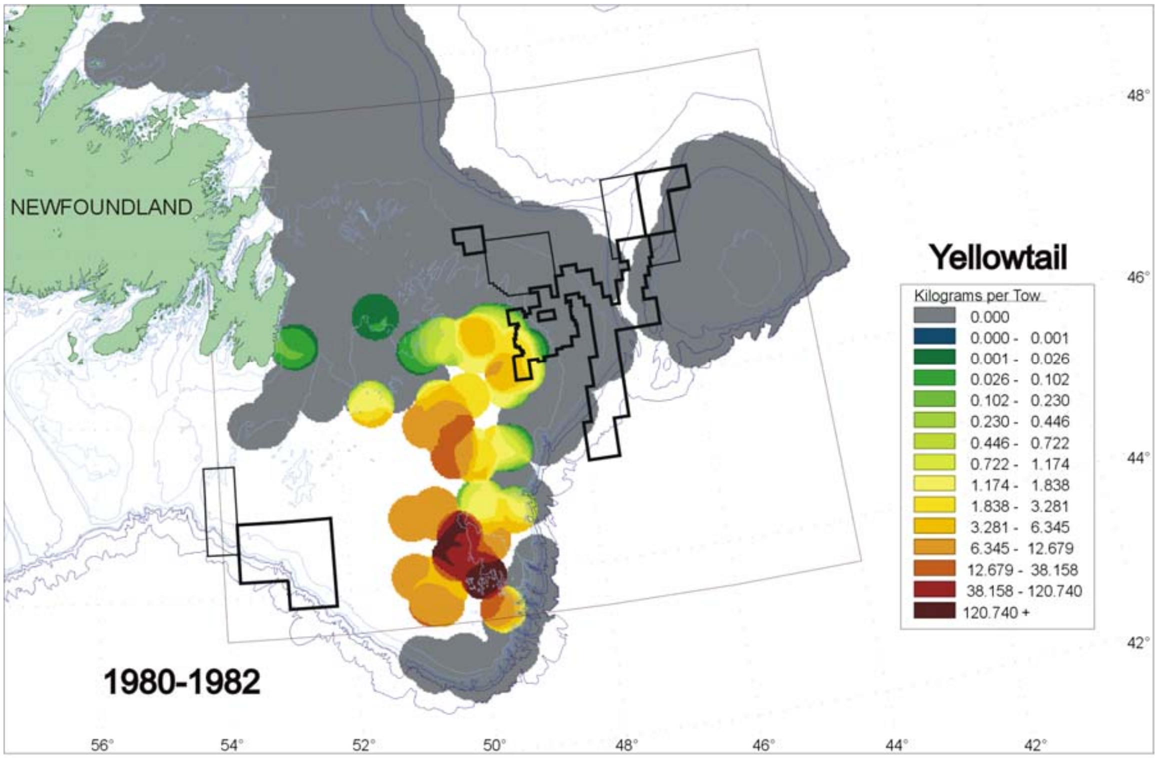


Figure 40d. Yellowtail flounder distribution based on spring research surveys from 1998-2000. Gray sections represent areas sampled with no catch rate values. (Yellowtail on map refers to yellowtail flounder).



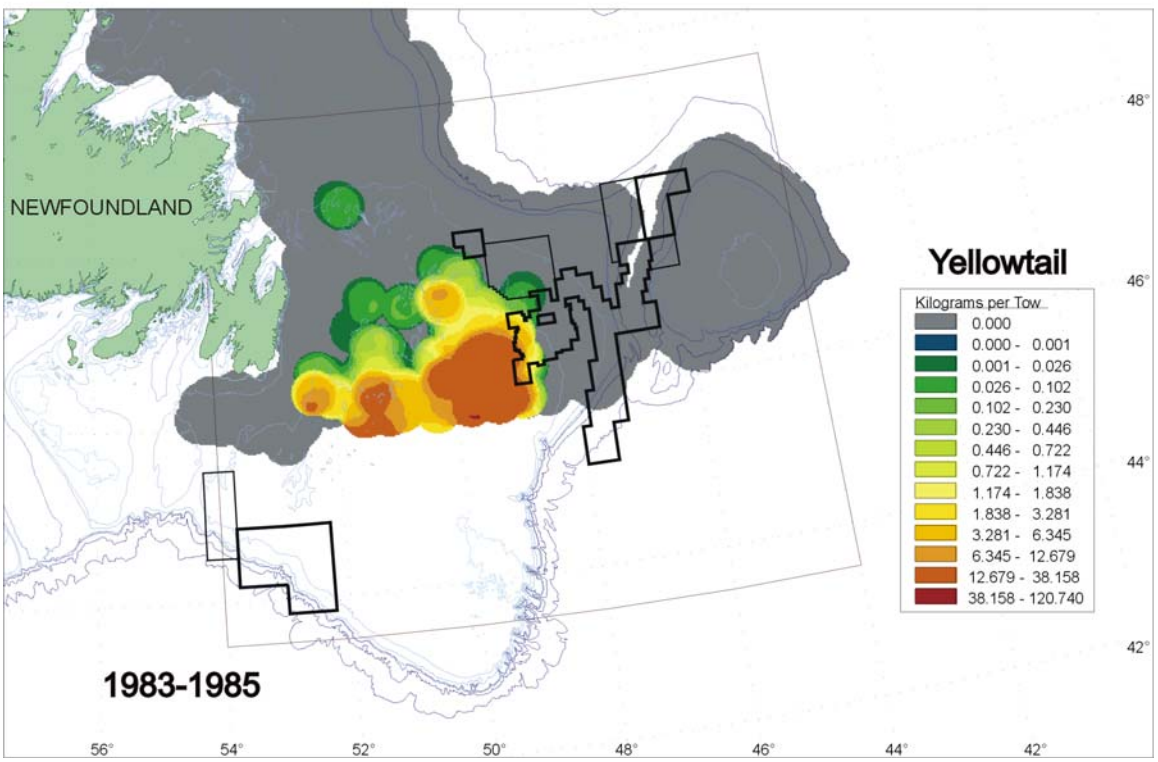
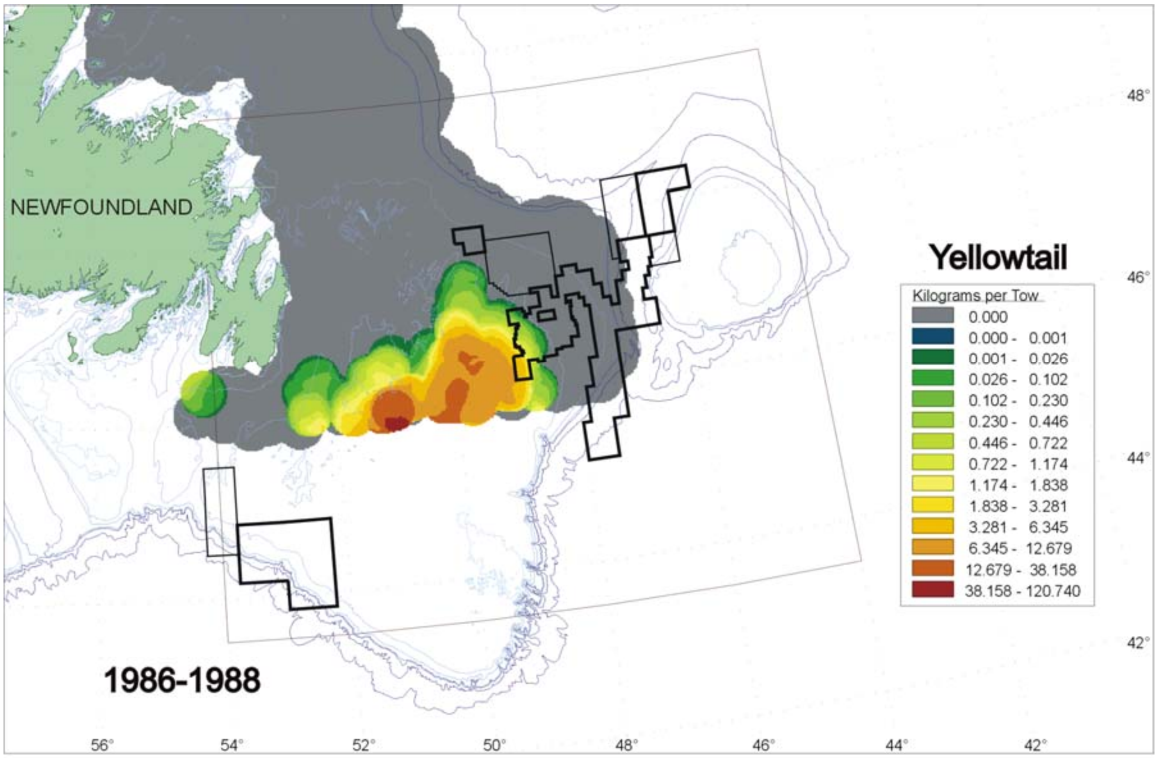


Figure 41a. Yellowtail flounder distribution based on fall research surveys from 1980-82 & 1983-85. Gray sections represent areas sampled with no catch rate values. (Yellowtail on map refers to yellowtail flounder).



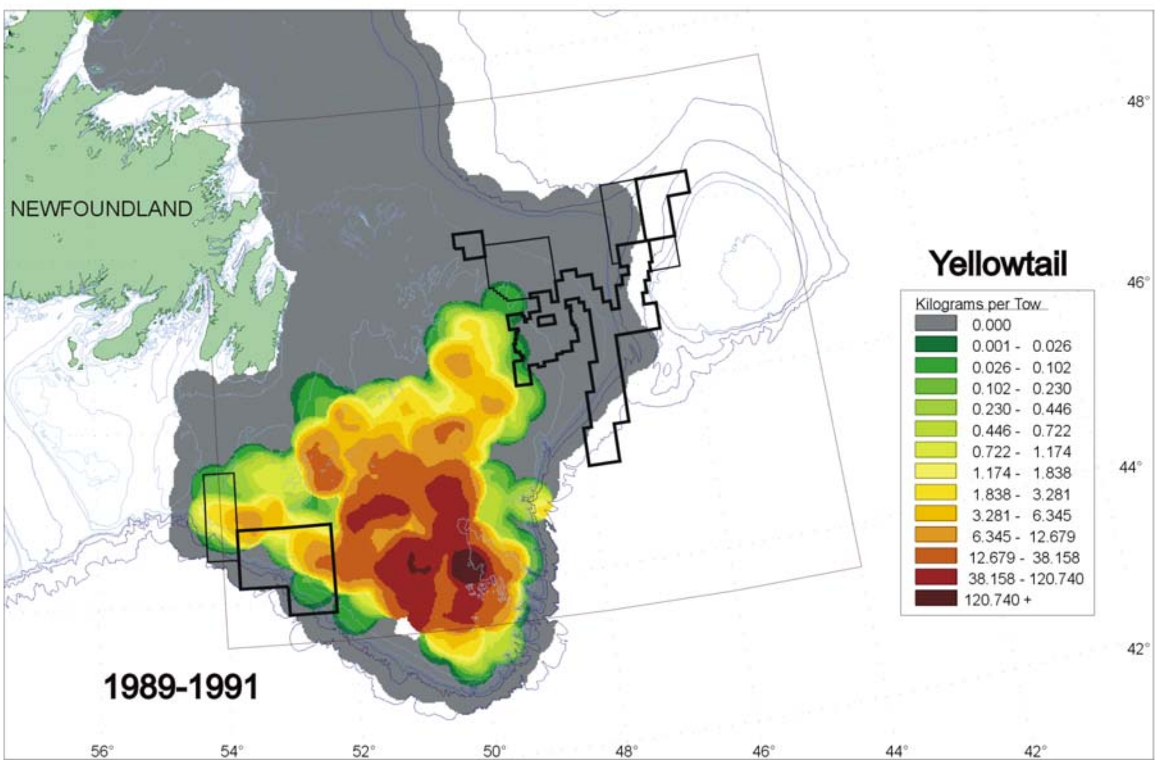
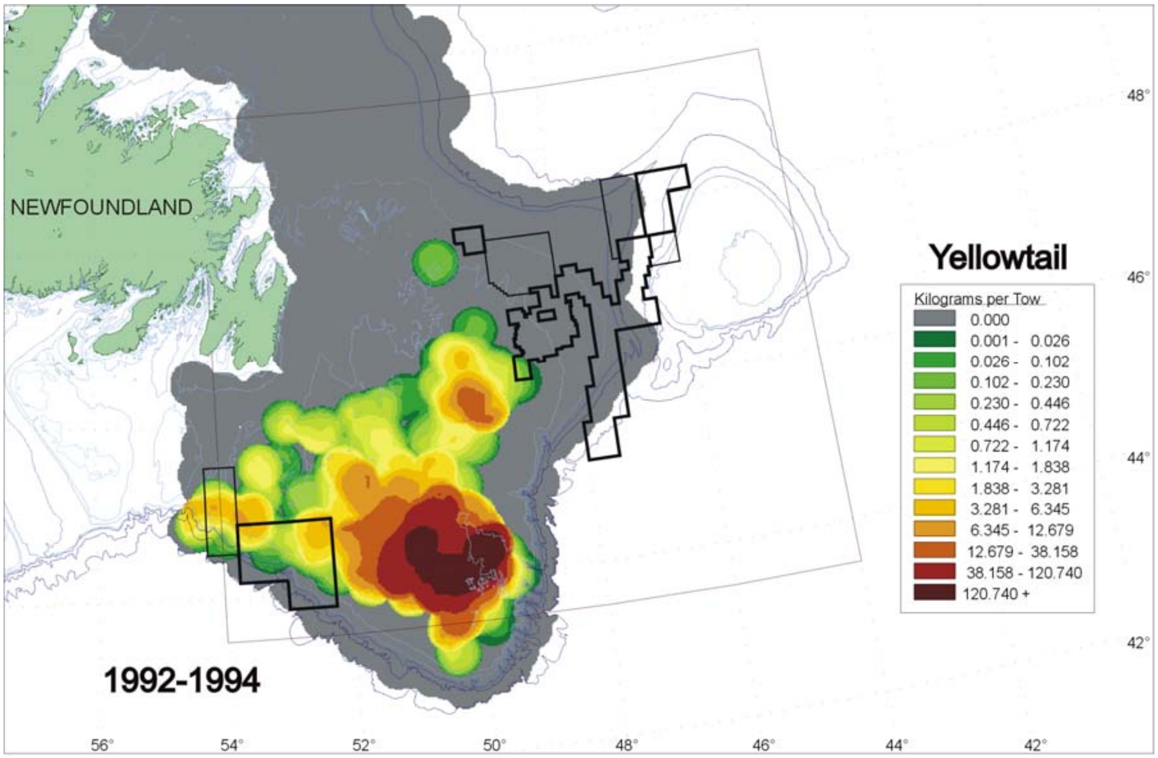


Figure 41b. Yellowtail flounder distribution based on fall research surveys from 1986-88 & 1989-91. Gray sections represent areas sampled with no catch rate values. (Yellowtail on map refers to yellowtail flounder).



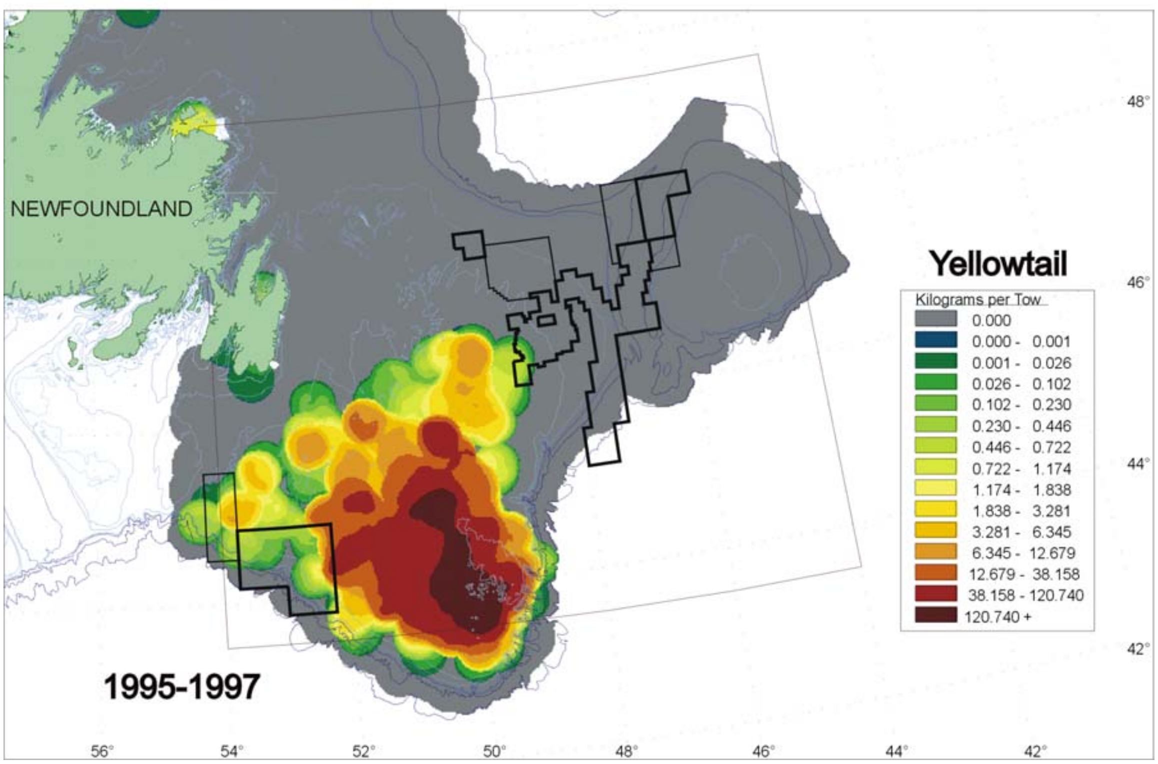


Figure 41c. Yellowtail flounder distribution based on fall research surveys from 1992-94 & 1995-97. Gray sections represent areas sampled with no catch rate values. (Yellowtail on map refers to yellowtail flounder).

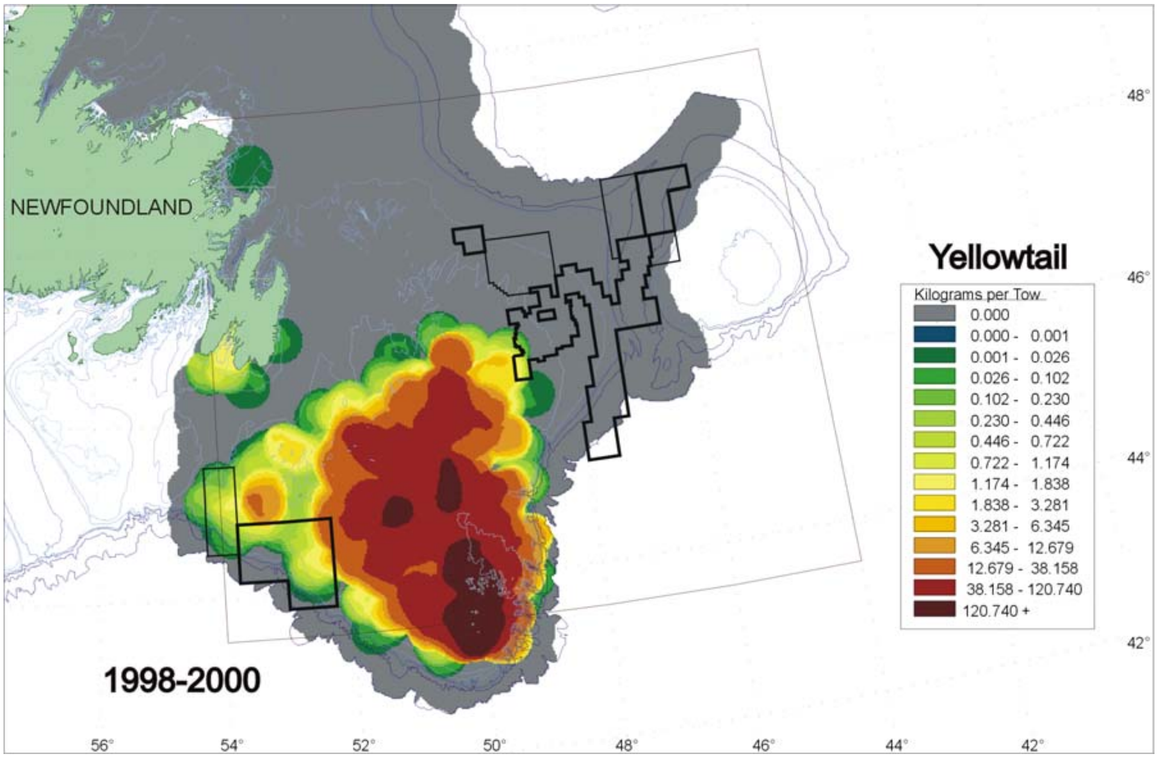


Figure 41d. Yellowtail flounder distribution based on fall research surveys from 1998-2000. Gray sections represent areas sampled with no catch rate values. (Yellowtail on map refers to yellowtail flounder).

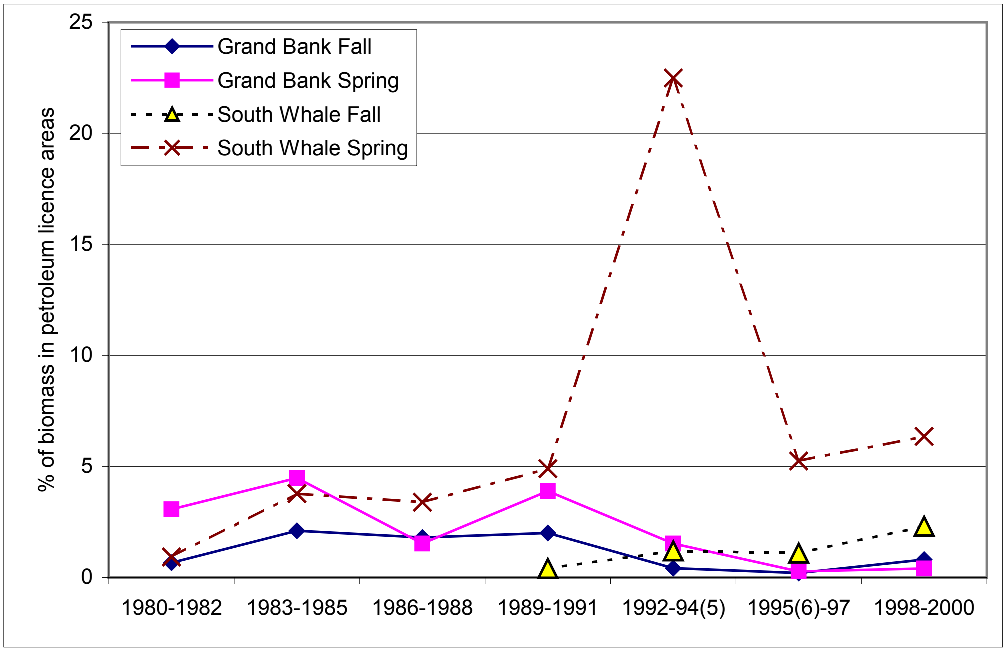


Figure 42. Atlantic cod biomass estimates based on fall and spring research surveys from 1980-2000 for the Northeast Grand Bank Area (NGBA) and South Whale Bank Area (SWBA). No sampling occurred in SWBA area during fall surveys from 1980-1988.

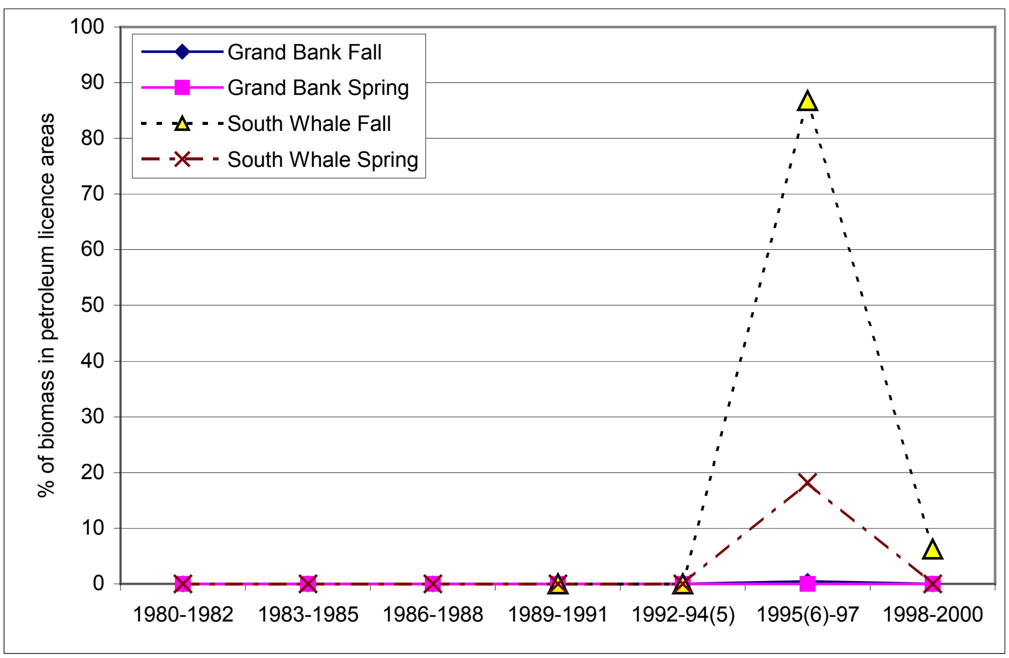


Figure 43. Cusk biomass estimates based on fall and spring research surveys from 1980-2000 for the Northeast Grand Bank Area (NGBA) and South Whale Bank Area (SWBA). No sampling occurred in SWBA during fall surveys from 1980-1988.

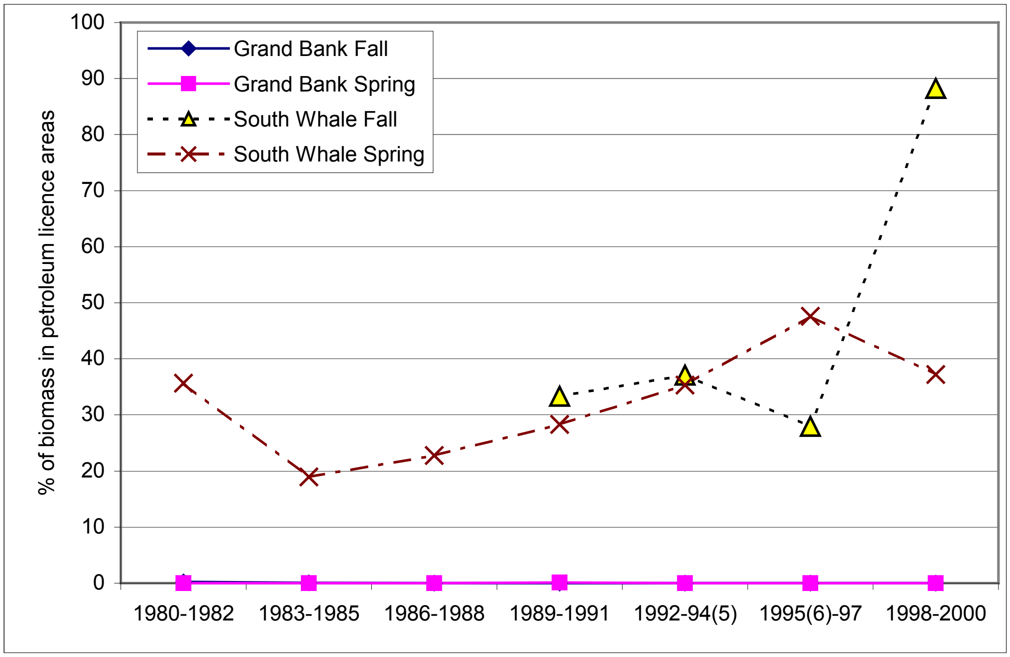


Figure 44. Haddock biomass estimates based on fall and spring research surveys from 1980-2000 for the Northeast Grand Bank Area (NGBA) and South Whale Bank Area (SWBA). No sampling occurred in SWBA during fall surveys from 1980-1988.

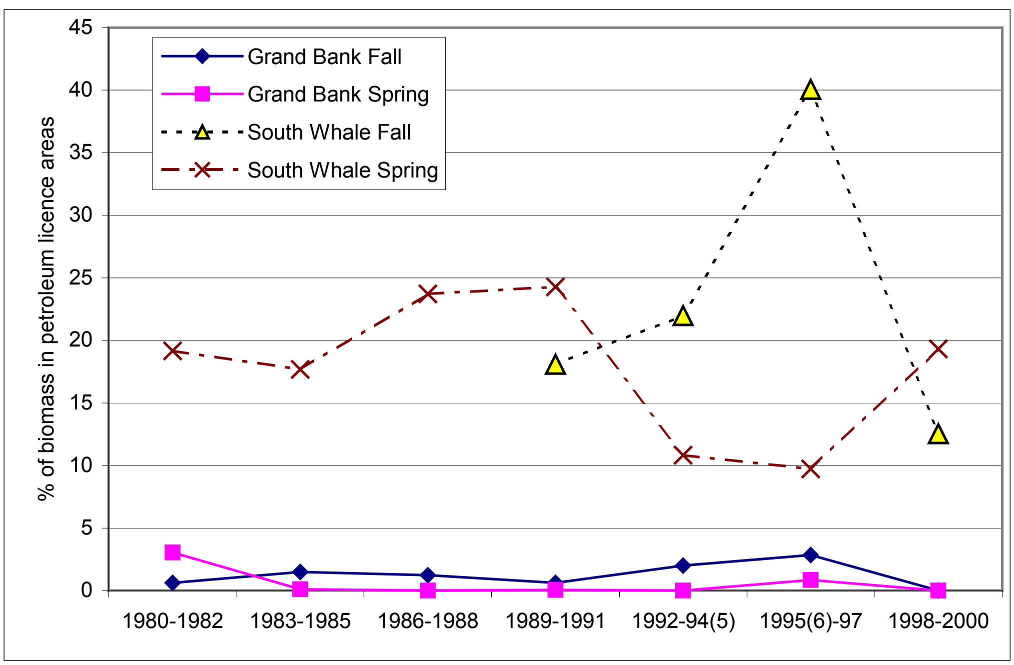


Figure 45. Atlantic halibut biomass estimates based on fall and spring research surveys from 1980-2000 for the Northeast Grand Bank Area (NGBA) and South Whale Bank Area (SWBA). No sampling occurred in SWBA during fall surveys from 1980-1988.

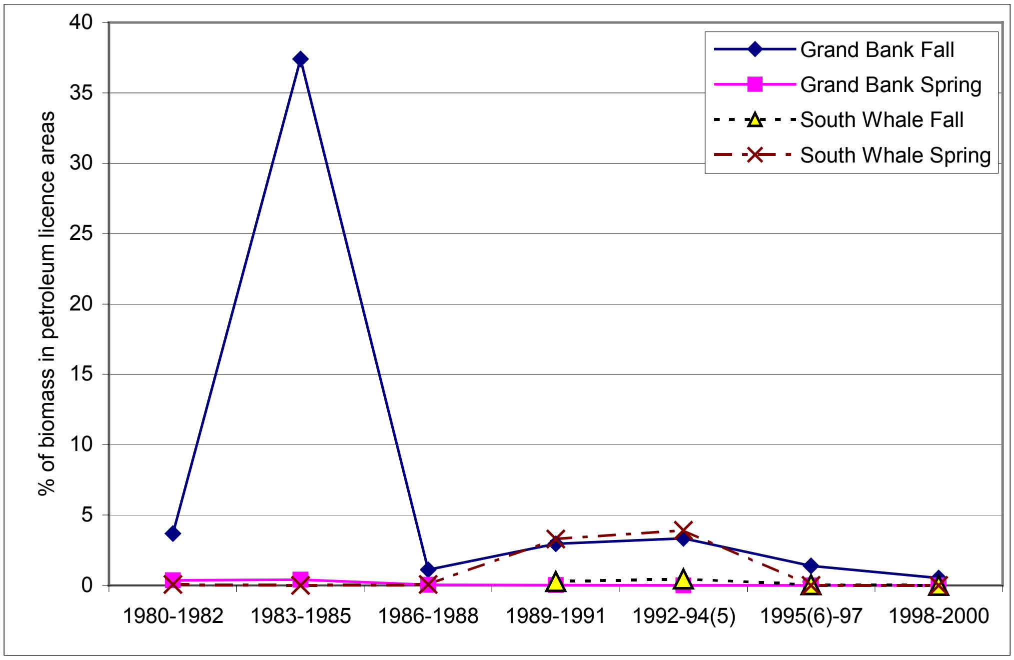


Figure 46. Lumpfish biomass estimates based on fall and spring research surveys from 1980-2000 for the Northeast Grand Bank Area (NGBA) and South Whale Bank Area (SWBA). No sampling occurred in SWBA during fall surveys from 1980-1988.

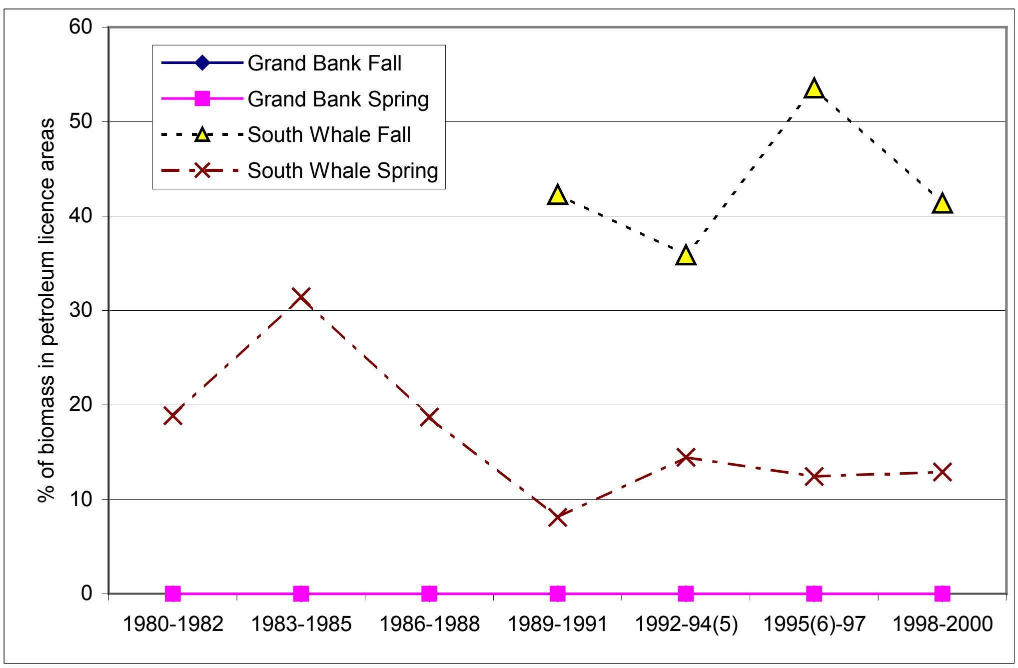


Figure 47. Monkfish biomass estimates based on fall and spring research surveys from 1980-2000 for the Northeast Grand Bank Area (NGBA) and South Whale Bank Area (SWBA). No sampling occurred in SWBA during fall surveys from 1980-1988.

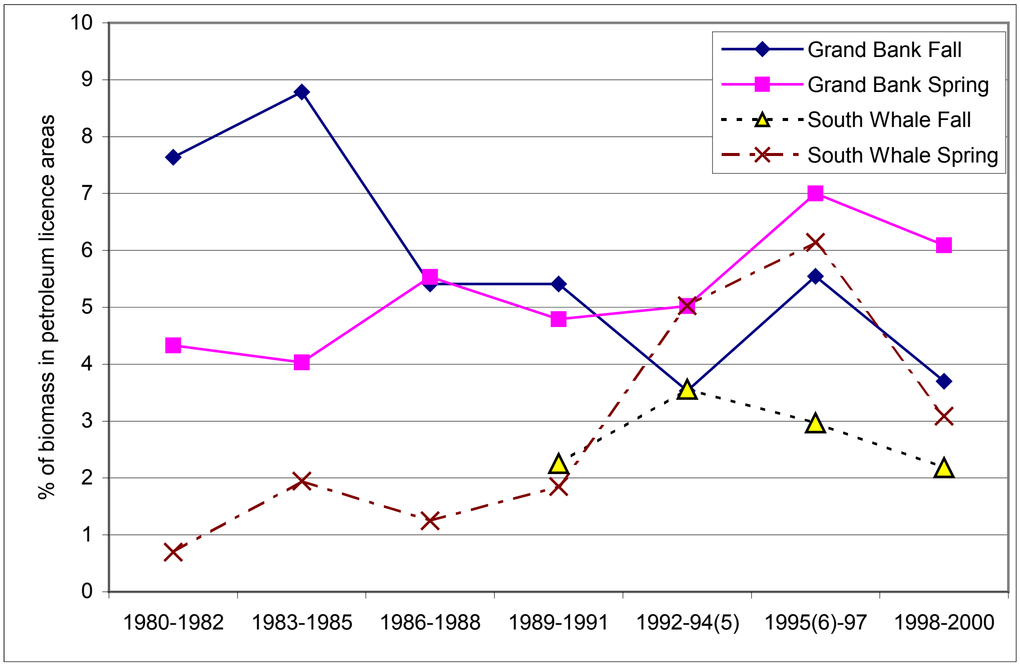


Figure 48. American plaice biomass estimates based on fall and spring research surveys from 1980-2000 for the Northeast Grand Bank Area (NGBA) and South Whale Bank Area (SWBA). No sampling occurred in SWBA during fall surveys from 1980-1988.

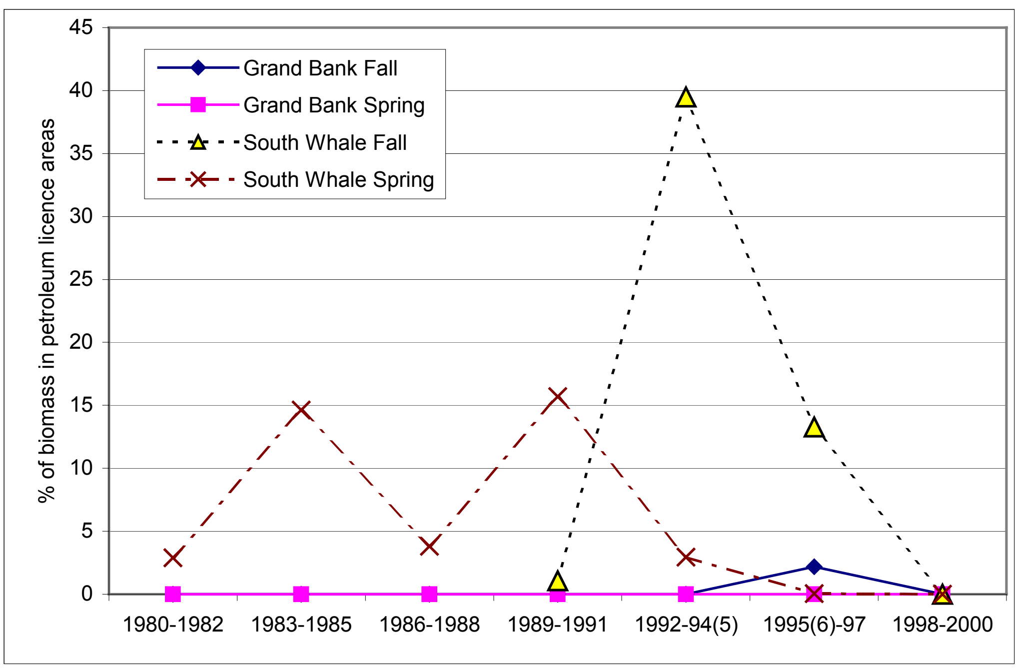


Figure 49. Pollock biomass estimates based on fall and spring research surveys from 1980-2000 for the Northeast Grand Bank Area (NGBA) and South Whale Bank Area (SWBA). No sampling occurred in SWBA during fall surveys from 1980-1988.

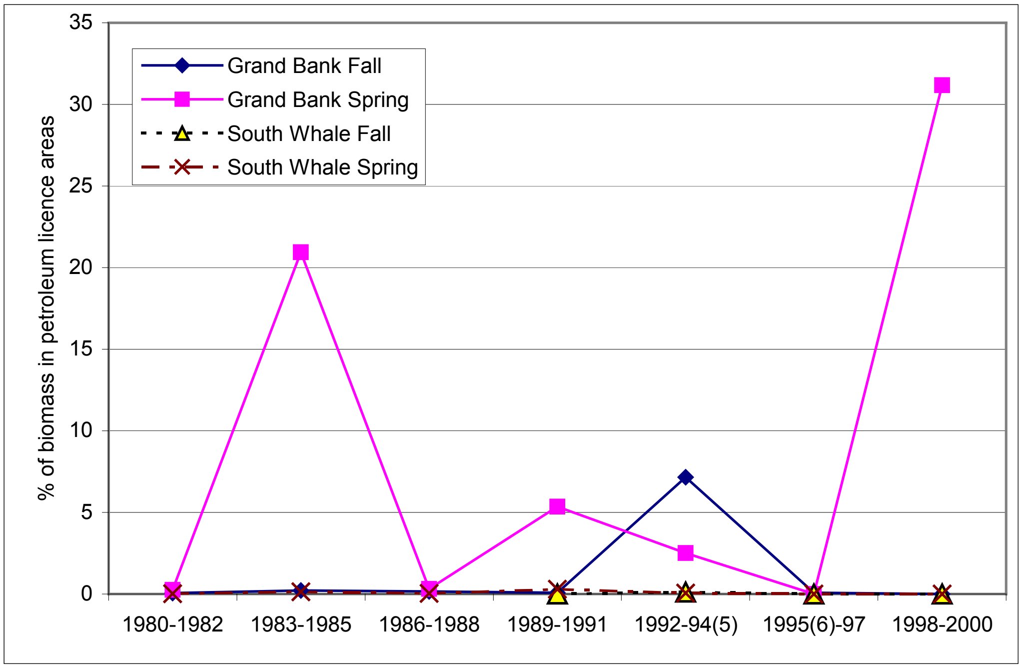


Figure 50. Redfish biomass estimates based on fall and spring research surveys from 1980-2000 for the Northeast Grand Bank Area (NGBA) and South Whale Bank Area (SWBA). No sampling occurred in SWBA during fall surveys from 1980-1988.

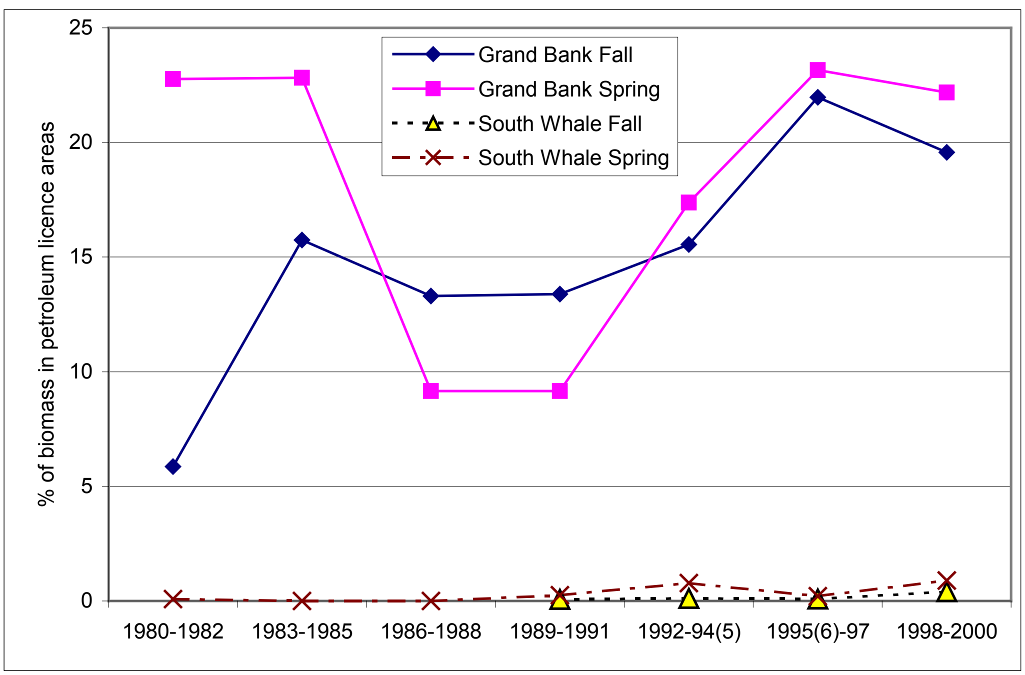


Figure 51. Roughhead grenadier biomass estimates based on fall and spring research surveys from 1980-2000 for the Northeast Grand Bank Area (NGBA) and South Whale Bank Area (SWBA). No sampling occurred in SWBA during fall surveys from 1980-1988.

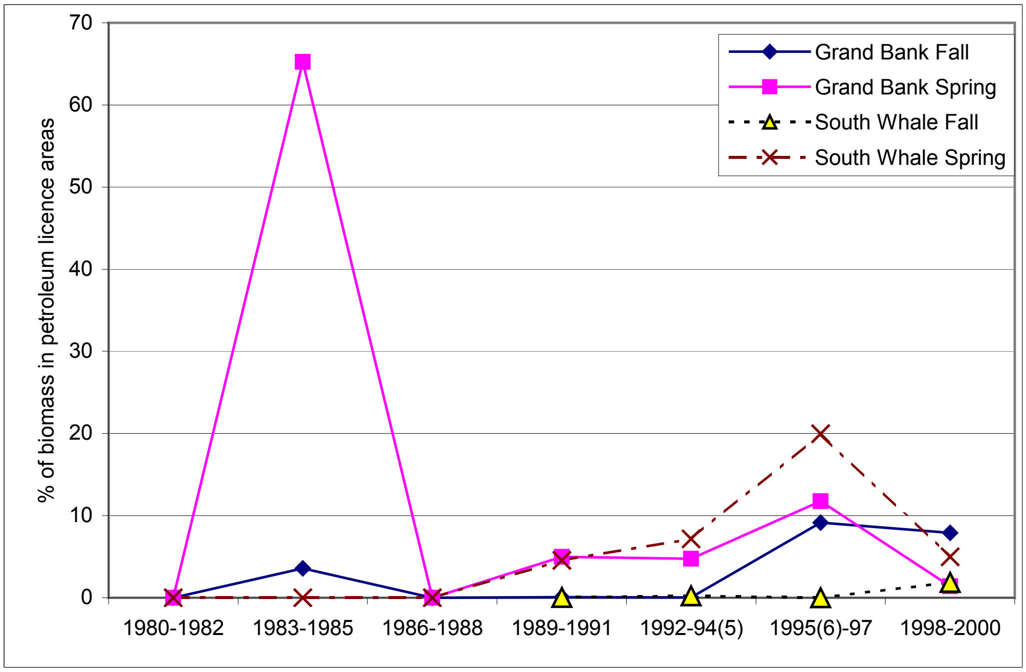


Figure 52. Roundnose grenadier biomass estimates based on fall and spring research surveys from 1980-2000 for the Northeast Grand Bank Area (NGBA) and South Whale Bank Area (SWBA). No sampling occurred in SWBA during fall surveys from 1980-1988.

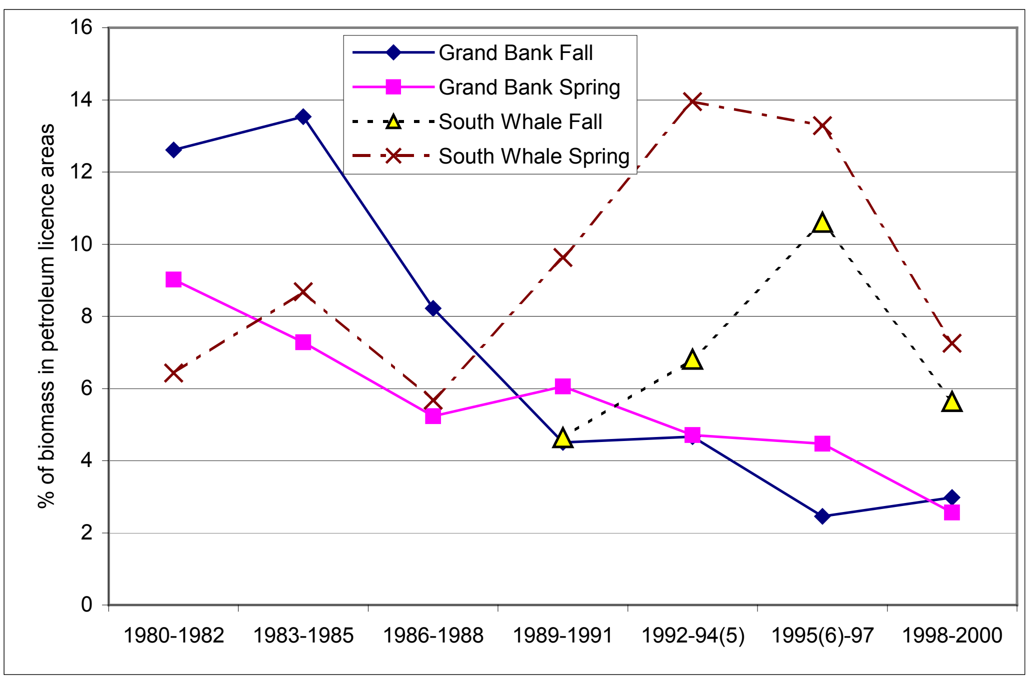


Figure 53. Thorny skate biomass estimates based on fall and spring research surveys from 1980-2000 for the Northeast Grand Bank Area (NGBA) and South Whale Bank Area (SWBA). No sampling occurred in SWBA during fall surveys from 1980-1988.

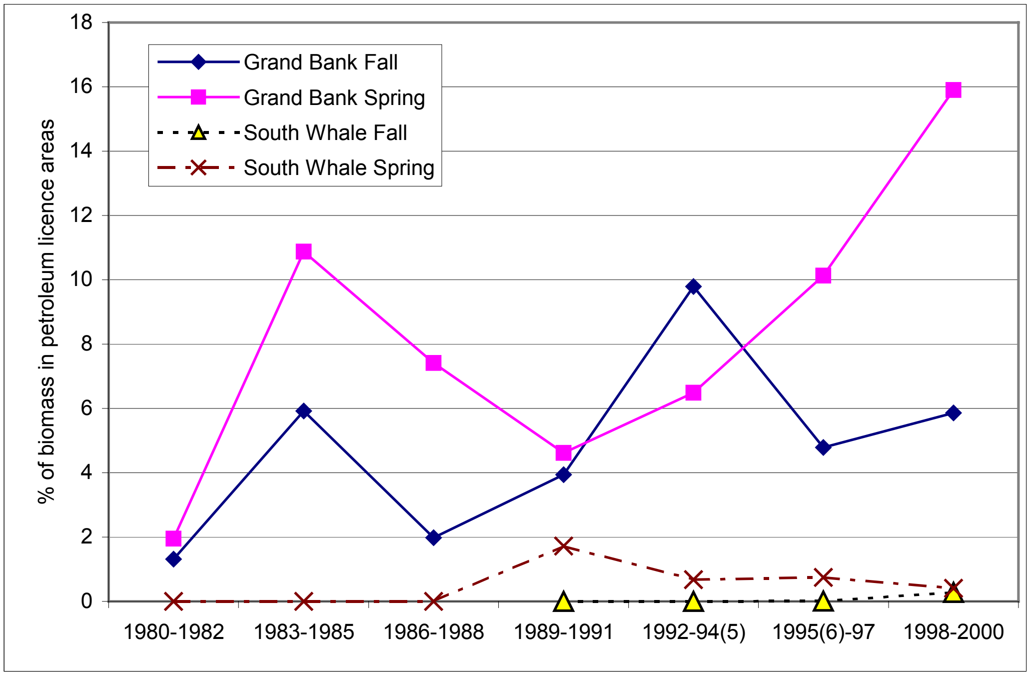


Figure 54. Spotted wolffish biomass estimates based on fall and spring research surveys from 1980-2000 for the Northeast Grand Bank Area (NGBA) and South Whale Bank Area (SWBA). No sampling occurred in SWBA during fall surveys from 1980-1988.

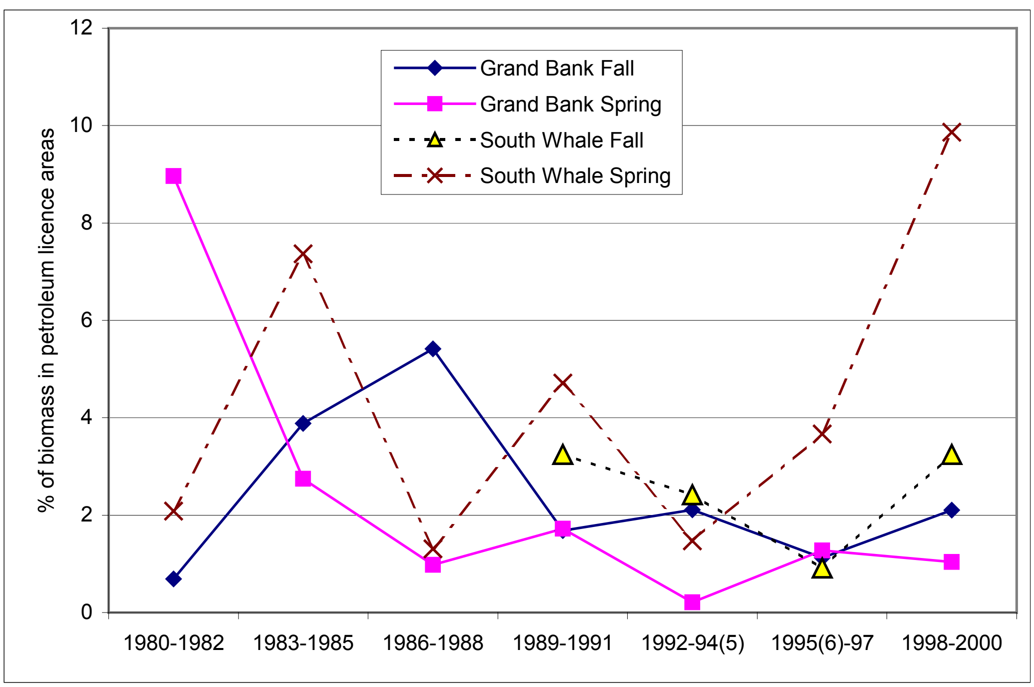


Figure 55. Striped wolffish biomass estimates based on fall and spring research surveys from 1980-2000 for the Northeast Grand Bank Area (NGBA) and South Whale Bank Area (SWBA). No sampling occurred in SWBA during fall surveys from 1980-1988.

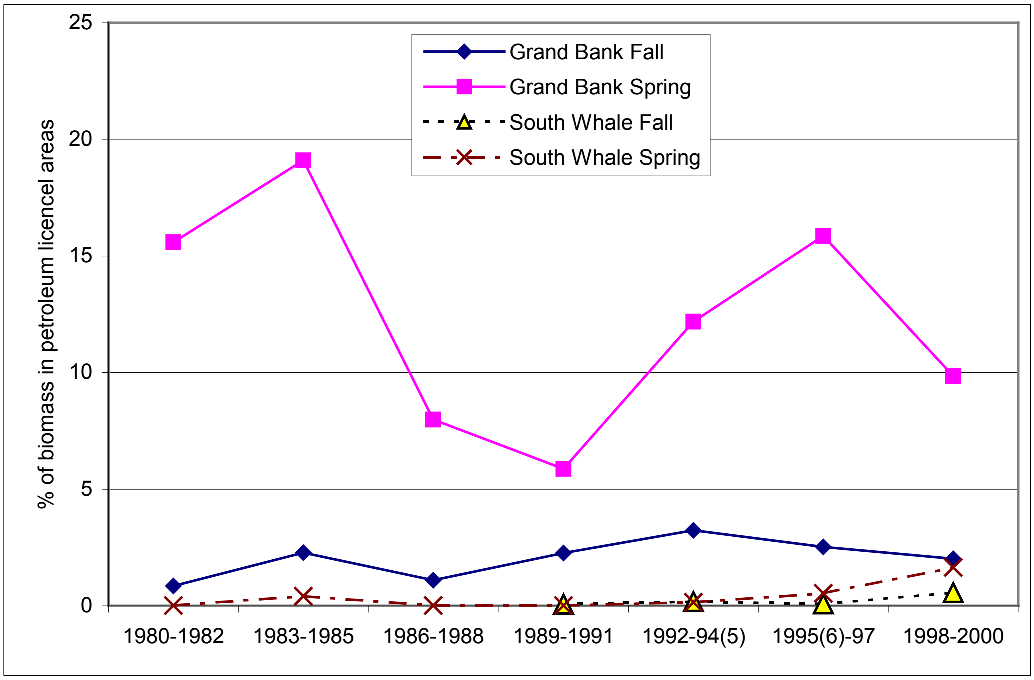


Figure 56. Greenland halibut biomass estimates based on fall and spring research surveys from 1980-2000 for the Northeast Grand Bank Area (NGBA) and South Whale Bank Area (SWBA). No sampling occurred in SWBA during fall surveys from 1980-1988.

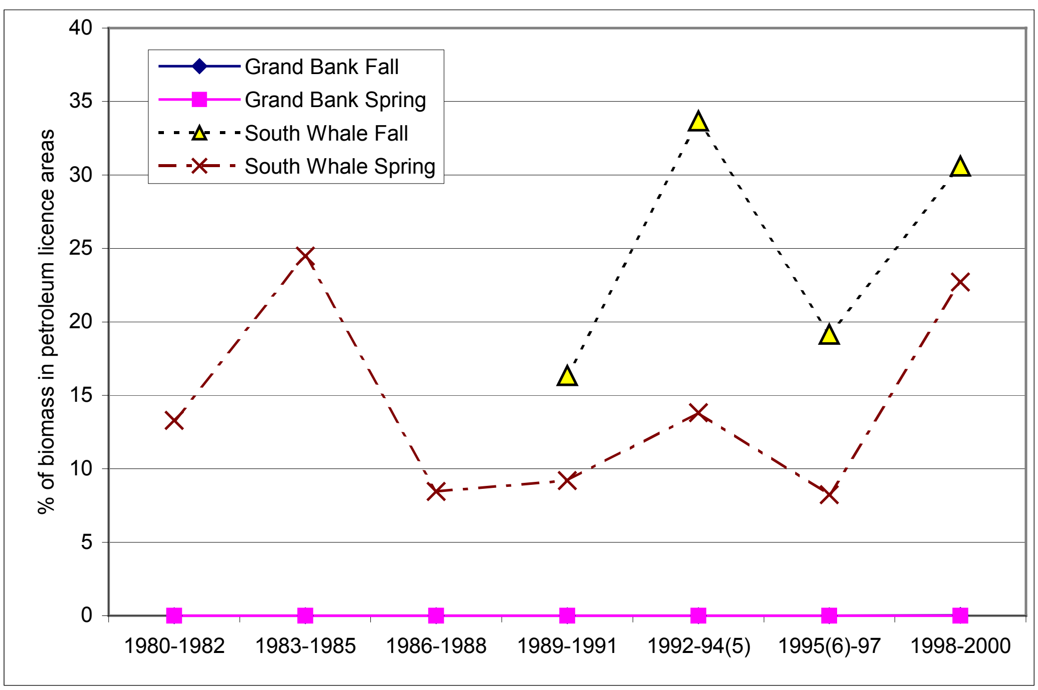


Figure 57. White hake biomass estimates based on fall and spring research surveys from 1980-2000 for the Northeast Grand Bank Area (NGBA) and South Whale Bank Area (SWBA). No sampling occurred in SWBA during fall surveys from 1980-1988.

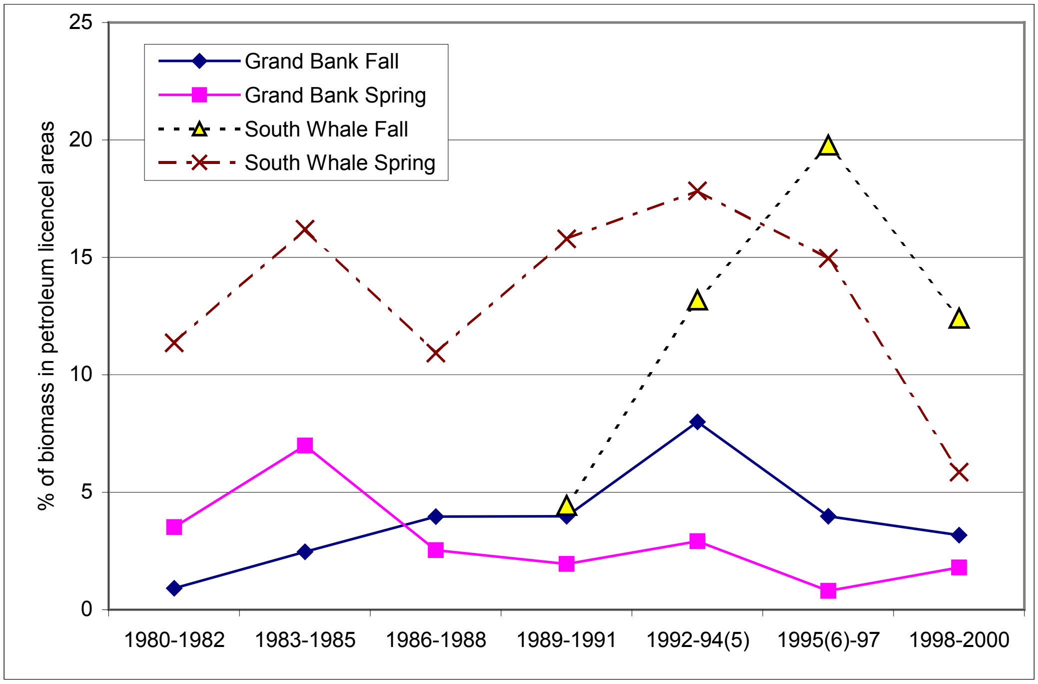


Figure 58. Witch flounder biomass estimates based on fall and spring research surveys from 1980-2000 for the Northeast Grand Bank Area (NGBA) and South Whale Bank Area (SWBA). No sampling occurred in SWBA during fall surveys from 1980-1988.

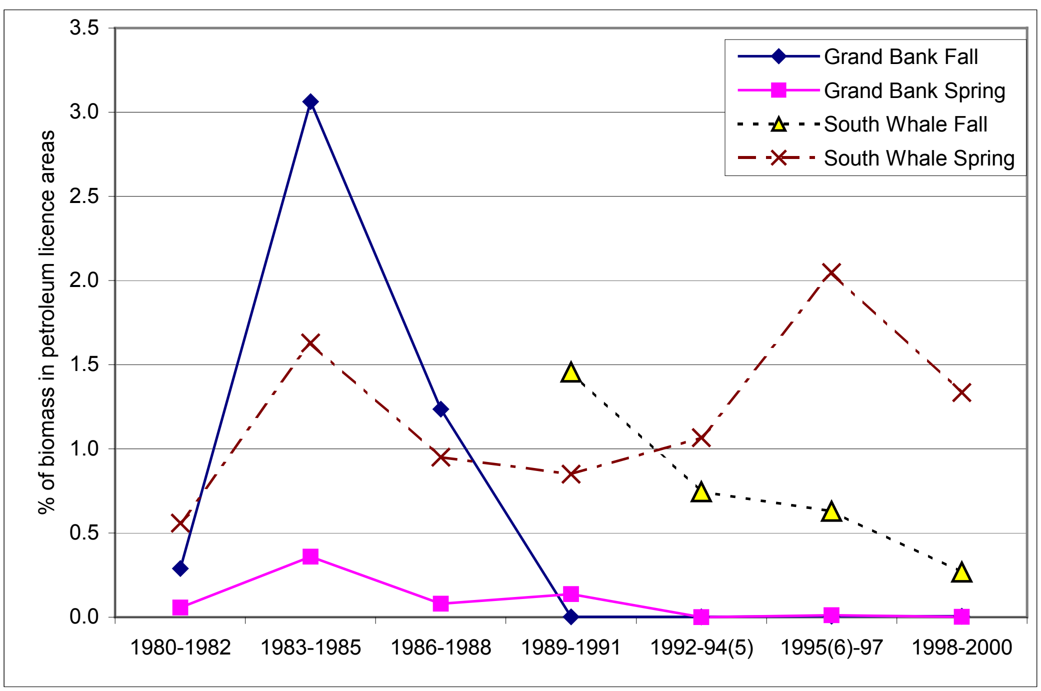


Figure 59. Yellowtail flounder biomass estimates based on fall and spring research surveys from 1980-2000 for the Northeast Grand Bank Area (NGBA) and South Whale Bank Area (SWBA). No sampling occurred in SWBA during fall surveys from 1980-1988.

Species	Year	% Biomass Fall NGBA	% Biomass Spring NGBA	% Biomass Fall SWBA	% Biomass Spring SWBA
Atlantic cod	1980-1982	0.7	3.1	N/A	0.9
Atlantic cod	1983-1985	2.1	4.5	N/A	3.8
Atlantic cod	1986-1988	1.8	1.5	N/A	3.4
Atlantic cod	1989-1991	2.0	3.9	0.4	4.9
Atlantic cod	1992-94(5)	0.4	1.5	1.2	22.5
Atlantic cod	1995(6)-97	0.2	0.3	1.1	5.2
Atlantic cod	1998-2000	0.8	0.4	2.3	6.4
Cusk	1980-1982	0.0	0.0	N/A	0.0
Cusk	1983-1985	0.0	0.0	N/A	0.0
Cusk	1986-1988	0.0	0.0	N/A	0.0
Cusk	1989-1991	0.0	0.0	0.0	0.0
Cusk	1992-94(5)	0.0	0.0	0.0	0.0
Cusk	1995(6)-97	0.5	0.0	86.8	18.2
Cusk	1998-2000	0.0	0.0	6.2	0.0
Haddock	1980-1982	0.2	0.0	N/A	35.7
Haddock	1983-1985	0.1	0.0	N/A	18.9
Haddock	1986-1988	0.0	0.0	N/A	22.8
Haddock	1989-1991	0.0	0.1	33.3	28.3
Haddock	1992-94(5)	0.0	0.0	37.1	35.4
Haddock	1995(6)-97	0.0	0.0	28.0	47.6
Haddock	1998-2000	0.0	0.0	88.2	37.2
Atlantic halibut	1980-1982	0.6	3.0	N/A	19.2
Atlantic halibut	1983-1985	1.5	0.1	N/A	17.7
Atlantic halibut	1986-1988	1.2	0.0	N/A	23.7
Atlantic halibut	1989-1991	0.6	0.1	18.1	24.3
Atlantic halibut	1992-94(5)	2.0	0.0	22.0	10.8
Atlantic halibut	1995(6)-97	2.8	0.8	40.1	9.7
Atlantic halibut	1998-2000	0.0	0.0	12.5	19.3
Lumpfish	1980-1982	3.7	0.4	N/A	0.1
Lumpfish	1983-1985	37.4	0.4	N/A	0.0
Lumpfish	1986-1988	1.1	0.0	N/A	0.1
Lumpfish	1989-1991	3.0	0.0	0.3	3.3
Lumpfish	1992-94(5)	3.3	0.0	0.5	3.9
Lumpfish	1995(6)-97	1.4	0.0	0.0	0.0
Lumpfish	1998-2000	0.5	0.0	0.0	0.0

Species	Year	% Biomass Fall NGBA	% Biomass Spring NGBA	% Biomass Fall SWBA	% Biomass Spring SWBA
Monkfish	1980-1982	0.0	0.0	N/A	18.9
Monkfish	1983-1985	0.0	0.0	N/A	31.5
Monkfish	1986-1988	0.0	0.0	N/A	18.7
Monkfish	1989-1991	0.0	0.0	42.3	8.1
Monkfish	1992-94(5)	0.0	0.0	35.9	14.5
Monkfish	1995(6)-97	0.0	0.0	53.6	12.4
Monkfish	1998-2000	0.0	0.0	41.4	12.9
Pollock	1980-1982	0.0	0.0	N/A	2.9
Pollock	1983-1985	0.0	0.0	N/A	14.6
Pollock	1986-1988	0.0	0.0	N/A	3.8
Pollock	1989-1991	0.0	0.0	1.1	15.7
Pollock	1992-94(5)	0.0	0.0	39.5	3.0
Pollock	1995(6)-97	2.2	0.0	13.3	0.1
Pollock	1998-2000	0.0	0.0	0.0	0.0
American plaice	1980-1982	7.6	4.3	N/A	0.7
American plaice	1983-1985	8.8	4.0	N/A	1.9
American plaice	1986-1988	5.4	5.5	N/A	1.2
American plaice	1989-1991	5.4	4.8	2.3	1.8
American plaice	1992-94(5)	3.5	5.0	3.6	5.0
American plaice	1995(6)-97	5.5	7.0	3.0	6.1
American plaice	1998-2000	3.7	6.1	2.2	3.1
Redfish	1980-1982	0.1	0.3	N/A	0.0
Redfish	1983-1985	0.2	20.9	N/A	0.1
Redfish	1986-1988	0.2	0.3	N/A	0.0
Redfish	1989-1991	0.1	5.4	0.0	0.3
Redfish	1992-94(5)	7.2	2.5	0.1	0.1
Redfish	1995(6)-97	0.1	0.0	0.0	0.0
Redfish	1998-2000	0.0	31.2	0.0	0.0
Roughhead grenadier	1980-1982	5.9	22.8	N/A	0.1
Roughhead grenadier	1983-1985	15.7	22.8	N/A	0.0
Roughhead grenadier	1986-1988	13.3	9.2	N/A	0.0
Roughhead grenadier	1989-1991	13.4	9.2	0.1	0.3
Roughhead grenadier	1992-94(5)	15.5	17.4	0.1	0.8
Roughhead grenadier	1995(6)-97	22.0	23.2	0.1	0.2
Roughhead grenadier	1998-2000	19.6	22.2	0.4	0.9

Species	Year	% Biomass Fall NGBA	% Biomass Spring NGBA	% Biomass Fall SWBA	% Biomass Spring SWBA
Roundnose grenadier	1980-1982	0.0	0.0	N/A	0.0
Roundnose grenadier	1983-1985	3.6	65.3	N/A	0.0
Roundnose grenadier	1986-1988	0.0	0.0	N/A	0.0
Roundnose grenadier	1989-1991	0.1	5.0	0.0	4.6
Roundnose grenadier	1992-94(5)	0.0	4.7	0.2	7.2
Roundnose grenadier	1995(6)-97	9.2	11.7	0.0	20.0
Roundnose grenadier	1998-2000	7.9	1.4	1.9	5.0
Thorny skate	1980-1982	12.6	9.0	N/A	6.4
Thorny skate	1983-1985	13.5	7.3	N/A	8.7
Thorny skate	1986-1988	8.2	5.2	N/A	5.7
Thorny skate	1989-1991	4.5	6.1	4.6	9.6
Thorny skate	1992-94(5)	4.7	4.7	6.8	14.0
Thorny skate	1995(6)-97	2.5	4.5	10.6	13.3
Thorny skate	1998-2000	3.0	2.6	5.6	7.3
Spotted wolffish	1980-1982	1.3	2.0	N/A	0.0
Spotted wolffish	1983-1985	5.9	10.9	N/A	0.0
Spotted wolffish	1986-1988	2.0	7.4	N/A	0.0
Spotted wolffish	1989-1991	3.9	4.6	0.0	1.7
Spotted wolffish	1992-94(5)	9.8	6.5	0.0	0.7
Spotted wolffish	1995(6)-97	4.8	10.1	0.0	0.8
Spotted wolffish	1998-2000	5.9	15.9	0.3	0.4
Striped wolffish	1980-1982	0.7	9.0	N/A	2.1
Striped wolffish	1983-1985	3.9	2.7	N/A	7.4
Striped wolffish	1986-1988	5.4	1.0	N/A	1.3
Striped wolffish	1989-1991	1.7	1.7	3.2	4.7
Striped wolffish	1992-94(5)	2.1	0.2	2.4	1.5
Striped wolffish	1995(6)-97	1.1	1.3	0.9	3.7
Striped wolffish	1998-2000	2.1	1.0	3.2	9.9
Greenland halibut	1980-1982	0.8	15.6	N/A	0.0
Greenland halibut	1983-1985	2.3	19.1	N/A	0.4
Greenland halibut	1986-1988	1.1	8.0	N/A	0.0
Greenland halibut	1989-1991	2.3	5.9	0.1	0.0
Greenland halibut	1992-94(5)	3.2	12.2	0.2	0.1
Greenland halibut	1995(6)-97	2.5	15.9	0.1	0.5
Greenland halibut	1998-2000	2.0	9.9	0.6	1.7

Species	Year	% Biomass Fall NGBA	% Biomass Spring NGBA	% Biomass Fall NGBA	% Biomass Spring NGBA
White hake	1980-1982	0.0	0.0	N/A	13.3
White hake	1983-1985	0.0	0.0	N/A	24.5
White hake	1986-1988	0.0	0.0	N/A	8.5
White hake	1989-1991	0.0	0.0	16.4	9.2
White hake	1992-94(5)	0.0	0.0	33.7	13.8
White hake	1995(6)-97	0.0	0.0	19.2	8.2
White hake	1998-2000	0.0	0.0	30.6	22.7
Witch flounder	1980-1982	0.9	3.5	N/A	11.4
Witch flounder	1983-1985	2.5	7.0	N/A	16.2
Witch flounder	1986-1988	4.0	2.5	N/A	10.9
Witch flounder	1989-1991	4.0	1.9	4.4	15.8
Witch flounder	1992-94(5)	8.0	2.9	13.2	17.8
Witch flounder	1995(6)-97	4.0	0.8	19.8	15.0
Witch flounder	1998-2000	3.2	1.8	12.4	5.9
Yellowtail flounder	1980-1982	0.3	0.1	N/A	0.6
Yellowtail flounder	1983-1985	3.1	0.4	N/A	1.6
Yellowtail flounder	1986-1988	1.2	0.1	N/A	1.0
Yellowtail flounder	1989-1991	0.0	0.1	1.5	0.8
Yellowtail flounder	1992-94(5)	0.0	0.0	0.7	1.1
Yellowtail flounder	1995(6)-97	0.0	0.0	0.6	2.0
Yellowtail flounder	1998-2000	0.0	0.0	0.3	1.3