Fisheries and Oceans Canada | Pêches et Océans Canada
Science | Sciences

Canadian Science Advisory Secretariat (CSAS)

Research Document 2013/099

Newfoundland and Labrador Region

Distribution and habitat associations of selected demersal fish species in the Laurentian Channel and Laurentian Area of Interest (AOI)

D.W. Kulka and N. Templeman

Science Branch
Fisheries and Oceans Canada
PO Box 5667
St. John's NL A1C 5X1

November 2013

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.

Published by:

Fisheries and Oceans Canada
Canadian Science Advisory Secretariat
200 Kent Street
Ottawa ON K1A 0E6

http://www.dfo-mpo.gc.ca/csas-sccs/
csas-sccs@dfo-mpo.gc.ca

ISSN 1919-5044

Correct citation for this publication:

Kulka, D. W., and Templeman, N. 2013. Distribution and habitat associations of selected demersal fish species in the Laurentian Channel and Laurentian Area of Interest (AOI). DFO Can. Sci. Advis. Sec. Res. Doc. 2013/099. v + 44 p.

TABLE OF CONTENTS

ABSTRACT

The identification of an Area of Interest (AOI) is the first step towards designating a location as a Marine Protected Area(s) (MPA). The Laurentian Channel was selected as an AOI under the MPA initiative in June 2010. In support of the development of a biophysical overview of the Laurentian Channel Study Area, this paper examines the distribution and habitat associations of 22 demersal fish species that occur within the Laurentian Channel AOI. Species are mapped such that depth and survey catch bottom rate at depth and bottom temperature within the AOI are compared to the broader surrounding areas. Species examined were selected based on two criteria: a) those that were most abundant in the AOI and the survey area surrounding the AOI that covers all of NAFO Div. 3Ps and b) 13 demersal fish species that were chosen from 18 potential conservation priorities for the area. The mapping revealed relative importance of each of the species within the AOI.

Aire de répartition et habitats propices aux espèces de poisson de fond dans le chenal Laurentien et dans la zone d'intérêt (ZI) du chenal Laurentien

RESUME

La désignation d'une zone d'intérêt (ZI) est la première étape du processus de désignation d'un emplacement en tant que zone de protection marine (ZPM). Le chenal Laurentien a été retenu comme ZI dans le cadre de l'initiative de la ZPM en juin 2010. Pour appuyer l'élaboration d'un aperçu des caractéristiques biophysiques de la zone d'étude du chenal Laurentien, le présent document examine l'aire de répartition et les associations d'habitats de 22 espèces de poisson de fond dans la ZI du chenal Laurentien. Ces espèces sont cartographiées de sorte que la profondeur et les levés de taux de prise en profondeur et à la température de fond au sein de la ZI sont comparés aux zones environnantes. Les espèces étudiées étaient sélectionnées selon deux critères : a) les espèces les plus abondantes dans la ZI et dans la zone de relevé environnante de la ZI qui couvre toutes les divisions 3Ps de l'OPANO et b) treize espèces de poisson de fond qui avaient été choisies parmi les dix-huit priorités potentielles en matière de conservation de la zone. La cartographie a révélé l'importance relative de chacune des espèces présentes dans la ZI.

INTRODUCTION

The Oceans Directorate of Fisheries and Oceans Canada (DFO), through The Oceans Secretariat, is mandated to monitor the Health of the Oceans (HOTO) initiative biannually and to produce annual performance reports on behalf of all five partnering departments and agencies. Results and achieved outcomes to date for each of the HOTO components are summarized in the Health of the Oceans Initiative webpage.

One of the key goals of the HOTO initiative is the establishment of six new *Oceans Act* MPAs within Canadian waters. Two of the primary criteria in identifying prospective MPA sites are i) inclusion in an existing integrated large ocean management area and ii) consideration of previous work conducted by DFO Science in describing Ecologically and Biologically Significant Areas (EBSAs) (CSAS 2007).

The identification of an AOI is the first step towards designating a location as an MPA. The Laurentian Channel was selected as an AOI under the Marine Protected Areas initiative in June 2010.

A key step in the evaluation of a potential MPA is the preparation of a biophysical overview to better inform the MPA development and designation process. As part of that process, this paper examines the distribution and habitat associations of 22 demersal fish species that occur within the Laurentian Channel Area of Interest (Fig. 1). Species are mapped such that depth and survey catch bottom rate at depth and bottom temperature within the AOI are compared to the broader surrounding areas. Species examined were selected based on two criteria: a) those that were most abundant in the AOI and the survey area surrounding the AOI (Fig. 1) that covers all of NAFO Div. 3Ps and b) 13 demersal fish species that were chosen from 18 potential conservation priorities for the area.

METHODS

SURVEYS

Several demersal trawl gears have been deployed over the life of the NL Region surveys for the purpose of estimating biomass and abundance. A Campelen-1800 shrimp trawl has been employed since fall of 1995 for both spring and fall surveys. While survey design has remained constant, additional strata have been included in recent years along with modifications to some of the original strata (Bishop 1994). One of the recent significant changes in the surveys is the addition of shallower (<~50 m) and deeper strata (>~700 m) after 1993. The demersal trawl survey data presented in this paper is from 1996 to 2009.

Newfoundland and Labrador (NL) demersal trawl surveys employed a stratified-random design (a pre-determined number of fishing locations chosen for each stratum in different locations each year), strata based on depth and latitude. A summary of the stratified-random survey design (adopted by the DFO - NL Region after 1970) can be found in Doubleday (1981). The surveys were originally designed to provide estimates of abundance for the major groundfish species such as cod (*Gadus morhua*). However, it also captures a multitude of demersal fish species and these data can be used to study distribution or habitat associations that were done in this study.

MAPPING AND SPATIAL ANALYSIS

SPANS GIS (Anon. 1997) was used to examine spatial distribution of species of interest using research trawl survey data. Details of potential mapping used for point-to-surface transformation (geo-referenced numbers per tow to areas depicting differential density of the species) is described in Kulka (1998). The extra sets that were not part of standard research surveys were also added to the dataset for the mapping of fish distributions. Although these sets are a deviation from the proportional allocation of sets in the estimation of abundance using random stratified design, the same sampling protocol was used. The addition of these sets increased sampling intensity but did not affect the point to surface transformation for producing distribution maps.

Data from all years when Campelen gear was deployed, 1996-2009 was used to describe distribution and habitat associations. Survey data were grouped into two periods: 1996-2002 and 2003-09 to examine temporal changes. A single legend (break points in density) comprising fifteen strata was set for a baseline, all years combined (1996-2009) then applied to the two time periods (method described in Kulka 1998).

A linear decay function was applied to the potential mapping to smooth the surface transition from one density stratum to another, thereby giving points on the periphery of scanning circles increasingly less weight in the averaging function.

For the resultant maps, darkest (red) areas represent highest densities of species (highest catch per tow) fading to green to represent the lowest catch rates. Grey areas depict sampled areas with no species catches while blank (clear) depicts unsampled areas.

TEMPERATURE AND DEPTH ASSOCIATIONS

Bottom temperature and depth are recorded with each set and these data were used to examine habitat associations. Both temperature and depth were categorized and relative abundance (mean number per tow) was plotted by depth category.

RESULTS

SPECIES DISTRIBUTIONS AND HABITAT ASSOCIATIONS

Table 1 shows a ranking of the most “important” commercial fish species plus other species determined to be of interest by other criteria such as sensitive or potentially at risk; where ”important” is defined as species of high abundance in Subdiv. 3Ps (spring NL Region Campelen survey) and ranked according to the proportion of number of fish caught in the Laurentian AOI compared to surrounding waters in Subdiv. 3P (see column named LaurAOI/Out). Five species, Redfish (*S. mentella*), Black Dogfish, Longfin Hake, Mailed Sculpin, and Common Grenadier comprised 85 % of the abundance of 22 demersal fish in Subdiv. 3Ps, with redfish being the dominant species (Table 1). Four species, Black Dogfish, Common Grenadier, Northern Wolffish, and Greenland Halibut had a higher proportion of catch within the AOI than in surrounding Div. 3P waters even though the AOI comprised only 15 % of the surveyed area. Several other species, namely Greenland Halibut, Smooth Skate, Witch Flounder, Longfin Hake and Hagfish had relatively high proportions (LaurAOI/Out > 0.5) within the AOI. Species of relatively little importance in the AOI compared to surrounding waters (but abundant within the survey footprint or chosen as species of interest for other reasons) were Mailed Sculpin, Haddock, Striped Wolffish, Pollock, Lumpfish, Redfish (*S. marinus*), Spiny Dogfish, and Atlantic Cod. All of these species were centered on the shelf rather than in the Channel.

Twenty-two species were mapped for their distribution and their association with depth and bottom temperature presented. Figure 1, upper panel shows that spring (April-June) bottom temperatures are higher (> 3 ^{o}C) in the deeper waters of the channels (Laurentian and

Hermitage) and the slope compared to the St Pierre Bank. The slope and Hermitage Channel are warmest at generally 5 to 6 ^{o}C. The area within the Laurentian AOI includes a portion of the slope and basin between 250 and 500 m. In total, the AOI measures ~17,600 sq. km, comprising about 15 % of the total survey footprint and about 40 % of the Laurentian Channel as defined by that area between 200 and 500 m within Div. 3P and 4Vn. Within that depth range in the AOI, the temperature is on average about 1 ^{o}C higher than surrounding waters of the same depth range (Fig. 1, lower panel). The waters in the basin of the Laurentian Channel are slightly cooler (3-5 ^{o}C) than the surrounding slope (5-6 ^{o}C) but warmer than the banks to the east (-1.3-3 ^{o}C).

The following description of demersal fish species distributions is based on the DFO NL Region Campelen survey from 1996 to 2009 (Fig. 2). The area covers all of Div. 3P and the fringe of Div. 3O to the east and Subdiv. 4Vn to the west (constituting the southwestern half of the Laurentian Channel). The southwestern portion of the Laurentian Channel (that area within Subdiv. 4Vn) was only surveyed in the early period, 1996, 1997, 2000 and 2002. Those sets were not part of the standard demersal survey but the same gear and set protocol was employed and allowed an extension of our view of the distribution to include the entire Laurentian Channel. Each species was also mapped during two periods 1996-2002 and 2003-09 to illustrate any changes in distribution over time (Fig. 3).

Black dogfish (*Centroscyllium fabrici,* Figs. 2a and 3a) – Black Dogfish is the third most abundant demersal fish in the St Pierre Bank/Laurentian Channel area (Div. 3P, Table 1). It is the second most abundant fish species in the Laurentian AOI after redfish (*S. mentella*) and it is mainly concentrated within the Laurentian Channel and the northern half of the AOI. In terms of depth, it is most densely distributed in a relatively narrow range of 400 to 550 m. In terms of ambient temperature, densest concentrations are found in 4.6-6.5 ^{o}C.

Kulka (2006) noted that “All evidence indicates that black dogfish in Canadian waters have a highly structured distribution with some separation by stage. Large (pregnant) females migrate to the shallow (< 400 m) portion/edge of the Laurentian Channel where pupping occurs. The young then move into deeper waters of the channel. As they mature they move out of the channel and onto the slope waters. As they grow they move into deeper waters of the slope.” It was also noted here that black dogfish abundance has been in decline since the early 1990s. This trend is reflected in Fig. 2 where although black dogfish are distributed similarly between 1996-2002 and 2003-09, they are recently at lower density. Thus, the AOI is important with respect to life history aspects of this species.

Common Grenadier (*Nezumia bairdi,* Figs. 2b and 3b) – Common grenadier is the fifth most abundant demersal fish in the St. Pierre Bank/Laurentian Channel area, but the majority of its abundance is concentrated in the AOI (Table 1), where it is the fourth most abundant species. It is concentrated in the northern part of the AOI. Unlike two other species of Grenadier (Roundnose, *Coryphanoides rupestris* and Roughhead, *Macrourus berglax*), this species has not been commercially exploited but may be sufficiently concentrated in the Laurentian Channel to support a fishery. Common Grenadier in the AOI corresponds with depths where the species is densely concentrated, although high concentrations are also found deeper (> 500 m; Fig. 2b). In terms of temperature, the highest density of common grenadier is found at 3.5-5.5 ^{o}C, a temperature range that occurs in the AOI. While there is no assessment of the status of this species, the similarity of their distribution between 1996-2002 and 2003-09 suggest little change in abundance (Fig. 3b).

Northern Wolffish (*Anarhichas denticulatus,* Fig. 2c) – Northern Wolffish is not one of the most abundant demersal fish in the St Pierre Bank/Laurentian Channel area (21st, see Table 1) but the majority of this species in Div. 3P is concentrated in the AOI. Simpson and Kulka (2002) indicated that prior to the mid-1980s, Northern Wolffish was far more abundant in Canadian waters (a decline of 99 %), and thus it is likely that prior to the decline, the species would have been more abundant relative to some of the other demersal species, particularly within the AOI. In the Laurentian Channel, it appears that the area occupied by Northern Wolffish has diminished somewhat between 1996-2002 and 2003-09 (Fig. 3). Density of the species at depths occurring within the AOI are relatively low compared to deeper waters of the slope. However, it distributes over most of the Laurentian Channel. Northern Wolffish are found at relatively high concentrations in 4-7 ^{o}C inside and outside the AOI.

Kulka et al*.* (2004) indicated that Northern Wolffish are found at much higher concentrations north of the study area and particularly from the northern Grand Bank slope to the outer edge of the Labrador Shelf, based on habitat associations over a greater part of the Grand Banks, the majority of its distribution in Canadian waters.

Greenland Halibut (*Reinhardtius hippoglossoides*, Fig. 2d) – Greenland Halibut, a commercially exploited species in other areas where it is more abundant (Grand Bank to Arctic slope waters), is the twelfth most abundant demersal fish in the St. Pierre Bank/Laurentian Channel area, but the majority of its abundance is concentrated in the AOI where it is sixth most abundant (Table 1). Its highest concentrations are at depths > 500 m. The AOI straddles depths where density is increasing. They are most abundant at temperatures > 3.5^{o} C peaking at 4-5 ^{o}C. Figure 3d indicates that Greenland Halibut has become considerably more densely concentrated in the AOI in 2003-09.

Healey (2009) describes Greenland Halibut as widely distributed throughout the waters off Labrador and eastern Newfoundland, and historically occurred in relatively high abundance along the deep slopes of the continental shelf, and in deep channels between banks rather contiguously into and through the 1980s. However, in the early 1990s, in unison with an overall significant decline in biomass, northern distribution of the species was greatly reduced with most of the fish occurring in the northeastern Grand Bank area (Healey 2009).

Smooth Skate (*Malacoraja senta,* Fig. 2e) – Kulka et al*.* (2006*a*) described the global distribution of this species and found that an area including the Laurentian Channel (as party of a larger unit extending into the Gulf of St. Lawrence part of the Channel and onto the Scotian Shelf) is an important part of the distribution of the species. Within the current survey footprint, most of the species is concentrated in the Laurentian Channel, including the AOI, where it is the twelfth most abundant species averaged over 1996-2009 (sixteenth over the entire survey area). Smooth Skate reaches it highest density within the Laurentian Channel including the AOI peaking at 350-500 m. In terms of temperature, it concentrates in the warmer available waters between 4 and 7 ^{o}C. Figure 3e indicates that smooth skate has become considerably more densely distributed but at the same Channel locations. This is corroborated by Kulka et al. (2006*a*) who reported an increase in abundance in Div. 3OP during that period.

Witch Flounder (*Glyptocephalus cynoglossus,* Fig. 2f) – Most of the high concentrations of witch flounder in the survey area occur within or partially within the AOI. The highest density concentrations also straddle the slope just outside the northeast boundary of the AOI. Thus, given relatively high concentrations both inside and just adjacent to the AOI, it is the sixth most abundant species in the survey area and fifth most abundant in the AOI. In terms of distribution by depth, highest densities occur within a fairly wide depth range encompassing the AOI, and slightly shallower and deeper (200-600 m). In terms of temperature, highest densities are observed where temperature exceeds 4 ^{o}C. The area of highest density has expanded to cover most of the AOI in 2003-09, increasing its importance in terms of abundance within the area (Fig. 3f). This is a commercially exploited species although there is no directed fishery in the AOI.

Longfin Hake (*Urophycis chesteri*, Fig. 2g) – Longfin Hake is a somewhat smaller species than the closely related and exploited white hake (see Fig. 2j). Moderate to high concentrations of this species are found in the Laurentian Channel but the highest concentrations are found are found along the shelf break off the southern edge of the Grand Banks. They are the third most abundant species in the survey area and in the AOI (Table 1). The depth range within the AOI is where Longfin Hake reach their highest density is 250-550 m. In terms of temperature, the species is most densely concentrated at temperatures exceeding 4 ^{o}C. In 2003-09, concentrations of Longfin Hake within the AOI were more extensive [more broadly distributed] than in 1996-2002.

Hagfish (*Myxine glutinosa*, Fig. 2h) – Hagfish is the seventh most abundant fish in the AOI and ninth most common in the survey area (Table 1). The highest concentrations of this species occur outside of the AOI within Subdiv. 4Vn and in the Hermitage Channel. Values of density within depth intervals inside the AOI and in the entire survey area is very similar and density peaks at 200-550 m for this species. In regards of temperature, highest concentrations are found at temperatures exceeding 4 ^{o}C. Distribution of Hagfish is similar between the two periods, 1996-2002 and 2003-09.

Monkfish (*Lophius americanus*, Fig. 2i) – The highest concentrations of monkfish in the southern Grand Bank survey area (Div. 3LNOPs) straddle the eastern border of the AOI. Monkfish constitutes the thirteenth most common species in the AOI and nineteenth most common in the survey area. Highest concentrations of this species are in the range of 200-400 m and 5-8 ^{o}C, seeking the warmest areas available. The distribution of Monkfish is nearly identical between 1996-2002 and 2003-09 (Fig. 3i).

White Hake (*Urophysis tenuis*, Fig. 2j) – The distribution of white hake is very similar to that of monkfish. The high concentrations of white hake straddle the eastern border of the AOI. It constitutes the ninth most common species in the AOI and tenth most common in the survey area. Highest concentrations of monkfish are in the range of 200-400 m and 5-8 ^{o}C, seeking the warmest areas available. The distribution was similar between 1996-2002 and 2003-09 (Fig. 3j).

Argentine (*Argentina silus*, Fig. 2k) – Argentine is the eleventh most abundant fish in the AOI and tenth most common in the survey area (Table 1). High concentrations straddle the eastern border of the AOI near the Hermitage Channel. Highest concentrations are located at 200-400 m and > 4.6 ^{o}C. Little change was observed in the distribution between1996-2002 and 2003-09 except that density was higher during the earlier period (Fig. 3k).

Spotted Wolffish (*Anarhichas minor*, Fig. 2l) – Spotted Wolffish distribution in Div. 3P is patchy and density is low inside and outside the AOI (lowest of all species examined, Table 1). This species is found at much higher and more extensive concentrations north of Div. 3P (Kulka et al. 2004). Spotted Wolffish are primarily concentrated between 100-400 m, but over a wide range of temperatures. Little change was observed in the distribution between 1996-2002 and 2003-09 except that density was somewhat higher during the later period (Fig. 3l).

Redfish (mentella) (*Sebastes mentella*, Fig. 2m) – Redfish (*S. mentella*) is by far the most abundant species in the survey area and in the AOI, eight times more abundant in Div. 3P than the next most abundant species, black dogfish (Table 1). Moderate concentrations were located within the AOI whereas highest densities were found in and around the Heritage Channel and along the continental slope. Redfish are located over a relatively wide range of depths (150-650 m) and temperatures (>1 ^{o}C), with higher concentrations occurring in warmer waters. Density is lower at similar depths and temperatures within the AOI compared to other locations. Little change was observed in the distribution between 1996-2002 and 2003-09 except that density was higher during the later period (Fig. 3m).

Thorny Skate (*Amblyraja radiata,* Fig. 2n) – Thorny Skate is the eleventh most abundant fish in the AOI and eighth most common in the survey area (Table 1). A dense concentration along the western outer shelf (St. Pierre Bank) straddles the AOI but most of the high density areas occur outside the AOI. Highest concentrations are observed between 200-500 m but are abundant over a wide range of temperatures. Distribution was very similar between 1996-2002 and 2003-09 (Fig. 3n). Simpson et al*.* (2010) also noted that abundance of this species has changed little since the mid-1990s.

Atlantic Cod (*Gadus morhua*, Fig. 2o) – Cod is the seventh most abundant species in the survey area and eighth most abundant in the AOI (Table 1). A dense concentration in the Heritage Channel straddles the AOI but most of the high density areas occur outside the AOI along the Newfoundland south coast and southern shelf. Highest concentrations were observed between 100-350 m but were abundant over a wide range of temperatures. Distribution is very similar between 1996-2002 and 2003-09 (Fig. 3n).

Atlantic Cod constitutes the largest fishery in this area.

Spiny Dogfish (*Squalus acanthias*, Fig. 2p) – Spiny Dogfish is the seventeenth most abundant species in the survey area, but distributes mostly outside of the AOI (Table 1). They occupy a narrow range of depths (mainly in 150-300 m) and temperatures (mainly > 6 ^{o}C). Spiny dogfish in this area is at the northern most extent of its distribution (where thermal conditions are marginal); concentrations are far more dense and extensive to the south on the Scotian Shelf/ Bay of Fundy/Gulf of Maine (Kulka 2006).

Redfish (marinus) (*Sebastes marinus,* Fig. 2q) – Redfish (*S. marinus*) within the survey area are concentrated in a small area near the southwest coast of Newfoundland, primarily in and around the Heritage Channel, outside the AOI. They are located primarily at shallow depths (150-300 m) and at temperatures > 4 ^{o}C, with higher concentrations located in warmer waters. Density is lower at similar depths within the AOI compared to other locations. Little change was observed in the distribution between 1996-2002 and 2003-09 (Fig. 3q).

Lumpfish (*Cyclopterus lumpus*, Fig. 2r) – Lumpfish is the eighteenth most abundant species in the survey area and is most highly concentrated near coastal locations. Few lumpfish are located in the Laurentian Channel/AOI (Table 1). This supported by the fact that they are primarily a shallow water species (<250 m peaking in abundance at 100 m), occupying a wide range of temperatures (dense concentrations observed in -1.0-4.0 ^{o}C). Little change was observed in the distribution between 1996-2002 and 2003-09 (Fig. 3r).

Lumpfish are taken in a directed gillnet fishery which is managed under licence but is assessed in terms of its status. Management is largely market driven.

Pollock (*Pollachius virens,* Fig. 2s) – Pollock is the fifteenth most abundant species in the survey area, but distributes mostly outside of the AOI (Table 1). Most of the area occupied by this species is located on the periphery of the banks and the Heritage Channel, primarily within a narrow depth range of 200-350 m. Pollock distributes at warmer temperatures, with highest concentrations at 6-7 ^{o}C in locations east of the AOI. Little change in distribution was observed between the two periods examined, 1996-2002 and 2003-09 (Fig. 3s).

Pollock is a minor commercial species that is more common to the south on the Scotian Shelf (Stone 2012). It is a warmer waters species that is on the Grand Banks at the northern extent where density is marginally sufficient to sustain commercial exploitation.

Striped Wolffish (*Anarhichas lupus,* Fig. 2t) – Striped wolffish is the fourteenth most abundant species in the survey area, but occurs mostly outside of the AOI (Table 1). Most of the area occupied by this species is located on the banks at depths shallower than 350 m. It distributes primarily at warmer temperatures, >6 ^{o}C, in locations east of the AOI. Little change in distribution was observed between the two periods examined, 1996-2002 and 2003-09 (Fig. 3t).

Striped wolffish are considered a species of interest because they are distributed in waters adjacent to the AOI and are listed under Canada's *Species at Risk Act* Schedule 1 as "Vulnerable".

Haddock (*Melanogrammus aeglefinus*, Fig. 2u) – Haddock is the thirteenth most abundant species in the survey area, but almost none are located in the AOI (Table 1). Most of the area occupied by this species is located on the banks at depths shallower than 250 m. It distributes primarily at warmer temperatures, >6 ^{o}C in locations east of the AOI. Little change in distribution was observed between the two periods examined, 1996-2002 and 2003-09 (Fig. 3u).

Haddock is a commercial species that was formerly much more abundant in the area (DFO 2005). It is a warmer waters species that is on the Grand Banks at the northern extent of where it is concentrated at densities sufficient for commercial exploitation.

Mailed Sculpin (*Triglops sp*., Fig. 2v) – Although mailed sculpin is the fourth most abundant species in the survey area, almost none are located in the AOI (Table 1). Most of the area occupied by this species is on the banks at depths shallower than 250 m and at cooler temperatures, < 3.5 ^{o}C, in locations east of the AOI. Little change in distribution was observed between the two periods examined, 1996-2002 and 2003-09 (Fig. 3v).

SPECIES ASSOCIATIONS

Based on distribution, the following groups of species were observed as biogeographic clusters:

Laurentian Channel – Black Dogfish, Common Grenadier, Northern Wolffish, Greenland Halibut, Smooth Skate, Witch, Hagfish. These species are those that were most closely associated with the AOI but were also distributed in the Heritage Channel to varying degrees.

Hermitage Channel – Argentine, Spotted Wolffish, Redfish (*S. marinus*). Outside of the AOI, this area represents an easterly extension of the Laurentian Channel but is not as deep. Some of the warmest temperatures in the AOI are found here.

Shelf edge – Longfin Hake, Monkfish, White Hake, Spiny Dogfish, Pollock, Striped Wolffish, Haddock. Outside, but directly adjacent to the AOI, this area is the shelf break along the south edge of St Pierre Bank.

Bank/shallow – These shallow water species include Mailed Sculpin, Lumpfish, Spotted Wolffish and are least associated with the AOI.

Widespread – Redish (*S. mentella*), Atlantic cod. These species cover most of the survey area including the Laurentian Channel.

DISCUSSION

The Laurentian Channel is a deep and rather broad, flat passage that extends from the shelf break between Nova Scotia and Newfoundland extending into the Gulf of St. Lawrence. It comprises an area that is deeper than the adjacent banks, but shallower than the shelf drop off. For this reason, the Laurentian Channel comprises a rather unique habitat – a broad canyon where the bottom is about 400 m and temperatures are relatively stable within a narrow range of about 4.5 to 5.0 C. Templeman et al (2010) describes the currents in this are as rather complex current streams flowing out of the Gulf on the western side with an inflow on the eastern side. These physical conditions also result in a rather unique habitat relative to other areas in the Region.

The Laurentian Channel separates generally warmer bottom waters to the south on the Scotian Shelf from those of the Grand Banks, which transition from warmer conditions off the south coast of Newfoundland to very cold conditions on the northern Grand Bank. For this reason, the area considered supports a mix of more southern and northern species of demersal fish.

As demonstrated through the analysis of species distributions and habitat associations from research vessel surveys of the greater 3LNOP (southern Grand Bank) area, several species specifically use the Laurentian Channel to meet defined temperature (seasonally consistently warm, about 4°C) and depth (350-450 m) preferences that, although not discussed here, are presumably vital to certain life history characteristics.

REFERENCES

Anon, 1997. SPANS. Vers. 7. Prospector Reference Manual. TYDAC Research Inc.

Bishop, C.A. 1994. Revisions and additions to stratification schemes used during research vessel surveys in NAFO Subareas 2 and 3. NAFO Sci. Coun. Res. Doc. Doc. 94/43. 10p.

DFO. 2005. Stock Assessment update on Groundfish in Newfoundland and Labrador Region. DFO Can. Sci. Advis. Sec. Sci. Advis. Rep. 2005/051.

DFO 2007. Ecologically and biologically significant areas (EBSA) in the estuary and Gulf of St. Lawrence: Identification and characterization. DFO Can. Sci. Advis. Sec. Sci. Advis. Rep. 2007/016.

Doubleday, W.G. 1981. Manual on groundfish surveys in the Northwest Atlantic. NAFO Sci. Counc. Stud. 2: 7-55.

Healey, B.P. 2009 Greenland halibut *(Reinhardtius hippoglossoides)* in NAFO Subarea 2 and Divisions 3KLMNO: Stock trends based on annual Canadian research vessel survey results during 1978-2008. NAFO SCR Doc. 09/033.

Kulka, D. W., 1998. SPANdex - SPANS geographic information system process manual for creation of biomass indices and distributions using potential mapping. DFO Atl. Fish. Res. Doc. 98/60 28p.

Kulka, D. W. 2006. Abundance and distribution of demersal sharks on the Grand Banks with particular reference to the NAFO Regulatory Area. NAFO SCR Doc. 06/20, N5237, 41p.

Kulka, D.W., Simpson, M.R., and Hooper, R.G. 2004. Changes in distribution and habitat associations of Wolffish (Anarhichidae) in the Grand Banks and Labrador Shelf. Atl. Fish. Res. Doc. 04/113. 44 pp.

Kulka, D., Hood, C., and Huntington, J. 2008. Recovery strategy for Northern Wolffish (*Anarhichas denticulatus*) and Spotted Wolffish (*Anarhichas minor*), and management plan for Atlantic Wolffish (*Anarhichas lupus*) in Canada. Fisheries and Oceans Canada: Newfoundland and Labrador Region. St. John's, NL. x + 103 p.

Kulka, D., Miri, C.M., and Simpson, M.R. 2007. Update of the status of white hake (*Urophycis tenuis*, Mitchill 1815) in NAFO Divisions 3L, 3N, 3O and Subdivision 3Ps. NAFO Res. Doc. 07/52, N54045, 50 p.

Kulka, D.W., Swain, D., Simpson, M.R., Miri, C.M., Simon, J., Gauthier, J., McPhie, R., Sulikowski, J. and Hamilton, R. 2006a. Distribution, abundance, and life history of *Malacoraja senta* (Smooth Skate) in Canadian Atlantic Waters with reference to its global distribution. DFO Can. Sci. Advis. Sec. Res. Doc. 06/93. 140 p.

Kulka, D.W., Simpson, M.R., and Miri, C.M. 2006b. An assessment of thorny skate (*Amblyraja radiata* Donovan, 1808) on the Grand Banks of Newfoundland. NAFO SCR Doc. 06/44, N5269, 66p.

Simpson, M.R., and Kulka, D.W. 2002. Status of three Wolfish species (*Anarhichus lupus, A. minor* and *A. denticulatus*) in Newfoundland waters (NAFO Divisions 2GHJ3KLNOP). DFO Atl. Fish. Res. Doc. 02/078. 40 p.

Simpson, M., and Miri, C. 2010. Assessment of Thorny Skate (*Amblyraja radiata* Donovan, 1808) in NAFO Divisions 3LNO and Subdivision 3Ps. NAFO SCR Doc. 10/24.

Stone, H.H. 2012. Biomass reference points for eastern component Pollock (4VW+4Xmn). DFO Can. Sci. Advis. Sec. Res. Doc. 2012/027.

Table 1a. Campelen 1996-2009 demersal survey. The list contains demersal fish species of highest abundance, in descending order in the study area (see Fig. 1) or are otherwise of importance to the Laurentian AOI and surrounding waters. "Number Caught" are total number of fish captured, "Out" in the survey in Division 3P outside of the Laurentian AOI, "Laur. AOI" inside the AOI. "Avg #/tow" is catch rate in numbers.

	Number Caught			**Ratio**	**Avg #/tow**			**Ratio**
	Out	Laur. AOI	Total	Laur. AOI/ Out	Out	Laur. AOI	Total	Laur. AOI/ Out
Black Dogfish	44,733	98,002	142,735	2.191	3.262	126.946	8.685	38.919
Common Grenadier	35,209	45,293	80,502	1.286	12.051	58.670	14.095	4.869
Northern Wolffish	64	68	132	1.063	0.118	0.088	0.117	0.746
Greenland Halibut	7,037	7,102	14,139	1.009	44.523	9.199	42.974	0.207
Smooth Skate	2,240	1,775	4,015	0.792	0.234	2.299	0.325	9.816
Witch	44,098	34,836	78,934	0.790	5.762	45.124	7.489	7.831
Longfin Hake	75,806	56,458	132,264	0.745	15.352	73.132	17.886	4.764
Hagfish	9,576	6,644	16,220	0.694	0.779	8.606	1.122	11.046
Monkfish	696	341	1,037	0.490	0.089	0.442	0.104	4.977
White Hake	12,181	3,561	15,742	0.292	1.862	4.613	1.983	2.477
Argentine	12,068	3,457	15,525	0.286	1.344	4.478	1.482	3.331
Spotted Wolffish	42	8	50	0.190	0.180	0.010	0.173	0.057
Redfish mentella	977,115	152,456	1,129,571	0.156	254.165	197.482	251.679	0.777
Thorny Skate	21,493	2,716	24,209	0.126	5.352	3.518	5.272	0.657
Atlantic Cod	72,903	5,795	78,698	0.079	11.497	7.506	11.322	0.653
Spiny Dogfish	3,655	281	3,936	0.077	0.224	0.364	0.230	1.628
Redfish marinus	750	41	791	0.055	0.284	0.053	0.274	0.187
Lumpfish	3,106	96	3,202	0.031	0.395	0.124	0.383	0.315
Pollock	4,049	60	4,109	0.015	0.252	0.078	0.244	0.308
Striped Wolffish	4,330	21	4,351	0.005	1.632	0.027	1.561	0.017
Haddock	7,236	34	7,270	0.005	1.308	0.044	1.253	0.034
Mailed Sculpin	101,450	30	101,480	0.000	58.281	0.039	55.727	0.001

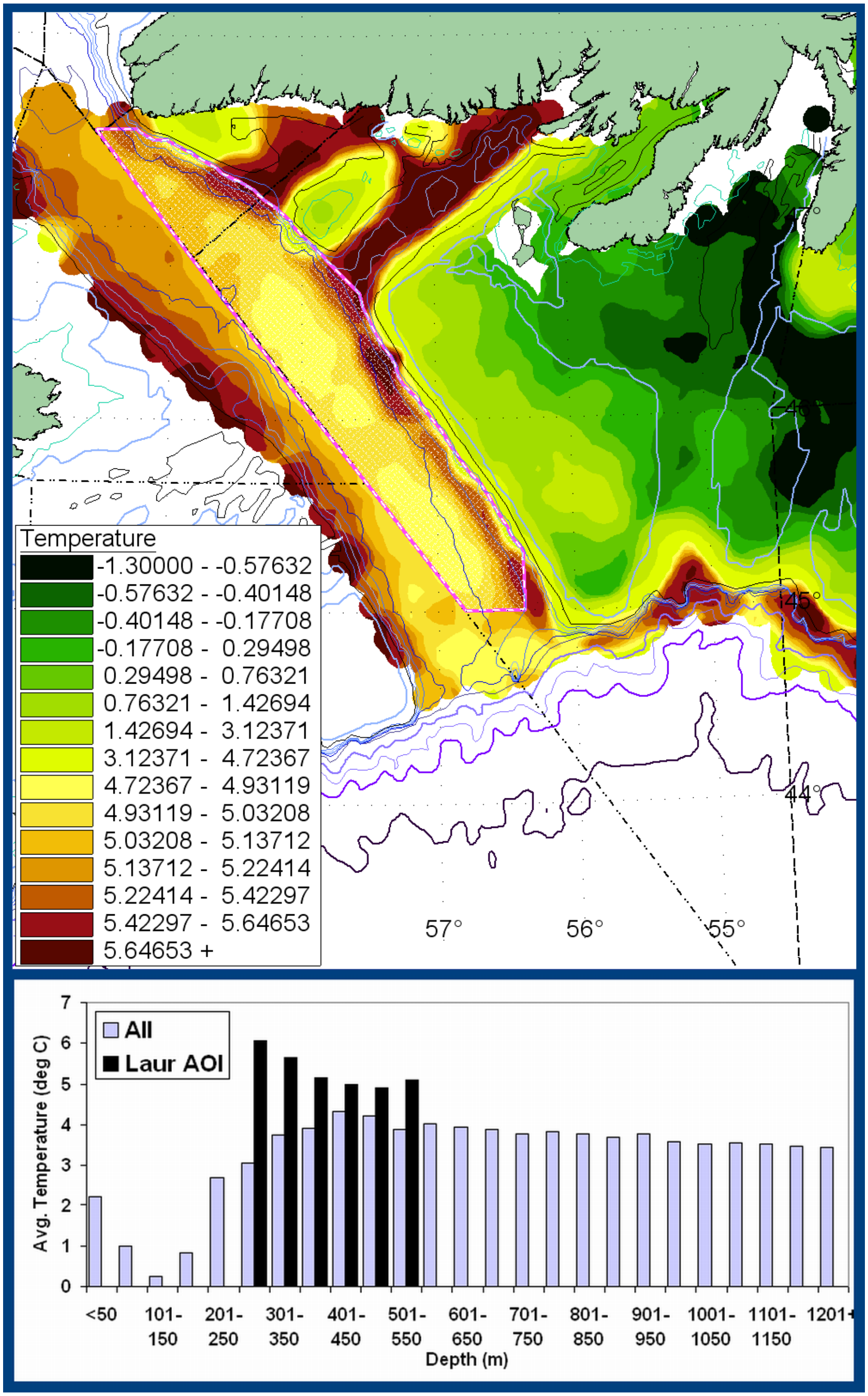

Figure 1. Upper Panel – Bottom temperature (deg. C) averaged over 1996-2009 from measurements gathered during April to June. Lower Panel – average temperature within depth intervals for a) the entire surveyed area and b) the Laurentian AOI (bordered by a candy-striped line).

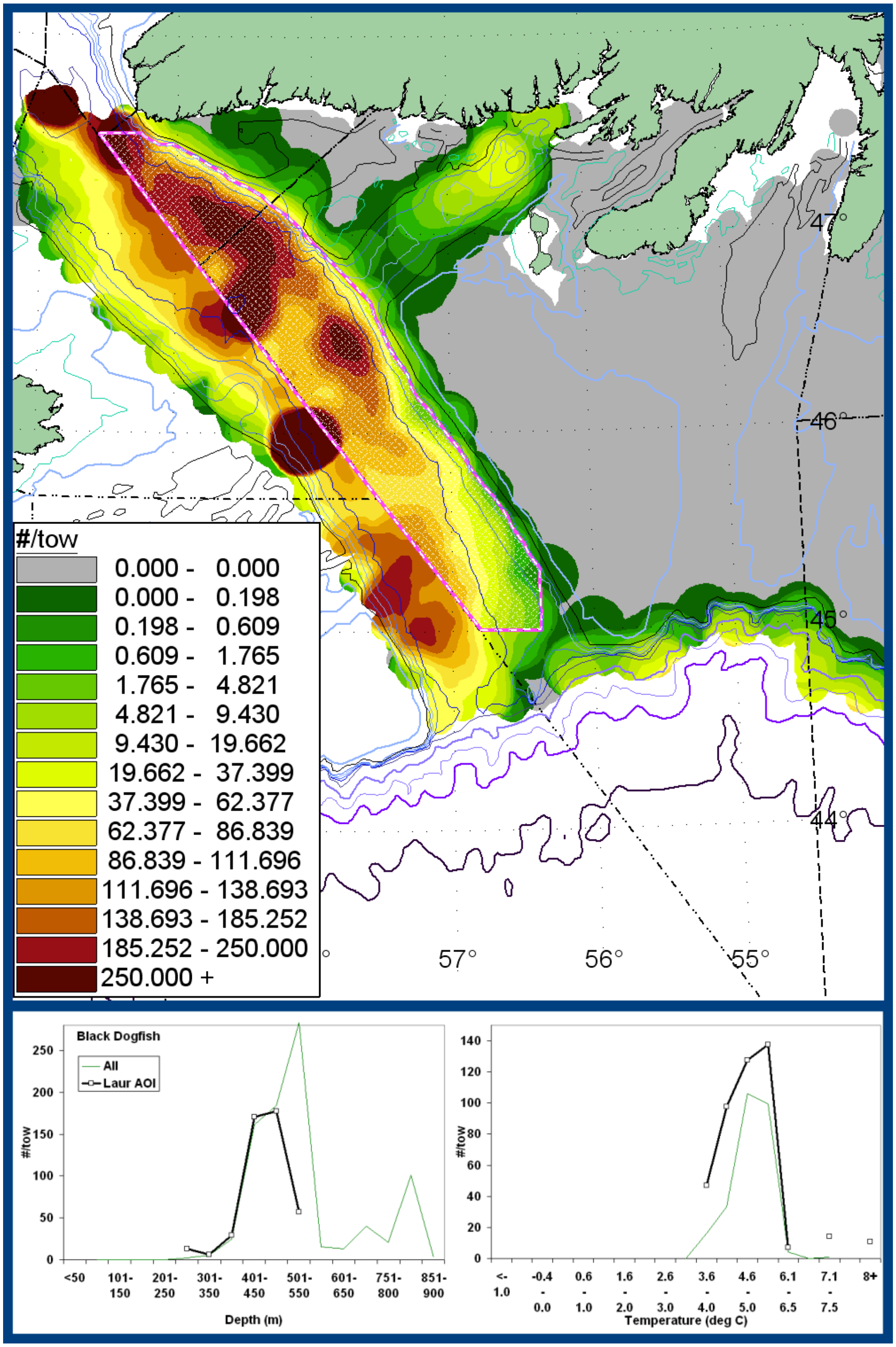

Figure 2a. Distributions (upper, abundance of fish in # caught /tow) and habitat association (#/tow at depth and temperature) for ***Black Dogfish (Centroscyllium fabrici)*** *in the Laurentian Channel and the adjacent St. Pierre Bank. Candy stripe line encloses the Laurentian AOI. Dashed black lines show the NAFO Divisions (Division 3P in the centre). Blue and purple lines are depths contours 20, 50, 100, 200, 250, 300, 350, 400, 500 1500 m and three thick lines 1000, 2000, 3000 m.*

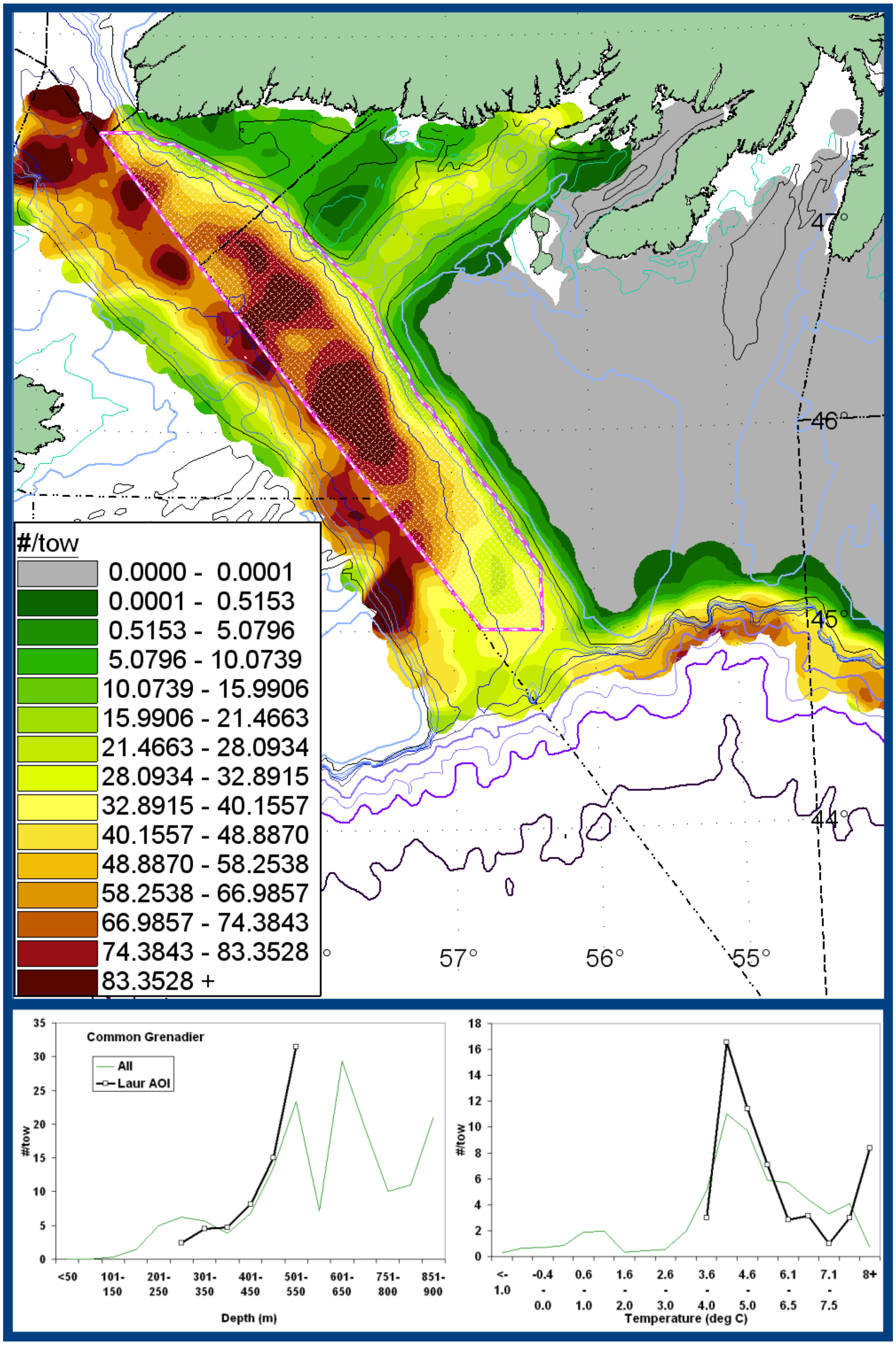

Figure 2b. Distributions (upper, abundance of fish in # caught /tow) and habitat association (#/tow at depth and temperature) for ***Common Grenadier (Nezumia bairdi)*** *in the Laurentian Channel and the adjacent St. Pierre Bank. Candy stripe line encloses the Laurentian AOI. Dashed black lines show the NAFO Divisions (Division 3P in the centre). Blue and purple lines are depths contours 20, 50, 100, 200, 250, 300, 350, 400, 500 1500 m and three thick lines 1000, 2000, 3000 m.*

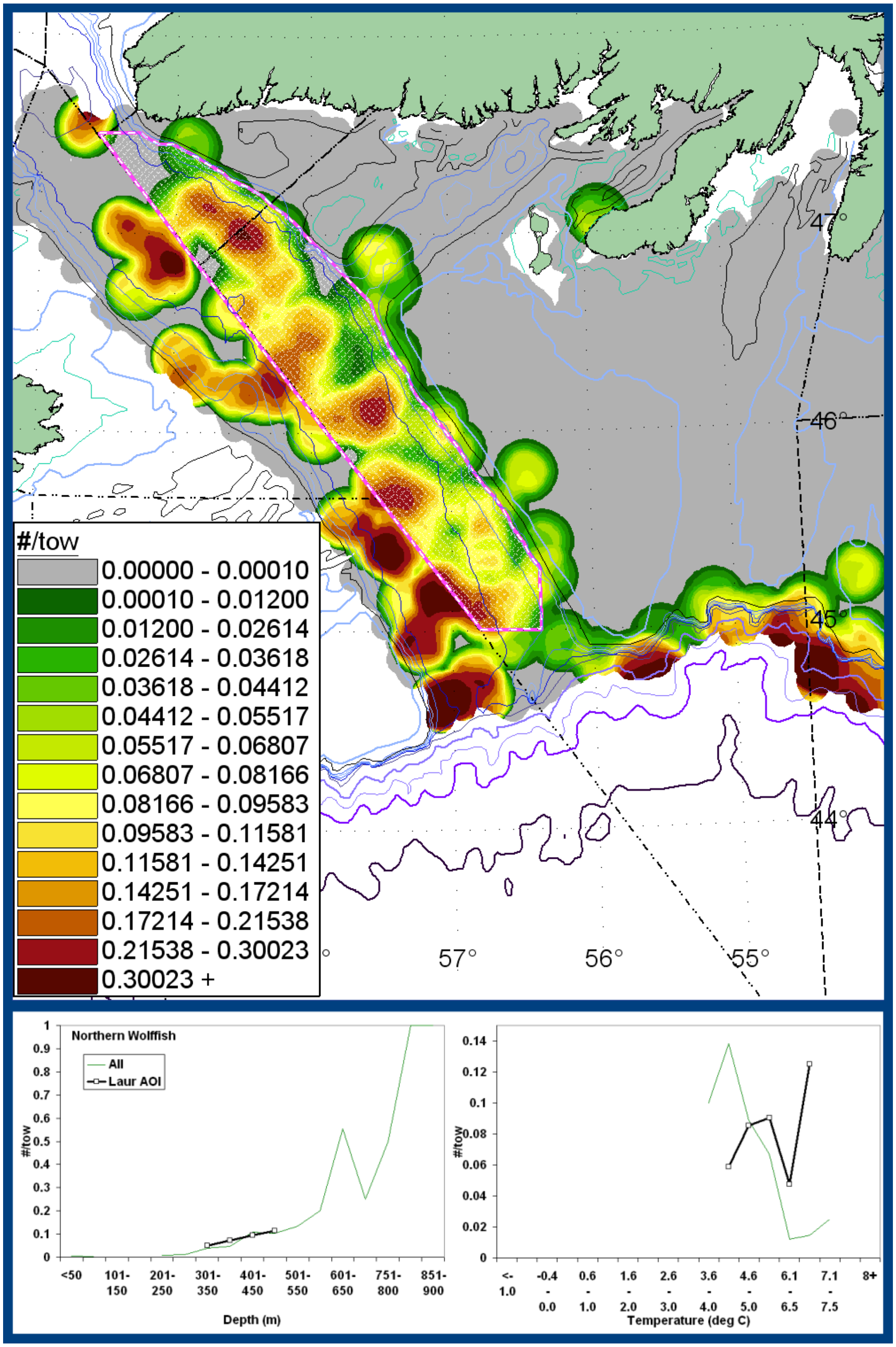

*Figure 2c. Distributions (upper, abundance of fish in # caught /tow) and habitat association (#/tow at depth and temperature) for **Northern Wolffish (Anarhichas denticulatus)** in the Laurentian Channel and the adjacent St. Pierre Bank. Candy stripe line encloses the Laurentian AOI. Dashed black lines show the NAFO Divisions (Division 3P in the centre). Blue and purple lines are depths contours 20, 50, 100, 200, 250, 300, 350, 400, 500 1500 m and three thick lines 1000, 2000, 3000 m.*

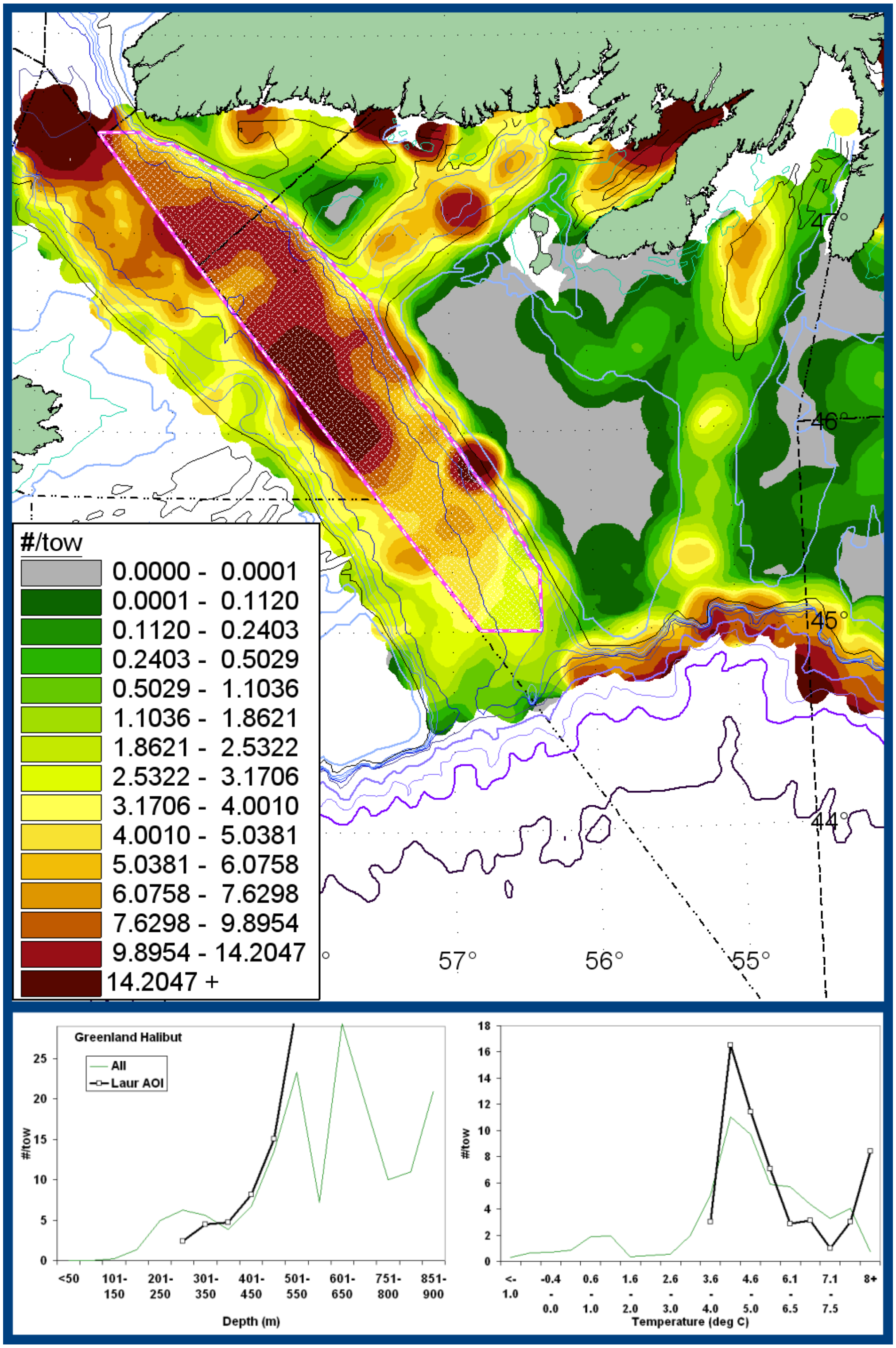

Figure 2d. Distributions (upper, abundance of fish in # caught /tow) and habitat association (#/tow at depth and temperature) for ***Greenland Halibut (Reinhardtius hippoglossoides)*** *in the Laurentian Channel and the adjacent St. Pierre Bank. Candy stripe line encloses the Laurentian AOI. Dashed black lines show the NAFO Divisions (Division 3P in the centre). Blue and purple lines are depths contours 20, 50, 100, 200, 250, 300, 350, 400, 500 1500 m and three thick lines 1000, 2000, 3000 m.*

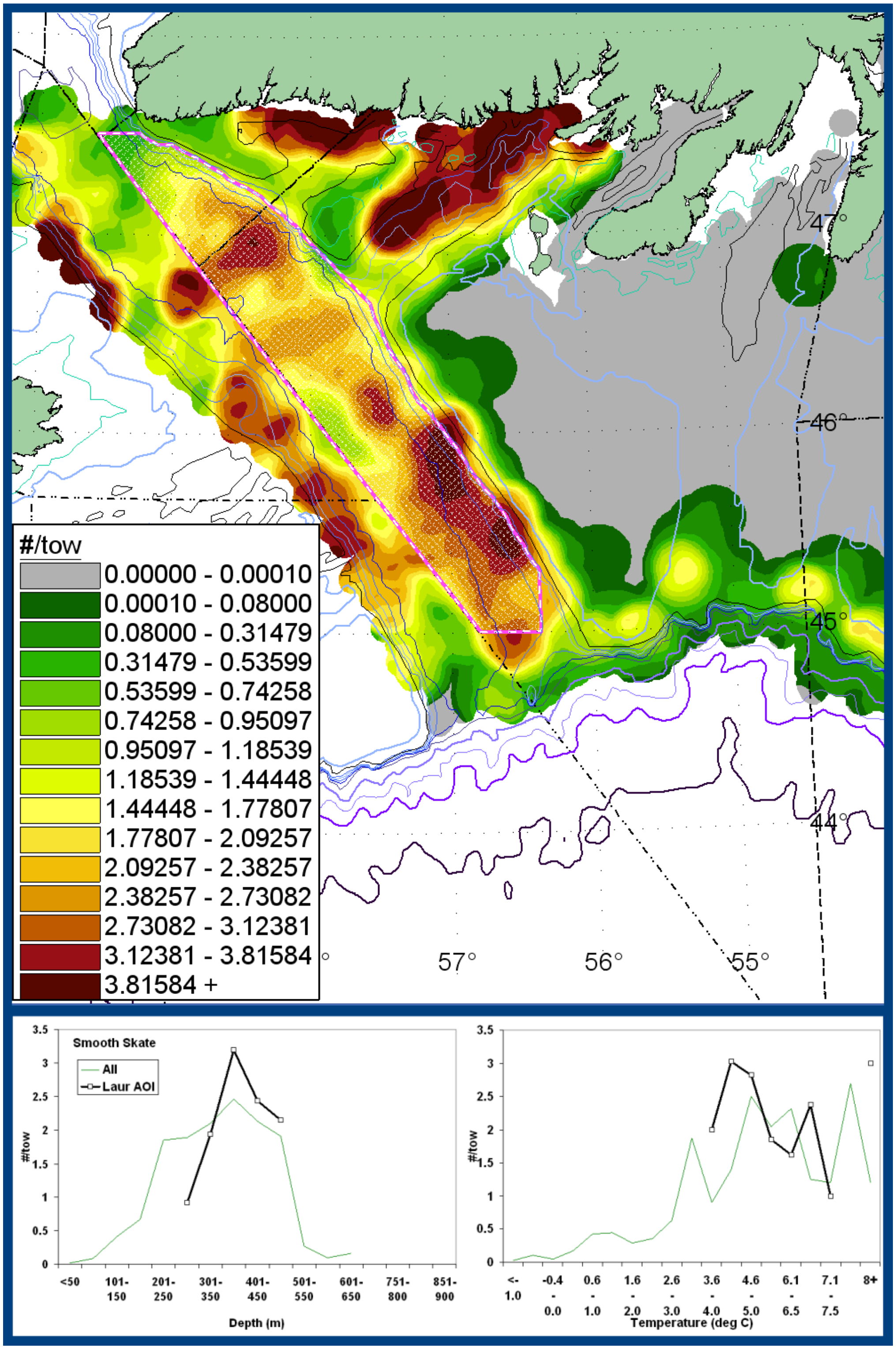

*Figure 2e. Distributions (upper, abundance of fish in # caught /tow) and habitat association (#/tow at depth and temperature) for **Smooth Skate (Malacoraja senta)** in the Laurentian Channel and the adjacent St. Pierre Bank. Candy stripe line encloses the Laurentian AOI. Dashed black lines show the NAFO Divisions (Division 3P in the centre). Blue and purple lines are depths contours 20, 50, 100, 200, 250, 300, 350, 400, 500 1500 m and three thick lines 1000, 2000, 3000 m.*

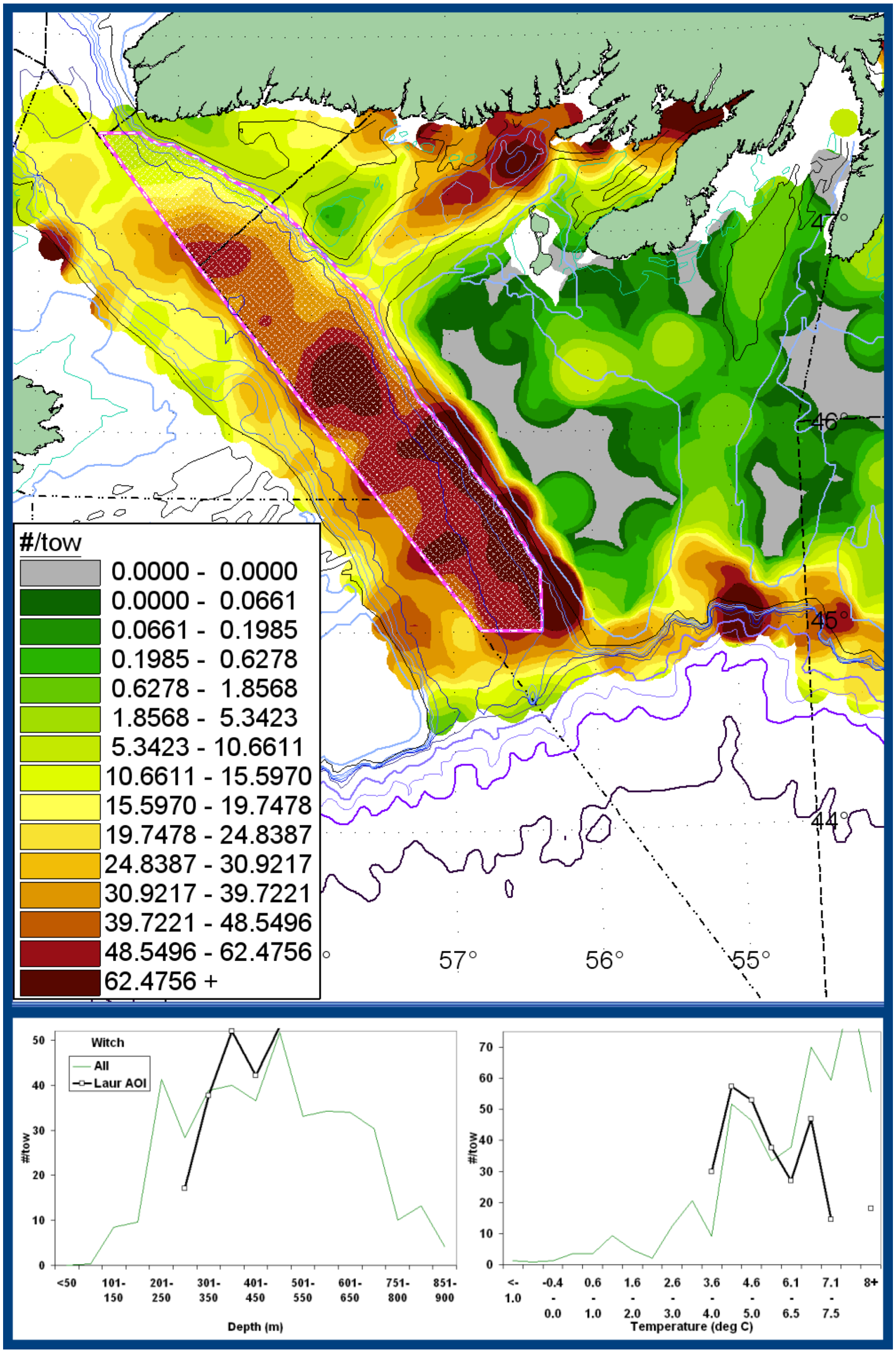

Figure 2f. Distributions (upper, abundance of fish in # caught /tow) and habitat association (#/tow at depth and temperature) for Witch (Glyptocephalus cynoglossus) in the Laurentian Channel and the adjacent St. Pierre Bank. Candy stripe line encloses the Laurentian AOI. Dashed black lines show the NAFO Divisions (Division 3P in the centre). Blue and purple lines are depths contours 20, 50, 100, 200, 250, 300, 350, 400, 500 1500 m and three thick lines 1000, 2000, 3000 m.

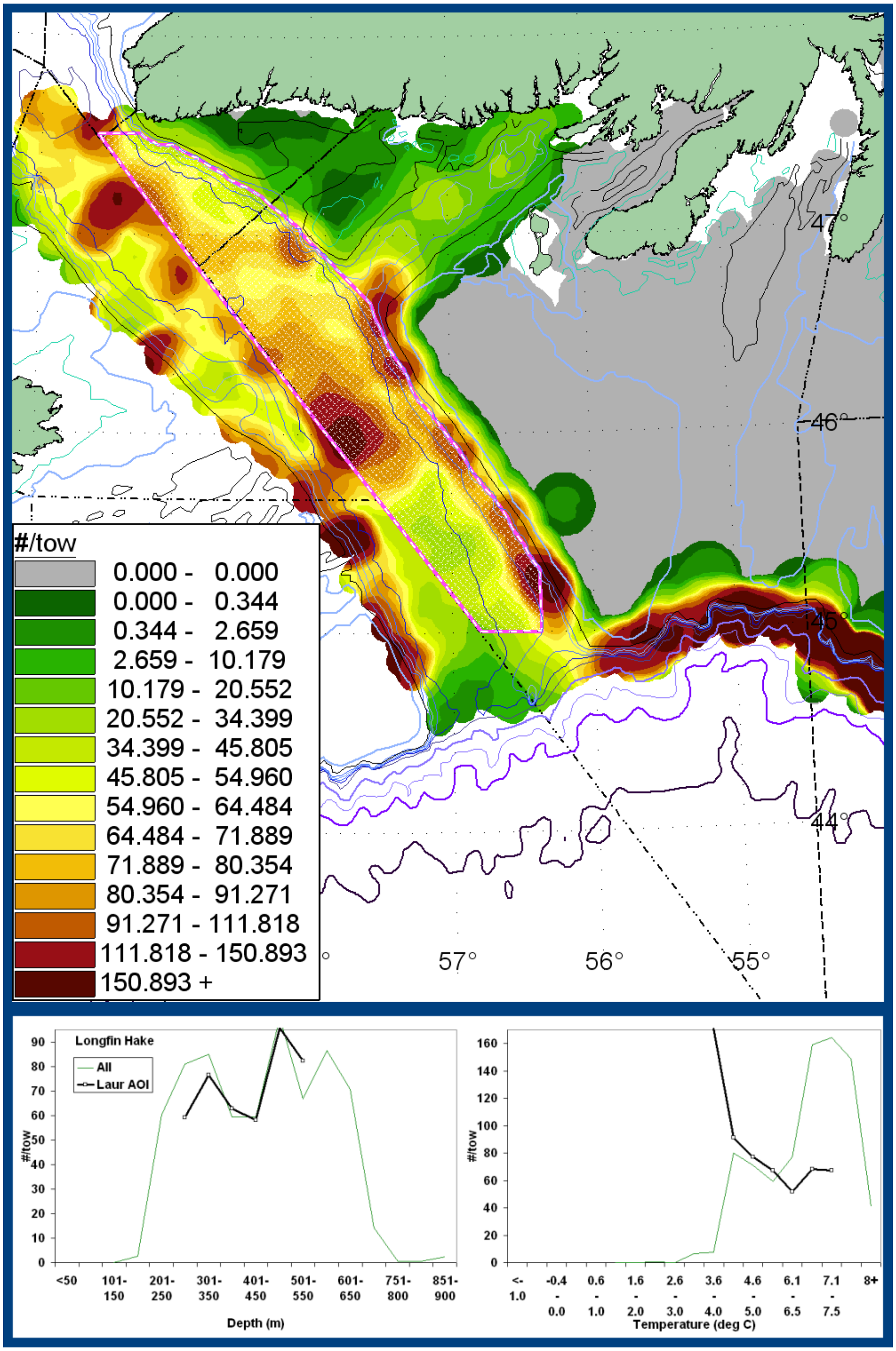

Figure 2g. Distributions (upper, abundance of fish in # caught /tow) and habitat association (#/tow at depth and temperature) for Longfin Hake (Urophycis chesteri) in the Laurentian Channel and the adjacent St. Pierre Bank. Candy stripe line encloses the Laurentian AOI. Dashed black lines show the NAFO Divisions (Division 3P in the centre). Blue and purple lines are depths contours 20, 50, 100, 200, 250, 300, 350, 400, 500 1500 m and three thick lines 1000, 2000, 3000 m.

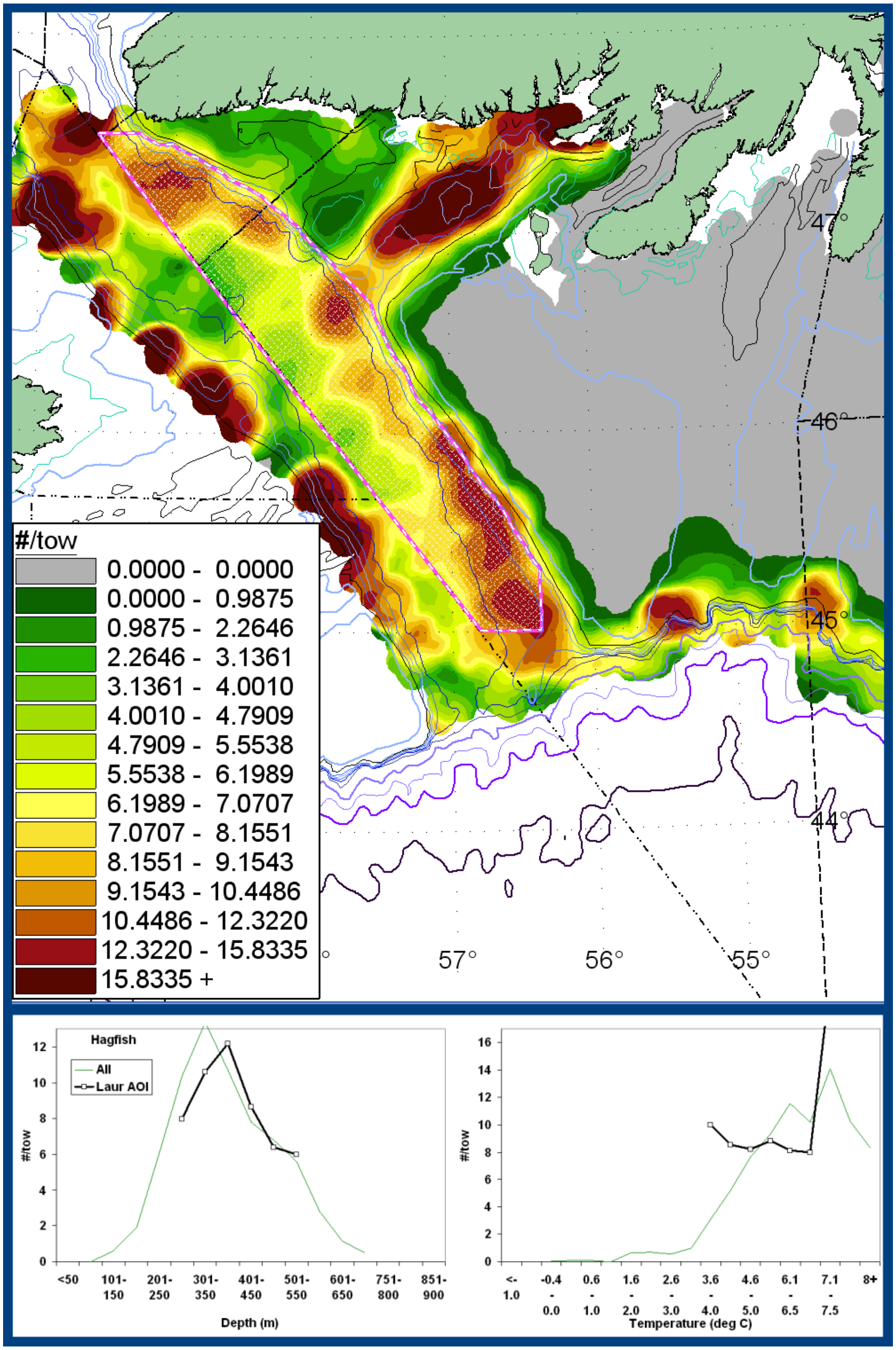

Figure 2h. Distributions (upper, abundance of fish in # caught /tow) and habitat association (#/tow at depth and temperature) for Hagfish (Myxine glutinosa) in the Laurentian Channel and the adjacent St. Pierre Bank. Candy stripe line encloses the Laurentian AOI. Dashed black lines show the NAFO Divisions (Division 3P in the centre). Blue and purple lines are depths contours 20, 50, 100, 200, 250, 300, 350, 400, 500 1500 m and three thick lines 1000, 2000, 3000 m.

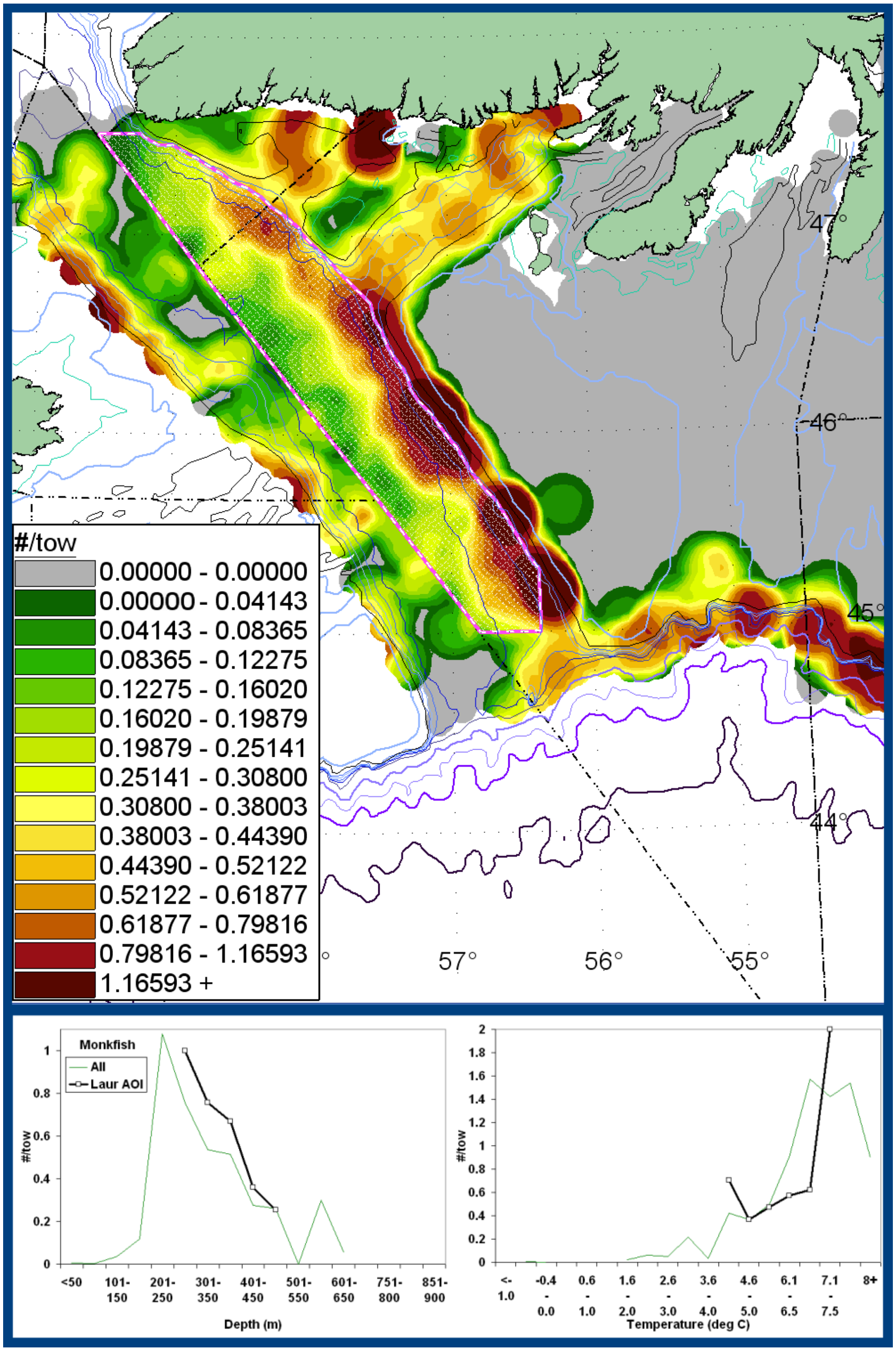

Figure 2i. Distributions (upper, abundance of fish in # caught /tow) and habitat association (#/tow at depth and temperature) for Monkfish (Lophius americanus) in the Laurentian Channel and the adjacent St. Pierre Bank. Candy stripe line encloses the Laurentian AOI. Dashed black lines show the NAFO Divisions (Division 3P in the centre). Blue and purple lines are depths contours 20, 50, 100, 200, 250, 300, 350, 400, 500 1500 m and three thick lines 1000, 2000, 3000 m.

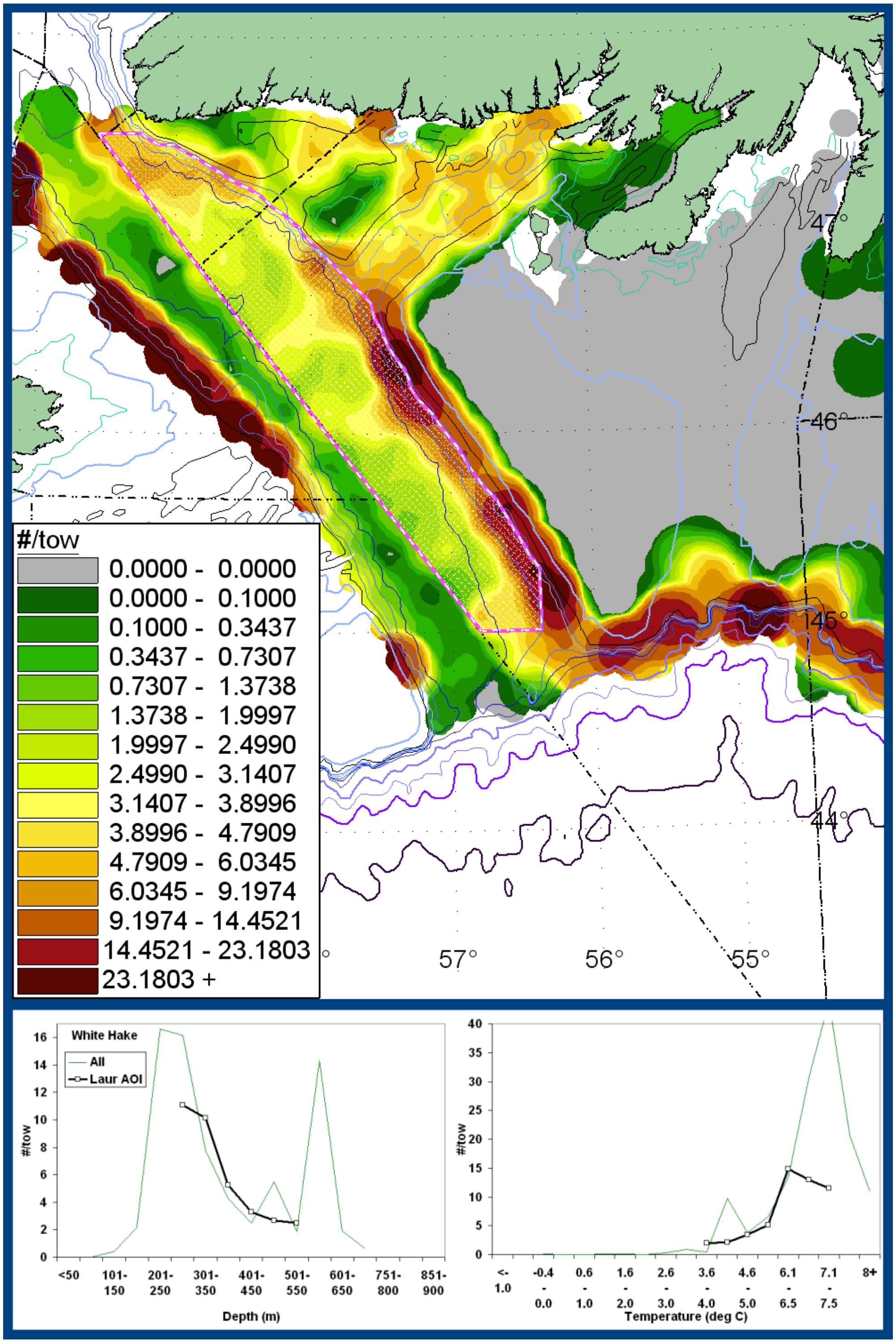

*Figure 2j. Distributions (upper, abundance of fish in # caught /tow) and habitat association (#/tow at depth and temperature) for **White Hake (Urophysis tenuis)** in the Laurentian Channel and the adjacent St. Pierre Bank. Candy stripe line encloses the Laurentian AOI. Dashed black lines show the NAFO Divisions (Division 3P in the centre). Blue and purple lines are depths contours 20, 50, 100, 200, 250, 300, 350, 400, 500 1500 m and three thick lines 1000, 2000, 3000 m.*

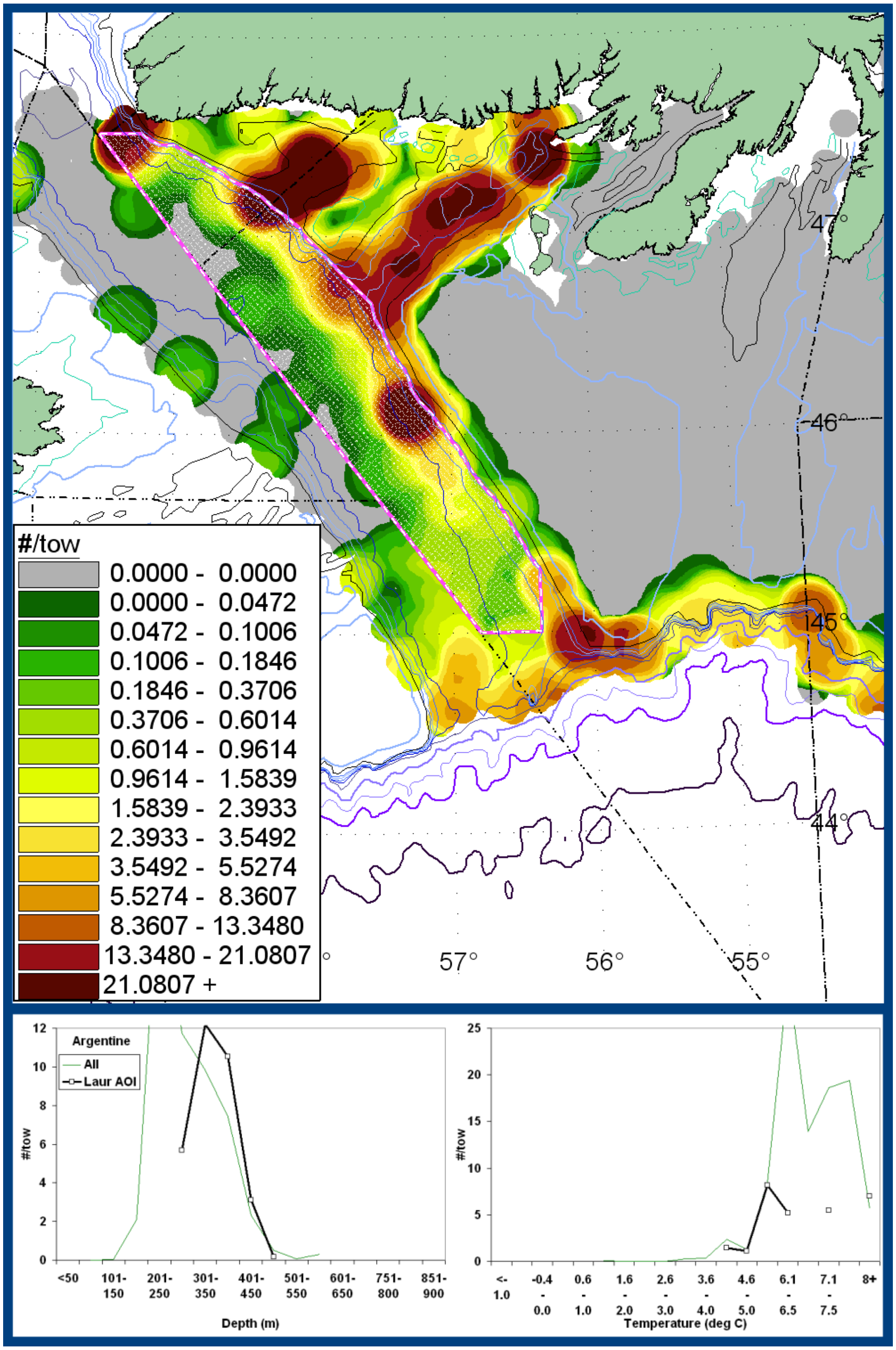

*Figure 2k. Distributions (upper, abundance of fish in # caught /tow) and habitat association (#/tow at depth and temperature) for **Argentine (Argentina silus)** in the Laurentian Channel and the adjacent St. Pierre Bank. Candy stripe line encloses the Laurentian AOI. Dashed black lines show the NAFO Divisions (Division 3P in the centre). Blue and purple lines are depths contours 20, 50, 100, 200, 250, 300, 350, 400, 500 1500 m and three thick lines 1000, 2000, 3000 m.*

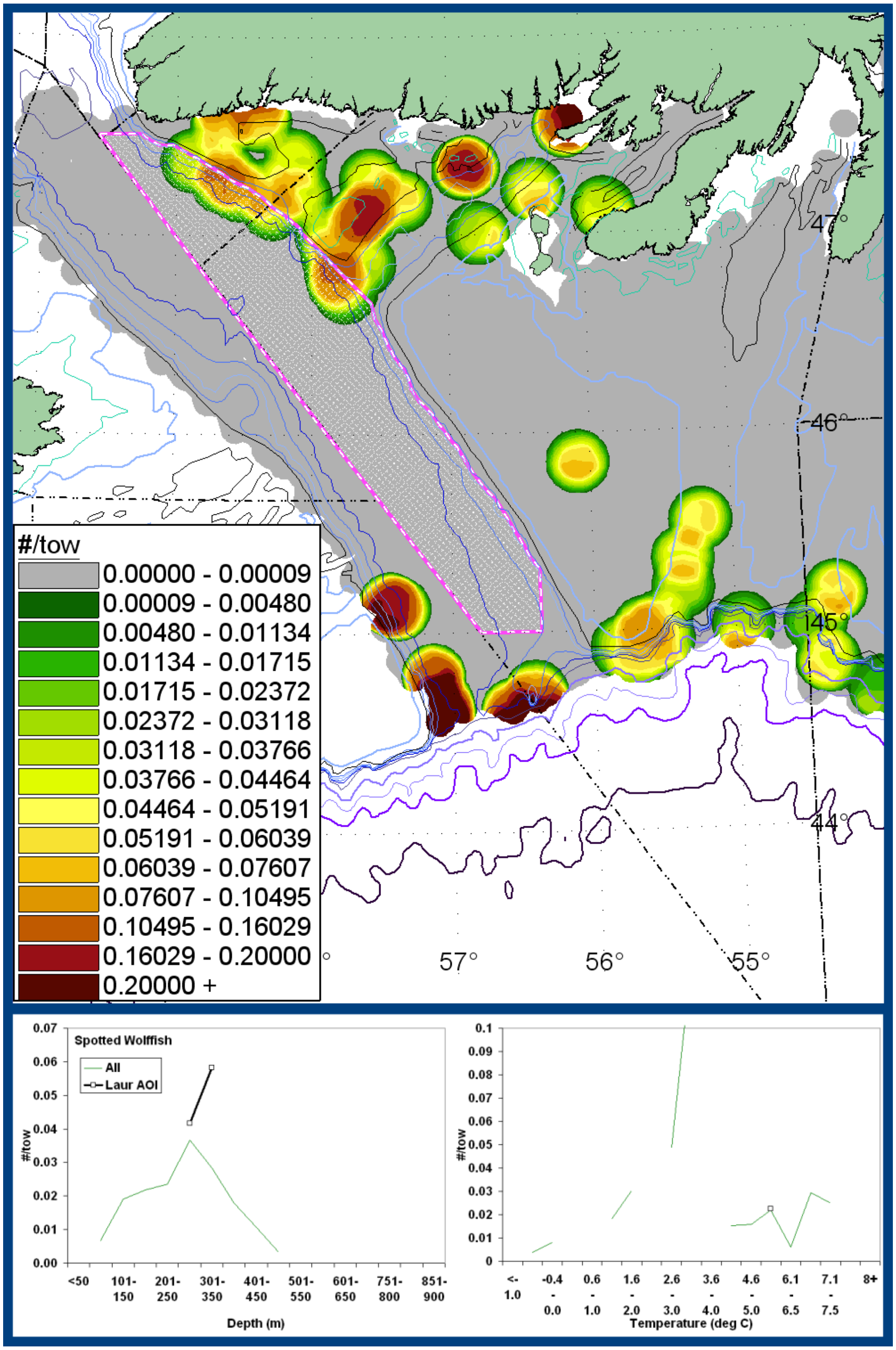

Figure 2l. Distributions (upper, abundance of fish in # caught /tow) and habitat association (#/tow at depth and temperature) for ***Spotted Wolffish (Anarhichas minor)*** *in the Laurentian Channel and the adjacent St. Pierre Bank. Candy stripe line encloses the Laurentian AOI. Dashed black lines show the NAFO Divisions (Division 3P in the centre). Blue and purple lines are depths contours 20, 50, 100, 200, 250, 300, 350, 400, 500 1500 m and three thick lines 1000, 2000, 3000 m.*

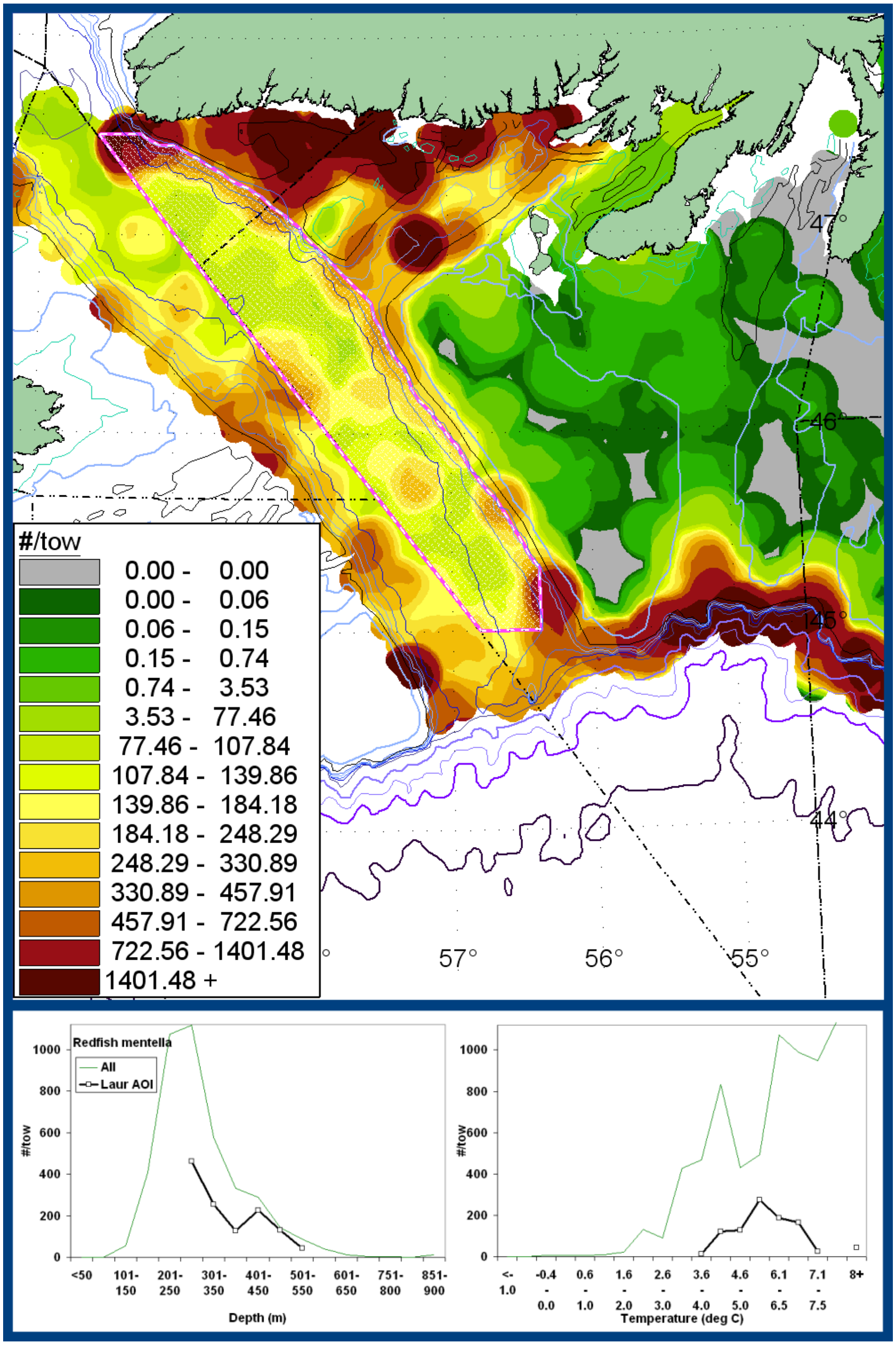

*Figure 2m. Distributions (upper, abundance of fish in # caught /tow) and habitat association (#/tow at depth and temperature) for **Redfish (Sebastes mentella)** in the Laurentian Channel and the adjacent St. Pierre Bank. Candy stripe line encloses the Laurentian AOI. Dashed black lines show the NAFO Divisions (Division 3P in the centre). Blue and purple lines are depths contours 20, 50, 100, 200, 250, 300, 350, 400, 500 1500 m and three thick lines 1000, 2000, 3000 m.*

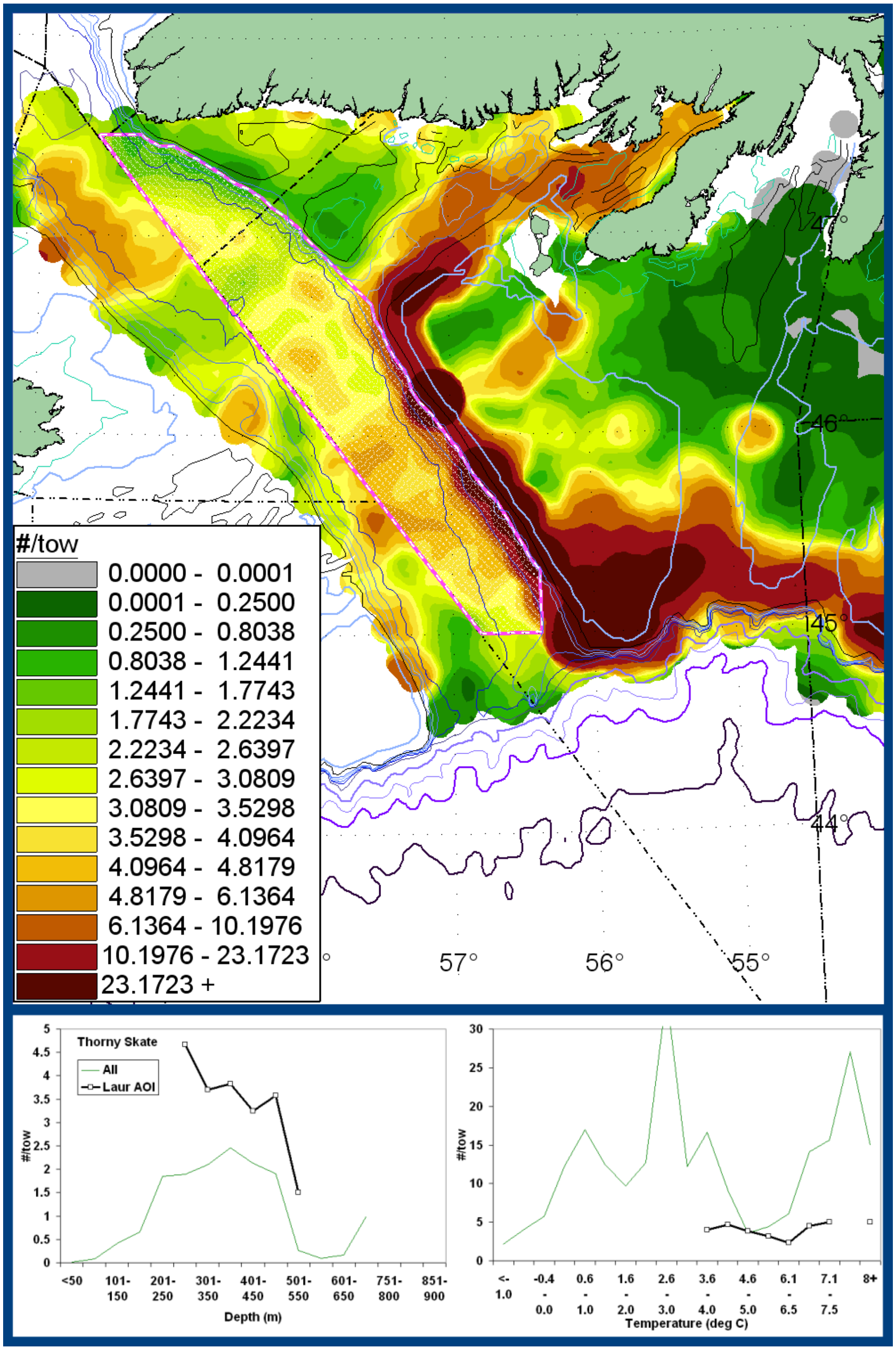

Figure 2n. Distributions (upper, abundance of fish in # caught /tow) and habitat association (#/tow at depth and temperature) for ***Thorny Skate (Amblyraja radiata)*** *in the Laurentian Channel and the adjacent St. Pierre Bank. Candy stripe line encloses the Laurentian AOI. Dashed black lines show the NAFO Divisions (Division 3P in the centre). Blue and purple lines are depths contours 20, 50, 100, 200, 250, 300, 350, 400, 500 1500 m and three thick lines 1000, 2000, 3000 m.*

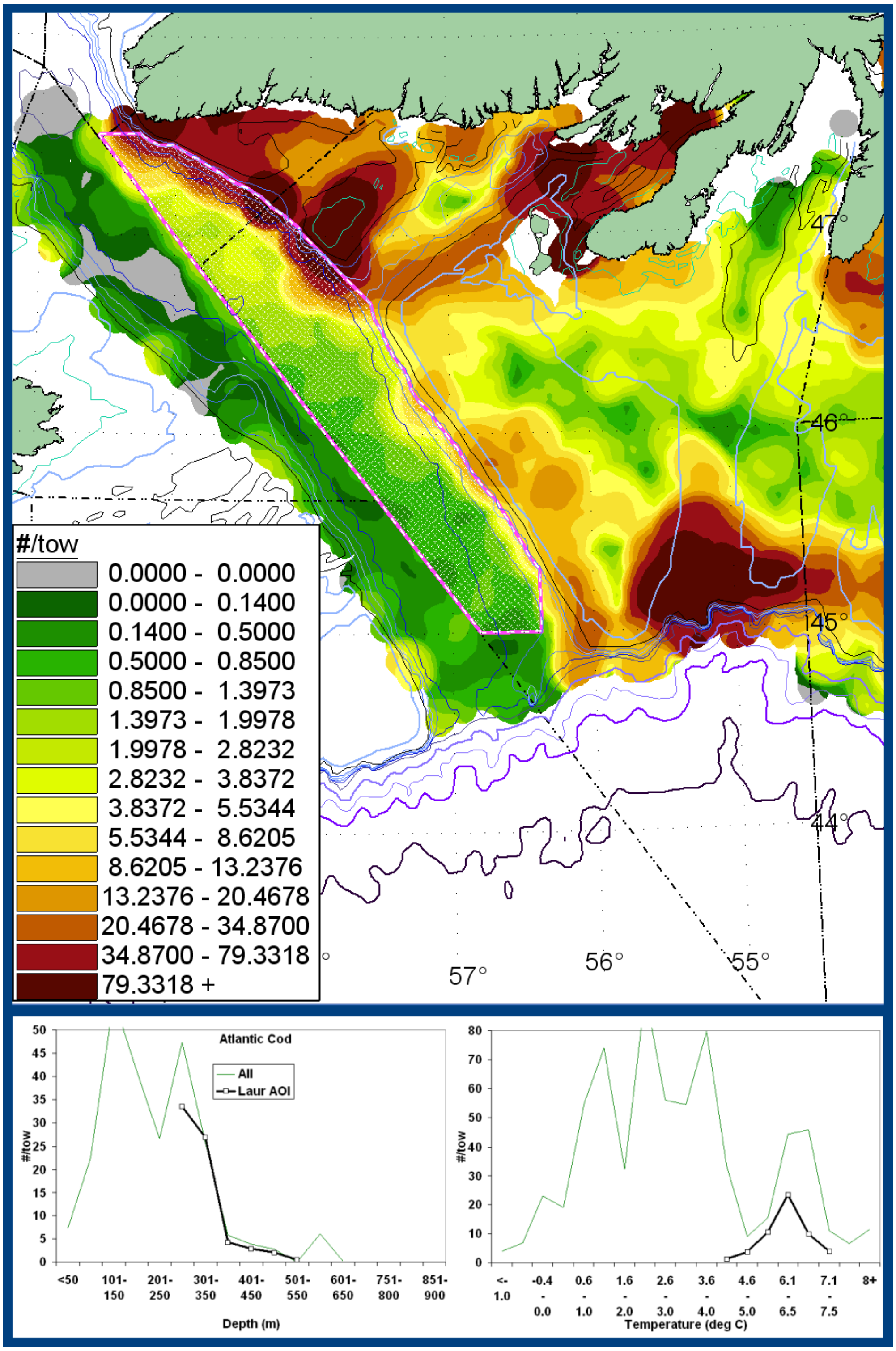

*Figure 2o. Distributions (upper, abundance of fish in # caught /tow) and habitat association (#/tow at depth and temperature) for **Atlantic Cod (Gadus morhua)** in the Laurentian Channel and the adjacent St. Pierre Bank. Candy stripe line encloses the Laurentian AOI. Dashed black lines show the NAFO Divisions (Division 3P in the centre). Blue and purple lines are depths contours 20, 50, 100, 200, 250, 300, 350, 400, 500 1500 m and three thick lines 1000, 2000, 3000 m.*

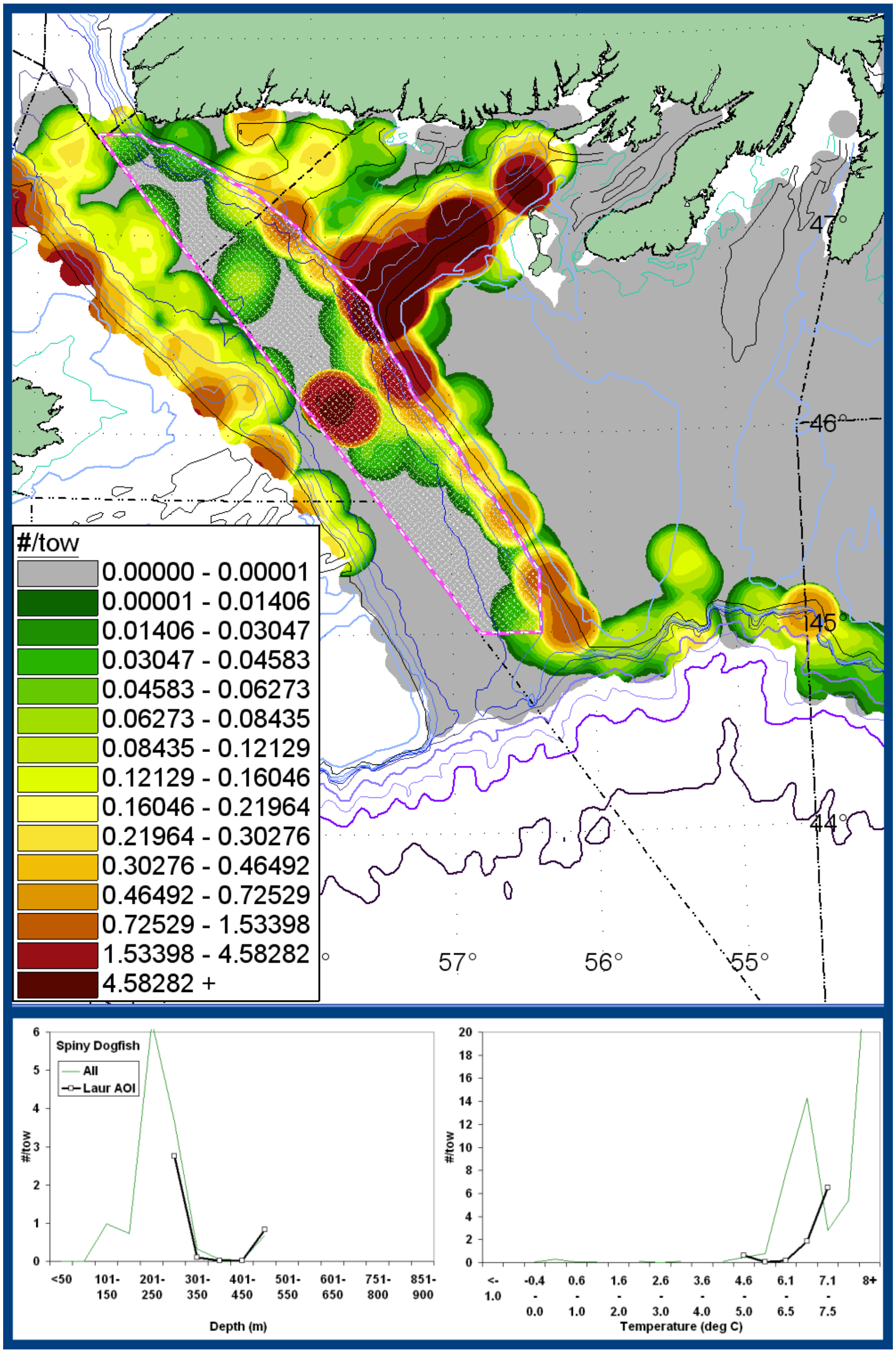

*Figure 2p. Distributions (upper, abundance of fish in # caught /tow) and habitat association (#/tow at depth and temperature) for **Spiny Dogfish (Squalus acanthias)** in the Laurentian Channel and the adjacent St. Pierre Bank. Candy stripe line encloses the Laurentian AOI. Dashed black lines show the NAFO Divisions (Division 3P in the centre). Blue and purple lines are depths contours 20, 50, 100, 200, 250, 300, 350, 400, 500 1500 m and three thick lines 1000, 2000, 3000 m.*

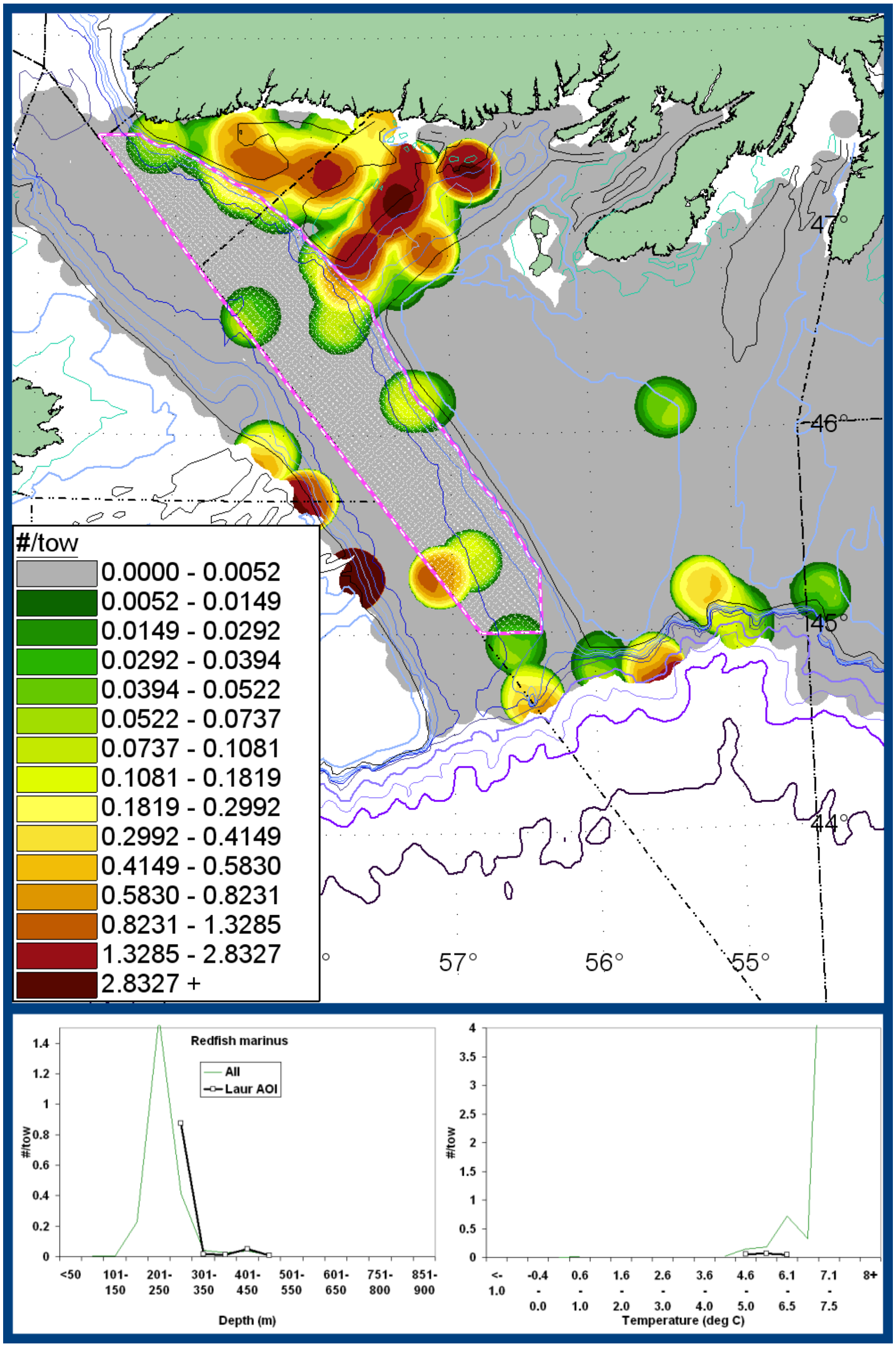

Figure 2q. Distributions (upper, abundance of fish in # caught /tow) and habitat association (#/tow at depth and temperature) for ***Redfish (Sebastes marinus)*** *in the Laurentian Channel and the adjacent St. Pierre Bank. Candy stripe line encloses the Laurentian AOI. Dashed black lines show the NAFO Divisions (Division 3P in the centre). Blue and purple lines are depths contours 20, 50, 100, 200, 250, 300, 350, 400, 500 1500 m and three thick lines 1000, 2000, 3000 m.*

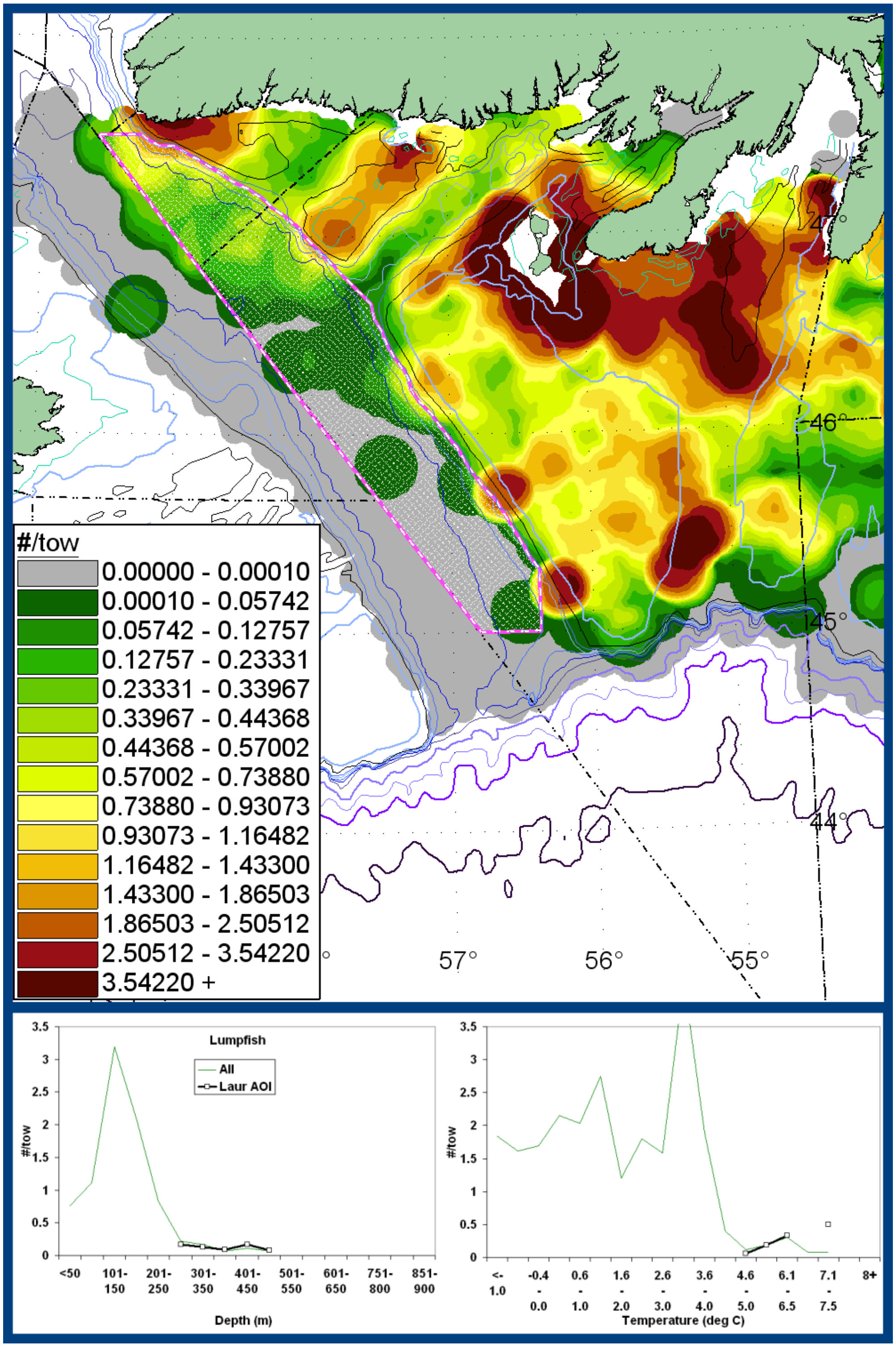

*Figure 2r. Distributions (upper, abundance of fish in # caught /tow) and habitat association (#/tow at depth and temperature) for **Lumpfish (Cyclopterus lumpus)** in the Laurentian Channel and the adjacent St. Pierre Bank. Candy stripe line encloses the Laurentian AOI. Dashed black lines show the NAFO Divisions (Division 3P in the centre). Blue and purple lines are depths contours 20, 50, 100, 200, 250, 300, 350, 400, 500 1500 m and three thick lines 1000, 2000, 3000 m.*

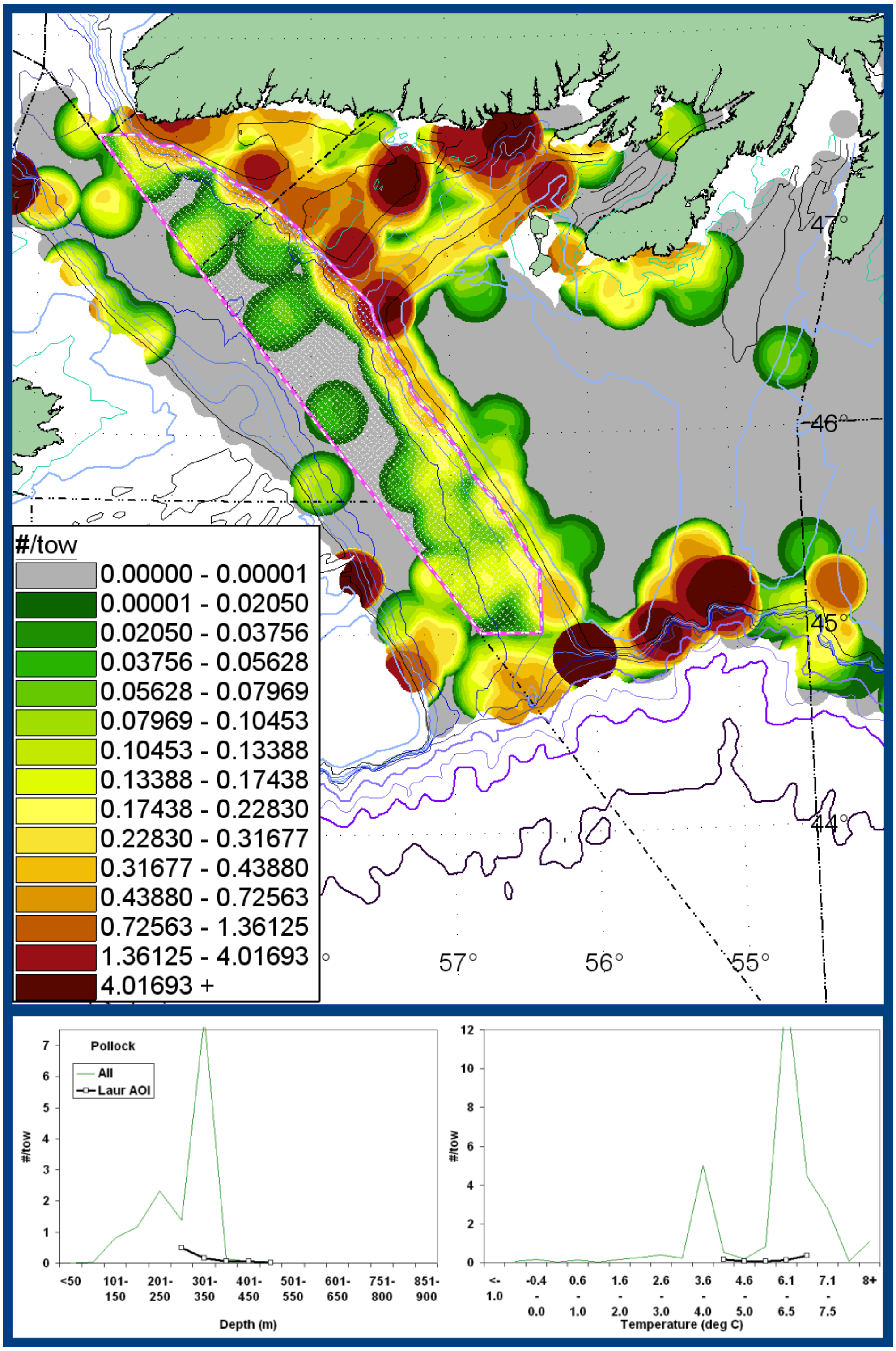

*Figure 2s. Distributions (upper, abundance of fish in # caught /tow) and habitat association (#/tow at depth and temperature) for **Pollock (Pollachius virens)** in the Laurentian Channel and the adjacent St. Pierre Bank. Candy stripe line encloses the Laurentian AOI. Dashed black lines show the NAFO Divisions (Division 3P in the centre). Blue and purple lines are depths contours 20, 50, 100, 200, 250, 300, 350, 400, 500 1500 m and three thick lines 1000, 2000, 3000 m.*

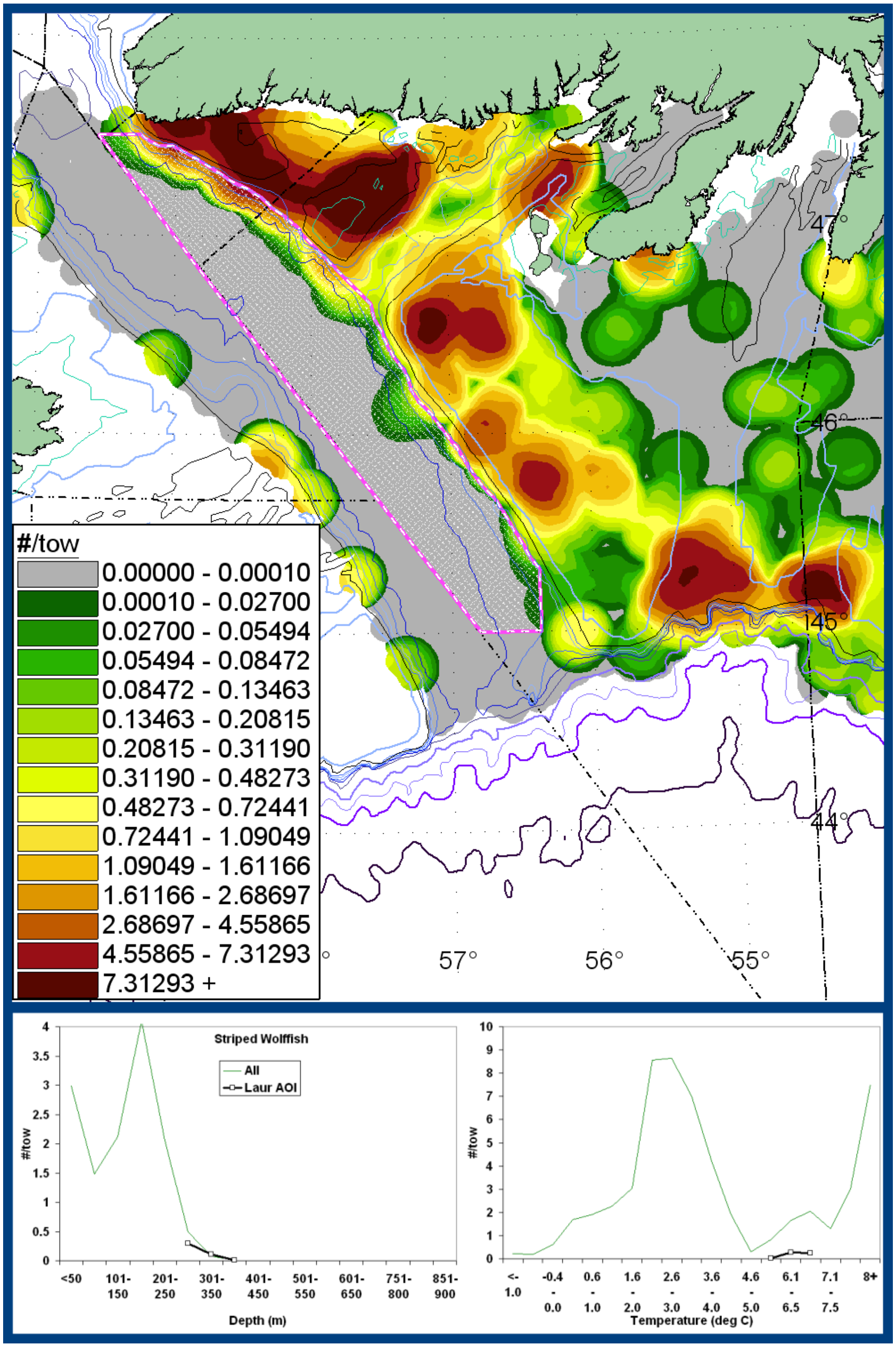

*Figure 2t. Distributions (upper, abundance of fish in # caught /tow) and habitat association (#/tow at depth and temperature) for **Striped Wolffish (Anarhichas lupus)** in the Laurentian Channel and the adjacent St. Pierre Bank. Candy stripe line encloses the Laurentian AOI. Dashed black lines show the NAFO Divisions (Division 3P in the centre). Blue and purple lines are depths contours 20, 50, 100, 200, 250, 300, 350, 400, 500 1500 m and three thick lines 1000, 2000, 3000 m.*

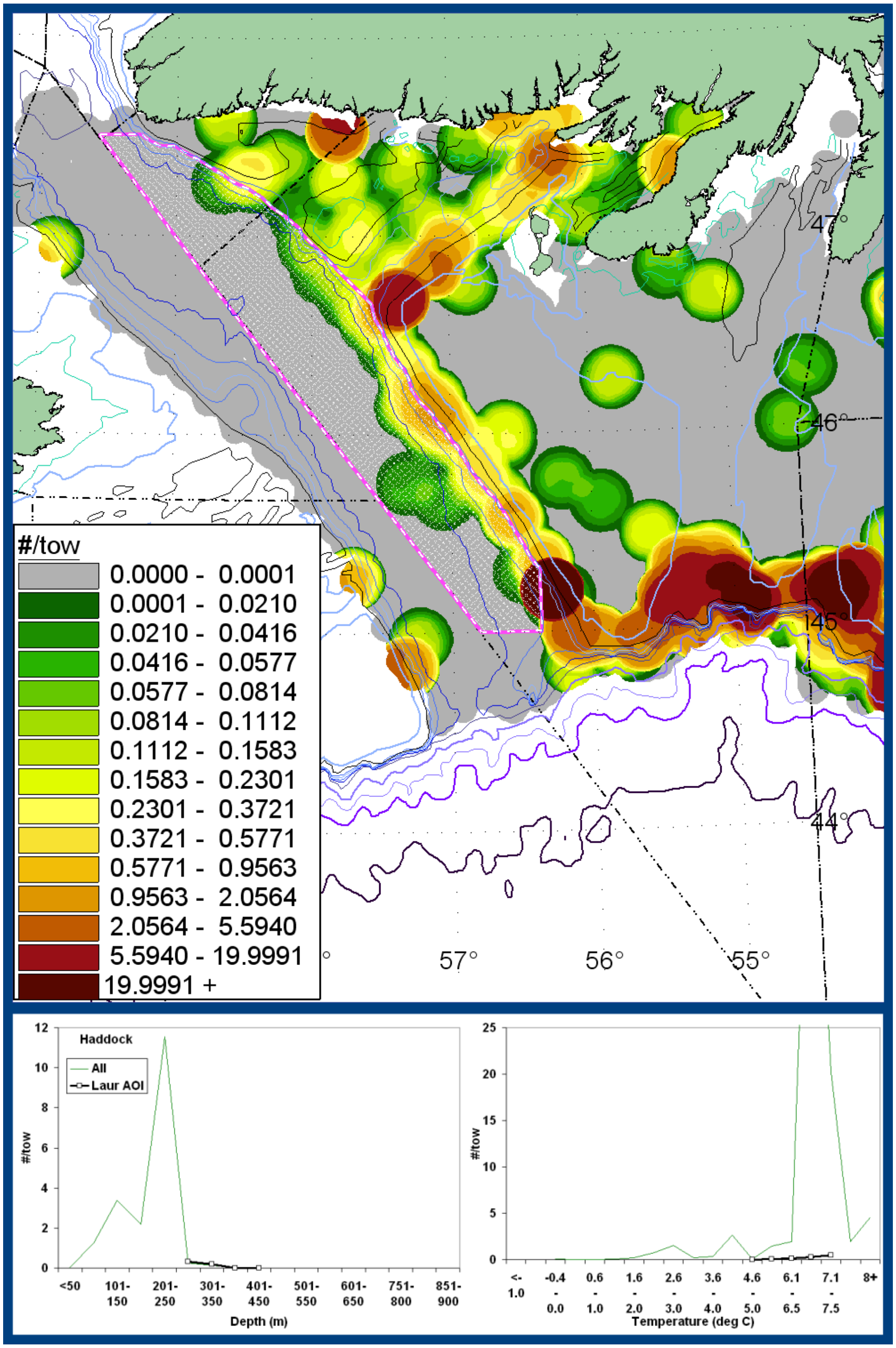

Figure 2u. Distributions (upper, abundance of fish in # caught /tow) and habitat association (#/tow at depth and temperature) for Haddock (Melanogrammus aeglefinus) in the Laurentian Channel and the adjacent St. Pierre Bank. Candy stripe line encloses the Laurentian AOI. Dashed black lines show the NAFO Divisions (Division 3P in the centre). Blue and purple lines are depths contours 20, 50, 100, 200, 250, 300, 350, 400, 500 1500 m and three thick lines 1000, 2000, 3000 m.

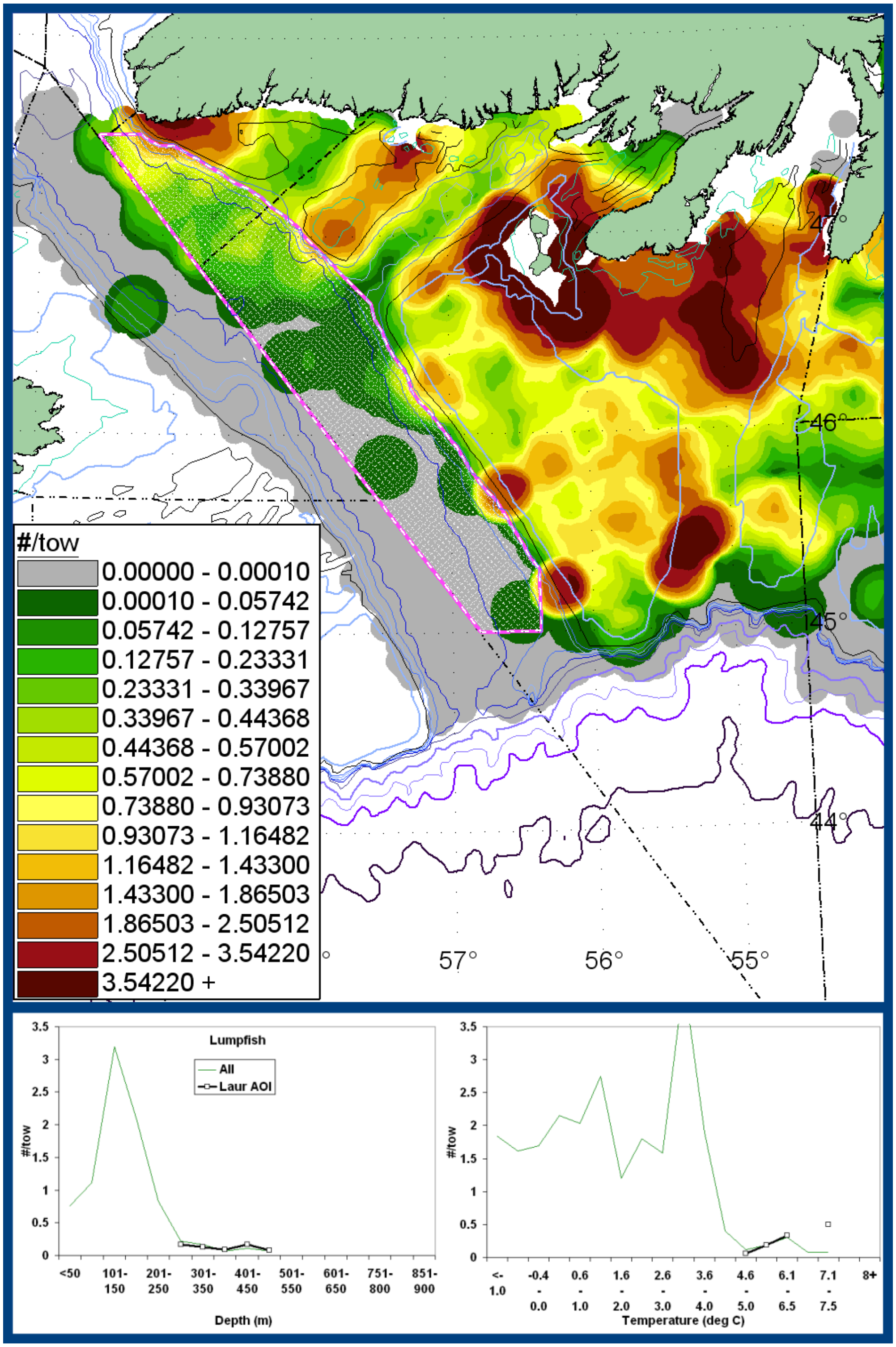

*Figure 2v. Distributions (upper, abundance of fish in # caught /tow) and habitat association (#/tow at depth and temperature) for **Mailed Sculpin (Triglops sp.)** in the Laurentian Channel and the adjacent St. Pierre Bank. Candy stripe line encloses the Laurentian AOI. Dashed black lines show the NAFO Divisions (Division 3P in the centre). Blue and purple lines are depths contours 20, 50, 100, 200, 250, 300, 350, 400, 500 1500 m and three thick lines 1000, 2000, 3000 m.*

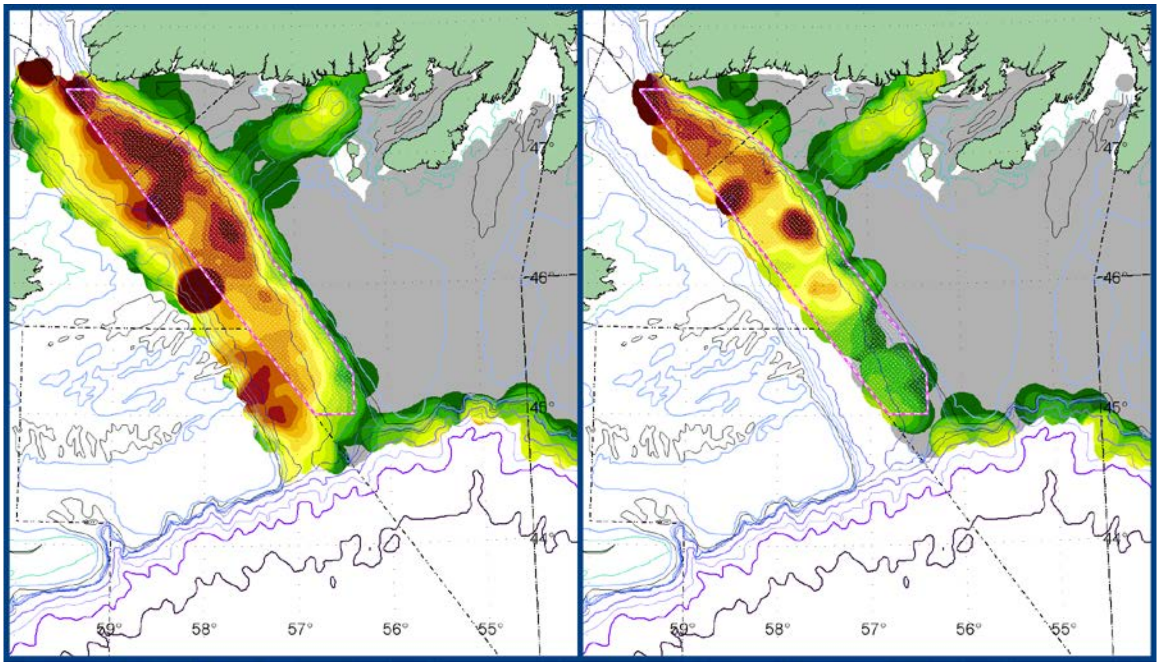

*Figure 3a. Distribution of **Black Dogfish** during two periods, 1996-2002 (left panel) and 2003-09 (right panel). See Figure 1 for the legend, description of the data and the base map. Note that a portion of the Laurentian Channel in Division 4Vn (southwestern half) was not sampled after 2002.*

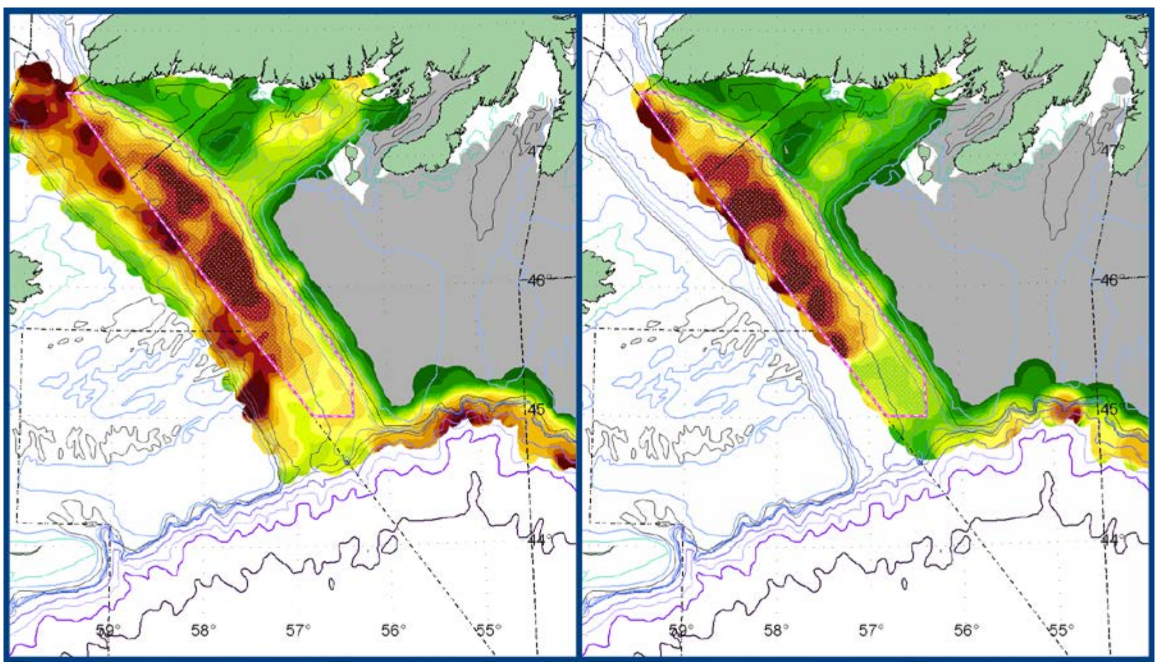

*Figure 3b. Distribution of **Common grenadier** during two periods, 1996-2002 (left panel) and 2003-09 (right panel). See Figure 1 for the legend, description of the data and the base map. Note that a portion of the Laurentian Channel in Division 4Vn (southwestern half) was not sampled after 2002.*

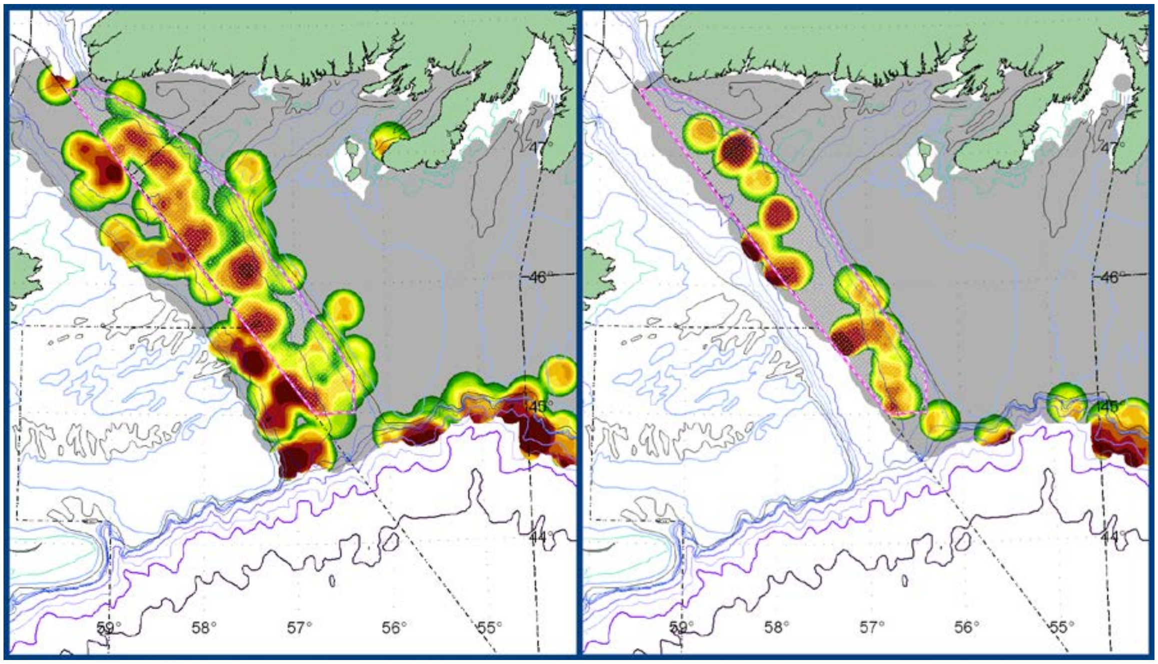

*Figure 3c. Distribution of **Northern wolffish** during two periods, 1996-2002 (left panel) and 2003-09 (right panel). See Figure 1 for the legend, description of the data and the base map. Note that a portion of the Laurentian Channel in Division 4Vn (southwestern half) was not sampled after 2002.*

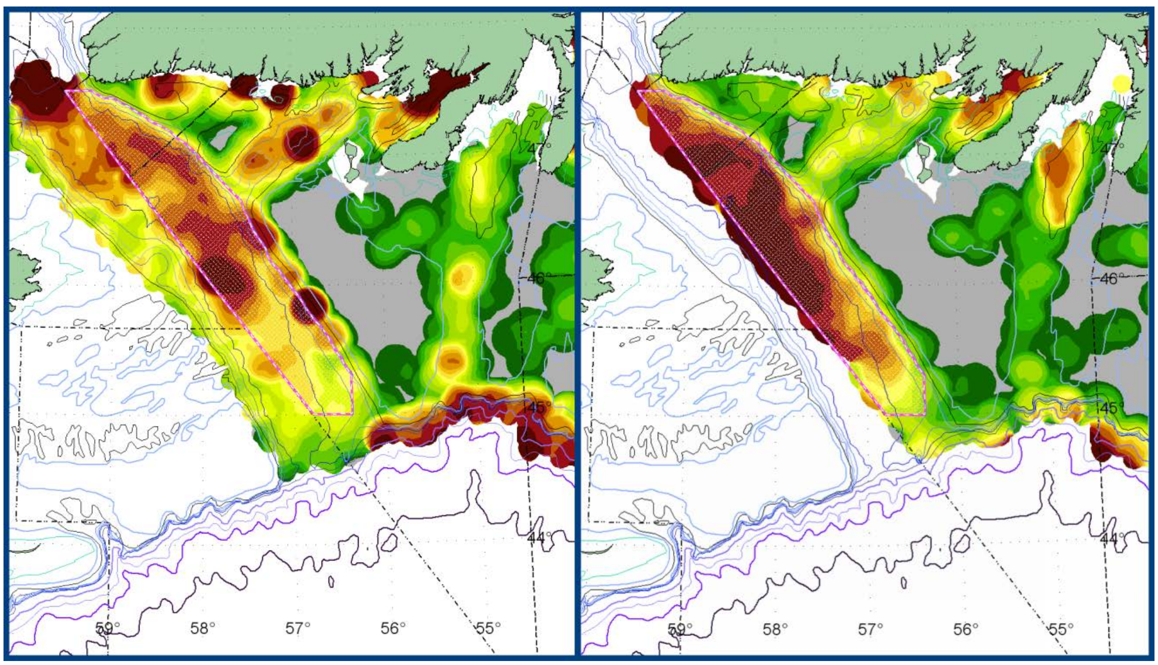

*Figure 3d. Distribution of **Greenland Halibut** during two periods, 1996-2002 (left panel) and 2003-09 (right panel). See Figure 1 for the legend, description of the data and the base map. Note that a portion of the Laurentian Channel in Division 4Vn (southwestern half) was not sampled after 2002.*

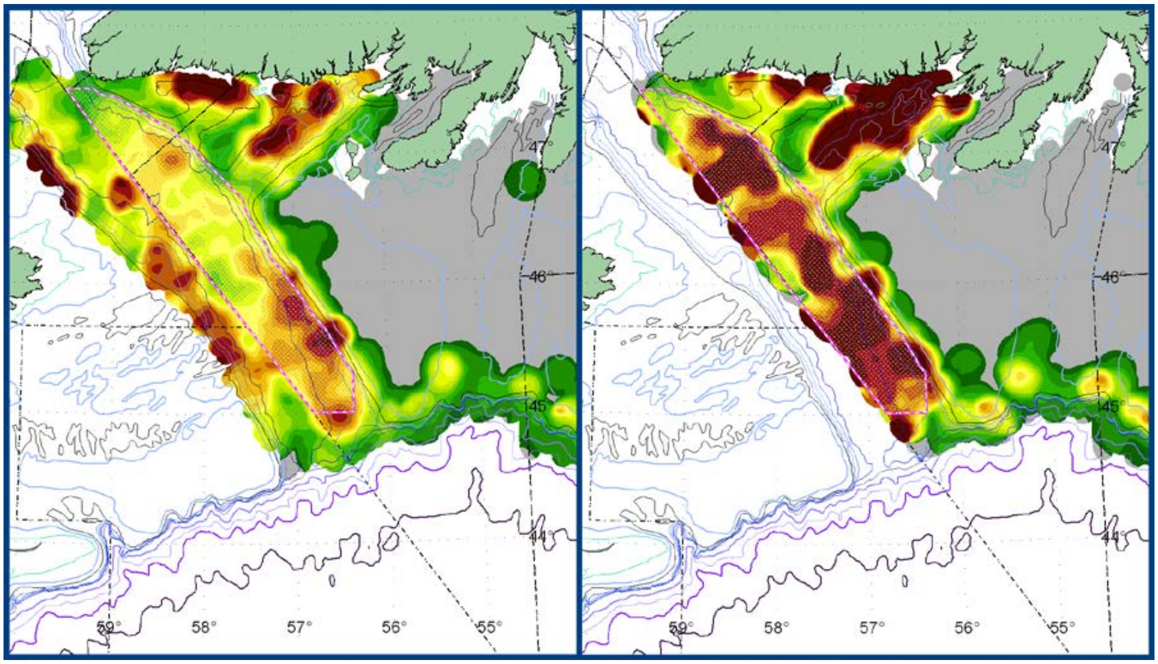

*Figure 3e. Distribution of **Smooth Skate** during two periods, 1996-2002 (left panel) and 2003-09 (right panel). See Figure 1 for the legend, description of the data and the base map. Note that a portion of the Laurentian Channel in Division 4Vn (southwestern half) was not sampled after 2002.*

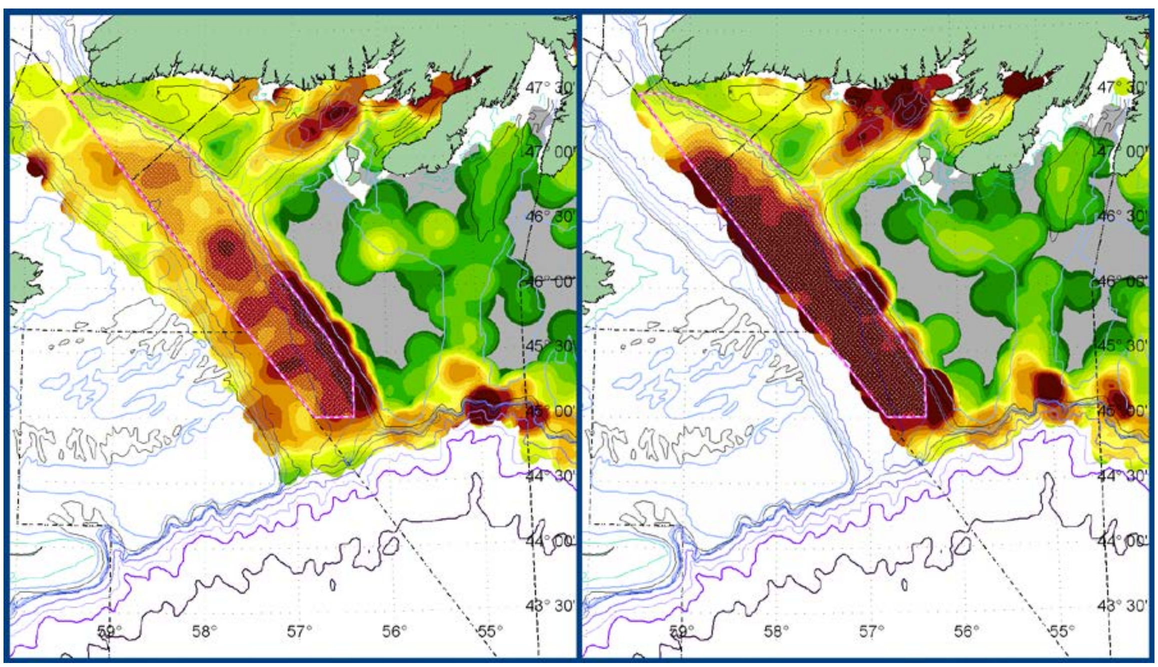

*Figure 3f. Distribution of **Witch** during two periods, 1996-2002 (left panel) and 2003-09 (right panel). See Figure 1 for the legend, description of the data and the base map. Note that a portion of the Laurentian Channel in Division 4Vn (southwestern half) was not sampled after 2002.*

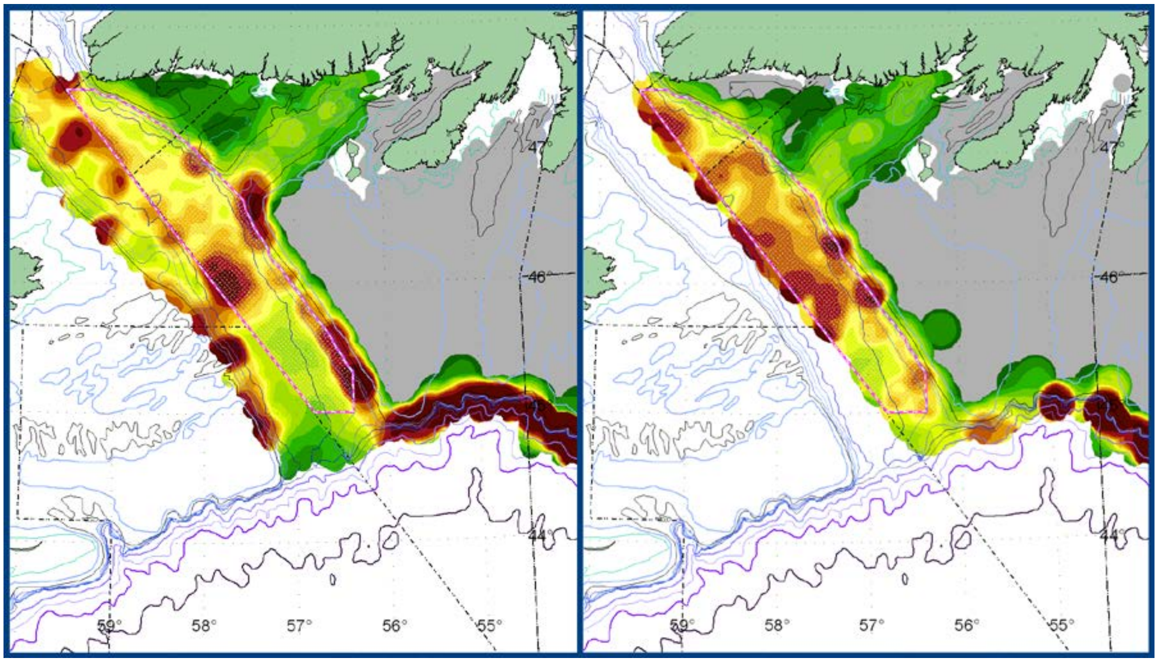

*Figure 3g. Distribution of **Longfin Hake** during two periods, 1996-2002 (left panel) and 2003-09 (right panel). See Figure 1 for the legend, description of the data and the base map. Note that a portion of the Laurentian Channel in Division 4Vn (southwestern half) was not sampled after 2002.*

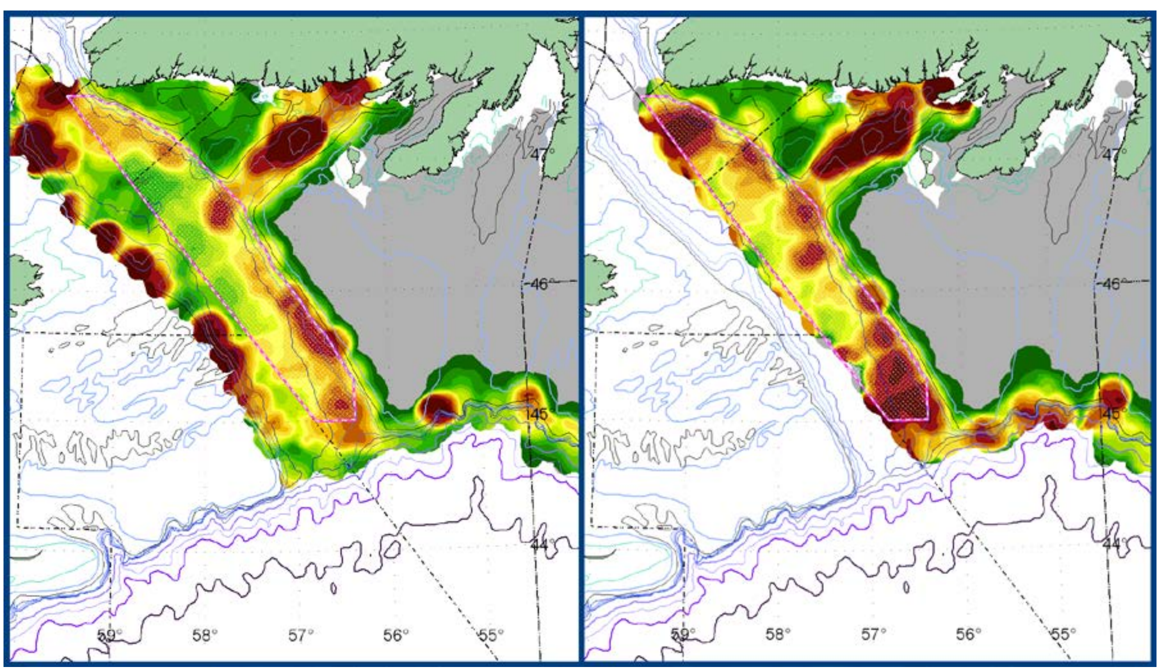

*Figure 3h. Distribution of **Hagfish** during two periods, 1996-2002 (left panel) and 2003-09 (right panel). See Figure 1 for the legend, description of the data and the base map. Note that a portion of the Laurentian Channel in Division 4Vn (southwestern half) was not sampled after 2002.*

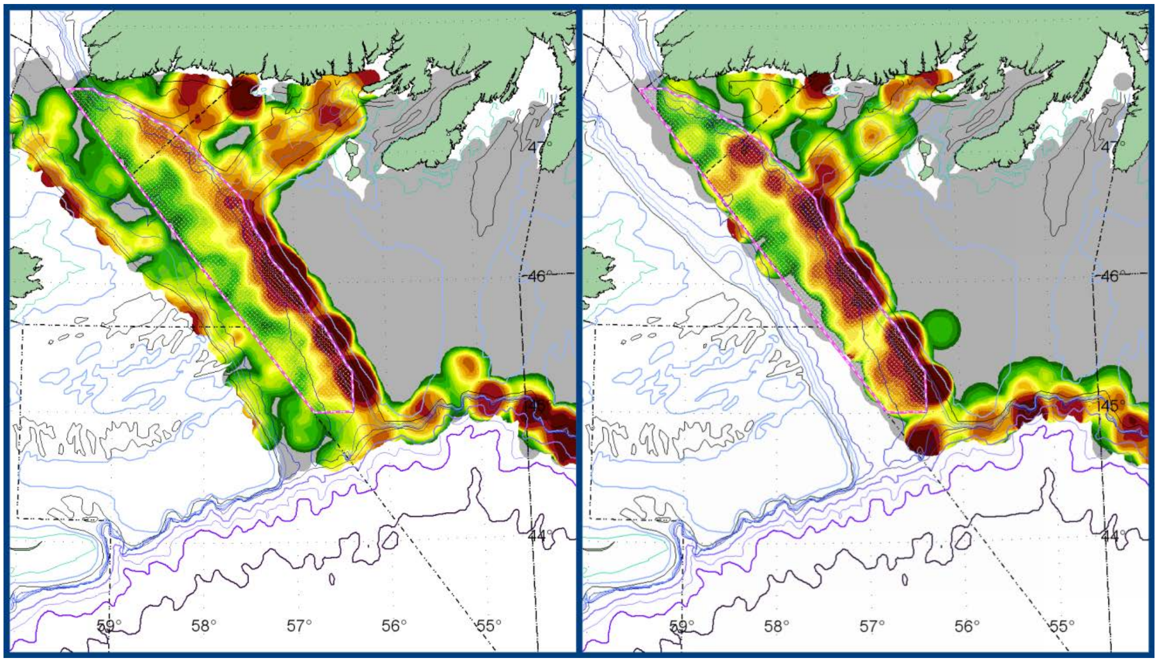

*Figure 3i. Distribution of **Monkfish** during two periods, 1996-2002 (left panel) and 2003-09 (right panel). See Figure 1 for the legend, description of the data and the base map. Note that a portion of the Laurentian Channel in Division 4Vn (southwestern half) was not sampled after 2002.*

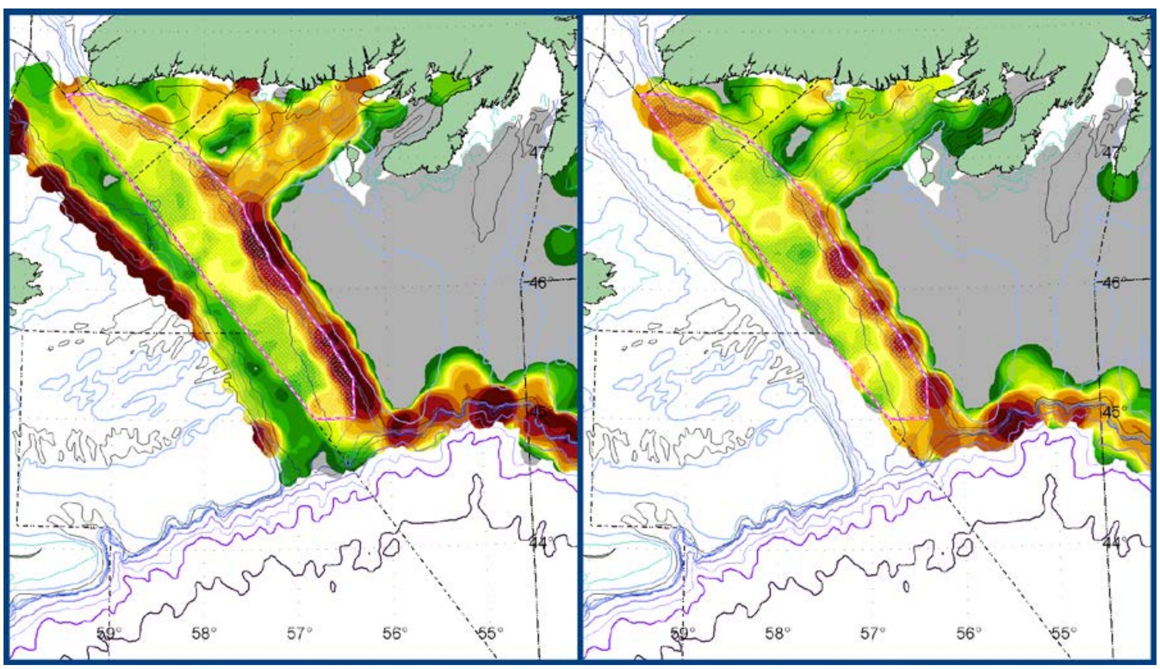

*Figure 3j. Distribution of **White Hake** during two periods, 1996-2002 (left panel) and 2003-09 (right panel). See Figure 1 for the legend, description of the data and the base map. Note that a portion of the Laurentian Channel in Division 4Vn (southwestern half) was not sampled after 2002.*

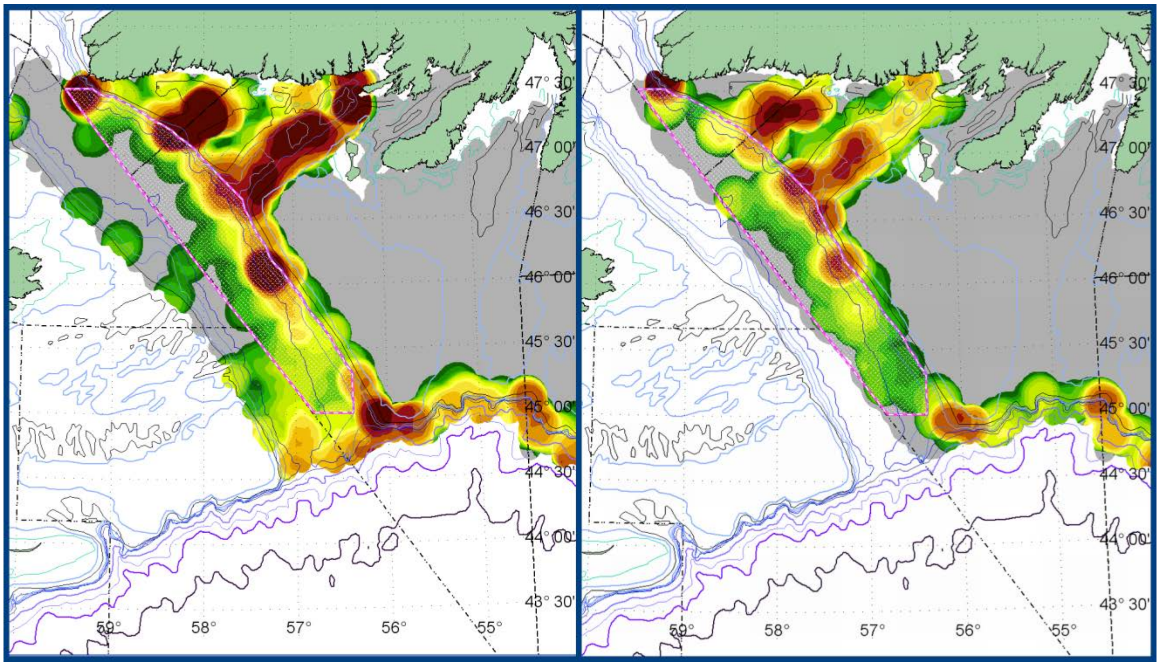

Figure 3k. Distribution of ***Argentine*** *during two periods, 1996-2002 (left panel) and 2003-09 (right panel). See Figure 1 for the legend, description of the data and the base map. Note that a portion of the Laurentian Channel in Division 4Vn (southwestern half) was not sampled after 2002.*

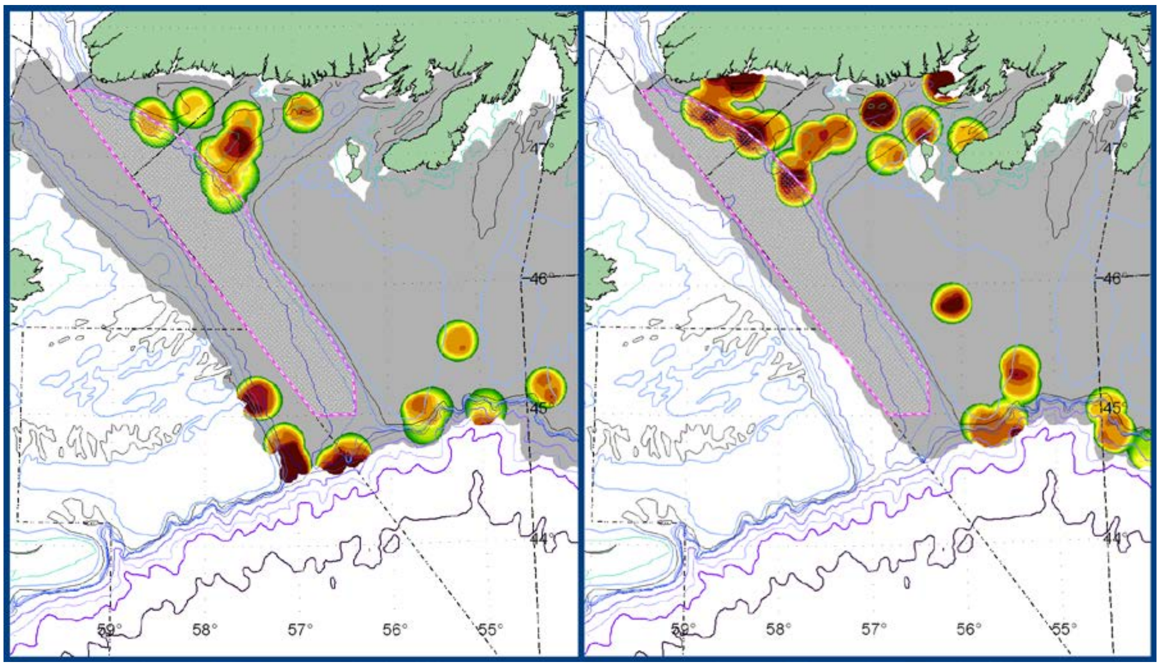

Figure 3l. Distribution of ***Spotted Wolffish*** *during two periods, 1996-2002 (left panel) and 2003-09 (right panel). See Figure 1 for the legend, description of the data and the base map. Note that a portion of the Laurentian Channel in Division 4Vn (southwestern half) was not sampled after 2002.*

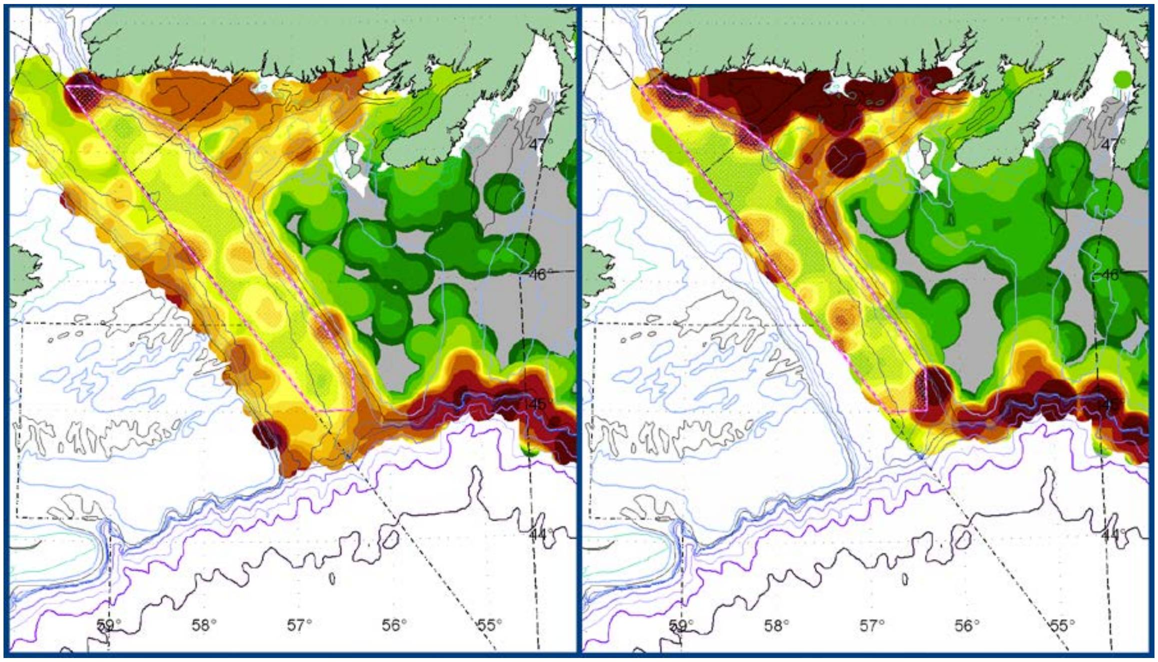

*Figure 3m. Distribution of **Redfish Mentella** during two periods, 1996-2002 (left panel) and 2003-09 (right panel). See Figure 1 for the legend, description of the data and the base map. Note that a portion of the Laurentian Channel in Division 4Vn (southwestern half) was not sampled after 2002.*

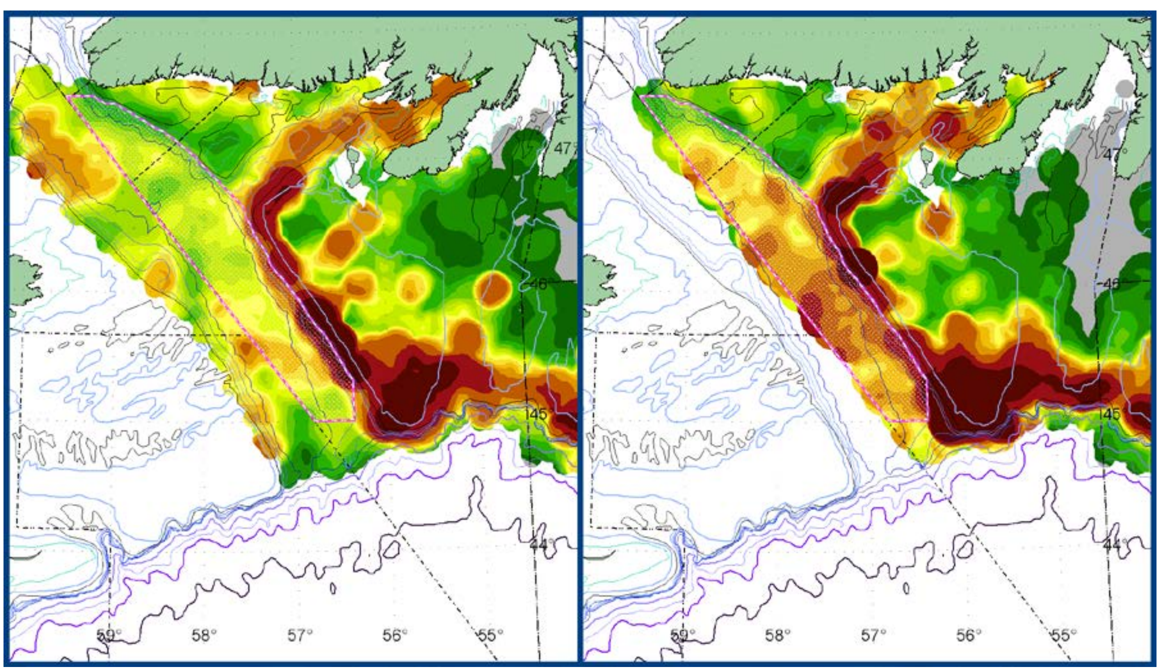

*Figure 3n. Distribution of **Thorny Skate** during two periods, 1996-2002 (left panel) and 2003-09 (right panel). See Figure 1 for the legend, description of the data and the base map. Note that a portion of the Laurentian Channel in Division 4Vn (southwestern half) was not sampled after 2002.*

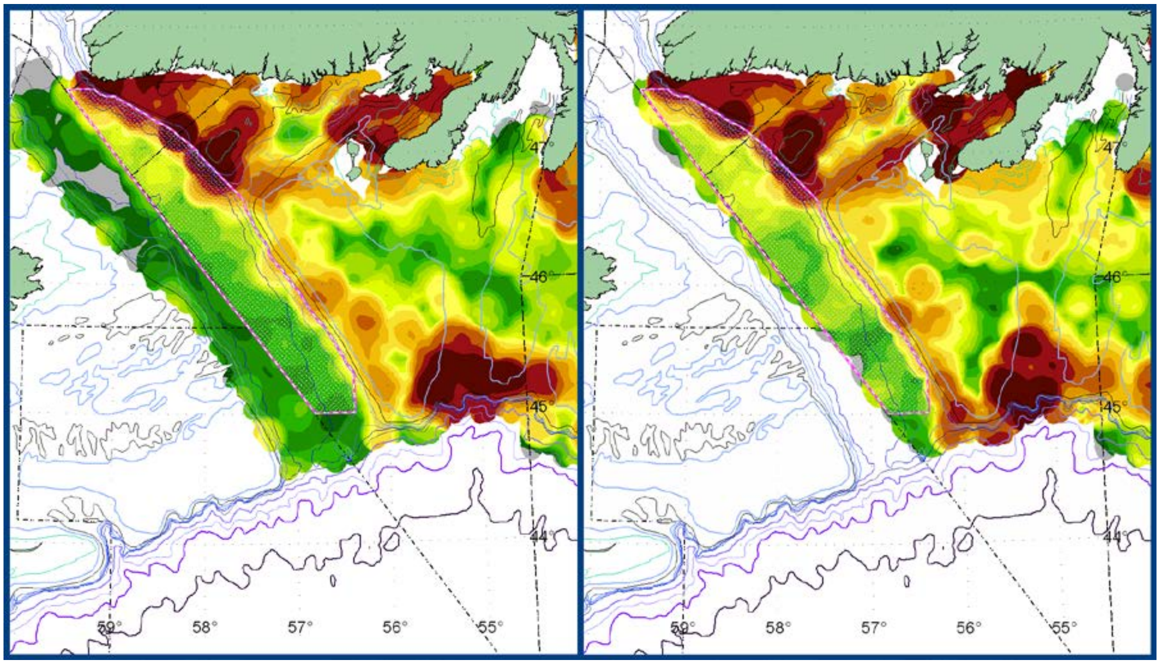

*Figure 3o. Distribution of **Atlantic cod** during two periods, 1996-2002 (left panel) and 2003-09 (right panel). See Figure 1 for the legend, description of the data and the base map. Note that a portion of the Laurentian Channel in Division 4Vn (southwestern half) was not sampled after 2002.*

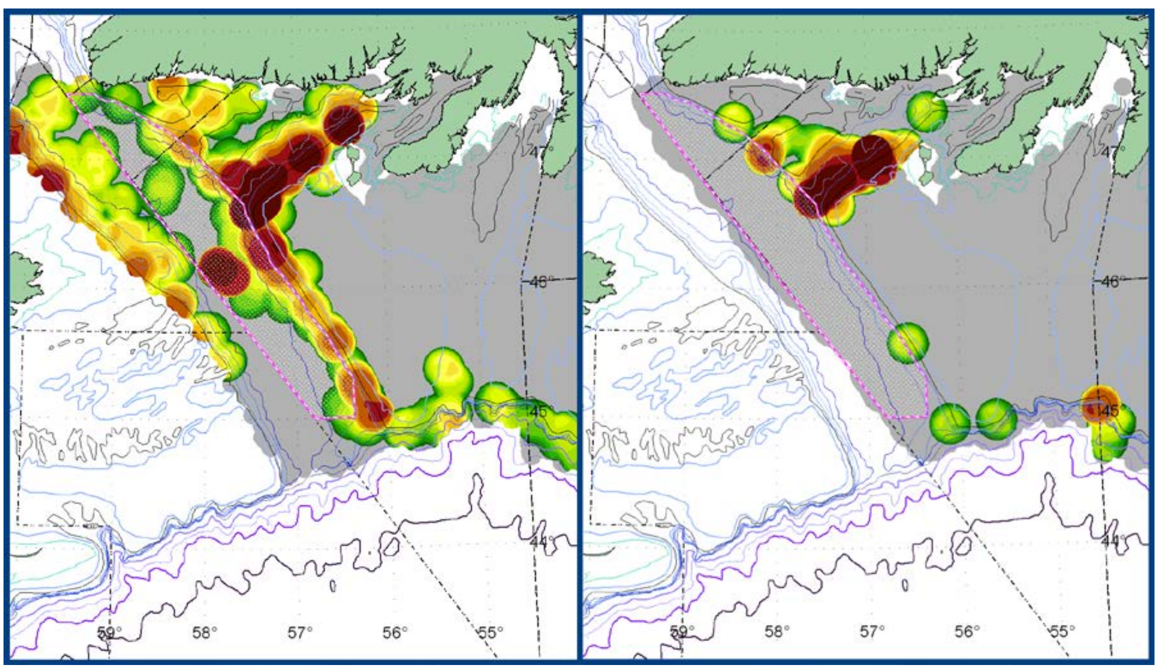

*Figure 3p. Distribution of **Spiny Dogfish** during two periods, 1996-2002 (left panel) and 2003-09 (right panel). See Figure 1 for the legend, description of the data and the base map. Note that a portion of the Laurentian Channel in Division 4Vn (southwestern half) was not sampled after 2002.*

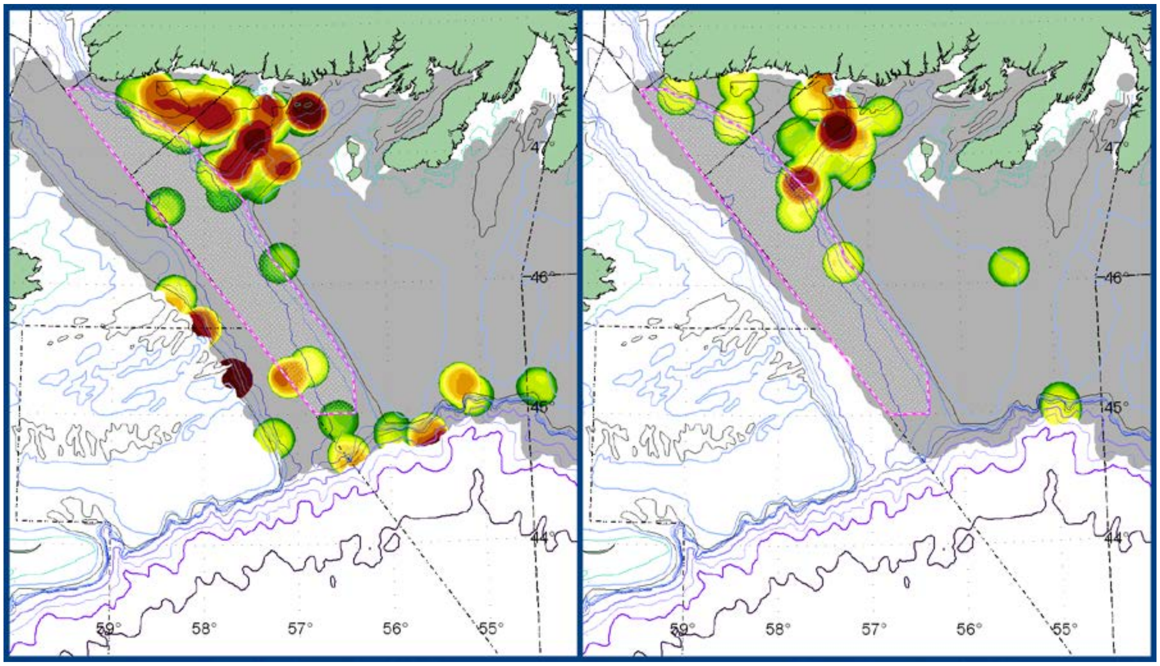

*Figure 3q. Distribution of **Redfish Marinus** during two periods, 1996-2002 (left panel) and 2003-09 (right panel). See Figure 1 for the legend, description of the data and the base map. Note that a portion of the Laurentian Channel in Division 4Vn (southwestern half) was not sampled after 2002.*

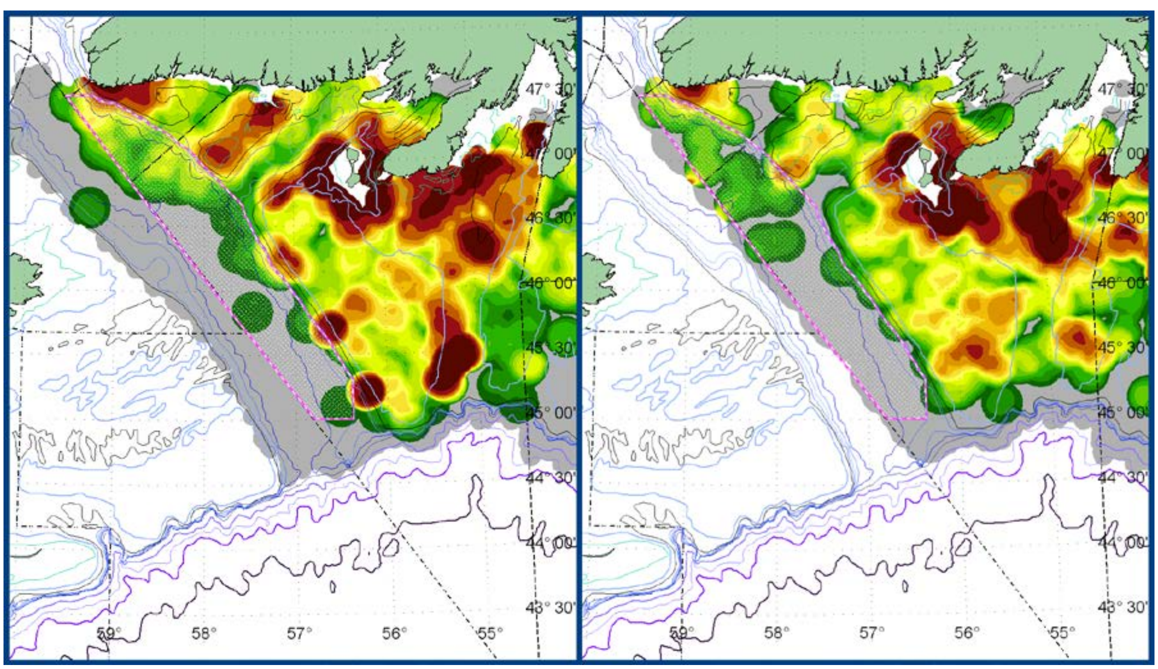

*Figure 3r. Distribution of **Lumpfish** during two periods, 1996-2002 (left panel) and 2003-09 (right panel). See Figure 1 for the legend, description of the data and the base map. Note that a portion of the Laurentian Channel in Division 4Vn (southwestern half) was not sampled after 2002.*

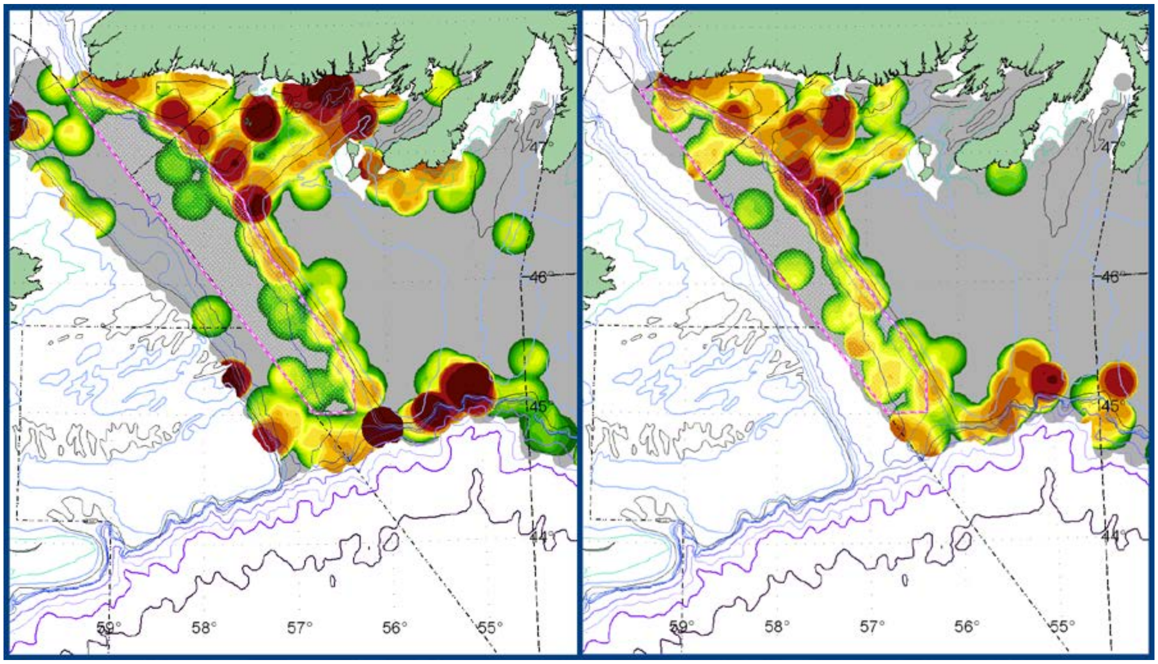

*Figure 3s. Distribution of **Pollock** during two periods, 1996-2002 (left panel) and 2003-09 (right panel). See Figure 1 for the legend, description of the data and the base map. Note that a portion of the Laurentian Channel in Division 4Vn (southwestern half) was not sampled after 2002.*

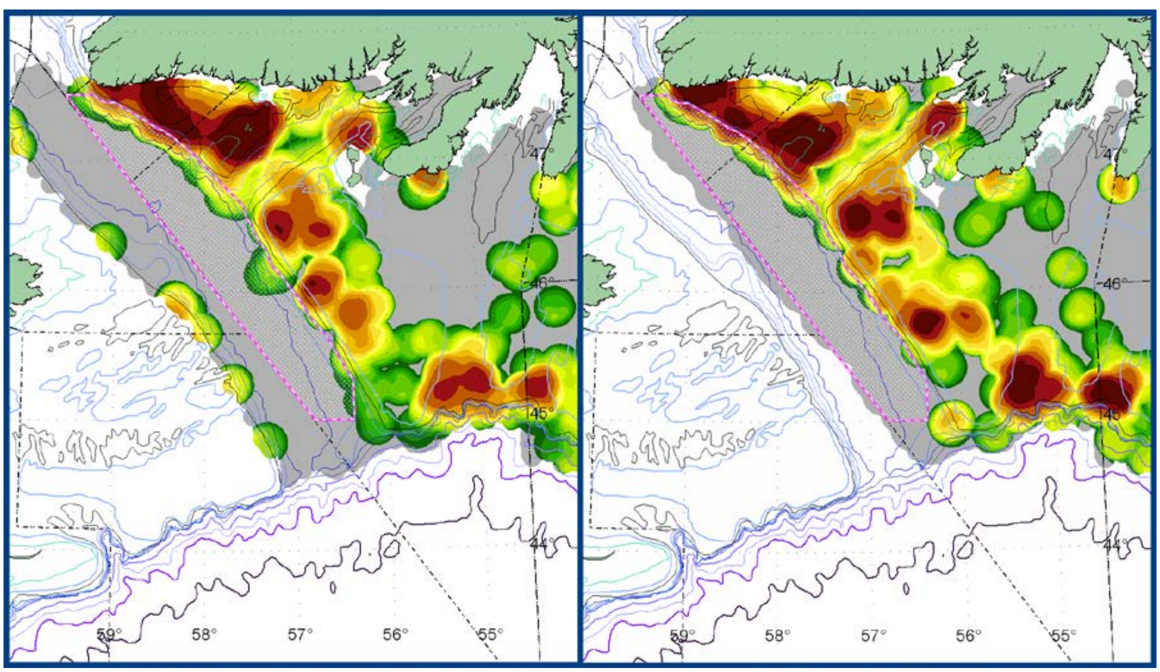

*Figure 3t. Distribution of **Striped Wolffish** during two periods, 1996-2002 (left panel) and 2003-09 (right panel). See Figure 1 for the legend, description of the data and the base map. Note that a portion of the Laurentian Channel in Division 4Vn (southwestern half) was not sampled after 2002.*

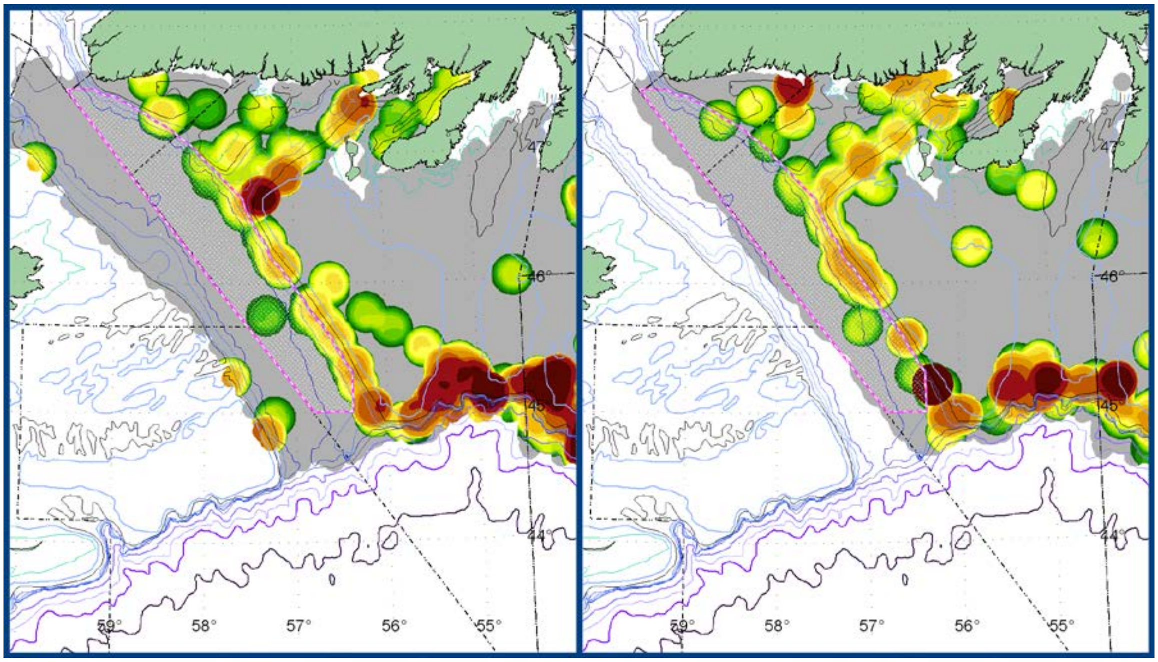

*Figure 3u. Distribution of **Haddock** during two periods, 1996-2002 (left panel) and 2003-09 (right panel). See Figure 1 for the legend, description of the data and the base map. Note that a portion of the Laurentian Channel in Division 4Vn (southwestern half) was not sampled after 2002.*

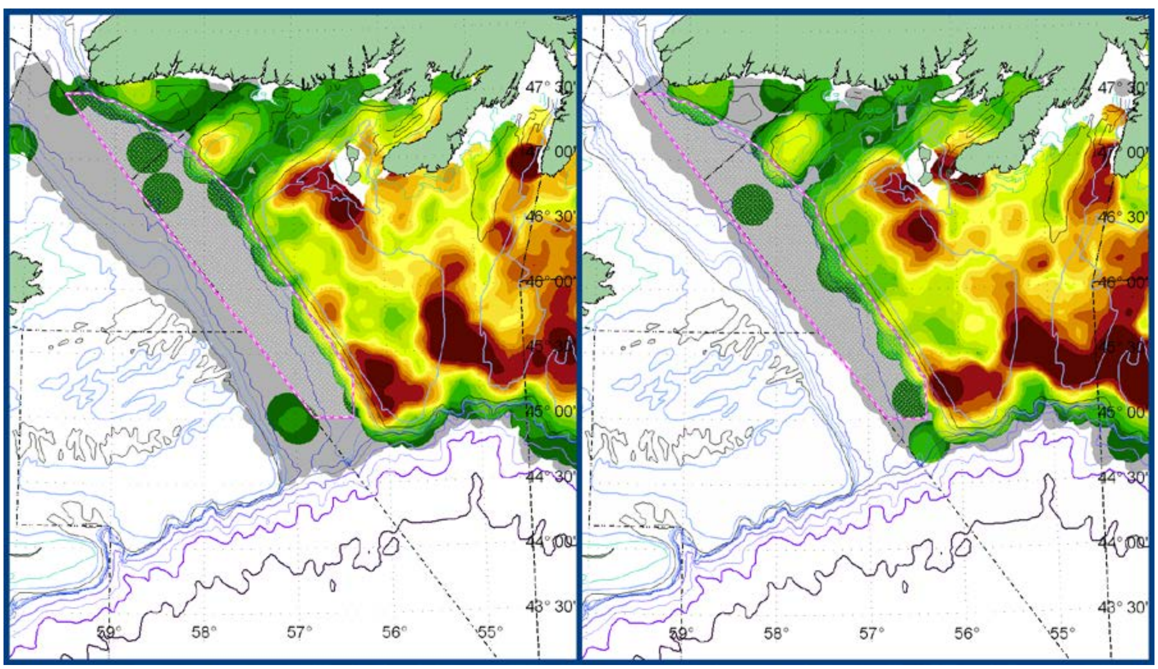

*Figure 3v. Distribution of **Mailed Sculpin** during two periods, 1996-2002 (left panel) and 2003-09 (right panel). See Figure 1 for the legend, description of the data and the base map. Note that a portion of the Laurentian Channel in Division 4Vn (southwestern half) was not sampled after 2002.*