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Indices of abundance to 2014 for six groundfish species based on the September research vessel and August sentinel vessel bottom-trawl surveys in the southern Gulf of St. Lawrence

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Canada

Foreword

This series documents the scientific basis for the evaluation of aquatic resources and ecosystems in Canada. As such, it addresses the issues of the day in the time frames required and the documents it contains are not intended as definitive statements on the subjects addressed but rather as progress reports on ongoing investigations.

Research documents are produced in the official language in which they are provided to the Secretariat.

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ABSTRACT

Each autumn since 1971 and each August since 2003, a standardized research vessel bottom-trawl survey (RV survey) and a sentinel bottom-trawl survey (SM survey) have been conducted in the southern Gulf of St. Lawrence (NAFO Division 4T). The primary objective of those surveys is to obtain abundance indices for the major demersal fish resources in the area. The biomass indices for southern Gulf cod, in 2011 and 2012 were at the lowest levels observed in the 44-year survey record, indicating that the abundance and biomass of this stock continue to be very low compared to the levels observed in the late 1970s and during the 1980s. The biomass index for 2014 increased to near the value observed in 2009. The SM survey showed a decreasing trend from 2003 to 2014. Indices from both surveys suggest that the abundance and biomass of white hake remain extremely low compared to the indices observed in the late 1980s and early 1990s. The abundance and biomass indices of American plaice reached their highest levels in the late 1970s. The stock has since declined and has reached its lowest level in recent years. In 2014, the overall biomass index for American plaice remained near the lowest levels observed in both surveys. The abundance and biomass from both surveys indices for witch flounder have been relatively stable since 2007. In 2014, the abundance and biomass indices were near the long-term average. The survey index for winter flounder abundance has been below the long term average in recent years and the biomass index has been generally declining since the late 1980s. The abundance index of yellowtail flounder in 2014 from the RV survey remained comparable to the long-term average. In contrast, the biomass index has declined since the mid-1990s. The biomass index for yellowtail from the SM survey decreased over the 2003-2014 time series, with the value in 2014 the lowest on record. The abundance and biomass indices of small yellowtail flounder (< 25 cm) for the areas surrounding the Magdalen Islands (strata 428 and 434 to 436) remained high in 2014 whereas large (≥ 25 cm) yellowtail flounder abundance indices remained low.

Indices des abondances jusqu’en 2014 de six espèces de poisson de fond provenant des relevés aux chaluts de fond de navire de recherche en septembre et de la pêche sentinelle en août dans le sud du golfe du Saint-Laurent

RÉSUMÉ

Chaque automne depuis 1971, un relevé normalisé au chalut de fond est effectué à bord d’un navire de recherche dans le sud du golfe du Saint-Laurent (division 4T de l’OPANO). En outre, un relevé de pêche sentinelle au chalut de fond a été effectué dans la même région annuellement en août depuis 2003, L’objectif principal de ces relevés est d’obtenir des indices d’abondance des principales espèces de poisson de fond de la région. Les indices de la biomasse pour la morue du sud du golfe, en 2011 et 2012, étaient au plus bas niveau observé au cours des 44 années du relevé, indiquant que l’abondance de ce stock continue d’être inférieure à celles observées à la fin des années 1970 et durant les années 1980. L'indice de biomasse pour 2014 a augmenté de près de la valeur observée en 2009. L’indice du relevé de pêche sentinelle a diminué depuis 2003 à 2014. Les indices des abondances et des biomasses de la merluche blanche des deux relevés demeurent extrêmement bas en comparaison avec les indices observés à la fin des années 1980 et au début des années 1990. Les indices d’abondance et biomasse de la plie canadienne ont atteint leur sommet vers la fin des années 1970. L’abondance du stock a diminué depuis, atteignant son plus bas niveau au cours des récentes années. En 2014, les indices de la biomasse globale de la plie canadienne dans les deux relevés se situaient aux plus bas niveaux observés. Les indices d’abondances et de biomasses de la plie grise sont relativement stables depuis 2007. En 2014, les indices étaient près de la moyenne à long terme. Les récentes valeurs des indices d’abondances de la plie rouge étaient inférieures à la moyenne à long terme, tandis que l’indice de biomasse à généralement décliné depuis la fin des années 1980. L’indice d'abondance de la limande à queue jaune du relevé de recherche en 2014 était comparable à la moyenne à long terme. En revanche, l'indice de biomasse a diminué depuis le milieu des années 1990. L’indice de biomasse du relevé de la pêche sentinelle a diminué sur la série temporelle de 2003 à 2014, la valeur en 2014 étant la plus basse de la série. Les indices d’abondances et de biomasses de la limande à queue jaune de petite taille (< 25 cm) aux environs des Îles-de-la-Madeleine (strates 428 et 434 à 436) sont demeurés élevés en 2014 tandis que les indices d’abondances de limande de grande taille (≥ 25 cm) sont bas.

SURVEY DESCRIPTION

SEPTEMBER BOTTOM-TRAWL SURVEY (RV SURVEY)

A stratified-random groundfish trawl survey (RV survey) of the southern Gulf of St. Lawrence has been conducted annually in September since 1971. Fishing was by the E.E. Prince using a Yankee 36 trawl from 1971 to 1985, by the Lady Hammond using a Western IIA trawl from 1985 to 1991, and by the CCGS Alfred Needler using a Western IIA trawl from 1992 to 2002. In 2004 and 2005, the survey was conducted by two vessels, the CCGS Teleost and CCGS Alfred Needler, both using the Western IIA trawl. During both surveys, comparative fishing experiments were conducted, with the two vessels trawling side-by-side. Stratified abundance estimates for 2004 and 2005 were calculated by averaging catches of the two vessels that occurred at the same location. Since 2006 surveys were done by the CCGS Teleost.

To maintain the consistency of the time series, comparative fishing experiments were conducted and conversion factors were applied where necessary to account for gear and/or vessel changes (Nielsen 1994; Swain et al. 1995; Benoît and Swain 2003; Benoît 2006).

In 2003, the regular survey vessel, the CCGS Alfred Needler, was disabled by a fire and the survey was conducted by the CCGS Wilfred Templeman. However, the start of the survey was delayed, and only 83 fishing stations were surveyed. Three strata (402, 425, 436 – see Figure 1) were sampled with only one fishing set and two strata (438, 439) were missed altogether. The catches made during the 2003 survey by the Wilfred Templeman cannot presently be converted or interpreted because the fishing efficiency of the Wilfred Templeman has not been evaluated relative to that of either the Teleost or the Alfred Needler when fishing the Western IIA.

2014 Survey

The 2014 RV survey of the southern Gulf of St. Lawrence was conducted from September 4–29 aboard the research vessel CCGS Teleost (Mission TEL-2014-133).

During the 2014 RV survey, 184 standard sets (30 minutes long at a speed of 3.5 knots) were attempted, of which 166 were successful. All sets were made in Northwest Atlantic Fisheries Organization (NAFO) Division 4T. The location of the fishing sets, stratification scheme and place names cited in the text are shown in Figure 1. The trawl geometry (door-spread, wing-spread, opening, clearance and depth) were monitored during every set with Scanmar™ acoustic sensors (the data were logged but were not used to adjust swept area calculations).

Data entry, validation and primary edits were conducted aboard the vessel as in previous years. Basic oceanographic data (profiles of temperature, salinity, dissolved oxygen, fluorescence and irradiance), as well as water samples for salinity, nutrients, dissolved CO_2 and chlorophyll determinations, were collected at each fishing station. Temperature/depth measurements were also made during each fishing set using a sensor attached to the survey trawl. Additional oceanographic sampling was conducted at 16 fishing stations and at the Shediac Valley fixed hydrographic station for the Atlantic Zone Monitoring Program. This sampling included vertical zooplankton net tows from the bottom to the surface and the collection of water samples from a variety of depths using Niskin™ water bottles.

Special collections were made for eleven (11) different projects in 2014 including: studies of the condition and growth of Atlantic cod; studies of the biology of smooth skate; samples for the stock assessment and biology of Atlantic herring; samples to determine the species composition of shrimp from each survey tow; observations on the frequency of deformed, diseased or scarred Atlantic cod; a study of the diet of Atlantic halibut; a collection of various species of fish for stable isotope sampling; samples of gadoids species (small cod <15 cm) for DNA sampling; gonads of small American plaice (<15cm) for maturity; pectoral fins from American plaice, witch flounder and Atlantic halibut for DNA sampling and various species of fish for a laboratory collection. Digital photographs were taken of a variety of fish and invertebrate species and of survey operations.

AUGUST SENTINEL BOTTOM-TRAWL SURVEY (SM SURVEY)

Following the collapse of several groundfish stocks in the Northwest Atlantic, sentinel surveys were introduced to the southern Gulf of St. Lawrence (sGSL) in 1994 as a way of obtaining complementary data to that obtained from the bottom-trawl research vessel (RV) survey conducted each September since 1971. Sentinel surveys were also intended to involve fish harvesters in the scientific assessment process and have incorporated certain elements of the contemporary fishing fleet, namely the timing of survey, the various types of fishing gears used by the fleet, as well as being performed by active commercial groundfish fish harvesters and their vessels.

The main objective of these surveys has been to gather information on stock composition and distribution, and to construct indices from which to infer trends in abundance. When used in conjunction with other survey data, other results may be derived, such as detecting changes in migration patterns for a given species. Currently, there are two types of sentinel surveys in the sGSL: the fixed gear survey which uses longlines, and the sentinel mobile bottom-trawl survey (SM survey) which uses bottom-trawls. The SM survey was initiated in 2003, following an internal review of the sentinel program (Gillis 2002). Since its inception, the survey has followed the stratified-random design used for the Fisheries and Oceans Canada (DFO) September bottom-trawl survey.

From 2003 to 2014, the SM survey was undertaken annually by four commercial otter-trawlers fishing in overlapping areas each fishing the same type of trawl know has #300 star balloon otter trawl. However, some of the vessels changed between years such that ten vessels have been used since the inception of the survey (Table 1). Vessels are chosen such that there is one participant from each of the following geographic regions: Prince Edward Island, Gaspé, Magdalen Islands and New Brunswick. The study area, which covered most of the NAFO division 4T fishing area, was sampled using the same stratified random sampling design used for the annual September bottom-trawl survey (Figure 1). Efforts have been made to ensure that vessels have the same numbers of sample sites within each stratum. This improved the estimates of each vessel’s relative fishing efficiency. Those analyses are explained in Savoie 2014.

The 2014 SM survey of the southern Gulf of St. Lawrence was conducted from August 1–24. During this survey, 166 standard sets were attempted, of which 156 were successful. The target fishing procedure at each sampling station consisted of a 30-minute trawl tow (with acceptable minimum tow duration of 20 minutes) at an approximate speed of 2.5 knots. A standard tow length was thus considered to be 1.25 nautical miles long. Fishing was limited to daylight hours between 06:00 hrs and 20:30 hrs (sunrise and sunset, Atlantic Standard Time) to minimize day/night effects for certain species (Benoît and Swain 2003; Casey and Myers 1998).

Data were collected by two fisheries observers on board each vessel. At each station, the tow start and end locations, the boat speed, the tow duration, as well as other relevant data were recorded. Details on the catch from each tow were also recorded: all fish and invertebrate species were sorted, weighed and counted. The length of up to 250 specimens was measured in each tow for each of the following species: cod, white hake, American plaice, Atlantic halibut, witch flounder, winter flounder, yellowtail flounder and Atlantic herring. Otoliths were collected from among the measured cod (one per centimeter) and white hake (one per centimeter per sex).

RESULTS

COD

The spatial distribution of cod catches prior to 2000 was mainly distributed all around the southern Gulf of St. Lawrence (Figure 2). Cod densities were highest in the Shediac Valley, to the west of Orphan Bank off the Gaspé Peninsula, north of Prince Edward Island (P.E.I.), and around the Cape Breton Trough. Since the beginning of 2000's, the cod distributions are found in more specific area. Cod densities are higher north of Shediac Valley, west of Orphan Bank off the Gaspé Peninsula and in the cape Breton Trough (Figure 2 & 3). In September, the densities are concentrated in the south of Laurentian Channel (stratum 426) and North West of P.E.I. (Figure 2). Relatively few cod were caught on Bradelle Bank (stratum 423) and in the waters off eastern, western and southern P.E.I.

The RV survey indices for cod, in 2013 and 2014 increased to near the values from 2005 to 2009 (Figure 4) after a period of where those indices were at the lowest levels observed in the 44-year record for the survey. The biomass index for commercial-sized cod in 2014 remained near the lowest levels observed (Figure 5c, d). The biomass index for smaller juvenile cod increased substantially in 2013 and 2014, from values near the lowest levels observed in 2010-2012 to a value near the relatively high 2009 level, though there is considerable uncertainty surrounding the 2013 and 2014 estimate (Figure 5a, b). Furthermore, it is important to note that the relatively high biomass index for juvenile cod in 2009 was not reflected in increased biomass at larger sizes in 2010-2012.

For the SM survey, the randomization test suggested significant vessel effects ($P = 0.006$) for catch weights. The *Cap Adèle*, the *Viking II* and the *Manon Yvon* had similar vessel effects, with a common relative fishing efficiency estimated at 1.49 by weight and 1.64 by numbers per tow compared to the reference vessel. The *Atlantic Quest I* and the *Tamara Louise* had similar vessel effects among themselves, estimated at 0.55 for catch weight and 0.46 for numbers per tow. The J.L.S.R. and the Cape Ryan had a strong vessel effects estimated at 3.63 and 2.75 by weight and 5.68 and 3.43 for numbers per tow respectively. The SM survey abundance and biomass index for cod in 2014 increased but stayed near the lowest levels observed (Figure 6) showing an overall decreasing trend from 2003 to 2014.

The length frequency distribution from the RV survey for the last 3 years indicates that the majority of cod were in the 28-42 cm length range (59% in 2014) (Figure 7). However catch rates of cod larger than the minimum commercial size of 42 cm have been decreasing since 2010. The SM survey length frequency distribution follows the same pattern. The majority of cod was found between the 28-42 cm range during the same period (69% in 2014) (Figure 8) and the commercial size have been decreasing since 2011.

WHITE HAKE

The spatial distribution of white hake is mainly distributed in the Cape Breton Trough, along the Laurentian Channel and in St. Georges Bay area (Figure 9 &10). White hake have seldom been caught in the shallow, central zone adjacent to Magdalen Islands. Few white hake have been caught in the western part of the southern Gulf since 1991 and in the St, Georges Bay area since 2005, suggesting that there has been a major contraction of the geographic range.

During RV survey, white hake have tended to exhibit a disjoint distribution, with concentrations occurring in the warmer waters of the survey area: either in shallow inshore areas around the Northumberland Strait or in the deep waters of the Laurentian Channel and Cape Breton Trough. The abundance and biomass indices for white hake use sets from strata 401, 403 and 415 to 439, and extend from 1984 to present (Figure 11 & 12). In 2014, the indices of abundance and biomass for white hake in the NAFO 4T survey area increase over but near the long-term average (1984-2014; 5.4 fish per tow and 3.4 kg per tow) (Figure 11).The RV survey biomass index for commercial-sized white hake declined sharply between the mid-1980s and mid-1990s, and has been at a very low level since then (Figure 12c, d). The biomass index for pre-commercial sizes has been relatively low in most years since 1993 (Figure 12a, b), though the decline in the index for these small sizes was not as sharp as the decline at larger sizes. Biomass at pre-commercial sizes was at about the same level in 2014 as in 2008-2013, but in 2013 was at the lowest level observed.

The randomization test suggested significant vessel effects (P = 0.001) for catch weights from the SM survey. Given the initial confounding of vessel and stratum effects in earlier survey years and the sparseness of white hake catches the data was not adjusted.The white hake biomass index from the SM survey declined from the start of the series to the lowest values in 2012 and 2013 (Figure 13) with a non-significant increase in 2014.

The length frequency distribution the RV and SM surveys (Figure 14 & 15) indicates that the majority of white hake were in the 28-45 cm length range. The proportion of fish larger than the commercial size (≥45 cm) remained very low. The abundance of incoming size-classes (≤30 cm) for 2014 remained below the average for the 2003-2014 period. Because of the scarcity of catches, the length frequency distributions from the SM survey are somewhat irregular and tracking of recruitment modes is not possible (Figure 15).

AMERICAN PLAICE

The spatial distribution of American plaice is widely distributed across NAFO division 4T but since the late 2000s, their densities observed north and east of Prince Edward Island, south of the Shediac Valley and in St. Georges Bay area have decreased to low levels compare to previous years (Figure 16 &17).

Overall biomass index for American plaice remained near the lowest levels observed in the RV survey of the southern Gulf (Figure 18). This was also the case for the indices for pre-commercial (<30 cm) and commercial (≥30 cm) lengths of plaice (Figure 19). The decline in biomass over the past 25 years has been more substantial for the larger sizes of plaice.

For the SM survey, the randomization test suggested significant vessel effects (P = 0.001) for catch weights. The *Cap Adèle*, and the *Manon Yvon* had similar vessel effects, with a common relative fishing efficiency estimated at 2.05 by weight and 2.06 by numbers per tow compared to the reference vessel. The *Tamara Louise* had a relative fishing efficiency estimated at 0.66 for catch weight and 0.58 for numbers per tow. The J.L.S.R. and the Cape Ryan had similar vessel effects, with a common relative fishing efficiency estimated at 4.24 by weight and 4.39 by numbers per tow. The American plaice indices from the SM survey declined from the start of the series to the lowest values in 2014 (Figure 20).

The length frequency distribution the RV and SM surveys (Figure 21 & 22) indicates that the majority of American plaice were in the 20-30 cm length range. The proportion of fish larger than the commercial size (≥30 cm) remained stable and very low. Length frequency distributions for plaice in the RV survey do not usually indicate strong modes at lengths less than 10 cm and it may be difficult to detect strong incoming recruitment based on length data. However surveys, since 2007, have recorded modes occurring at less than 10 cm (Figure 21) and we are able to follow this recruitment throughout the years (the 2007, 2010 and 2011 year-classes). Due to the size of mesh used in the SM survey almost no plaice less than 10 cm in size were caught.

WITCH FLOUNDER

Witch flounder are found primarily in the deep waters of the Laurentian Channel. The southern Gulf of St. Lawrence survey provides an indication of abundance only in 4T, and not for the entire stock area which comprises NAFO 4RST. Data from the survey of the northern Gulf undertaken by DFO's Quebec Region are also used to follow trends in the abundance of this stock (information from that survey are available separately).

The spatial distribution of witch flounder is mainly distributed in the Cape Breton Trough, along the Laurentian Channel and to the west of Orphan Bank off the Gaspé Peninsula (Figures 23 & 24).

The RV survey abundance and biomass indices for witch flounder in 4T have fluctuated between relatively low and high values during the 2004 to 2014 period (Figure 25). In 2014, the abundance and biomass indices dropped but were near the long-term average (3.3 fish and 1.4 kg per tow). Those fluctuations in the indices are mainly due to larger witch flounder (≥30 cm), because indices for smaller fish (<30 cm) remained very stable during this period (Figure 26).

The randomization test suggested significant vessel effects ($P = 0.03$) for catch weights from the SM survey. Given the initial confounding of vessel and stratum effects in earlier survey years and the sparseness of witch flounder catches the data was not adjusted. The witch flounder indices from the SM survey have been relatively steady since 2007 at around 1.3 fish and 0.4 kg per tow. However, these catch rates are lower than those observed from 2003 to 2006 (Figure 27).

Juvenile witch flounder tend to be distributed in deep water, mostly outside of the area covered by the September survey. Thus, most of the witch flounder caught in the both surveys tends to be adult fish (≥30 cm). In 2014, over 80% of the catches were composed of fish 30 cm and greater (Figure 28 & 29).

WINTER FLOUNDER

The spatial distribution of winter flounder is distributed in the shallow coastal strata of NAFO division 4T, off northeastern New Brunswick, around the Magdalen Islands, Prince Edward Island and in St. Georges Bay (Figure 30 & 31).

Winter flounder is found inshore, from the shoreline to approximately 20 fathoms. The abundance index for this species comprises sets from all strata (401-439) and does not cover a large portion of its inshore distribution. Interpretations of the results must be tempered with the fact that winter flounder is a coastal species whose distribution stretches to the coastline. Therefore there is a broad, shallow area of winter flounder habitat that is not sampled by the survey and fluctuations in the indices may be due to changes in spatial distribution with respect to the boundaries of the study area.

Yearly fluctuations in the index are common and confidence intervals on mean estimates are wide (Figure 32).Though the abundance index has largely fluctuated without trend, its values since 2011 were at the lowest in the series. The biomass index has followed a declining trend since the late 1980s.

Trends in the biomass index mainly reflect decreases in the abundance and biomass of large (≥25 cm) winter flounder (Figure 33). The abundance and biomass of smaller winter flounder has varied without trend.

The randomization test suggested significant vessel effects (P = 0.006) for catch weights from the SM survey. Given the initial confounding of vessel and stratum effects in earlier survey years and the sparseness of witch flounder catches the data was not adjusted. The biomass index for winter flounder from the SM survey has declined since the start of the survey in 2003 (Figure 34). This index was at the lowest levels on record in 2012 to 2014, averaging 5% of the 2003 value in these three years.

Length frequency distributions of winter flounder in the RV survey vary from year to year, but tend to be dome-shaped, composed of fish up to 40 cm, with most ranging between 15 and 30 cm (Figure 35). No change was observed in the relative size composition for winter flounder from in the SM survey. In 2014, 83% of catches were composed of fish between 20 and 30 cm which is comparable with the long term trend (Figure 36).

YELLOWTAIL FLOUNDER

The spatial distribution of yellowtail flounder is distributed in the shallow coastal strata of NAFO division 4T, off northeastern New Brunswick, around the Magdalen Islands and Prince Edward Island (Figure 37 & 38).

The abundance index of yellowtail flounder from the RV survey in 2014 remained comparable to the long-term average of 19.1 fish per tow. In contrast, the biomass index has declined since the mid-1990s (Figure 39). The main fishery for yellowtail flounder occurs in the waters off the Magdalen Islands. The abundance index for the area near the Magdalen Islands (strata 428 and 434 to 436) remained high in 2014, compared to the low values observed in the 1980s. In contrast, the biomass index in that area has been relatively low since 2007, compared to the values observed in 1993-2006 (Figure 39).

The RV survey biomass index for pre-commercial sized yellowtail flounder increased greatly from the mid-1980s to the mid-2000s and then levelled off (Figure 40a). In contrast, the biomass index for commercial-sized yellowtail decreased sharply from the mid-1990s to the present (Figure 40c). The RV survey biomass indices for yellowtail in the strata surrounding the Magdalen Islands are shown in Figure 41. Like in the 4T area as a whole, biomass at pre-commercial sizes increased sharply from the late 1980s to the mid-2000s in the area around the Magdalen Islands whereas biomass at commercial sizes dropped sharply between the mid-1990s and late 2000s in this area. Commercial biomass has been at the lowest level observed since 2007.

The randomization test suggested significant vessel effects (P = 0.02) for catch weights from the SM survey. Given the initial confounding of vessel and stratum effects in earlier survey years and the sparseness of yellowtail flounder catches the data was not adjusted. Similarly, the biomass index for yellowtail from the SM survey decreased over the 2003-2014 time series, with the value in 2014 the lowest on record (Figure 42).

The modal length of yellowtail flounder caught, in the RV survey, decreased from 23 in 2004 to 18 cm in 2014, and the proportion of yellowtail below the legal size of 25 cm has increased yearly, from 74% in 2002 to 88% in 2014 (Figure 43). The catches of yellowtail flounder from the SM survey are mainly composed of fish between 15 and 30 cm (Figure 44). In 2014, 21% of the catch was composed of fish ≥25 cm, which is considerably less than in past years.

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TABLES

Table 1. Characteristics of otter-trawlers that participated in the NAFO division 4T sentinel bottom-trawl survey since 2003.

Vessel	*CFVN*	*Region*	*Years of participation*	*Overall Length*	*Gross Tonnage*	*Horsepower*	*Year Built*	*Hull Type*
L'Alberto	11873	Gaspé, QC	2003	55’	62	600	1987	Wood
Manon Yvon	17354	Îles-de-la-Madeleine, QC	2003-2005	66'	80	500	1987	Steel
Atlantic Quest I	64796	Prince Edward Island (PEI)	2007-2009	62’	62	500	1972	Fibreglass
Riding It Out	5688	Prince Edward Island (PEI)	2003-2006	58'	67	470	1981	Wood
Tamara Louise	100278	Prince Edward Island (PEI)	2010-2014	44’	35	470	1986	Fibreglass
Miss Lamèque	151347	New Brunswick (NB)	2003-2013	44'	34	350	1987	Aluminum
Viking II	17790	Gaspé, QC	2004-2013	55’	62	500	1989	Fibreglass
Cap Adèle	11870	Îles-de-la-Madeleine, QC	2006-2014	58'	53	450	1986	Fibreglass
J.L.S.R.	11502	Gaspé, QC	2014	51’	70	470	1985	Fibreglass
Cape Ryan	151573	New Brunswick (NB)	2014	57’	106	685	1988	Steel

FIGURES

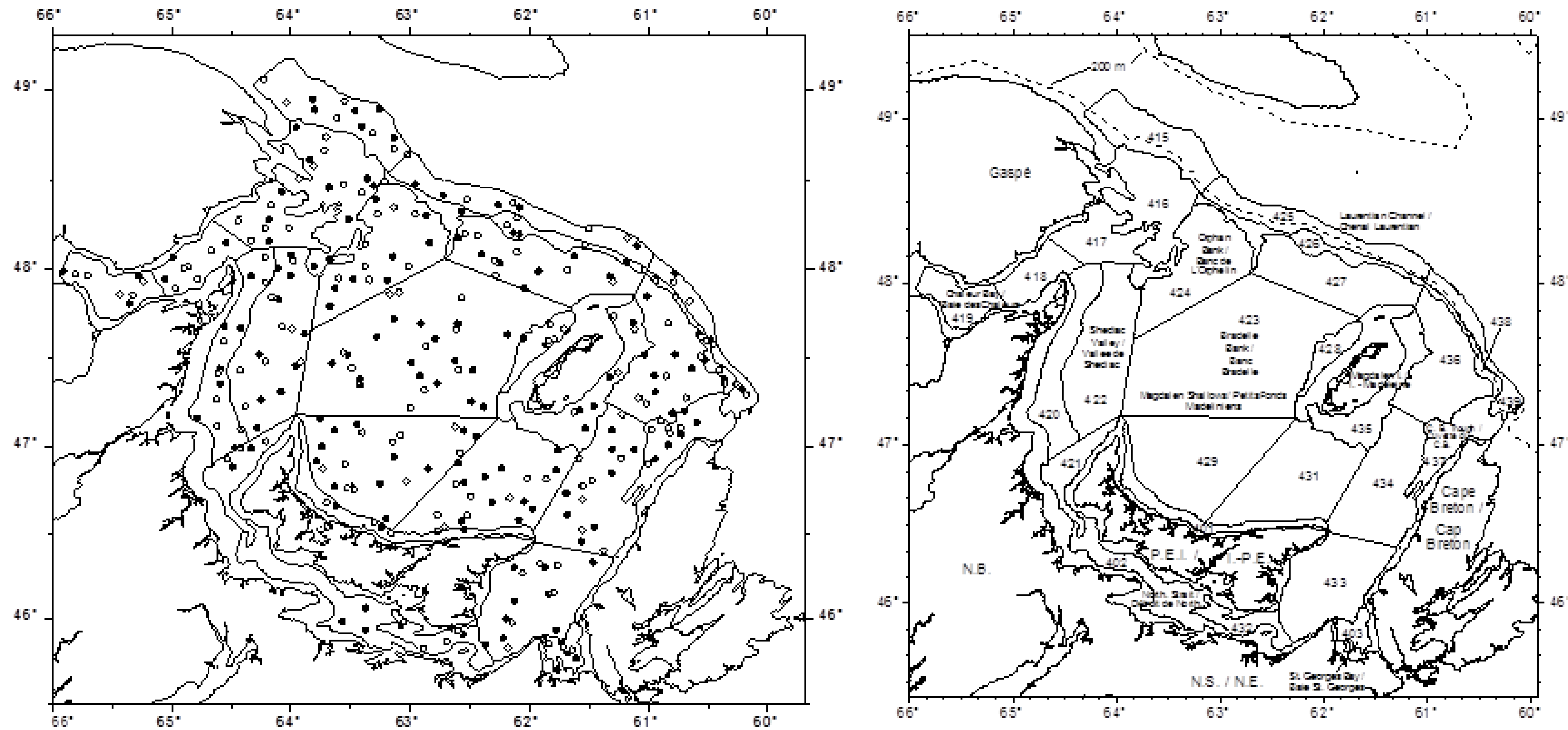


Figure 1. Location of the fishing sets from the September trawl survey (black points) and the August sentinel trawl survey 2014 (white points) (left panel) and the stratification scheme and place names cited in the text (right panel).

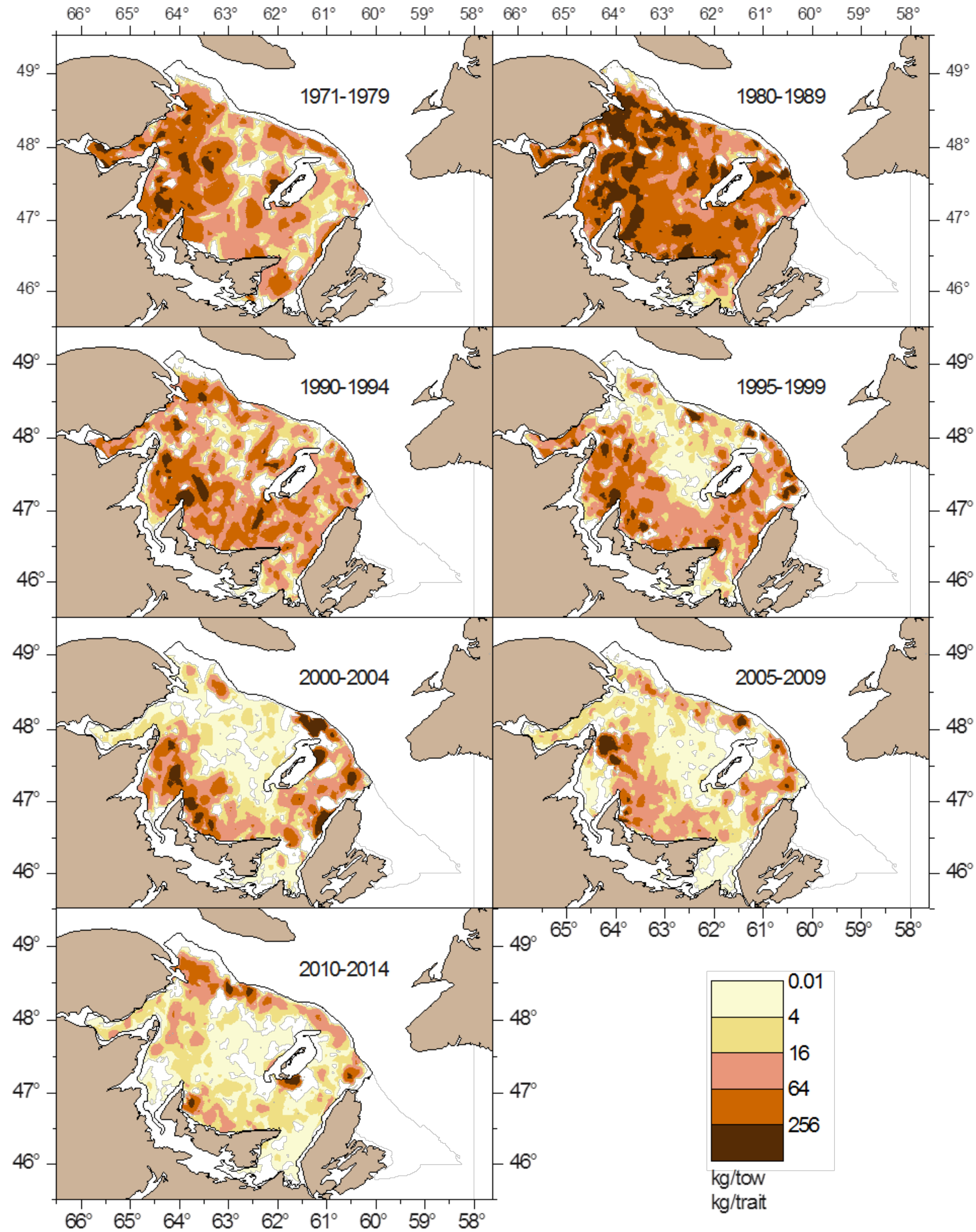


Figure 2. Spatial distribution of cod catches over time in the southern Gulf of St. Lawrence from September bottom-trawl surveys.

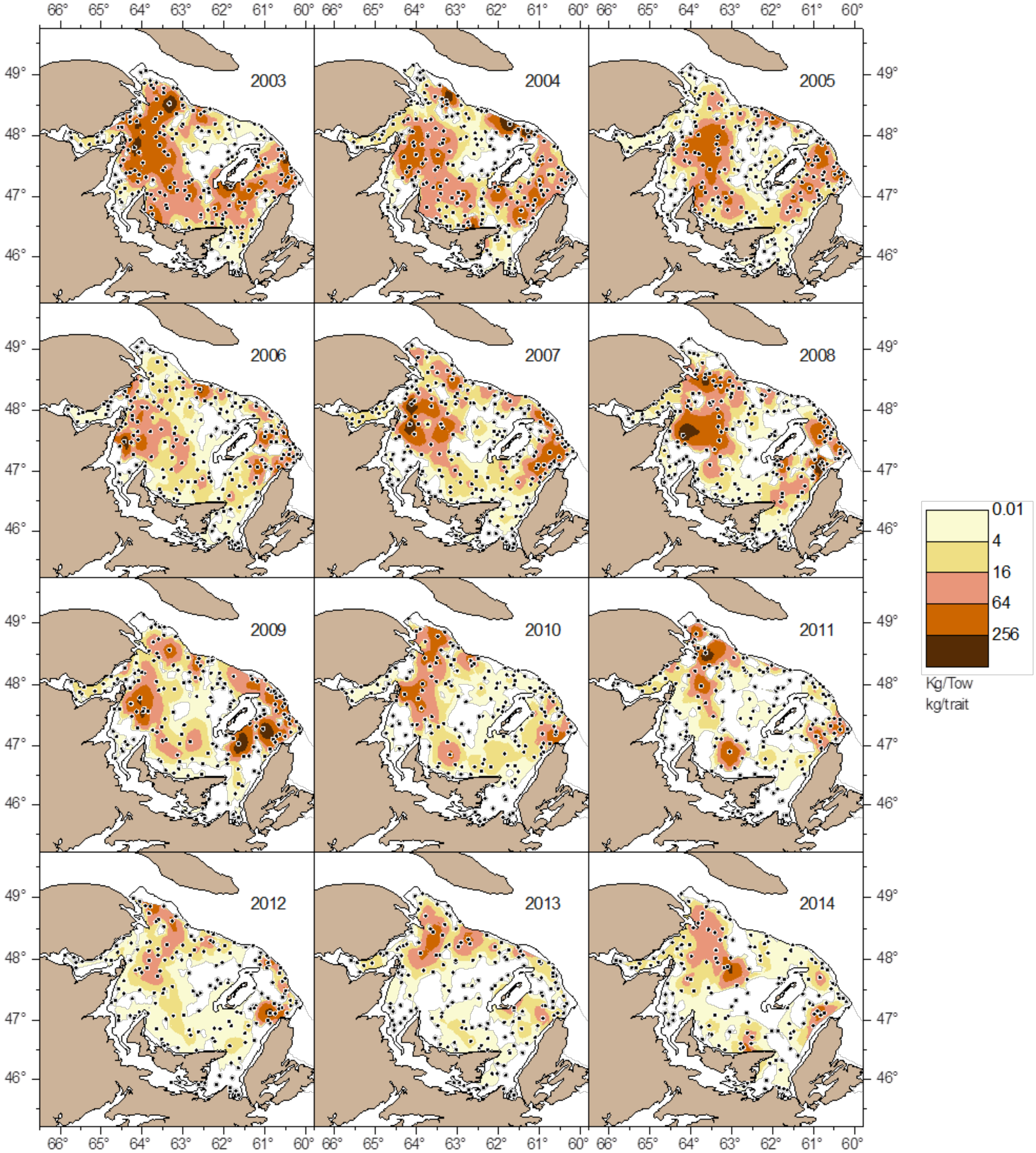


Figure 3. Spatial distribution of cod catches over time in the southern Gulf of St. Lawrence from August sentinel bottom-trawl surveys. Catches have been adjusted for vessel differences. The dots indicate the location of fishing sets.

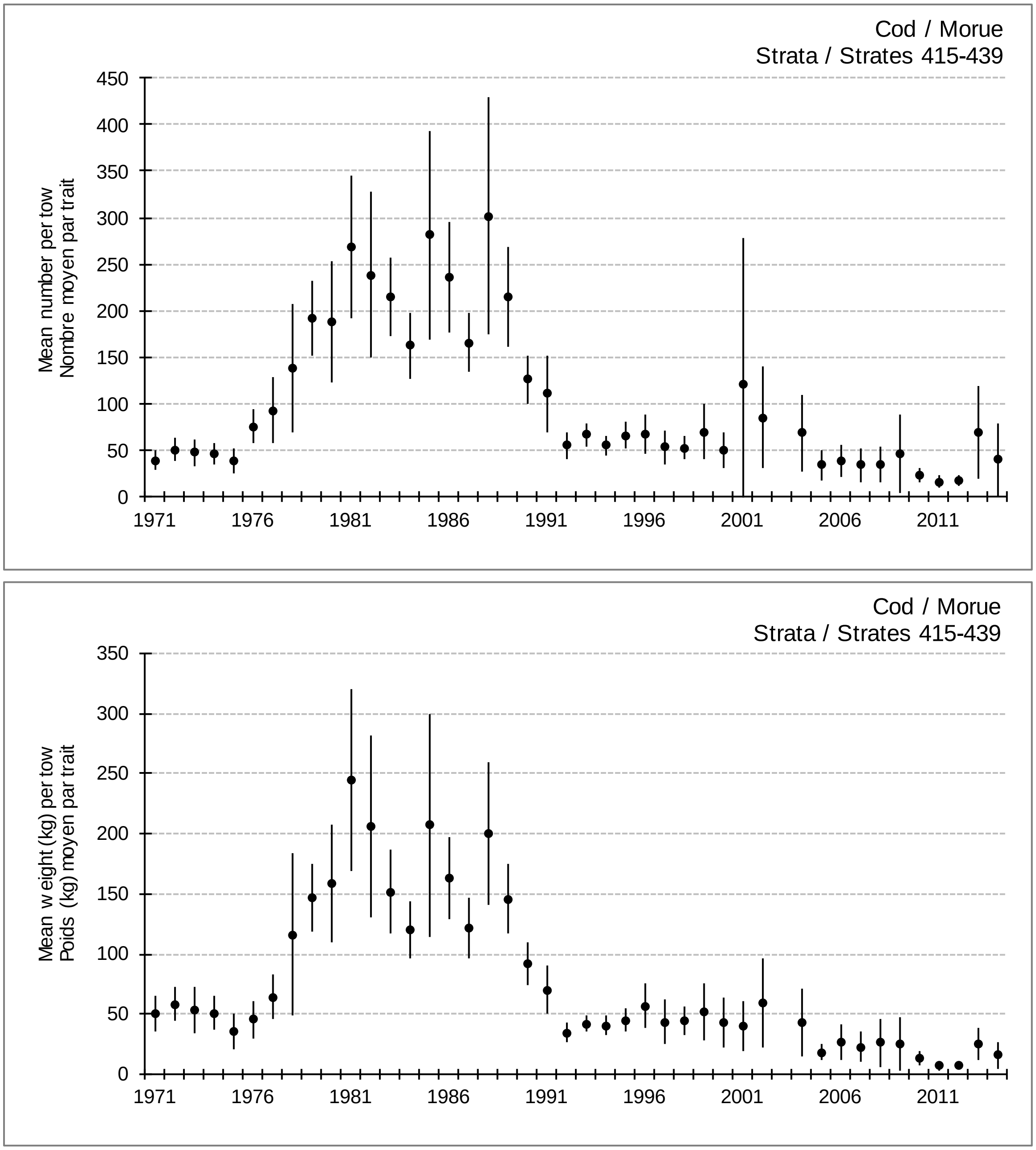


Figure 4. Mean annual catch abundance (top) and weight (bottom) per tow of cod in the southern Gulf of St. Lawrence September bottom-trawl surveys. Vertical lines denote approximate 95% confidence limits (± 2 standard errors).

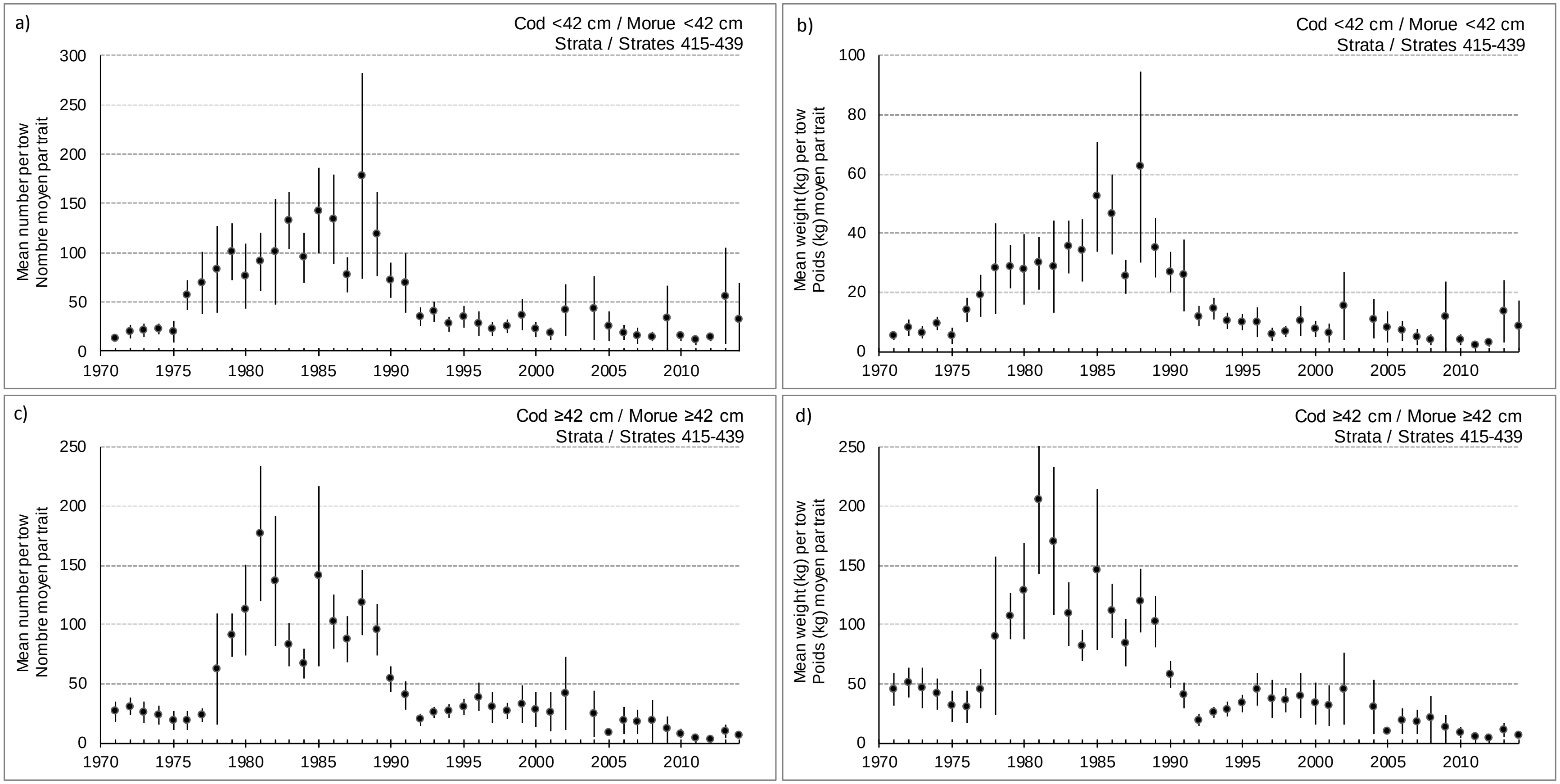


Figure 5. Mean annual catch abundance and weight per tow of cod <42 cm in length (top) and ≥42 cm (bottom) in the southern Gulf of St. Lawrence September bottom-trawl surveys. Vertical lines denote approximate 95% confidence limits (± 2 standard errors).

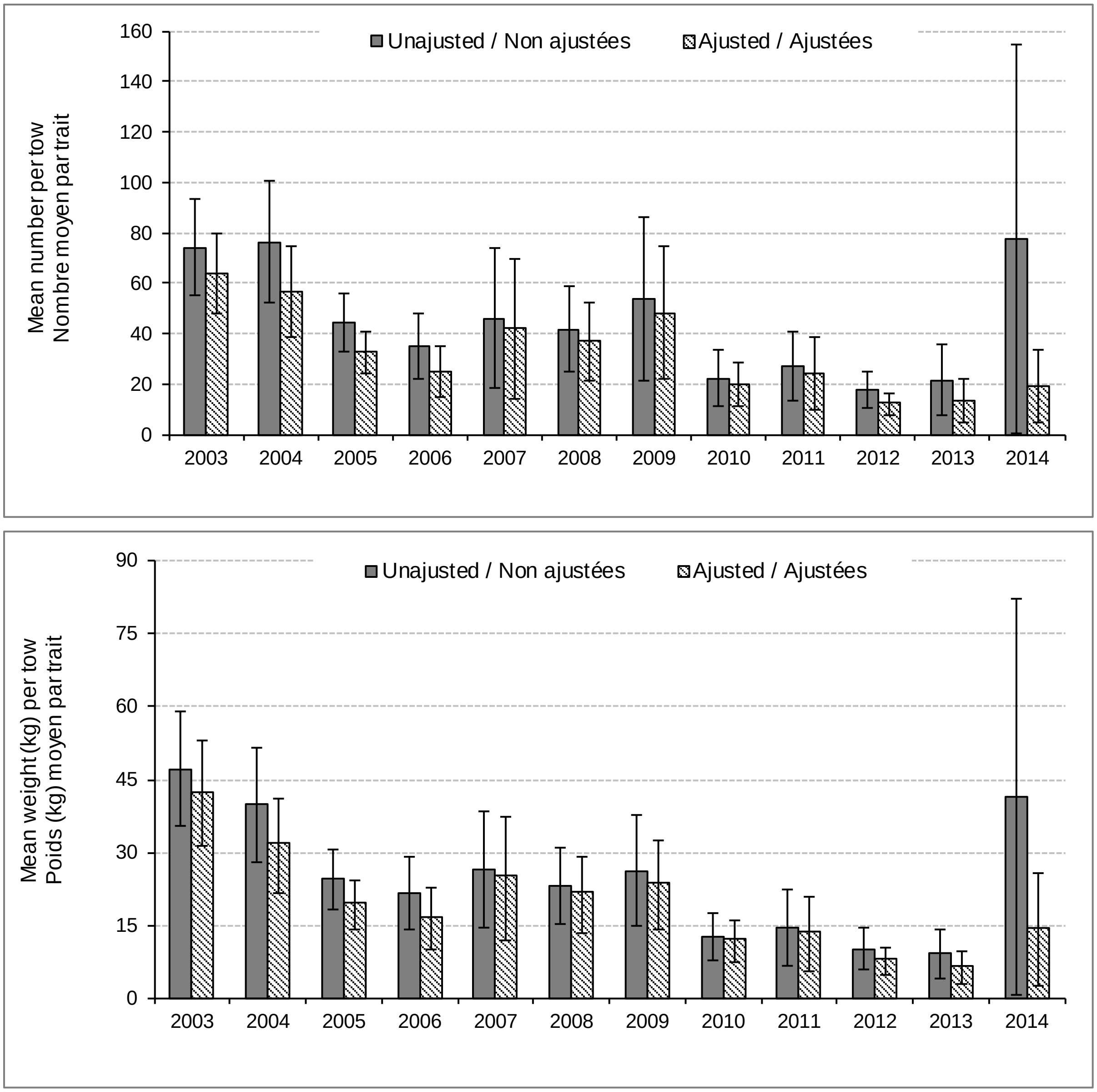


Figure 6. Mean annual numbers (top) and weight (bottom) per tow of cod in the August sentinel bottom-trawl surveys of the southern Gulf of St. Lawrence. Adjusted values for vessel efficiency are represented by stripped bars, and unadjusted ones are represented by grey bars. Vertical lines denote approximate 95% confidence limits (± 2 standard errors).

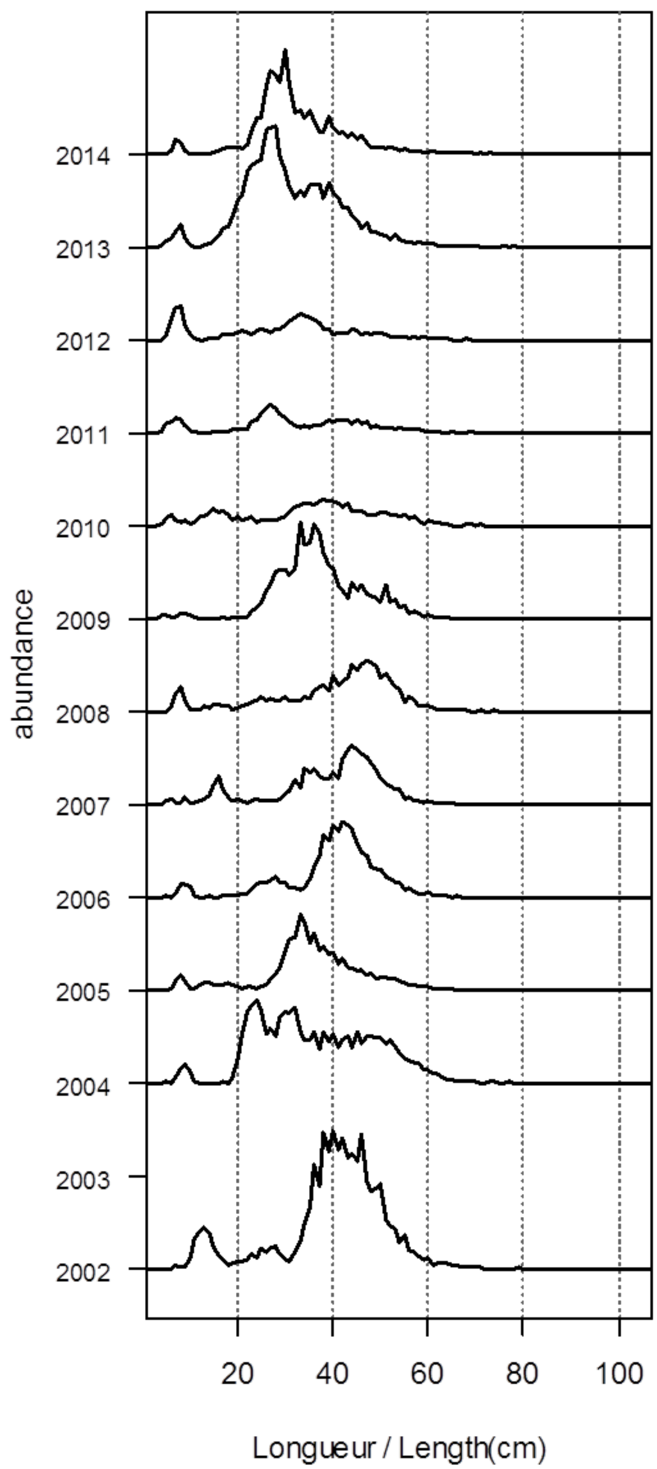


Figure 7. Length frequencies of cod in in the southern Gulf of St. Lawrence from September bottom-trawl surveys from 2002 to 2014. Strata 415 to 439 are those used for the cod abundance index.

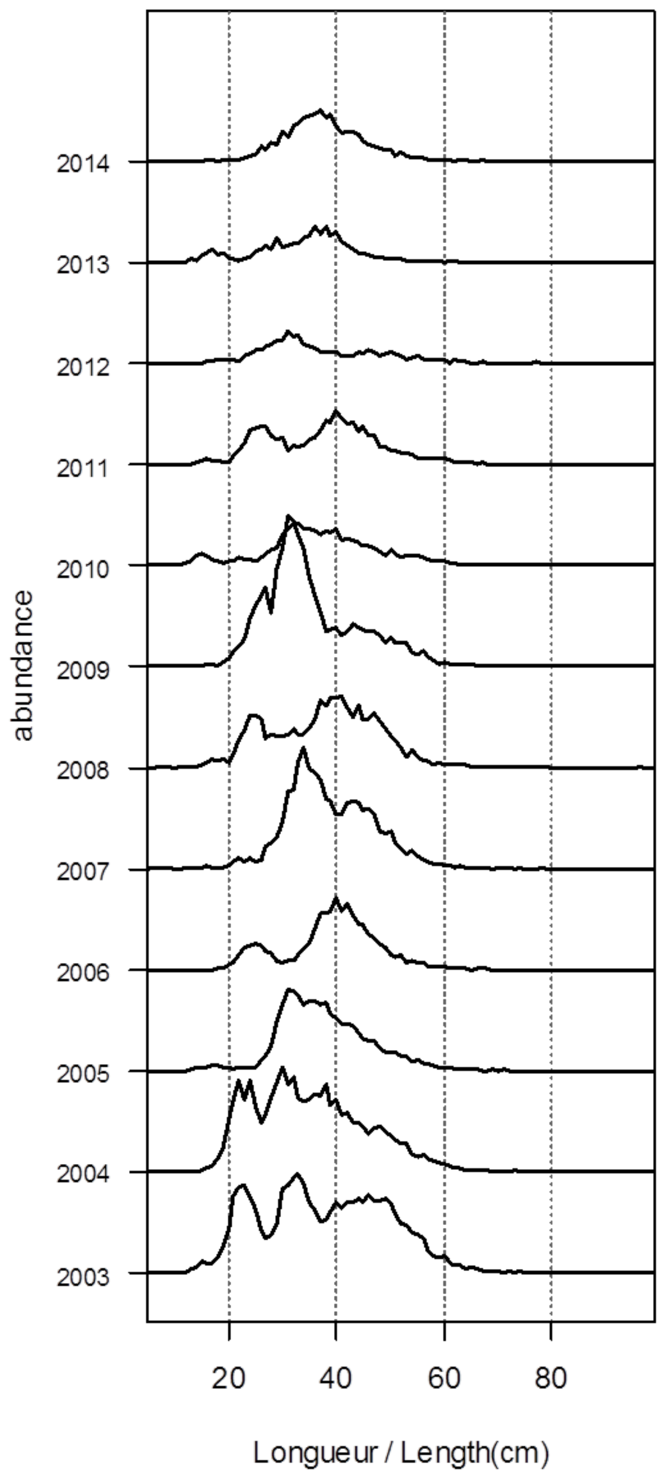


Figure 8. Length frequencies of cod in in the southern Gulf of St. Lawrence from August sentinel bottom-trawl surveys from 2003 to 2014. Strata 401 to 439 are those used for the cod abundance index.

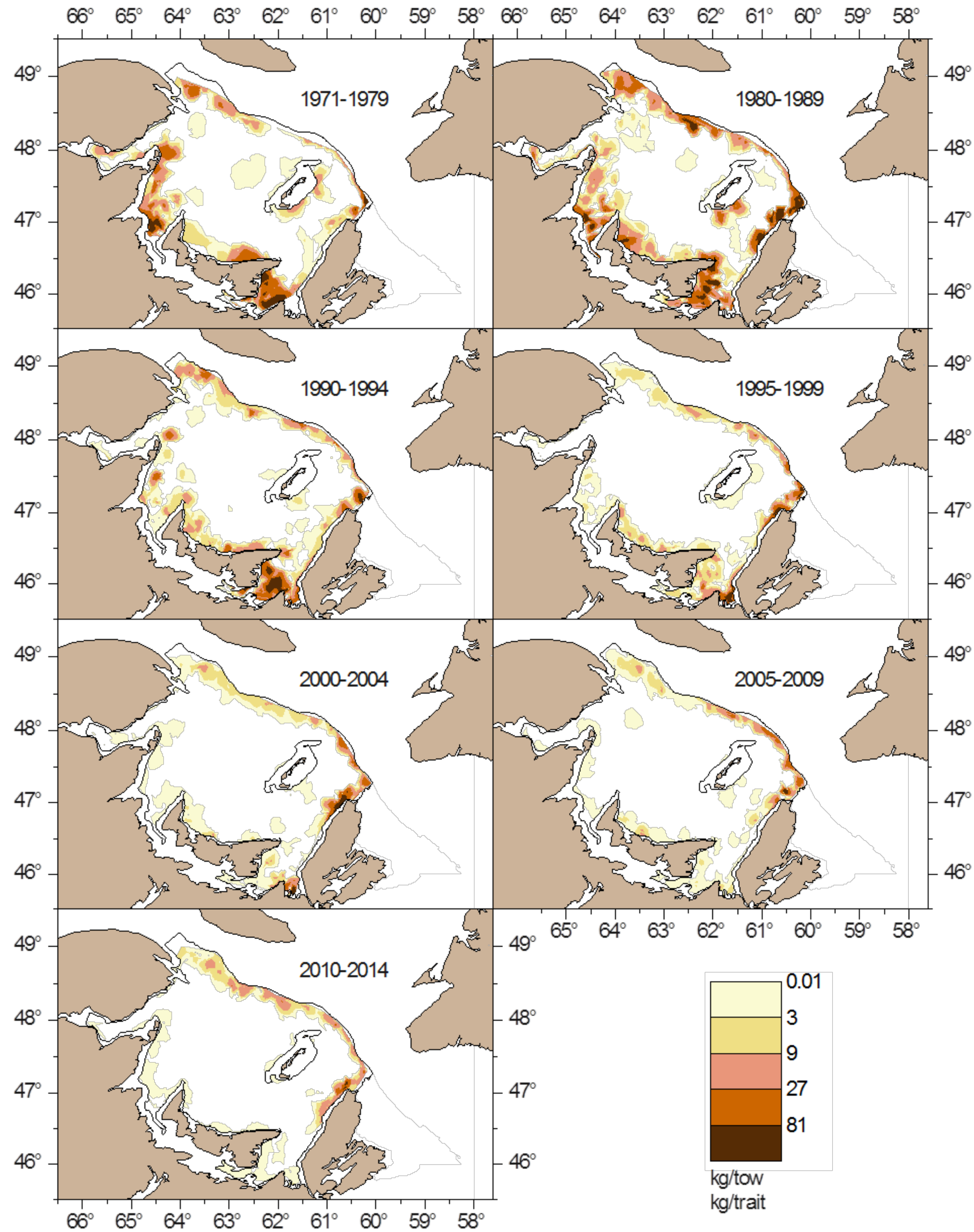


Figure 9. Spatial distribution of white hake catches over time in the southern Gulf of St. Lawrence from September bottom-trawl surveys.

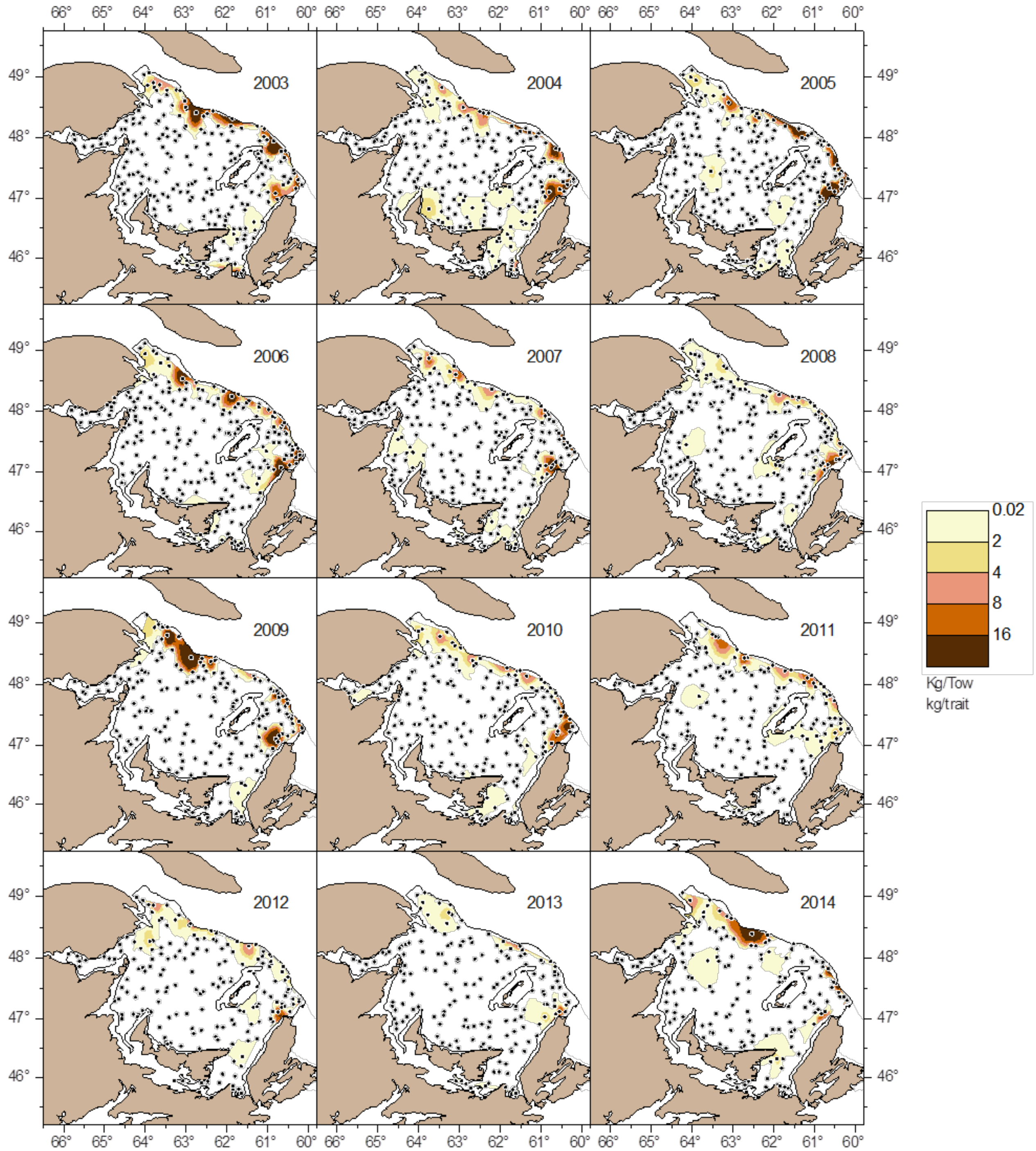
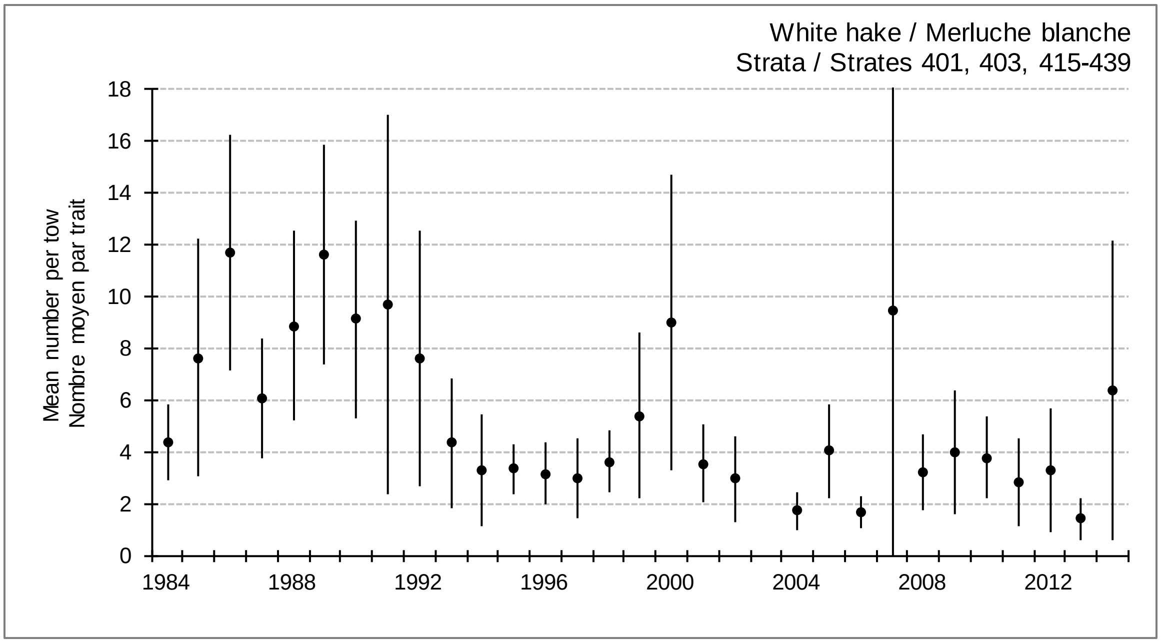


Figure 10. Spatial distribution of white hake catches over time in the southern Gulf of St. Lawrence from August sentinel bottom-trawl surveys. Catches were not adjusted for vessel differences. The dots indicate the location of fishing sets.



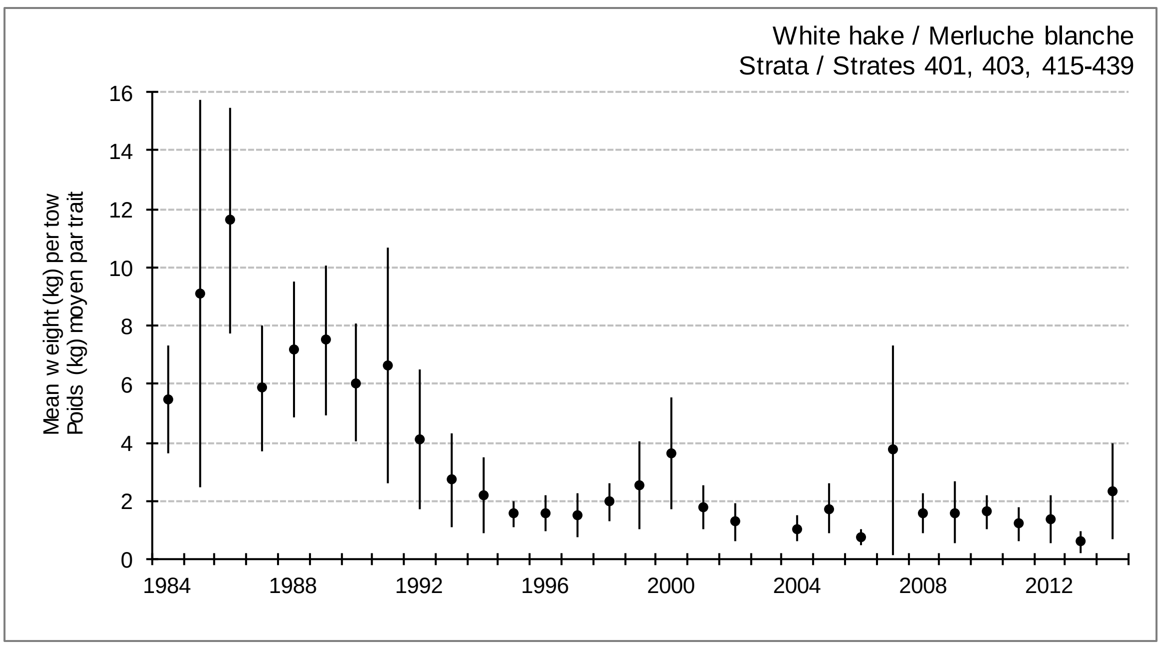


Figure 11. Mean annual catch abundance (top) and weight (bottom) per tow of white hake in the southern Gulf of St. Lawrence September bottom-trawl surveys. Vertical lines denote approximate 95% confidence limits (± 2 standard errors).

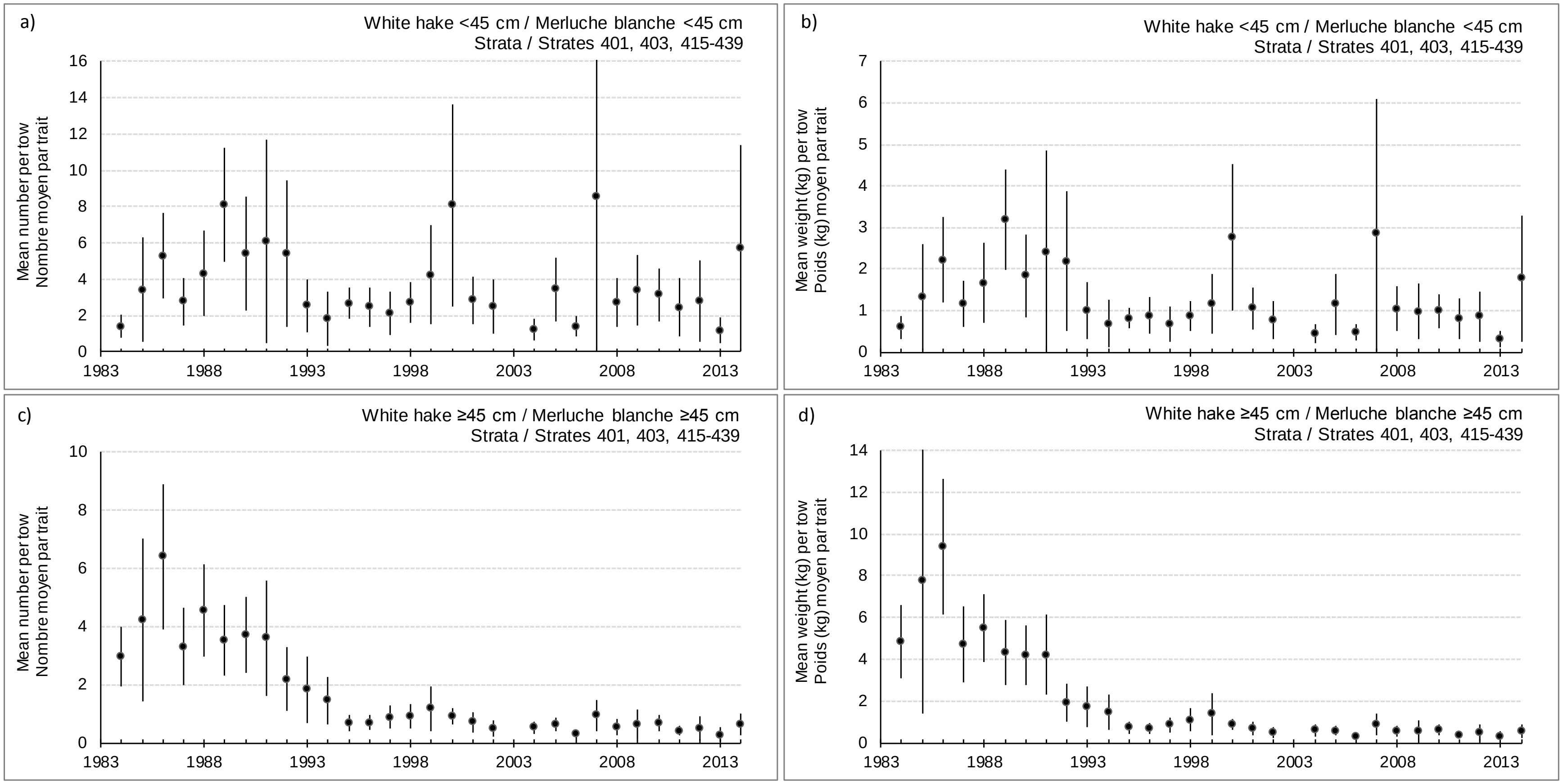


Figure 12. Mean annual catch abundance and weight per tow of white hake <45 cm in length (top) and ≥45 cm (bottom) in the southern Gulf of St. Lawrence September bottom-trawl surveys. Vertical lines denote approximate 95% confidence limits (± 2 standard errors).

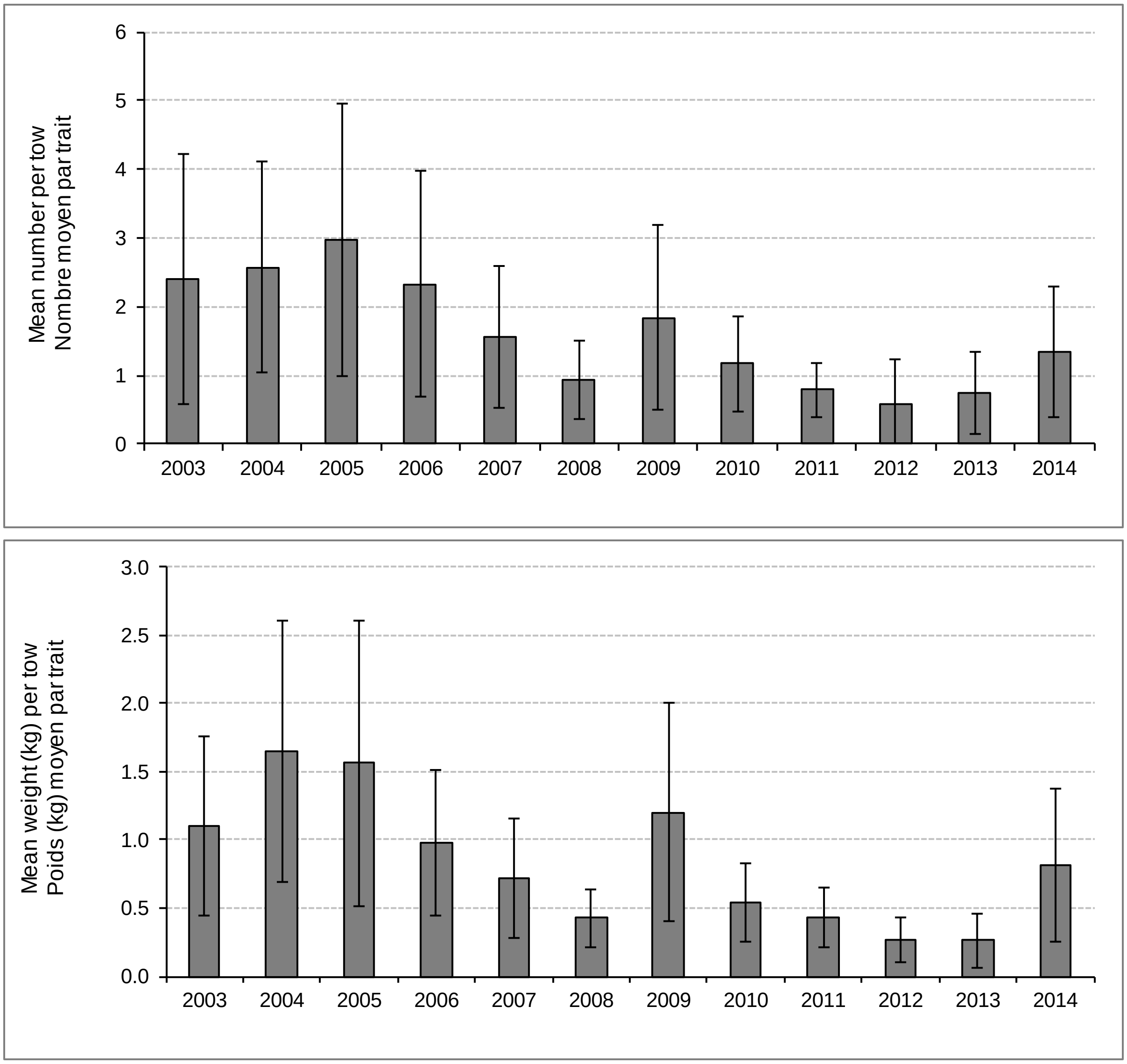


Figure 13. Mean annual numbers (top) and weight (bottom) per tow of white hake in the August sentinel bottom-trawl surveys of the southern Gulf of St. Lawrence. Vertical lines denote approximate 95% confidence limits (± 2 standard errors).

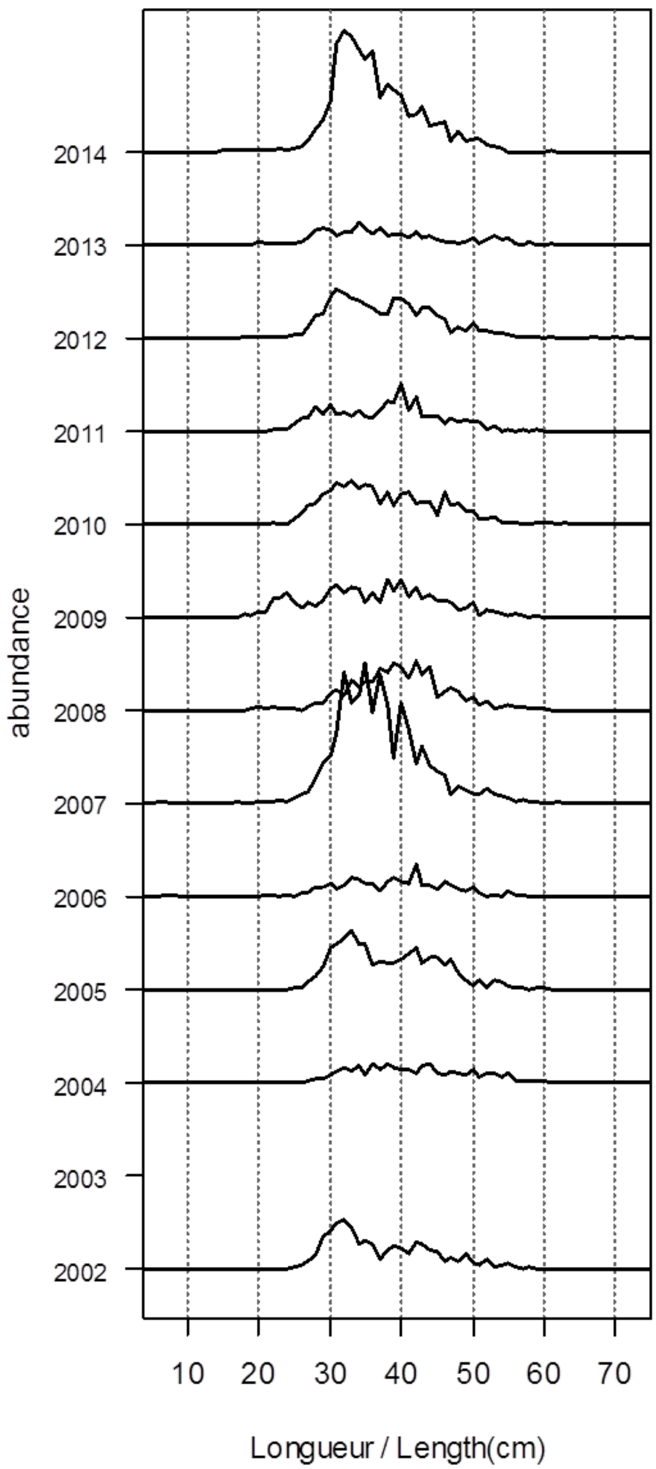


Figure 14. Length frequencies of white hake in in the southern Gulf of St. Lawrence from September bottom-trawl surveys from 2002 to 2014. Strata 401, 403 and 415 to 439 are those used for the white hake abundance index.

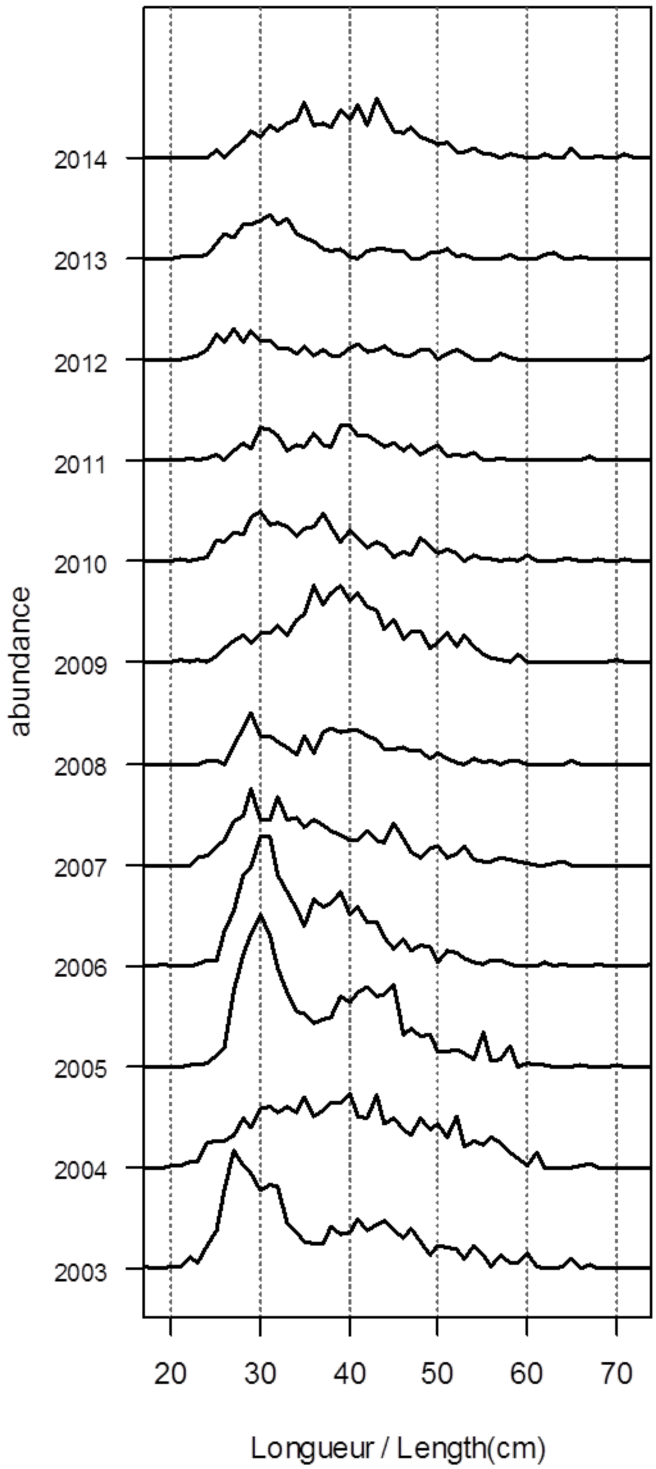


Figure 15. Length frequencies of white hake in in the southern Gulf of St. Lawrence from August sentinel bottom-trawl surveys from 2003 to 2014. Strata 401 to 439 are those used for the white hake abundance index.

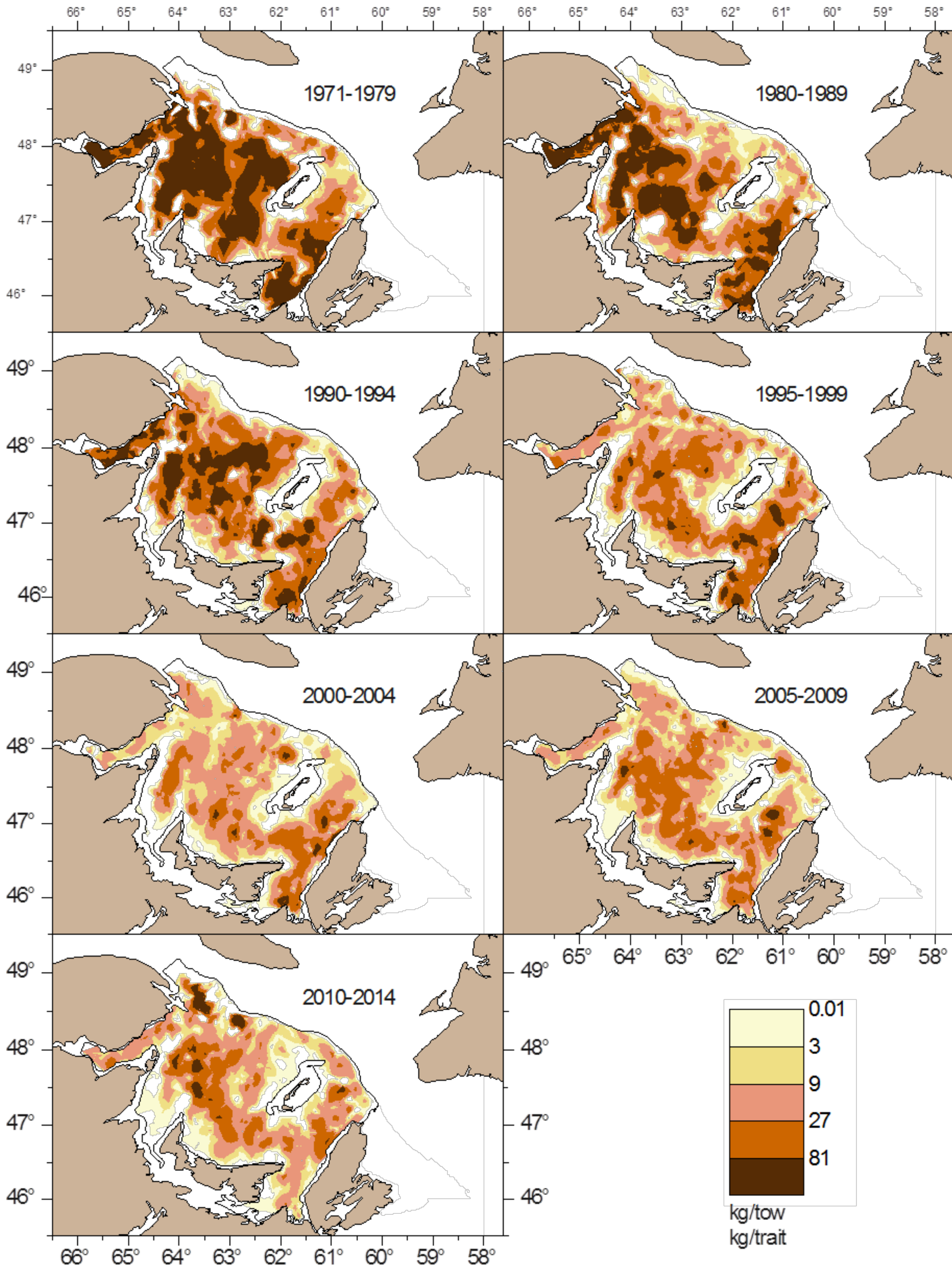


Figure 16. Spatial distribution of American plaice catches over time in the southern Gulf of St. Lawrence from September bottom-trawl surveys.

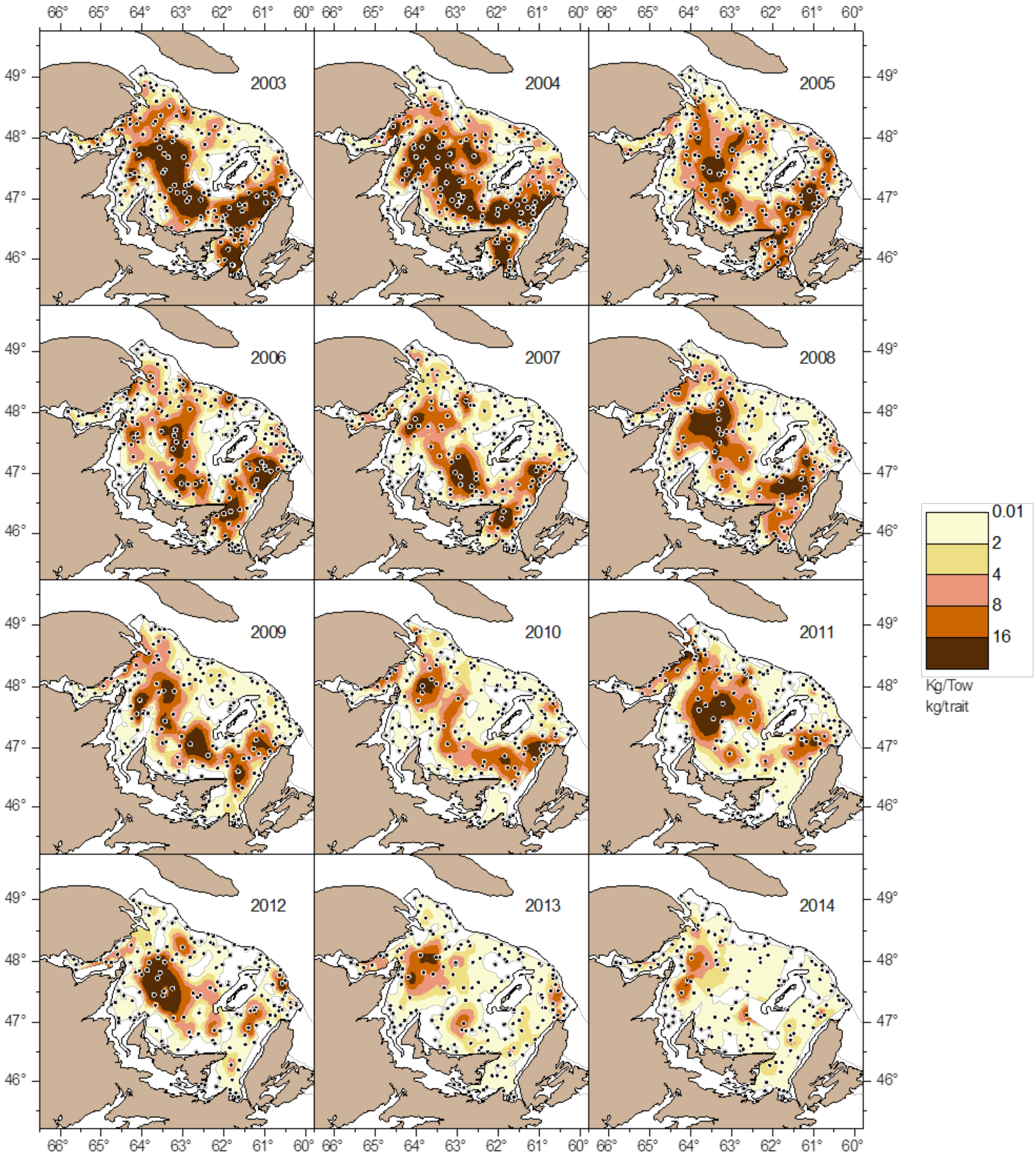


Figure 17. Spatial distribution of American plaice catches over time in the southern Gulf of St. Lawrence from August sentinel bottom-trawl surveys. Catches have been adjusted for vessel differences. The dots indicate the location of fishing sets.

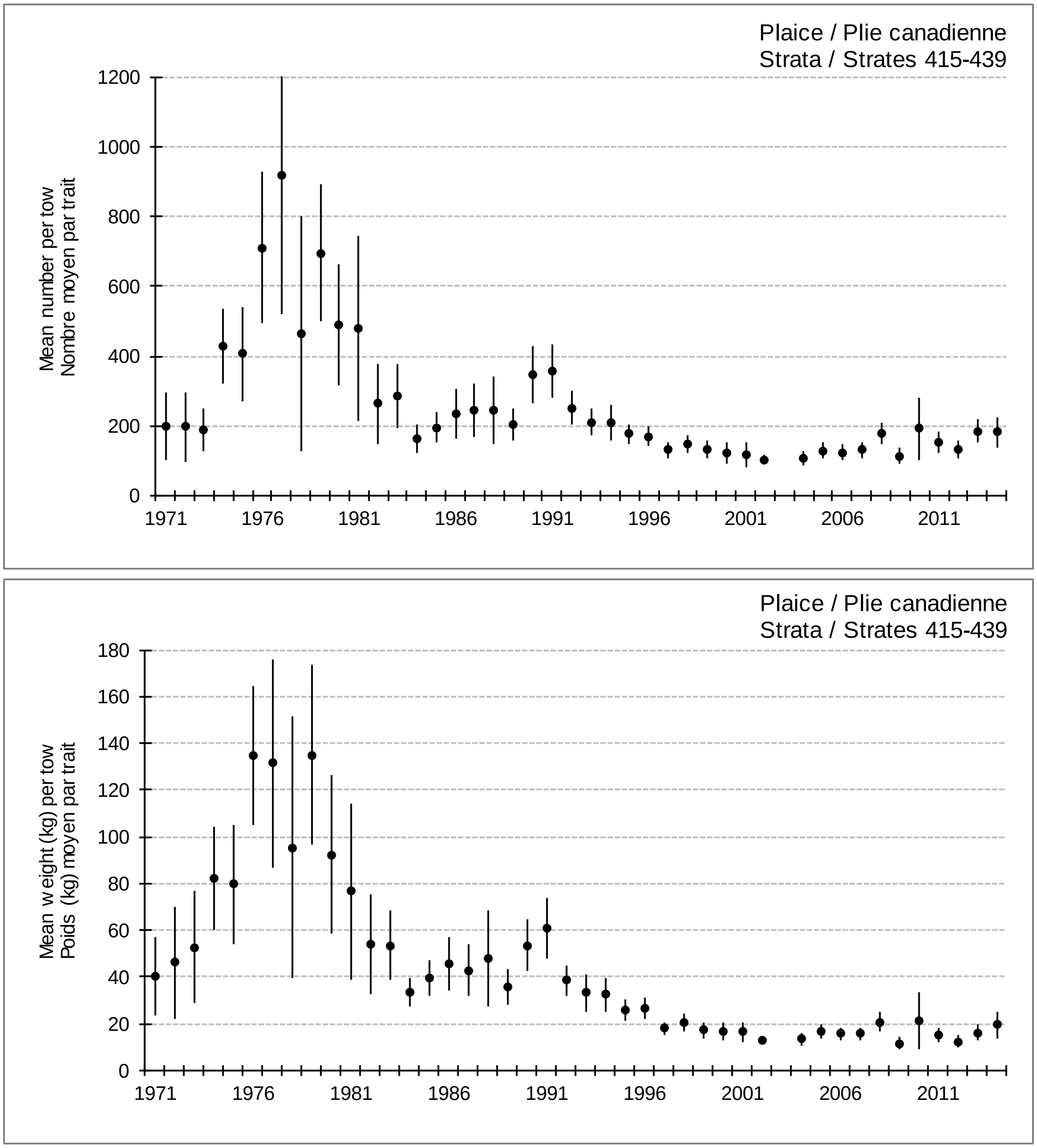


Figure 18. Mean annual catch abundance (top) and weight (bottom) per tow of American plaice in the southern Gulf of St. Lawrence September bottom-trawl surveys. Vertical lines denote approximate 95% confidence limits (± 2 standard errors).

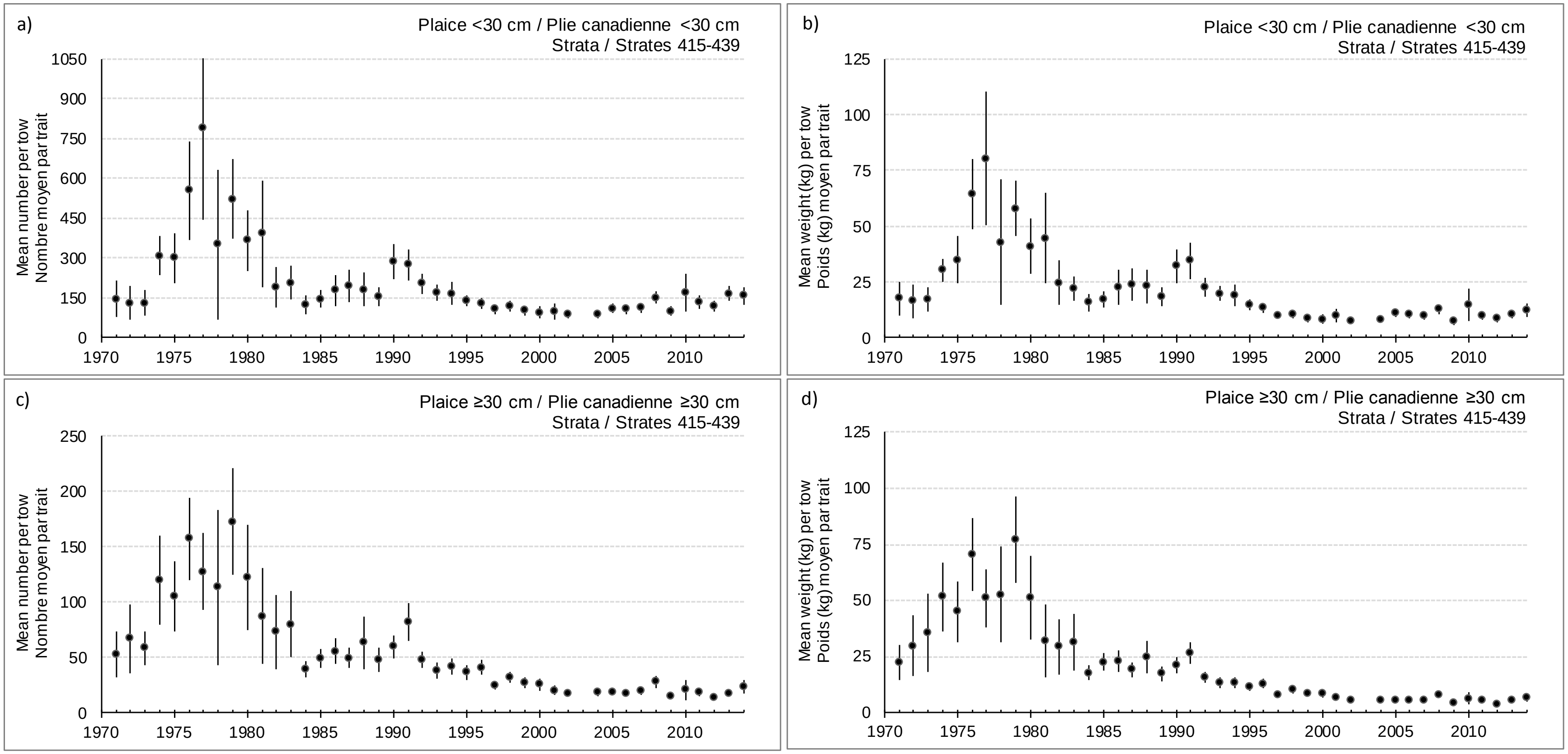


Figure 19. Mean annual catch abundance and weight per tow of American plaice <30 cm in length (top) and ≥30 cm (bottom) in the southern Gulf of St. Lawrence September bottom-trawl surveys. Vertical lines denote approximate 95% confidence limits (± 2 standard errors).

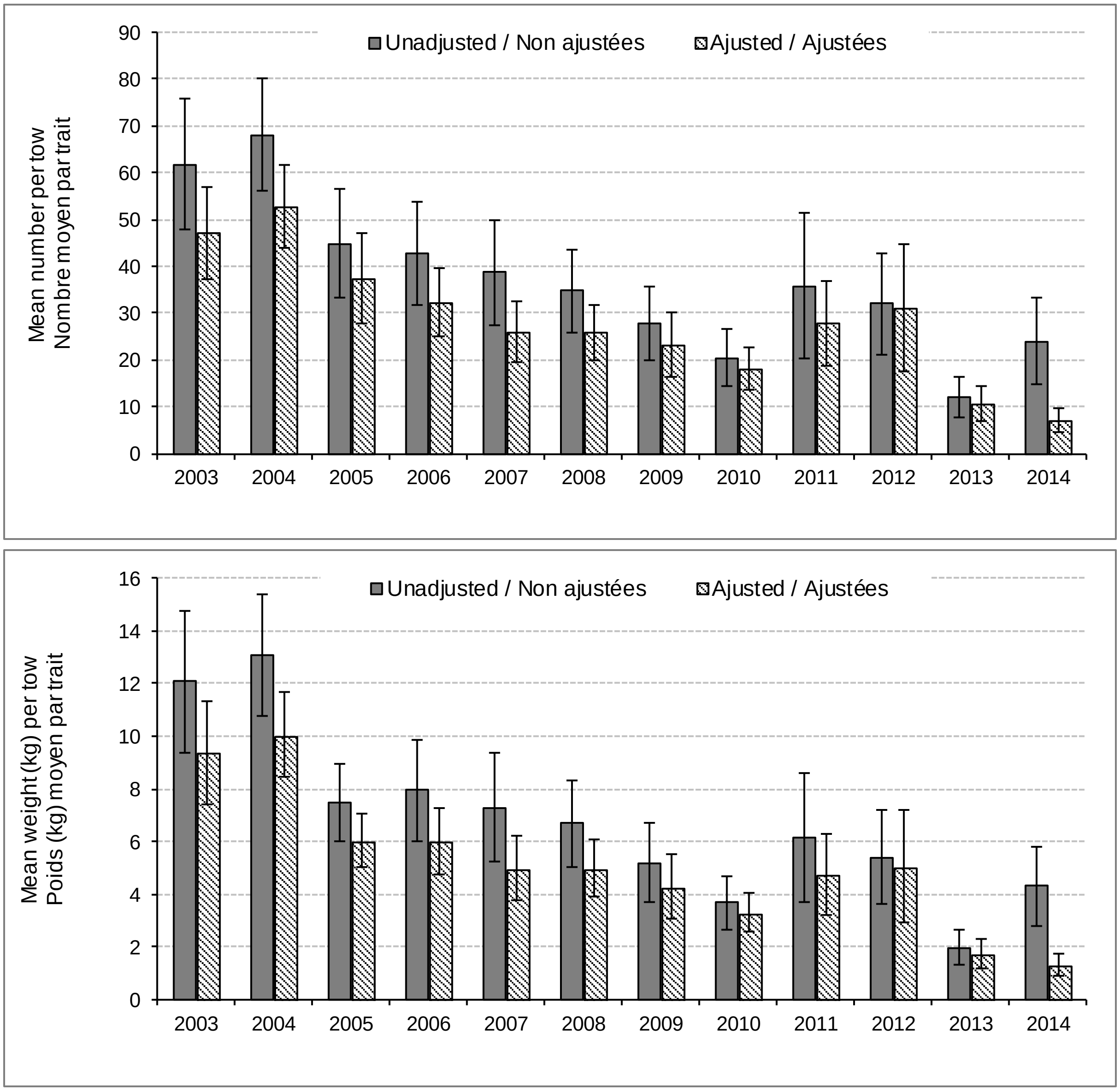


Figure 20. Mean annual numbers (top) and weight (bottom) per tow of American plaice in the August sentinel bottom-trawl surveys of the southern Gulf of St. Lawrence. Adjusted values for vessel efficiency are represented by stripped bars, and unadjusted ones are represented by grey bars. Vertical lines denote approximate 95% confidence limits (± 2 standard errors).

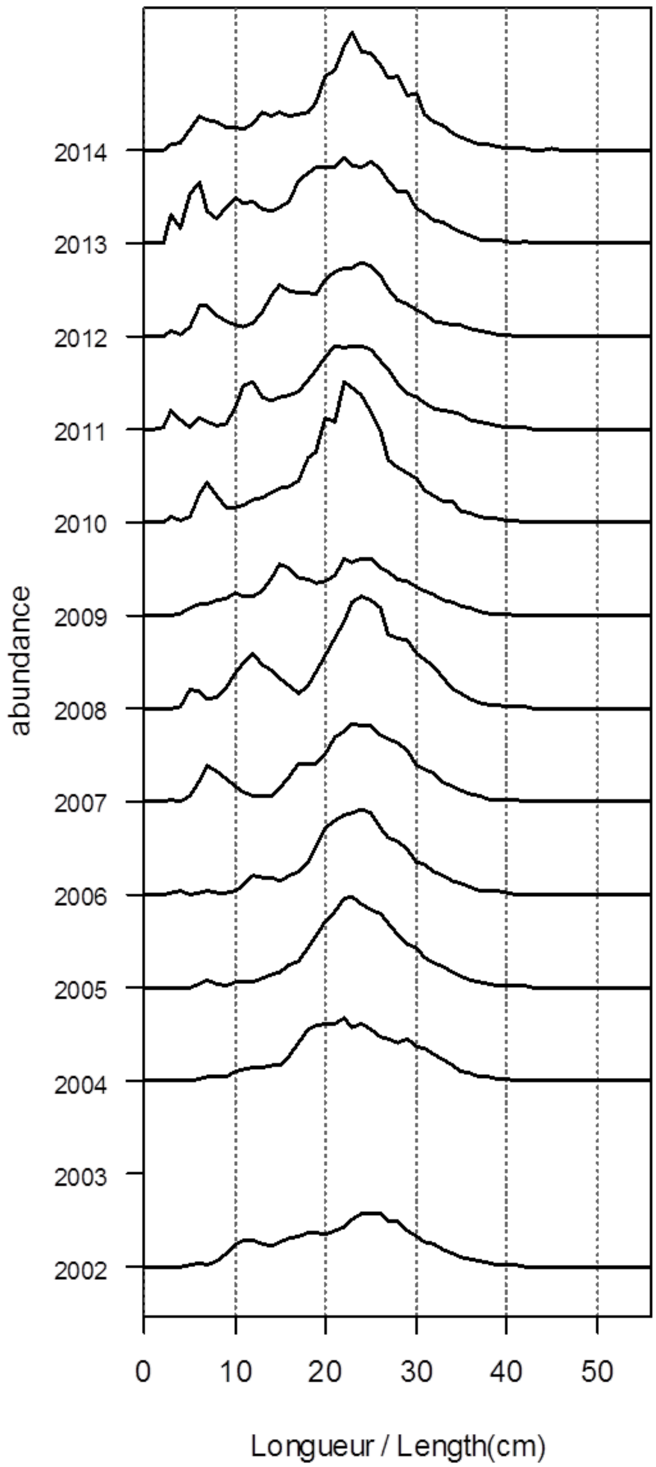


Figure 21. Length frequencies of American plaice in in the southern Gulf of St. Lawrence from September bottom-trawl surveys from 2002 to 2014. Strata 415 to 439 are those used for the American plaice abundance index.

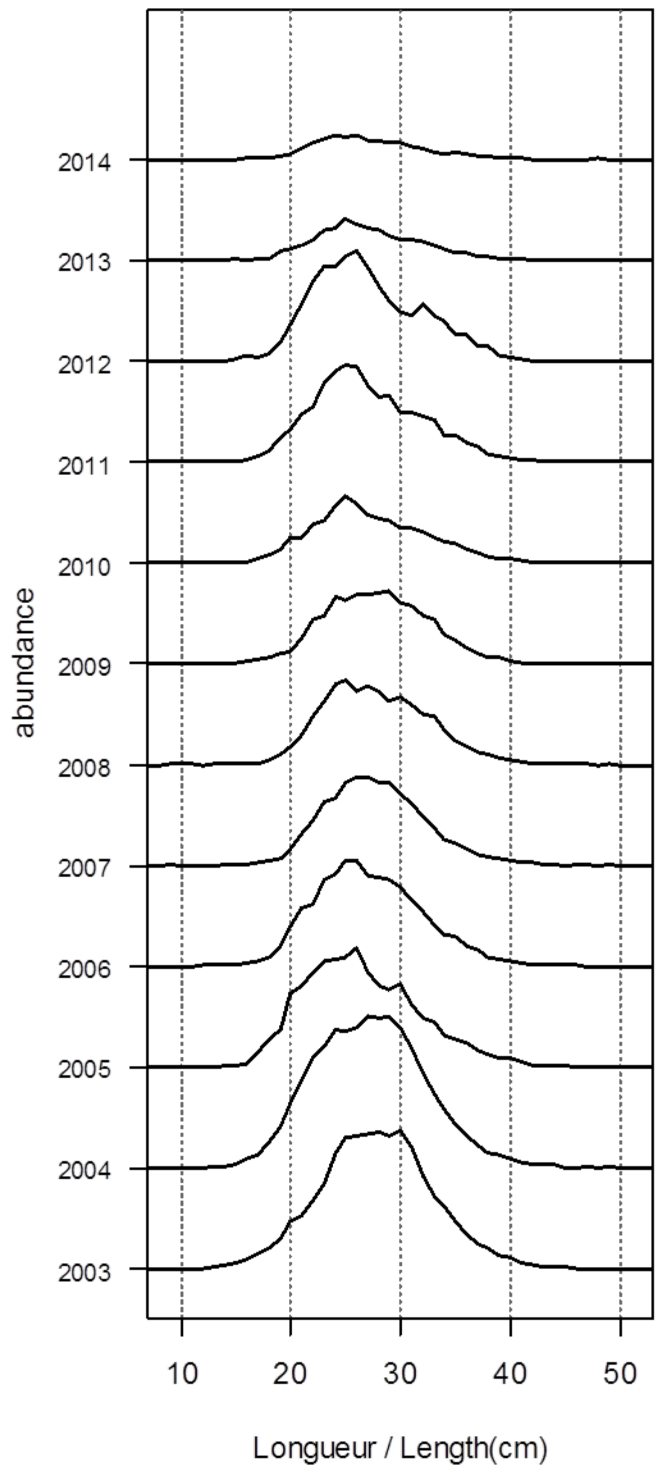


Figure 22. Length frequencies of American plaice in in the southern Gulf of St. Lawrence from August sentinel bottom-trawl surveys from 2003 to 2014. Strata 401 to 439 are those used for the American plaice abundance index.

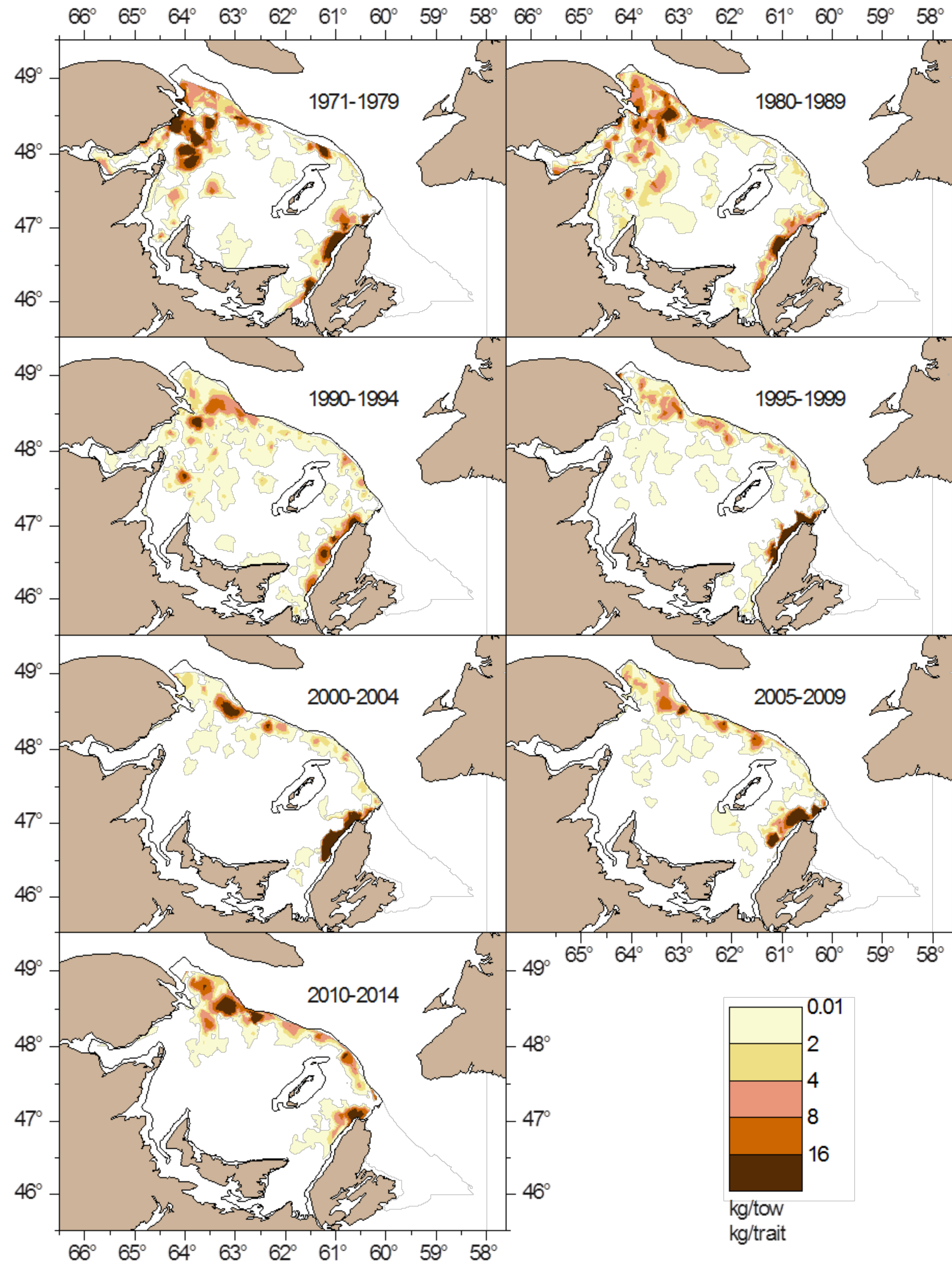


Figure 23. Spatial distribution of witch flounder catches over time in the southern Gulf of St. Lawrence from September bottom-trawl surveys.

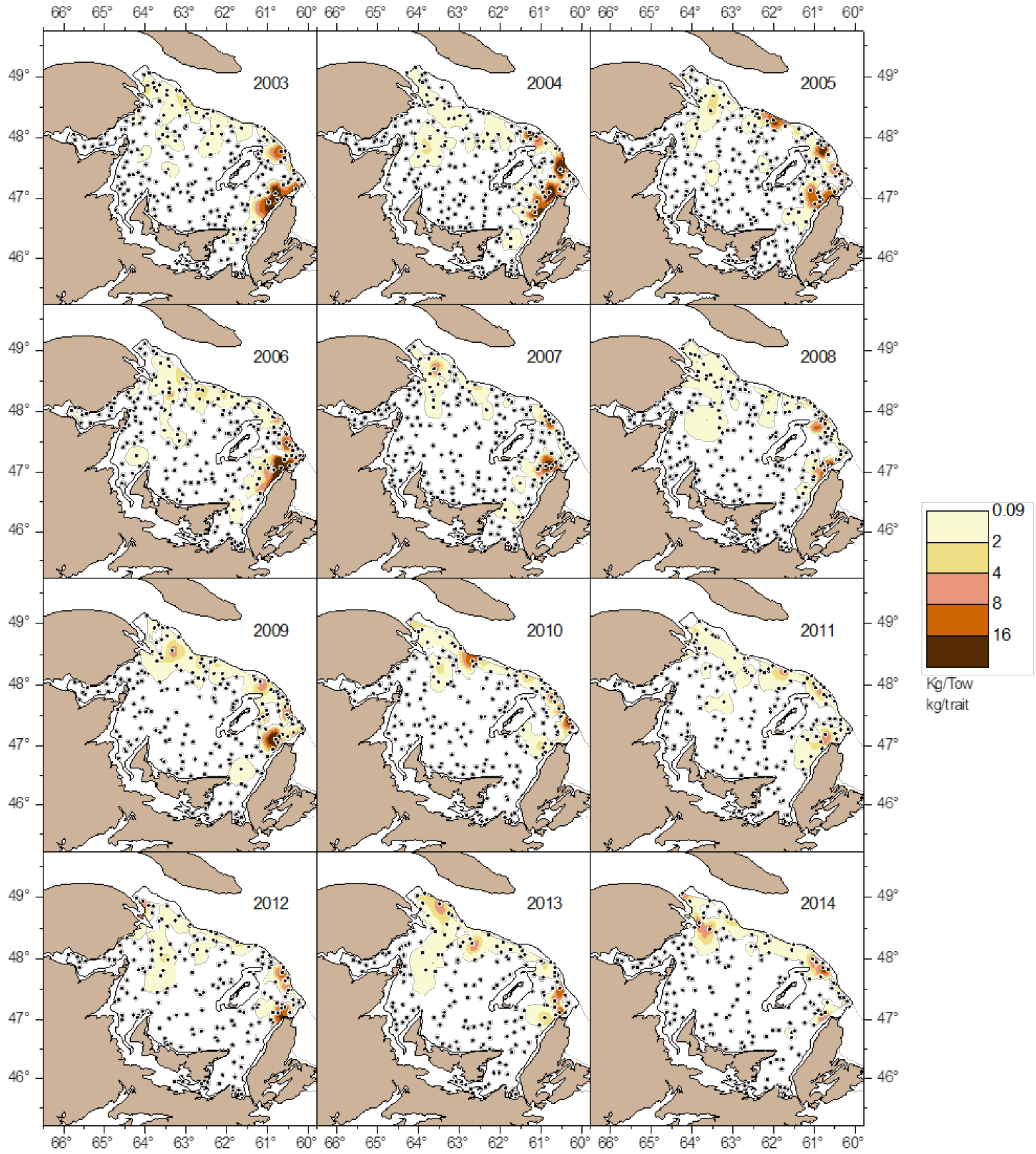


Figure 24. Spatial distribution of witch flounder catches over time in the southern Gulf of St. Lawrence from August sentinel bottom-trawl surveys. Catches were not adjusted for vessel differences. The dots indicate the location of fishing sets.

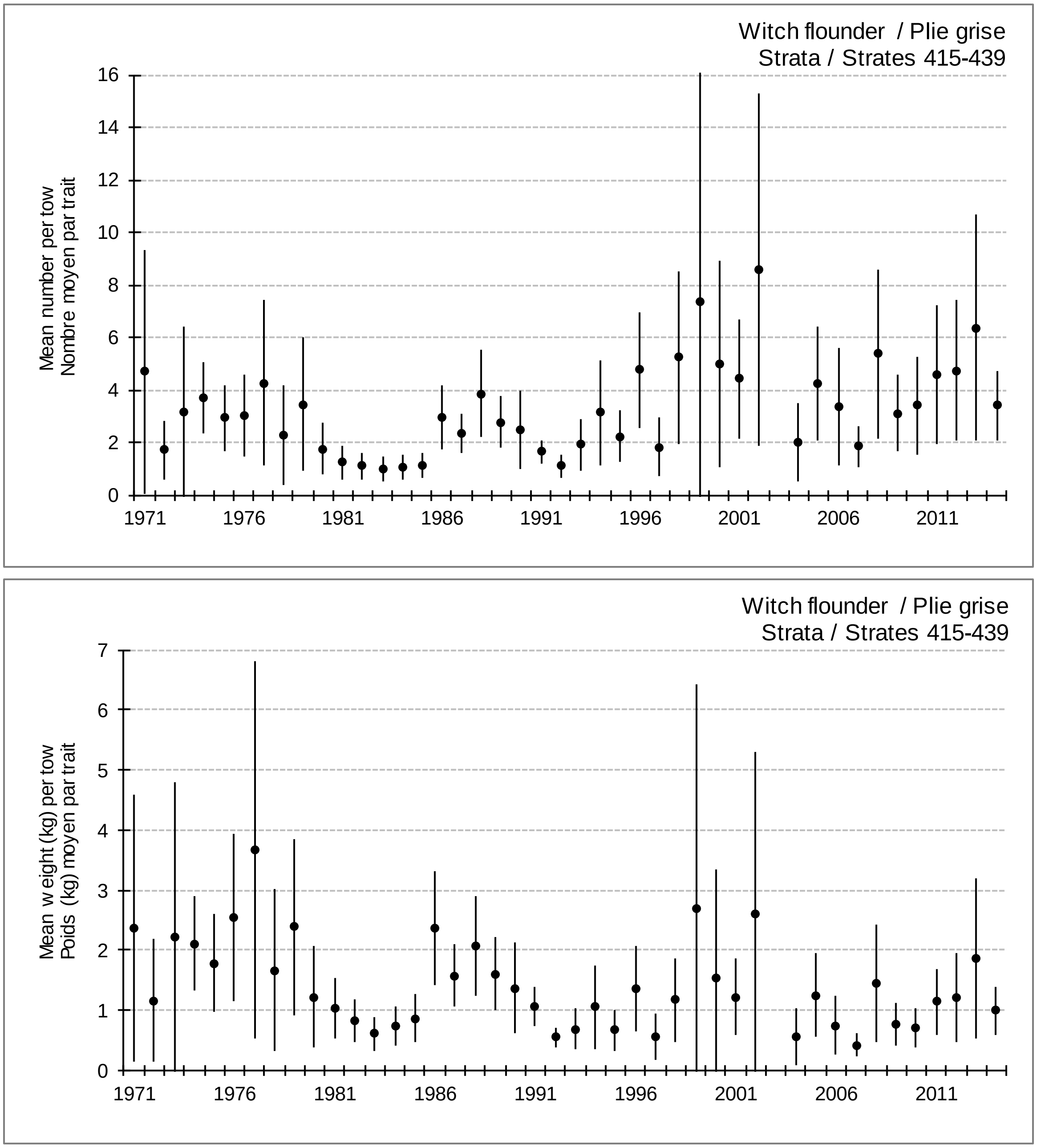


Figure 25. Mean annual catch abundance (top) and weight (bottom) per tow of witch flounder in the southern Gulf of St. Lawrence September bottom-trawl surveys. Vertical lines denote approximate 95% confidence limits (± 2 standard errors).

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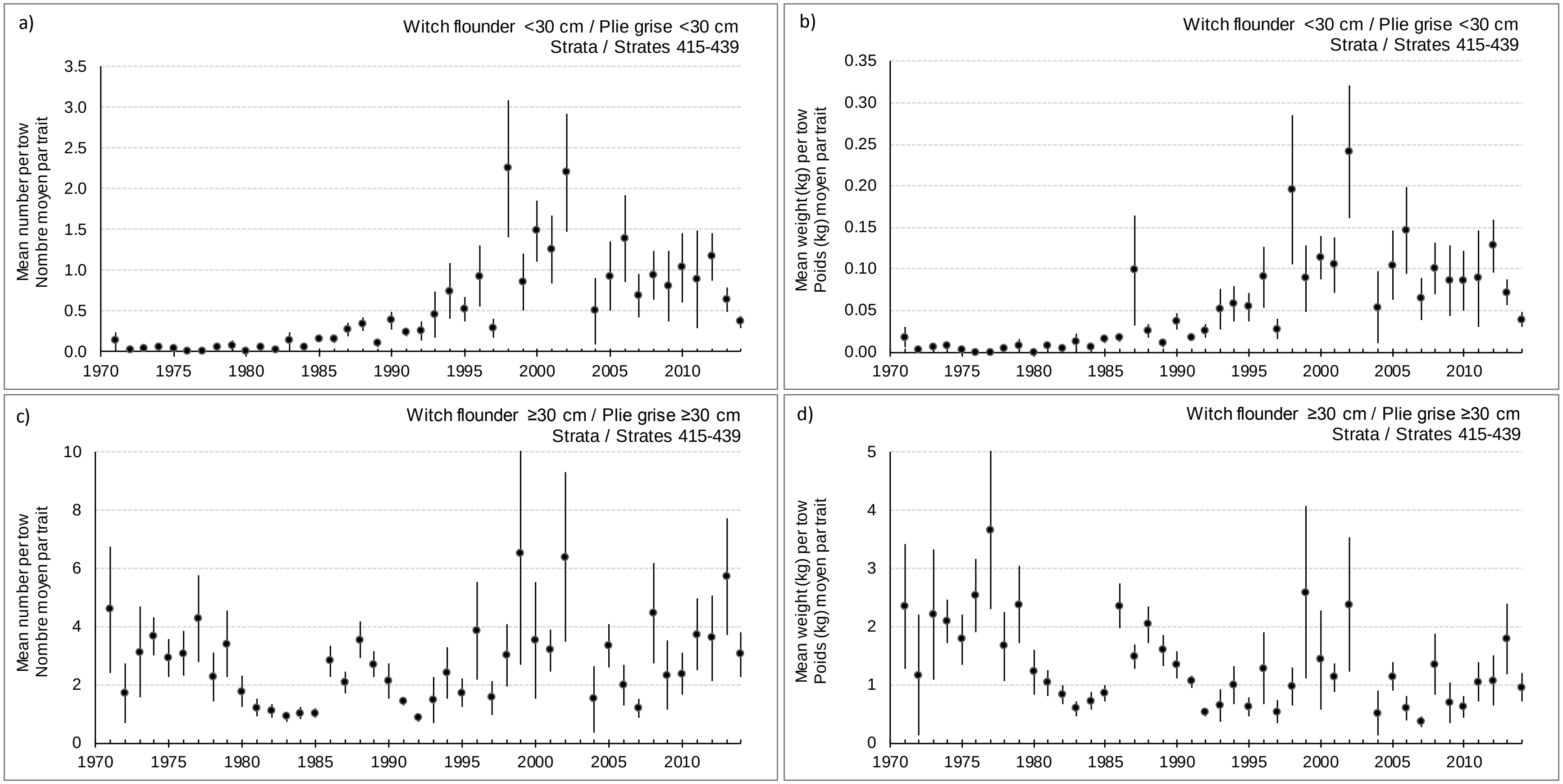
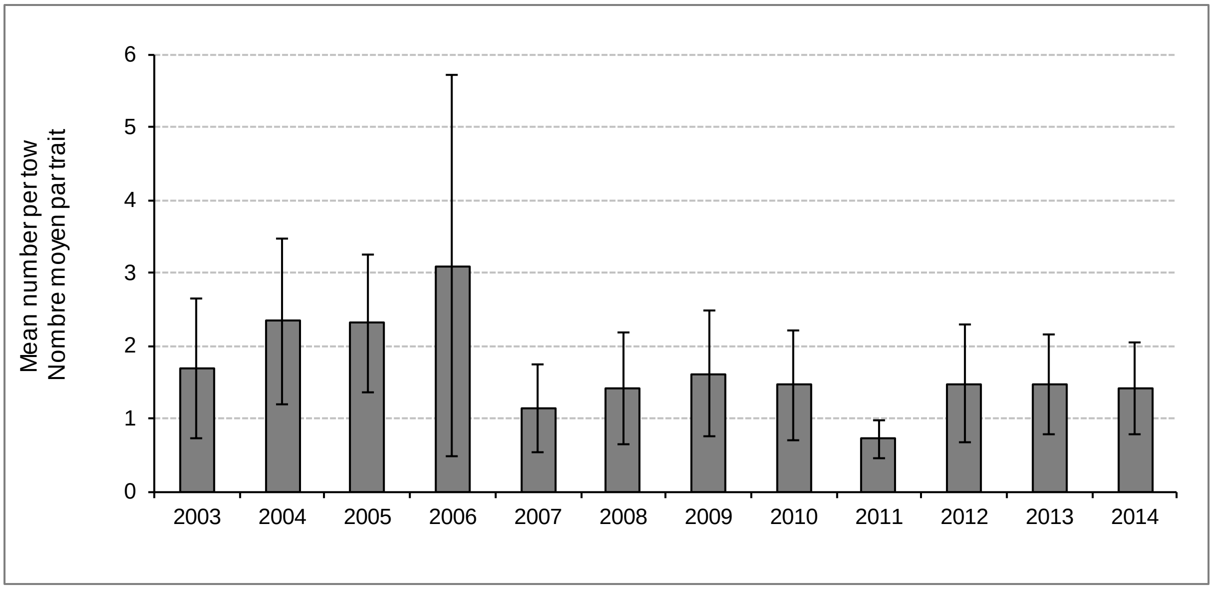


Figure 26. Mean annual catch abundance and weight per tow of witch flounder <30 cm in length (top) and ≥30 cm (bottom) in the southern Gulf of St. Lawrence September bottom-trawl surveys. Vertical lines denote approximate 95% confidence limits (± 2 standard errors).



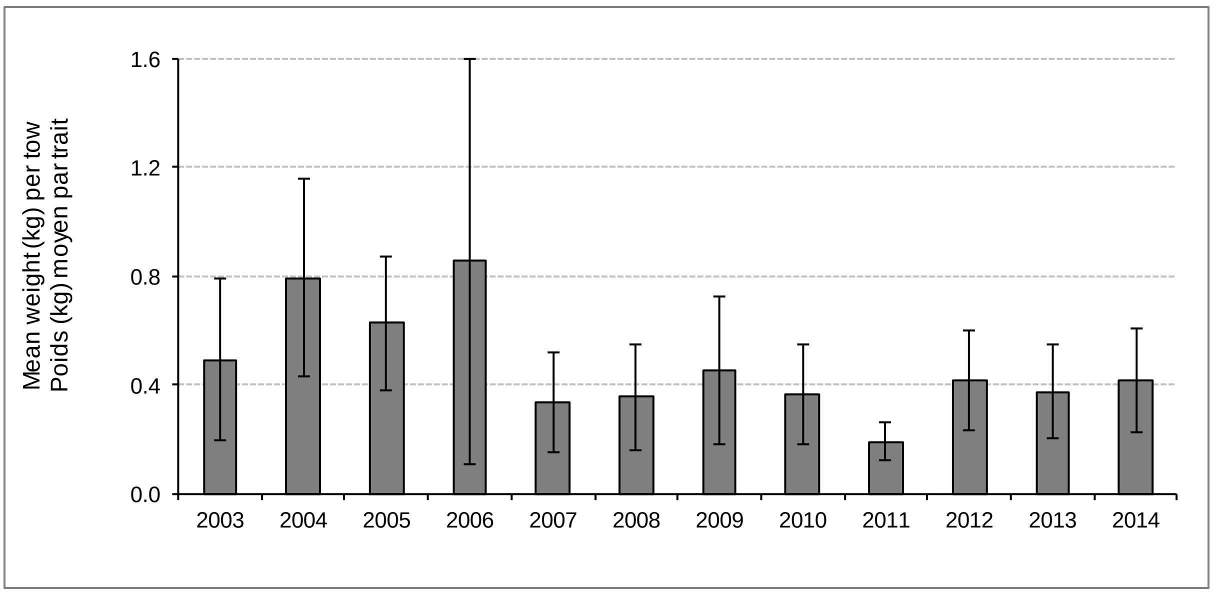


Figure 27. Mean annual numbers (top) and weight (bottom) per tow of witch flounder in the August sentinel bottom-trawl surveys of the southern Gulf of St. Lawrence. Vertical lines denote approximate 95% confidence limits (± 2 standard errors).

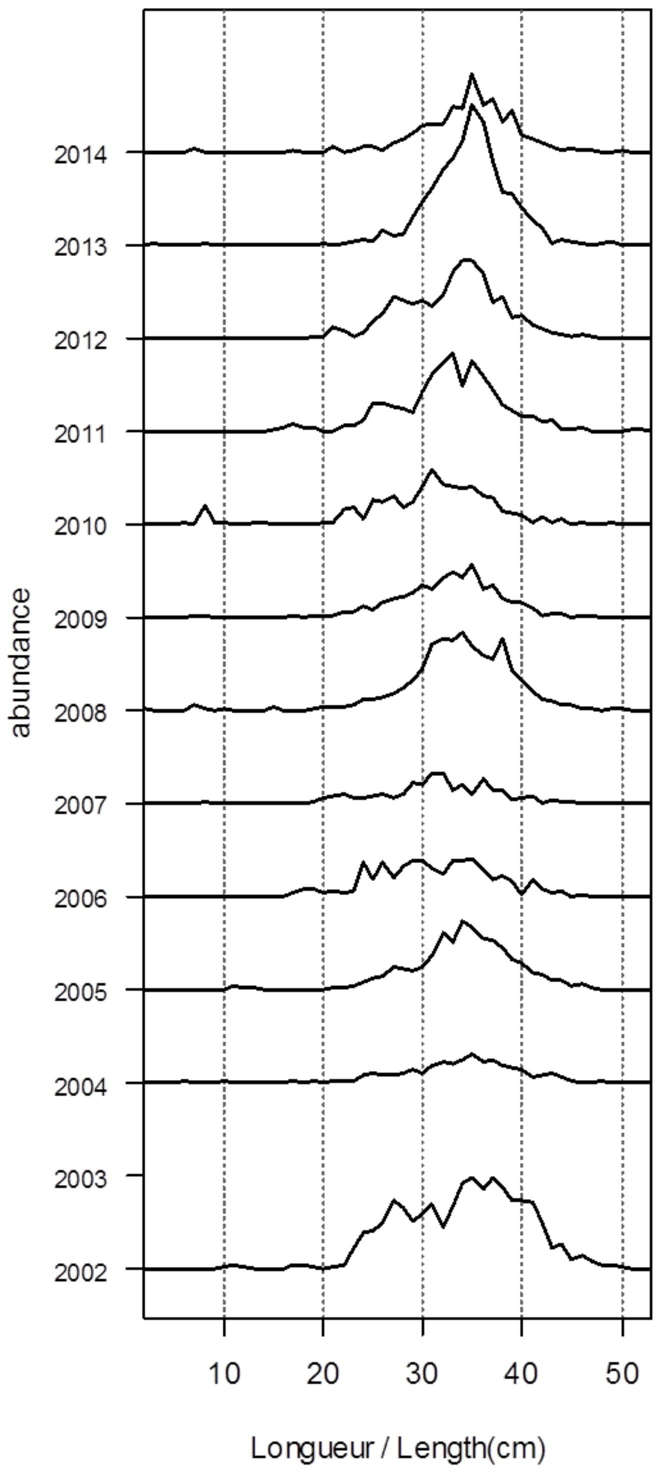


Figure 28. Length frequencies of witch flounder in in the southern Gulf of St. Lawrence from September bottom-trawl surveys from 2002 to 2014. Strata 415 to 439 are those used for the witch flounder abundance index.

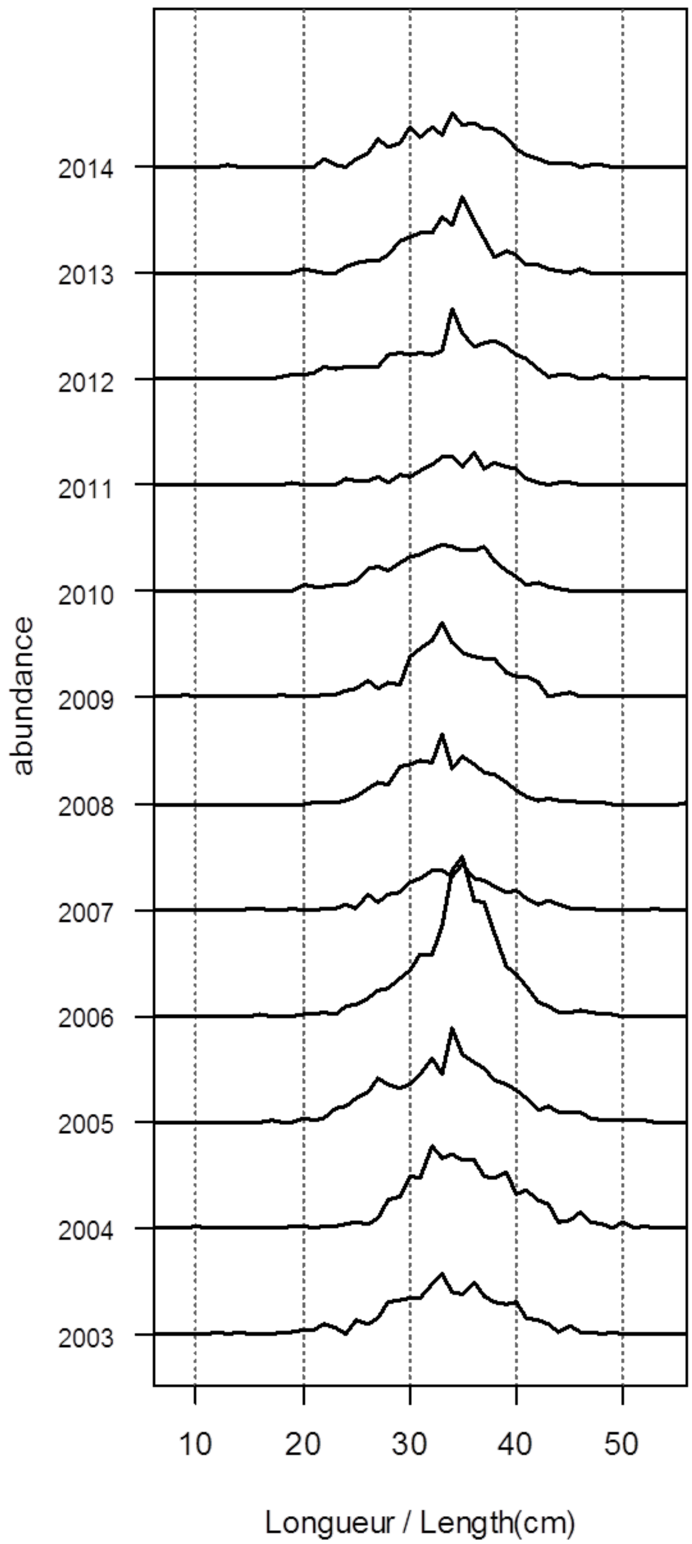


Figure 29. Length frequencies of witch flounder in in the southern Gulf of St. Lawrence from August sentinel bottom-trawl surveys from 2003 to 2014. Strata 401 to 439 are those used for the witch flounder abundance index.

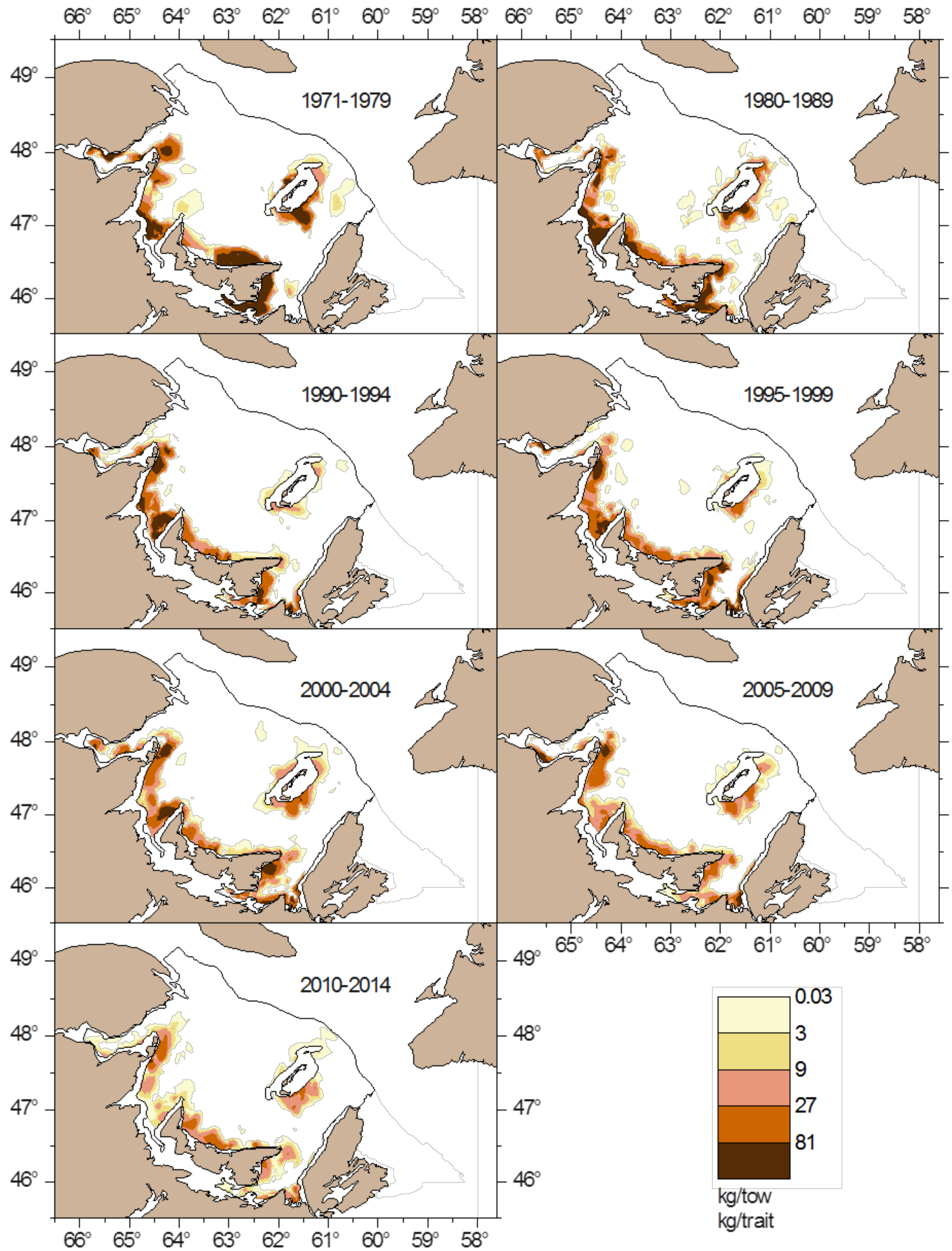


Figure 30. Spatial distribution of winter flounder catches over time in the southern Gulf of St. Lawrence from September bottom-trawl surveys.

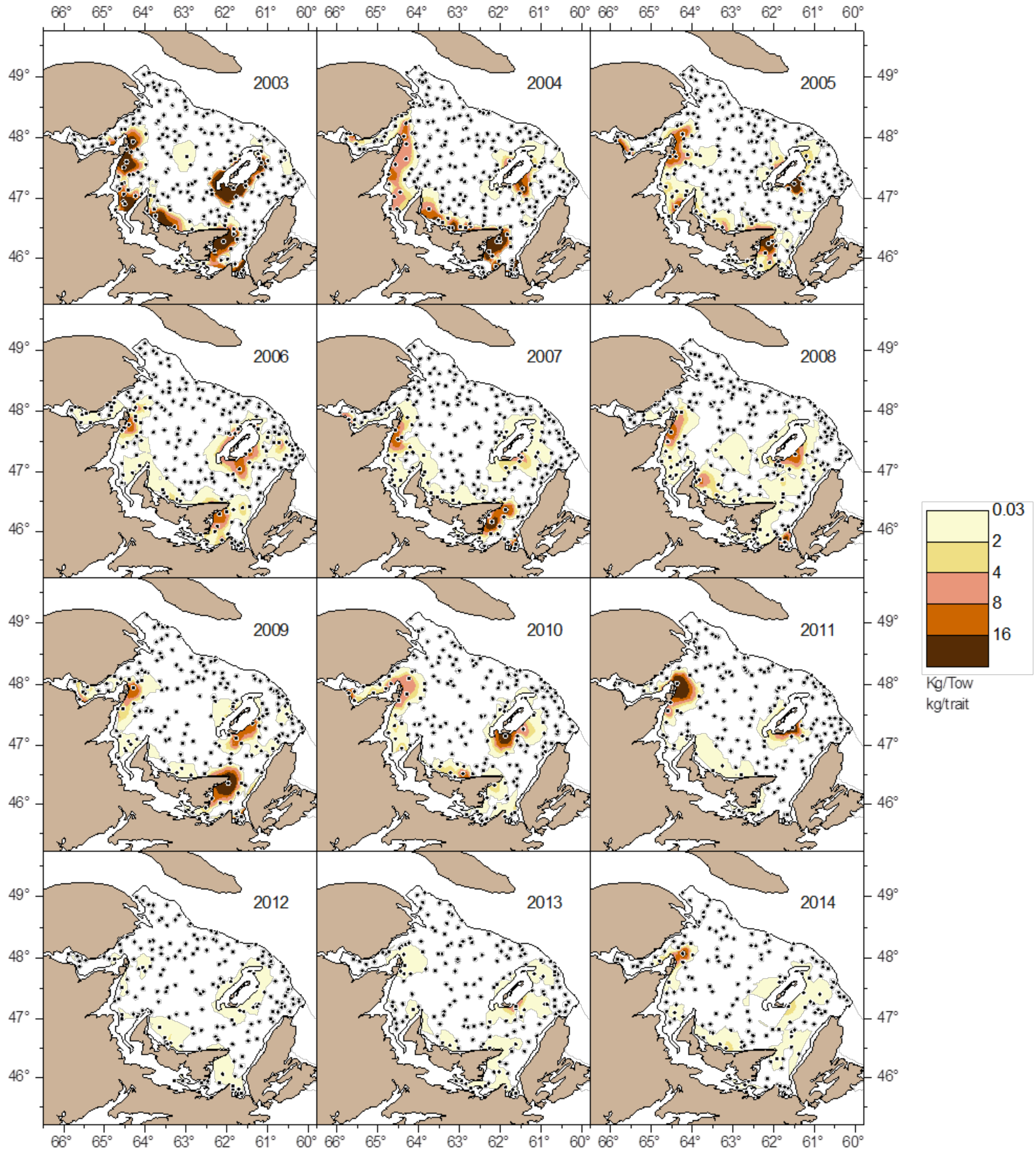


Figure 31. Spatial distribution of winter flounder catches over time in the southern Gulf of St. Lawrence from August sentinel bottom-trawl surveys. Catches were not adjusted for vessel differences. The dots indicate the location of fishing sets.

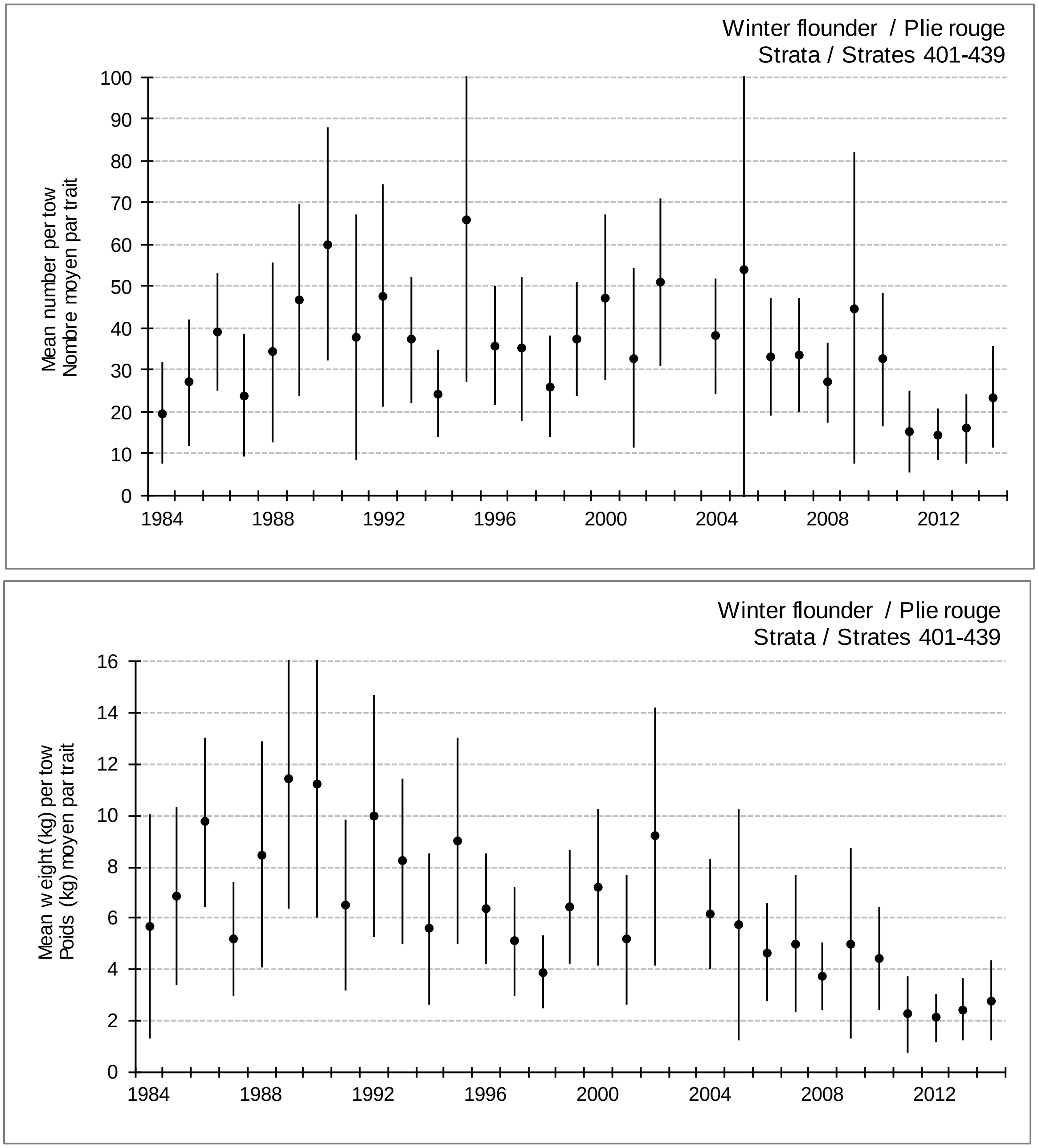


Figure 32. Mean annual catch abundance (top) and weight (bottom) per tow of winter flounder in the southern Gulf of St. Lawrence September bottom-trawl surveys. Vertical lines denote approximate 95% confidence limits (± 2 standard errors).

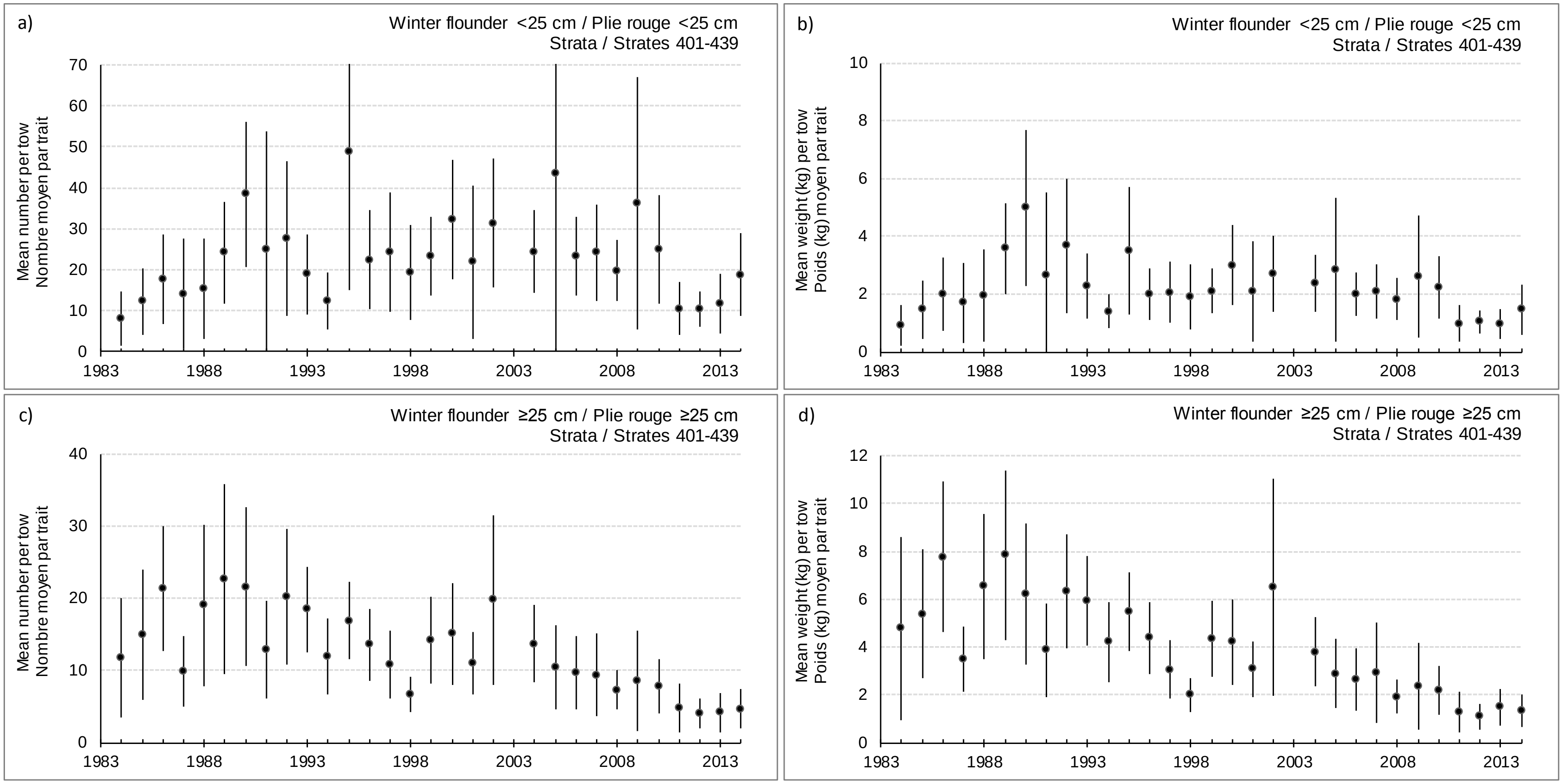


Figure 33. Mean annual catch abundance and weight per tow of winter flounder <25 cm in length (top) and ≥25 cm (bottom) in the southern Gulf of St. Lawrence September bottom-trawl surveys. Vertical lines denote approximate 95% confidence limits (± 2 standard errors).

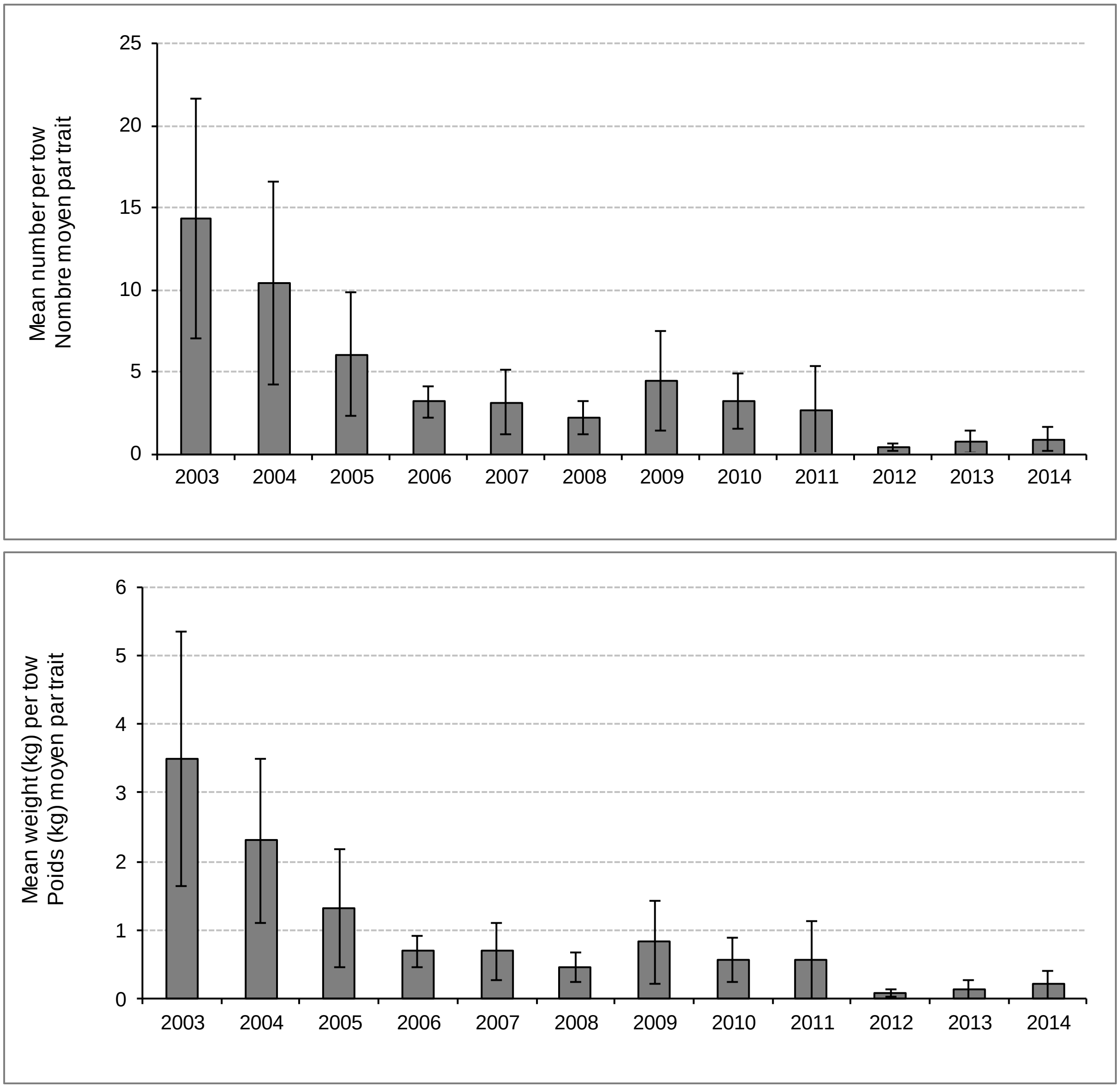


Figure 34. Mean annual numbers (top) and weight (bottom) per tow of winter flounder in the August sentinel bottom-trawl surveys of the southern Gulf of St. Lawrence. Vertical lines denote approximate 95% confidence limits (± 2 standard errors).

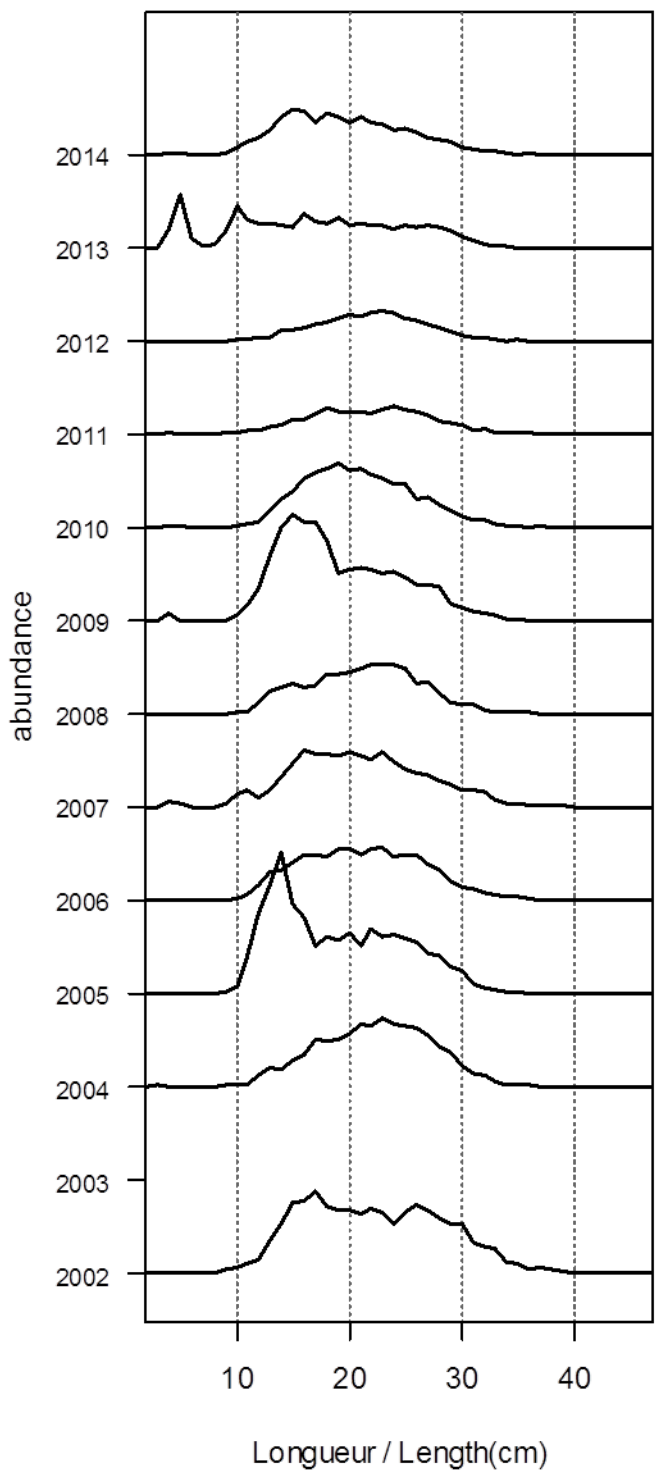


Figure 35. Length frequencies of winter flounder in in the southern Gulf of St. Lawrence from September bottom-trawl surveys from 2002 to 2014. Strata 401 to 439 are those used for the winter flounder abundance index.

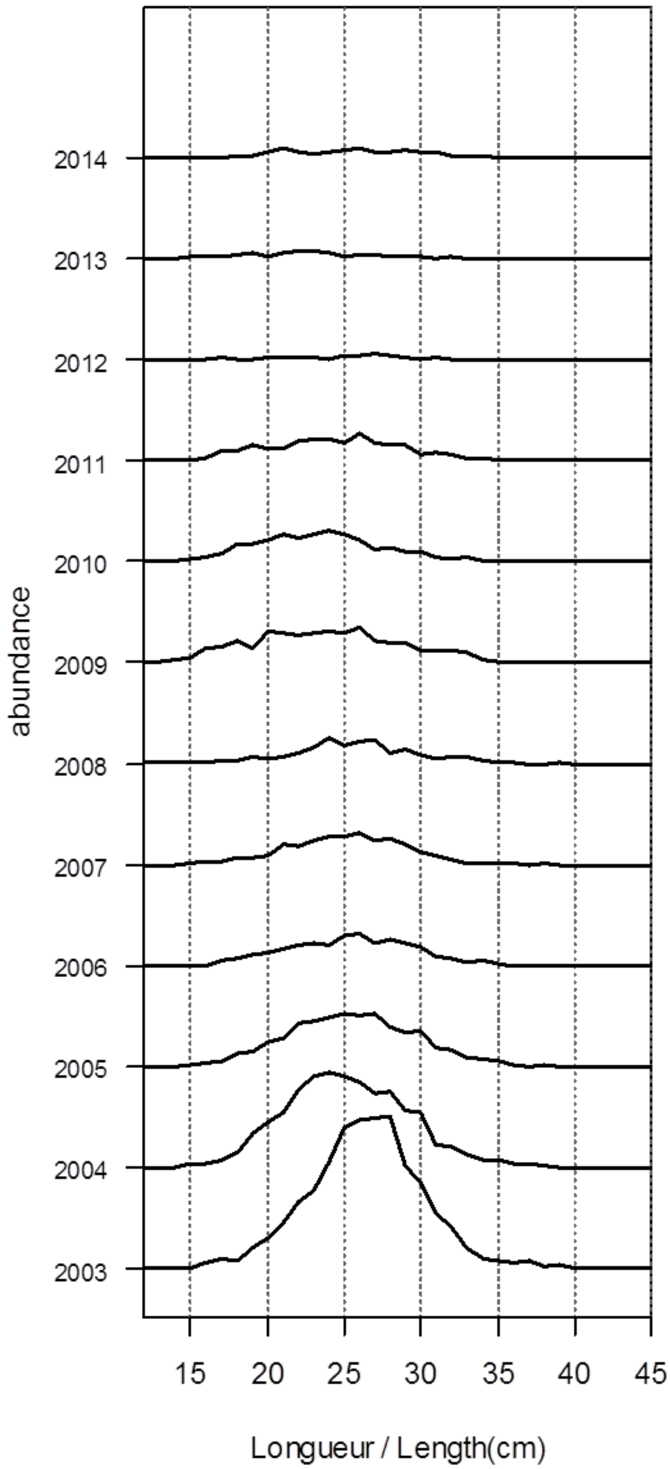


Figure 36. Length frequencies of winter flounder in in the southern Gulf of St. Lawrence from August sentinel bottom-trawl surveys from 2003 to 2014. Strata 401 to 439 are those used for the winter flounder abundance index.

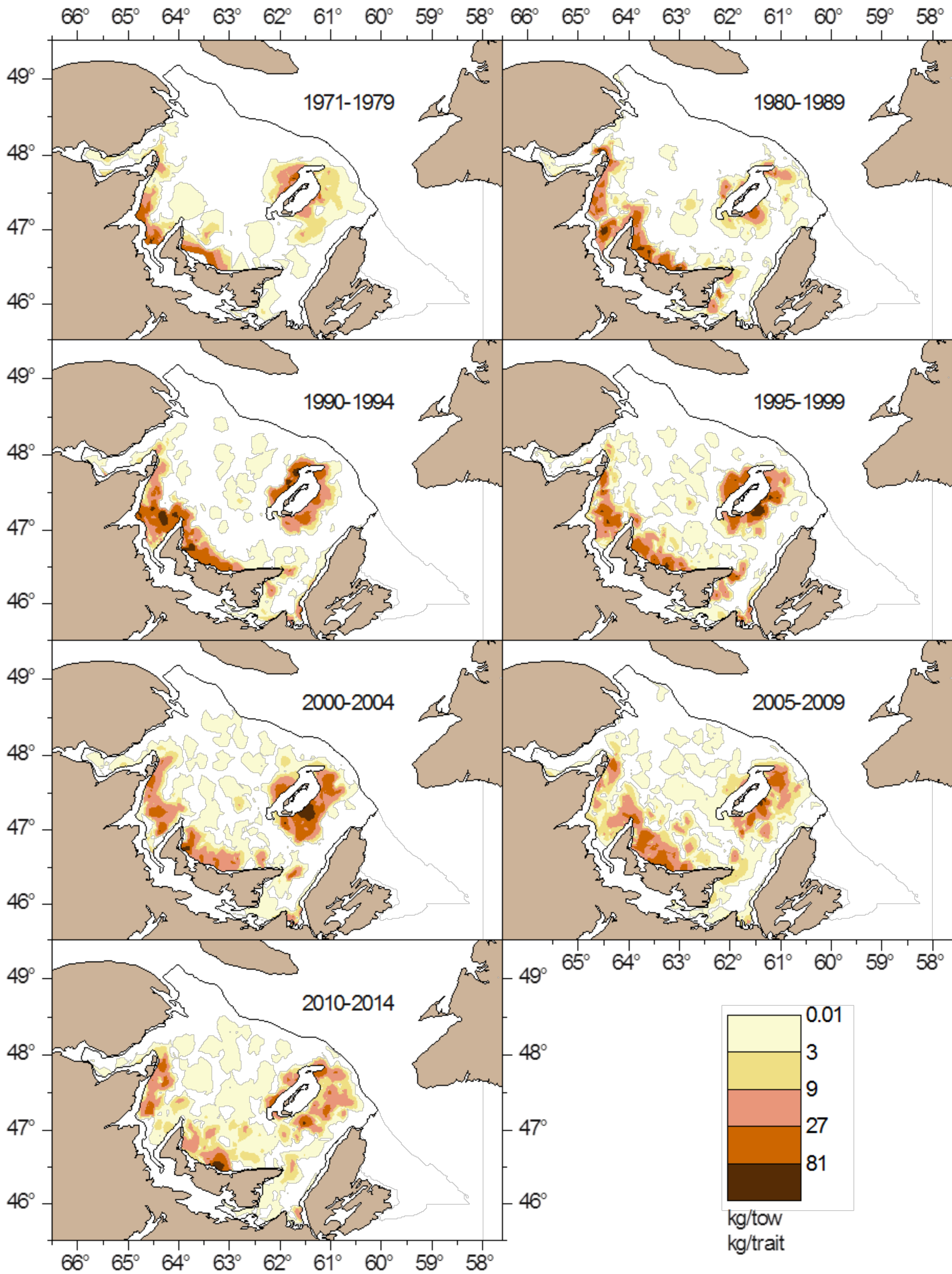


Figure 37. Spatial distribution of yellowtail flounder catches over time in the southern Gulf of St. Lawrence from September bottom-trawl surveys.

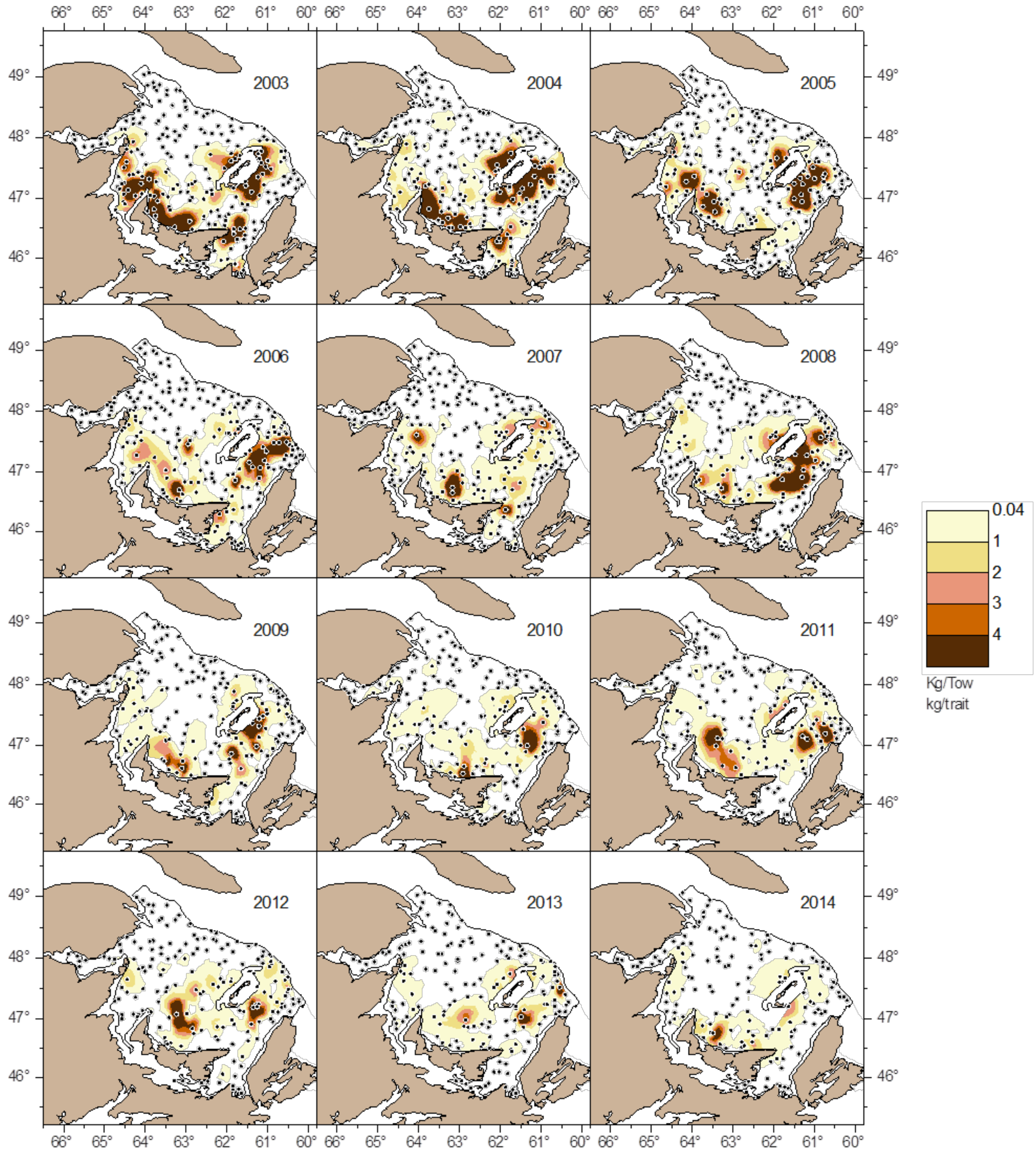


Figure 38. Spatial distribution of yellowtail flounder catches over time in the southern Gulf of St. Lawrence from August sentinel bottom-trawl surveys. Catches were not adjusted for vessel differences. The dots indicate the location of fishing sets.

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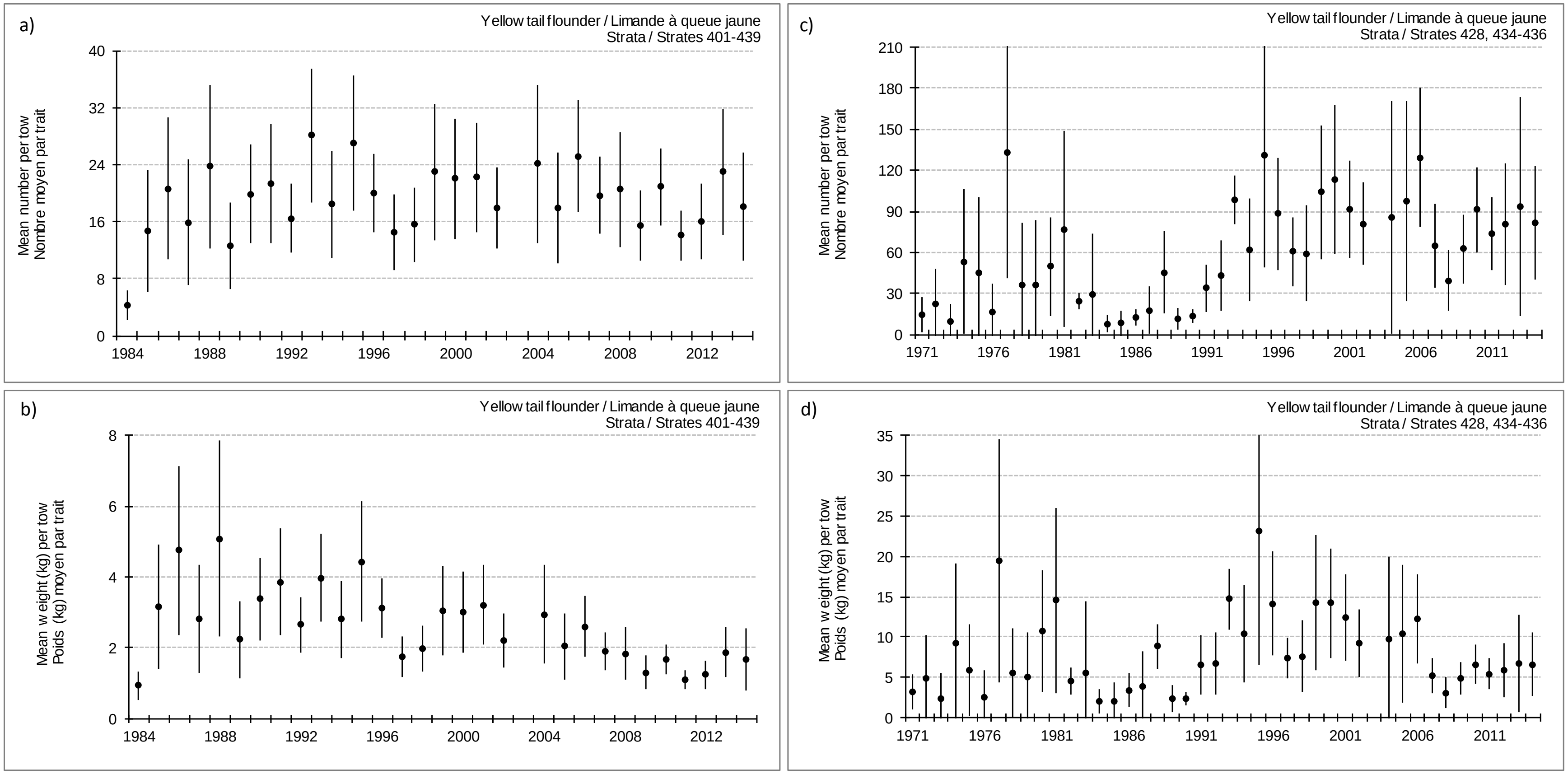

Figure 39. Mean annual catch abundance (top) and weight (bottom) per tow of yellowtail flounder in the southern Gulf of St. Lawrence September bottom-trawl surveys as a whole (left panels) and in strata near the Magdalen Islands (right panels; strata 428 and 434 to 436). Vertical lines denote approximate 95% confidence limits (± 2 standard errors).

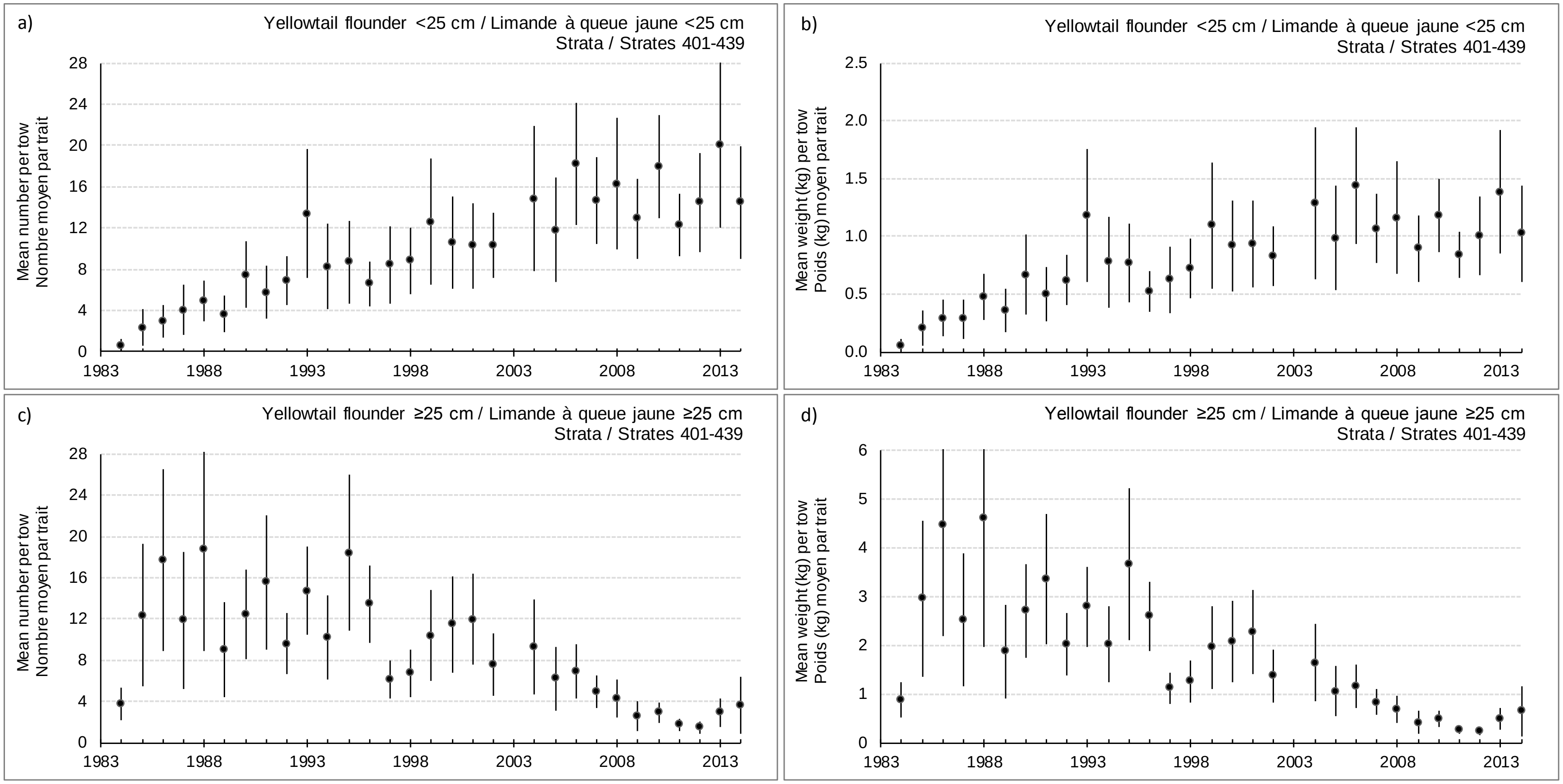

Figure 40. Mean annual catch abundance and weight per tow of yellowtail flounder <25 cm in length (top) and ≥25 cm (bottom) in the southern Gulf of St. Lawrence September bottom-trawl surveys. Vertical lines denote approximate 95% confidence limits (± 2 standard errors).

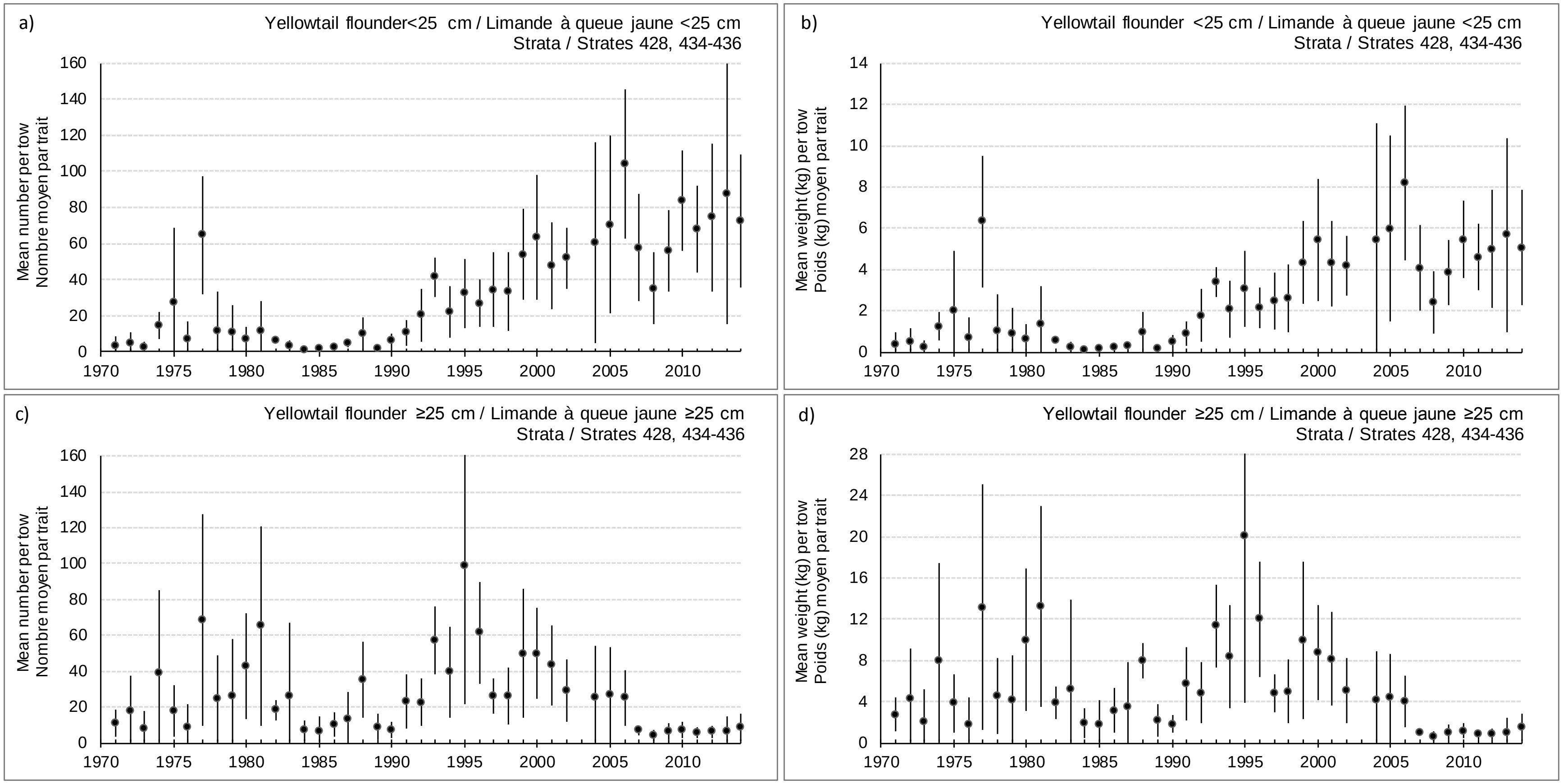

Figure 41. Mean annual catch abundance and weight per tow of yellowtail flounder <25 cm in length (top) and ≥25 cm (bottom) in strata near the Magdalen Islands from the September bottom-trawl surveys. Vertical lines denote approximate 95% confidence limits (± 2 standard errors).

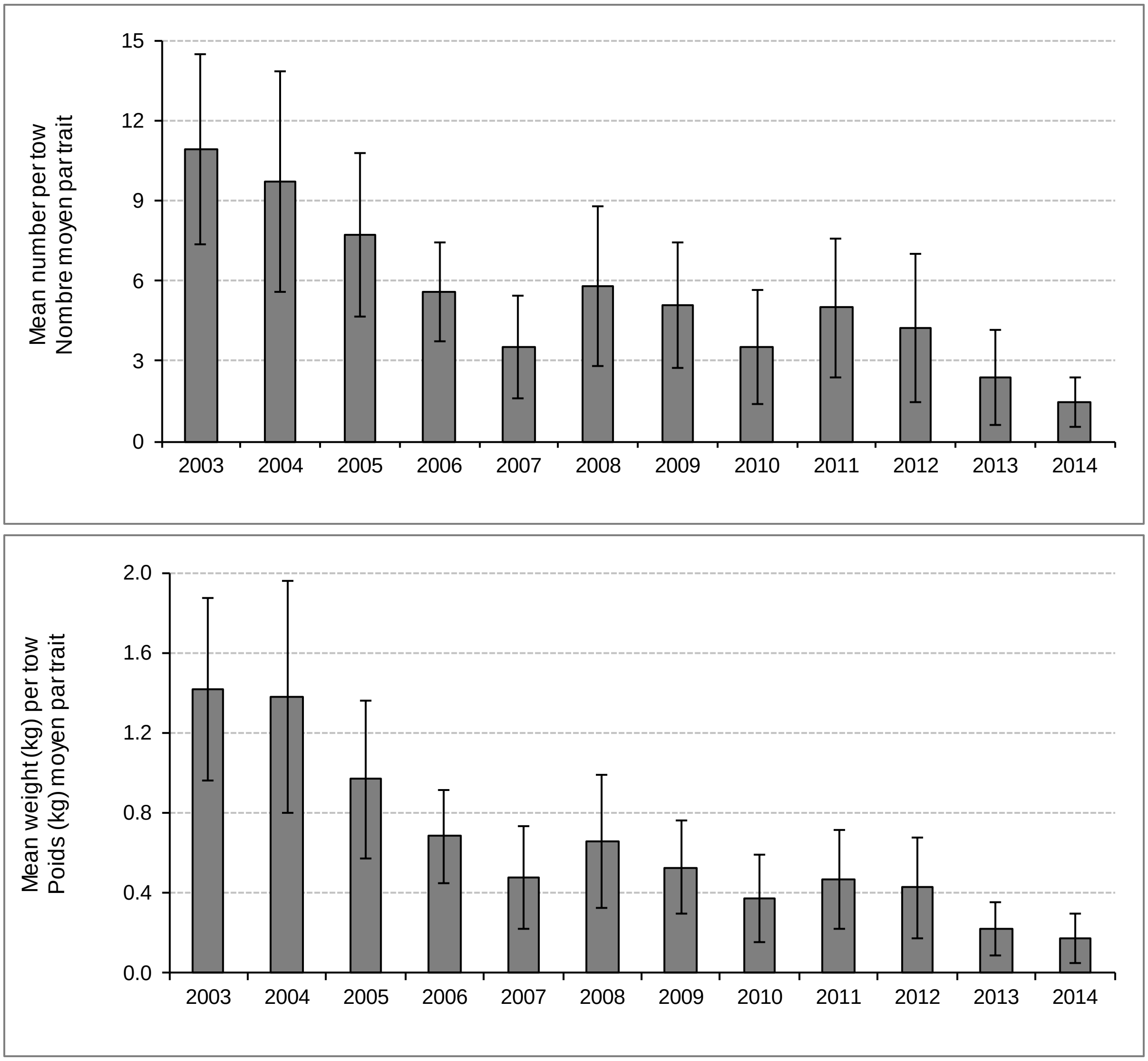

Figure 42. Mean annual numbers (top) and weight (bottom) per tow of yellowtail flounder in the August sentinel bottom-trawl surveys of the southern Gulf of St. Lawrence. Vertical lines denote approximate 95% confidence limits (± 2 standard errors).

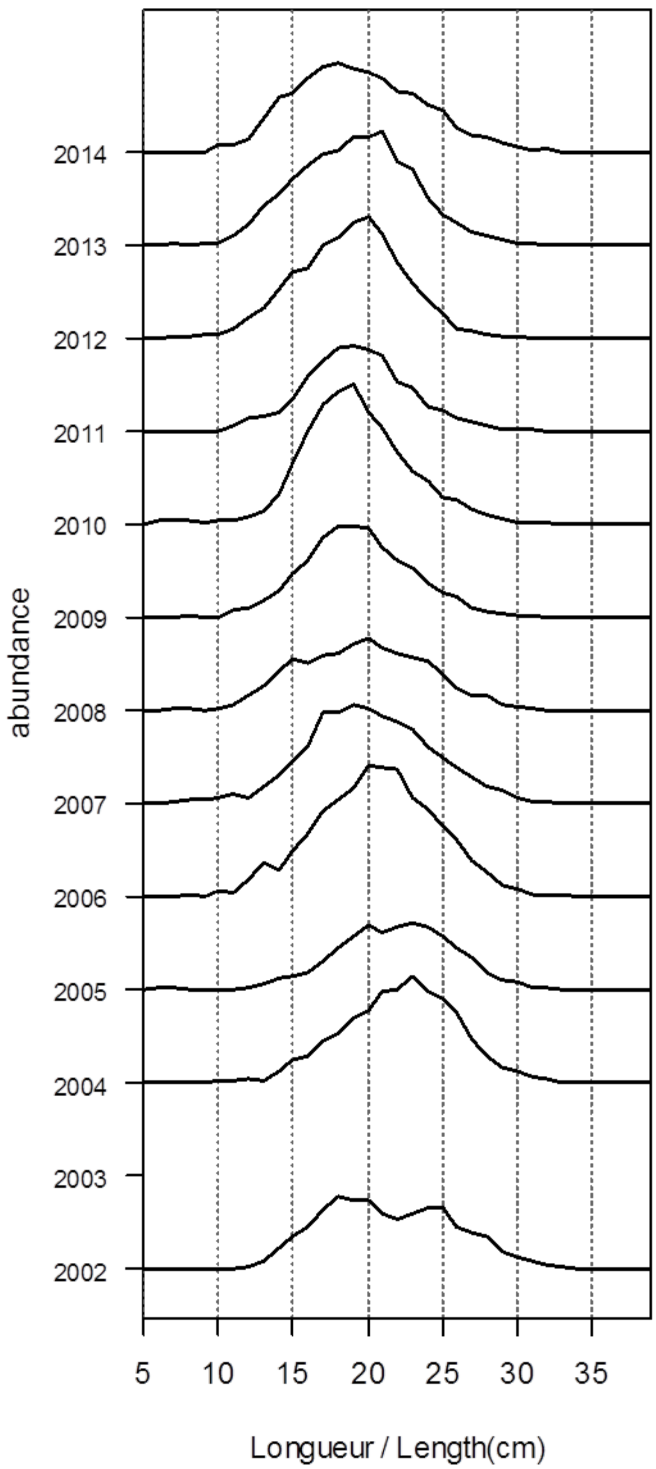

Figure 43. Length frequencies of yellowtail flounder in in the southern Gulf of St. Lawrence from September bottom-trawl surveys from 2002 to 2014. Strata 401 to 439 are those used for the yellowtail flounder abundance index.

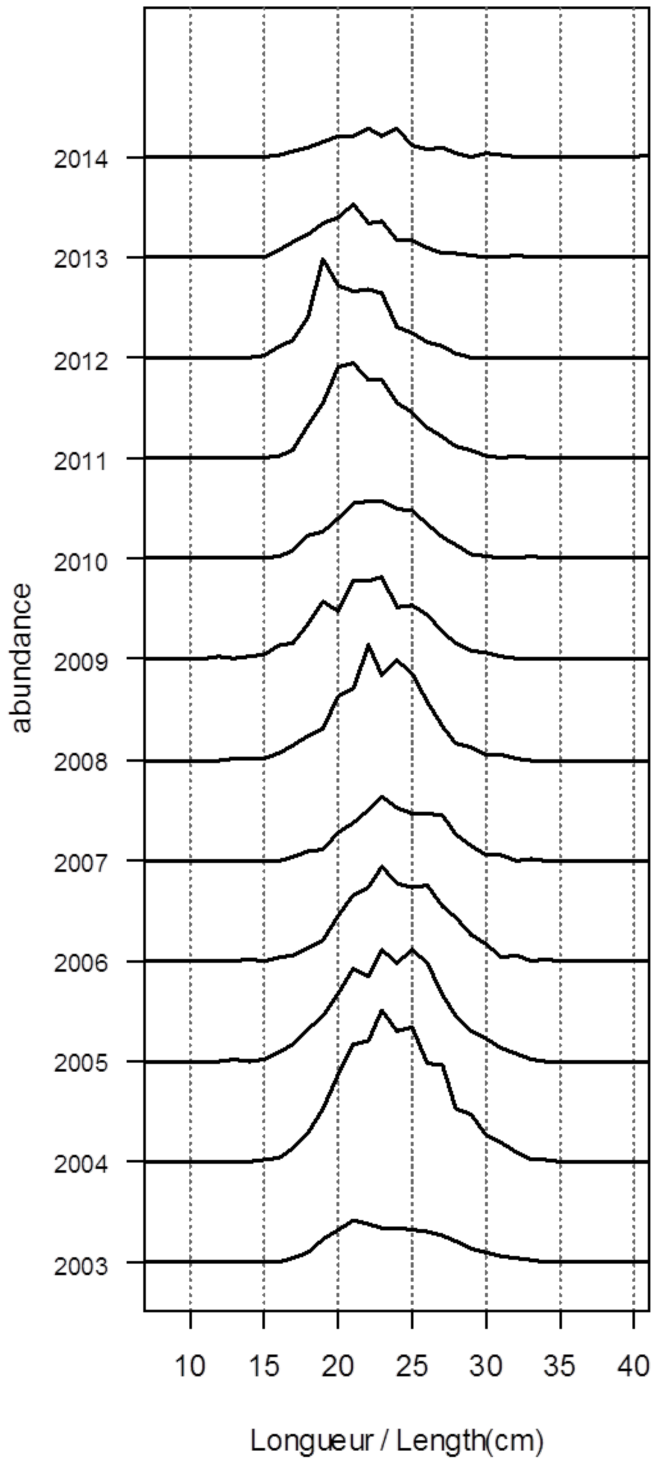

Figure 44. Length frequencies of yellowtail flounder in in the southern Gulf of St. Lawrence from August sentinel bottom-trawl surveys from 2003 to 2014. Strata 401 to 439 are those used for the yellowtail flounder abundance index.