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June 2007

Mapping the Spatial Distribution of Juveniles for Nine Selected Finfish Species Found in the Gulf of St. Lawrence

by

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ABSTRACT

Data collected during the Fisheries and Oceans Canada research vessel (RV) surveys were used to map the spatial and temporal distributions of juveniles for nine selected fish species found in the Gulf of St. Lawrence. A Geographic Information System (GIS) used interpreted length data collected on the surveys to produce annual maps illustrating juvenile distributions over an eleven year period between 1995 and 2005. The data used in this study were collected by DFO's Quebec and Gulf regions, herein referred to as northern and southern gulf respectively. Although these data were combined and modeled together, discussion of the juvenile distributions was done separately because the regions employed different survey tow lengths. In the northern region of the Gulf, the largest catches, for most species studied, were typically found near the west coast of Newfoundland, in the St. Lawrence River estuary and around Anticosti Island. The southern gulf saw juvenile catches over much of the region; however, the areas along the southern edge of the Laurentian Channel, north of Cape Breton Island and to the west of Prince Edward Island showed the largest catches for most of the species included in the study.

Les données recueillies lors des relevés effectués par les navires de recherche du ministère des Pêches et des Océans (MPO) ont permis de cartographier la distribution spatiotemporelle des juvéniles de neuf espèces de poissons du golfe du Saint Laurent. Grâce à un système d'information géographique (SIG) on a produit, à partir des données sur la longueur des poissons recueillies lors des relevés, des cartes annuelles illustrant la distribution des juvéniles sur une période de dix ans, soit entre 1995 et 2005. Les données utilisées dans cette étude ont été recueillies par des scientifiques des Régions du Québec et du Golfe appelées ici nord du golfe et sud du golfe, respectivement. Ces données ont été regroupées et modélisées, toutefois, les rapports scientifiques sur la distribution des juvéniles ont été rédigés séparément puisque les longueurs de trait différaient d'une Région à l'autre. Dans le nord du golfe, les prises les plus importantes pour la plupart des espèces étudiées ont été observées près de la côte ouest de Terre Neuve, dans l'estuaire du Saint Laurent et autour de l'île d'Anticosti. Dans le sud du golfe, on a observé des prises de juvéniles dans l'ensemble de la zone, toutefois, les prises les plus importantes pour la plupart des espèces visées par l'étude ont été observées dans les secteurs situés à la bordure sud du chenal Laurentien, au nord du Cap Breton et à l'ouest de l'Île du Prince Édouard.

INTRODUCTION

Payne, J.F., Andrews, C.A., Fancey, L.L., Cook, A.L., and Christian, J.R. 2007.
Pilot study on the effect of seismic air gun noise on lobster (Homarus americanus).
Can. Tech. Rep. Fish. Aquat. Sci. 2712: v + 46.

Because of the large number and diversity of the interests present, the Gulf of St. Lawrence was identified as one of five Large Oceans Management Areas in Canada in the Oceans Action Plan. It plays an important role in valuable commercial fishery and aquaculture industries, oil and gas exploration, marine transportation, and many land based activities. (DFO, 2006)

Oil and gas are becoming an increasingly important resource in the Gulf of St. Lawrence. Although this region has seen oil and gas exploration for over 160 years, much of this activity had been land based. The mid 1990s saw an increase in exploration activities along the Gaspé Peninsula, Anticosti Island and Magdalen Islands. To date, seven exploratory wells have been drilled in the area. The foremost emerging technology that has fuelled offshore oil exploration in the Gulf is the seismic survey. This technology uses sound fired from an airgun to map underneath the seafloor to find structures where hydrocarbons might be found. (DFO, 2006)

The study area includes NAFO divisions 4RST and 3Pn, as shown in Fig. 1. The division between the northern and southern sections of the Gulf is shown in Fig. 2. The study area lies between 45.5° to 52.25° north and 56.5° to 72° west. The Gulf of St. Lawrence is a large area consisting of approximately 168,000 km2, with 103,000 km2 in the northern gulf and 65,000 km2 in the southern gulf. It is bordered in the north and west by Quebec, in the south by New Brunswick and Nova Scotia and by Newfoundland to the east. Refer to Fig. 3.

This study modeled DFO research vessel data to produce maps illustrating areas of higher intensity of juvenile fish catches for nine selected species found in the Gulf of St. Lawrence. These maps should prove invaluable to the oil and gas industry, including operators and industry regulators (e.g., C-NLOPB, DFO) when planning seismic exploration activities. Other stakeholders could potentially use these maps as an information base from which to discuss concerns with respect to seismic survey operations.

It is hoped that this report can be used in directing these seismic surveys so that they minimize any potential impacts on the juvenile fish in the region. Knowing where the highest concentrations of juvenile fish have been in the past may help those in industry and the regulatory bodies to manage these activities so as to minimize any impacts on the environment.

In this project, Atlantic cod (Gadus morhua), white hake (Urophycis tenuis), American plaice (Hippoglossoides platessoides), witch flounder (Glyptocephalus cynoglossus), yellowtail flounder (Limanda ferruginea), Atlantic wolffish (Anarhichas lupus), thorny skate (Raja radiata), fourbeard rockling (Enchelyopus cimbrius) and winter flounder (Pseudopleuronectes americanus) were studied.

METHODS

The methodology used in the Gulf of St. Lawrence juvenile mapping project was taken directly from 2004 work that was done in which a GIS was used to map the distribution of selected spawning finfish species found on the Grand Banks. The analytical methods developed for and used to map the Grand Banks spawning data were applied to the Gulf of St. Lawrence juvenile data. Because of the similarities in the two studies, a summarized methods section will be presented and anyone requiring more detailed information may refer to Ollerhead, et al., 2004, for further reading.

The Gulf of St. Lawrence RV surveys employed a stratified random sampling method where the samples were distributed proportionately to the stratum surface. These surveys were carried out on the CCGS Alfred Needler using one of two gears. In the Northern Gulf, a URI shrimp trawl was used, while a Western IIA was used in the Southern Gulf. The Northern and Southern Gulf surveys were carried out in August and September respectively. These surveys provide a snapshot of the summer juvenile distributions, and it is important to note that these data cannot be used to infer distributions at other times of the year. Readers are referred to Bourdages et al., 2003, for additional background on the Northern Gulf surveys.

In similar studies, Castonguay and Valois (2007) and Swain and Benoit (2007) have used the Gulf RV data as part of the Gulf of St. Lawrence Ecologically and Biologically Significant Areas (EBSA) exercise. Using the RV data, contoured surfaces were created that represented aspects of species distribution, such as diversity and richness, to help identify areas of the Gulf that could have valuable biological or ecological significance.

Length-maturity data were used to model and map the distributions of juvenile fish. To obtain these data, a measurement of the length and a species-specific length key were used to determine the maturity of individuals. Individuals less than a pre-determined cut-off length were considered juvenile. For some species, there were various cut-off values for males and females. The length-maturity keys used in the Gulf of St. Lawrence RV surveys can be found in Table 1.

Yearly maps of the juvenile distributions for the Gulf of St. Lawrence were created for an eleven-year span from 1995 to 2005. These maps are specific to each species and provide a yearly perspective of the juvenile distributions represented as the average number of juveniles per set. Annual effort maps depicting the fishing effort and survey extents have also been created. The effort maps were created by mapping all sets taken for a given year, regardless of whether or not they were successful in catching the species of interest. Table 2 lists the annual number of data points for each species in the study.

Much of the Gulf of St. Lawrence was mapped during the study period. NAFO divisions 4RS and 3Pn comprised the Northern Gulf and 4T represents the Southern Gulf (Fig. 2). It is imperative to note that when the data were collected for this project, different tow lengths were used in the northern and southern regions of the Gulf . In the Northern Gulf, a tow length of 2.22 km (personal correspondence, Martin Castonguay, DFO Mont-Joli) was used and in the Southern Gulf, tows were standardized to 3.24 km. (Hurlbut and Clay, 1990). Because of the difference between the Northern and Southern Gulf tow lengths, discussions of the juvenile distributions for each region were done independently. Also note that there are no 2004 data for the Northern Gulf for any of the species studied.

POTENTIAL MAPPING

The modeled surfaces in this report were generated using SPANS potential mapping. Potential mapping is a spatial analysis technique that uses discrete point data to create continuous, or near continuous, trend surfaces. This modeling technique is appropriate for the RV data, which has a high degree of variability and an uneven spatial distribution (Burke, 1997). The use of potential mapping to model RV survey data has been adapted from the methods used by Kulka (1998) and Kulka et al. (2003)

Potential mapping has two important user definable model parameters— grid size and sampling radius—that impact how the trend surface is calculated. Potential mapping creates a grid over the entire study area and then uses this grid on which to build the modeled surface. The size of each grid cell governs the resolution of the modeled surface. It is defined to create grid cells sized to the input data and to produce a visually appealing cartographic product. Here the grid cells were chosen at 233 m2. Sampling radius is the parameter that determines the area of influence around each data point for which the interpolation will be calculated. The optimum sampling radius for the volume and distribution of these data was 5 km. Choosing a sampling radius that is too small for a dataset will not produce a continuous surface, while a very large sampling radius could potentially hide trends in the data.

The modeled surfaces were then classified into one of eight predetermined legend categories. These legend categories were calculated by the system to create maps that reflected approximately equal distributions in each of the legend classes. Legend categories and colours were kept consistent within each species in order to illustrate any changes over time.

MAP PRODUCTION

The resulting trend surface maps from the potential mapping analysis were then imported into another GIS application, MapInfo (MapInfo Corporation). MapInfo is a more powerful GIS with respect to cartographic layout and map production. In MapInfo the basemap layers were created and common colour schemes were applied to the modeled surfaces. The resulting maps were then imported into CorelDraw version 13 (Corel Corporation), where the final annotations were added, and once finalized, the maps were then placed into Microsoft Word (Microsoft Corporation) for publication.

A single project basemap was developed to create a frame of reference for the distribution of juvenile fish models. This map is comprised of both physical features and political and regulatory boundaries of oil and fishing industries. Figure 1 shows these boundaries that depict functional boundaries and special references for both the oil and fishing industries. This basemap was common to all juvenile fish distribution maps, and it was therefore necessary to document these features only once and understand that it will be consistent throughout the entire report. The final basemap, shown in Figure 4, contains both major physical and political features that provide a spatially referenced backdrop for the juvenile fish distribution maps.

RESULTS

AMERICAN PLAICE (Hippoglossoides platessoides)

Large catches of juvenile American plaice were found over much of the Southern Gulf region. The highest densities were found on the Orphan Bank, Magdalen Shallows and Bradelle Bank. The Northumberland Strait was the only portion of the entire region that had consistently smaller catches. These areas of larger and smaller catches were consistent throughout the study period.

In contrast to the Southern Gulf, Juvenile American plaice were only found in some areas of the Northern Gulf region that were surveyed. The largest catches were found in the shallower areas off the west coast of Newfoundland in NAFO division 4R and in Jacques Cartier Strait. Juveniles were also found in other areas, but these catches were typically smaller and less consistent over the study period. Refer to Fig. 5a-k.

ATLANTIC COD (Gadus morhua)

With the exception of 2002 and 2003, the highest densities of juveniles in the Southern Gulf were found near the western and northern shores of Prince Edward Island as well as in the Magdalen Shallows. The years 2002 and 2003 showed that the higher density areas were slightly more dispersed with some areas to the north of Cape Breton Island near the edge of the Laurentian Channel.

In the Northern Gulf the largest distributions of juveniles were located near the west coast of Newfoundland in 4R along the shelf edges. There were some larger catches south of Anticosti Island, but these were sparse. Refer to Fig. 6a-k.

ATLANTIC WOLFFISH (Anarhichas lupus)

In the Southern Gulf catches of juvenile Atlantic wolffish were sparse but consistent in their distribution throughout the study period. The highest densities were at the northern tip of Cape Breton Island and along the southern edge of the Laurentian Channel.

Excluding 2000 and 2001, juvenile catches of Atlantic wolfish in the Northern Gulf were very small. Within the scope of the surveys most juveniles were found along the west coast of Newfoundland in 4R. The years 2000 and 2001 saw the largest catches during the 11 year study period. Refer to Fig. 7a-k.

FOURBEARD ROCKLING (Enchelyopus cimbrius)

The juvenile catches of fourbeard rockling in the Southern Gulf during the study period were sparse. The largest distributions were found along the southern edge of the Laurentian Channel, on the Orphan Bank and in the western portion of Northumberland Strait.

For most of the study period in the Northern Gulf, the largest catches of juveniles were found primarily along the southern edge of the Laurentian Channel. In 2003, there were some larger catches south of Anticosti Island. Refer to Fig. 8a-k.

THORNY SKATE (Raja radiata)

The largest distributions of juvenile thorny skate in the Southern Gulf were found along the edge of the Laurentian Channel and to the northwest of Cape Breton Island. This distribution pattern was consistent between 1995 and 2005.

Juvenile thorny skate were found over much of the area surveyed in the Northern Gulf. The largest catches occurred in the St. Lawrence River estuary with some smaller catches found to the northeast of Anticosti Island and along the west coast of Newfoundland. Refer to Fig. 9a-k.

WHITE HAKE (Urophycis tenuis)

The largest catches of white hake in the Southern Gulf were found along the southern edge of the Laurentian Channel, on the Orphan Bank and in Northumberland Strait. This distribution represented the predominant trend in the data for the 1995–2005 study period.

The largest catches in the Northern Gulf were found off the coast of the Port Au Port peninsula in Newfoundland along the 4R-4S boundary, Cabot Strait, the Anticosti Channel and in 3Pn. This distribution pattern remained unchanged for the entire study period. Refer to Fig. 10a-k.

WINTER FLOUNDER (Pseudopleuronectes americanus)

Between 1995 and 2005, the largest catches of juvenile winter flounder in the Southern Gulf were found in Northumberland Strait and west of Prince Edward Island. During some years of the study period, additional catches were found around the Magdalen Islands.

Juvenile catches in the Northern Gulf for this species were almost non existent. Only a very few juveniles were caught and they were found in the Esquiman Channel in 1995 and in the Laurentian Channel in 1999. Refer to Fig. 11a-k.

WITCH FLOUNDER (Glyptocephalus cynoglossus)

Juvenile catches of witch flounder in the Southern Gulf region were found almost exclusively along the southern edge of the Laurentian Channel and near the northwestern shores of Cape Breton Island. This distribution of higher density areas was consistent from 1995 through to 2005.

In the Northern Gulf, juvenile witch flounder were found over much of the area sampled during the 1995–2005 study period. The larger catches of juveniles were found in the St. Lawrence River estuary, south of Anticosti Island in the Honguedo Strait, in the Anticosti Channel and in NAFO division 3Pn. Refer to Fig. 12a-k.

YELLOWTAIL FLOUNDER (Limanda Ferruginea)

In the Southern Gulf, the juvenile catches were largest in the Magdalen Shallows, Bradelle Bank, the north shore of Prince Edward Island and the southeast part of Northumberland Strait. This distribution remained consistent for the entire study period.

The Northern Gulf saw extremely small catches of juvenile yellowtail flounder. The few juveniles that were caught during the study period were found near the Port Au Port peninsula on west coast of Newfoundland. Refer to Fig. 13a-k.

DISCUSSION

This study mapped the juvenile distribution in the Gulf of St. Lawrence of nine selected fish species between 1995 and 2005. These maps depict the juvenile distributions throughout the Gulf of St. Lawrence that occurred within the scope of the research vessel surveys. The study was carried out using interpreted data collected by two DFO regions covering a large portion of the Gulf of St. Lawrence. It is imperative to note that the regions used different tow lengths for their survey sets, and therefore no comparisons were made between the Northern and Southern Gulf datasets. All data were modeled as one; however, discussions of juvenile distributions were done within-region.

It is also important to note that the distributions, as discussed within this publication, are distributions within the scope of the research vessels' surveys for the study period. It is very possible that juveniles could have been found in other parts of the Gulf outside of the surveyed area.

CONCLUSIONS

The Gulf of St. Lawrence is home to a valuable and diverse biological community as well as a growing oil and gas sector. Oil and gas exploration depends heavily on the use of seismic surveys to identify areas where reserves may be found. This project was designed to help stakeholders manage the resources found in the Gulf of St. Lawrence and to protect the Gulf fisheries resources from any potentially harmful effects from oil/gas development and exploration. The maps may be used in planning exploration activities to avoid or minimize any impacts on juvenile fish in the region.

ACKNOWLEDGEMENTS

The authors would like to thank the Environmental Studies Research Funds for providing the necessary resources to make this project possible. Doug Swain at the Gulf Fisheries Centre and Martin Castonguay and Marie-Noelle Bourassa at the Maurice Lamontagne Institute provided all the fisheries data used to create the trend surface maps. More importantly, they also provided invaluable advice and insight regarding the background behind these data to ensure they were properly interpreted. The authors would also like to thank Tony Bowdring and, once again, Martin Castonguay for reviewing this manuscript and providing comments and advice.

REFERENCES

Bourdages, H., Archambault, D., Morin, B., Fréchet, A., Savard, L., Grégoire, F. and Bérubé, M. (2003). Preliminary results from the groundfish and shrimp multidisciplinary survey from August 2003 in the northern Gulf of St. Lawrence. Can. Sci. Adv. Doc. 2003/078.

Burke, D. (1997). SPANS prospector manual. Tydac Research Inc., 106 p.

Castonguay, M. and Valois, S. (2007). Zones d'importance écologique et biologique pour les poissons démersaux dans le nord du Golfe du Saint-Laurent. MPO, Séc. Can. Cons. Sci., Doc. Rech. 2007/014.

DFO (2006). Proceedings of the zonal workshop on the identification of ecologically and biologically significant areas (EBSA) within the Gulf of St. Lawrence and Estuary, February 21–23, 2006. CSAS Proc. Ser. 2006/011.

Hurlbut, T. and Clay, D. (eds) (1990). Protocols for Research Vessel Cruises within the Gulf Region (Demersal Fish) (1970–1987). Can. MS Rep. Fish. Aquat. Sci. No. 2082: 143 p.

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

Kulka, D.W. (1998). SPANdex–Spans geographic information system process manual for creation of biomass indices and distributions using potential mapping. DFO Can. Stock Access. Sec. Res. Doc. 98/60. 28 p.

Ollerhead L.M.N., Morgan, M.J., Scruton, D.A. and Marrie, B. (2004). Mapping and spawning times and locations for 10 commercially important fish species found on the Grand Banks of Newfoundland. Can. Tech. Rep. Fish. Aquat. Sci. 2522: iv + 45 p.

Swain, D. and Benoit, H.P. (2007). Ecologically and biologically significant areas for demersal fishes in the southern Gulf of St. Lawrence. DFO Can. Advis. Sec. Res. Doc 2007/012.

RESULTS

TABLE 1. JUVENILE MATURITY LENGTHS IN CENTIMETRES

Species	Male	Female
American plaice	<20	<34
Atlantic cod	<35	<35
Atlantic wolffish	<55	<55
Fourbeard rockling	<15	<15
Thorny skate	<50	<50
White hake	<40	<47
Winter flounder	<20	<25
Witch flounder	<32	<42
Yellowtail flounder	<19	<21

TABLE 2. ANNUAL COUNTS OF DATA POINTS, BY SPECIES

Year	Cod	White Hake	American Plaice	Witch Flounder	Yellowtail Flounder	Atlantic Wolffish	Thorny Skate	Four-beard Rockling	Witch Flounder
1995	149	90	242	136	38	22	157	20	36
1996	198	99	297	158	53	17	185	15	40
1997	203	103	271	133	63	31	169	20	51
1998	188	117	289	156	52	28	166	26	42
1999	190	123	273	181	56	31	173	13	45
2000	197	143	307	194	42	44	186	7	45
2001	144	99	226	158	39	27	157	5	32
2002	144	74	236	131	54	22	118	10	42
2003	95	83	203	149	24	27	134	14	20
2004	142	38	185	26	61	4	35	13	60
2005	195	86	337	155	70	23	158	24	47

Figure 1.
Study Area

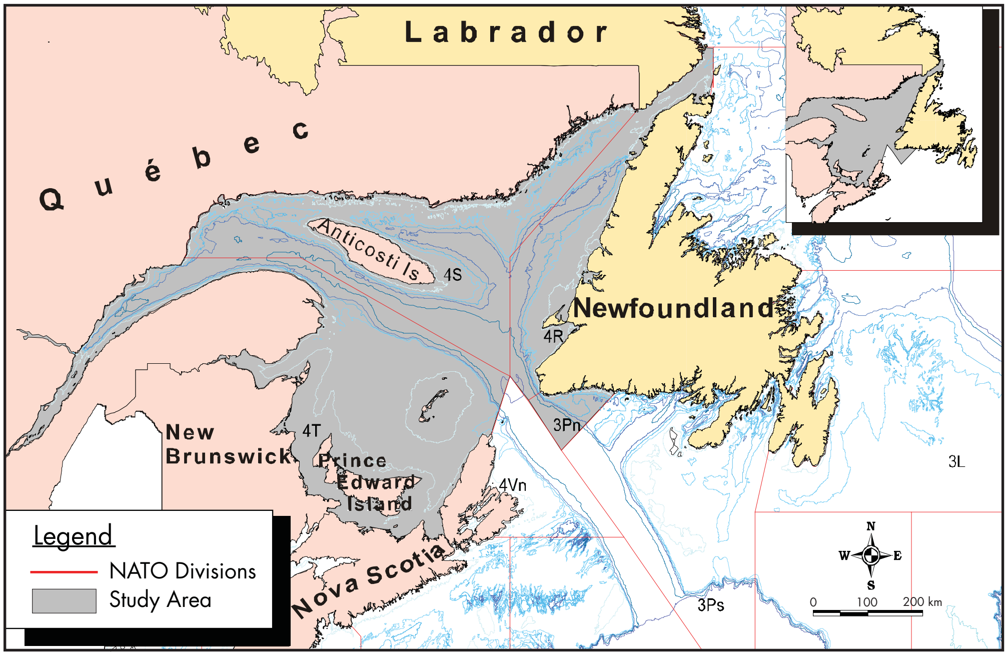


Figure 2.
Northern and Southern Regions of the Gulf of St. Lawrence

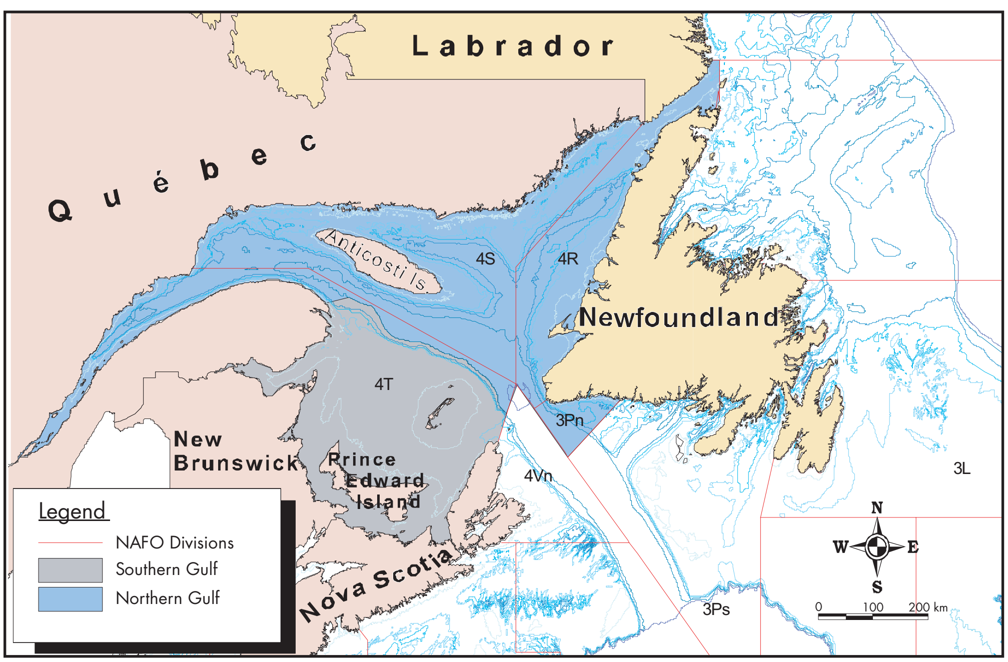


Figure 3.
Detailed Study Area

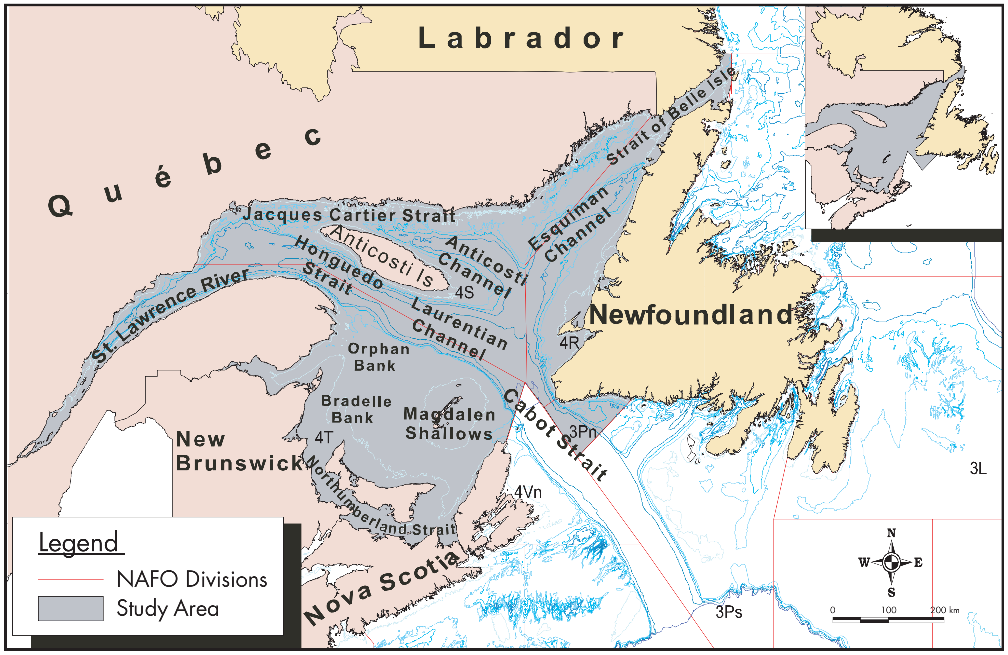


Figure 4.
Basemap Project

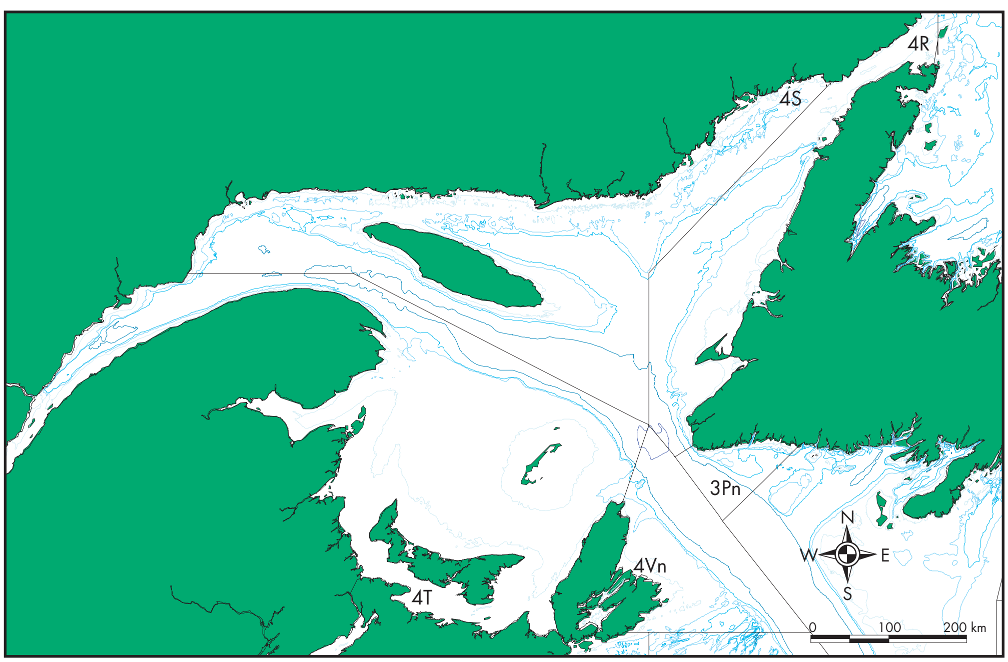


Figure 5 a.
Distribution of Juvenile American Plaice, 1995

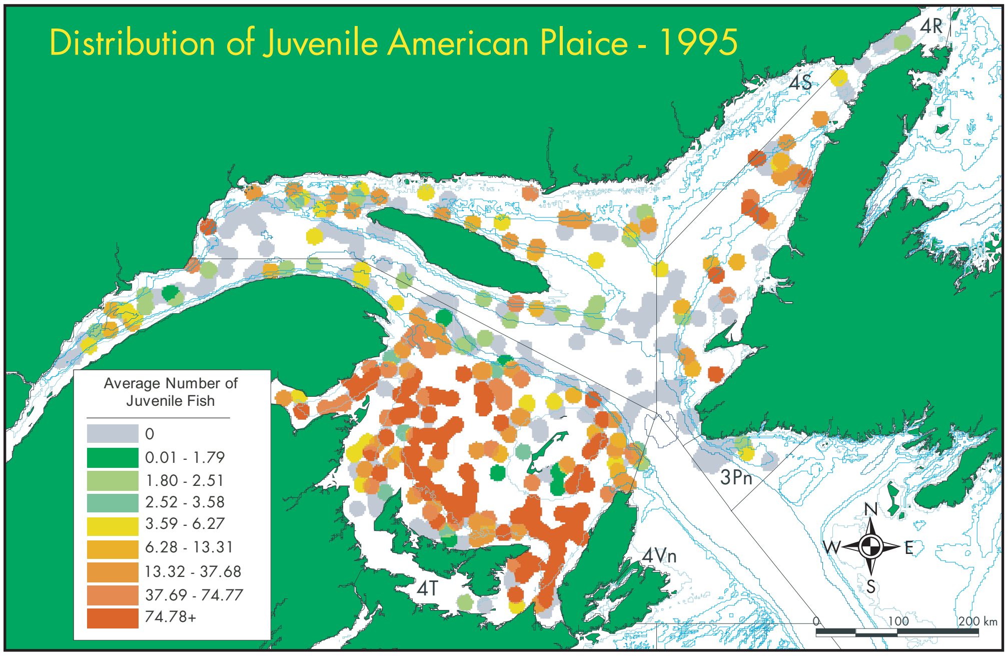


Figure 5 b.
Distribution of Juvenile American Plaice 1996

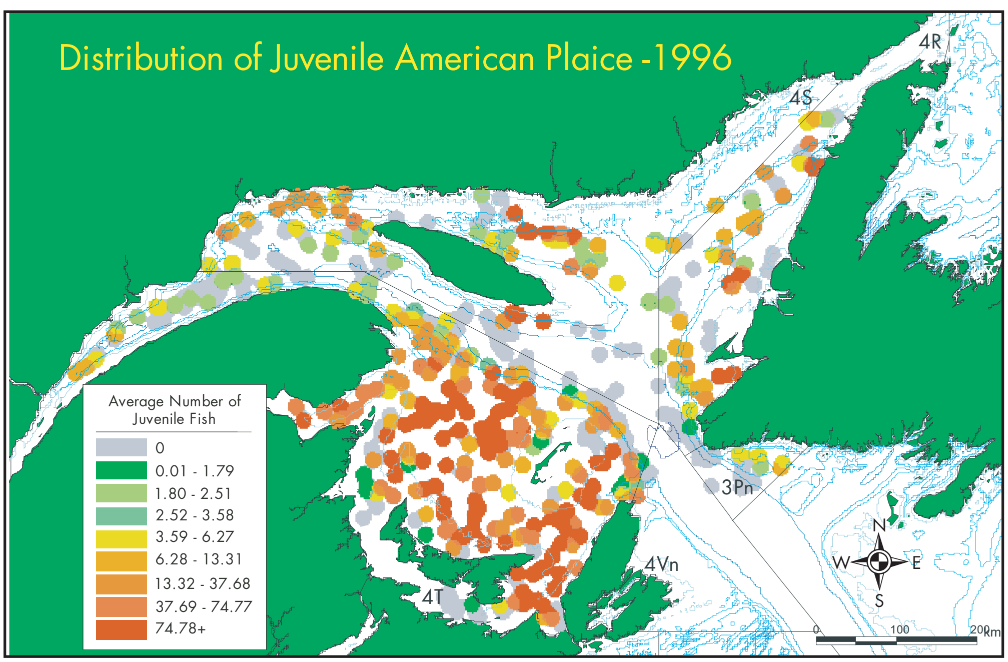


Figure 5 c.
Distribution of Juvenile American Plaice 1997

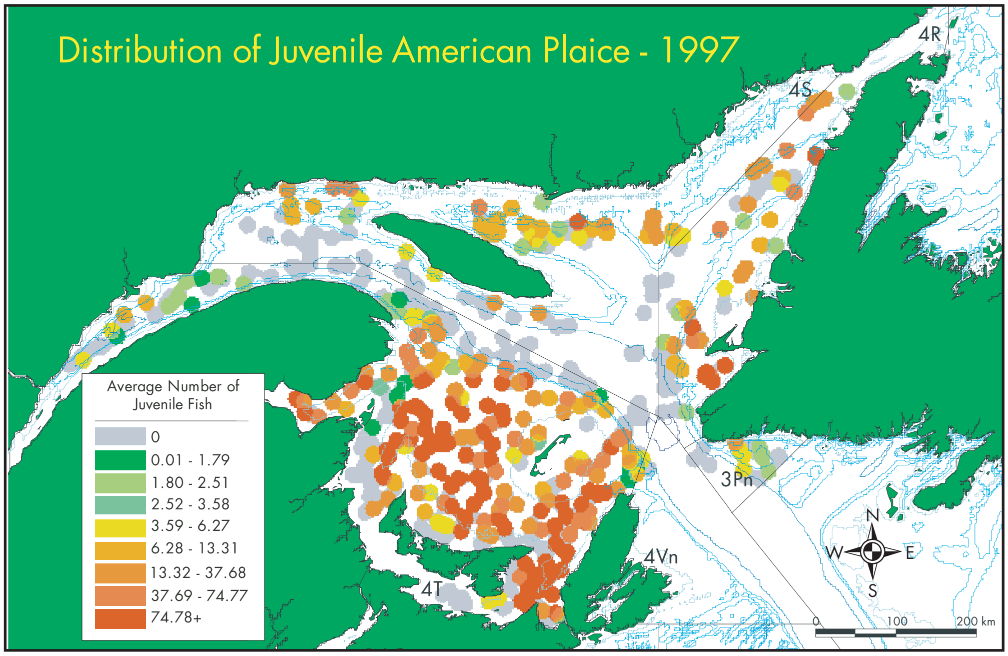


Figure 5 d.
Distribution of Juvenile American Plaice 1998

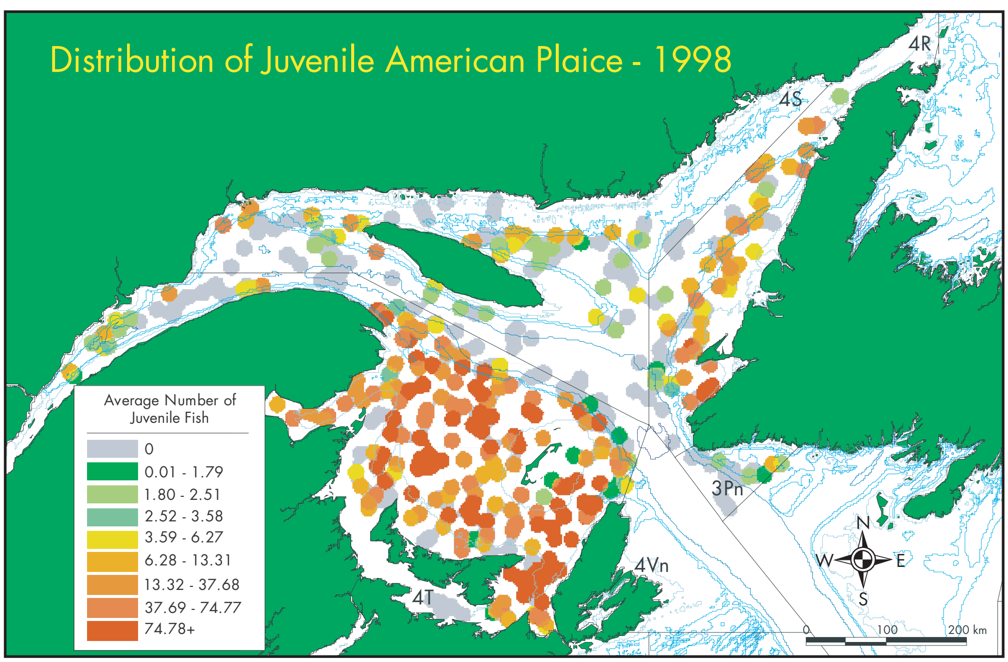


Figure 5 e.
Distribution of Juvenile American Plaice 1999

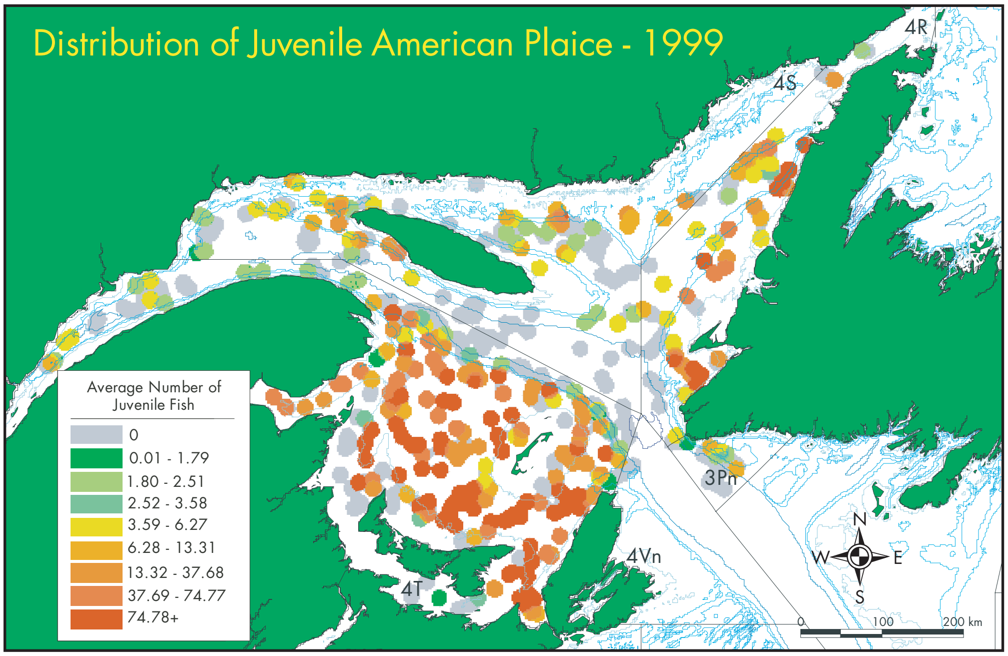


Figure 5 f.
Distribution of Juvenile American Plaice 2000

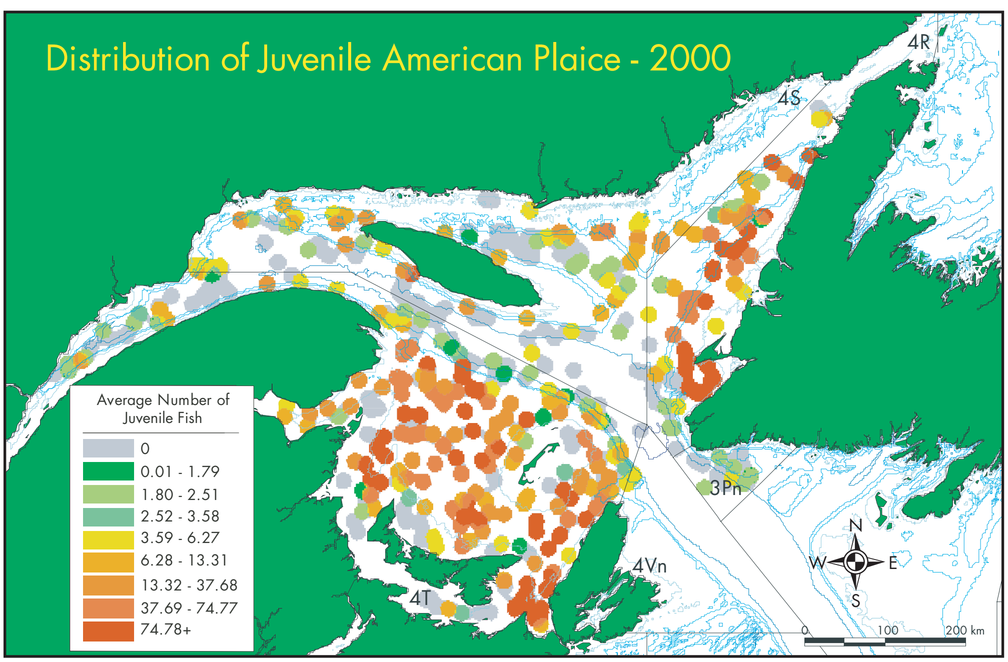


Figure 5 g.
Distribution of Juvenile American Plaice 2001

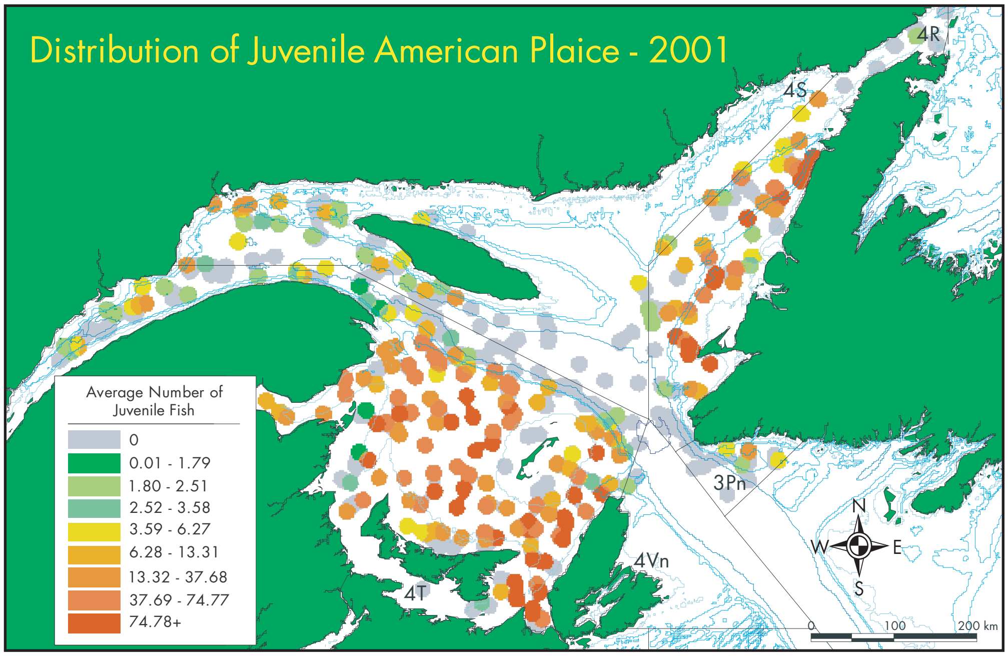


Figure 5 h.
Distribution of Juvenile American Plaice 2002

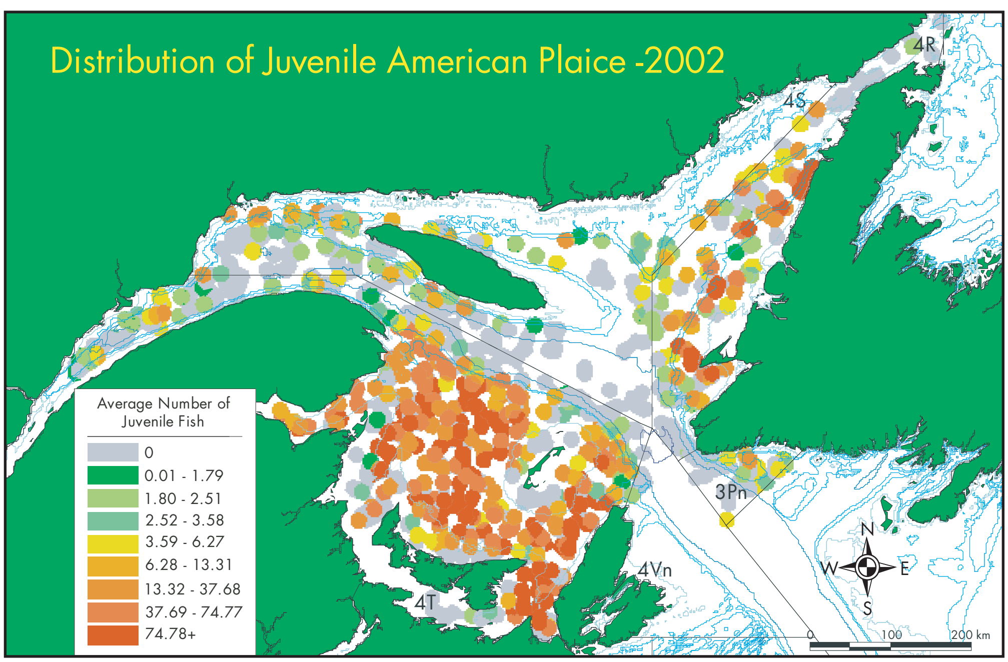


Figure 5 i.
Distribution of Juvenile American Plaice 2003

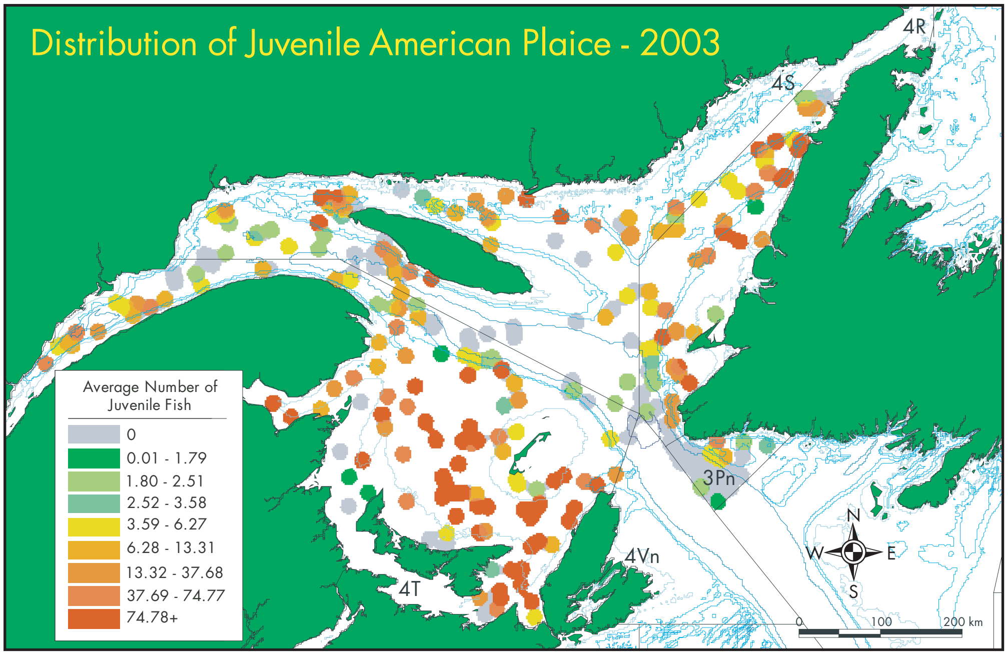


Figure 5 j.
Distribution of Juvenile American Plaice 2004

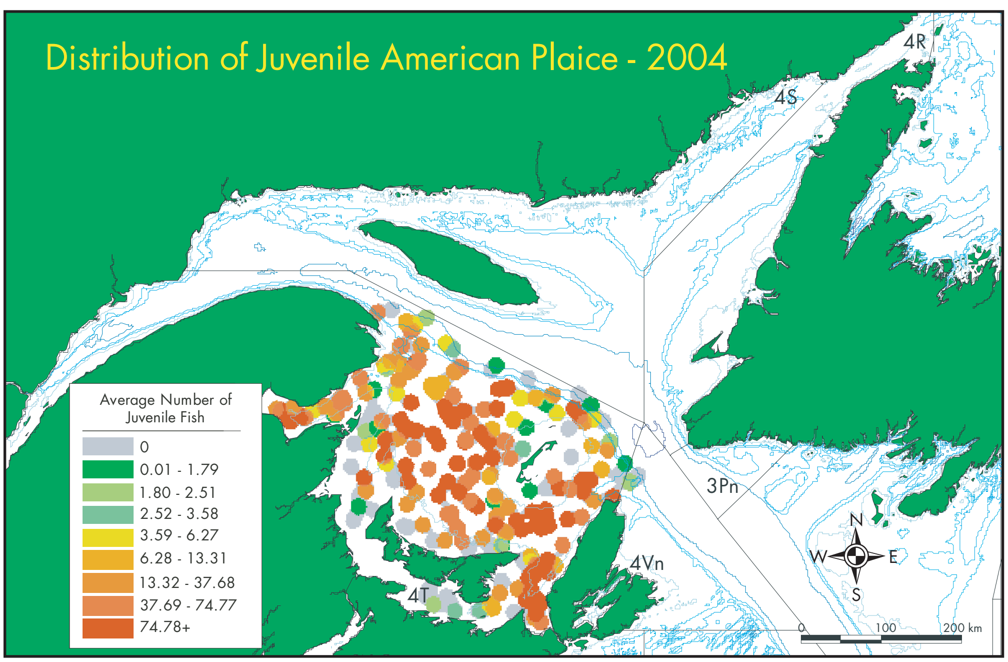


Figure 5 k.
Distribution of Juvenile American Plaice 2005

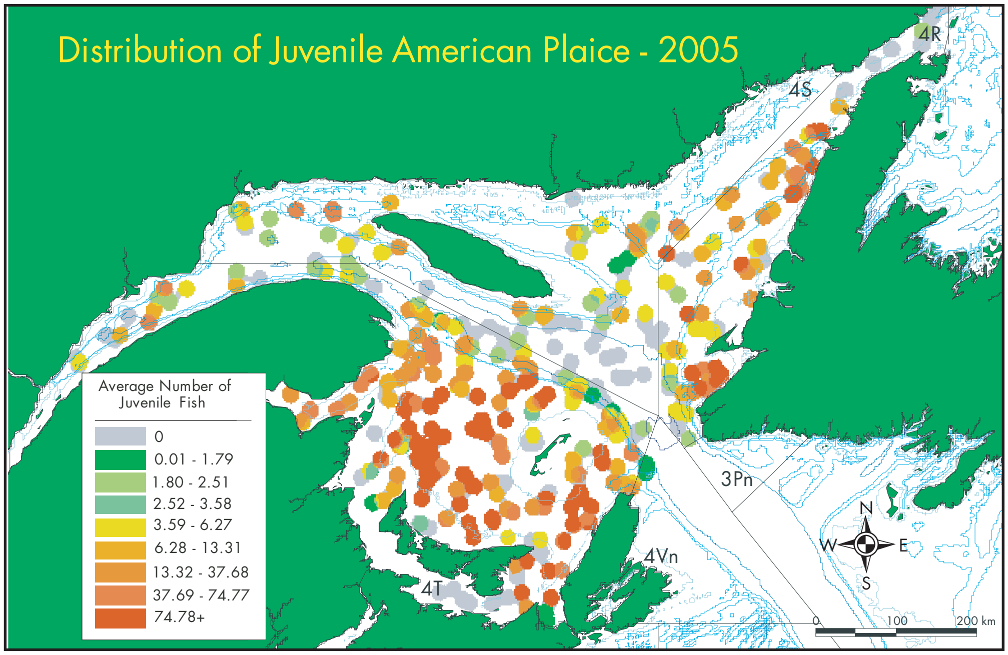


Figure 6 a.
Distribution of Juvenile Atlantic Cod 1995

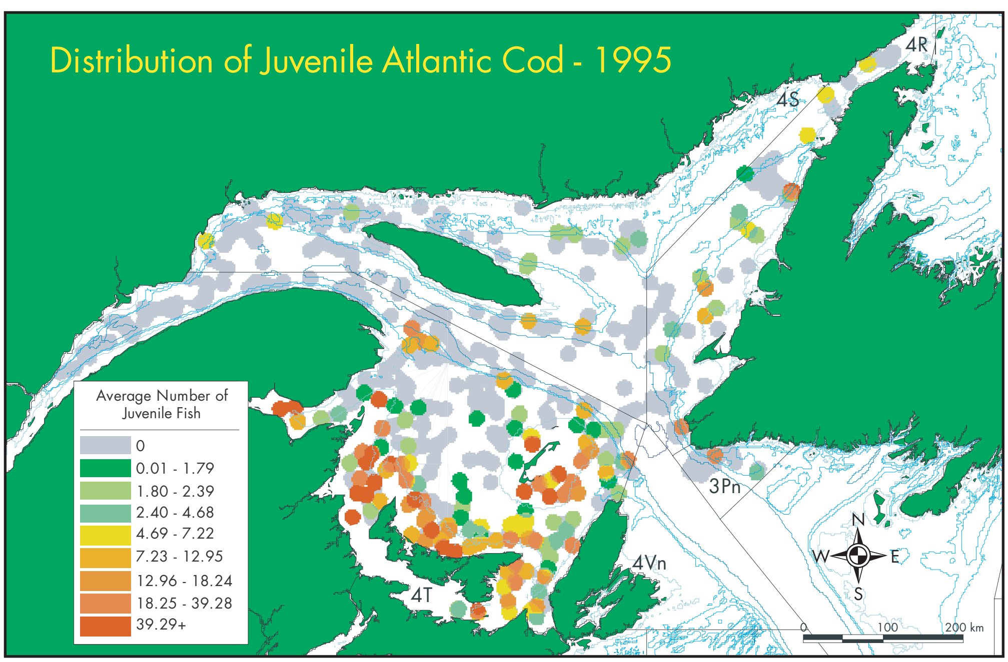


Figure 6 b.
Distribution of Juvenile Atlantic Cod 1996

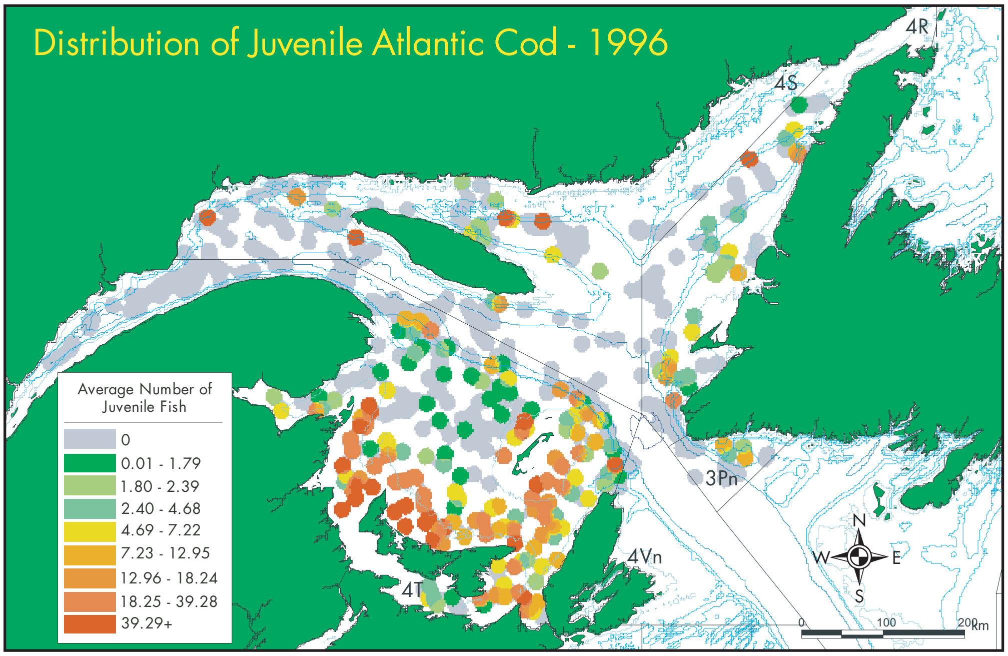


Figure 6 c.
Distribution of Juvenile Atlantic Cod 1997

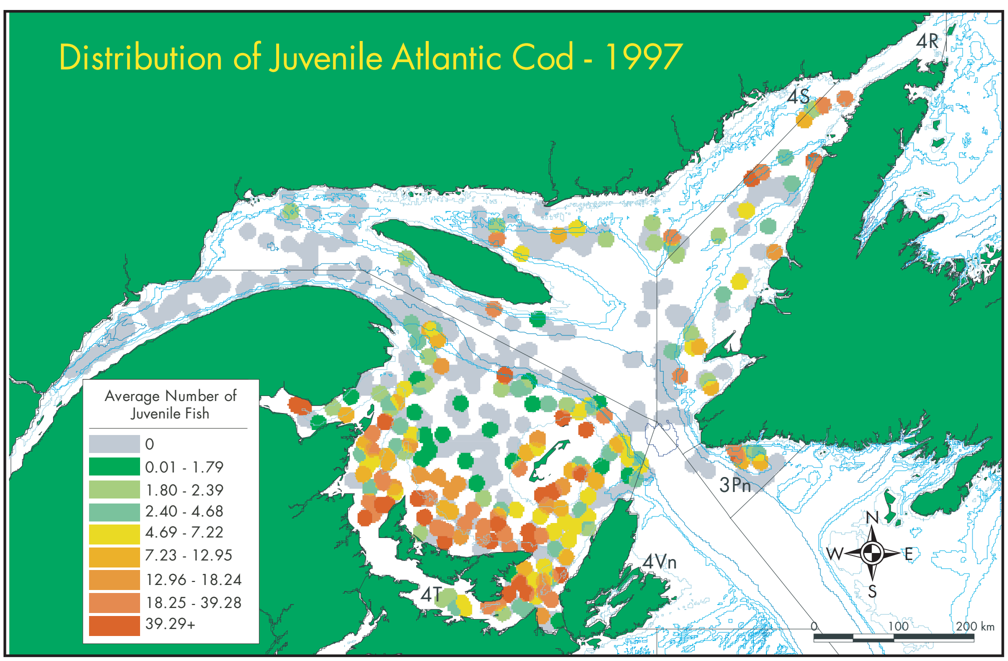


Figure 6 d.
Distribution of Juvenile Atlantic Cod 1998

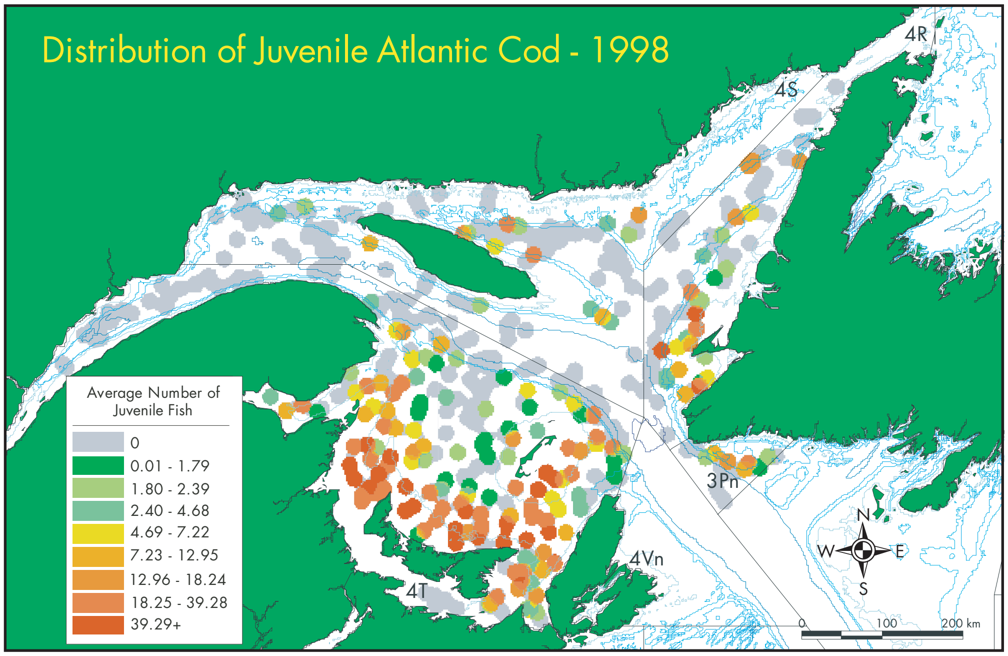


Figure 6 e.
Distribution of Juvenile Atlantic Cod 1999

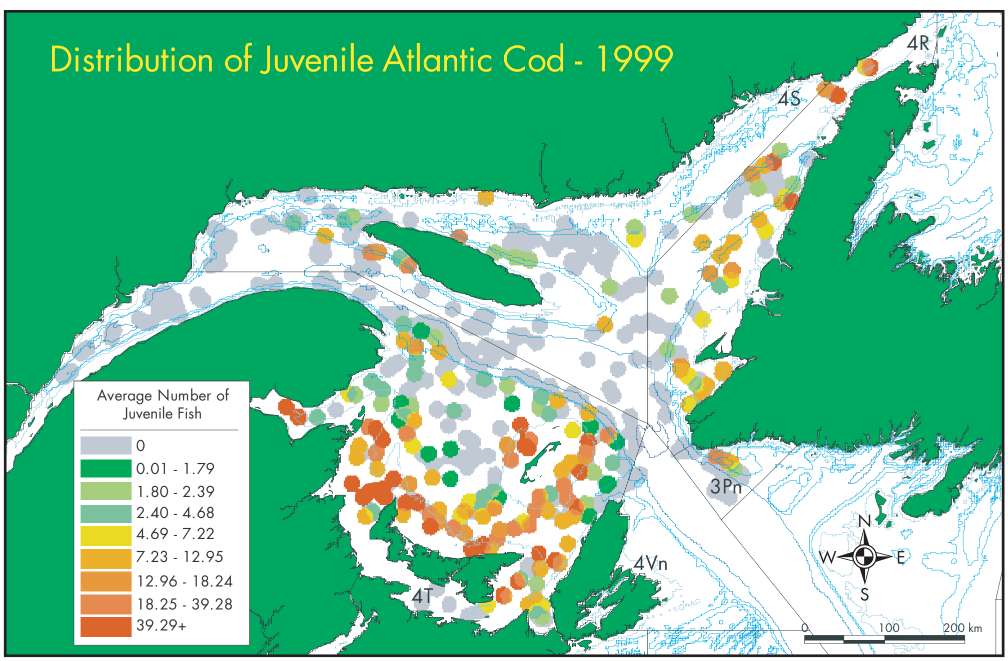


Figure 6 f.
Distribution of Juvenile Atlantic Cod 2000

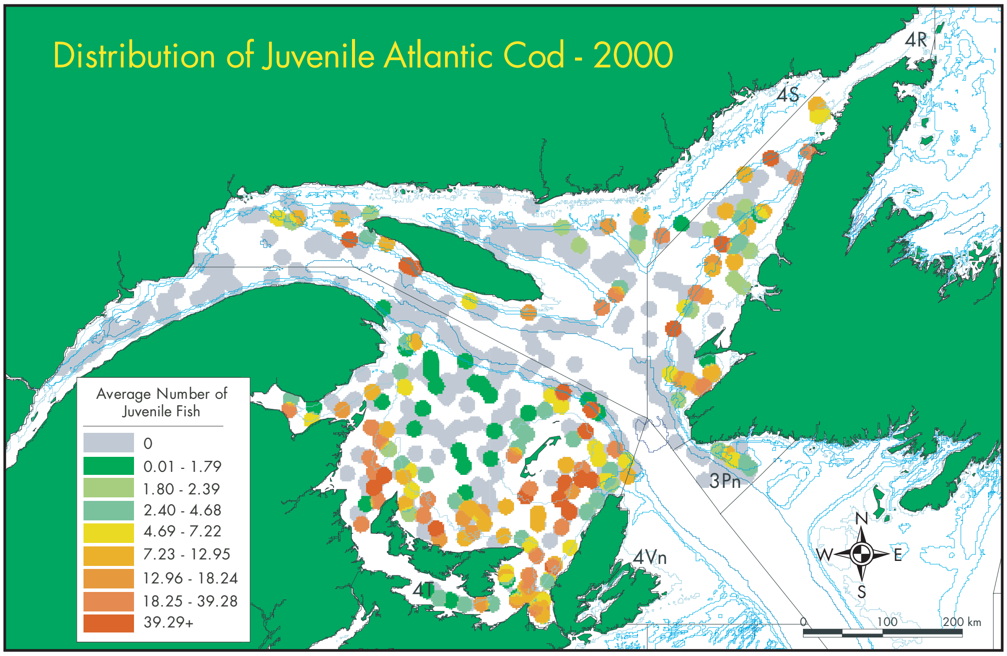


Figure 6 g.
Distribution of Juvenile Atlantic Cod 2001

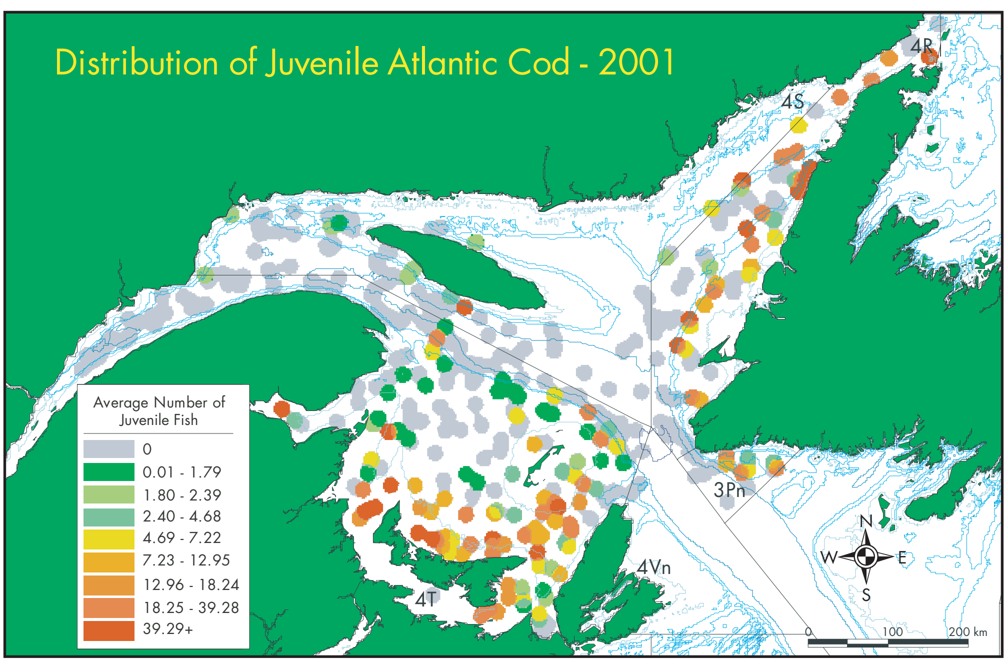


Figure 6 h.
Distribution of Juvenile Atlantic Cod 2002

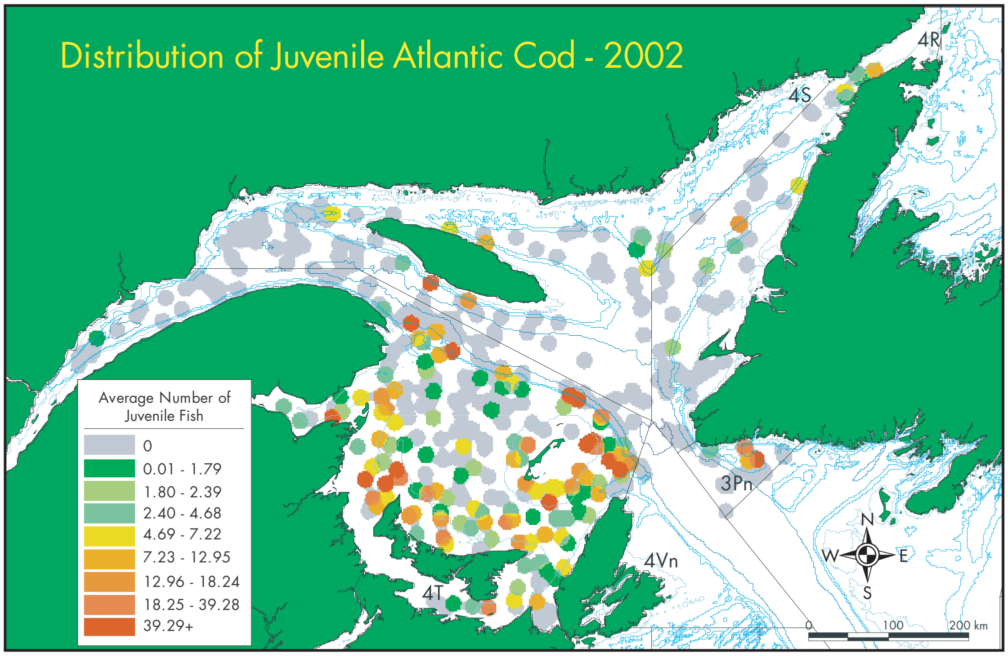


Figure 6 i.
Distribution of Juvenile Atlantic Cod 2003

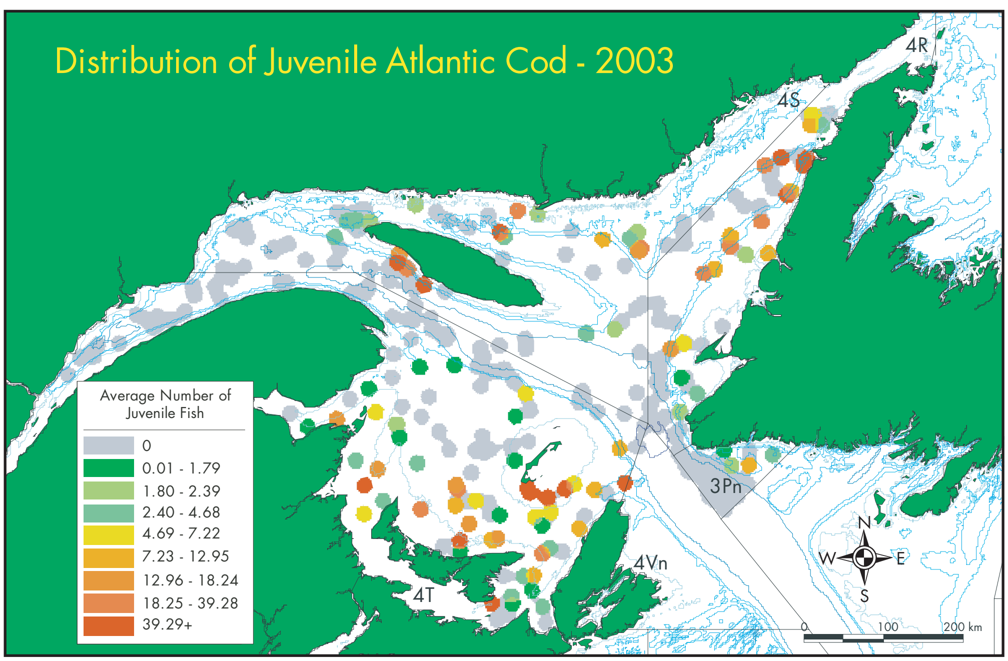


Figure 6 j.
Distribution of Juvenile Atlantic Cod 2004

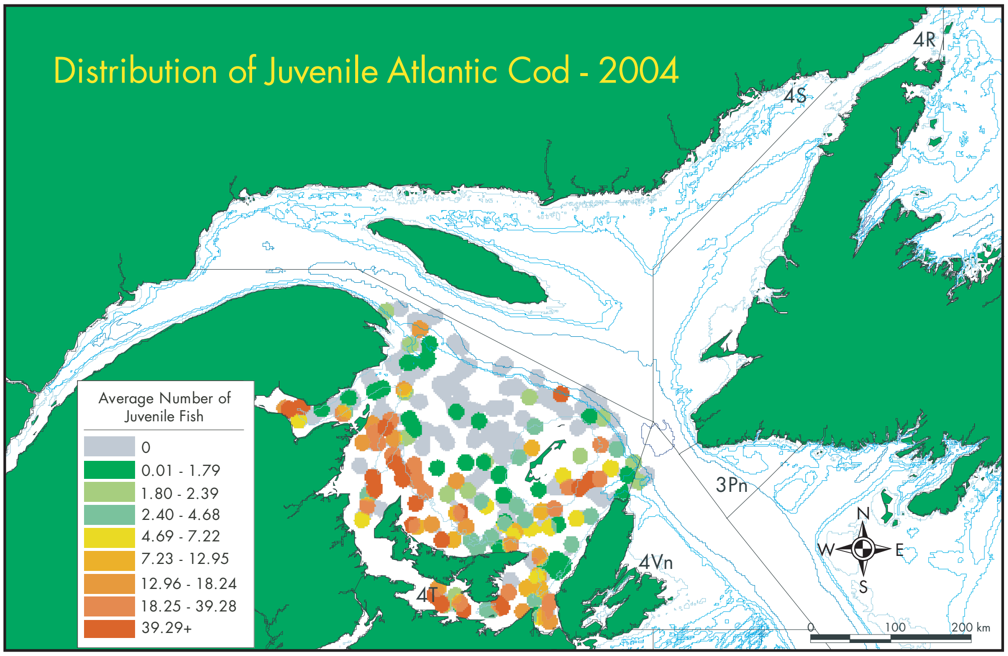


Figure 6 k.
Distribution of Juvenile Atlantic Cod 2005

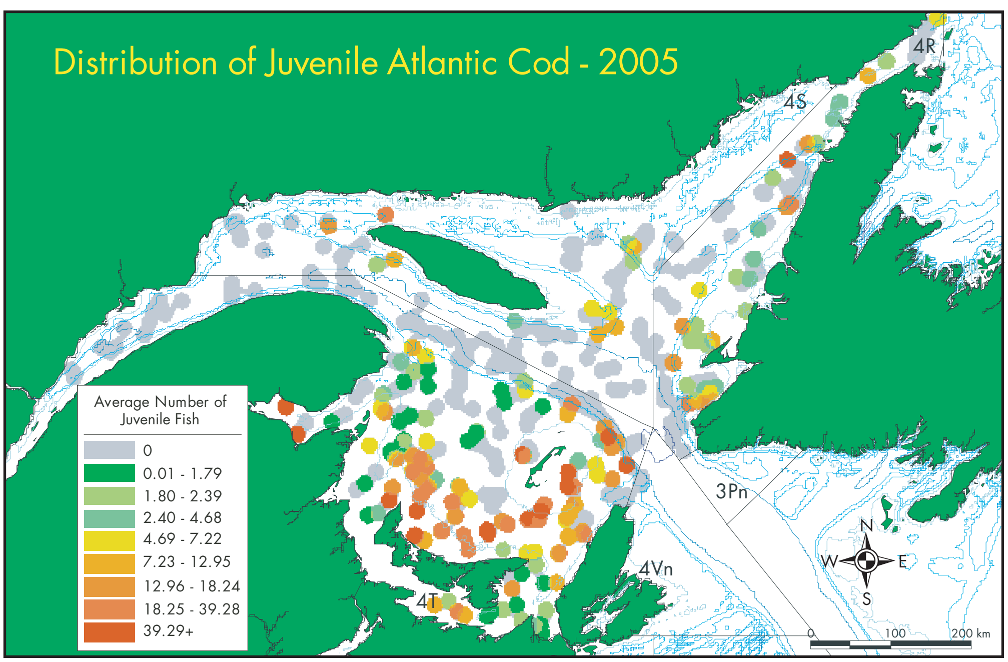


Figure 7 a.
Distribution of Juvenile Atlantic Wolffish 1995

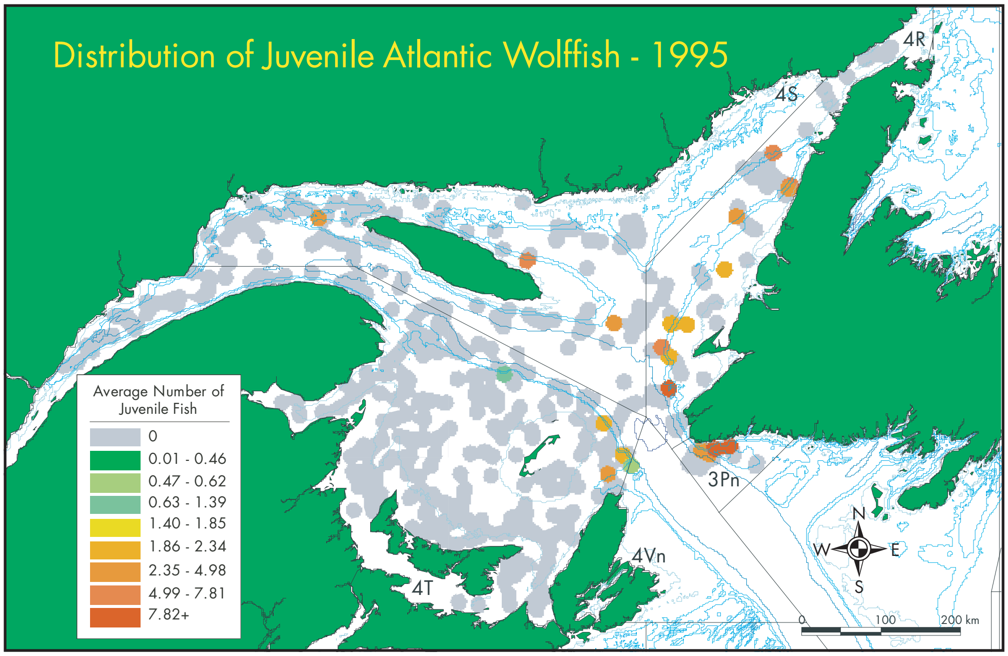


Figure 7 b.
Distribution of Juvenile Atlantic Wolffish 1996

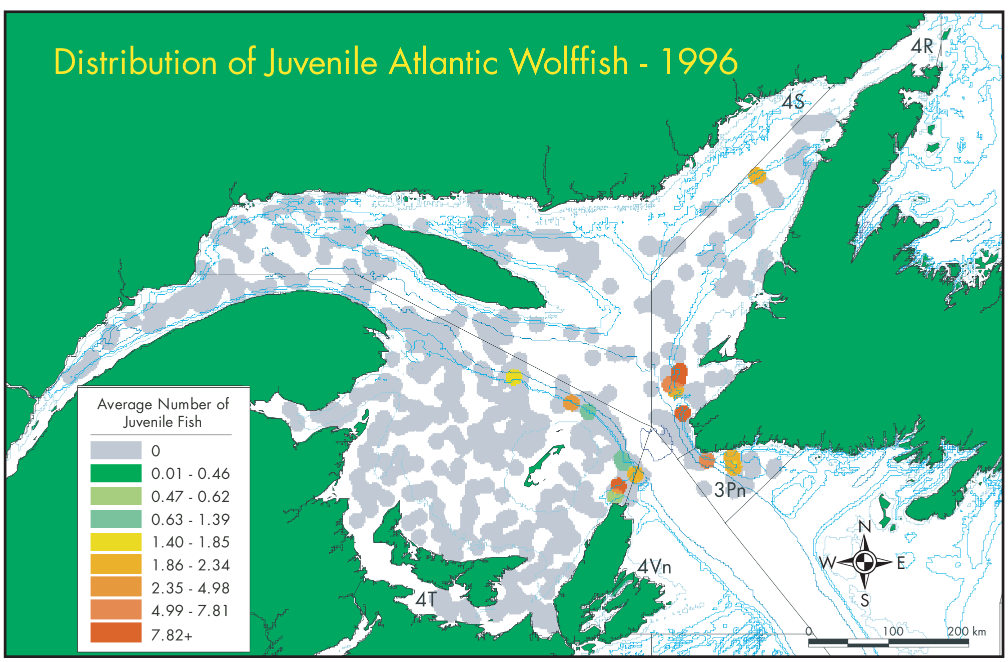


Figure 7 c.
Distribution of Juvenile Atlantic Wolffish 1997

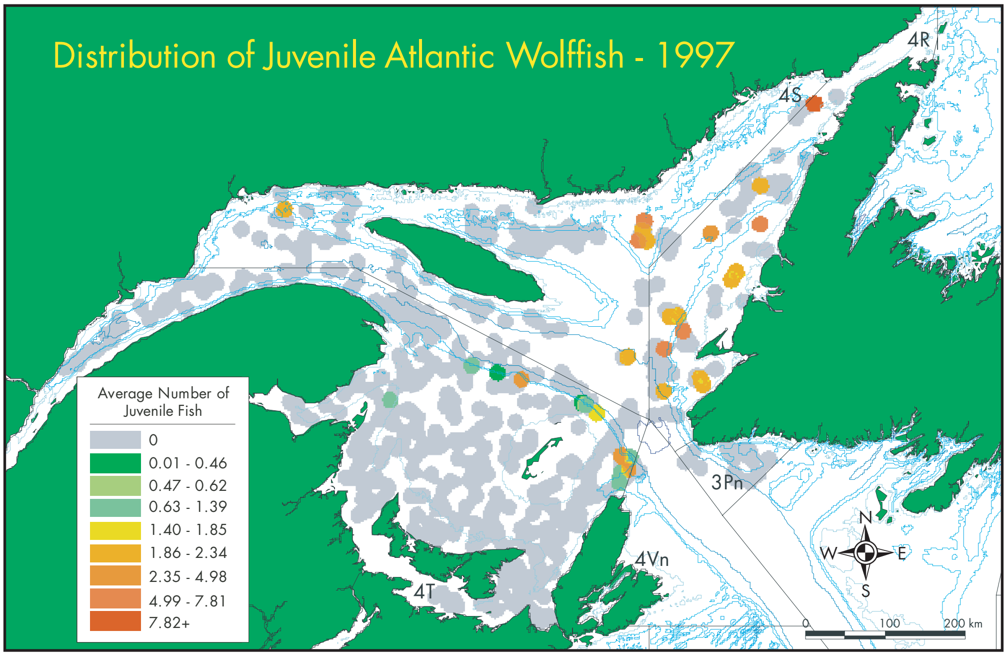


Figure 7 d.
Distribution of Juvenile Atlantic Wolffish 1998

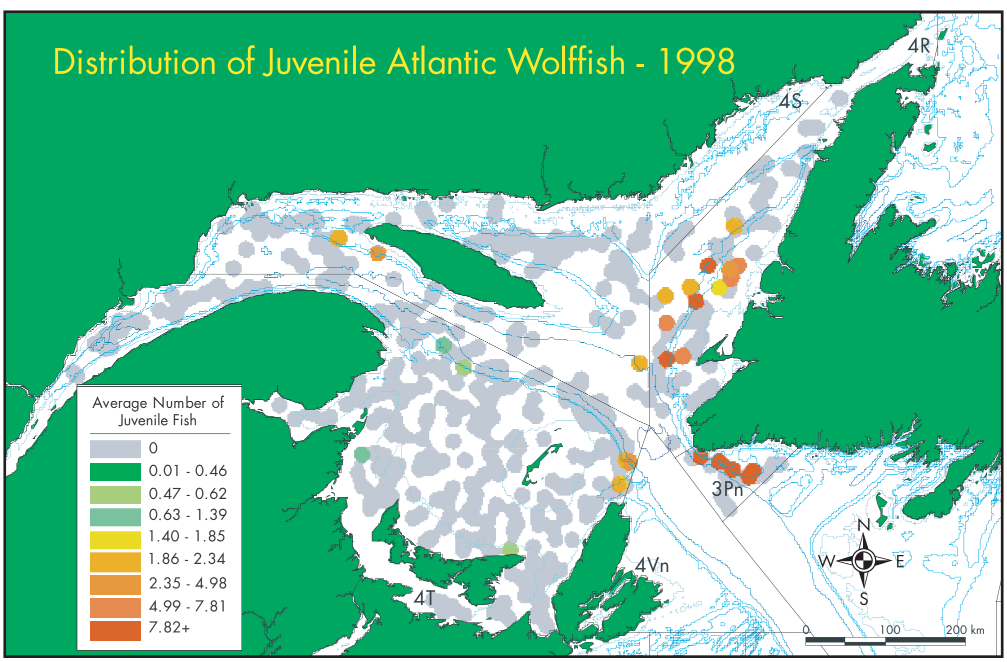
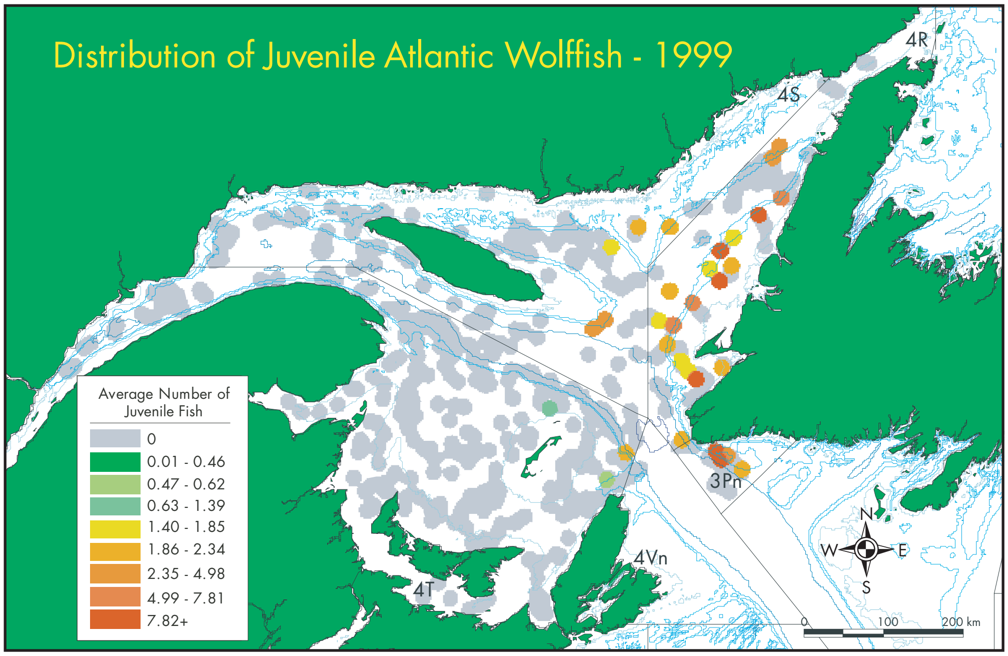


Figure 7 e.
Distribution of Juvenile Atlantic Wolffish 1999



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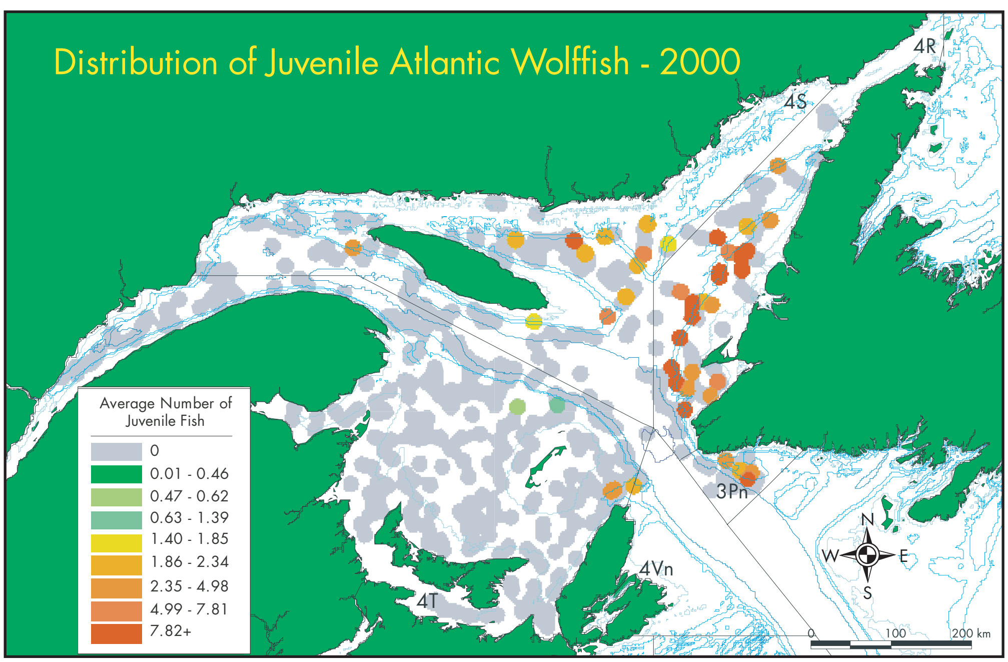
Distribution of Juvenile Atlantic Wolffish 2000



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Distribution of Juvenile Atlantic Wolffish 2001

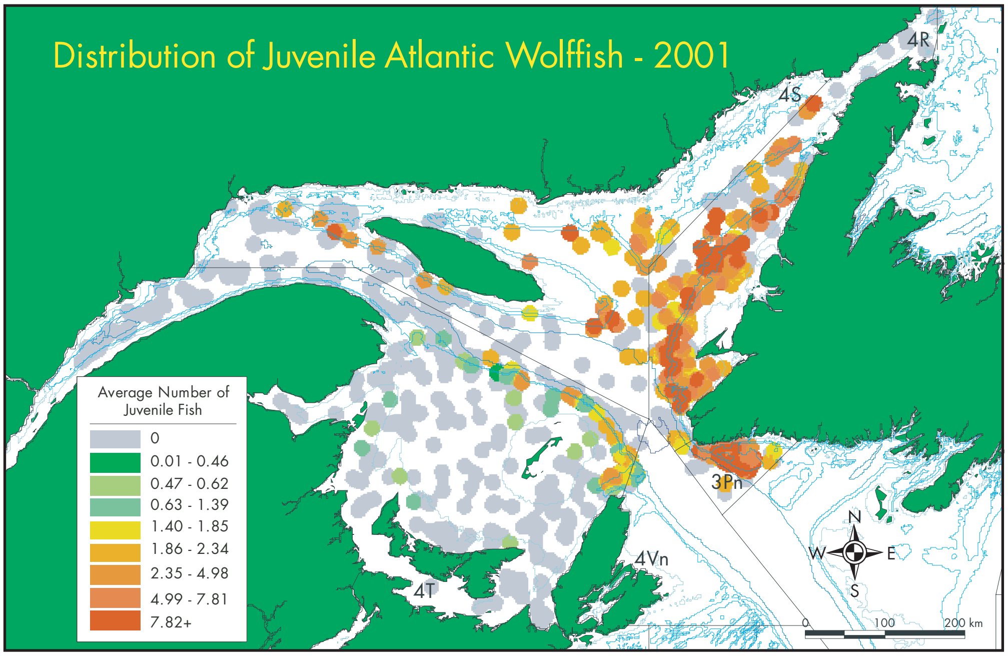


Figure 7 h.
Distribution of Juvenile Atlantic Wolffish 2002

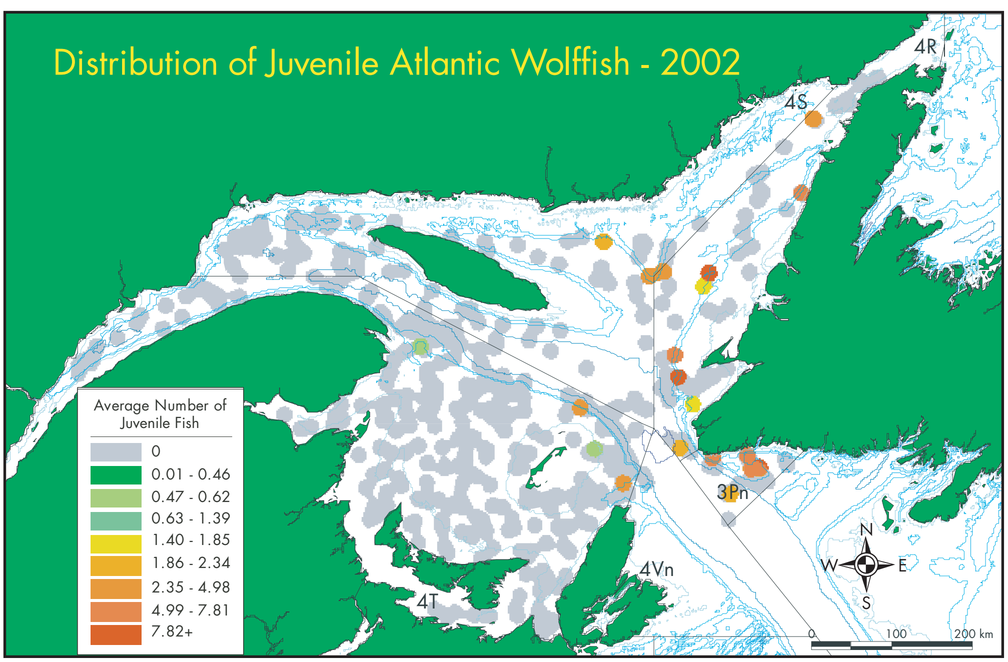


Figure 7 i.
Distribution of Juvenile Atlantic Wolffish 2003

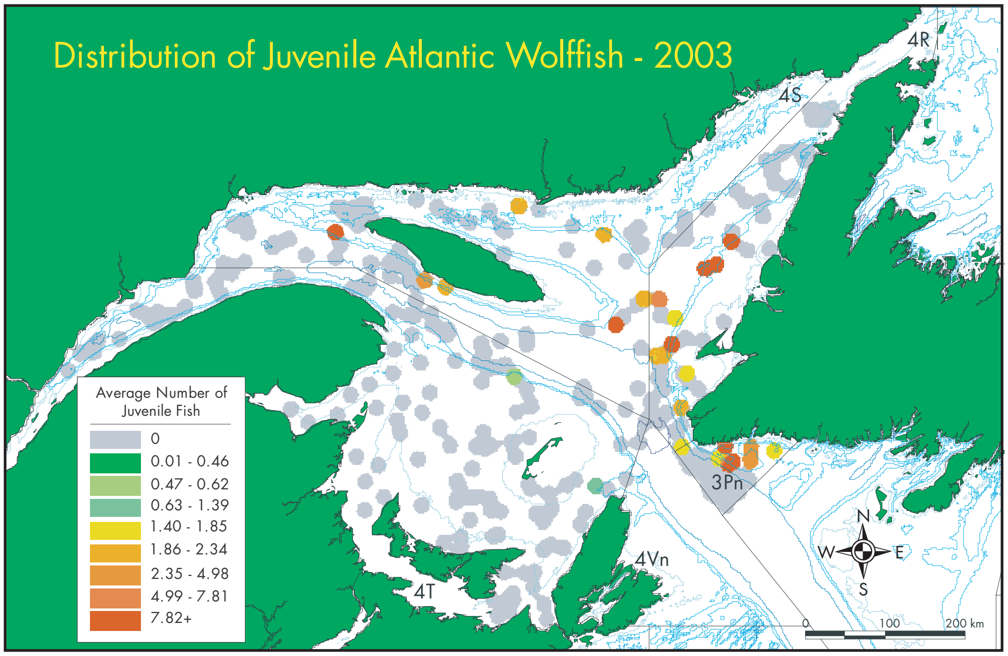


Figure 7 j.
Distribution of Juvenile Atlantic Wolffish 2004

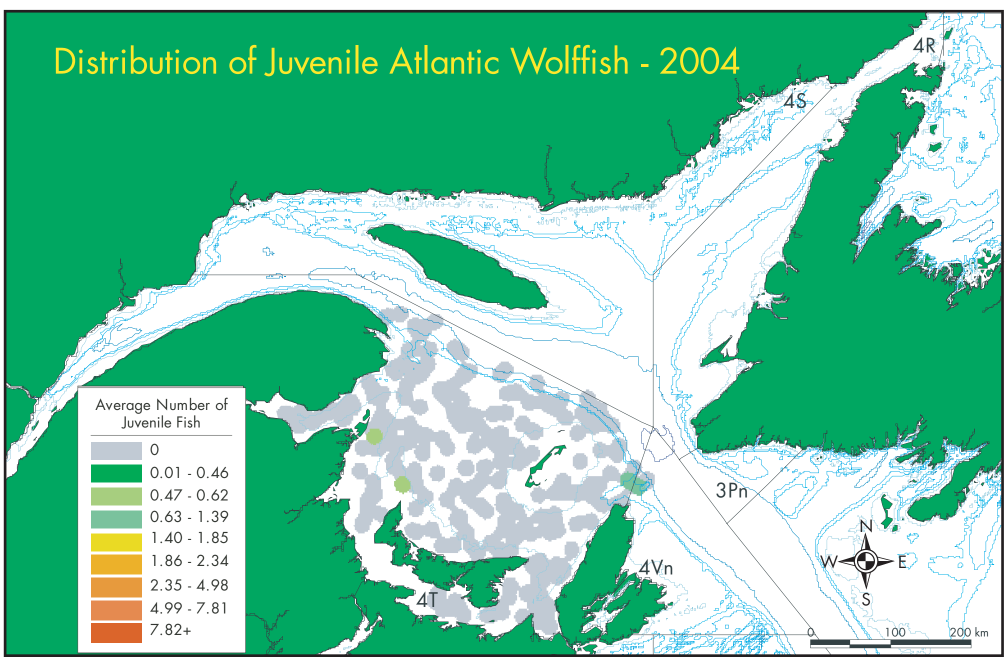


Figure 7 k.
Distribution of Juvenile Atlantic Wolffish 2005

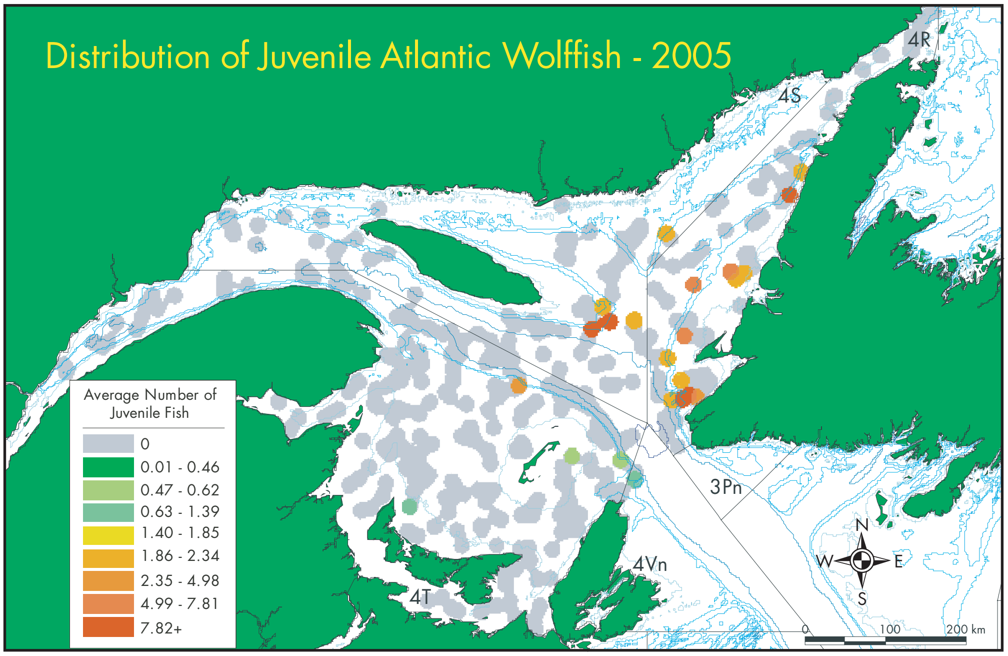


Figure 8 a.
Distribution of Juvenile Fourbeard Rockling 1995

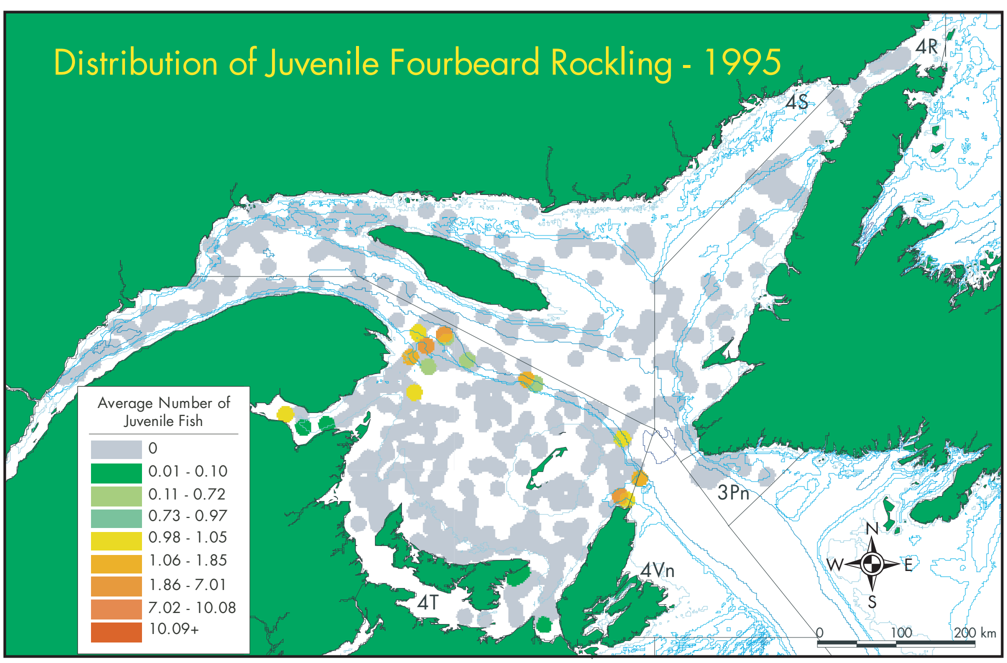


Figure 8 b.
Distribution of Juvenile Fourbeard Rockling 1996

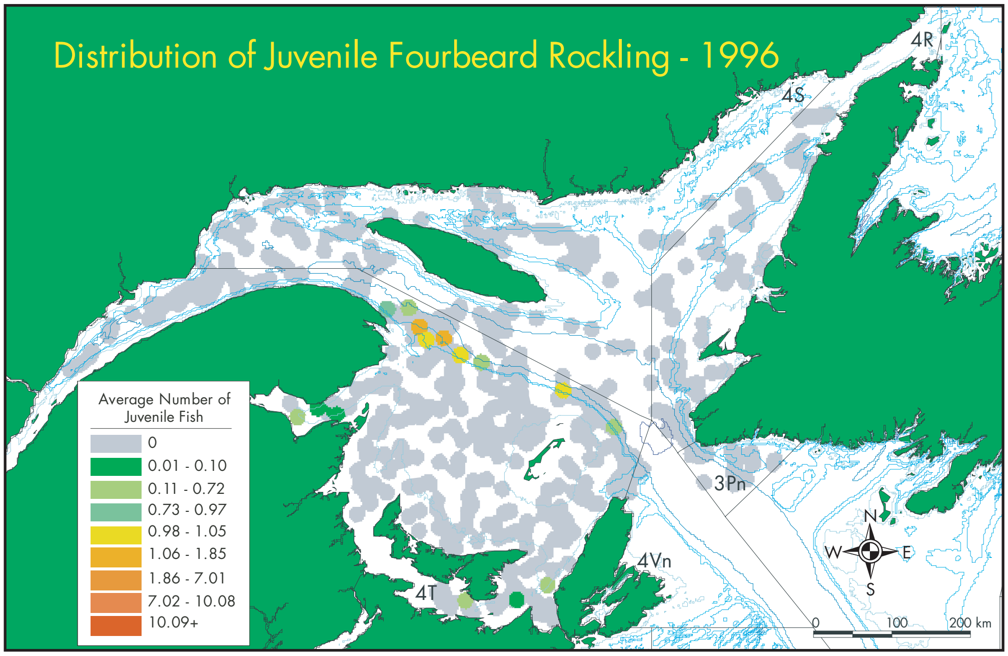
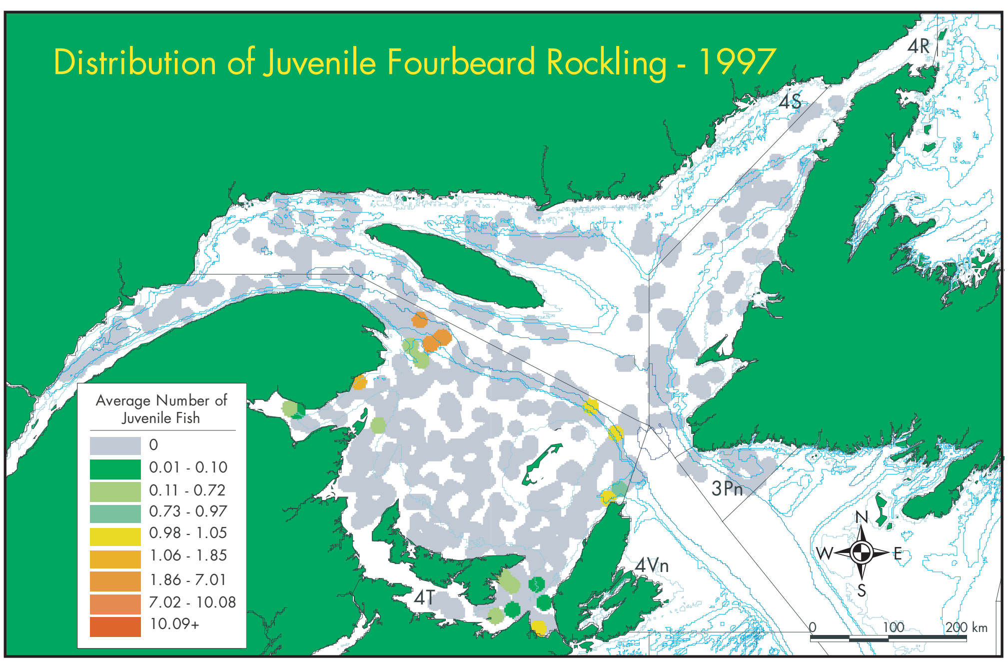


Figure 8 c.
Distribution of Juvenile Fourbeard Rockling 1997



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Distribution of Juvenile Fourbeard Rockling 1998

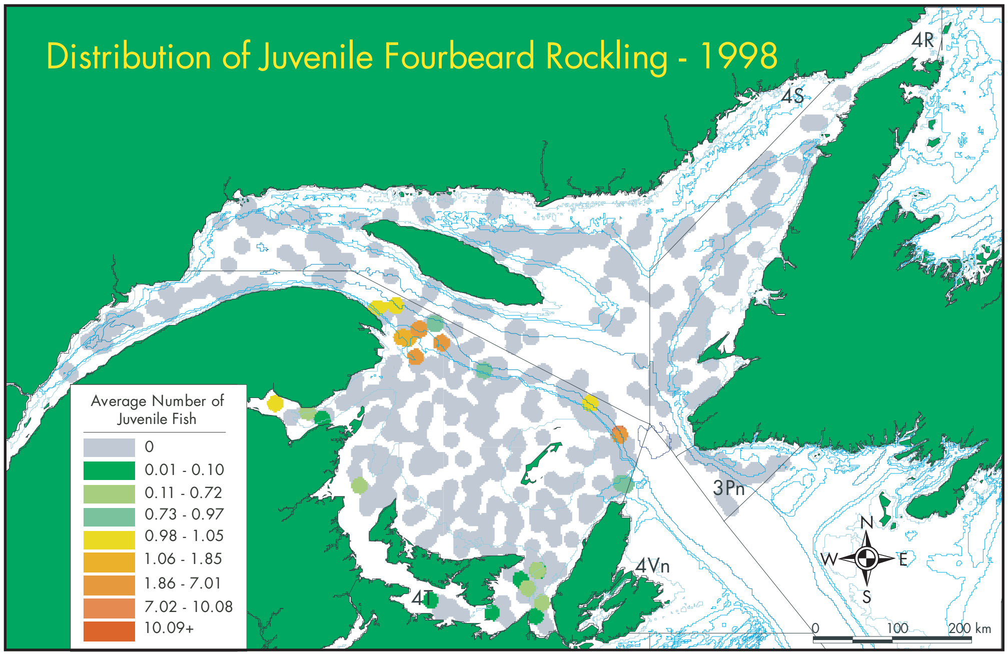
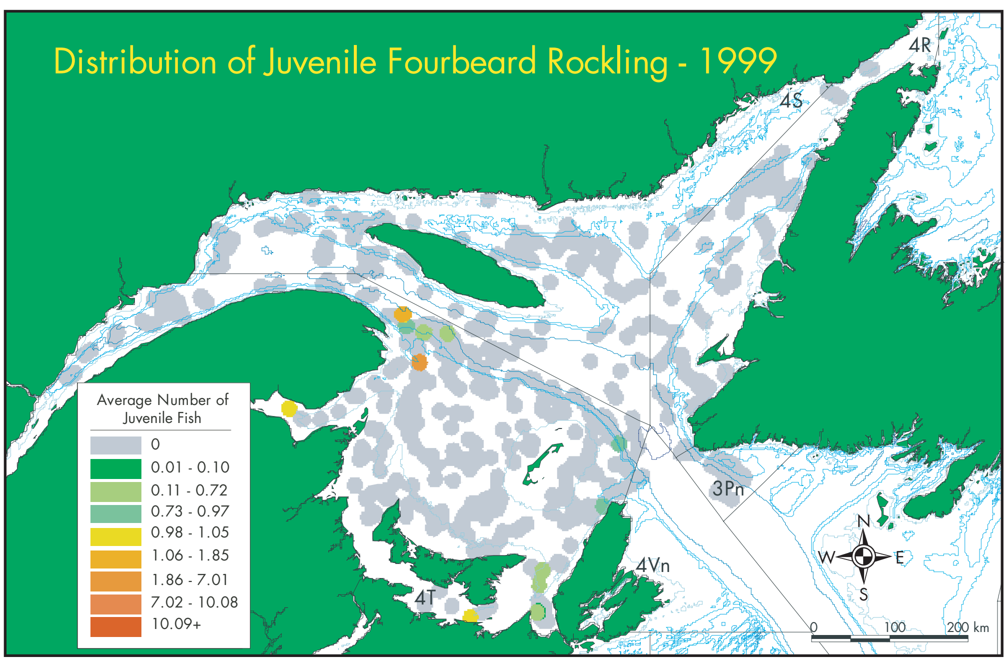


Figure 8 e.
Distribution of Juvenile Fourbeard Rockling 1999



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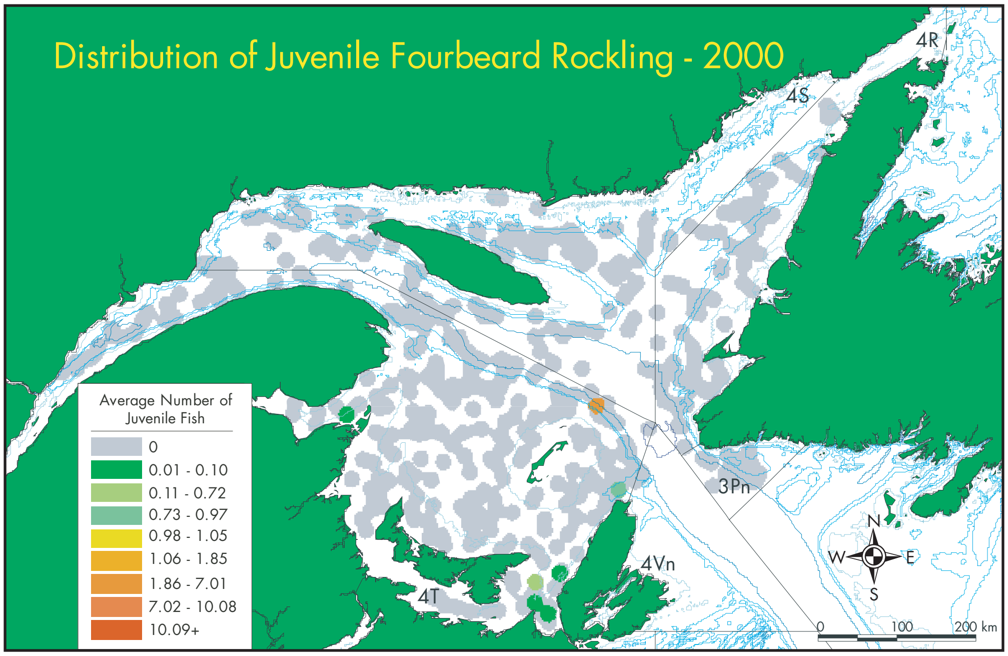
Distribution of Juvenile Fourbeard Rockling 2000



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Distribution of Juvenile Fourbeard Rockling 2001

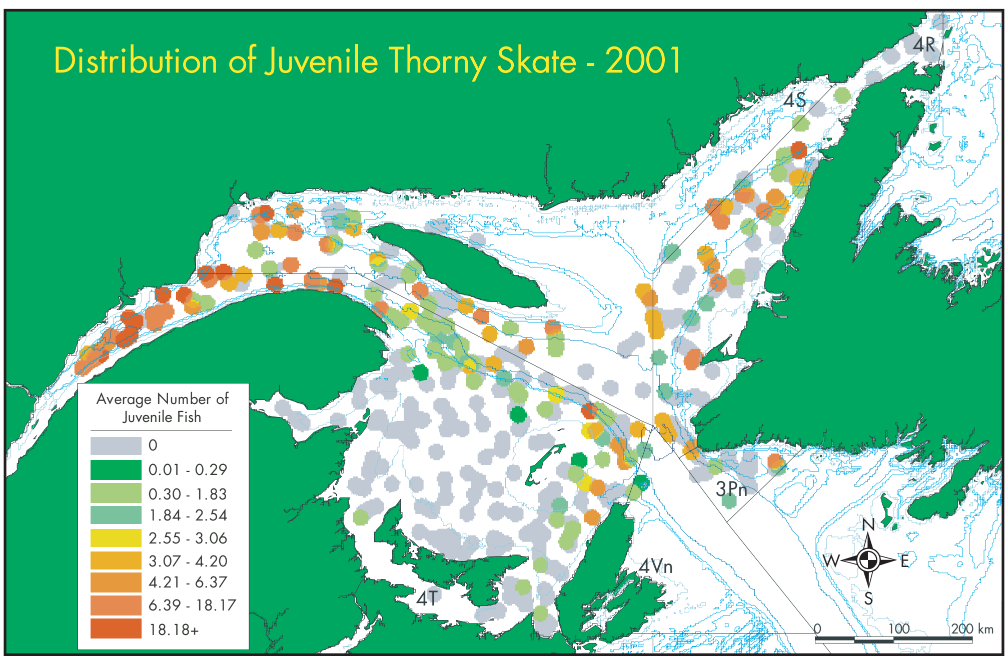


Figure 8 h.
Distribution of Juvenile Fourbeard Rockling 2002

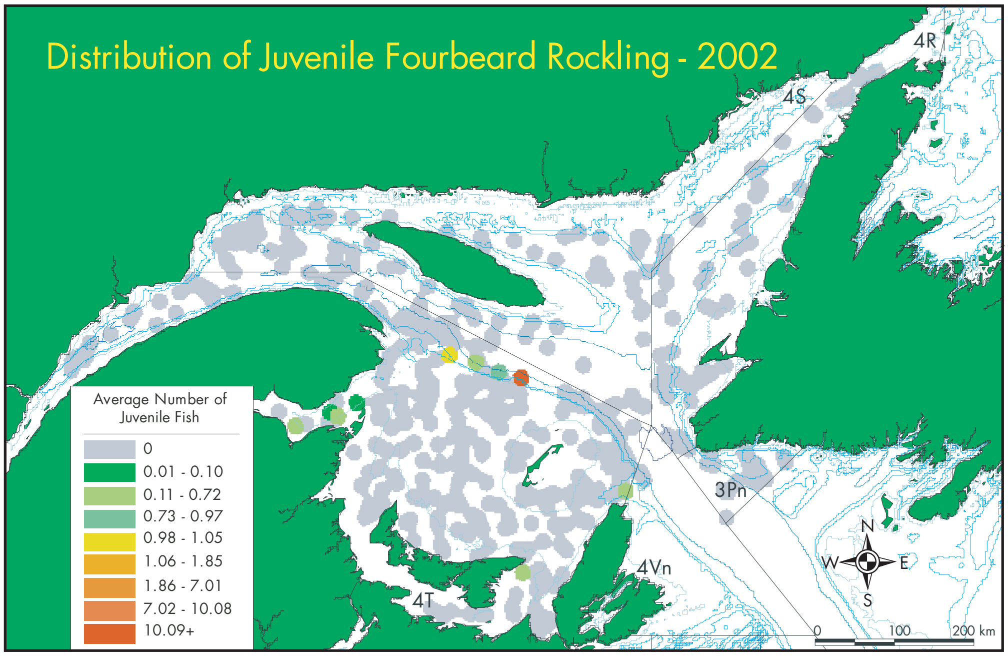
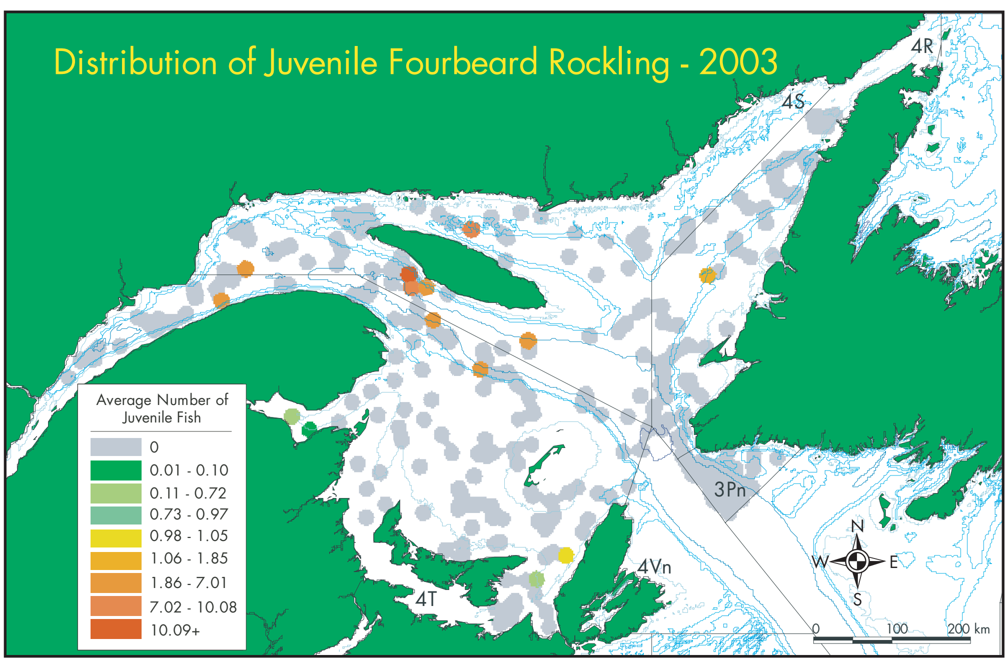


Figure 8 i.
Distribution of Juvenile Fourbeard Rockling 2003



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Distribution of Juvenile Fourbeard Rockling 2004

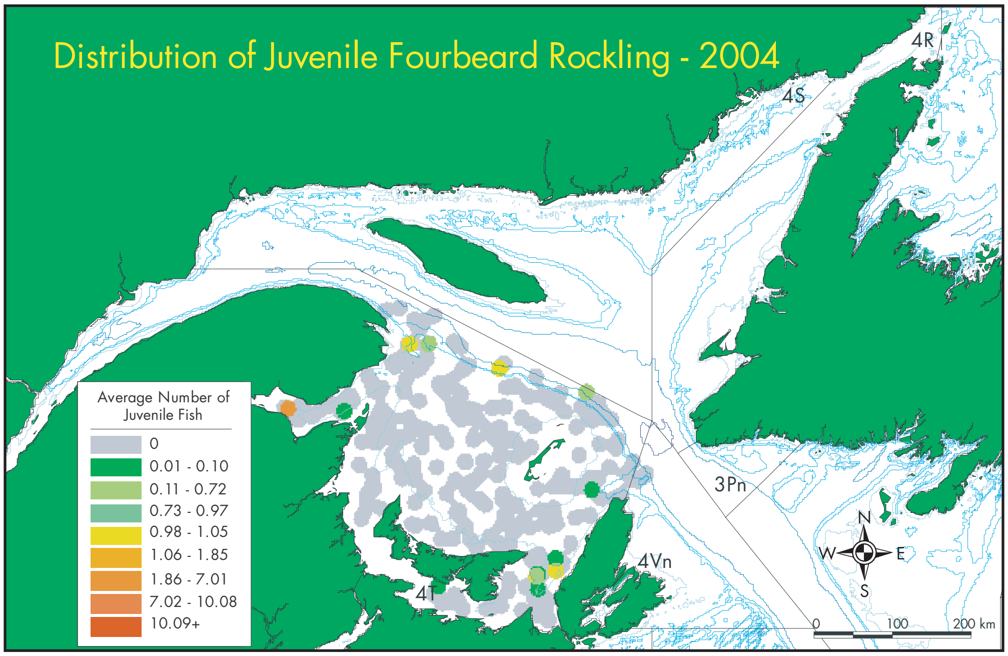


Figure 8 k.
Distribution of Juvenile Fourbeard Rockling 2005

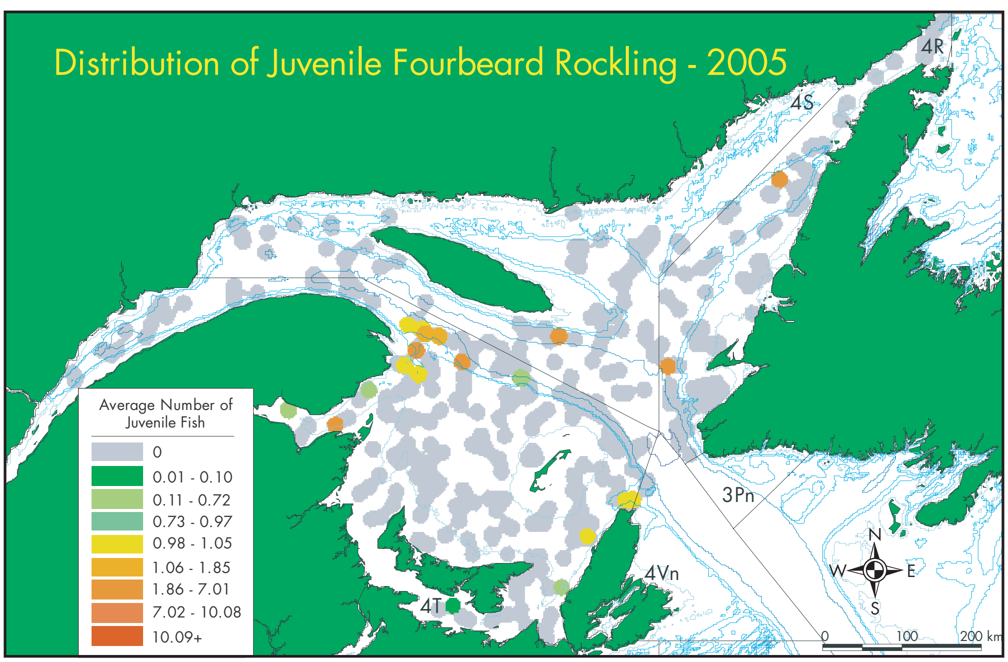


Figure 9 a.
Distribution of Juvenile Thorny Skate 1995

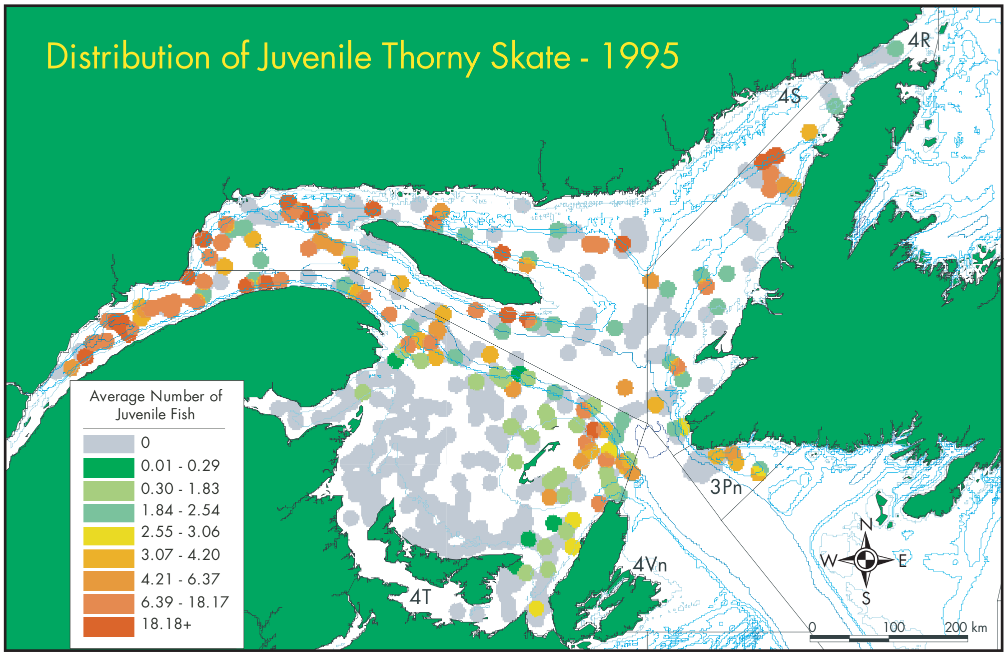
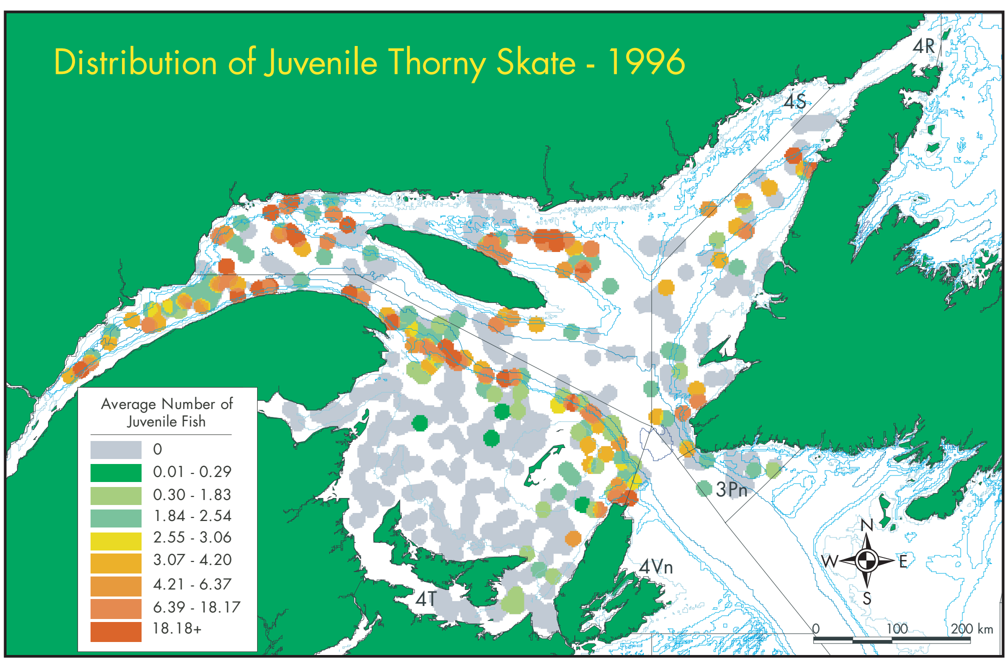


Figure 9 b.
Distribution of Juvenile Thorny Skate 1996



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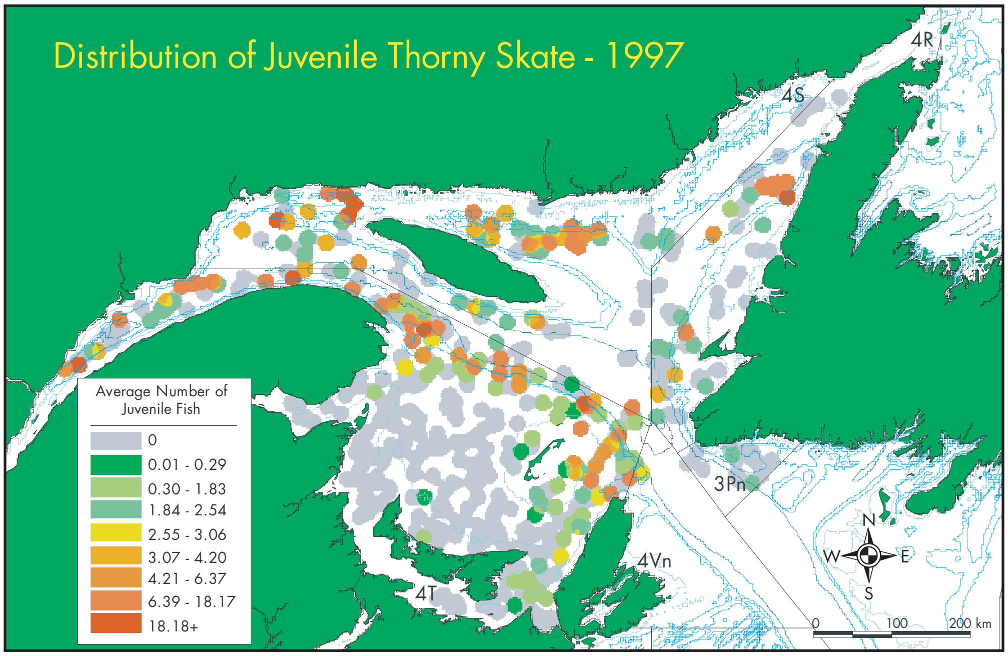
Distribution of Juvenile Thorny Skate 1997



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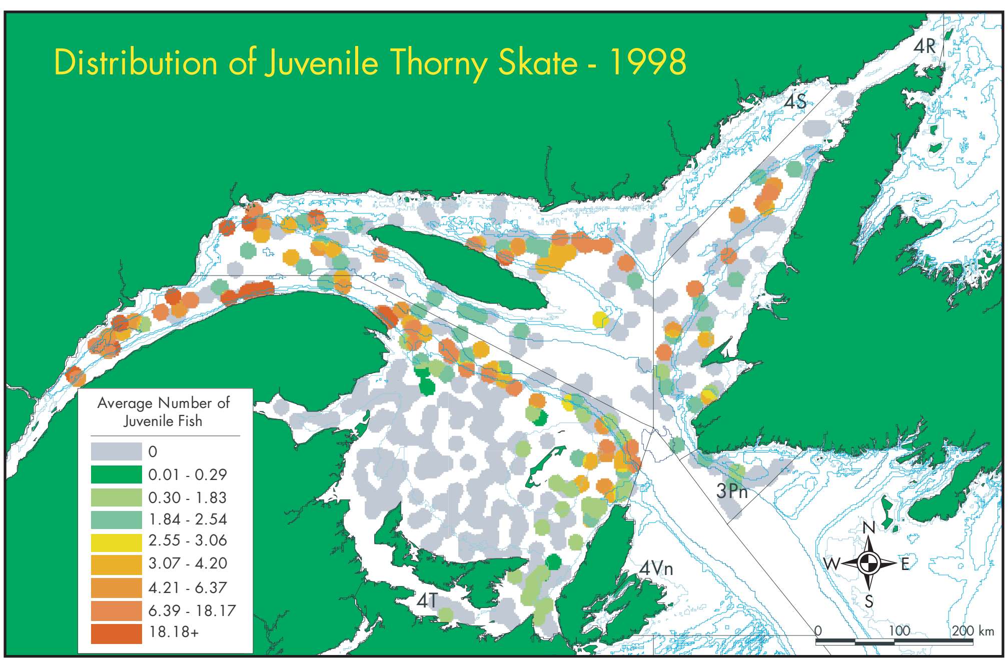
Distribution of Juvenile Thorny Skate 1998



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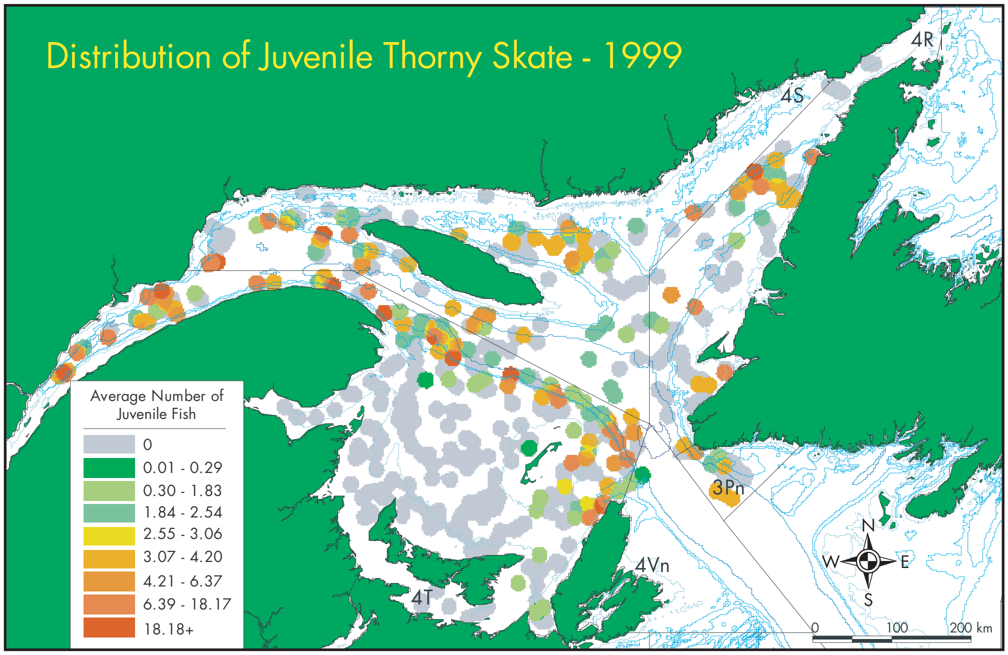
Distribution of Juvenile Thorny Skate 1999



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Distribution of Juvenile Thorny Skate 2000

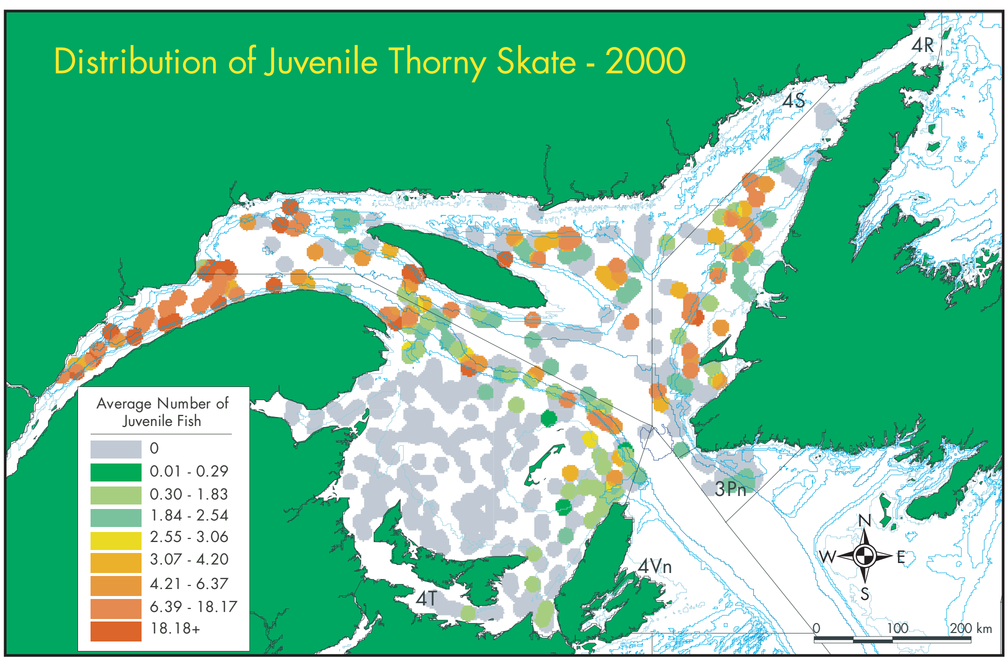
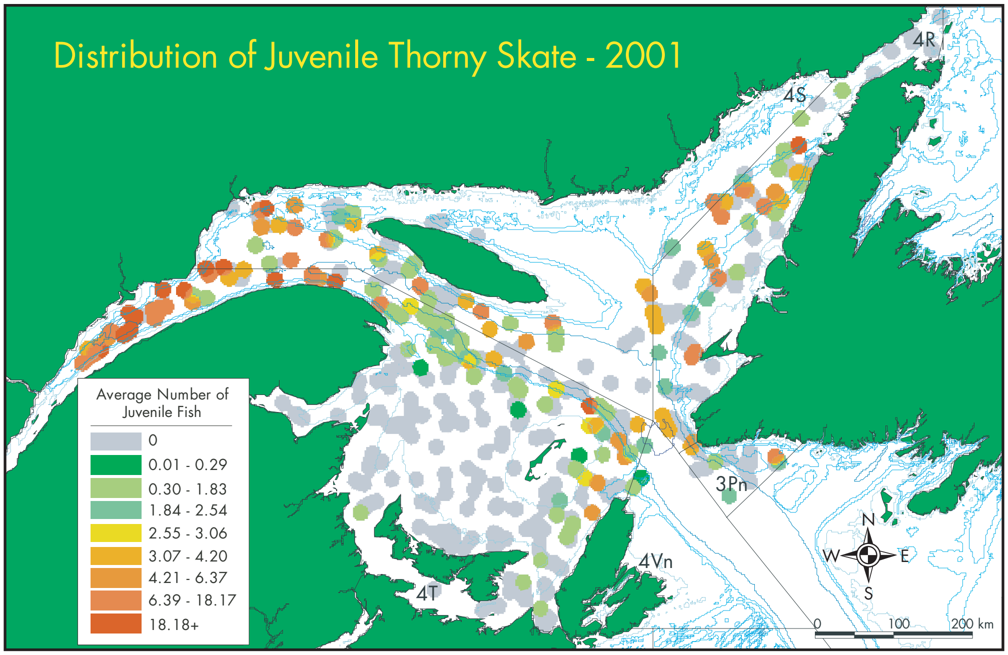


Figure 9 g.
Distribution of Juvenile Thorny Skate 2001



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Distribution of Juvenile Thorny Skate 2002

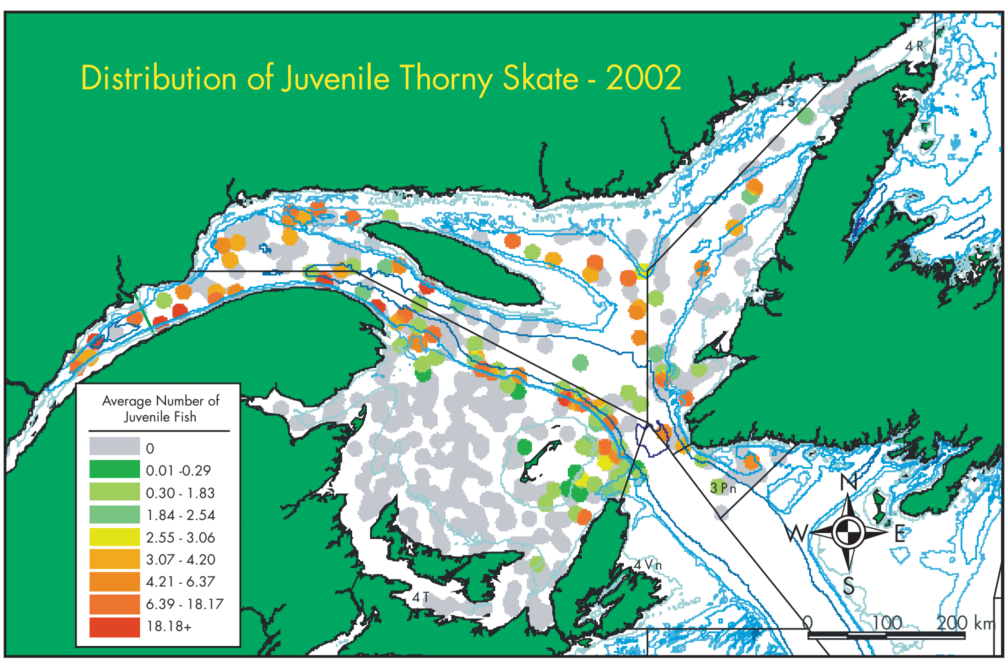


Figure 9 i.
Distribution of Juvenile Thorny Skate 2003

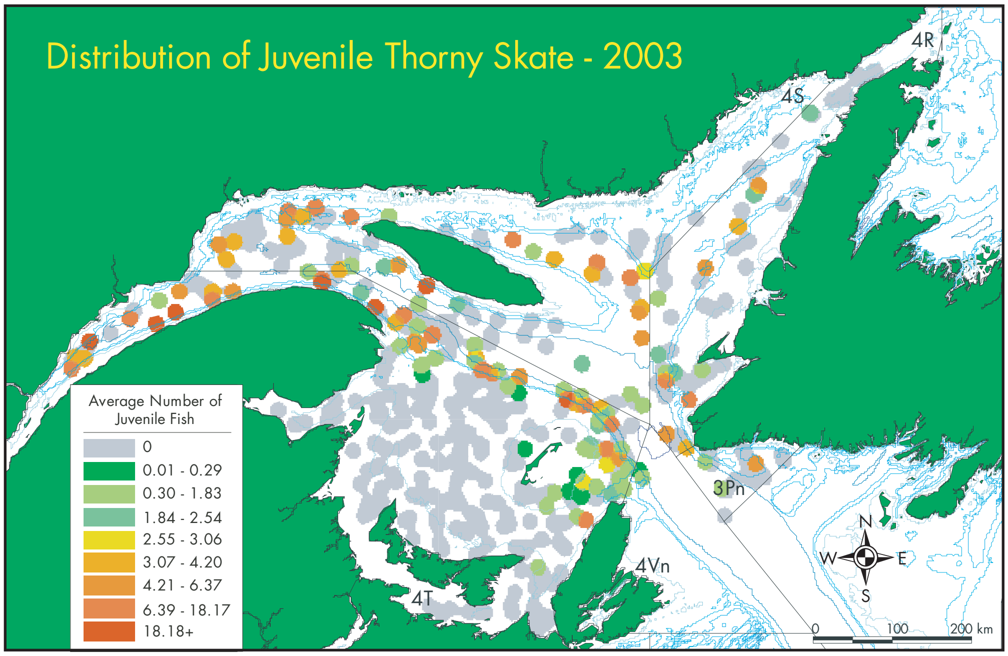


Figure 9 j.
Distribution of Juvenile Thorny Skate 2004

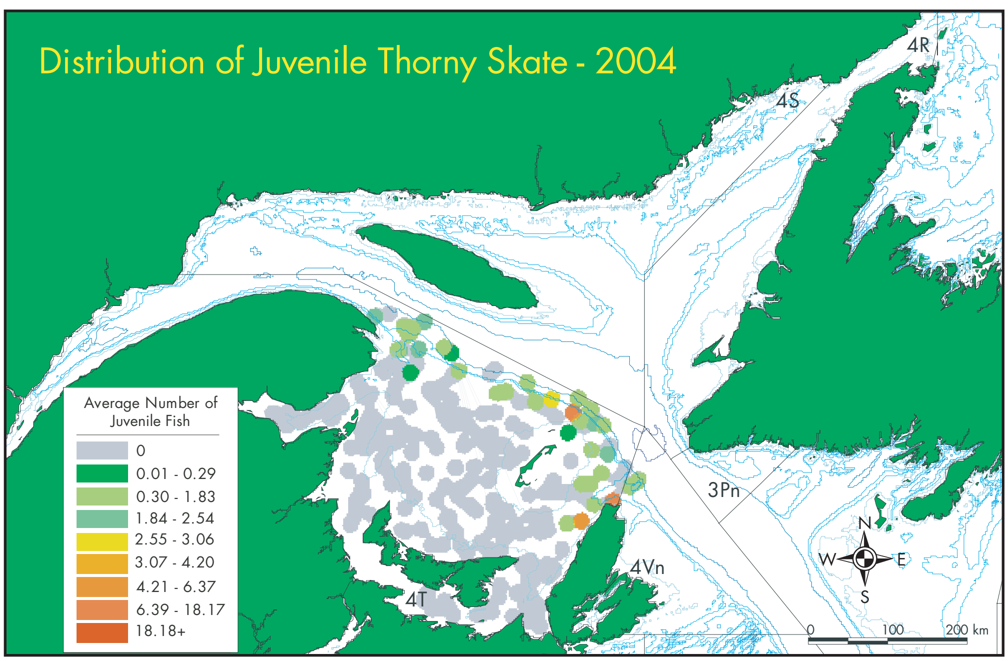


Figure 9 k.
Distribution of Juvenile Thorny Skate 2005

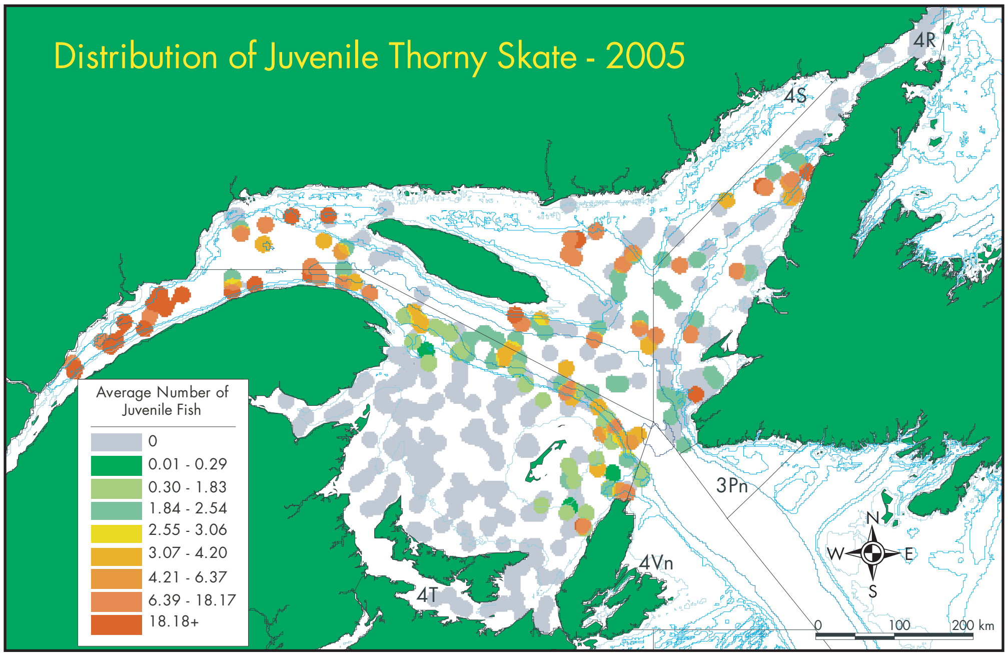


Figure 10 a.
Distribution of Juvenile White Hake 1995

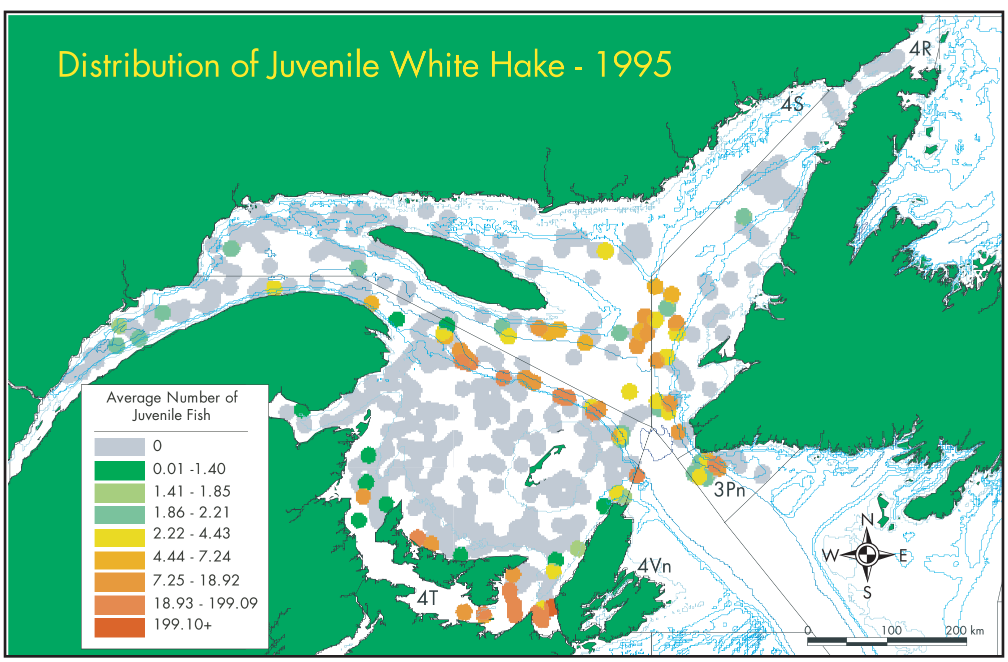


Figure 10 b.
Distribution of Juvenile White Hake 1996

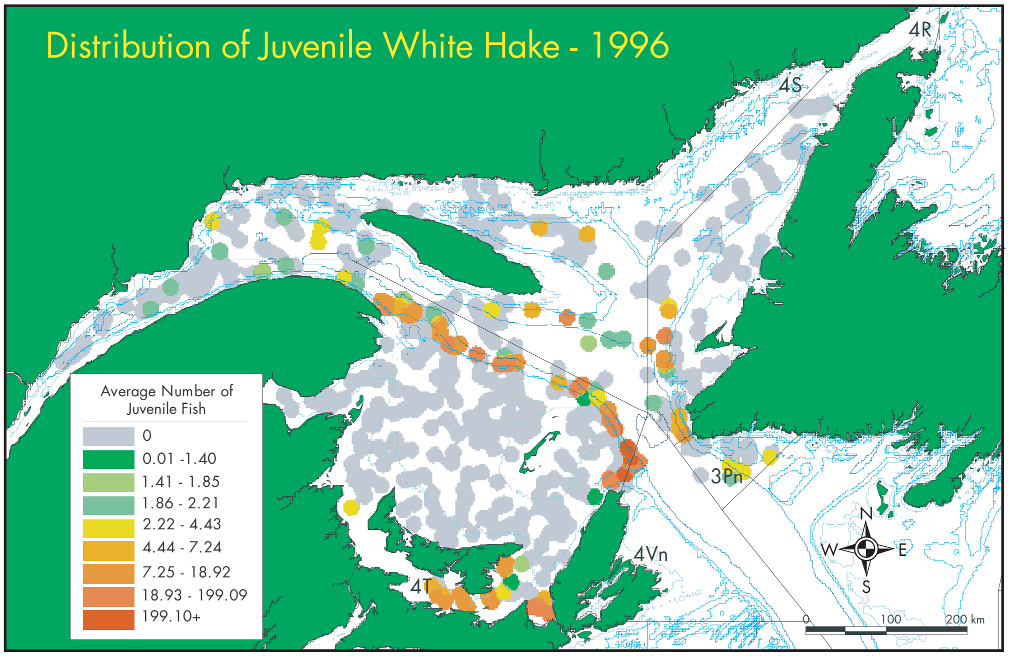
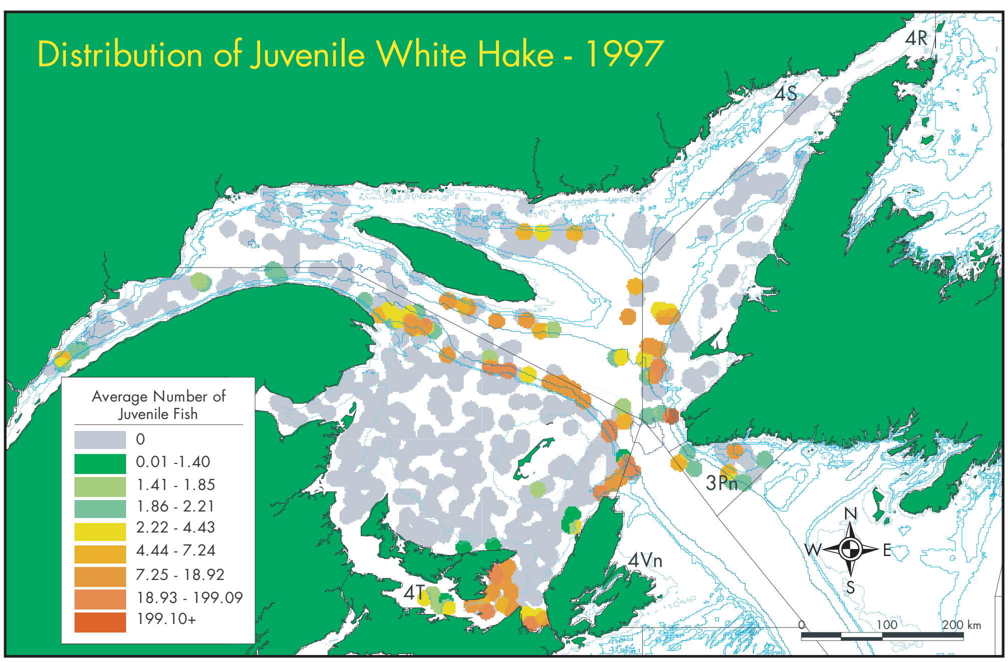


Figure 10 c.
Distribution of Juvenile White Hake 1997



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Distribution of Juvenile White Hake 1998

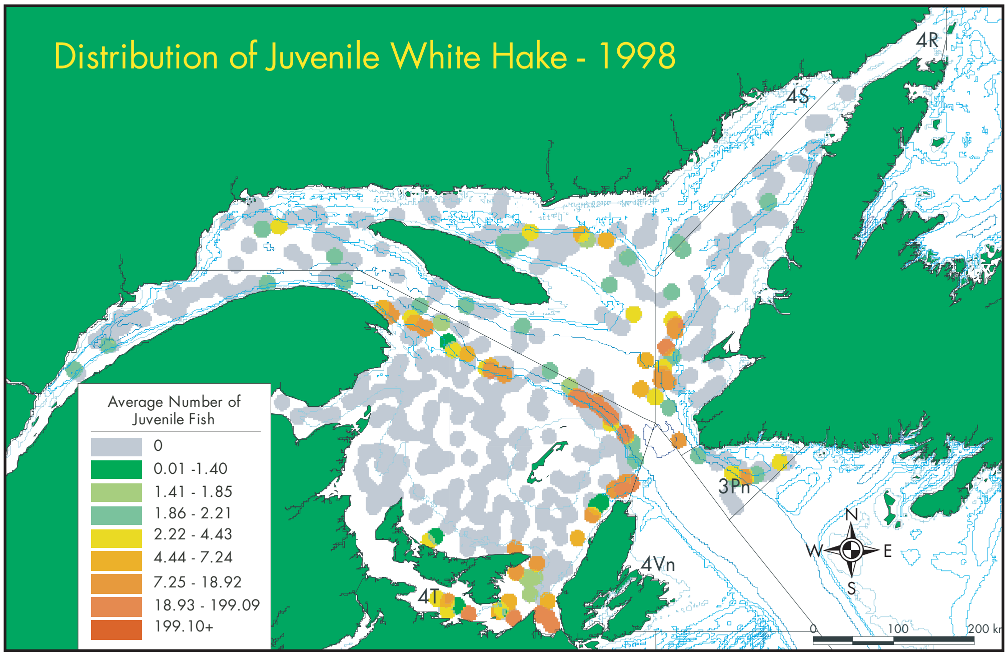
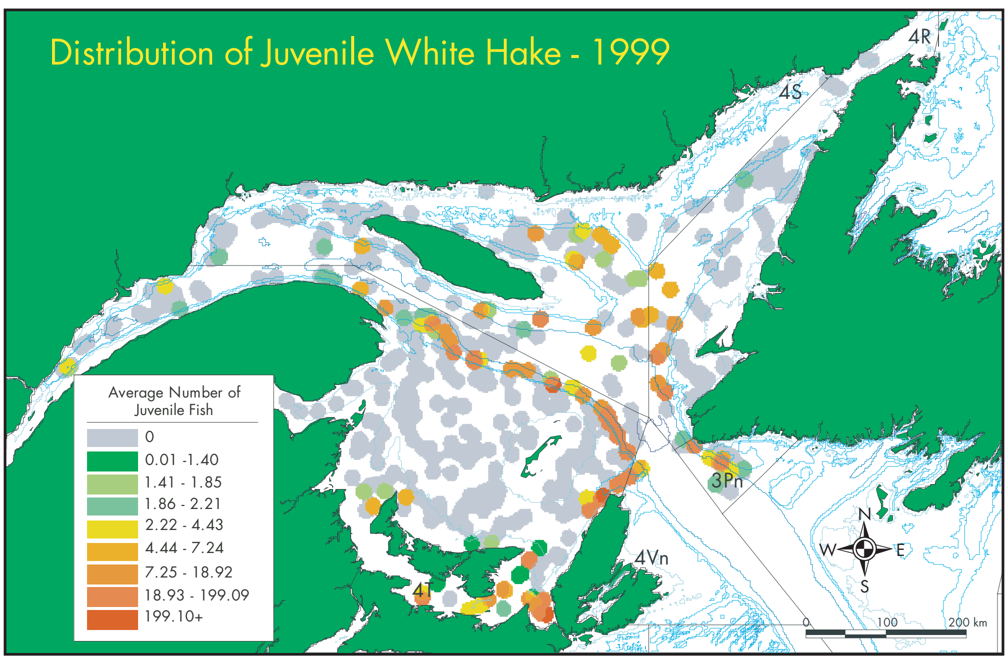


Figure 10 e.
Distribution of Juvenile White Hake 1999



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Distribution of Juvenile White Hake 2000

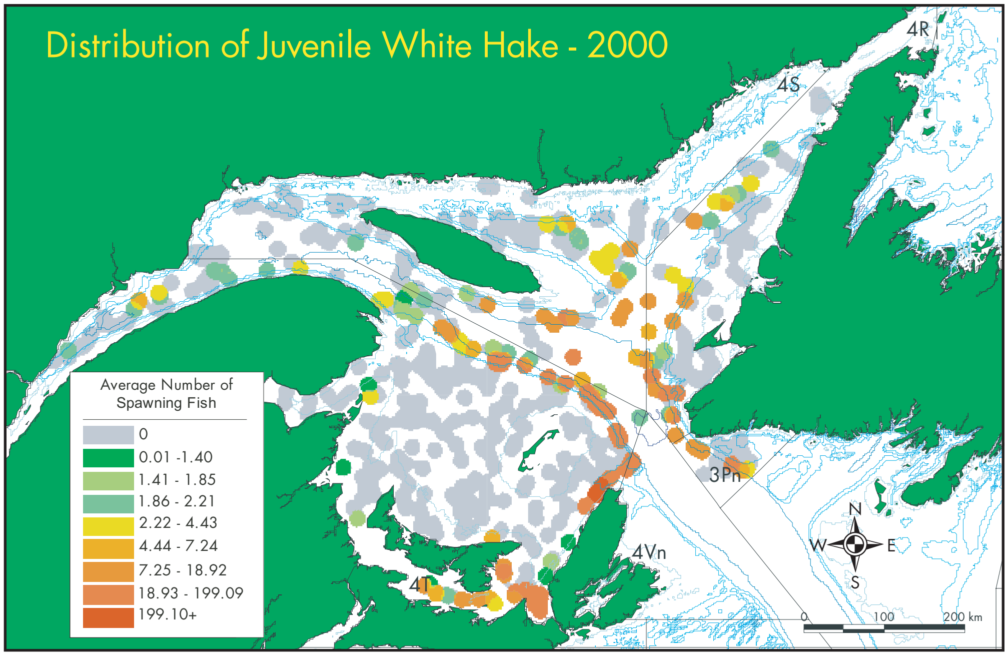


Figure 10 g.
Distribution of Juvenile White Hake 2001

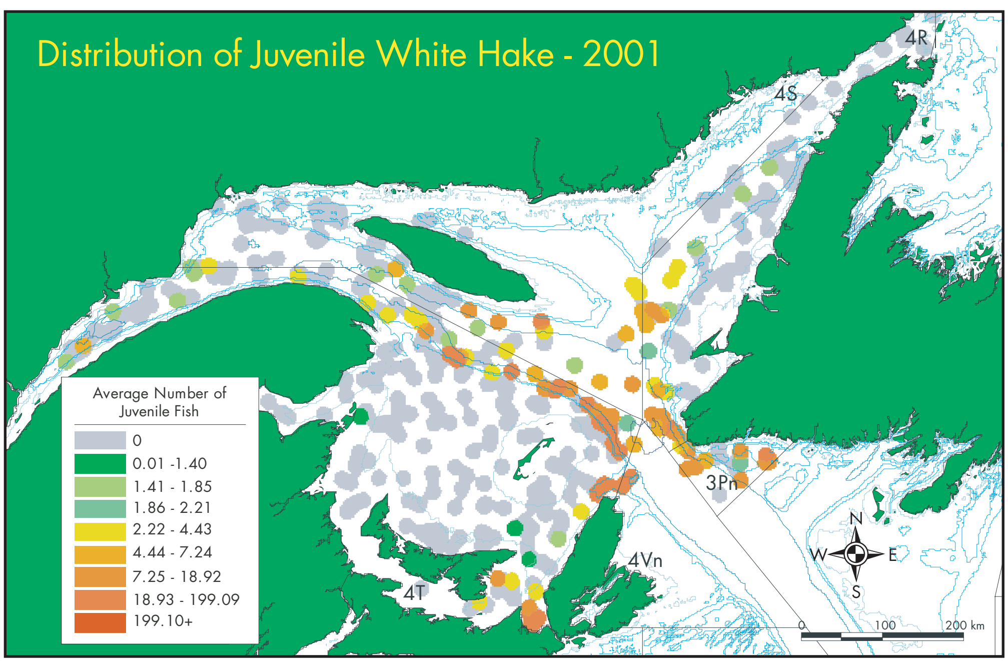


Figure 10 h.
Distribution of Juvenile White Hake 2002

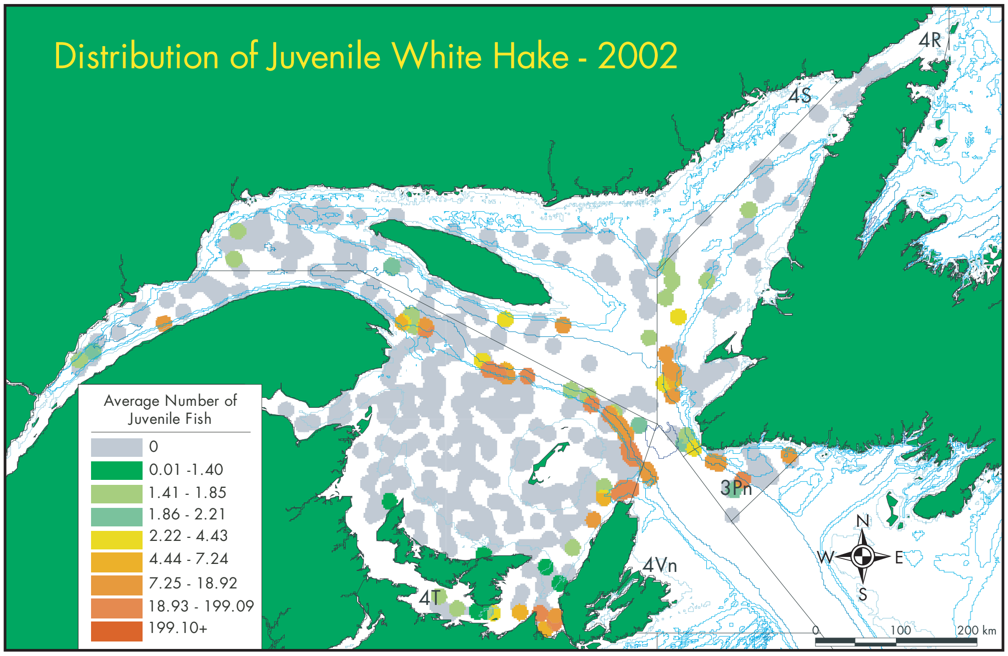
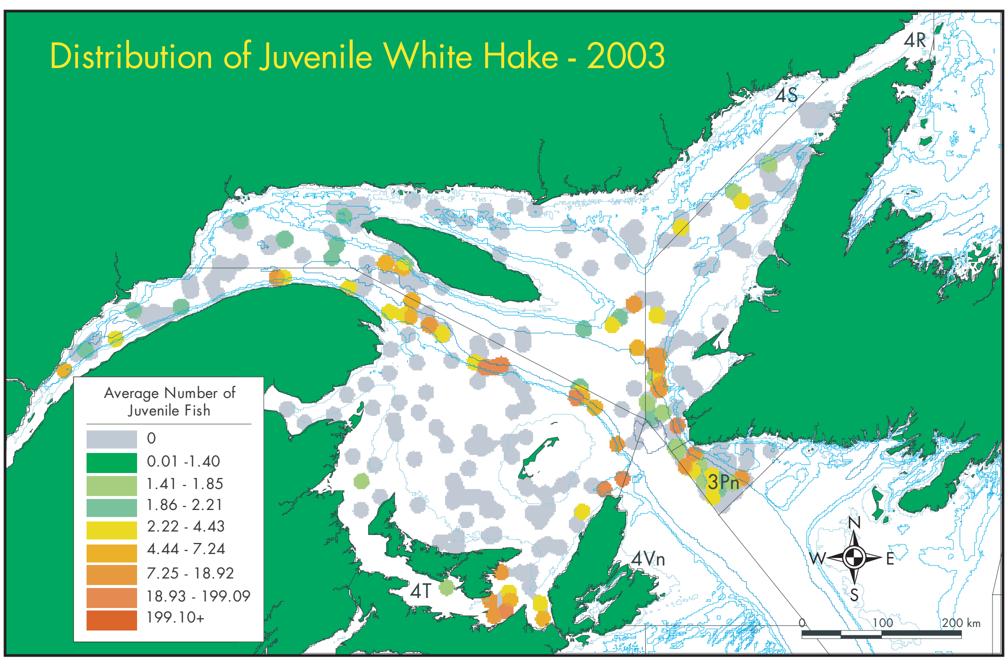


Figure 10 i.
Distribution of Juvenile White Hake 2003



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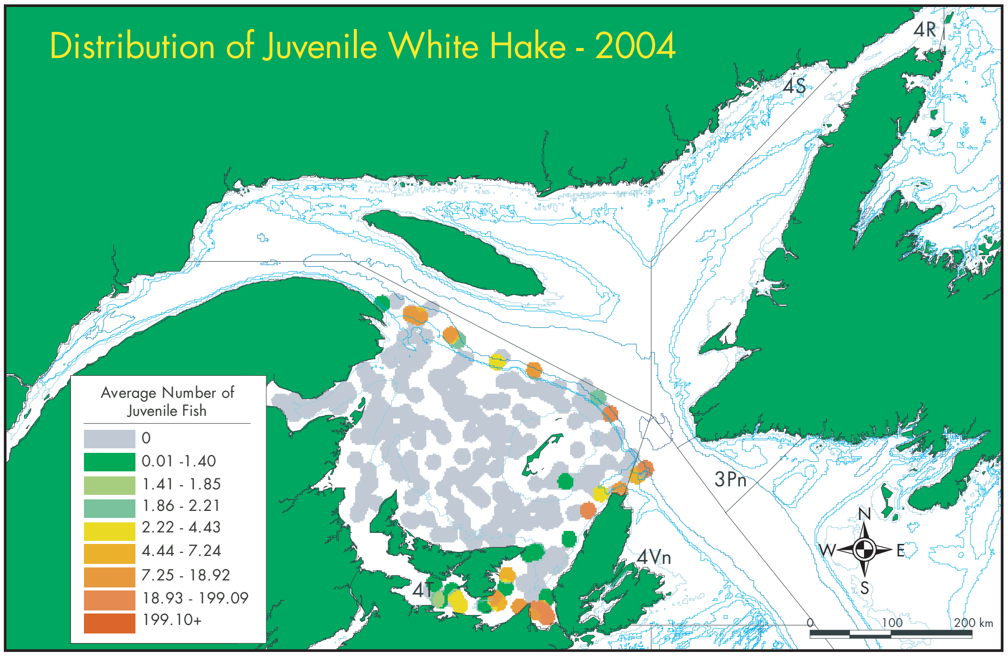
Distribution of Juvenile White Hake 2004



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Distribution of Juvenile White Hake 2005

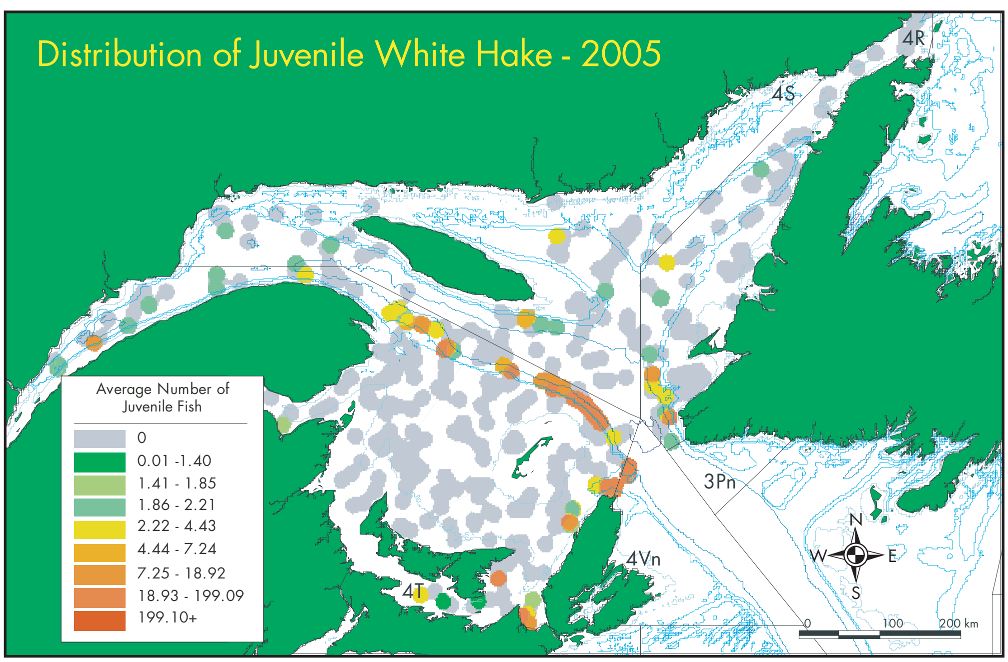


Figure 11 a.
Distribution of Juvenile Winter Flounder 1995

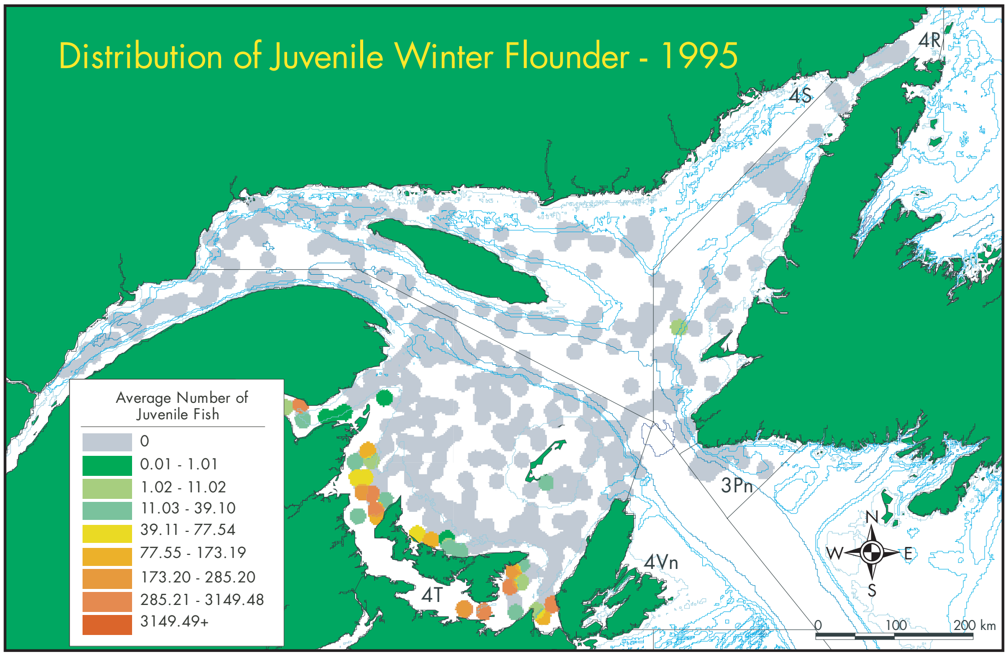


Figure 11 b.
Distribution of Juvenile Winter Flounder 1996

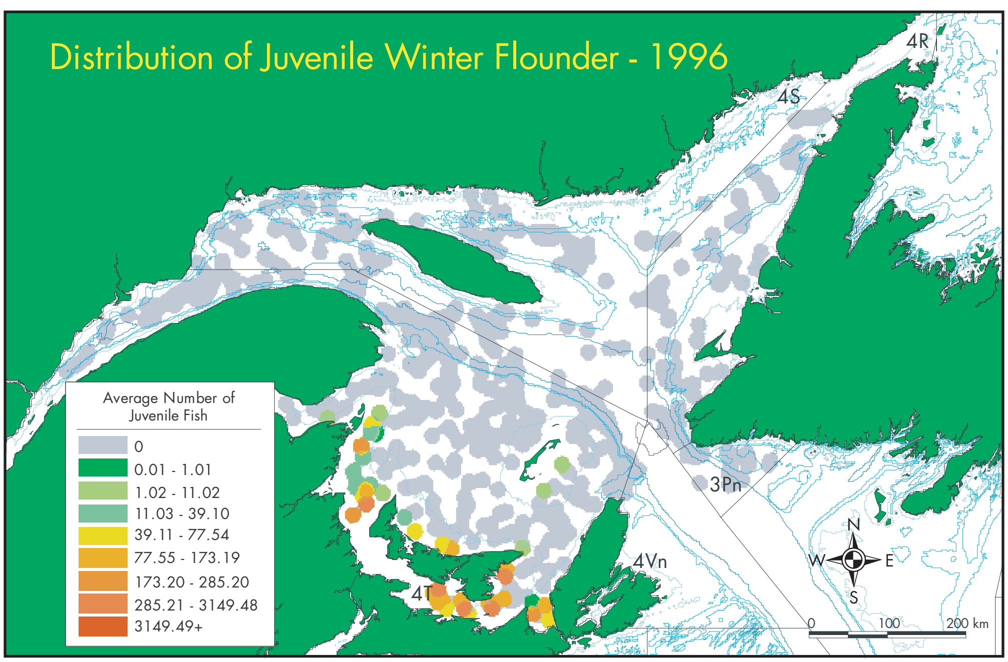


Figure 11 c.
Distribution of Juvenile Winter Flounder 1997

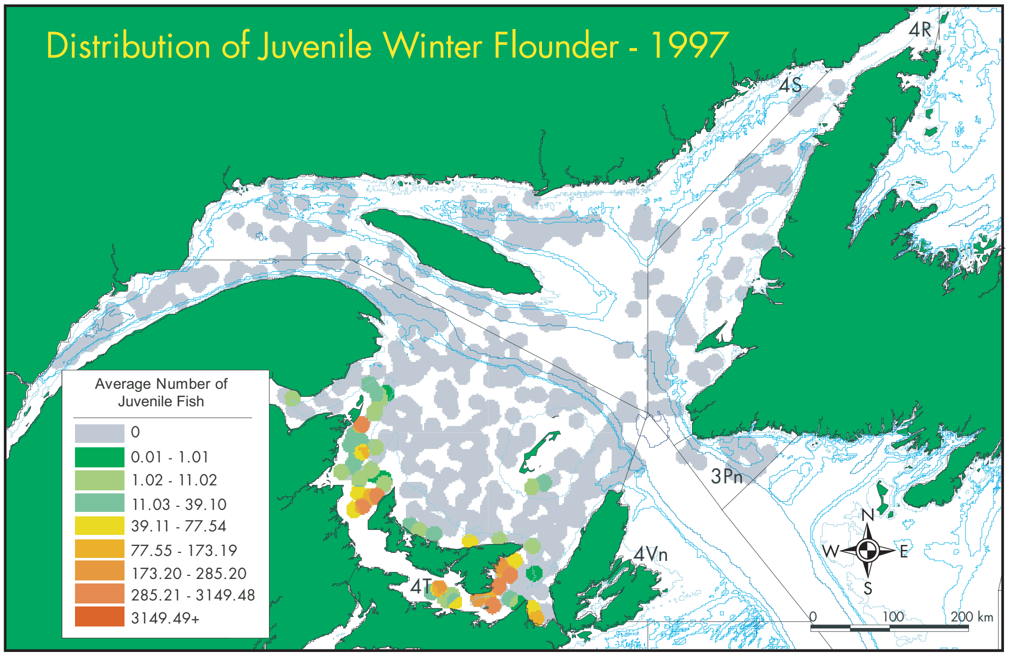


Figure 11 d.
Distribution of Juvenile Winter Flounder 1998

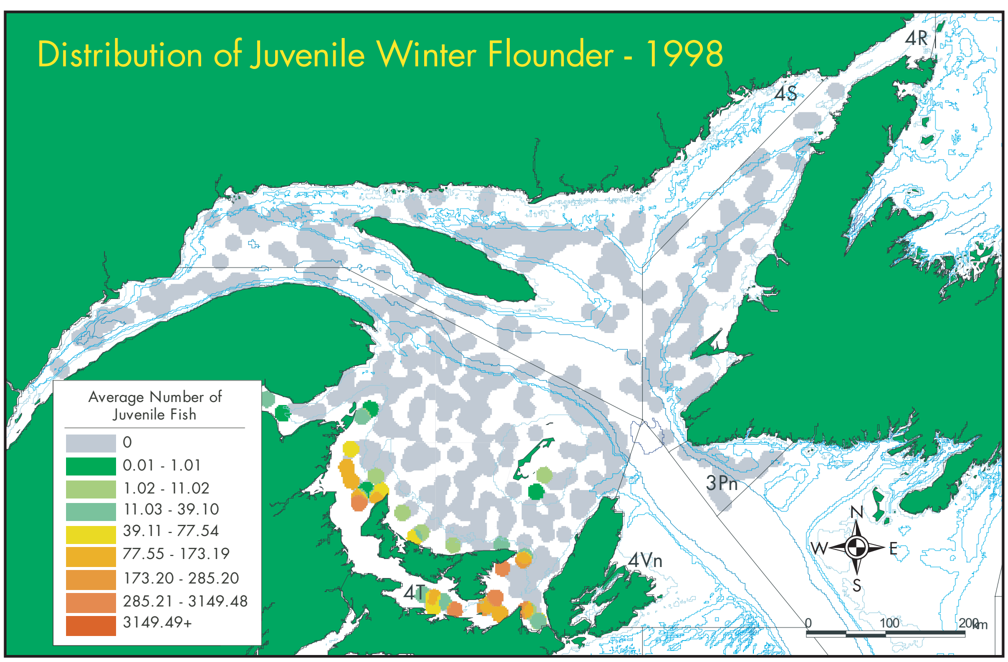


Figure 11 e.
Distribution of Juvenile Winter Flounder 1999

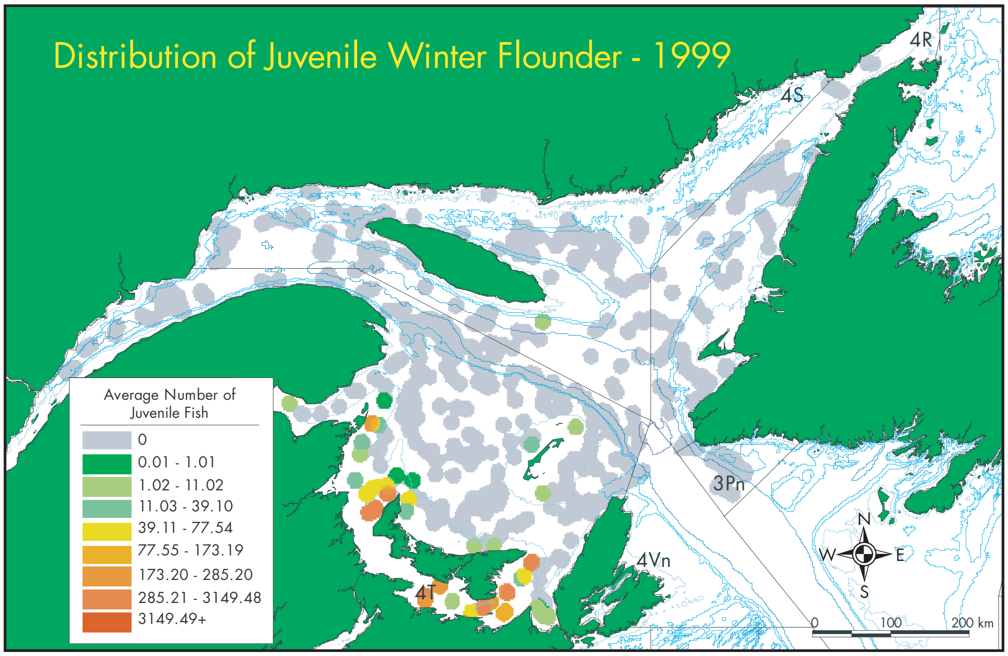


Figure 11 f.
Distribution of Juvenile Winter Flounder 2000

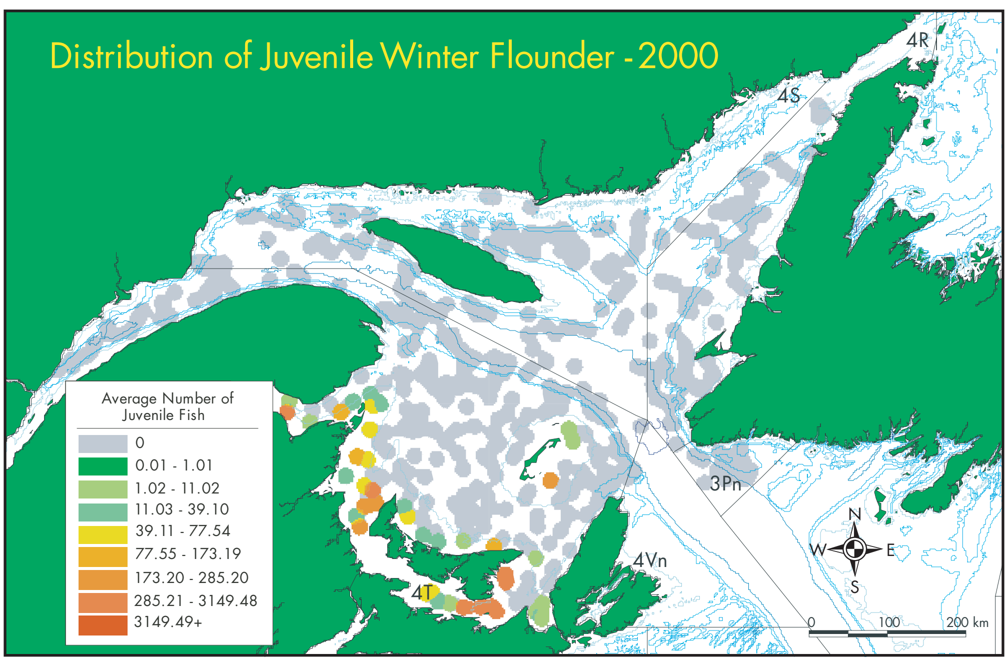


Figure 11 g.
Distribution of Juvenile Winter Flounder 2001

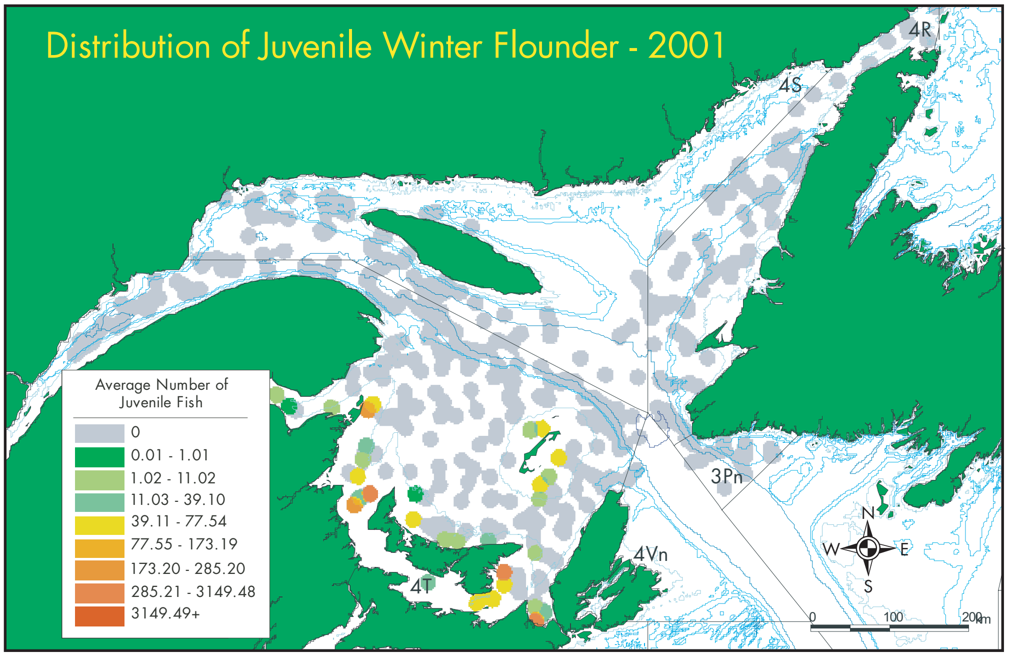


Figure 11 h.
Distribution of Juvenile Winter Flounder 2002

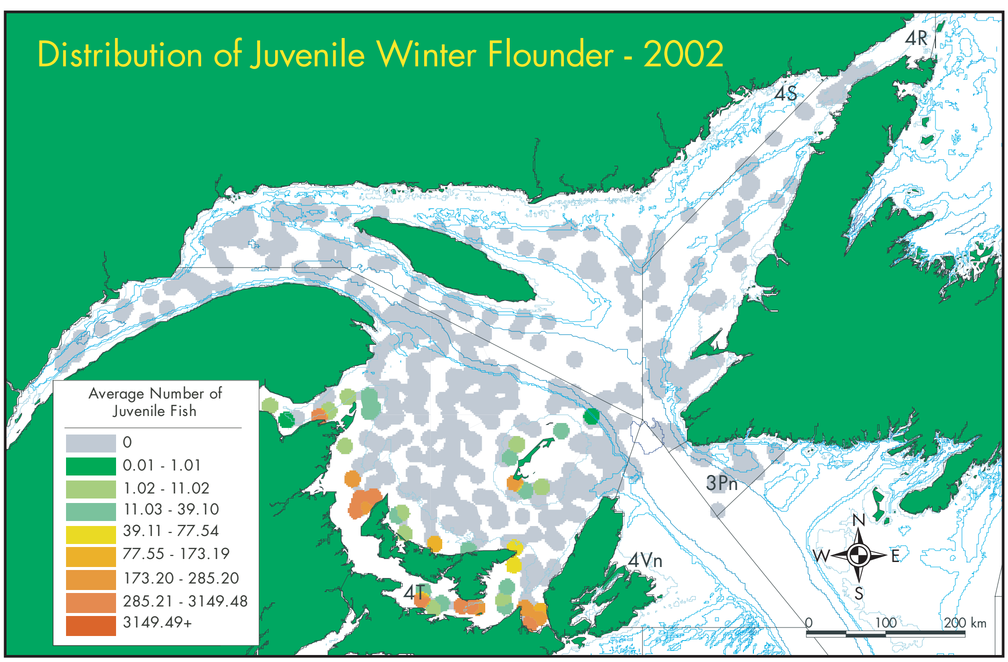
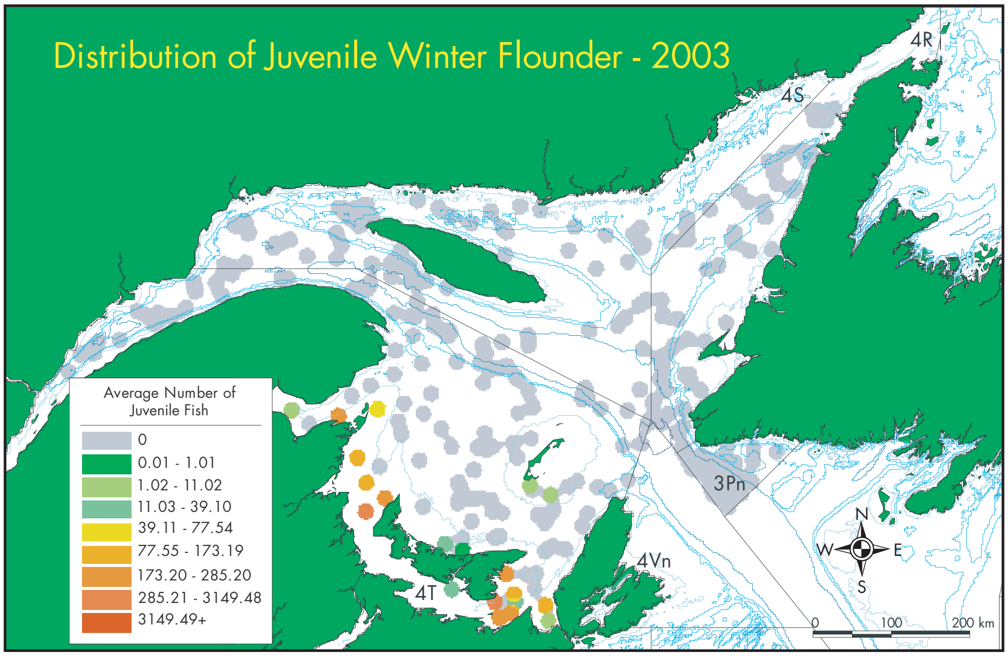


Figure 11 i.
Distribution of Juvenile Winter Flounder 2003



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Distribution of Juvenile Winter Flounder 2004

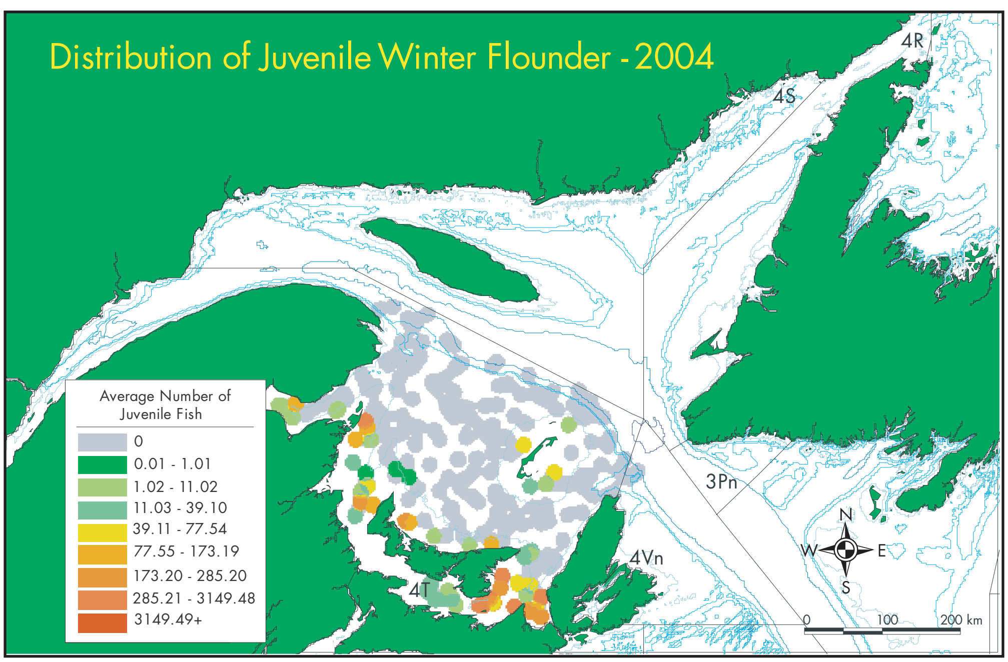


Figure 11 k.
Distribution of Juvenile Winter Flounder 2005

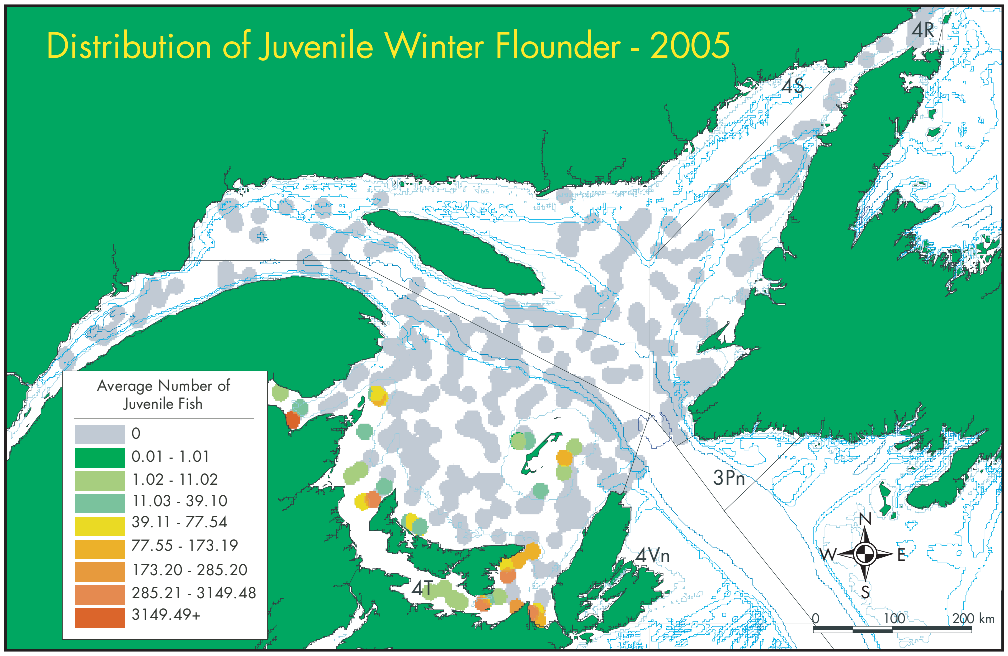


Figure 12 a.
Distribution of Juvenile Witch Flounder 1995

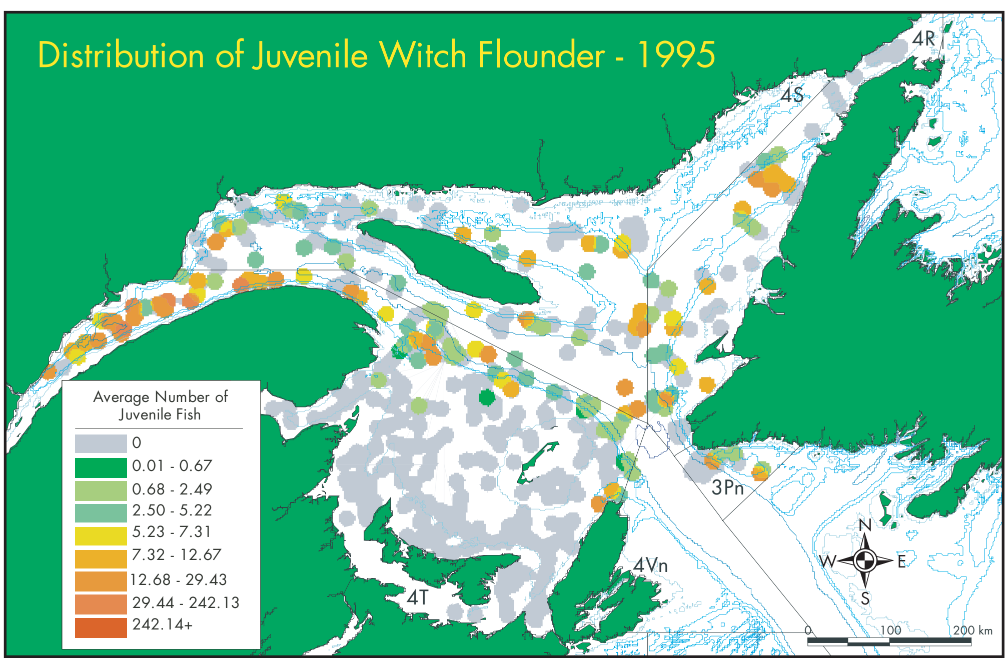


Figure 12 b.
Distribution of Juvenile Witch Flounder 1996

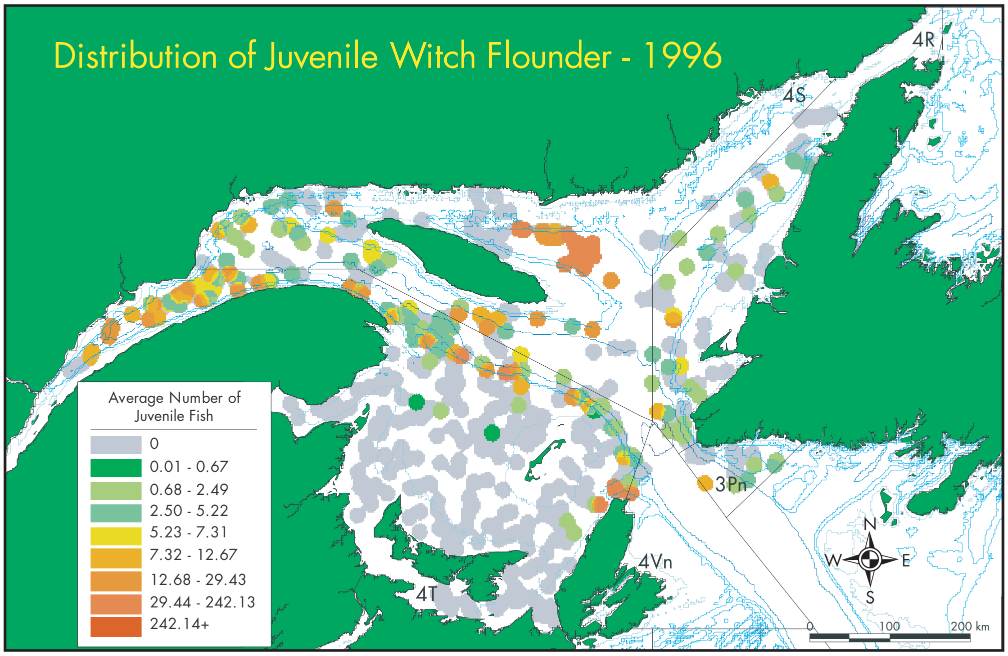


Figure 12 c.
Distribution of Juvenile Witch Flounder 1997

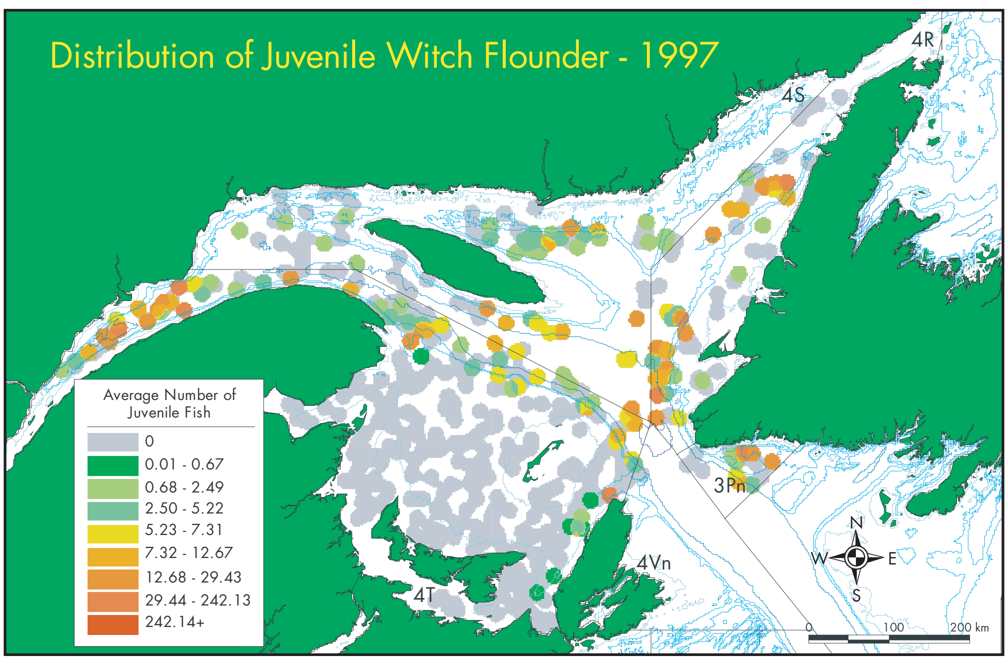


Figure 12 d.
Distribution of Juvenile Witch Flounder 1998

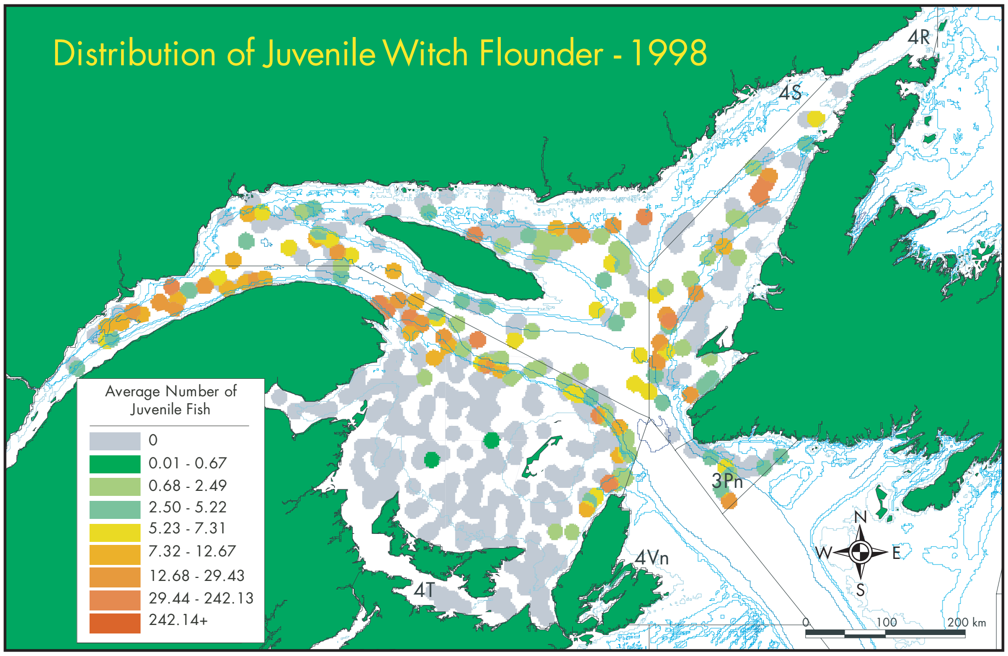


Figure 12 e.
Distribution of Juvenile Witch Flounder 1999

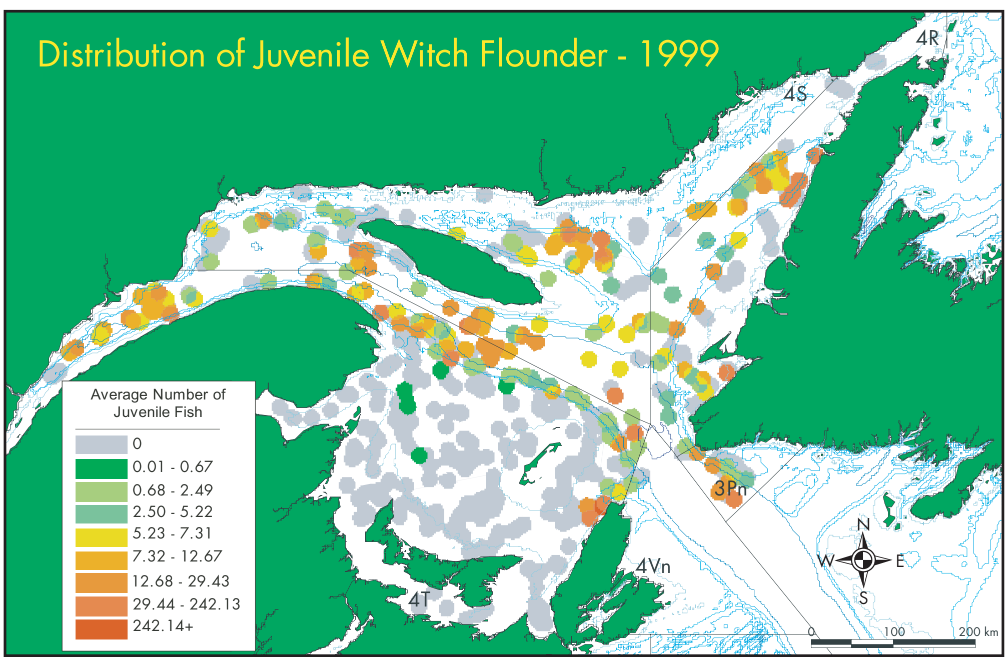


Figure 12 f.
Distribution of Juvenile Witch Flounder 2000

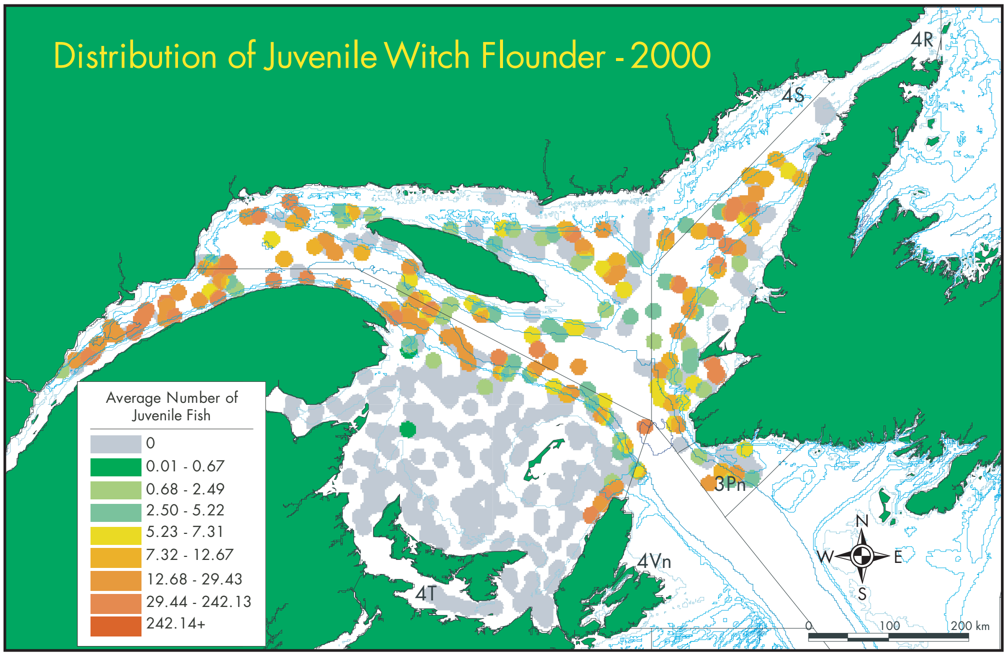


Figure 12 g.
Distribution of Juvenile Witch Flounder 2001

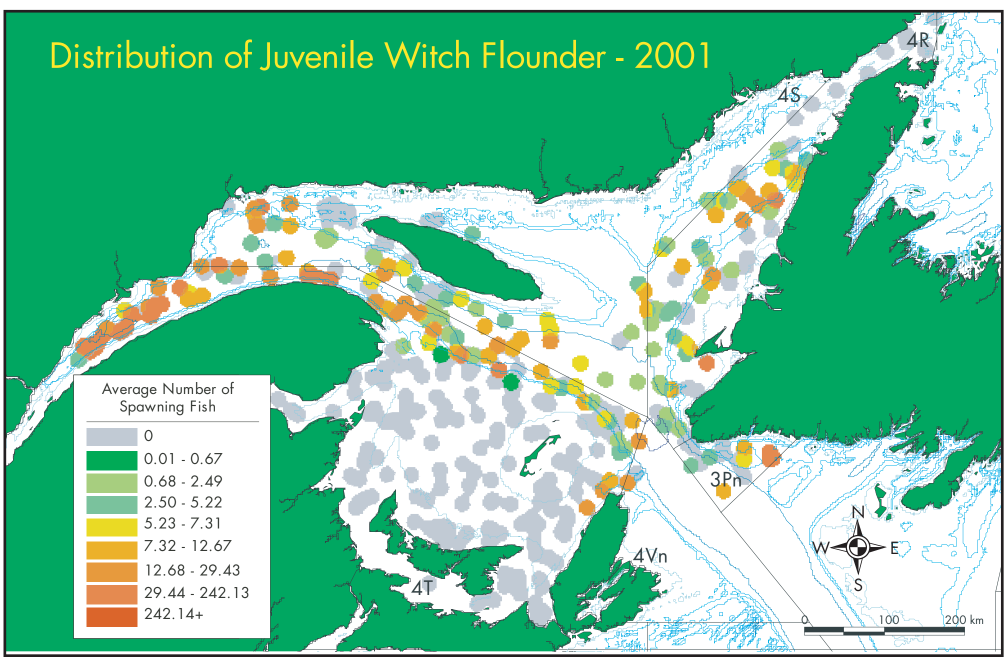


Figure 12 h.
Distribution of Juvenile Witch Flounder 2002

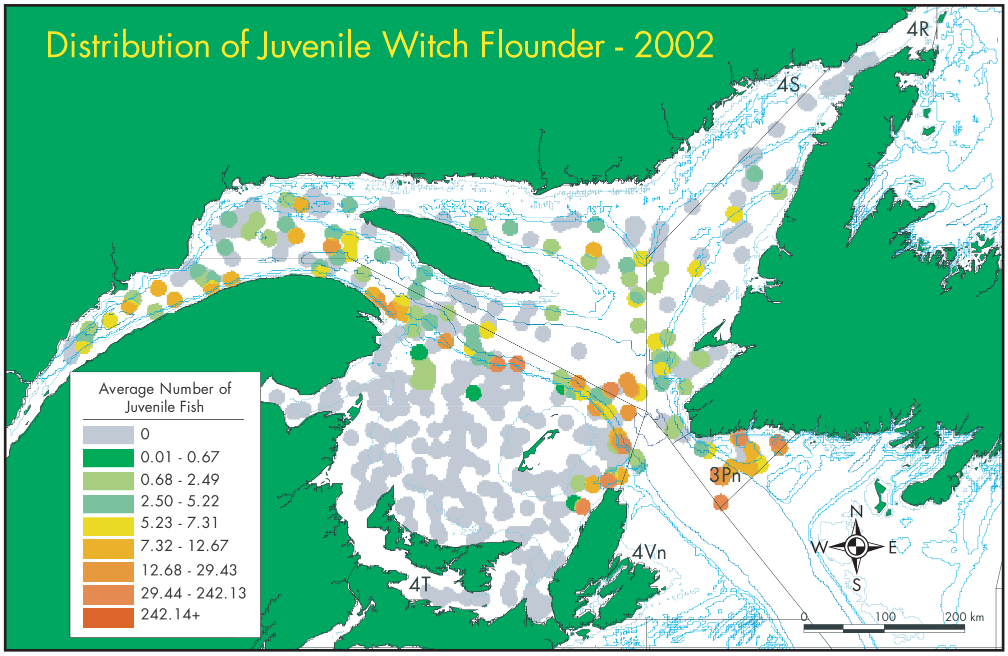


Figure 12 i.
Distribution of Juvenile Witch Flounder 2003

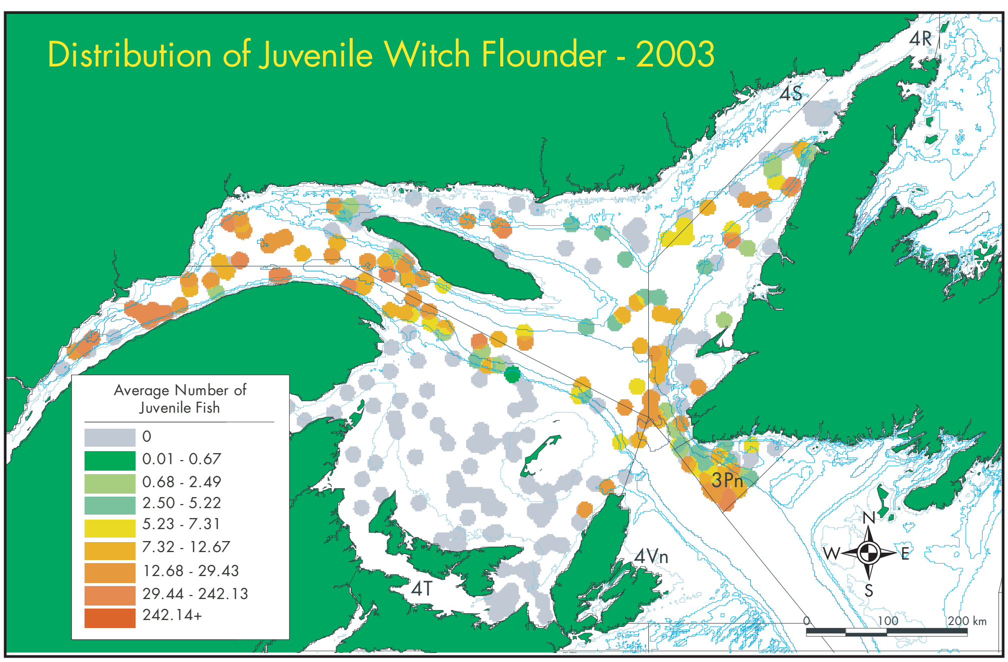


Figure 12 j.
Distribution of Juvenile Witch Flounder 2004

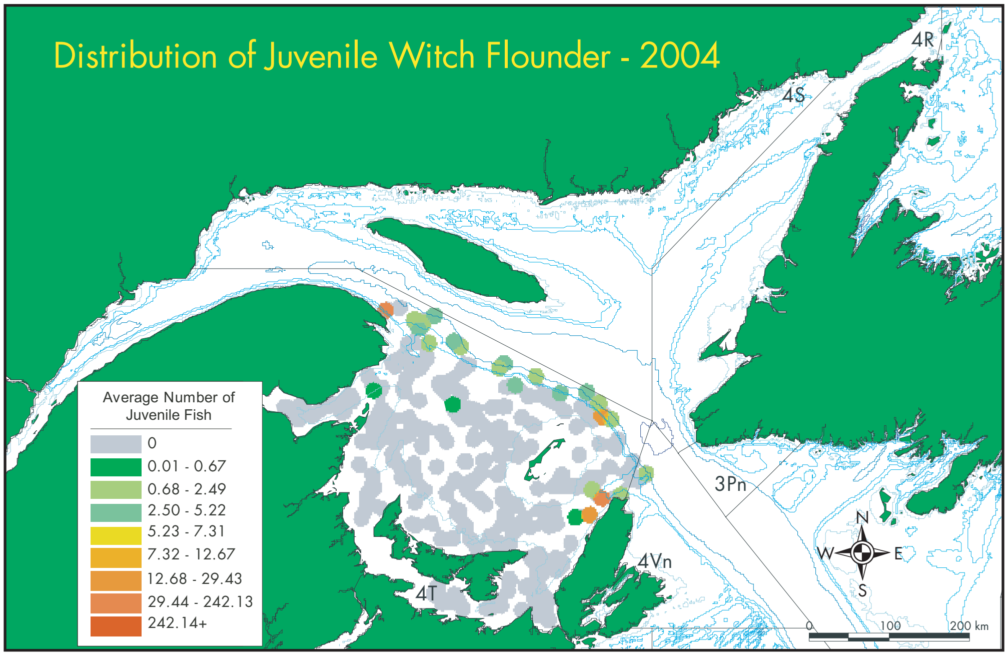


Figure 12 k.
Distribution of Juvenile Witch Flounder 2005

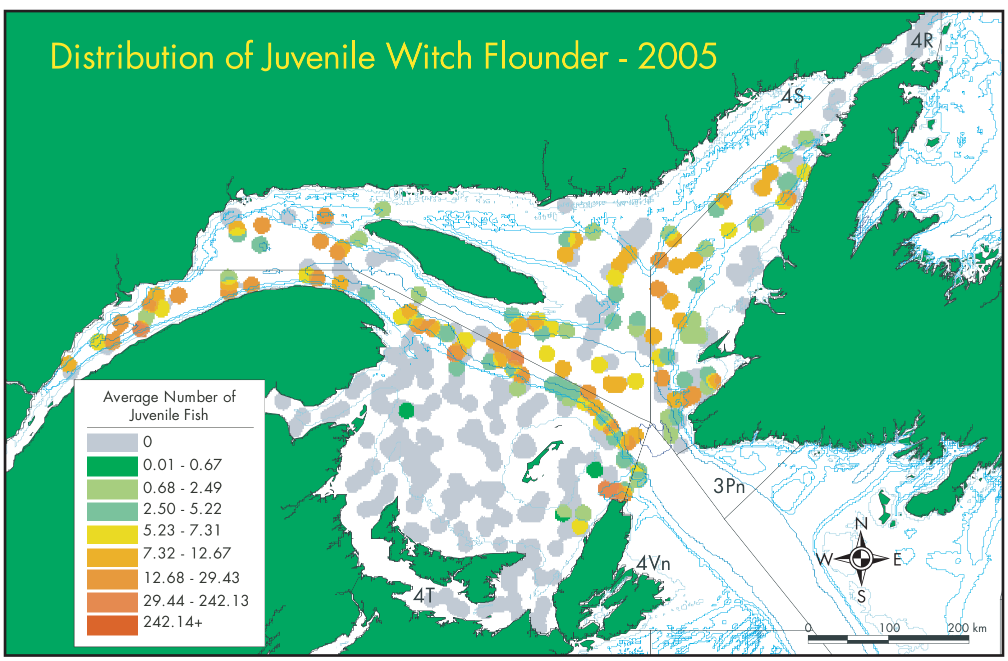


Figure 13 a.
Distribution of Juvenile Yellowtail Flounder 1995

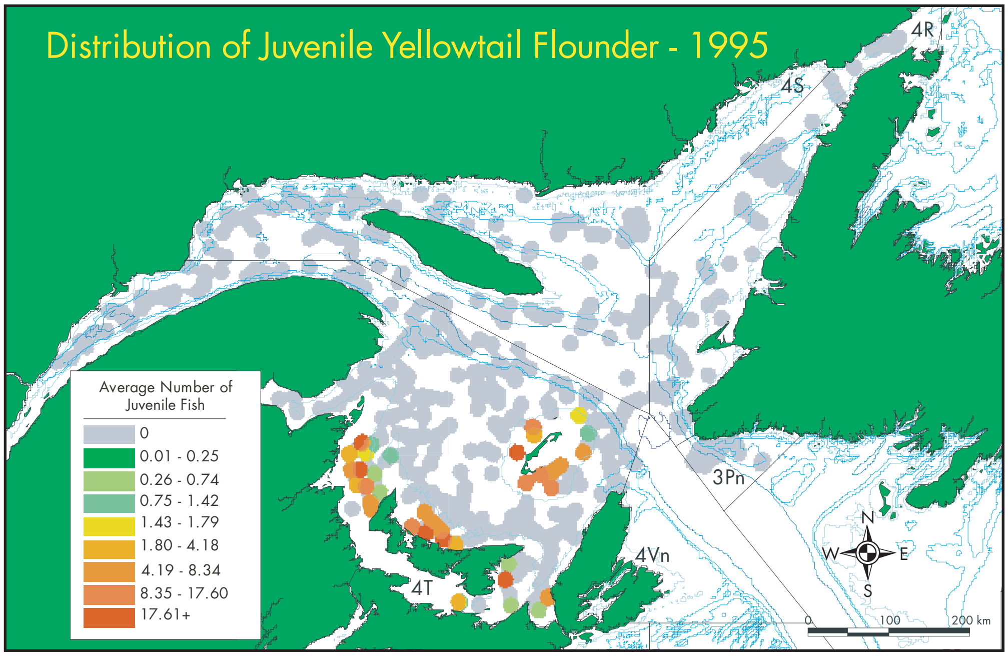


Figure 13 b.
Distribution of Juvenile Yellowtail Flounder 1996

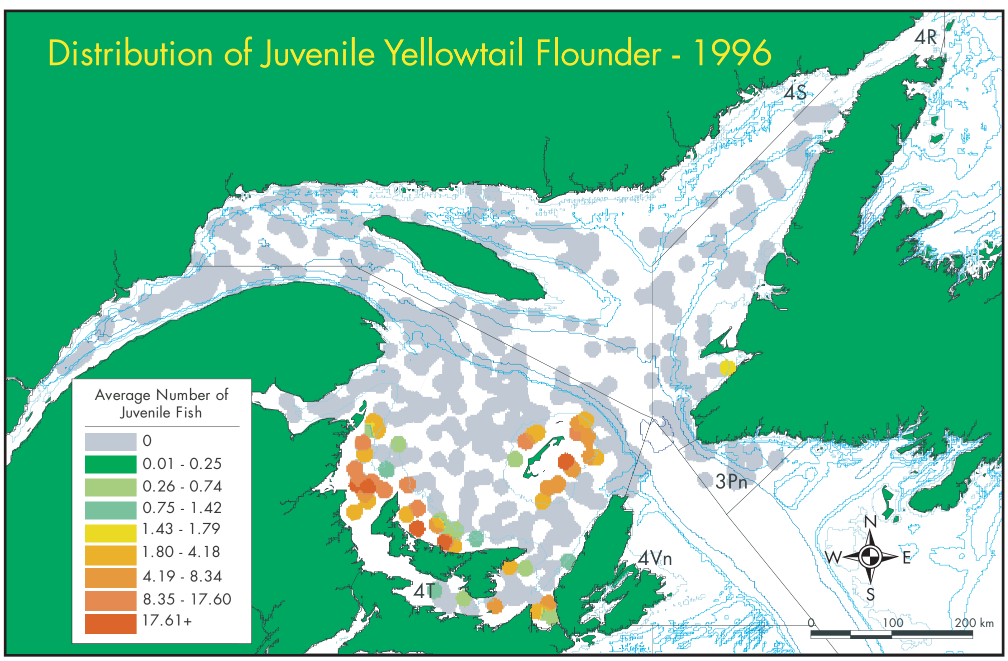


Figure 13 c.
Distribution of Juvenile Yellowtail Flounder 1997

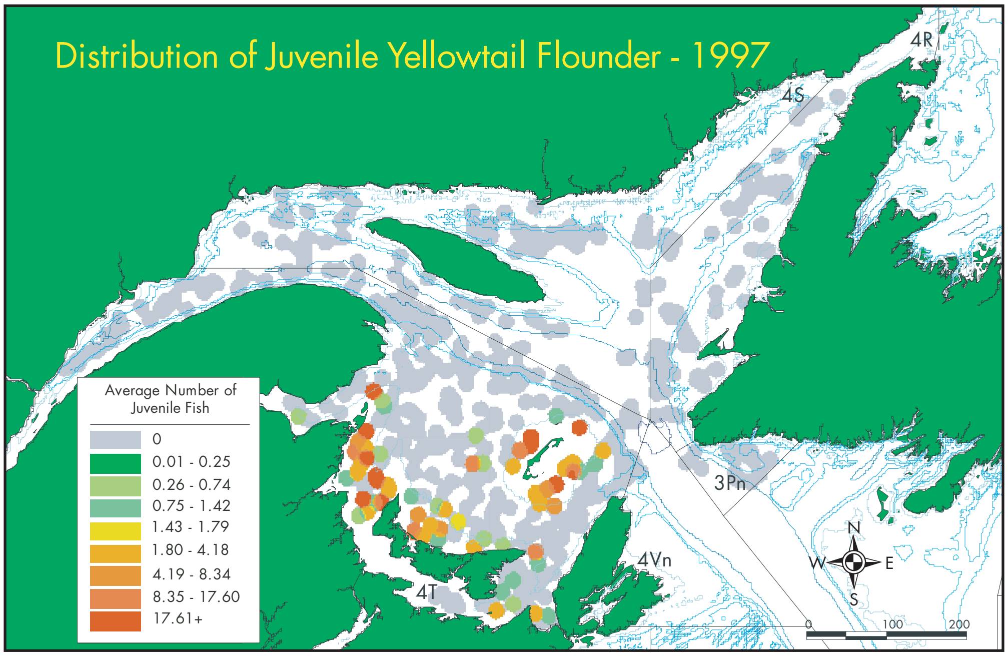


Figure 13 d.
Distribution of Juvenile Yellowtail Flounder 1998

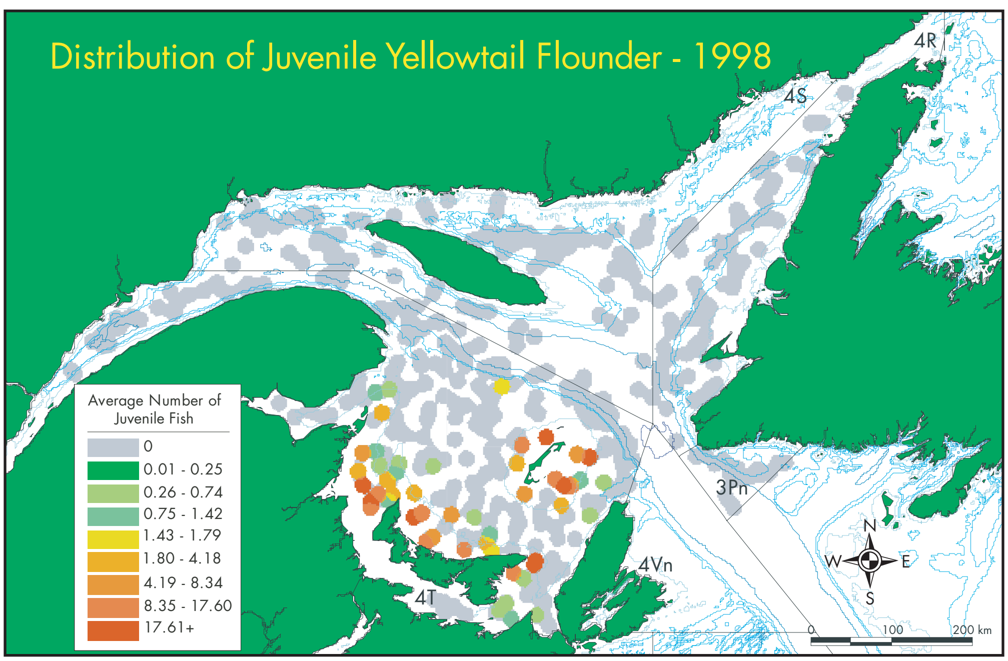


Figure 13 e.
Distribution of Juvenile Yellowtail Flounder 1999

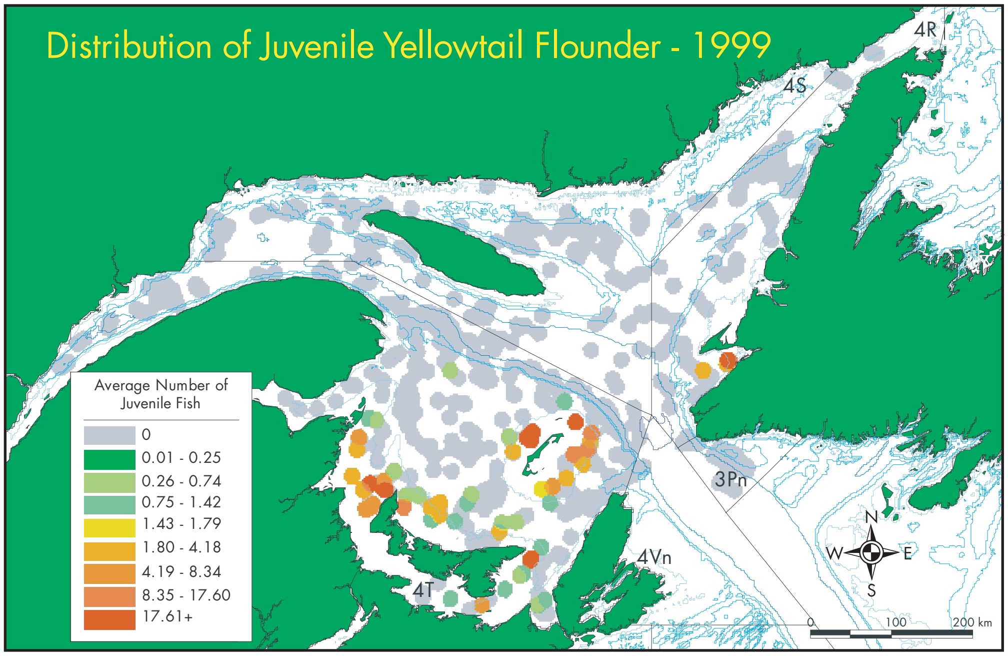


Figure 13 f.
Distribution of Juvenile Yellowtail Flounder 2000

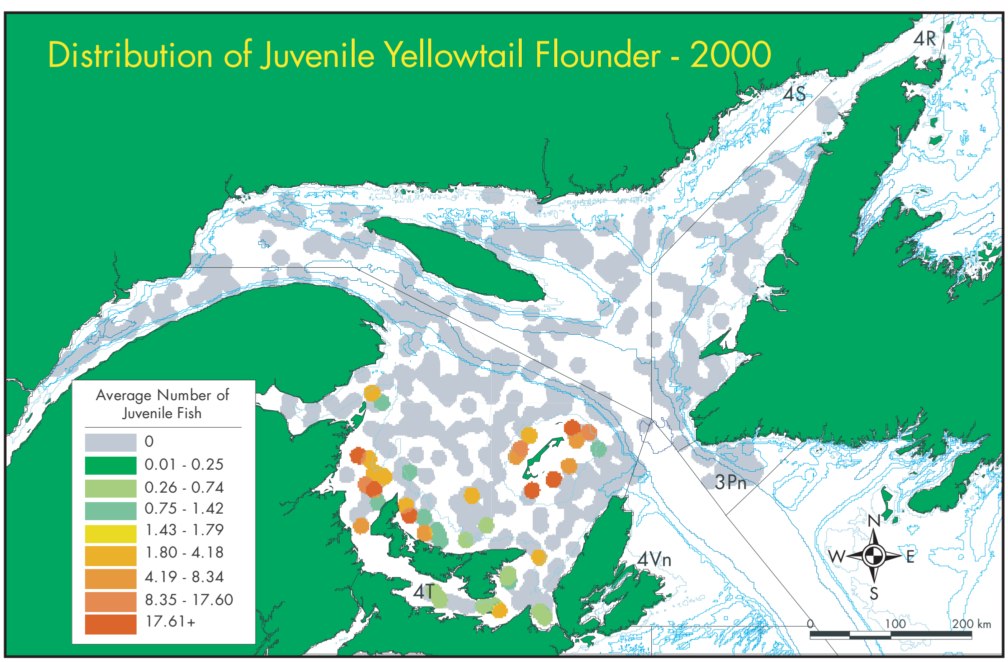


Figure 13 g.
Distribution of Juvenile Yellowtail Flounder 2001

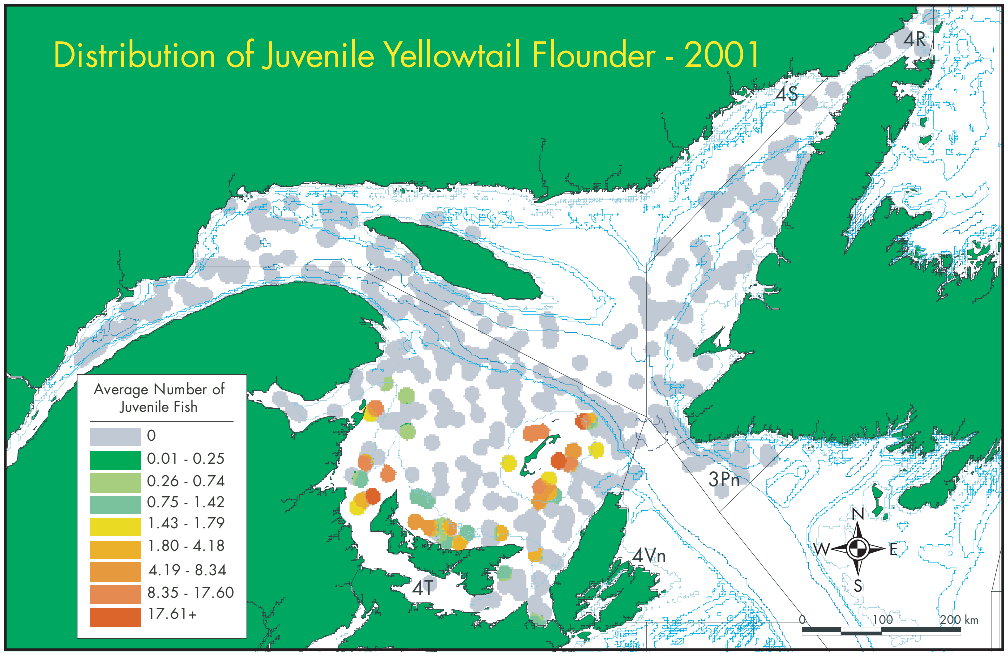


Figure 13 h.
Distribution of Juvenile Yellowtail Flounder 2002

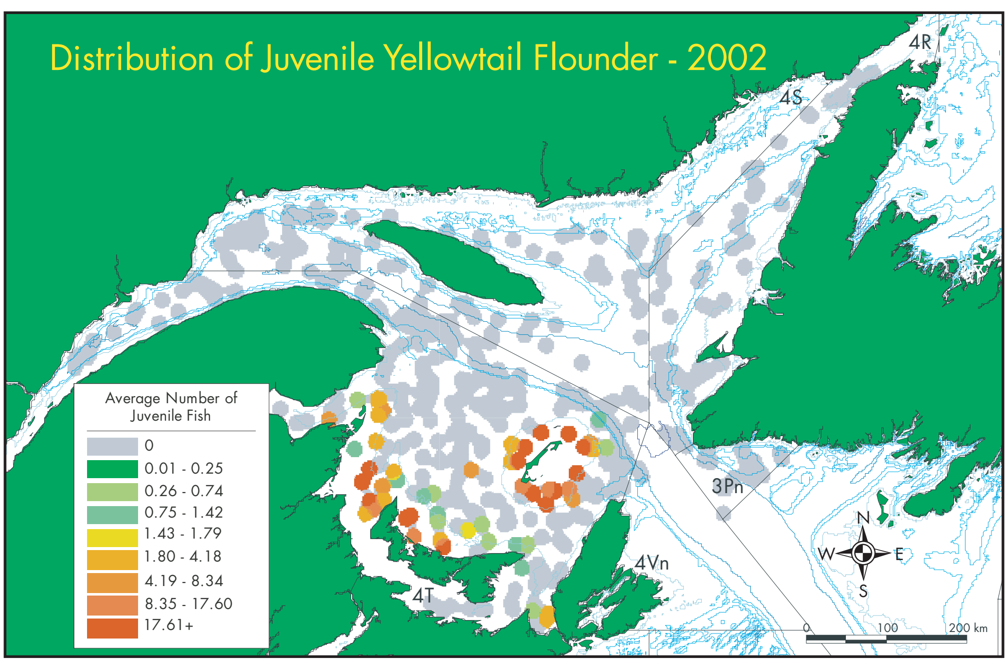


Figure 13 i.
Distribution of Juvenile Yellowtail Flounder 2003

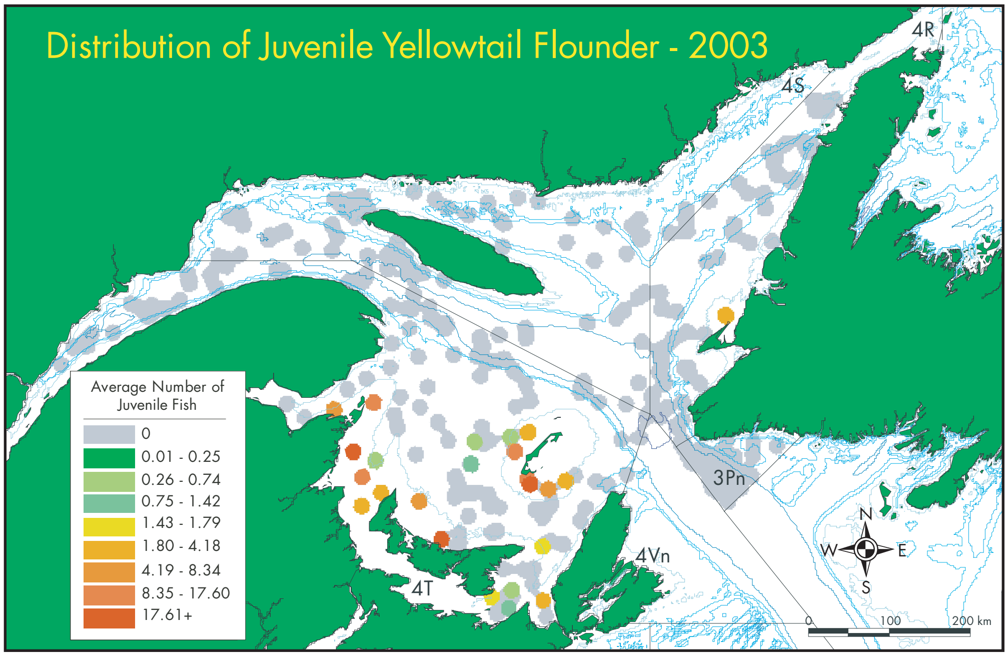


Figure 13 j.
Distribution of Juvenile Yellowtail Flounder 2004

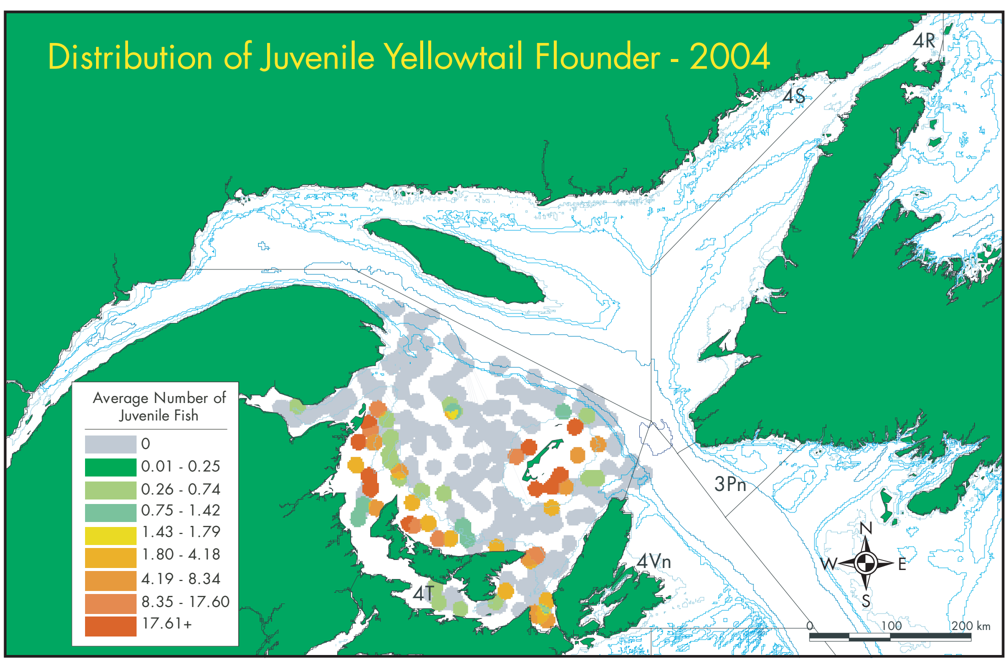
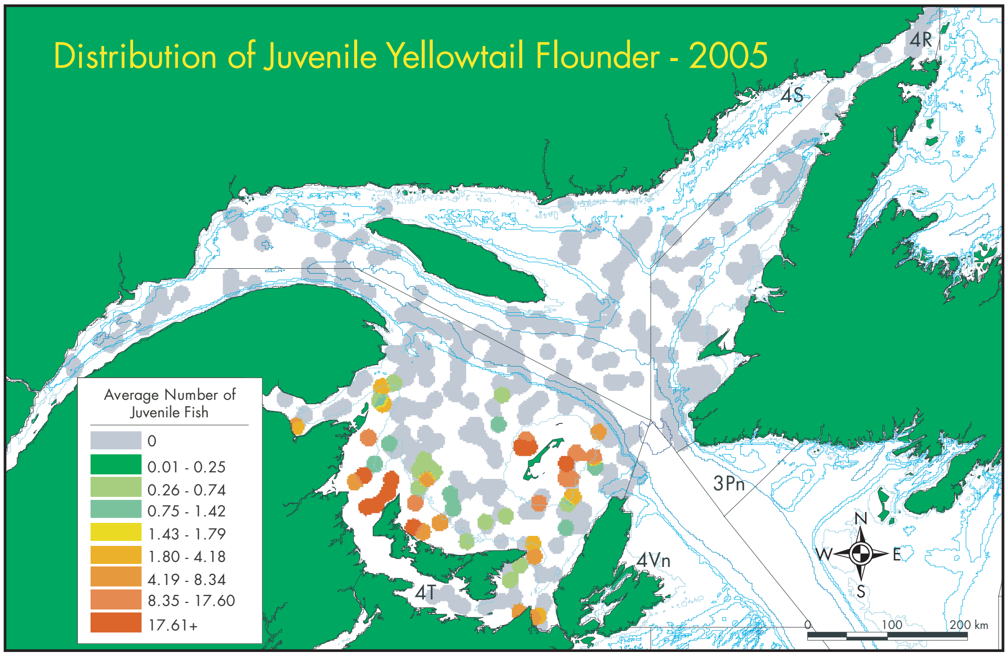


Figure 13 k.
Distribution of Juvenile Yellowtail Flounder 2005



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