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Identification and Characterization of Important Areas based on Fish and Invertebrate Species in the Coastal Waters of the Southern Gulf of St. Lawrence

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Foreword

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

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

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ABSTRACT

Identification and designation of Ecologically and Biologically Significant Areas (EBSA) is recognized both nationally and internationally as a useful tool for aquatic resource conservation, management, and planning. In eastern Canada, previous work focused on offshore waters with the highly productive coastal areas intentionally excluded. The aim of this study was to apply the EBSA criteria of uniqueness, aggregation, and fitness consequences to the coastal area of the southern Gulf of St. Lawrence. The criteria were applied to 32 fish and 23 benthic invertebrate taxa to identify important areas (IA). Based on data from multi-species surveys and literature reviews, three IA were identified in order of precedence: Northumberland Strait, St. George's Bay, and water at the eastern end of Prince Edward Island. These IA stood out primarily due to the presence of likely-endemic species (i.e. lady crab and winter skate), and all three IA had previously been identified as EBSA. Although not identified as IA, special consideration could be assigned to Chaleur Bay and the Shediac Valley for their importance in the migration of several anadromous species.

Identification et caractérisation de zones d’intérêt basées sur les espèces de poissons et d’invertébrés dans les eaux côtières du sud du golfe du Saint-Laurent

RÉSUMÉ

L’identification et la désignation des zones d’importance écologiques et biologiques (ZIEB) est reconnu nationalement et internationalement comme étant un outil efficace pour la conservation des ressources aquatiques de même que pour la gestion et la planification. Dans l’est du Canada, les travaux antérieurs portaient principalement sur le milieu hauturier alors que le milieu côtier hautement productif avait été intentionnellement mis de côté. L’objectif de cette étude visait à appliquer les critères d’unicité, d’agrégation et de conséquences sur la valeur adaptative des ZIEB dans la zone côtière du sud du golfe du Saint-Laurent. Ces critères ont été considérés en lien avec 32 espèces de poissons et 23 espèces d’invertébrés benthiques afin d’identifier les aires d’importance (AI). Selon les données des relevés de recherche plurispécifique et d’une revue de la littérature, trois AI ont été identifiées en ordre de précédence : le détroit de Northumberland, la baie St. George et les eaux de l’extrémité est de l’Île-du-Prince-Édouard. Ces trois AI se démarquent principalement par la présence d’espèces présumées endémiques (c.-à.-d. le crabe calicot et la raie tachetée) et toutes les trois ont précédemment été identifiées à titre de ZIEB. Bien qu’elles ne sont pas identifiées comme AI, la baie des Chaleurs de même que la vallée de Shédiac pourraient bénéficier d’une considération particulière pour leur importance lors de la migration de plusieurs espèces anadromes.

INTRODUCTION

Canada's Oceans Act (1997) authorizes the Department of Fisheries and Oceans (DFO) to provide enhanced protection to areas of the oceans and coasts that are ecologically or biologically significant through mechanisms such as Marine Protected Areas. Ocean areas can be ecologically or biologically "significant" because of the functions that they serve in the ecosystem and/or because of structural properties (DFO 2004). Identifying Ecologically and Biologically Significant Areas (EBSA) is not a general strategy for protecting all habitats and marine communities that have some ecological significance. Rather, it is a tool for calling attention to an area that has particularly high ecological or biological significance, to facilitate provision of a greater-than-usual degree of risk aversion in management of activities in these areas (DFO 2004).

DFO established criteria to identify EBSA (DFO 2004) and applied these to features in the Gulf of St. Lawrence (DFO 2006). Ten EBSA were identified, all offshore (DFO 2007, Savenkoff et al. 2007). There were many discussions during the 2006 meeting regarding the inclusion of coastal areas in the EBSA evaluation for the Gulf but no consensus was reached on how to consider the ecological and biological significance of coastal and estuarine areas within a classification system that is based primarily upon the relationship with large scale oceanographic features or processes (DFO 2006). The review at that time excluded coastal features such as barachois, salt marshes, and eel grass beds on the premise that they may have a high local significance but they likely do not have a substantive effect on the functioning of the much larger oceanic ecosystem (DFO 2006).

Following several EBSA exercises within Canadian waters, a reflection was made on the overall efficiency of the EBSA process and to provide guidance in future application its criteria (DFO 2011). It was recognized that the three primary criteria (aggregation, uniqueness, and fitness consequences) were applicable to coastal habitat with the acknowledgment that some ecological functions and processes in these systems differ from comparable ones in marine systems (DFO 2011). It was also proposed to use heat maps to illustrate the different criteria when possible.

The identification of EBSAs in the coastal zone is necessary to complete the ecological profile of the estuary and the Gulf of St. Lawrence and for the planning of the network of marine protected areas. In order to determine if the coastal zone meets the EBSA criteria, a zonal peer review meeting was held in Mont-Joli, Quebec in December 2014 (DFO 2015). A two-step approach was considered during the meeting. The first step was to agree on a definition of the coastal zone and to identify and describe the data sets that could be used to apply the EBSA criteria to the coastal zone. The second step was a formal review process of the data and information applied to the EBSA criteria to yield a number of important areas (IA). This study presents the information, data, and analyses considered for the identification of IA in the southern Gulf of St. Lawrence (sGSL) based upon invertebrates and fishes.

MATERIALS AND METHODS

STUDY AREA

Standardized data from three surveys were used for modeling to predict the probability of detecting the presence of a taxon in a standardized tow. Survey data and environmental variables were defined for the same 2.5 x 2.5 km (6.25 km2) grid derived by Dutil et al. (2012) for the entire sGSL. The study area was defined as waters between 0 and 40 m deep (mean value of the cell) within the sGSL but excluded estuaries and semi-enclosed embayments. The estuary/coastal area boundaries were determined by the presence of barrier islands or peninsulas, and cells with centroids inside of those features were removed. Also, cells east of New Carlisle along the Gaspé Peninsula and east of Cape North in Cape Breton (i.e., outside the sGSL) were removed. The final grid for the sGSL coastal study area was comprised of 4,486 cells (Fig. 1).

DATA SOURCES

Quantitative data were retrieved from three surveys:

- the annual September bottom trawl survey in the sGSL (RV survey);
- the annual Northumberland Strait bottom trawl survey (NS survey); and
- two recent scallop-dredge surveys.

These surveys record data on most of the animal species captured and have substantial sampling effort within the coastal waters of the sGSL. The shallow-water depth threshold (roughly 4 m chart datum) for the small-boat surveys (NS, scallop-dredge) was determined by the draft of the survey ships. The RV survey was designed to survey waters deeper than ~20 m. The survey catch data were transformed to presence-absence for modeling purposes. The annual snow crab survey was not considered for this study because nearly all stations are in water >40 m deep.

Annual September bottom trawl survey in the sGSL (RV survey)

A bottom-trawl survey of the sGSL has been conducted in September since 1971 and provides the longest time-series of distributions and relative abundances for fishes and invertebrates in the sGSL. The RV survey follows a stratified random design, with stratification based on depth and geographic area. Twenty-four strata have been fished since 1971 and three inshore strata were added in 1984.

The RV survey uses the same standardized fishing procedures each year: a 30-minute tow at a speed of 6.5 km/h. Five ships using two types of trawls (“Yankee-36” and “Western IIA”) have been used during the time series. Corrections and adjustments for net efficiency, net swept area, and vessel effects are described by Hurlbut and Clay (1990), Benoît and Swain (2003a), and Benoît (2006). The difference in catchability of certain species based on the time of day was assessed by Benoît and Swain (2003b).

Between 100 and 200 tows were attempted during the RV survey each year (Fig. 2). Because of issues with data quality and accuracy in the identification of some species, only data collected between 1976 and 2013 were used in this study.

Northumberland Strait bottom trawl survey (NS survey)

Between July and August, the demersal community of the Northumberland Strait was sampled annually since 2000. Two bottom trawls were used, depending upon the survey’s goals. For all years except 2010 and 2011, when a Nephrops trawl was used, the survey gear was a number 286 bottom trawl equipped with rockhopper footgear (rockhopper trawl). The NS survey area (Fig. 3) was overlain with a 3.7 x 3.7 km grid (starting point 46°30’ N; 64°00’ W), establishing over 1,100 possible sampling stations (Voutier and Hanson 2008; Bosman et al. 2011; Kelly and Hanson 2013a, b). The study area was originally divided into nine strata, based on bottom composition and water mass characteristics, and surveys followed a random block sampling design. Starting in 2010, some strata were dropped and stations were randomly selected (at a reduced sampling intensity) from within the original grid (see Rondeau et al. 2014 for details).

During the NS survey, the rockhopper trawl was towed for 15 minutes at a speed of 4.6 km/h. However, because of the gap under the rollers, the net was inefficient at catching Atlantic rock crab (*Cancer irroratus*), a species that plays an important role in the coastal ecosystem in terms of energy cycling (Hanson et al. 2014; Rondeau et al. 2014). To address this shortcoming, a Nephrops trawl that digs into the bottom (Conan et al. 1994), and is more efficient at capturing crabs, lobster, and many other benthic organisms, was used in 2010 and 2011 (Hanson *et al.* 2014; Hanson and Wilson 2014). The Nephrops trawl was towed at a speed of 3.7 km/h for only 5 minutes because large amounts of sediment and debris were retained. Between 101 and 255 valid tows were done per survey from 2000 to 2013 (Fig. 3).

Scallop-dredge survey

A scallop-dredge survey was conducted in 2012 and 2013 to gather information on the distribution and abundance of adult and juvenile sea scallop (*Placopecten magellanicus*) within the sGSL. The survey gear was an 8 bucket Digby-type dredge (total length of 3.3 m) fitted with a Vexar® mesh liner (mesh size of 12-14 mm) to retain scallop recruits and small benthic species. The dredge was towed for 2 minutes at a speed of 3.7 to 4.6 km/h at 67 randomly selected stations in Northumberland Strait (2012) and at 87 stations in Chaleur Bay (2013) (Fig. 4).

SPECIES SELECTION

Sampling protocols for multi-species surveys specified that all organisms encountered be identified to the lowest practical taxon (typically species). Unfortunately, identification effort and taxonomic expertise has not been constant throughout the RV survey time series. Nevertheless, with a few exceptions, most fish species encountered are thought to have been accurately identified to species level over the years and as such were considered as the primary source of information. One exception is the combination of blueback herring and alewife to match commercial catch recordings (where they are called “gaspereau”). Some deep-water species were eliminated from the analysis even if they were caught at the margin of the study area to minimize their influence on the modelling predictions. Hereafter, fish and invertebrate species or taxa were identified by their common names. Based on the three benthic surveys, there were usable data for 32 fish taxa (Table 1). The final species selection was done after consultation with peers following a CSAS meeting on the application of EBSA criteria to the coastal area (DFO 2015).

The list of invertebrates was more difficult to establish. For the RV survey, a consistent effort to identify and record catch information on invertebrate taxa only started in 1989. Hence, invertebrate data prior to 1989 were not considered. In the NS survey, most of the sampling in the early years was focusing at large decapod crustaceans and fishes. Data from American lobster, Atlantic rock crab, snow crab, lady crab, and toad crab sampled in 2003, and between 2005 and 2013, were used. For small-bodied taxa, only data starting in 2010 were considered reliable. Invertebrate data from both years of the scallop-dredge survey were retained. Furthermore, some species or taxa still needed to be removed from the potential data set because of uncertainties in their identification. In some instances, species were only identified to a higher taxonomic level (e.g., sponges, sea anemones) which most likely includes both coastal and deep water taxa. Since the latter was not considered in our analysis, species identified at high taxonomic levels (i.e., above genus level, excepting mussels) were not selected. As for fish species, recognized deep water invertebrate species were excluded from the analysis (e.g., sea potato *Boltenia ovifera*, Iceland scallop *Chlamys islandica*) and the final list of species retained was vetted by peers. For this study, 23 invertebrate species and/or taxa (Table 2) were included. Over 18 shrimp species can be found in the sGSL, and some (especially *Crangon* *septemspinosa*) are known to play an important role in the coastal-ecosystem food web (Hanson 2011; Kelly and Hanson 2013a; Hanson and Wilson 2014; Hanson et al. 2014;). Unfortunately, because of data availability issues, it was not possible to incorporate the information on shrimp in the analysis.

Information on the selected species of fish and invertebrate from the three surveys was transformed into presence-absence data and a minimum of ten occurrences was arbitrarily selected as the threshold for a taxon to be retained for modeling.

DATA PROCESSING AND MODELING

The presence-absence data were modeled to predict the probability (0 to 1) of detecting a taxon in a standardized tow within a grid location. In addition to environmental variables, spatial and gear effects were included as predictors. Five environmental variables from Dutil et al. (2012) known to or are presumed to affect species distributions were included in the model testing:

- mean water depth in the grid cell,
- mean bottom temperature at the mean water depth within the grid cell,
- mean bottom salinity at the mean water depth within the grid cell,
- mean tidal current (cm/sec) associated with the "principal lunar semi-diurnal" component of the tide (M2), and
- mean annual wind speed (m/sec).

Generalized Additive Models (GAM) were used to model binary presence-absence data. Using a forward stepwise approach, the model having the lowest total Akaike information criterion (AIC, Burnham and Anderson 2002) value over the 14 selected taxa (Table 3) was selected and used for spatial predictions.

Smoothing terms over space (i.e. latitude and longitude coordinates converted into UTM), water depth, bottom temperature, bottom salinity, tidal current and annual wind speed were included were added one by one, choosing the smoothing term which contributed to the largest decrease in AIC value at each step or until the total AIC increased. The selected model was:

Presence ~ s(T_BOT_MEAN) + s(DEPTHMEAN) + s(x, y) + gear

where s(T_BOT_MEAN) is an additive smoothing term for mean bottom water temperature, s(DEPTHMEAN) is a smoothing term over water depth, s(x,y) is a spatial smoothing term and gear is an additive term denoting the type of gear used. The data from each survey is not on the same scale, the gear effects correct for (logit) linear differences in scale, such that any linear transform of data observations applied to surveys other than the reference survey leave the end result unaffected, as the gear effect parameters will scale accordingly in the estimation.

The selected model was applied to all data available from the coastline up to the 60 m isobaths, the data between 40 m and 60 m were included so as to obtain a better adjustment at the margins of the study area (i.e. near 40 m). Contour maps of the restricted study area (0-40 m) were then produced using the predicted probability of capturing a given taxon for a standard tow of 1.75 nautical miles (nm) with a Western IIA trawl (as used in the RV survey) for each grid cell. Since lady crab and mud crab were not caught in the RV survey, their predictions were based on Nephrops trawl of standard tow length 0.125 nm from the NS survey rather than the Western IIA trawl.

The predicted species distribution from the model depended on the spatial and temporal occurrence of the survey sampling stations; therefore, the predicted species distribution could be misleading if sampling was limited or absent (i.e., upper Chaleur Bay, western Cape Breton and a caution for the northern part of Magdalen Islands). Sampling gear can also affect the catchability, therefore, the observed species occurrences can be affected by the spatial distributions of the gear used. Contour maps for all species and taxa were either presented in the analysis section of this document or in Appendix 1.

Biodiversity contour maps were produced separately for fish and invertebrate taxa by summing single-taxon predictions by grid cell, which yielded the number of taxa expected to be captured in a grid cell. For invertebrates, since many different species were encompassed within a single taxon (e.g., toad crab includes *Hyas araneus* and *H. coarctatus*; Table 2), and many groups were not included (e.g., shrimps, polychaetes), the biodiversity indicator displayed on the map is severely underestimated and should be interpreted as a “pseudo-diversity” map. This is also true to a lesser extent for the fish “pseudo-diversity” map because only a few fish taxa were comprised of more than one species (Table 1).

When considering 55 species or taxa for the identification and characterization of potential IA in the coastal zone of the sGSL, special considerations must be made for the species-at-risk. However, the EBSA process is separated from the one dealing with critical habitat designation under the Species at Risk Act (SARA). The Committee on the Status of Endangered Wildlife in Canada (COSEWIC) has already evaluated twelve fish species identified in this IA process and are suspected of being at risk of extinction or extirpation (Table 4). However, at the moment only three species are assigned a status under SARA, one has been rejected (winter skate; Canada Gazette 2010), and the others are still under consideration. Data on five of the twelve species evaluated by COSEWIC were available from our trawl surveys; for the remaining seven, capturability was very low or nil (e.g., bluefin tuna *Thunnus thynnus* and white shark *Carcharodon carcharias* are fast-swimming pelagic species that have never been captured in our survey trawls).

EVALUATION CRITERIA

To identify important areas (IA), the evaluation of the coastal waters in the sGSL was based on the same three criteria or dimensions proposed for EBSA (DFO, 2004): uniqueness, aggregation, and fitness consequences. These criteria have already been used for the identification of mid-shore and offshore EBSAs, and they could be equally applied to coastal waters (DFO, 2011). It must be recognized that to identify IA, the ecological consequences of a severe perturbation in that area would be greater than an equal perturbation of most other areas in the region. An IA should be different from unexceptional areas; in the latter case, this does not make the area an unimportant area.

Based on the uniqueness criterion, an area would be deemed important if it contains unique, rare, or distinct characteristics when compared to other areas in the region. Either the biological processes that are taking place in such an area, or the species that are present, should reveal some uniqueness. Special considerations at the species level were given to rare and/or potential endemic species as well as species evaluated under COSEWIC or SARA.

For the aggregation criterion, the species as well as the pseudo-diversity contour maps were used to identify areas of high abundance (concentrations), and where the greatest number of species occurred. These observations, however, only reflect the period when the data were collected, i.e., during the summer months. Additional information from the literature (Appendix 2), commercial landings, traditional ecological knowledge and expert opinion were considered to fill the gaps and increase the reliability of the overall evaluation.

The fitness consequences criterion was used to identify key or important areas where crucial life history activities are undertaken. The criterion was divided into five ecological functions:

- feeding,
- reproduction,
- nursery area,
- migration, and
- seasonal refugia.

Based on the available literature, the connectivity among the areas where these ecological functions were observed was also discussed. Fishes are mobile and several areas can serve as locations for different ecological functions. In contrast, the majority of the invertebrate species are either sessile or are benthic with minimal seasonal movements (i.e., can be considered sedentary), and a single site serves for most fitness functions. Information on invertebrates was mainly considered for the aggregation criterion (the pseudo-diversity contour maps); however, uniqueness was applicable for the lady crab, a likely undescribed endemic whose entire distribution is within Northumberland Strait (Voutier and Hanson 2008).

ANALYSIS

GENERAL CHARACTERISTICS OF THE STUDY AREA

The coastal zone was defined as the area with waters ≤40 m deep (DFO 2015). Consequently, this coastal zone actually comprises areas where the warm surface waters contact the bottom (typically ≤30 m) and includes much of the transition zone between the surface layer and the cold intermediate layer (CIL; Gilbert and Pettigrew 1997). Hence, fish species that prefer cold and tolerate low temperatures occur at the shallow edge of their distributions in the coastal zone but most of the population is located in or below the CIL. In contrast, the species that prefer warm waters have the deep-water boundary of their distribution within the transition zone. Finally, diadromous species are a major component of the warm-water fish community, and are all but absent from the cold-water community. The study area, except for the Magdalen Islands (Fig. 5), includes rivers large enough for spawning by anadromous fishes and there is relatively little difference in species diversity of anadromous species. A major exception is the Miramichi River, which is the only known spawning area for striped bass and American shad.

The shallow coastal zone is characterized by seasonal extremes in environmental conditions. During summer months, bottom-water temperatures can exceed 21°C in many areas (often >25°C in embayments and estuaries) while there is an extended period of land-fast and sea ice during winter with bottom water temperatures as low as ca. -1.7°C. The areas exposed to sea ice are subjected to moving ice and ice ridges that can cause bottom scouring down to 20 m depths (Brown et al. 2001; Forbes et al. 2004; Prisenberg et al. 2006). In addition, there is extensive down-welling of ice crystals during storms. Contact with ice or exposure to water below the freezing point of fish tissue can be fatal and consequently most fishes migrate out of the danger zone for the winter months (Clay 1991) often following well-defined migration corridors.

The sGSL is characterized by an array of different environments and habitats but some features of its coastal zone need to be emphasized. Within the study area, Northumberland Strait (Fig. 5) is the only area bounded by land on two sides and it is characterized by almost 100% warm and shallow (<30 m) habitat. There is a prominent cool-water (10-12°C during summer) upwelling area near Wood Island that corresponds to the end of a narrow channel running along the southeastern shore of Prince Edward Island (PEI). Part of that trench is deeper than 40m and has been excluded from the study area (Fig. 1). The blocking in 1954 of the Canso Strait by a causeway created a major disruption in St. George's Bay (Fig. 5) as it closed an important migration route for many long-distance migrants (e.g., the three *Alosa* species, Atlantic saury, butterfish, and perhaps bluefin tuna). The coastal area west of Cape Breton is limited to a narrow band with limited presence of shallow water (Fig. 1). One distinctive feature of the Magdalen Islands is the near-absence of freshwater input in the coastal habitat resulting in the near absence of anadromous species.

ECOLOGICAL PROPERTIES

Uniqueness

White hake (Fig. 6) and winter skate (Fig. 7), two suspected undescribed endemics, now occur at very low abundance, and there has been severe range compression to small areas where the population remnants are concentrated (COSEWIC 2005, 2013; Kelly and Hanson 2013a, 2013b). The areas occupied by those two species are therefore unique as they represent their last stronghold.

St. George's Bay and the eastern end of Northumberland Strait constitute the only remaining spawning area for white hake (Fig. 6) as well as a critical summer feeding area (COSEWIC 2013). When migrating out to the Laurentian Channel and Cabot Strait for the winter, adults go through the Northumberland Strait and then follow the west coast of Cape Breton.

While formerly widespread, winter skate is now mainly restricted to the western half of Northumberland Strait (Fig. 7) where they feed and release most of their eggs. In late autumn, they spread from the shallow waters of Northumberland Strait out into the deeper waters of the sGSL; however, some remain in waters ≤ 40 m deep.

The sGSL also shelters a lady crab that is likely an undescribed endemic species (Voutier and Hanson 2008; J.-M. Gagnon, Canadian Museum of Nature, Ottawa) (Fig. 8). Should there be a negative effect that eliminates the lady crab population in the Strait, this would represent a species extinction. The lady crab population from the Northumberland Strait has not been assessed by COSEWIC.

Aggregation

Given the endangered status of white hake population (COSEWIC 2013), concentrations of this species, especially the juveniles, in Northumberland Strait, St. George's Bay and east of PEI (Fig. 6) increase the importance of these areas. The species also formerly occupied the Shediac Valley (Fig. 5), which is no longer the case (Benoit et al. 2003; Swain et al. 2012).

Juvenile Atlantic cod occur at the shallow edge of the CIL and well into the transition zone waters (Fig. 9), and large numbers of age-0 (semi-pelagic) individuals occur in warm waters such as Northumberland Strait. Aggregations of juvenile Atlantic cod occur east of PEI but that is only one of many areas of aggregation (Hanson 1996; Benoit et al. 2003; Darbyson and Benoit 2003). In autumn, juvenile Atlantic cod follow after the adults and they appear to concentrate north of the Magdalen Islands and along the edge of the Laurentian Channel for the winter. Mixed groups of adult and juvenile Atlantic cod return to the sGSL in spring, shortly after the ice melts.

Atlantic halibut is not a coastal species per se; however, part of the population occurs closer to shore in the Gaspe and Cheticamp troughs during summer and early autumn (Benoit et al. 2003; Darbyson and Benoit 2003). Based on our data, the Atlantic halibut was mostly observed in the waters from northeastern New Brunswick (NB), on the north side of PEI, and east of the Magdalen Islands (Fig. 10).

Most individuals from the Atlantic salmon, alewife, and American eel populations that migrate into the Restigouche River, to either spawn (anadromous) or feed (catadromous), must congregate, even temporarily, in Chaleur Bay and this area would be important for their fitness. Unfortunately, the map generated from our alewife data (Fig. 11) does not reflect this expectation because data were collected mostly in the summer months. The aggregation of alewife occurs in a brief period during spring and is limited geographically; hence, it is unlikely that it could be observed in the traditional bottom trawl surveys, i.e., illustrating data limitation. Similarly, the entire breeding population of American shad and striped bass must cross the eastern NB area to access their single spawning site in the Miramichi River (Chaput and Bradford 2003; Douglas et al. 2009; COSEWIC 2012b; DFO 2014a), so this transition area is important in terms of the aggregation of those species.

Although our contour map for butterfish (Fig. 12) suggests a single aggregation within Northumberland Strait, they also occupied several other areas in the summer and the fall. However, other than occasional captures in the Miramichi Estuary (Hanson and Courtenay 1995), they have not been captured in areas west of North Point, PEI (Benoit et al. 2003; Darbyson and Benoit 2003).

The pseudo-diversity contour map for fish (Fig. 13) indicated the greatest numbers of species were captured in the Northumberland Strait, St. George’s Bay, and Chaleur Bay. Based on the available data, numerous species found in these areas were indeed very abundant (e.g. Atlantic herring, longhorn sculpin, rainbow smelt, alewife, winter flounder) and therefore had a very high predicted probability of capture. Aggregation of fish species was less important around the Magdalen Islands mostly because of the absence of anadromous species. Coastal waters west of Cape Breton are restricted to a very narrow band and limited data were available from our surveys to generate the model’s predictions which could explain why fewer species seemed to be present in that area.

The pseudo-diversity contour map for invertebrates suggests that relatively high numbers of species occur in the Shediac Valley, Chaleur Bay, and just south of the Magdalen Islands; and that lower numbers of species are present in the Northumberland Strait, St. George’s Bay, and eastern PEI (Fig. 14). This is quite the opposite of the results based on fish species (Fig. 13). The invertebrate pseudo-diversity contour map seems to be driven by the high number of echinoderm species in our database, and transient invertebrate species (i.e., at the upper limit of the CIL). Sea stars, sea cucumbers, and sea urchins are easy to identify compared to many other taxa that were not included in this evaluation, such as shrimps, polychaetes, small crustaceans (i.e., mysids, cumaceans, and amphipods), sponges, sea anemones, tunicates, and small mollusks. Thus, the pseudo-diversity contour map for invertebrates based on the available information is a biased representation of the coastal invertebrate community and is a severely biased indicator of the aggregation criterion. Consequently, it should not be considered in the identification and characterization of coastal IA.

Fitness consequences

Feeding

The majority of the research trawl surveys occur between early July and late September. Thus, summer species’ distributions represent areas where fishes are observed actively feeding and growing. With a few exceptions, fishes that remain in the sGSL during winter do not feed or feed at greatly reduced levels.

Adult white hake currently only feed in St. George’s Bay and the eastern end of Northumberland Strait (Fig. 6) so key food source for that species might only be available there; however, their main prey are Atlantic herring and Atlantic mackerel, two widespread species (Hanson 2011). It is recognized that there are high concentrations of forage fish in St. George's Bay such as juvenile and adult Atlantic herring, Atlantic saury, and juvenile alosids in autumn and spring. This area along with the eastern end of Northumberland Strait is critical to the fitness of the white hake population since the remnant of the adult population feeds there and it is two of the three locations, along with Shediac Valley, where juveniles feed. There is an October feeding migration of juvenile white hake into estuaries of Northumberland Strait and up to at least the Miramichi Estuary (Hanson and Courtenay 1995; Bardford et al. 1997; Swain et al. 2012) adjacent to the Shediac Valley (Fig. 5).

The western end of Northumberland Strait is the only feeding area for the lady crab (Voutier and Hanson 2008) and the summer feeding area for the remnant population of winter skate (Kelly and Hanson 2013a, 2013b), both species having a high likelihood to be undescribed endemics. The warm water (probably too warm for most of the transition water/CIL species), sand substrate, and currents result in Northumberland Strait being the only area suitable for lady crabs north of the United States eastern seaboard (with the exception of a small population in Minas Basin) (Voutier and Hanson 2008).

Large proportions of the alewife (Fig. 11), windowpane flounder (Fig. 15), rainbow smelt (Fig. 16), and American shad populations also feed within Northumberland Strait, where there also are high concentrations of forage fish such as juvenile Atlantic herring (McQuinn et al. 2012). The area is also used consistently for feeding by most anadromous species. Rainbow smelt are very common in the <35 m depths in bottom trawl surveys and occur along all the shoreline of the sGSL except the Magdalen Islands (Fig. 16) during the ice-free season. Typically, there are large concentrations of rainbow smelt feeding in waters <30 m deep in Chaleur Bay, eastern NB, and throughout Northumberland Strait (Benoit et al. 2003; Bosman et al. 2011; Savoie 2014a). Juvenile rainbow smelt have the same general distribution of adults once they enter full salt water, but the juveniles tend to be closer to shore.

There are at least four marine fish species (transient marine species) that enter the sGSL coastal waters to feed during summer months: bluefin tuna, butterfish, Atlantic saury, and spiny dogfish (Appendix 2). The bluefin tuna and Atlantic saury are pelagic species and not captured in DFO trawl surveys but based on commercial and reported commercial fisheries landings (DFO 2010; Vanderlaan et al. 2014) feeding aggregation information could be deduced. The largest numbers of bluefin tuna occur along the north coast of PEI and at the eastern end of the Strait where they feed actively. The Shediac Valley is the third high-density feeding areas for bluefin tuna (based on landings) within the sGSL making those areas rather important for the fitness of that species. Atlantic saury is noteworthy for its feeding concentrations during autumn in a small area of St. George's Bay (Chaput and Hurlbut 2010; DFO 2010) - they presumably enter and exit along the west coast of Cape Breton. Butterfish enter the sGSL sometime during summer with very small numbers caught in the NS survey, and from central Strait to St. George's Bay (Fig. 12) in September and October. Large incursions of spiny dogfish occur when its population in adjacent ecosystems is at high levels (COSEWIC 2010b). Spiny dogfish mainly occur during late summer and autumn in coastal waters from Miscou Island through Northumberland Strait and the north Shore of PEI to eastern PEI, with a concentration on the east side of the Magdalen Islands (Benoit et al. 2003; COSEWIC 2010b) (Fig. 17). During autumn, these aggregations of spiny dogfish likely are concentrating on spawning aggregations of Atlantic herring.

A group of anadromous species does not leave the sGSL and uses the coastal zone as their primary open-water feeding area. Some species tend to stay very close to shore (e.g., striped bass and brook trout) and others are simply poorly sampled (e.g., Atlantic tomcod and threespine stickleback), because much of the population occurs, again, close to shore or is pelagic (not mutually exclusive mechanisms), resulting in the absence or quasi-absence of these species in our research trawl surveys.

Migration corridors

Of the fish species that show significant seasonal movements, most appear to undergo diffuse migration between summer feeding areas and overwinter refuges. There are notable exceptions. The entire near-shore area from Gaspé to roughly the Margaree Estuary in Cape Breton represents the seasonal migration corridor for striped bass (Robinson et al. 2004; Douglas et al. 2009; S. Douglas, Gulf Fisheries Centre, pers. comm.) (Fig. 18); however, this species does not move out of the sGSL. American eel, the three alosid species, butterfish, Atlantic saury, and spiny dogfish, all are thought to migrate along the coast, and especially in Northumberland Strait, to the west coast of Cape Breton and then out along the northern tip of Cape Breton. Atlantic cod shows a similar migration pattern in and out of the sGSL (Hanson 1996; Campana et al. 1999; Comeau et al. 2001). While Atlantic mackerel and bluefin tuna do not necessarily stay in coastal waters when feeding, they mostly pass along the north tip of Cape Breton as they enter and exit the sGSL. White hake also migrate along the west coast of Cape Breton (current low population pattern) and showed a similar migration along the coastal areas of both sides of PEI when population numbers were higher. Thus there clearly is a major migration corridor primarily through Northumberland Strait (and to a lesser degree along the north shore of PEI), along the west coast of Cape Breton, and then a highly significant choke point at the northern tip of Cape Breton Island (Fig. 18).

The three alosid species (alewife, blueback herring, and American shad) undergo long-distance migrations to overwinter well outside the sGSL (Chaput and Bradford 2003; Darbyson and Benoit 2003; McQuinn et al. 2012). The three species spawn in rivers during spring or early summer; the young-of-the-year move down the estuary as they grow; they join the large juveniles and adults in coastal waters (especially in Northumberland Strait) during late summer or early fall, and all sizes leave the sGSL before ice formation. The migration appears to run along the shoreline of the mainland (mainly Northumberland Strait) and, for a while, there can be large numbers concentrated at the eastern end of St. George’s Bay. Eventually, all the migrants exit along the west coast of Cape Breton, leaving the sGSL completely during winter. All sizes of alosids return to the sGSL as the ice melts, adults enter freshwater to spawn, and the post-spawners move back down to coastal waters to feed for the summer – along with the immature fishes (Hanson and Courtenay 1995; Bosman et al. 2011; J.M. Hanson, unpublished data). A very large proportion of the populations of the three alosid species, butterfish, striped bass (in the Miramichi River and a few nearby rivers), and adult American eels migrate through the Northumberland Strait in autumn to overwinter or to breeding sites (reverse migrations in spring for diadromous species). For species entering rivers within the Strait, there is no other route so the area is an obligatory passage. Winter skate migrate into the Strait from overwinter areas to feed and breed. As an obligatory passage to local end points (either to breeding, feeding, or overwinter sites), this area is critical for the fitness of many anadromous species, such as striped bass and American shad, and for winter skate.

Atlantic mackerel is also a long distance migrant. They migrate to US coastal shelf region to overwinter, returning in spring to spawn, and both adults and juveniles feed pelagically in the coastal zone all summer (McQuinn et al. 2012; DFO 2014b). Like the three alosid species, the migrants must pass through the choke point at northern tip of Cape Breton (Fig. 18) during both migrations.

As a deep-water species, adult Atlantic cod mainly occur in the cold waters of the CIL although, when population numbers were high, some occurred in the transition waters. The migration path of Atlantic cod is well-known (Swain et al. 1998; Campana et al. 1999; Comeau et al. 2001); the western group moves in waters offshore from the north shore of PEI in October, joins up with eastern group along west coast of Cape Breton, and move to the edge of the Cape Breton Trough up to the north tip Cape Breton in November. The adults migrate ahead of the ice-edge in Cabot Strait as winter progresses and ultimately out onto the Scotian Shelf.

As described earlier, bluefin tuna, butterfish, Atlantic saury, and spiny dogfish are known to enter the sGSL to feed. Presumably, all enter and exit via the passage at the tip of Cape Breton and pass along the west coast of Cape Breton, presumably between the shore and edge of the Laurentian Channel.

Anadromous species spawn in freshwater and have migrations of varying lengths. Corridors leading to those freshwater spawning locations are therefore important for the fitness of the anadromous species in the sGSL. Chaleur Bay is an obligatory passage for salmon, alewife, and American eels going into rivers like the Restigouche, and likely for striped bass during its feeding migrations. Similarly, eastern NB (coastal Shediac Valley) is also an obligatory passage for these species going into other rivers. Furthermore, the Miramichi River is the only known spawning site for striped bass and American shad so the entire population funnels through the area coming either from the northern and southern route (Fig. 18) before entering the river. Young-of-the-year striped bass and American shad move down the river and into the estuary as they grow and then disperse all along the coast in mid-summer (Chaput and Bradford 2003; Robinson et al. 2004). Finally, most of the juvenile and adult alewife and rainbow smelt go through the Miramichi Estuary to migrate into Northumberland Strait to feed during the summer months.

There is an October feeding migration of juveniles of white hake from the Shediac Valley into the Miramichi Estuary (eastern NB) where fish aggregate for a month or so before leaving to overwintering locations (Hanson and Courtenay 1995; Bradford et al. 1997; Swain et al. 2012; COSEWIC 2013). Eastern NB is therefore important for the fitness of this endangered species. Since there is also a feeding migration of juvenile white hake in rivers of Northumberland Strait, that area must also be of some importance.

Atlantic salmon undertakes a long feeding migration. Small juvenile Atlantic salmon (smolts) migrate down the estuaries of their natal rivers during spring. The pelagic smolts from several major rivers apparently congregate for a short time in the Miramichi “outer-bay” area and move as a group across the Magdalen Shallows, crossing to the Strait of Belle Isle, and ending up near Greenland (COSEWIC 2010c). The return migration is not synchronous with fish fresh from the ocean appearing in fresh waters from late June through October. Locations of the adults in transit are poorly understood, and they are all but immune to our survey gears because they are pelagic and fast-moving; hence, possible migration corridors (if any) cannot be inferred. The adults spawn during autumn and the surviving spent fish move back down the estuary during spring (feeding as they go) and out to sea. Some of the spent fish that migrate back to the ocean sea will return to spawn in subsequent years.

Longhorn sculpin, sea raven, yellowtail flounder, windowpane, and ocean pout are widely distributed and most individuals appear to leave the <30 m waters occupied during summer and move to the deeper waters within the sGSL to overwinter with no specific migration corridor (Bosman et al. 2011; Hanson and Wilson 2014). Similarly, the almost ubiquitous winter flounder shows two types of migration to overwinter refuges. Some individuals move to the edge of the Laurentian Channel while others enter estuaries during autumn and exit shortly after ice-melt (Hanson and Courtenay 1995, 1996; Darbyson and Benoit 2003).

Some warm-water coastal-zone species do not appear to migrate (see Appendix 2). Cunner hides under rocks or buries in sediment and enters a state of torpor as water temperatures drop below 5 to 8 °C (Johansen 1925; Dew et al. 1976; Green et al. 1984). Rock gunnel mainly lives under rocks close to shore and inside estuaries (Scott and Scott 1988). Wrymouth live in deep burrows (Scott and Scott 1988). Presumably these species remain in their preferred habitat year-round. Grubby (almost exclusively close to shore and in estuaries) and northern sand lance are not well sampled and their seasonal movements cannot be discerned.

The Canso Strait was most likely an important passageway for many species (e.g., Atlantic herring, Atlantic saury, and *Alosa* spp.) but since its blockage, each side now acts as a retention area (depending on the season) where migratory fish species are caught up until they take an alternative route out and around Cape Breton, i.e., along the west coast of Cape Breton in the sGSL. A significant proportion of the migratory species populations pass along the west coast of Cape Breton. Atlantic salmon populations using the rivers in the area must migrate through St. George's Bay to access spawning endpoints. St. George's Bay formerly was very important for the fitness of species migrating through the Canso Strait but now marine fish are going around Cape Breton following the shore west of Cape Breton or a bit offshore.

Invertebrate species do not show much in the way of seasonal movements although some adult American lobsters do make short seasonal movements to slightly deeper water if cover is not available in the <30 m depths (Bowlby et al. 2007, 2008). Consequently, no area can be identified as being important for the fitness of invertebrate species based on migration.

Spawning locations

Fish populations in the sGSL can be classed in four guilds by spawning behavior; anadromous species, those that do not spawn in the sGSL, species with known spawning beds, and species where no spawning area has been located (the vast majority of species). Anadromous, catadromous, and transient species do not spawn in the sGSL marine coastal habitat and therefore their spawning grounds can be ignored for the purpose of this report. With few exceptions (e.g., Atlantic herring, white hake, winter skate), distinct spawning areas are unknown for most marine resident species.

The St. George's Bay is unique as it is the only remaining breeding location for coastal white hake (Swain et al. 2012; COSEWIC 2013); the entire breeding population is present and the loss of this location would most likely result in the extirpation or extinction of white hake. As the only breeding area for lady crab (Fig. 8) and most of the remnant winter skate population (Fig. 7), the western half of Northumberland Strait is critical for these species. The loss of this breeding area would most likely result in the extinction of lady crab and winter skate. Baie Verte located in central Northumberland Strait (Fig. 5) used to be one of the two known spawning location for white hake (with St. George's Bay) but this function is now lost (Swain et al. 2012).

Atlantic herring (spring and fall spawners) have many spawning beds (e.g., Miscou Island, both ends of Northumberland Strait, Chaleur Bay) (Messieh 1987) but usage is not consistent from year to year. Historically, there have been spring and fall herring spawning beds for the entire sGSL but some of them seem to have disappeared (McQuinn et al. 2012).

Capelin probably spawns on offshore banks and perhaps beaches from Miscou Island to roughly Gaspé Bay; however, actual locations have not been documented.

Winter sampling in the lower Miramichi Estuary has detected Greenland cod and shorthorn sculpin in spawning condition (ripe and running and newly spent; Hanson and Courtenay 1995) but whether winter spawning in the lower section of estuaries is the rule for sGSL populations is unknown.

Beside St. George's Bay and Northumberland Strait, no other areas can be identified as being important for the reproductive fitness of fish species. As for the invertebrate species, very little information on breeding grounds is available. As said previously, most species are sessile or sedentary and will complete their whole life cycle within the same area.

Nursery areas

The possibility of distinct nursery areas has not been investigated for most marine species. Estuaries, for varying lengths of time, represent important nursery areas for all of the diadromous fishes except Atlantic salmon and sea lamprey (whose young pass quickly through the zone en route to marine feeding areas). There are very few juveniles of diadromous species in shallows of St. George's Bay and the Magdalen Islands because of the small number and the total absence of inflowing rivers, respectively. For most species, the juvenile fish essentially share the same locations as the adults although there is a moderate tendency for the juveniles to be in shallower waters.

Distinct nursery areas are known for Atlantic herring, and are located within Northumberland Strait and the end of Chaleur Bay (LeBlanc et al. 1998; Bosman et al. 2011). There are also some concentrations of juvenile herring in St. George's Bay (McQuinn et al. 2012).

For Atlantic cod, the major concentrations of juveniles occur around the north point of PEI, immediately west of the Magdalen Islands, and along the north and east coasts of PEI. Some concentrations of age-0 and small juveniles occur within Northumberland Strait during summer (Bosman et al. 2011).

Juvenile white hake are now only found in three locations: St. George's Bay, Northumberland Strait, and eastern PEI (Hanson and Courtenay 1995; Swain et al. 2012; COSEWIC 2013) with no area being more important than the others for the fitness of the remnant population. The western half and central Northumberland Strait is also the only nursery area for lady crab and remnant winter skate population; meaning it is critical for the fitness of both species. In addition to those two likely-endemic species, there are large concentrations of age-0 and juveniles of the three alosid species and striped bass. High concentrations of adult windowpane (Fig. 15) and winter flounder probably indicate that the area is used as a breeding and nursery area as well as for feeding.

Seasonal refuge

With one exception, there is no significant winter refuge in the coastal zone of the sGSL. Most strictly warm-water coastal fishes migrate to deeper waters outside the coastal area or enter estuaries for the winter, including all of the rare (COSEWIC ranked) or suspected endemic fishes (winter skate and white hake). A few widely-distributed warm-water fishes (e.g., wrymouth, cunner, and rock gunnel) remain in their burrows, hide under rocks, or bury in the sediments to overwinter. Furthermore, seasonal migrations by benthic invertebrate species, including the likely undescribed endemic population of lady crab, are minimal or non-existent. The whole population of lady crab is restricted to the western half of Northumberland Strait year-round so the area is its sole refuge. The fitness (i.e., continued survival) of this species depends on this area.

DISCUSSION

In contrast with the identification and characterization of important areas (IA) in the coastal waters, the workshop held in 2006 (DFO 2007) was not limited by depth, per se. The focus of the 2006 workshop was more "offshore" largely because the RV survey typically has very few sets in water <25 m deep. Nevertheless, two of the ten identified EBSAs (St. George's Bay and the western Northumberland Strait; DFO 2007) occur entirely in waters ≤40 m deep (Table 5). Furthermore, two other EBSA (Western Cape Breton and southwestern coast of the Gulf; DFO

2007) were very large areas that covered much deeper waters (>40 m) but included large portions of coastal waters (Table 5).

Based on the information available, the Northumberland Strait area is the highest ranked IA. Its importance is paramount considering the three evaluation criteria; uniqueness, aggregation and fitness consequences. The high importance in terms of these three criteria is mainly driven by the presence of two likely-endemic species (lady crab and winter skate) in the center and western half of the Strait, and by its being the only remaining spawning location for the coastal white hake (eastern half). Moreover, the only other known spawning location for these white hake was within the Strait in Baie Verte (Swain et al. 2012). In addition, the Northumberland Strait is a major migration corridor for fishes (butterfish, striped bass, *Alosa* spp. and adult American eels) with a bottleneck at both ends. The western part of the Strait was identified as an EBSA (see Table 5) in the 2006 workshop (DFO 2007) mainly because of the presence of the lady crab (Chabot et al. 2007) and remnant winter skate population (Swain and Benoît 2007), and more recently for its importance for small pelagic fishes in the eastern half (McQuinn et al. 2012). However, given the similarity of the oceanographic processes within Northumberland Strait (Chassé et al. 2014), the entire area could be characterized as a single unit.

St. George’s Bay was previously identified as an EBSA (St. George’s Bay EBSA 2; DFO 2007), and since the entire bay is <40 m, and the same dataset was used, we could also consider it as a coastal IA (Table 5), and de facto as a coastal EBSA. St. George’s Bay ranked high because it is part of the only remaining breeding location for white hake, and losing this area would result in its extirpation or extinction (Swain and Benoît 2007). Additionally, concentrations of juvenile white hake are found there. St. George’s Bay is an important feeding area for many fishes (e.g., juvenile and adult Atlantic herring, juvenile *Alosa* spp., white hake and Atlantic saury) and many fish species aggregate there during part of their migration in and out the sGSL. The area was designated as an EBSA in 2006 mostly for its major role for meroplankton (largest array and abundance in the sGSL) as well as for its usage by groundfish and pelagic fish (DFO 2007).

The coastal areas at the eastern end of PEI and along the western shore of Cape Breton are encompassed by a much larger area that was identified and characterized as an EBSA (DFO, 2007). At the 2006 EBSA meeting, western Cape Breton was designated as an EBSA (EBSA 1; DFO 2007) because of its major role for meroplankton (with a large array of species), high biomasses and large concentrations of small (<1 mm) and large (>1 mm) meso-zooplankton and its importance to groundfish (Swain and Benoît 2007). The Cape Breton Channel serves as a migration corridor (spring and fall) for many fishes but especially for Atlantic cod and white hake (Swain and Benoît 2007). However, the main ecological functions are more important in the offshore portion of the western Cape Breton EBSA. Indeed, the EBSA is mostly comprised of the deep waters (>40 m) that occur between PEI and Cape Breton rather than coastal waters. Within the context of the current study, the coastal zone (<40 m) along the western coast of Cape Breton is a narrow band, and does not appear to be of critical importance to any of the species considered in the present evaluation; therefore, it would not be designated as IA (Table 5). In contrast, the coastal zone at the eastern end of PEI is wider and is directly connected to the adjacent IAs (i.e., Northumberland Strait and St. George’s Bay). Thus, it should be considered an IA (Table 5), mainly because of the presence of white hake, but also due to its importance to pelagic fishes (McQuinn et al. 2012).

Chaleur Bay and the coastal waters west of the Shediac Valley (i.e., eastern NB) should not be considered an IA; however, the deeper waters adjacent to these coastal areas have been identified as EBSA (Table 5) and might warrant special consideration. The relative importance of these areas refers mainly to migratory anadromous species (e.g., Atlantic salmon, alewife, and American eels) going into the Restigouche river and with American shad and striped bass (their only spawning locations in the sGSL) going into the Miramichi River (which also supports much larger populations of salmon, alewife, and American eels than the Restigouche River). These two areas are comprised within the southwestern coast of the Gulf EBSA identified during the 2006 workshop and represent most of its coastal portion (<40 m). The discrepancy between the two evaluations seems to be the depth restriction and additional layers of information. First, the southwestern coast of the Gulf EBSA is influenced by the Gaspé current and both the Miramichi and Restigouche rivers empty into the area creating special physical processes including retention potential, resurgence, and important tidal mixing (DFO 2007). Consequently, with the influence of the Gaspé current carrying nutrients and phytoplankton cells, high phytoplankton concentrations can be observed in the area. That would explain the importance of that area for pelagic fishes (DFO 2007; McQuinn et al. 2012). Second, fishes and invertebrates are high in numbers but the species listed is indicative of species that prefer lower temperatures and thus more abundant, or present, at depth >40 m. Furthermore, Chaleur Bay represents one of the principal wintering areas for juvenile Atlantic herring (DFO 2007; McQuinn et al. 2012), but this occurs in waters >40 m and hence was not considered in our identification for coastal IA (Table 5). Also, the southwestern coast of the Gulf was identified as an EBSA because of a significant feeding area for several marine mammal species, but offshore from Gaspé (DFO 2007), not in the coastal area. Finally, Swain and Benoît (2007) indicated the importance of Chaleur Bay (their IA-7) as low and Shediac Valley (their IA-5) as moderate (Table 5) based on information for demersal fishes.

Finally, coastal areas north of PEI and around Magdalen Islands ranked the lowest as IA based on the three evaluation criteria and all the ecological functions. These locations have no distinctive features and do not seem to be essential for any of the fish or invertebrate species accounted for this evaluation of coastal IA. Similarly, they were not given any special consideration during the identification and characterization process to established EBSA in 2006 (Table 5).

DATA AND RESEARCH LIMITATIONS

The framework and concepts for the identification of IA rely on data availability and quality. Our evaluation had limitations due to gaps in survey coverage in shallow waters of the coastal habitat. For waters < 25 m deep, only Northumberland Strait was well-surveyed; with reasonably good coverage in the eastern half of the Strait only starting in 2005. Waters of Northumberland Strait < 4 m deep could not be sampled due to the draft of the survey trawlers; consequently, distributions of many species described within this study are truncated. Elsewhere in the sGSL (including St. Georges Bay), there is little information for depths < 25 m, and extrapolating the results from this study to the entire coastal zone should be done with caution.

Lack of sampling in the coastal habitat also reflects, among other things, heterogeneous rough bottoms in some areas which prevent sampling by bottom trawls during some surveys. Rocky hard bottoms (e.g., boulder, reefs) in the sGSL are largely located in ≤ 40 m depths. Also, some areas, specifically the western half of Northumberland Strait, could not be sampled during the annual RV survey due to ongoing fishing activities (i.e., the large numbers of lobster traps). Hence, the only information available for this area comes from the NS survey that began in 2000, reflecting inconsistencies in the sampling coverage and sampling gears for the data considered. Filling the data gap in these areas would be difficult for many species.

Trawl efficiency is also an issue for many fish and invertebrate species, especially small bodied species but also for epibenthic (including demersal fishes such as flatfishes) and endobenthic species which are not well-sampled with the trawls used in most multispecies surveys. This is problematic for species such as the sevenspine bay shrimp (*Crangon septemspinosa*) and the Atlantic rock crab that play a critical role in the coastal zone food web (Hanson 2011; Kelly and Hanson 2013a; Hanson and Wilson 2014;Hanson et al. 2014). However, basic information such as abundance and distribution is lacking for these species for most of the sGSL. Information on buried invertebrates (e.g., small and large bivalves, polychaetes, some tunicates, some echinoderms) is also lacking or with very limited spatial coverage even if it is recognized that species of the endobenthos are an important link within ecosystem food webs.

Correct species identification in the different surveys continues to be an issue. Species diversity, even for fishes in our study, is affected by taxonomic shortcomings such as pooling two species for alewife and blueback herring (similar to commercial landings) or the separation of small stichaeids (daubed shanny, stout eel blenny; slender eel blenny, juvenile snakeblenny) that has not been done consistently in the surveys' time series. The issue with the invertebrate data availability bears repeating. Many groups, including higher taxa, are pooled to class or phylum level in the database. In some cases, species-level identification work has been done (e.g., shrimps since 2002) following surveys but their entry into the database has been slow and this information was not available for the present study. With only one shrimp species in the warm-water part of the coastal zone versus at least 14 species occurring in the transition waters and CIL, the difference in biodiversity between the two depth zones is greatly underestimated.

Data-rich areas are more likely to be considered as important, creating a bias compare to data-poor areas. Unique characteristics, evidence of aggregations of some species, and the functionality of an area are easier to identify with a wealth of data and information. Also, the large amount of data on commercial species could predispose the identification of IA to those species and not for whole ecosystem processes.

CONCLUSION

The process for identification and characterization of coastal important areas (IA) reveals three locations that rank high based on fish species and one crab species: Northumberland Strait, St George's Bay, and eastern coast of PEI. These areas stand out primarily because of the presence of likely-endemic species. Chaleur Bay and coastal Shediac Valley are important mainly for the migration of several anadromous species and may warrant some special consideration. The area along the west coast of Cape Breton has a major role as a migration corridor, but more so in the > 40 m deep portion of the area and especially at the "choke point" for many fish species. Finally, there is no evidence to consider northern PEI and Magdalen Islands as IA, as per the previous EBSA identification and characterization meeting in 2006 (DFO 2007).

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TABLES

Table 1. Fish species or group of species considered for modeling.

Common name	Scientific name
Gaspereau	*Alosa pseudoharengus, A. aestivalis*
American plaice	*Hippoglossoides platessoides*
American shad	*Alosa sapidissima*
Atlantic cod	*Gadus morhua*
Atlantic halibut	*Hippoglossus hippoglossus*
Atlantic herring	*Clupea harengus*
Atlantic mackerel	*Scomber scombrus*
Atlantic tomcod	*Microgadus tomcod*
Butterfish	*Peprilus triacanthus*
Capelin	*Mallotus villosus*
Cunner	*Tautoglabrus adspersus*
Daubed shanny	*Leptoclinus maculatus*
Fourbeard rockling	*Enchelyopus cimbrius*
Greenland cod	*Gadus ogac*
Grubby	*Myoxocephalus aenaeus*
Longhorn sculpin	*Myoxocephalus octodecemspinosus*
Lumpfish	*Cyclopterus lumpus*
Northern sandlance	*Ammodytes sp.*
Ocean pout	*Zoarces americanus*
Rainbow smelt	*Osmerus mordax*
Rock gunnel	*Pholis gunnelus*
Sea raven	*Hemitripterus americanus*
Shorthorn sculpin	*Myoxocephalus scorpius*
Snakeblenny	*Lumpenus lampretaeformis*
Spiny dogfish	*Squalus acanthias*
Threespine stickleback	*Gasterosteus aculeatus*
White hake	*Urophycis tenuis*
Windowpane	*Scophthalmus aquosus*
Winter flounder	*Pseudopleuronectes americanus*
Winter skate	*Leucoraja c.f. ocellata*
Wrymouth	*Cryptacanthodes maculatus*
Yellowtail flounder	*Limanda ferruginea*

Table 2. Invertebrate species and taxa considered for modeling.

Taxon or species	Scientific name	Phylum	RV data
American lobster	*Homarus americanus*	Arthropoda	1989-2013
Atlantic rock crab	*Cancer irroratus*	Arthropoda	1989-2013
Lady crab	*Ovalipes c.f. ocellatus*	Arthropoda	NA
Mud crab	*Dyspanopeus sayi*	Arthropoda	NA
Pagurus	*Pagurus sp.*	Arthropoda	1989-2013
Toad crab	*Hyas sp.*	Arthropoda	1989-2013
Sea strawberries	*Gersemia sp.*	Cnidaria	2003-2013
Asterias	*Asterias sp.*	Echinodermata	2004-2013
Blood star	*Henricia sp.*	Echinodermata	1989-2013
Brittle star	*Ophiuroidea*	Echinodermata	1989-2013
Leptasterias polaris	*Leptasterias polaris*	Echinodermata	2004-2013
Purple sunstar	*Solaster endeca*	Echinodermata	2005-2013
Sand dollars	*Echinarachnius parma*	Echinodermata	1989-2013
Scarlet psolus	*Psolus fabricii*	Echinodermata	1995-2013
Sea cucumber	*Cucumaria frondosa*	Echinodermata	1989-2013
Sea urchins	*Strongylocantrotus sp.*	Echinodermata	1989-2013
Spiny sunstar	*Crossaster papposus*	Echinodermata	2005-2013
Mussels	*Mytilus edulis*	Mollusca	1989-2013
Northern moonsnail	*Euspira eros*	Mollusca	1989-2013
Ocean quahaug	*Arctica islandica*	Mollusca	1989-2013
Sea scallop	*Placopecten magellanicus*	Mollusca	1989-2013
Sea slugs	*Nudibranchia*	Mollusca	2002-2013
Whelks	*Buccinum sp.*	Mollusca	1989-2013

Table 3. Test taxa included in the model selection process for selecting the most common best fitting model to be applied to the whole taxa list.

Fish species	Invertebrates species
Alewife	American lobster
American plaice	Atlantic rock crab
Atlantic cod	Lady crab
Atlantic herring	Sea scallop
Rainbow smelt	Snow crab
Winter flounder	Toad crab
Winter skate	
Yellowtail flounder	

Table 4. List of species that have been evaluated by the Committee on the Status of Endangered Wildlife in Canada with their status and year of assessment. Species and populations listed under the Species At Risk Act (SARA) are identified. Species for which trawl-survey data were available to this study are underlined.

Common name	Scientific name	Status	Year of assessment
American eel	*Anguilla rostrata*	Threatened	2012
<u>American plaice</u>	*Hippoglossoides platessoides*	Threatened	2009
<u>Atlantic cod</u>	*Gadus morhua*	Endangered	2010
Atlantic salmon	*Salmo salar*	Special concern	2010
Atlantic wolffish	*Anarhichas lupus*	SARA - Special concern	2003
Bluefin tuna	*Thunnus thynnus*	Endangered	2011
<u>Spiny dogfish</u>	*Squalus acanthias*	Special concern	2010
Striped bass	*Morone saxatilis*	Special concern	2012
Thorny skate	*Amblyraja radiata*	Special concern	2012
<u>White hake</u>	*Urophycis tenuis*	Endangered	2013
White shark	*Carcharodon carcharias*	SARA – Endangered Atlantic population	2006
<u>Winter skate</u>	*Leucoraja ocellata*	Endangered	2005

Table 5. Comparison of the Ecologically and Biologically Significant Areas (EBSA) and important areas (IA) within the southern Gulf of St. Lawrence (sGSL). EBSA locations (as indicated in Figure 5) are based on DFO (CSAS 2007/016), Swain and Benoît (CSAS 2007/012) and McQuinn et al. (CSAS 2012/087), and possible coastal IA based on fish and invertebrate species are from the present study. NB = New Brunswick; PEI = Prince Edward Island.

Locations	Coastal IA	CSAS 2007/016	status	CSAS 2007/012	status	CSAS 2012/087	status
Northumberland Strait	yes	part of EBSA 3	High	IA 3 (part)	High	IA 7, 9, 24	High
St. George's Bay	yes	EBSA 2	High	IA 2	High	IA 7, 9, 24	High
East PEI	yes	Part of EBSA 1	High	None	Low	IA 9, 24 (part)	High
West of Cape Breton	no	Part of EBSA 1	High	IA 1 (part)	High	None	Low
Coastal Shediac Valley	no	Part of EBSA 5	High	IA 5	Moderate	IA 8, 23 and 1 (part)	High
Chaleurs Bay	no	Part of EBSA 5	High	IA 7	Low	IA 3, 12, 1 (part)	High
North PEI	no	None	Low	None	Low	IA 13	Moderate
Magdalen Islands	no	None	Low	None	Low	None	Low

FIGURES

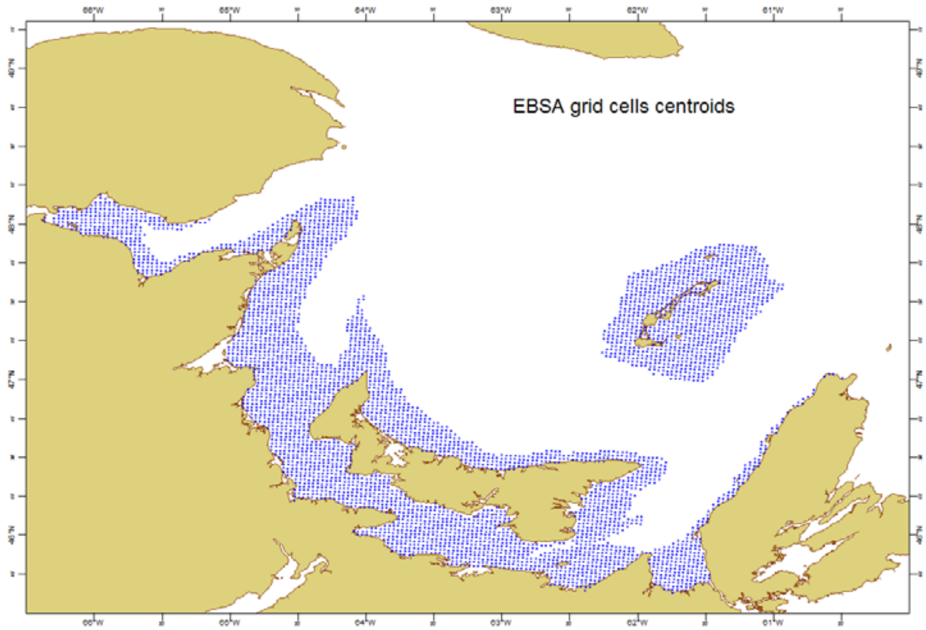


Figure 1. Map of the southern Gulf of St. Lawrence with the cell grid centroids between 0 and 40 m water depth, excluding cells within estuaries and semi-enclosed embayments.

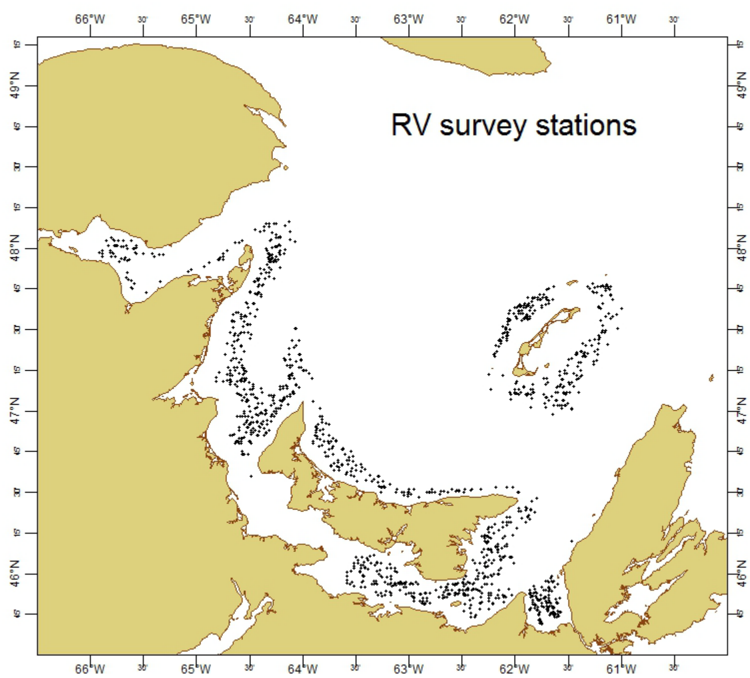


Figure 2. Map of the southern Gulf of St. Lawrence with the annual September bottom trawl survey (RV survey) sampling stations between 0 and 40 m deep, 1976 - 2013. Mid-tow locations were used for plotting the stations.

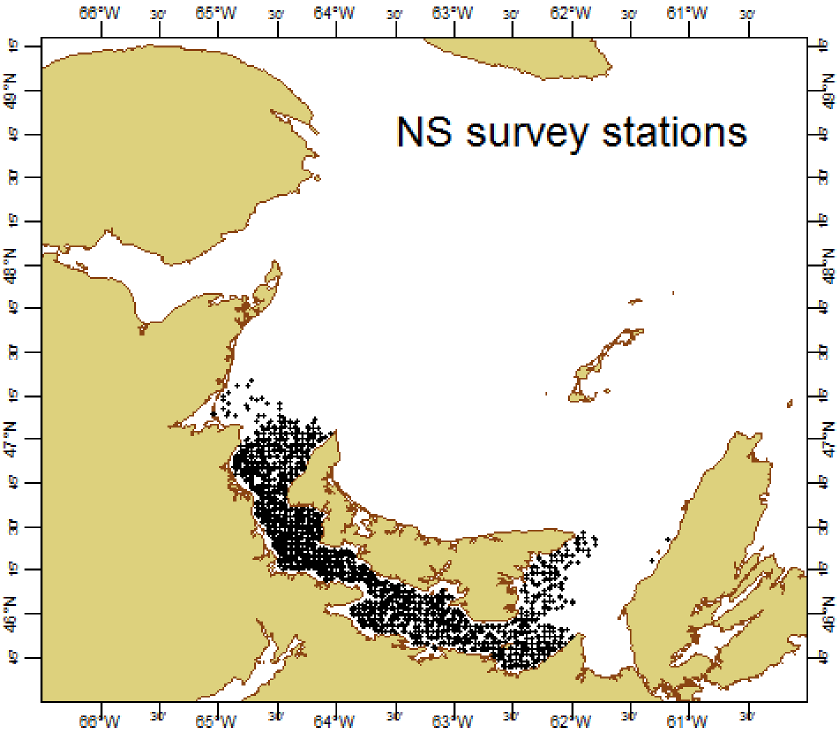


Figure 3. Map of the southern Gulf of St. Lawrence with the annual Northumberland Strait bottom trawl survey (NS survey) sampling stations between 0 and 40 m deep, 2000 - 2013. Mid-tow locations were used for plotting the stations.

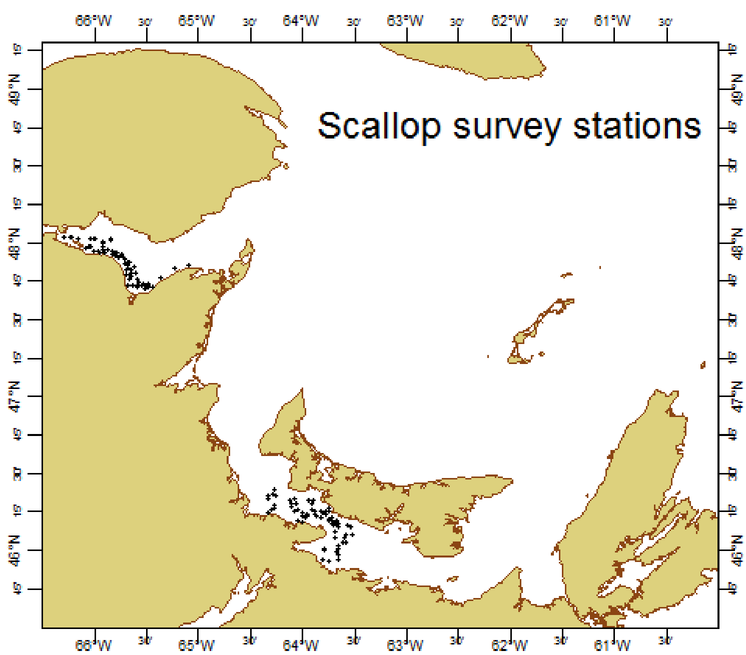


Figure 4. Map of the southern Gulf of St. Lawrence with the scallop survey sampling stations between 0 and 40 m deep in 2012 and 2013. Mid-tow locations were used for plotting the stations.

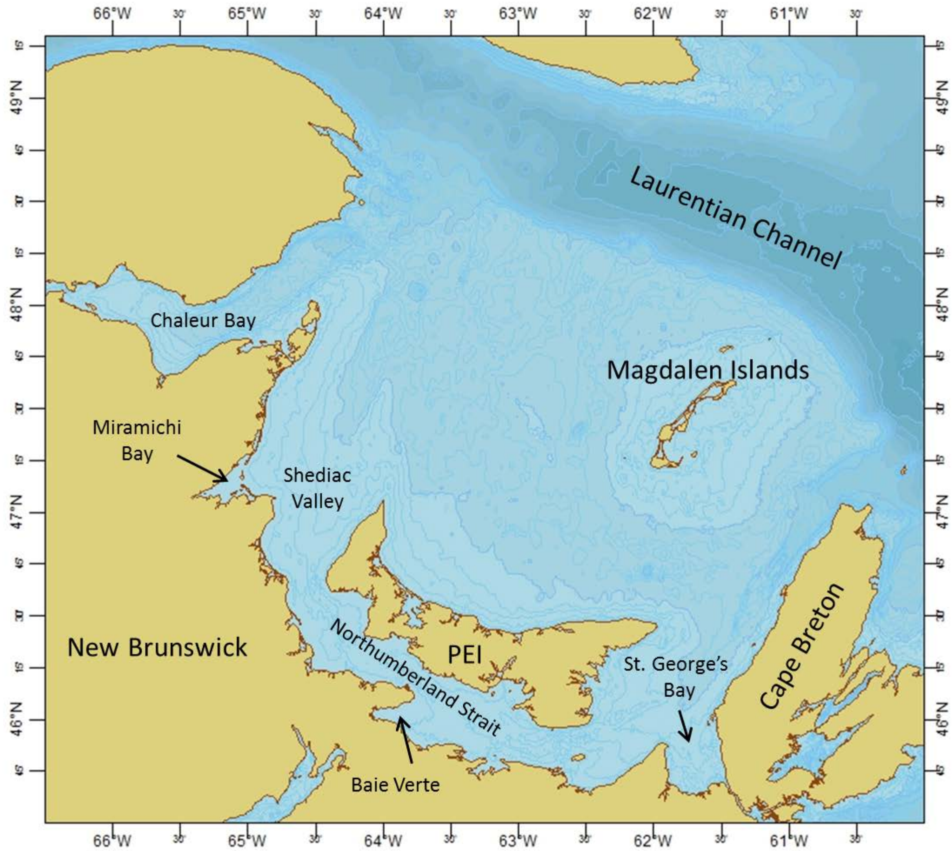


Figure 5. Map of the southern Gulf of St. Lawrence with place names identified. (Prince Edward Island = PEI).

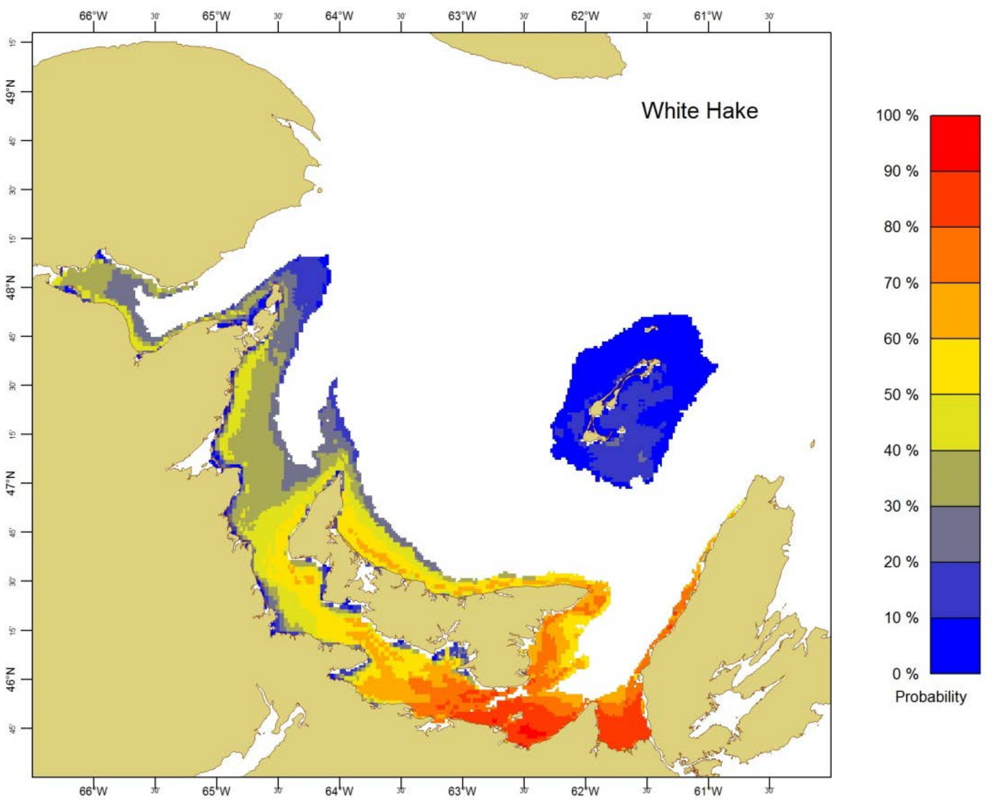


Figure 6. Contour map showing the predicted probabilities of capturing white hake (Urophycis tenuis) during a standard tow, using a Western IIA bottom trawl.

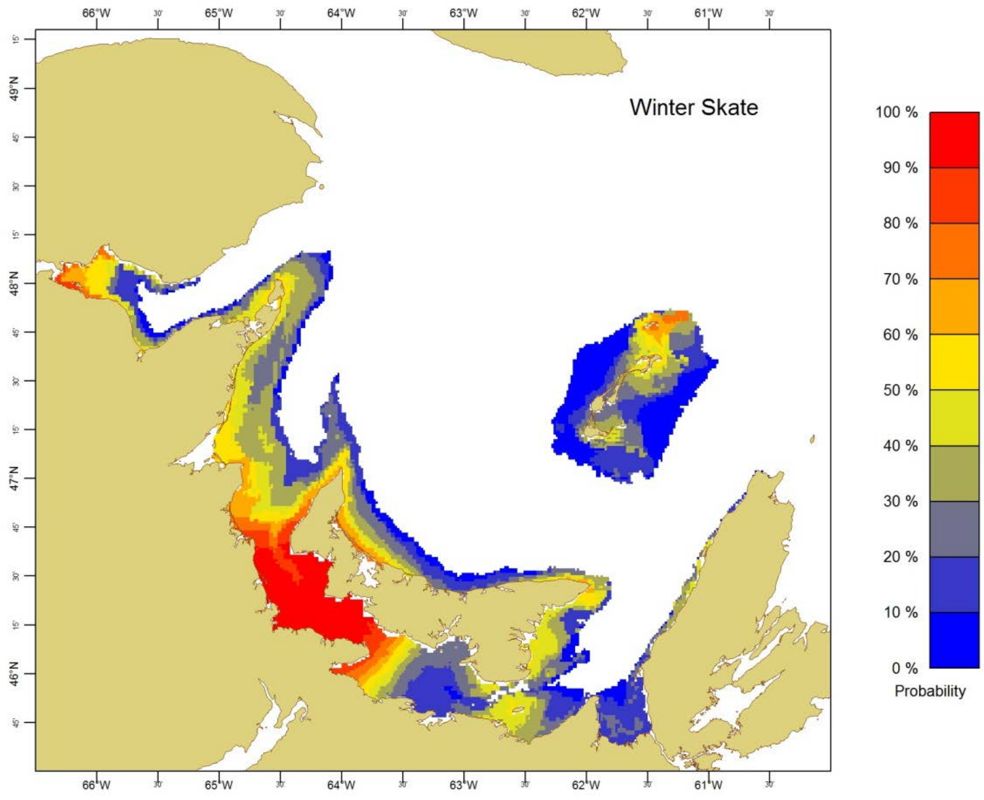


Figure 7. Contour map showing the predicted probabilities of capturing winter skate (Leucoraja ocellata) during a standard tow, using a Western IIA bottom trawl.

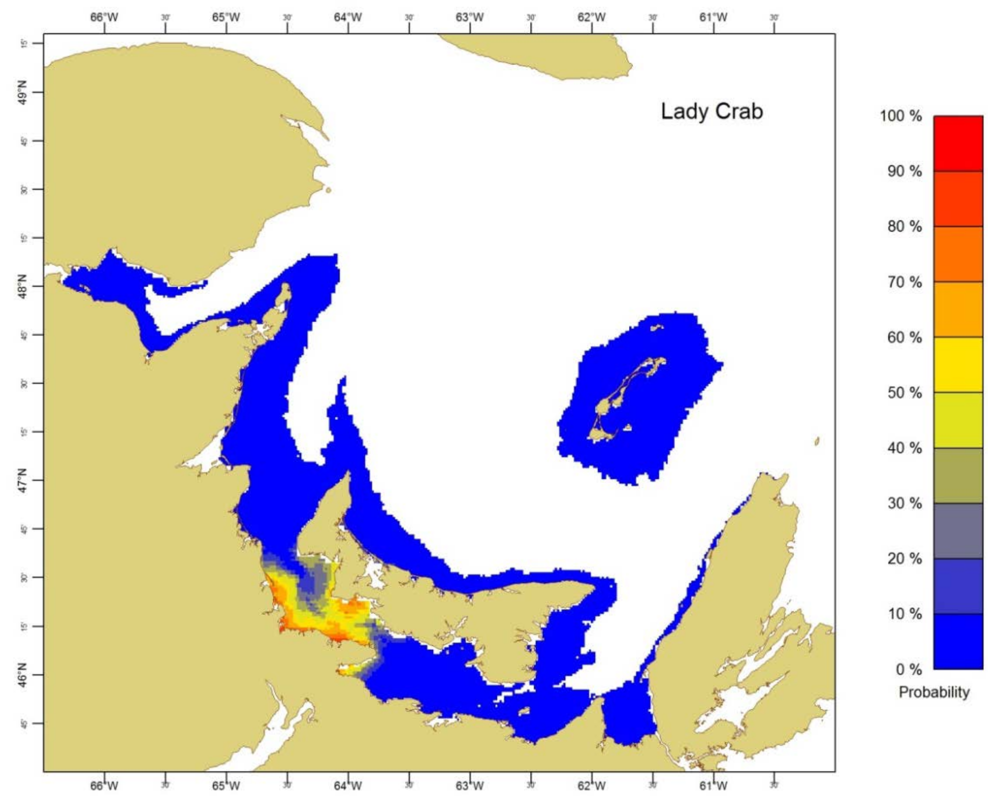


Figure 8. Contour map showing the predicted probabilities of capturing lady crab (Ovalipes ocellatus) during a standard tow, using a Nephrops trawl.

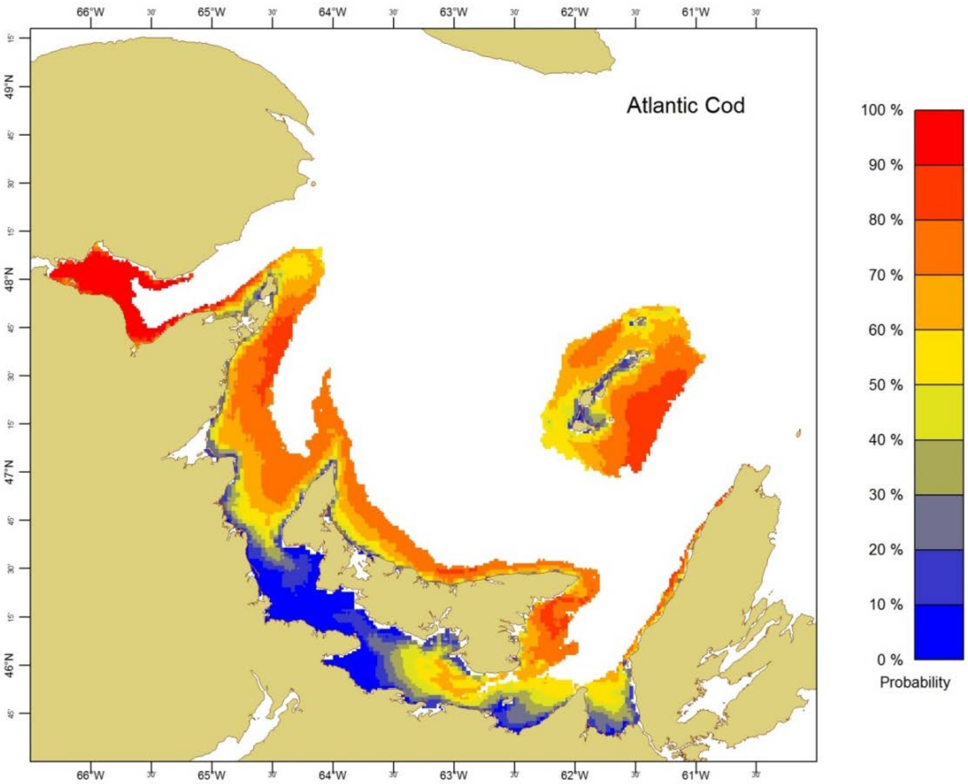


Figure 9. Contour map showing the predicted probabilities of capturing Atlantic cod (Gadus morhua) during a standard tow, using a Western IIA bottom trawl.

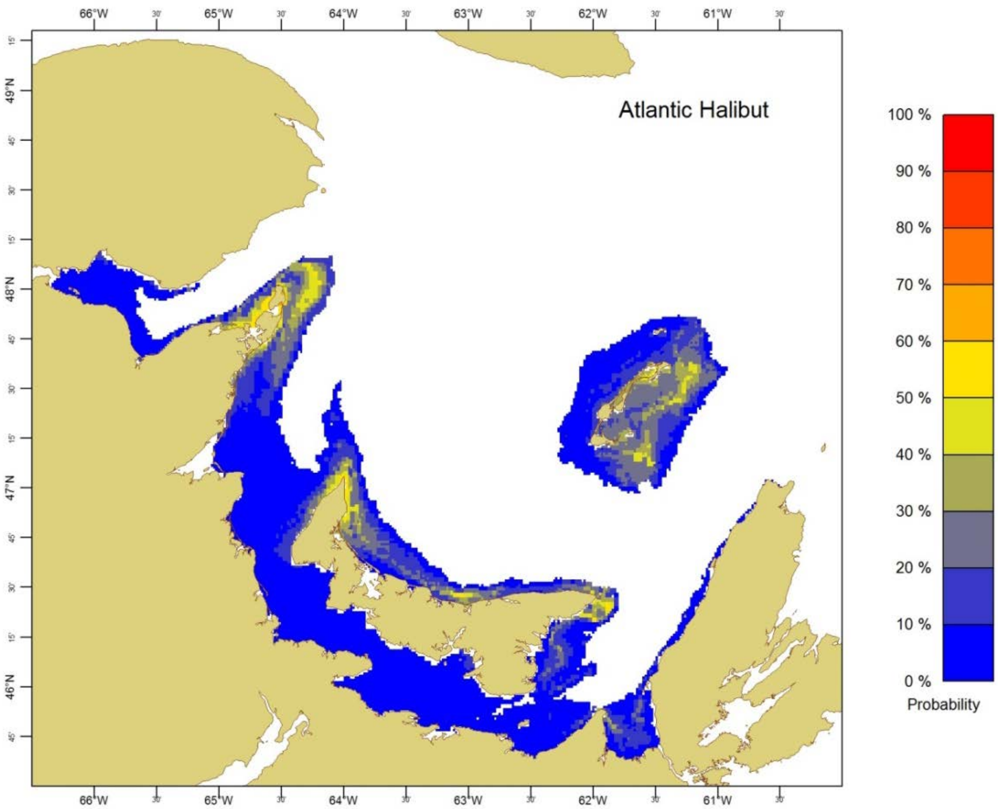


Figure 10. Contour map showing the predicted probabilities of capturing Atlantic halibut (Hippoglossus hippoglossus) during a standard tow, using a Western IIA bottom trawl.

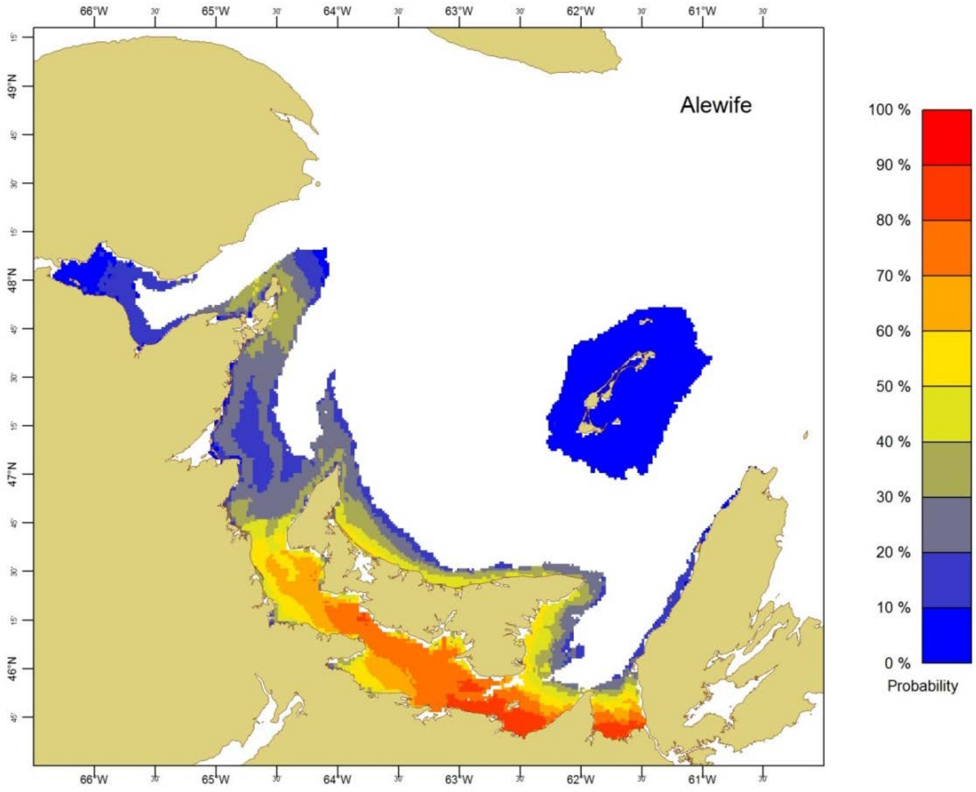


Figure 11. Contour map showing the predicted probabilities of capturing Alewife (Alosa pseudoharengus) during a standard tow, using a Western IIA bottom trawl.

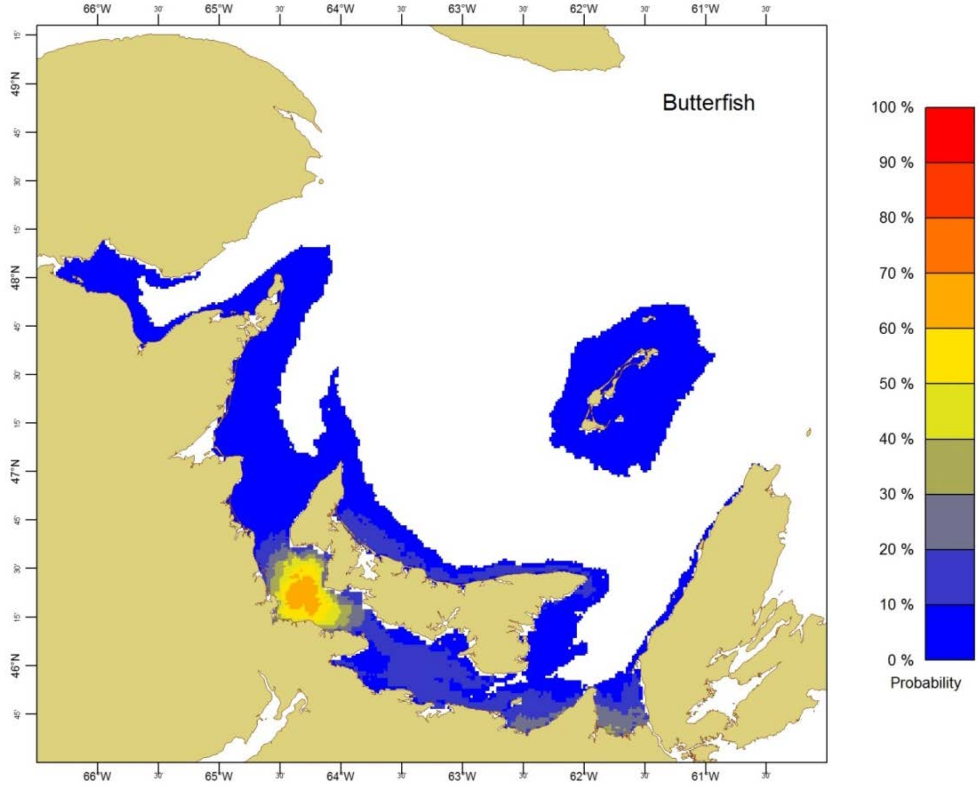


Figure 12. Contour map showing the predicted probabilities of capturing Butterfish (Peprilus triacanthus) during a standard tow, using a Western IIA bottom trawl.

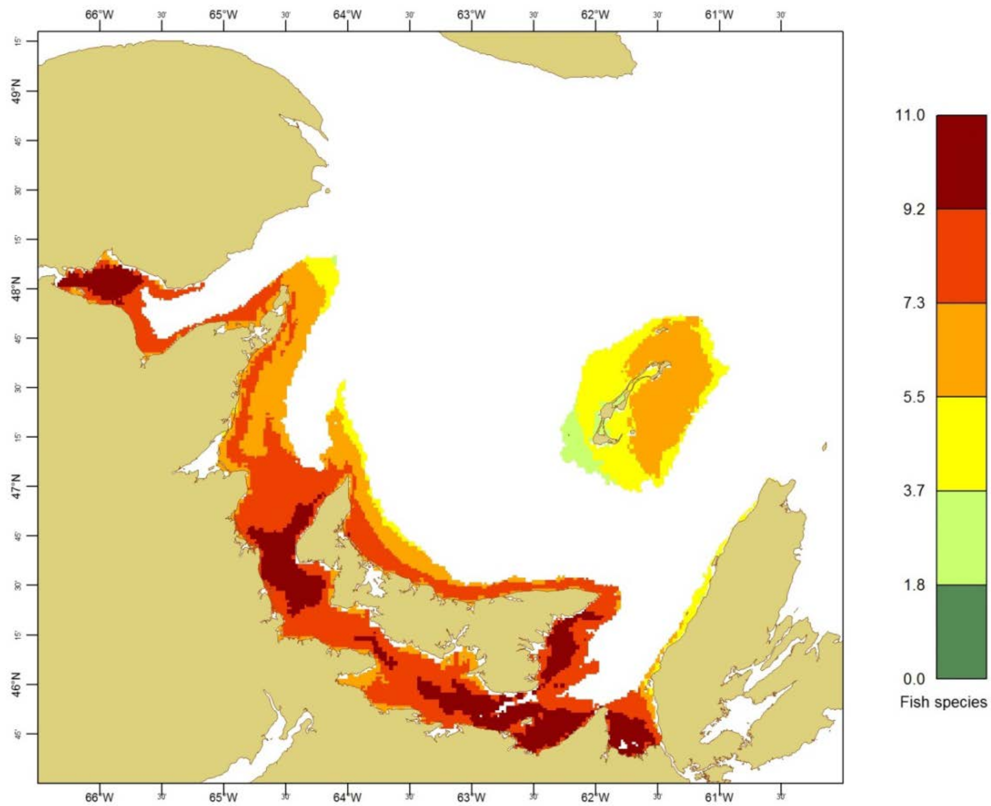


Figure 13. Pseudo-diversity contour map based on the 32 fish species examined.

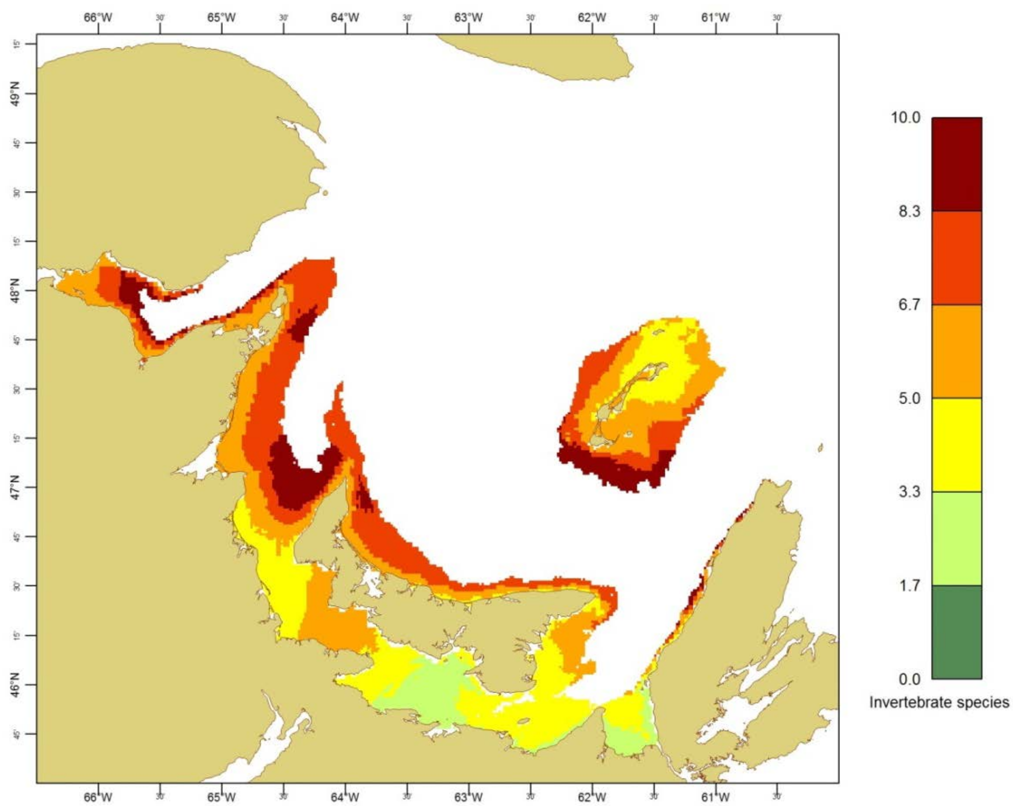


Figure 14. Pseudo-diversity contour map based on the 23 invertebrate species examined.

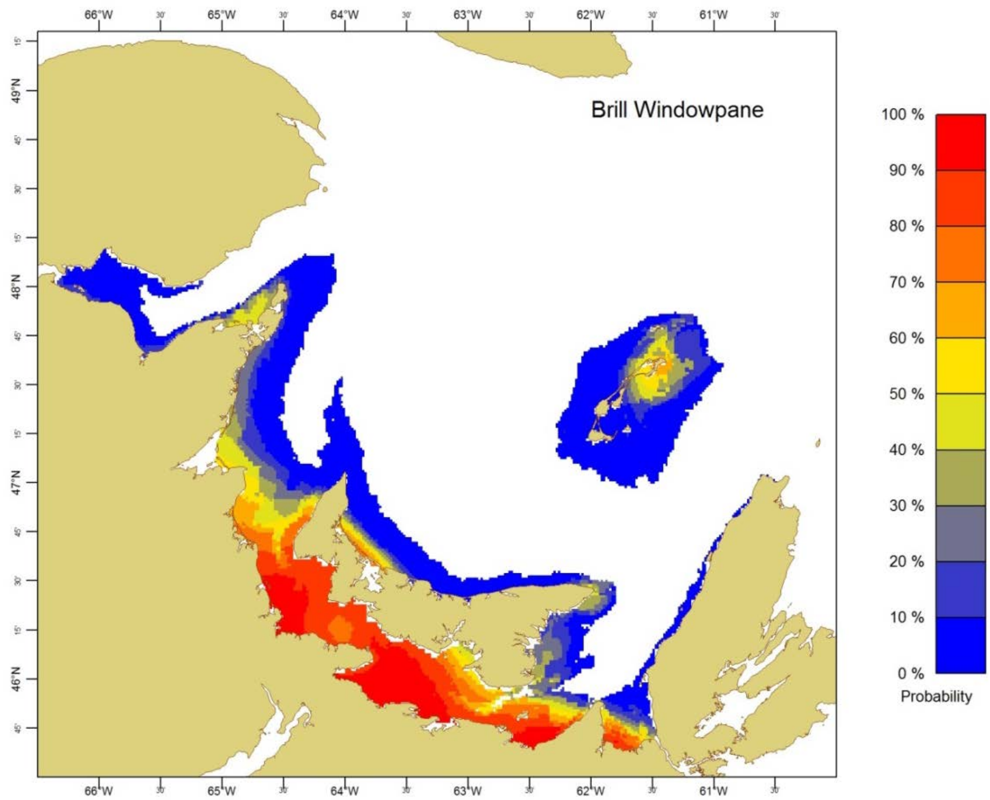


Figure 15. Contour map showing the predicted probabilities of capturing windowpane (Scophthalmus aquosus) during a standard tow, using a Western IIA bottom trawl.

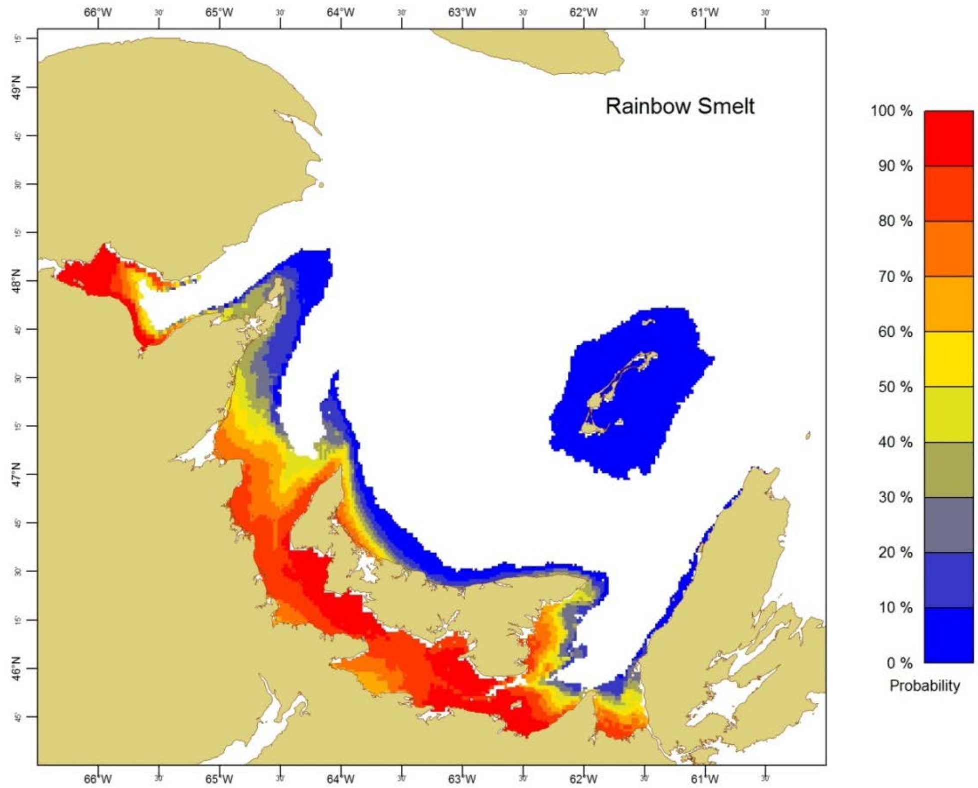


Figure 16. Contour map showing the predicted probabilities of capturing rainbow smelt (Osmerus mordax) during a standard tow, using a Western IIA bottom trawl.

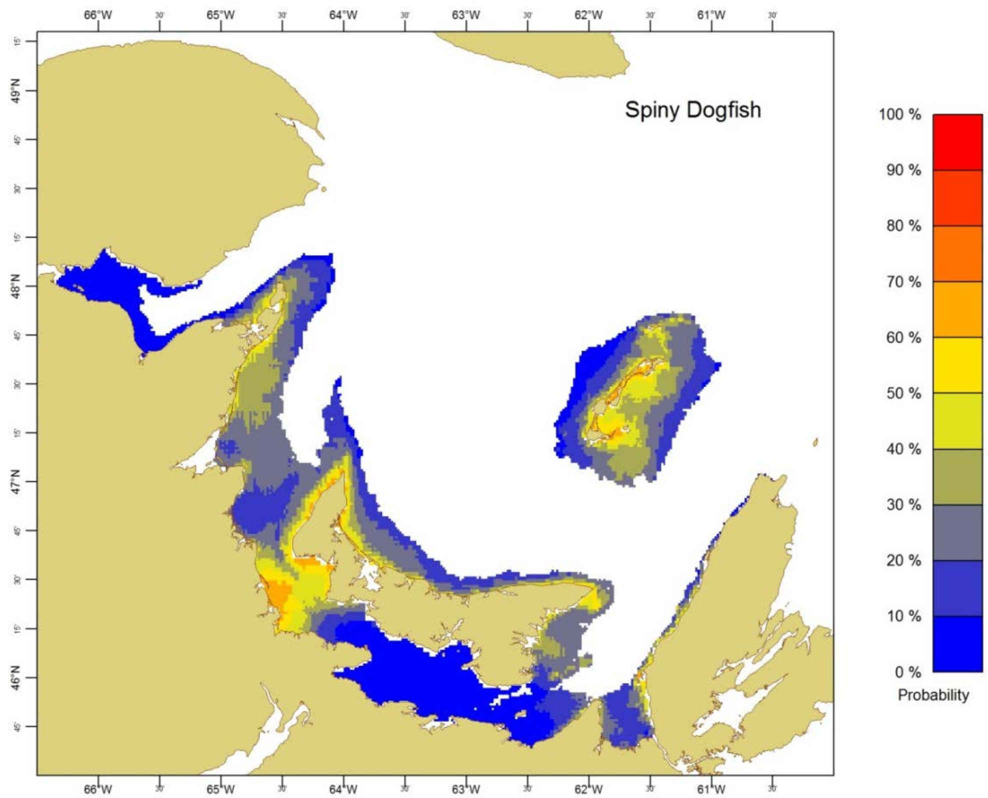


Figure 17. Contour map showing the predicted probabilities of capturing spiny dogfish (Squalus acanthias) during a standard tow, using a Western IIA bottom trawl.

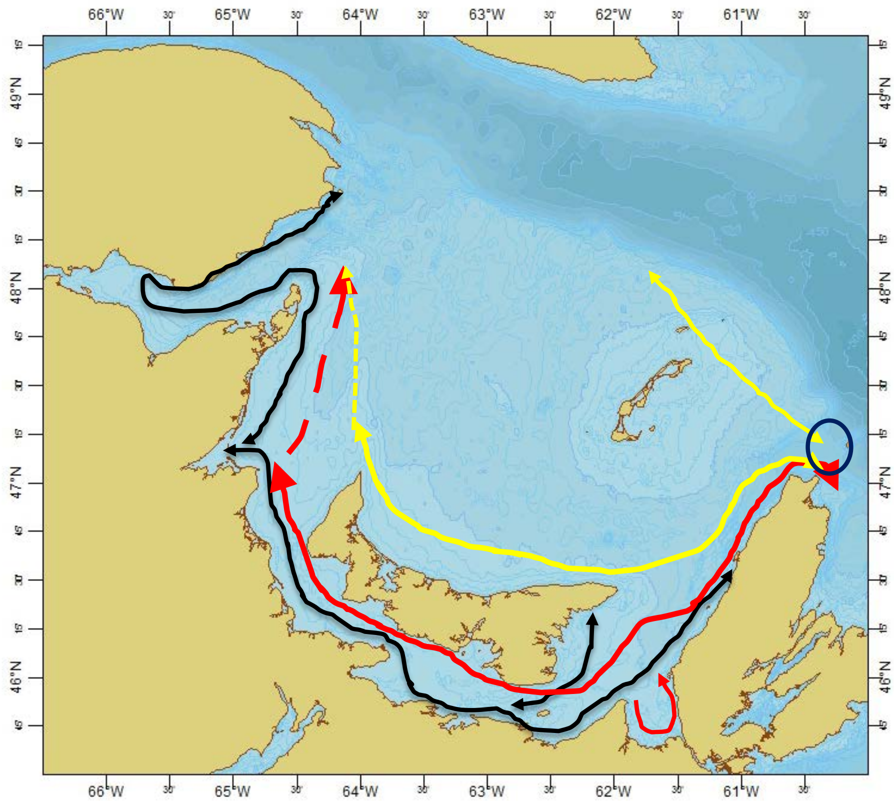
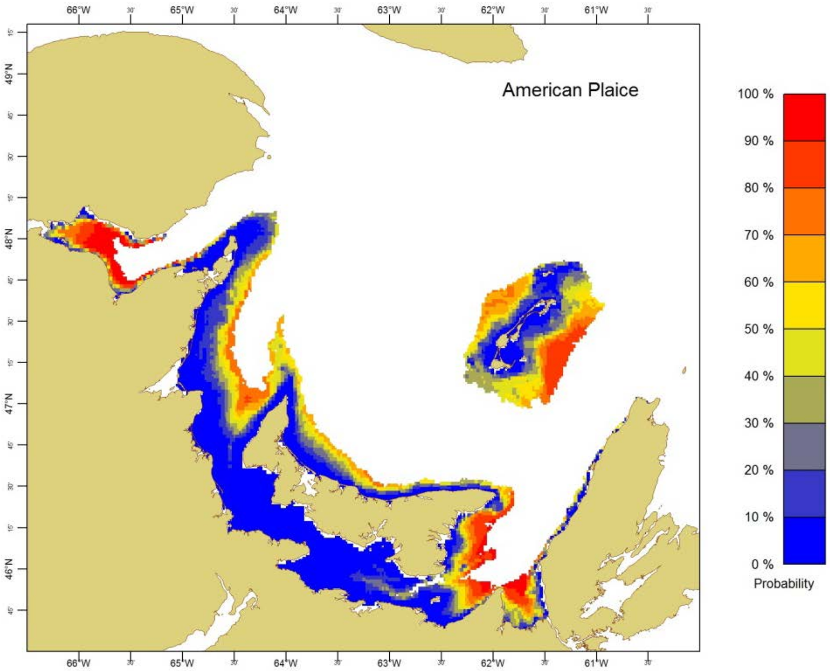


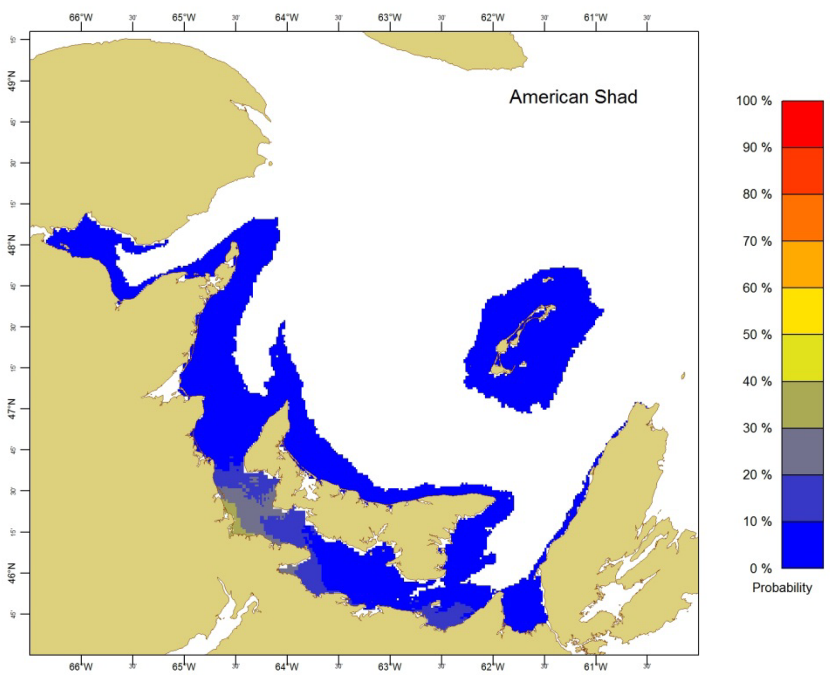
Figure 18. Major migration corridors for striped bass (black) and long distance migrants (red and yellow) with the most important route for anadromous species shown in red. The choke point through which most species presumably pass to exit the Gulf of St. Lawrence (southern route) is indicated by a dark blue circle between the tip of Cape Breton and St. Paul Island. NB. Striped bass migrate very close to shore, usually within several hundred meters, but this could not be shown to scale.

APPENDICES

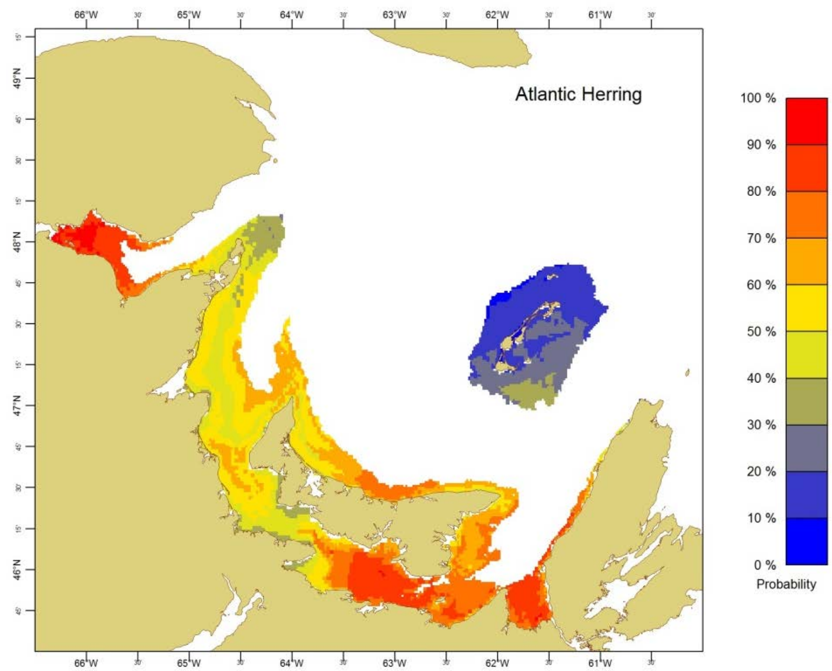
APPENDIX 1: CONTOUR MAPS OF DISTRIBUTION OF FISH AND INVERTEBRATES SPECIES



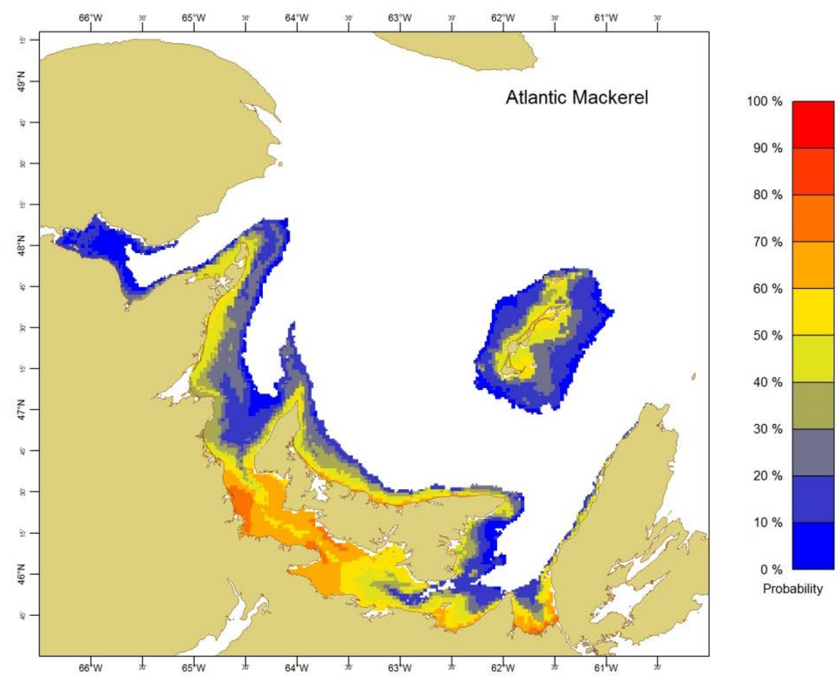
Map 1. Contour map showing the predicted probabilities of capturing American plaice (Hippogloissoides platessoides) during a standard tow, using a Western IIA bottom trawl.



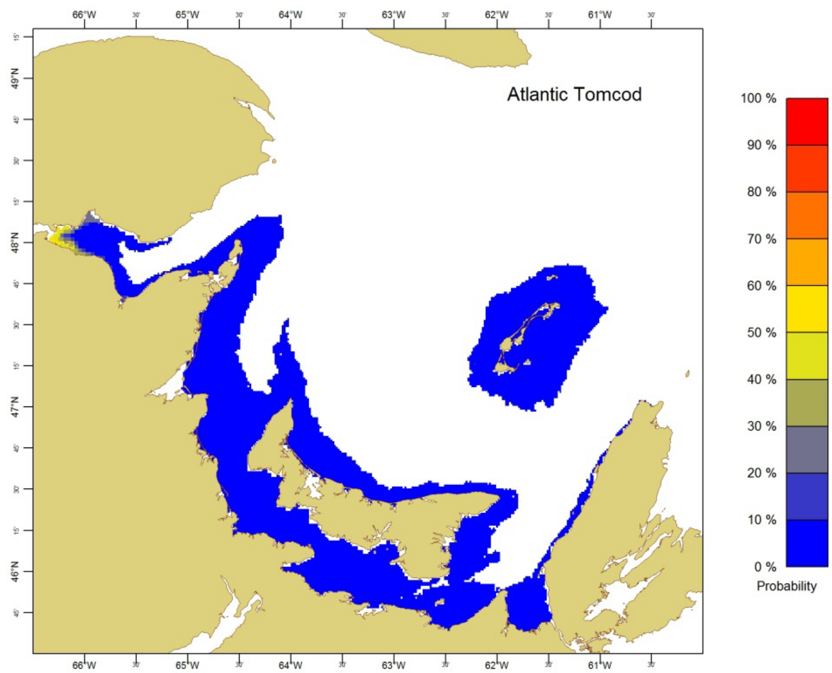
Map 2. Contour map showing the predicted probabilities of capturing American shad (Alosa sapidissima) during a standard tow, using a Western IIA bottom trawl.



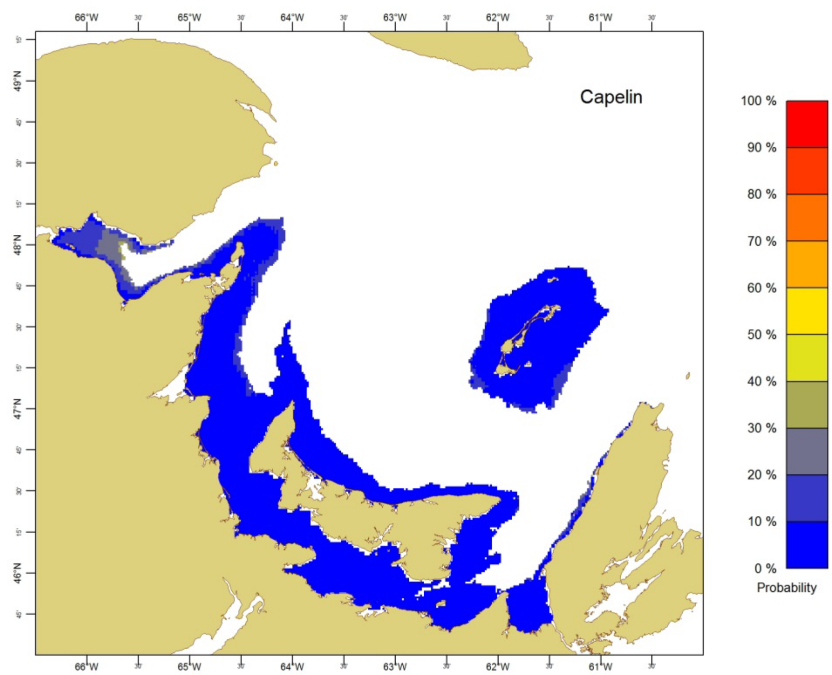
Map 3. Contour map showing the predicted probabilities of capturing Atlantic herring (Clupea harengus) during a standard tow, using a Western IIA bottom trawl.



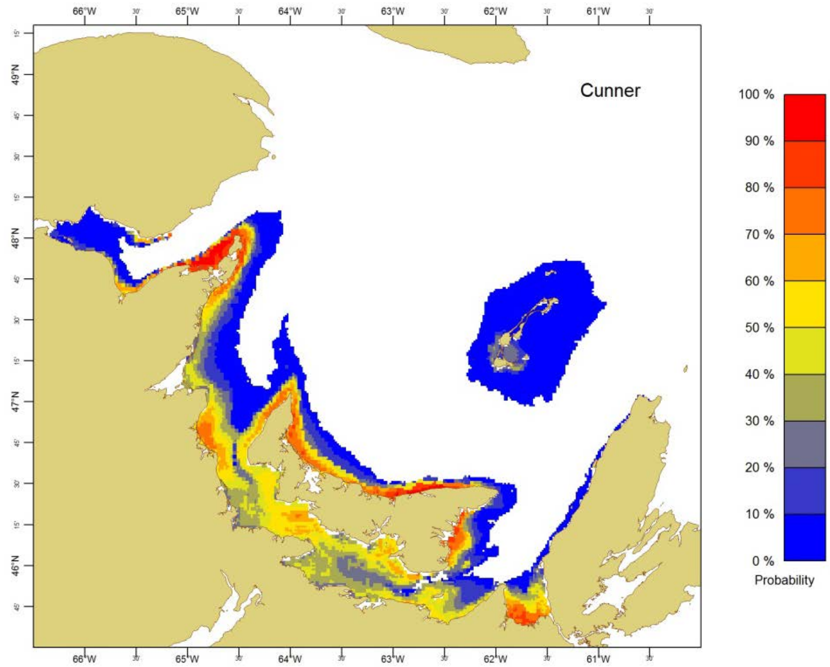
Map 4. Contour map showing the predicted probabilities of capturing Atlantic mackerel (Scomber scombrus) during a standard tow, using a Western IIA bottom trawl.



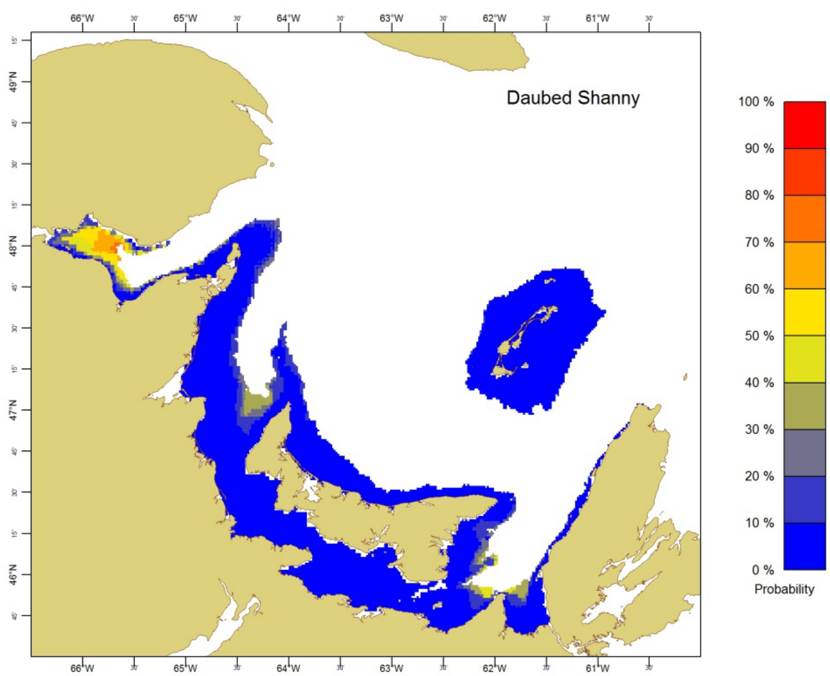
Map 5. Contour map showing the predicted probabilities of capturing Atlantic tomcod (Microgadus tomcod) during a standard tow, using a Western IIA bottom trawl.



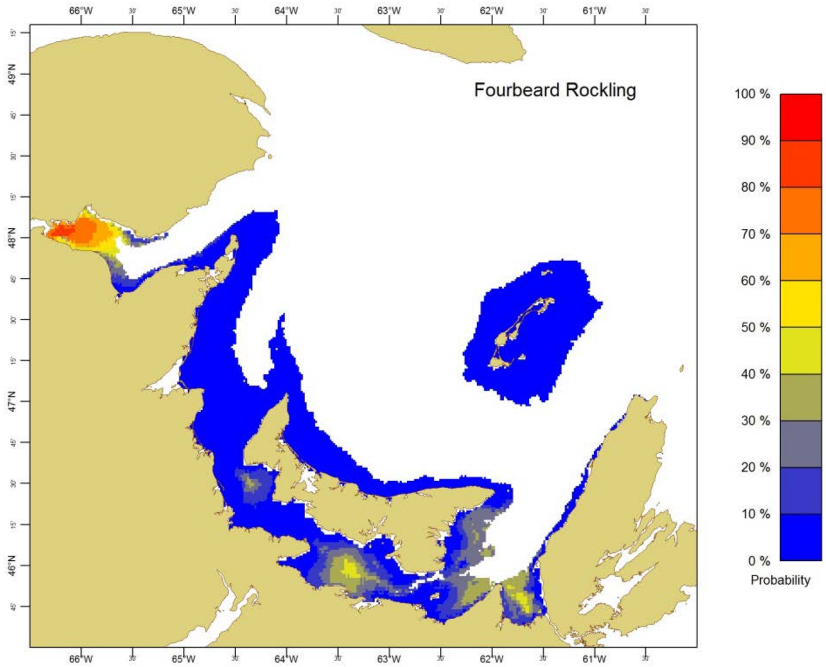
Map 6. Contour map showing the predicted probabilities of capturing capelin (Mallotus villosus) during a standard tow, using a Western IIA bottom trawl.



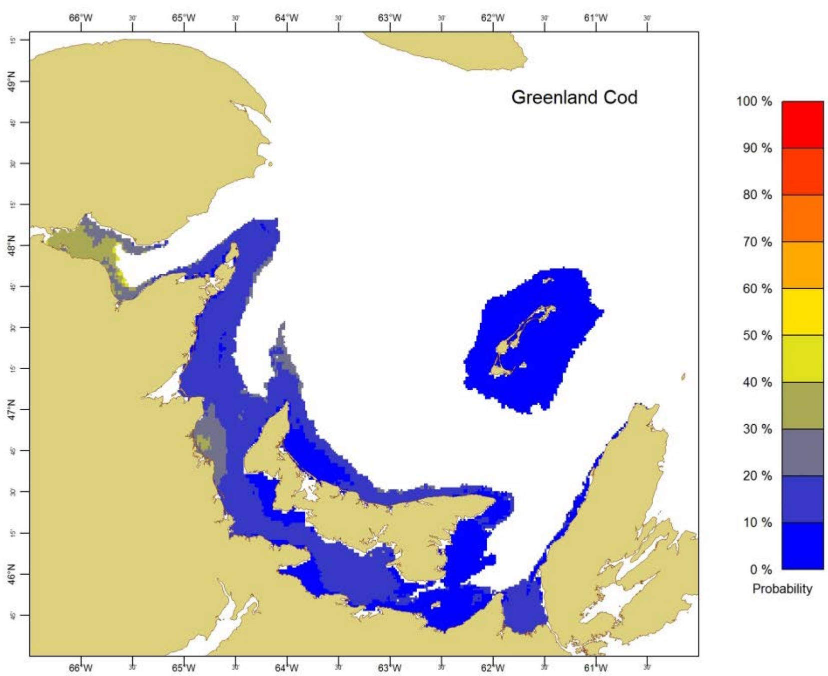
Map 7. Contour map showing the predicted probabilities of capturing cunner (Tautoglabrus adspersus) during a standard tow, using a Western IIA bottom trawl.



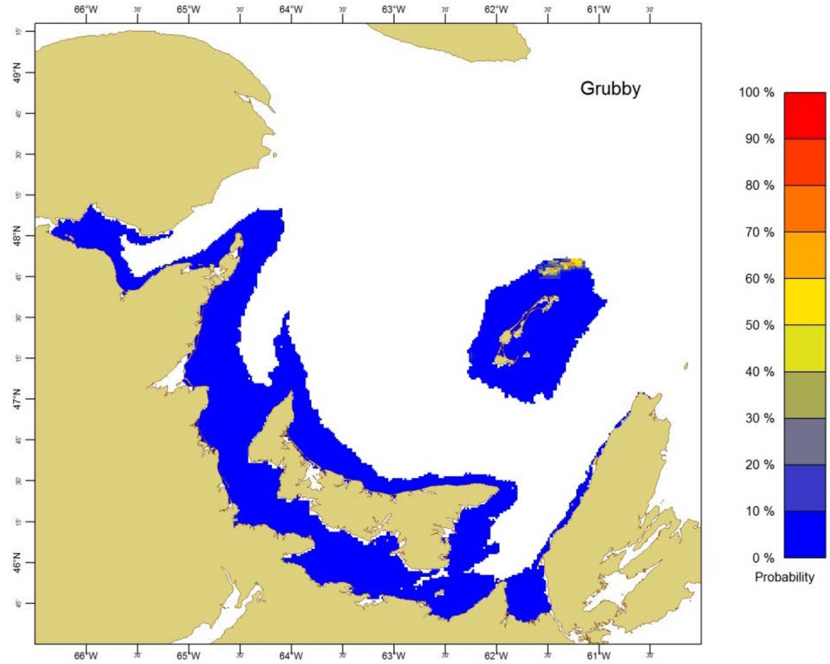
Map 8. Contour map showing the predicted probabilities of capturing daubed shanny (Leptoclinus maculatus) during a standard tow, using a Western IIA bottom trawl.



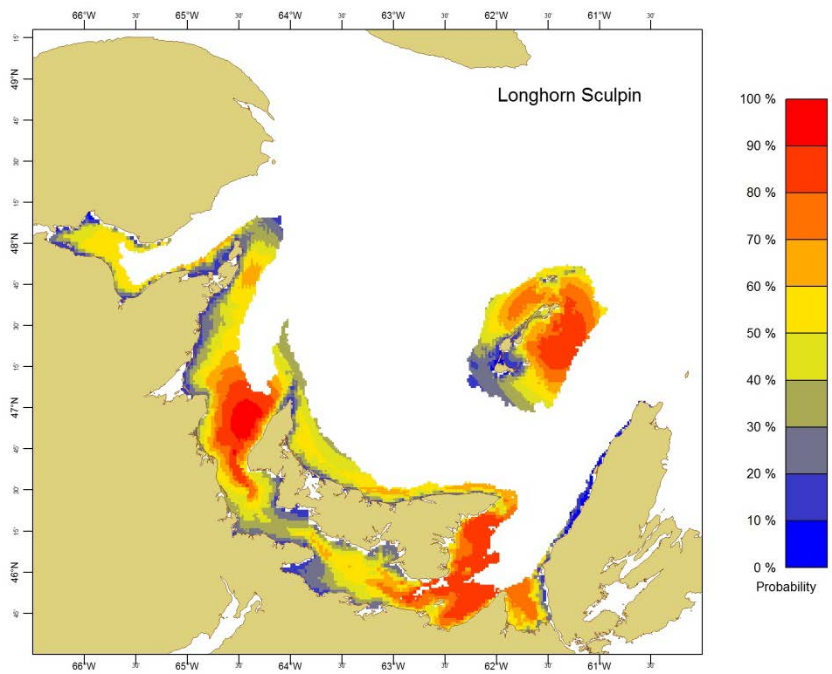
Map 9. Contour map showing the predicted probabilities of capturing fourbeard rockling (Enchelyopus cimbrius) during a standard tow, using a Western IIA bottom trawl.



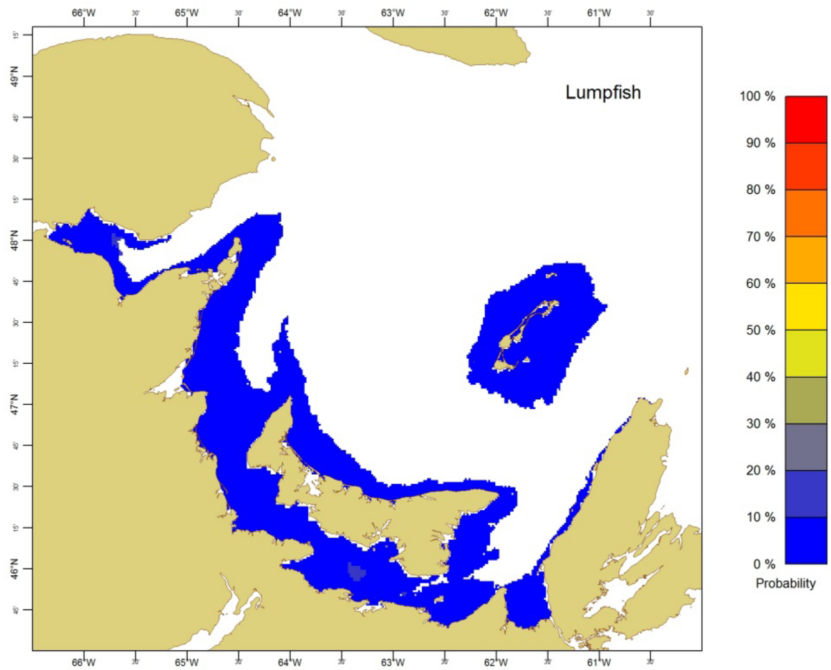
Map 10. Contour map showing the predicted probabilities of capturing Greenland cod (Gadus ogac) during a standard tow, using a Western IIA bottom trawl.



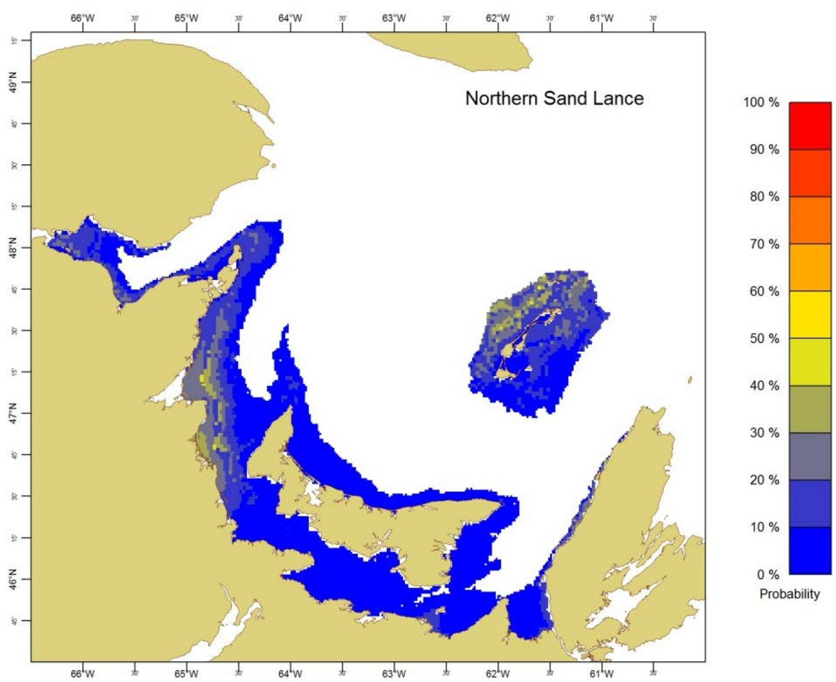
Map 11. Contour map showing the predicted probabilities of capturing grubby (Myoxocephalus aenaeus) during a standard tow, using a Western IIA bottom trawl.



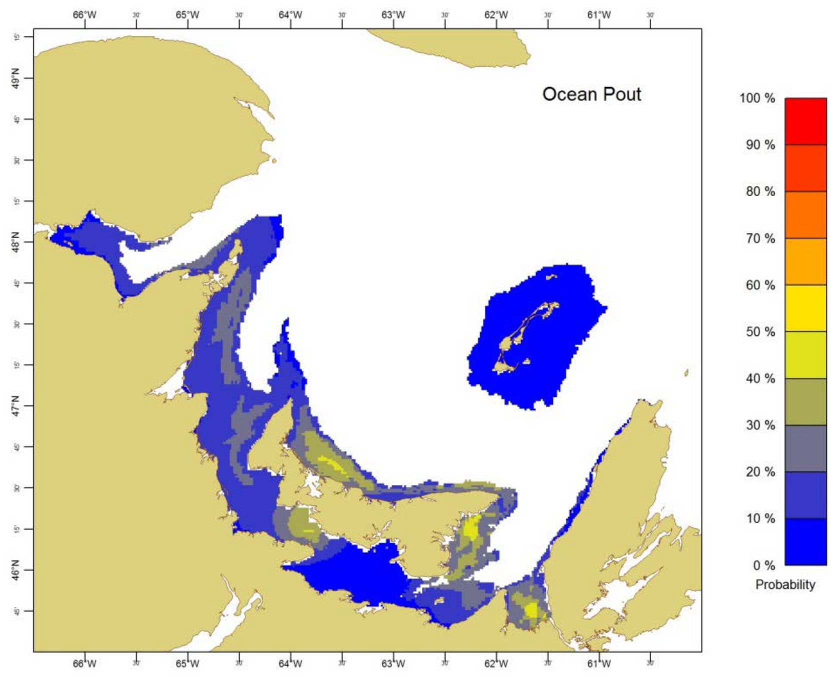
Map 12. Contour map showing the predicted probabilities of capturing longhorn sculpin (Myoxocephalus octodecemspinosus) during a standard tow, using a Western IIA bottom trawl.



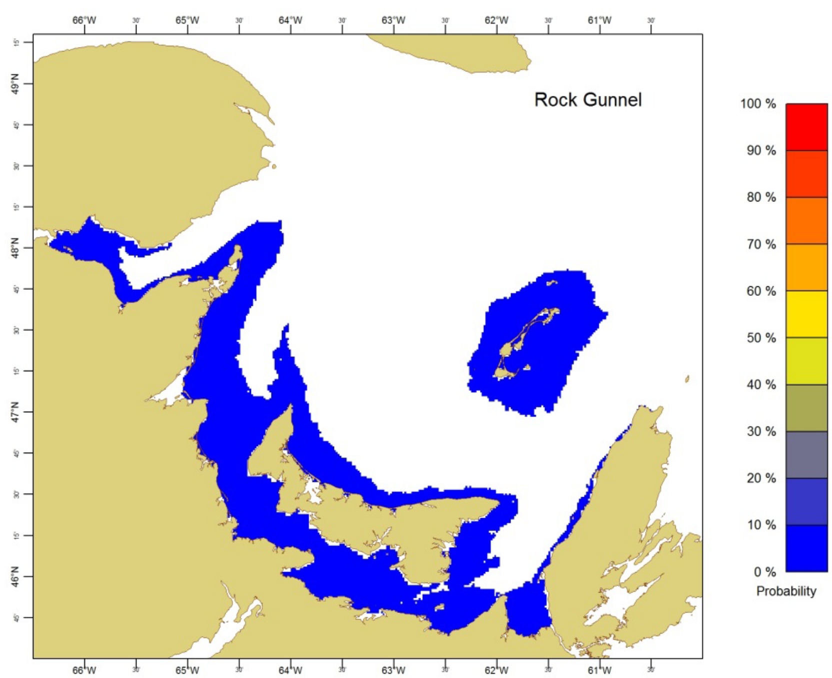
Map 13. Contour map showing the predicted probabilities of capturing lumpfish (Cyclopterus lumpus) during a standard tow, using a Western IIA bottom trawl.



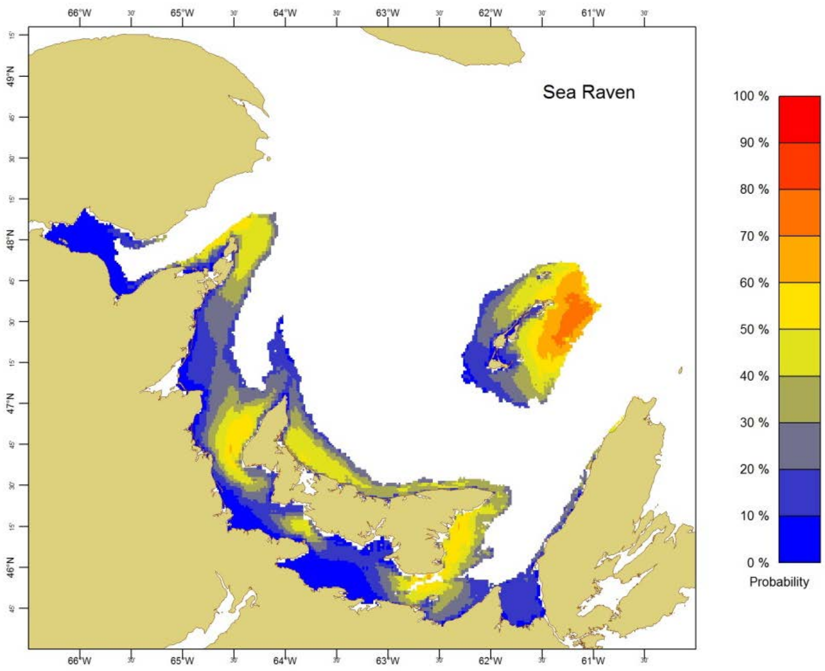
Map 14. Contour map showing the predicted probabilities of capturing northern sand lance (Ammodytes sp.) during a standard tow, using a Western IIA bottom trawl.



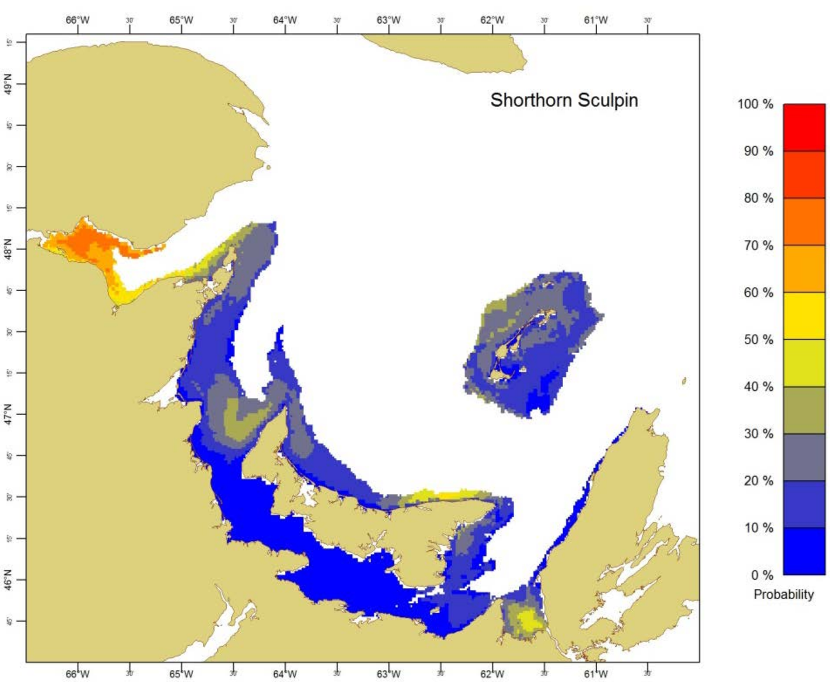
Map 15. Contour map showing the predicted probabilities of capturing ocean pout (Zoarces americanus) during a standard tow, using a Western IIA bottom trawl.



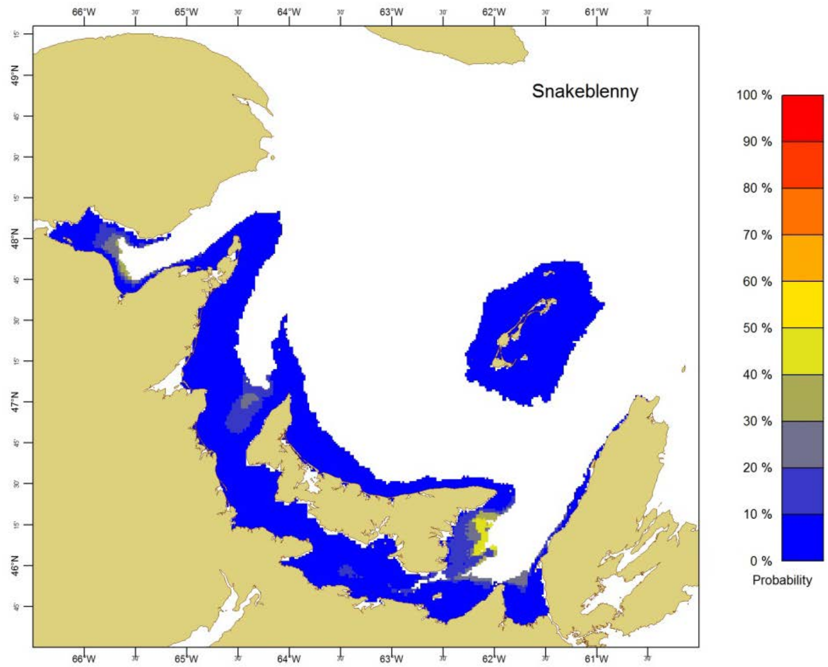
Map 16. Contour map showing the predicted probabilities of capturing rock gunnel (Pholis gunnelus) during a standard tow, using a Western IIA bottom trawl.



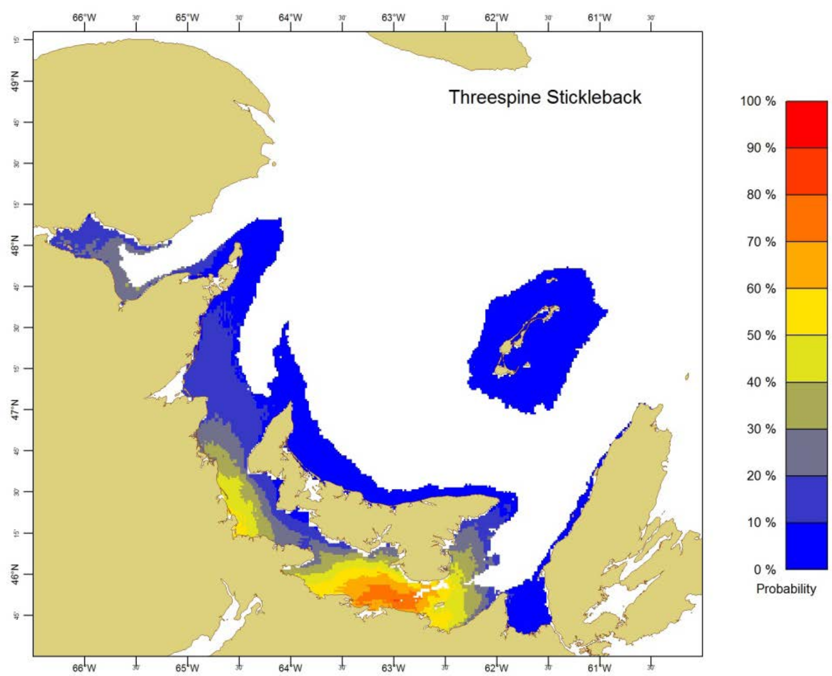
Map 17. Contour map showing the predicted probabilities of capturing sea raven (Hemitripterus americanus) during a standard tow, using a Western IIA bottom trawl.



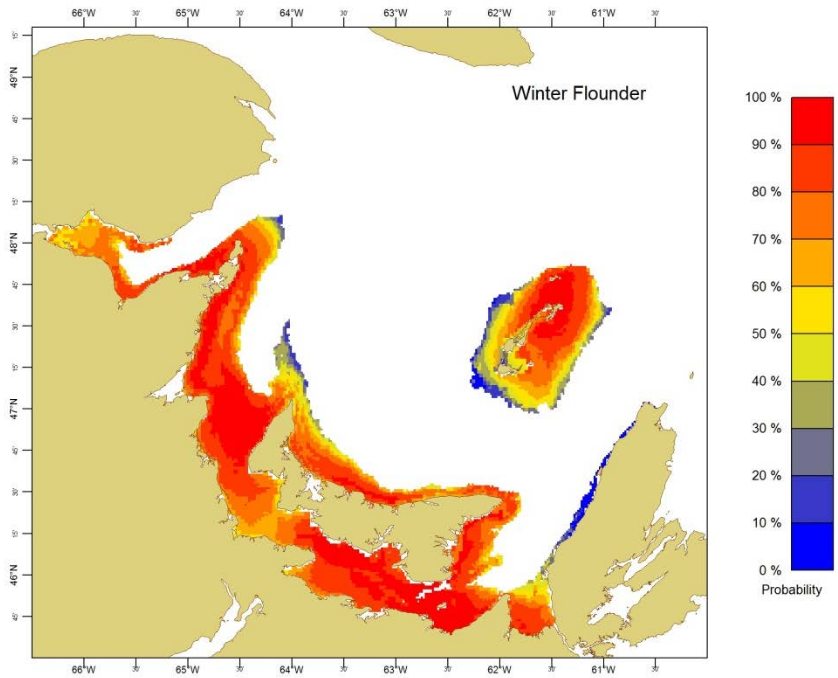
Map 18. Contour map showing the predicted probabilities of capturing shorthorn sculpin (Myoxocephalus scorpius) during a standard tow, using a Western IIA bottom trawl.



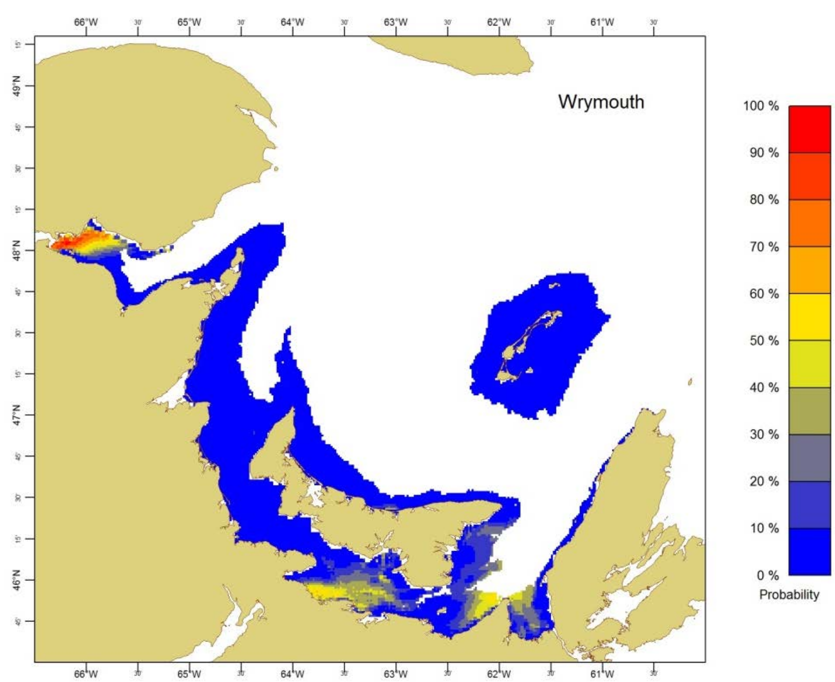
Map 19. Contour map showing the predicted probabilities of capturing snakeblenny (Lumpenus lampretaeformis) during a standard tow, using a Western IIA bottom trawl.



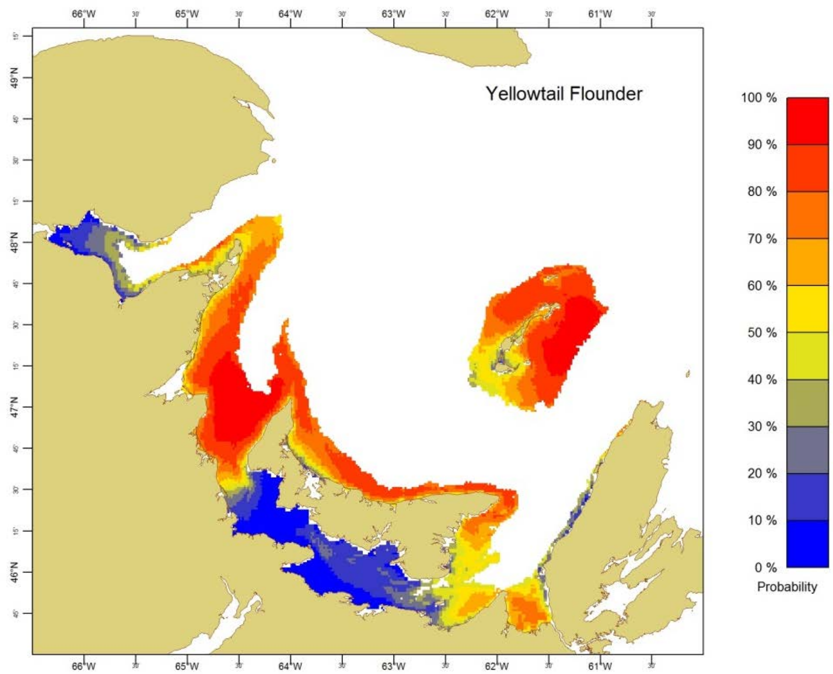
Map 20. Contour map showing the predicted probabilities of capturing threespine stickleback (Gasterosteus aculeatus) during a standard tow, using a Western IIA bottom trawl.



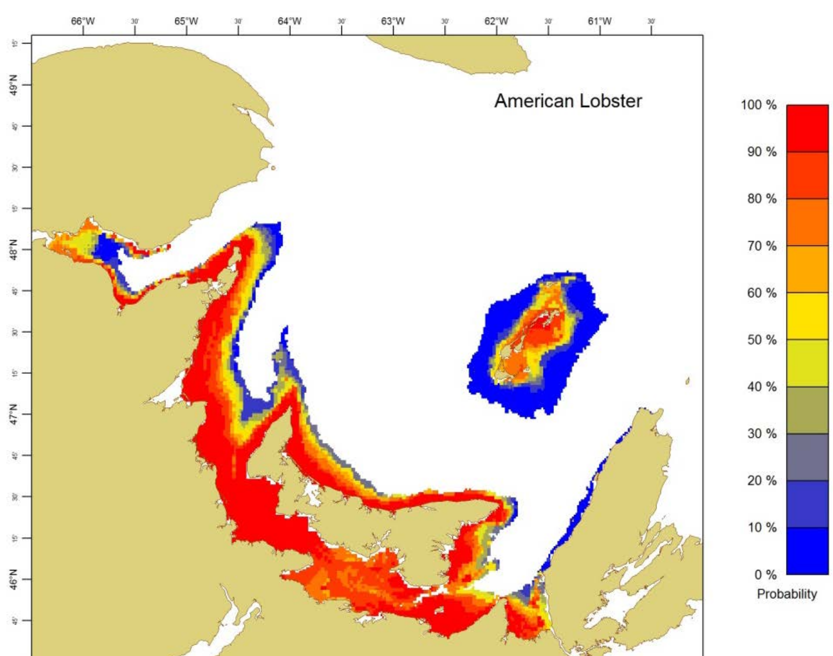
Map 21. Contour map showing the predicted probabilities of capturing winter flounder (Pseudopleuronectes americanus) during a standard tow, using a Western IIA bottom trawl.



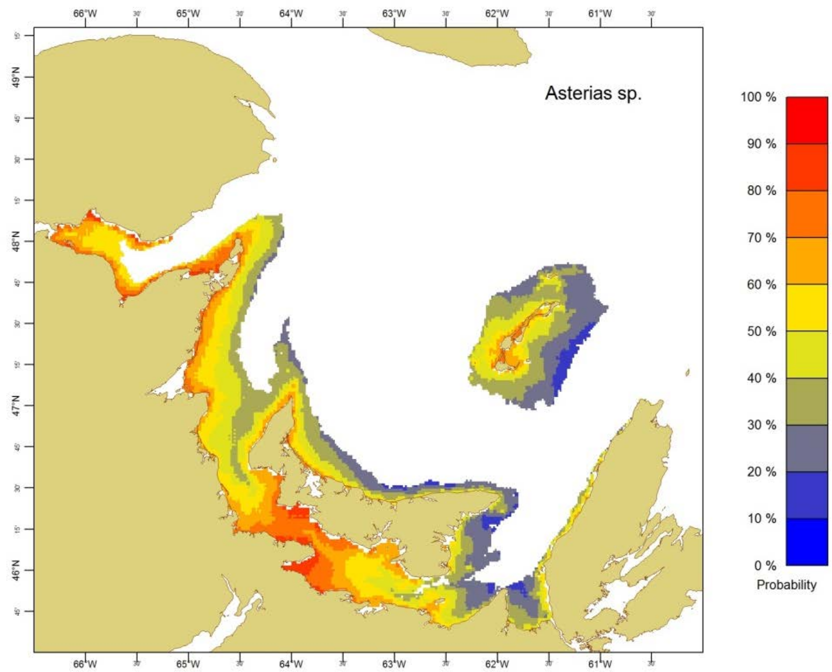
Map 22. Contour map showing the predicted probabilities of capturing wrymouth (Cryptacanthodes maculatus) during a standard tow, using a Western IIA bottom trawl.



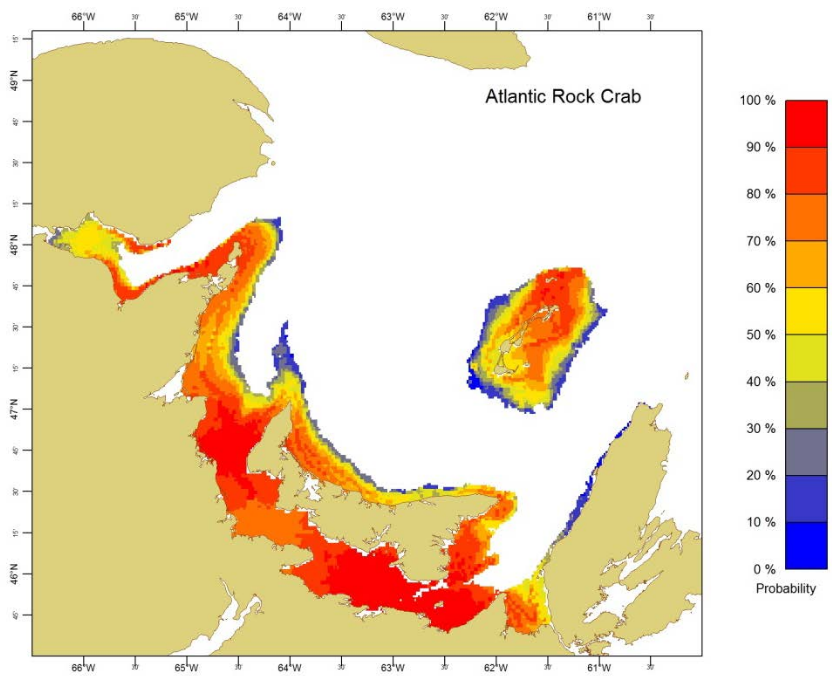
Map 23. Contour map showing the predicted probabilities of capturing yellowtail flounder (Limanda ferruginea) during a standard tow, using a Western IIA bottom trawl.



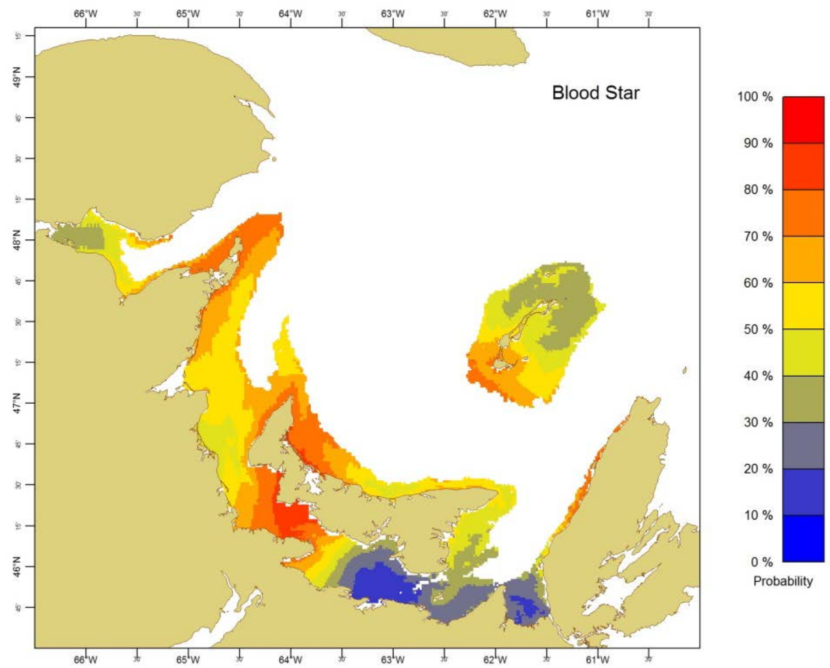
Map 24. Contour map showing the predicted probabilities of capturing American lobster (Homarus americanus) during a standard tow, using a Western IIA bottom trawl.



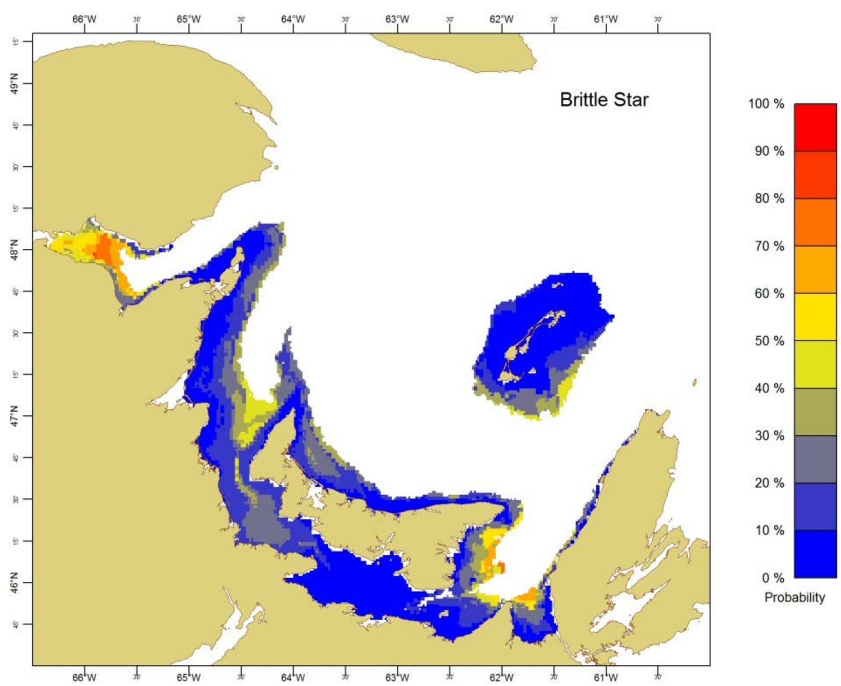
Map 25. Contour map showing the predicted probabilities of capturing asterias (Asterias sp.) during a standard tow, using a Western IIA bottom trawl.



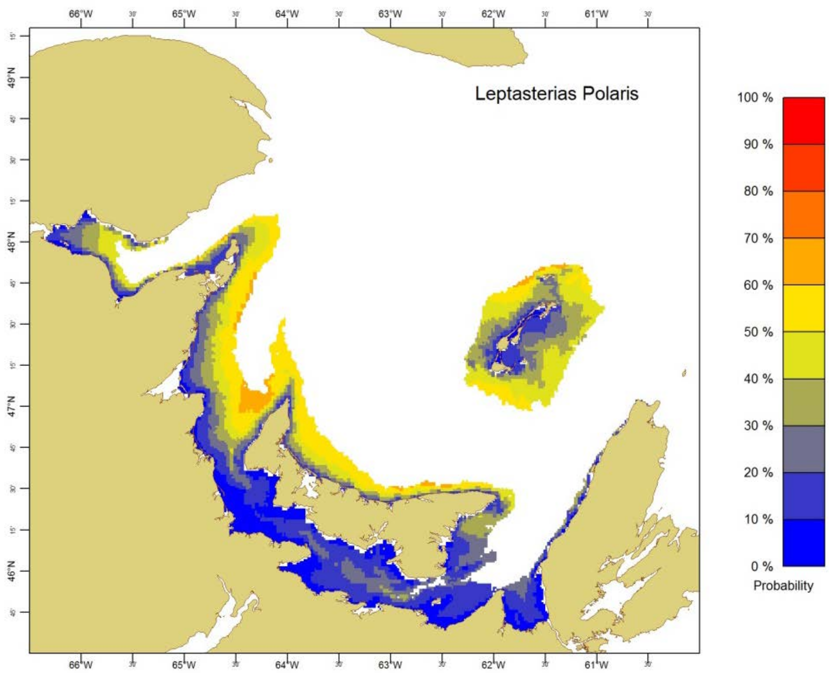
Map 26. Contour map showing the predicted probabilities of capturing Atlantic rock crab (Cancer irroratus) during a standard tow, using a Western IIA bottom trawl.



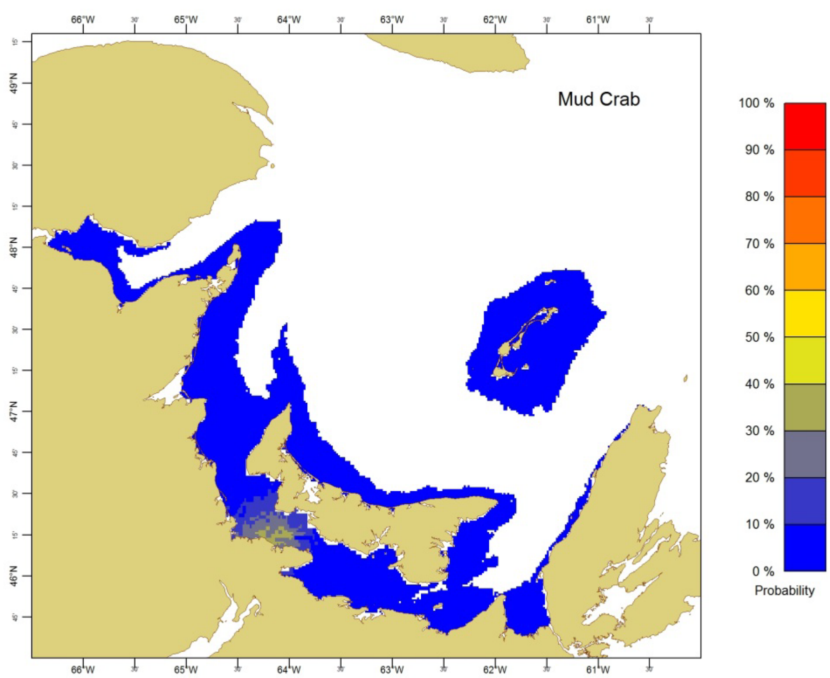
Map 27. Contour map showing the predicted probabilities of capturing blood star (Henricia sp.) during a standard tow, using a Western IIA bottom trawl.



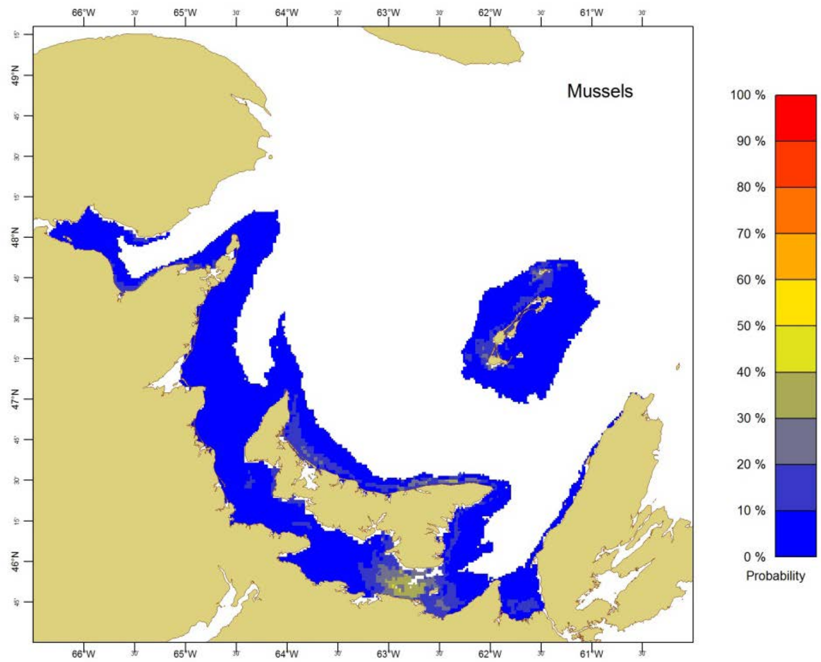
Map 28. Contour map showing the predicted probabilities of capturing brittle star (Ophiuroidea) during a standard tow, using a Western IIA bottom trawl.



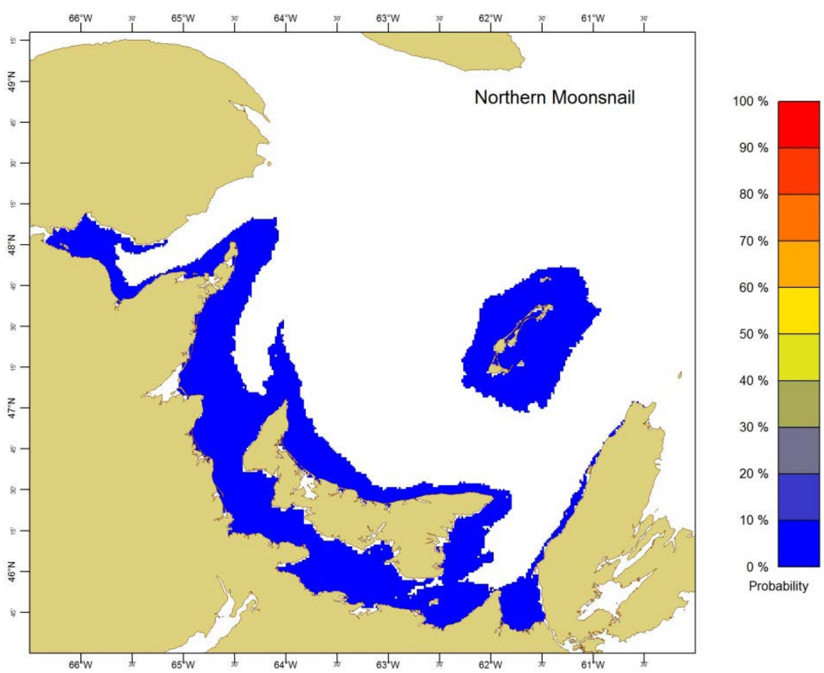
Map 29. Contour map showing the predicted probabilities of capturing polar sea star (Leptasterias polaris) during a standard tow, using a Western IIA bottom trawl.



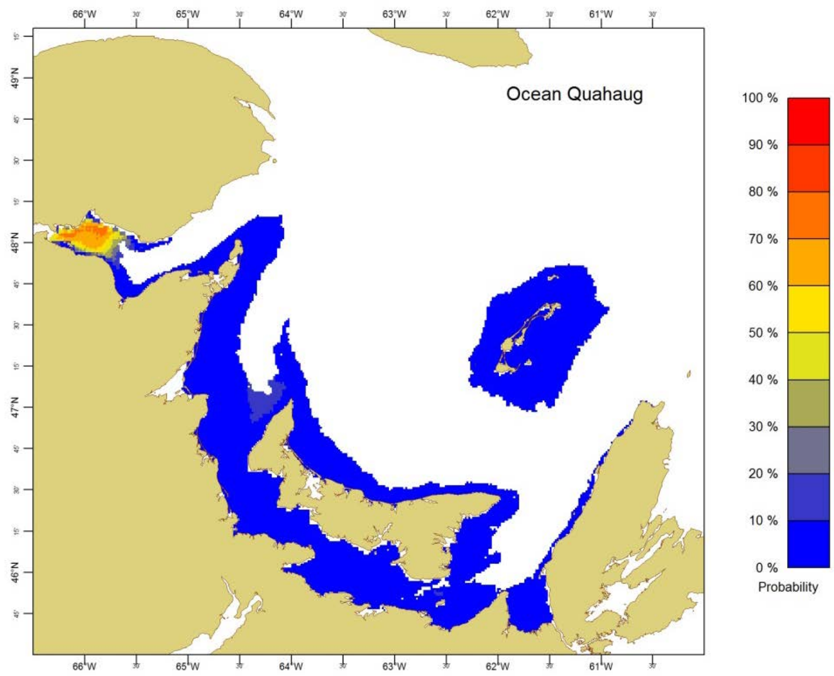
Map 30. Contour map showing the predicted probabilities of capturing mud crab (Dyspanopeus sayi) during a standard tow, using a Nephrops *trawl.*



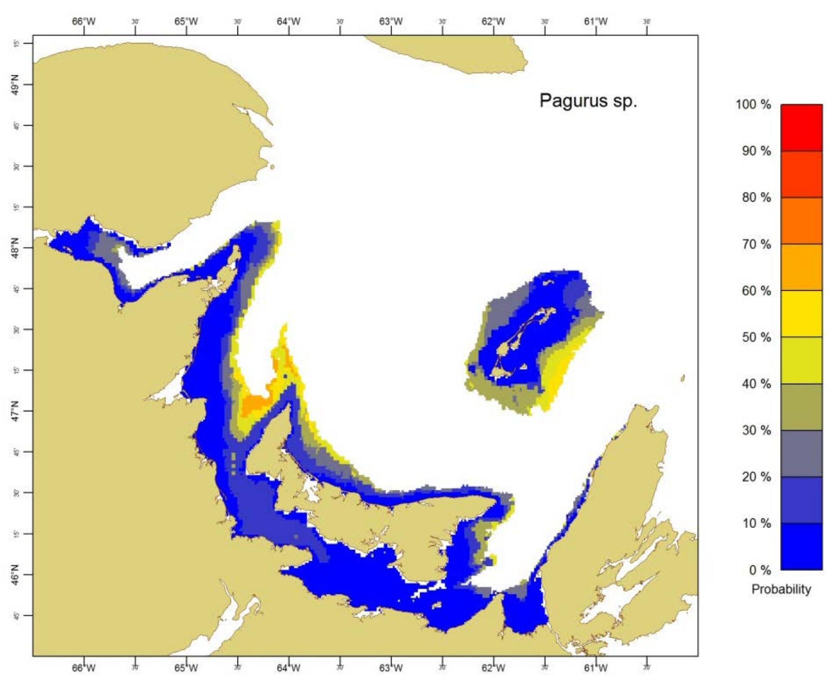
Map 31. Contour map showing the predicted probabilities of capturing mussels (includes Mytilus edulis, Musculus niger and Modiolus modiolus) during a standard tow, using a Western IIA bottom trawl.



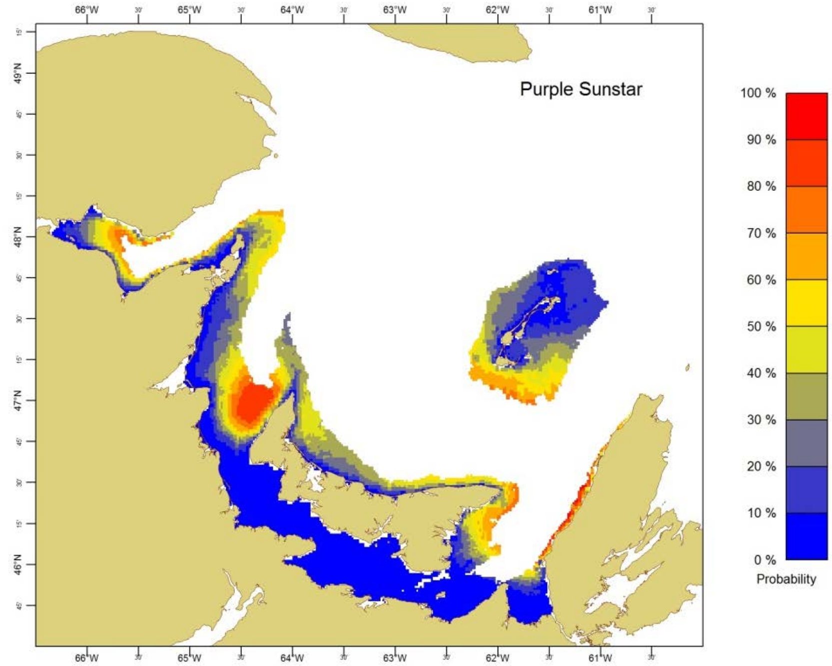
Map 32. Contour map showing the predicted probabilities of capturing northern moonsnail (Euspira eros) during a standard tow, using a Western IIA bottom trawl.



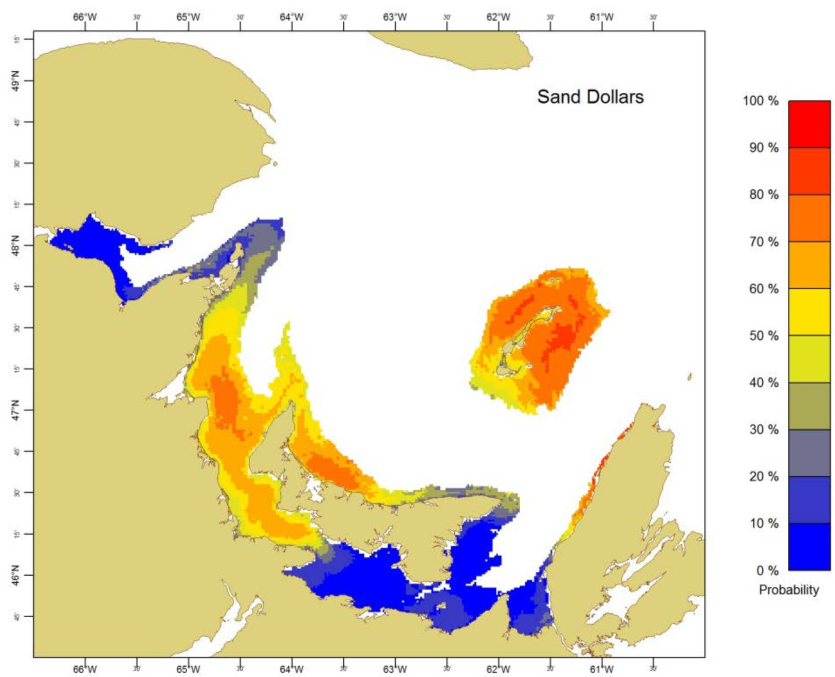
Map 33. Contour map showing the predicted probabilities of capturing ocean quahaug (Arctica islandica) during a standard tow, using a Western IIA bottom trawl.



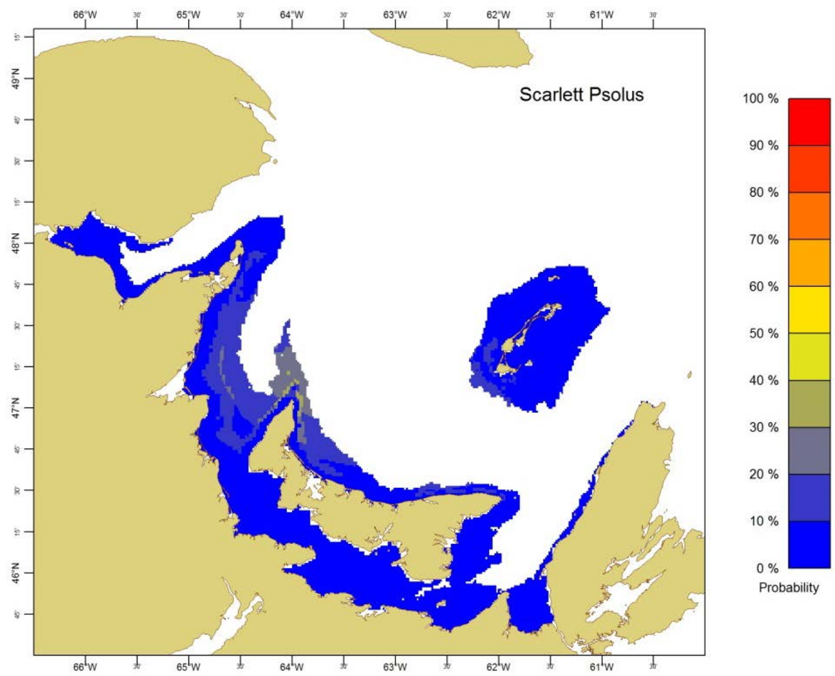
Map 34. Contour map showing the predicted probabilities of capturing hermit crab (Pagurus sp.) during a standard tow, using a Western IIA bottom trawl.



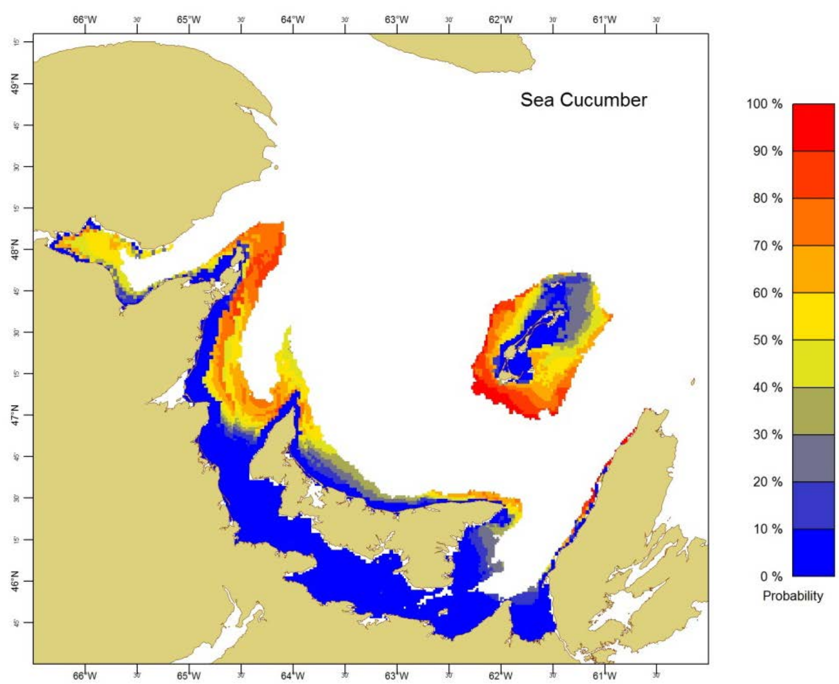
Map 35. Contour map showing the predicted probabilities of capturing purple sunstar (Solaster endeca) during a standard tow, using a Western IIA bottom trawl.



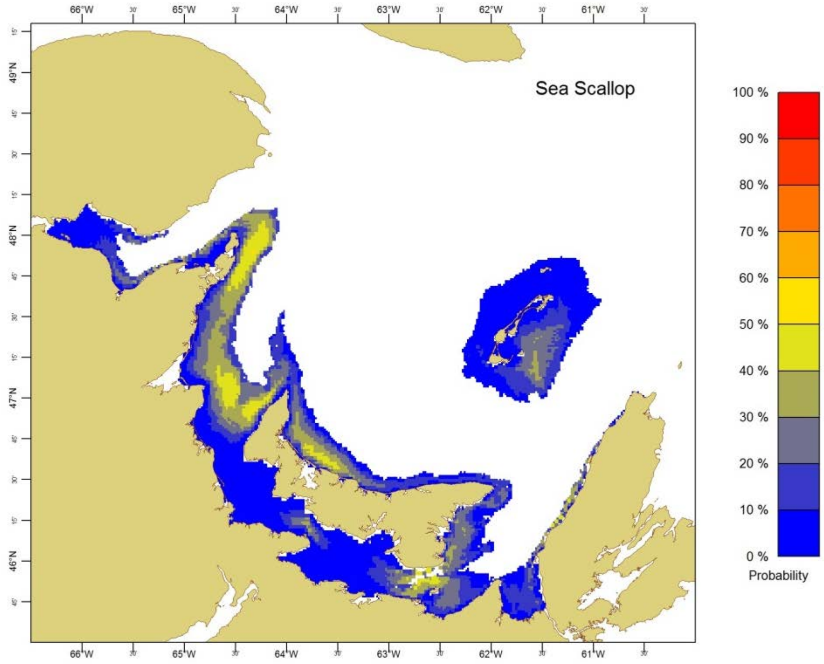
Map 36. Contour map showing the predicted probabilities of capturing sand dollars (Echinarachnius parma) during a standard tow, using a Western IIA bottom trawl.



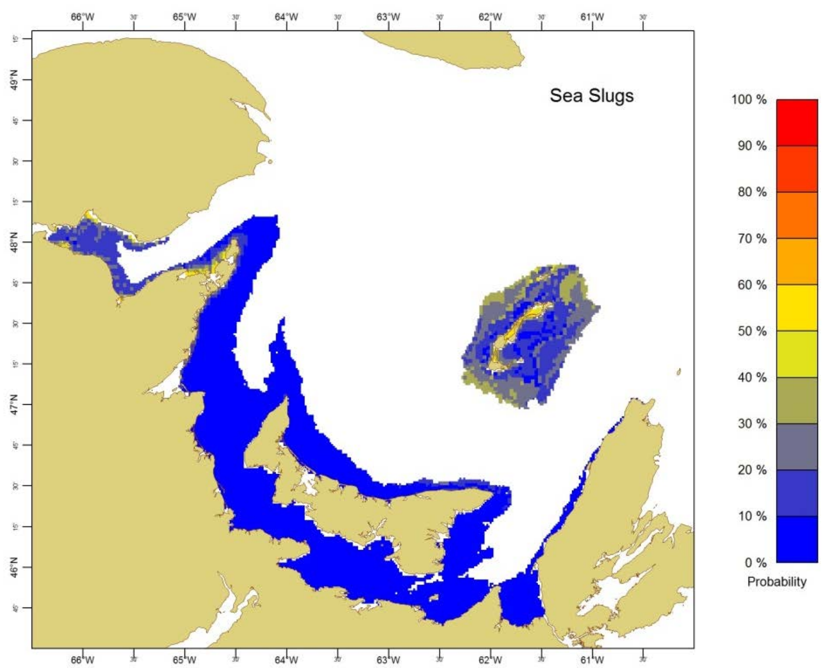
Map 37. Contour map showing the predicted probabilities of capturing scarlet psolus (Psolus fabricii) during a standard tow, using a Western IIA bottom trawl.



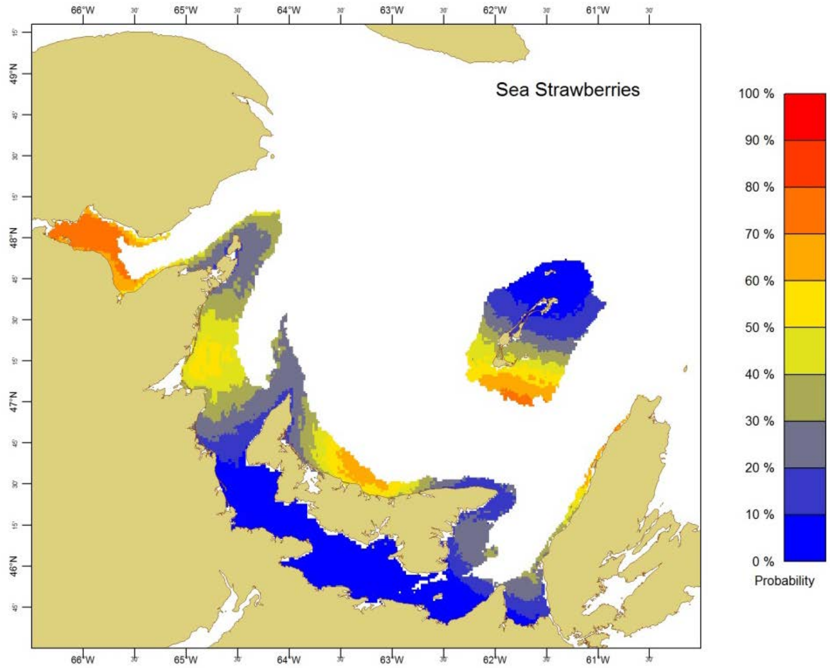
Map 38. Contour map showing the predicted probabilities of capturing sea cucumber (Cucumaria frondosa) during a standard tow, using a Western IIA bottom trawl.



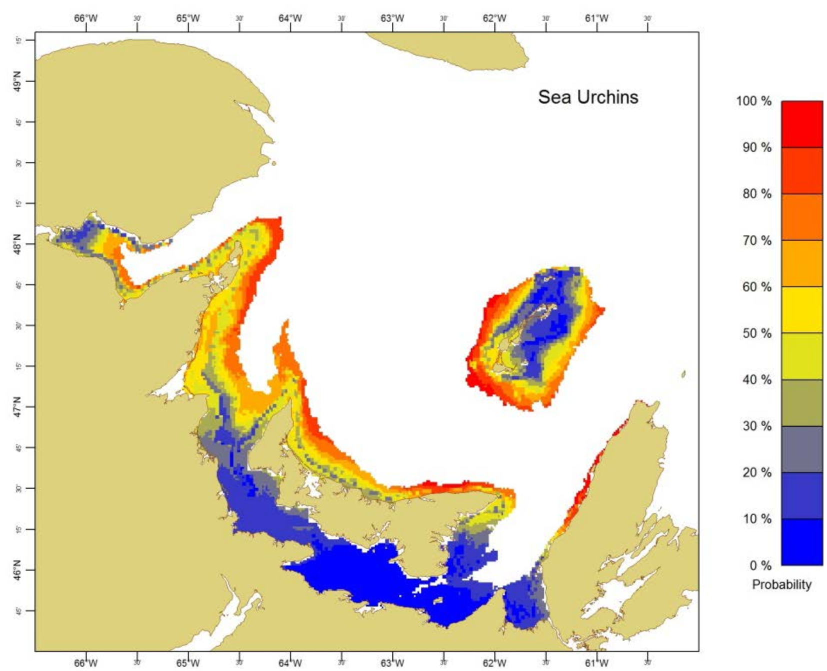
Map 39. Contour map showing the predicted probabilities of capturing sea scallop (Placopecten magellanicus) during a standard tow, using a Western IIA bottom trawl.



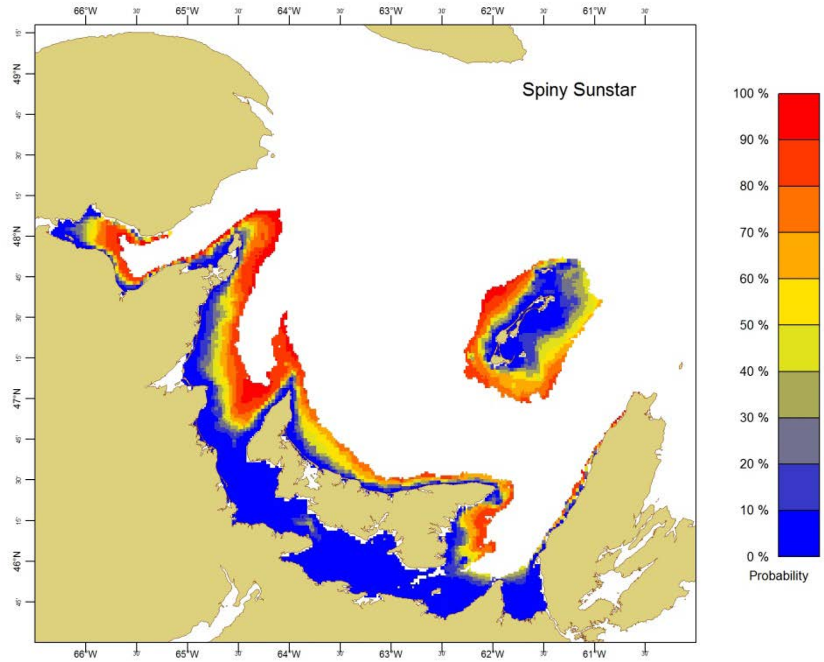
Map 40. Contour map showing the predicted probabilities of capturing sea slugs (Nudibranchia) during a standard tow, using a Western IIA bottom trawl.



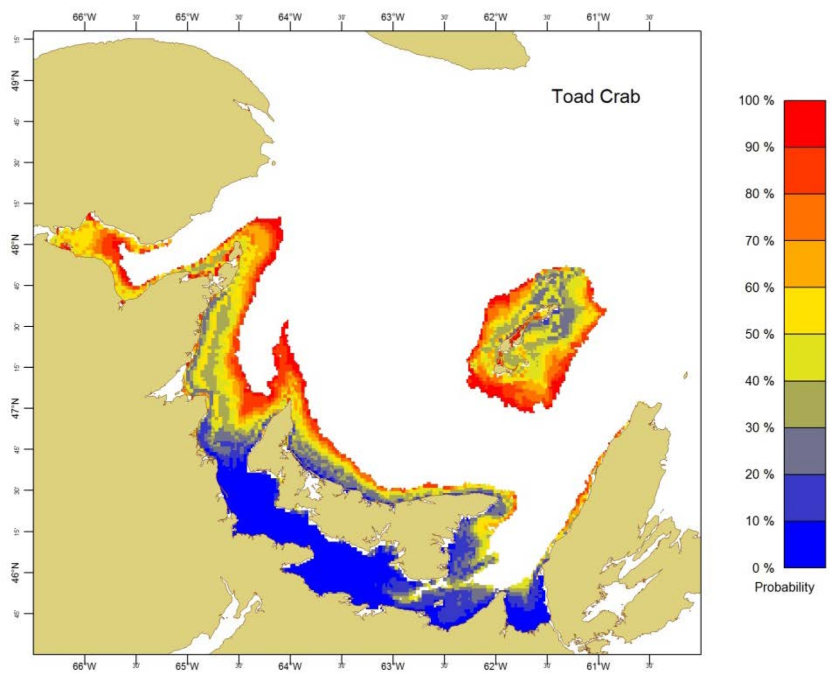
Map 41. Contour map showing the predicted probabilities of capturing sea strawberries (Gersemia sp.) during a standard tow, using a Western IIA bottom trawl.



Map 42. Contour map showing the predicted probabilities of capturing sea urchins (Strongylocentrotus sp.) during a standard tow, using a Western IIA bottom trawl.



Map 43. Contour map showing the predicted probabilities of capturing spriny sunstar (Crossaster papposus) during a standard tow, using a Western IIA bottom trawl.



Map 44. Contour map showing the predicted probabilities of capturing toad crab (Hyas sp.) during a standard tow, using a Western IIA bottom trawl.

Appendix 2. Summary of the available distribution and major habitat information[1] for the fish community (plus lady crab) found in the ≤40 m depth (coastal and upper part of the transition zone) within the southern Gulf of St. Lawrence (sGSL).

Species (reference)[1]	Guild	Portion used	Presence/ Area used
American eel (COSEWIC 2012a; DFO 2013a)	Catadromous Long-distance migrant Adults leave sGSL to breed	Both juveniles and adults transit through the study area on their migrations between oceanic spawning grounds and continental growth areas. Juveniles feed during these migrations but adults do not.	Just passing through Absent around Magdalen Islands
Atlantic salmon (COSEWIC 2010c)	Anadromous Long-distance migrant Juveniles and adults leave sGSL to feed	Pelagic Brief feeding while in transit	Just passing through
Alewife / blueback herring (Bosman et al. 2011; Cairns 1997; Darbyson and Benoît 2003; Hanson and Courtenay 1995; McQuinn et al. 2012)	Anadromous Long-distance migrant Feeding/nursery Leaves sGSL for winter	Shallow warm waters	High concentration in Northumberland Strait Absent around Magdalen Islands Leaves sGSL for winter
American shad (Bosman et al. 2011; Cairns 1997; Chaput and Bradford 2003; Hanson and Courtenay 1995; McQuinn et al. 2012)	Anadromous Long-distance migrant Feeding/nursery	Shallow warm waters	Mainly in East NB and Northumberland Strait Absent around Magdalen Islands Leaves sGSL for winter
Striped bass (Cairns 1997; COSEWIC 2012b; DFO 2014a; Douglas et al. 2009; Robinson et al. 2004)	Anadromous Resident Feeding/nursery.	Very shallow, close to shore	Absent around Magdalen Islands and north of PEI
Threespine stickleback (Bosman et al. 2011; Cairns 1997; Hanson and Courtenay 1995)	Anadromous Resident Feeding/nursery	Very shallow, close to shore	Probably ubiquitous
Atlantic tomcod (Bosman et al. 2011; Cairns 1997; Hanson and Courtenay 1995)	Anadromous Resident Feeding/nursery	Very shallow, close to shore	Absent around Magdalen Islands
Rainbow smelt (Bosman et al. 2011; Cairns 1997; Hanson and Courtenay 1995; LeBlanc et al. 1998; McQuinn et al. 2012)	Anadromous Resident Feeding/nursery	Shallow warm waters	Absent around Magdalen Islands

Species (reference)[1]	Guild	Portion used	Presence/ Area used
Butterfish (McQuinn et al. 2012)	Transient marine species Feeding only	Very shallow and estuaries Pelagic	Mainly around PEI Absent around Magdalen Islands and in Chaleur Bay Leaves sGSL for winter
Atlantic saury (Chaput and Hurlbut 2010; DFO 2010)	Transient marine species Feeding only	Poorly sampled Pelagic	Only in St. George's Bay Leaves sGSL for winter
Spiny dogfish (COSEWIC 2010b)	Transient marine species Feeding only Periodic outbursts	Shallow warm waters Semi-pelagic	Rare in Chaleur Bay Leaves sGSL for winter
Bluefin tuna (COSEWIC 2011; Vanderlaan et al. 2014)	Transient marine species Feeding only	Warm waters Pelagic	Not in Chaleur Bay Leaves sGSL for winter
Atlantic mackerel (DFO 2014b; McQuinn et al. 2012)	Marine resident Long-distance migrant	Warm waters Pelagic	Ubiquitous Leaves sGSL for winter
Juvenile white hake (Bradford et al. 1997; COSEWIC 2013; Hanson and Courtenay 1995; Swain et al. 2012)	Marine resident Winter migration to deeper waters Unique autumn feeding migration into estuaries Possible endemic	Warm waters	Currently, "high" juvenile numbers in St. George's Bay, Northumberland Strait, and east of PEI
White hake (COSEWIC 2013; Hanson and Courtenay 1995; Swain et al. 2012)	Marine resident Winter migration to deeper waters Possible endemic	Warm waters	Formerly ubiquitous. Only spawning site is in St. George's Bay
Winter skate (Clay 1991; COSEWIC 2005; Kelly and Hanson 2013a, 2013b)	Marine resident Spreads to deeper waters for winter but some stay in ≤ 40 m depths Highly likely an endemic	Warm waters	Formerly ubiquitous Now almost exclusively in Northumberland Strait (the only known breeding area)
Lady crab (Voutier and Hanson 2008)	Marine resident No seasonal movement Highly likely an endemic	Warm waters – sand	Entire lifecycle in Northumberland Strait
Cunner (Bosman et al. 2011; Dew 1976; Green et al. 1984; Johansen 1925)	Marine resident No seasonal migration	Warm waters	Ubiquitous
Rock gunnel (Scott and Scott 1988)	Marine resident No seasonal migration	Warm waters, lives under rocks	Likely ubiquitous
Wrymouth (Scott and Scott 1988)	Marine resident No seasonal migration	Warm waters, lives in burrows (need mud)	Found in Chaleur Bay, Northumberland Strait, east of PEI and St. George's Bay
Greenland cod (Bosman et al. 2011; Hanson and Courtenay 1995)	Marine resident No clear seasonal migration	May occur at all depths	Ubiquitous but scarce; may spawn in estuaries during winter

Species (reference)[1]	Guild	Portion used	Presence/ Area used
Windowpane flounder (Hanson and Wilson 2014)	Marine resident Winter migration to deeper waters Small-bodied ecotype	Warm waters	Widely distributed but scarce in Chaleur Bay, north of PEI and west of Cape Breton
Atlantic herring (Bosman et al. 2011; LeBlanc et al. 1998; McQuinn et al. 2012; Messieh 1987)	Marine resident Winter migration to deeper waters	Warm waters to transition zone	Ubiquitous Spawning rare or absent in St. George's Bay, west of Cape Breton and around Magdalen Islands
Juvenile Atlantic herring (LeBlanc et al. 1998; McQuinn et al. 2012; Messieh 1987)	Marine resident Winter migration to deeper waters	Warm waters	Rare or absent in St. George's Bay, west of Cape Breton and around Magdalen Islands
Sea raven (Bosman et al. 2011)	Marine resident Winter migration to deeper waters	Warm waters to transition waters (rare in CIL)	Ubiquitous
Longhorn sculpin (Bosman et al. 2011)	Marine resident Winter migration to deeper waters	Warm waters to transition waters Rare in <15 m depths	Ubiquitous
Winter flounder (Bosman et al. 2011; Clay 1991; Hanson and Courtenay 1995, 1996)]	Marine resident Winter migration into estuaries and to deeper waters	Warm waters to transition waters	Ubiquitous
Yellowtail flounder (Bosman et al. 2011)	Marine resident Winter migration to deeper waters	Warm waters to transition waters Rare <15 m depths	Ubiquitous
Atlantic halibut (DFO 2013b; Savoie 2014a)	Marine resident Winter migration to deeper waters	Warm waters to deep waters Rare <15 m depths	Rare species Absent from central part of Northumberland Strait
Atlantic cod juveniles (Bosman et al. 2011; Hanson 1996, 2011)	Marine resident Winter migration to deeper waters	Cooler waters – some in CIL	0+ in Northumberland Strait and most places; larger juveniles in most places
Ocean pout (Bosman et al. 2011)	Marine resident Winter migration to deeper waters	Cooler waters – some in CIL	Ubiquitous but rare in Northumberland Strait
Shorthorn sculpin (Hanson and Courtenay 1995)	Marine resident No clear seasonal migration	Found in warm and cooler waters	Ubiquitous
Atlantic cod adults (Campana et al. 1999; Comeau et al. 2001; COSEWIC 2010a; Hanson 2011; Swain et al. 1998)	Marine resident Migratory; leave sGSL for winter	Mainly a cold-water species	Ubiquitous in deepest fringe (absent from Northumberland Strait)
American plaice (COSEWIC 2009; Swain et al. 1998)	Marine resident Migratory; move to deeper waters	Mainly a cold-water species	Low numbers in Northumberland Strait

Species (reference)[1]	Guild	Portion used	Presence/ Area used
Capelin (McQuinn et al. 2012)	Marine resident No clear seasonal migration	Mainly a cold-water species	Deepest margins, not in Northumberland Strait

[1] Most of the species listed have substantial use of coastal waters except for the adult Atlantic cod, American plaice and capelin, which are mainly cold-water species. Most distribution data come from the probability maps generated for this study and atlases or survey documents derived from the September trawl surveys and sentinel surveys (Benoît 2006; Benoît et al. 2003; Benoît and Swain 2003a, 2003b; Darbyson and Benoît 2003; Savoie 2014a, 2014b). Supplemental references are provided below the species name. CIL refers to the Cold Intermediate Layer.