4.2.1.7 Marine Fish

Marine fish in the Study Area collectively exhibit a broad range of ecological roles, habitat requirements and morphologies and range from small planktivorous fish to large predatory sharks (Table 4.6). The ecological role of these species change over their life history, often beginning as eggs and larvae in the planktonic community and changing diets and habitats as they mature. Aside from their inherent ecological importance, species in this group are further recognized for their commercial, and cultural importance.

Table 4.6 Overview of Marine Fishes that are Known or Likely to Occur in the Study Area

Family	Species
Anguilliformes – Eels and Morays	American Eel (*Anguilla rostrata*)
	Longnose Eel (*Synaphobranchus kaupii*)
Carcharhiniformes – Ground Sharks	Blue Shark (*Prionace glauca*)
Clupeiformes – Herrings	Atlantic Herring (*Clupea harengus harengus*)
Gadiformes – Codfishes	Atlantic cod (*Gadus morhua*)
	Blue hake (*Antimora rostrata*)
	Cusk (*Brosme brosme*)
	Haddock (*Melanogrammus aeglefinus*)
	Longfin hake (*Phycis chesteri*)
	Common grenadier (*Nezumia bairdii*)
	Pollock (*Pollachius virens*)
	Roughhead grenadier (*Macrourus berglax*)
	Roundnose grenadier (*Coryphaenoides rupestris*)
	White hake (*Urophycis tenuis*)
Lamniformes – Mackerel Sharks	Basking shark (*Cetorhinus maximus*)
	Porbeagle (*Lamna nasus*)
	Shortfin mako (*Isurus oxyrinchus*)
	White shark (*Carcharodon carcharias*)
Lophiformes – Anglerfishes	Monkfish (*Lophius americanus*)
Myctophidae (family) - Lanternfishes	Lanternfish (Myctophidae)
Osmeriformes – Smelts	Capelin (*Mallotus villosus*)
Perciformes – Perch-like Fishes	Albacore tuna (*Thunnus alalunga*)
	Atlantic bluefin tuna (*Thunnus thynnus*)
	Atlantic mackerel (*Scomber scombrus*)
	Atlantic wolffish (*Anarhichas lupus*)
	Bigeye tuna (*Thunnus obesus*)
	Northern sand lance (*Ammodytes dubius*)
	Northern wolffish (*Anarhichas denticulatus*)
	Spotted wolffish (*Anarhichas minor*)
	Swordfish (*Xiphias gladius*)
	Vahl's eelpout (*Lycodes vahlii*)
Pleuronectiformes - Flatfishes	American plaice (*Hippoglossoides platessoides*)
	Atlantic halibut (*Hippoglossus hippoglossus*)
	Greenland halibut (*Reinhardtius hippoglossoides*)
	Witch flounder (*Glyptocephalus cynoglossus*)
	Yellowtail flounder (*Limanda ferruginea*)
Rajiformes – Skates and Rays	Barndoor skate (*Dipturus laevis*)
	Smooth skate (*Malacoraja senta*)
	Thorny skate (*Amblyraja radiata*)

Family	Species
	Winter skate (*Leucoraja ocellata*)
Salmoniformes – Salmon	Atlantic salmon (*Salmo salar*)
Scorpaeniformes – Scorpionfishes	Redfish (*Sebastes mentella*, *Sebastes norvegicus*, *Sebastes fasciatus*)
	Sculpin (*Triglops* sp.)
Squaliformes – Dogfish Sharks	Black dogfish (*Centroscyllium fabricii*)
	Greenland shark (*Somniosus microcephalus*)
	Spiny dogfish (*Squalus acanthias*)

General information describing marine fish species known to inhabit the region (Table 4.6) has previously been described in the Eastern Newfoundland SEA (Amec 2014, see Section 4.2.1). The sections that follow identify and describe key demersal and pelagic marine fish species that occur in the Study Area for this EA, and describe species assemblages associated with particular depth zones. While fish are mobile, oceanographic conditions and features may result in "boundaries" to migration for some species. For example, the anti-cyclonic gyre on the Flemish Cap results in high larval retention within that area and the large depths of the Flemish Pass also acts as a barrier to migration between the Newfoundland Shelf and Flemish Cap for many groundfish species (Pérez-Rodríguez et al 2012, 2016). Fish assemblages have also been tied to depth zones and the associated environmental parameters within those zones (Gomes et al 1992; Nogueira et al 2017).

As there are no comprehensive data sets for the entire Study Area, data from the Canadian RV surveys were used to establish marine fish assemblages for areas greater than 1,500 m depth within the 200 nautical mile EEZ (Table 4.7). Fish species associated with the Flemish Cap and Flemish Pass and deeper areas of the Study Area (less than 3,000 m depth) were determined from peer reviewed publications of EU RV surveys in those areas (Murua and Cardenas 2005; Vázquez et al 2013; Nogueira et al 2017).

Table 4.7 Summary of Depth Categories used to Present Canadian RV Survey Data (2008-2012)

Depth Zone	Proportion of Survey Area (%)	No. of Species to make up 95% of Catch	Dominant Fish Species (% of Catch)	Dominant Fish Species Catch	Total Fish Species Catch
Shelf (0-250 m)	55.72	6	Sand lance (45.7%)	494,229	1,660,503
Shallow Slope (250-600 m)	17.65	7	Golden redfish (64.6%)	328,971	1,081,516
Middle Slope (600-1,000 m)	9.95	12	Lanternfish (36.1%)	19,491	509,125
Transition Slope (1,000-1300m)	13.07	12	Roundnose grenadier (21.4%)	2,628	54,005
Deep Slope (>1300 m)	3.6	17	Blue hake (18.3%)	654	12,292

Fish catches on the Newfoundland Shelf in the Canadian RV survey were highest in the shelf and shallow slope depth zones in areas less than 600 m depth. There were relatively lower fish catches in middle to deep slope areas and it is reflective of the higher productivity at shallower depths. Within the shelf (less than 250 m) depth zones, sand lance, capelin, and sculpin are the predominant species

captured in the Canadian RV trawls (Table 4.8). Golden redfish, capelin and lanternfish were the main species captured at the shallow slope (250-600 m) depth zone. These species comprise over 80 percent of the total catches in each depth zone. The shelf and shallow slope areas with nutrient influxes and light levels support phytoplankton levels. Zooplankton that feed on phytoplankton are a key part of these fish species diets, supporting their populations at shallow depths. Species assemblages were different on the Flemish Cap in comparison to the Newfoundland Shelf, likely due to the oceanographic and habitat boundaries that that retain larvae and adults in the area (Dalley and Anderson 1998; Borovkov et al 2007). Redfish species including Golden and Acadian redfish were the dominant species for shelf (less than 250 m) and shallow slope (250-600 m) assemblages (Table 4.8). Deepwater redfish which were dominant in shelf areas (less than 250 m) of the Newfoundland Shelf were a main assemblage species in shallow slope (250-600 m) areas of the Flemish Cap (Nogueira et al 2017). Atlantic cod were predominantly found in areas of less than 600 m depth and shelf and shallow slope areas across the Study Area (Nogueira et al 2017) (Table 4.9). American plaice was common on the Grand Bank and Flemish Cap in the Shelf depth zones. Other small flatfish species, including yellowtail flounder and witch flounder were also limited to the shelf areas. Greenland halibut is a species part of middle and transition slope assemblages (over 250 m depth) on the Newfoundland Shelf and Flemish Cap areas. Wolffish species, that are also species at risk, were additionally key assemblage species on the Flemish Cap at areas less than 600 m depths. These species did not have relatively high abundances in Canadian RV surveys within the Study Area.

Table 4.8 Numerically Dominant Fish Species (95% of Overall Abundance) within the Study Area inside the EEZ by Depth Zone (Canadian RV Surveys, 2008-2012)

Depth Zone	Common Name	Scientific Name	Total Species Catch	% Abundance
Shelf (0-250 m)	Sand lance	*Ammodytes dubius*	494,230	45.7
	Capelin	*Mallotus villosus*	425,869	39.4
	Sculpins (Triglops)	*Triglops* sp.	45,759	4.2
	American plaice	*Hippoglossoides platessoides*	29,454	2.7
	Deepwater redfish	*Sebastes mentella*	19,444	1.8
	Yellowtail flounder	*Limanda ferruginea*	16,364	1.5
Shallow Slope (250-600 m)	Golden redfish	*Sebastes norvegicus*	328,971	64.6
	Capelin	*Mallotus villosus*	97,352	19.1
	Lanternfish	Myctophidae	21,217	4.2
	Atlantic cod	*Gadus morhua*	12,180	2.4
	Atlantic halibut	*Hippoglossus hippoglossus*	12,178	2.4
	Roughhead grenadier	*Macrourus berglax*	5,932	1.2
	Greenland halibut	*Reinhardtius hippoglossoides*	5,691	1.1
Middle Slope (600-1,000 m)	Lanternfish	Myctophidae	19,491	36.1
	Blue hake	*Antimora rostrata*	6,800	12.6
	Golden redfish	*Sebastes norvegicus*	6,723	12.4
	Roughhead grenadier	*Macrourus berglax*	4,609	8.5
	Common grenadier	*Nezumia bairdii*	3,768	7.0
	Longnose eel	*Synaphobranchus kaupii*	3,010	5.6

Depth Zone	Common Name	Scientific Name	Total Species Catch	% Abundance
	Greenland halibut	*Reinhardtius hippoglossoides*	2,409	4.5
	Atlantic Halibut	*Hippoglossus hippoglossus*	1,385	2.6
	Roundnose Grenadier	*Coryphaenoides rupestris*	1,072	2.0
	Witch Flounder	*Glyptocephalus cynoglossus*	827	1.5
	Barracudina	Paralepidae	717	1.3
	Vahl's eelpout	*Lycodes vahlii*	390	0.7
Transition Slope (1,000-1,300 m)	Roundnose grenadier	*Coryphaenoides rupestris*	2,628	21.4
	Blue hake	*Antimora rostrata*	2,333	19.0
	Lanternfish	*Myctophidae*	1,731	14.1
	Longnose eel	*Synaphobranchus kaupii*	1,502	12.2
	Roughhead grenadier	*Macrourus berglax*	1,436	11.7
	Common grenadier	*Nezumia bairdii*	645	5.2
	Greenland halibut	*Reinhardtius hippoglossoides*	571	4.6
	Black dogfish	*Centroscyllium fabricii*	293	2.4
	Dragonfish	*Stomias boa ferox*	226	1.8
	Blacksmelts	*Bathylagus sp.*	112	0.9
	Viperfish	*Chauliodus sloani*	110	0.9
	Shortnose snipe eel	*Serrivomer beani*	102	0.8
Deep slope (>1,300 m)	Blue hake	*Antimora rostrata*	654	18.3
	Roundnose grenadier	*Coryphaenoides rupestris*	581	16.2
	Roughhead grenadier	*Macrourus berglax*	559	15.6
	Longnose eel	*Synaphobranchus kaupii*	485	13.5
	Lanternfish	Myctophidae	410	11.5
	Greenland halibut	*Reinhardtius hippoglossoides*	253	7.1
	Blacksmelts	*Bathylagus sp.*	88	2.5
	Dragonfish	*Stomias boa*	61	1.7
	Threebeard rockling	*Gaidropsarus ensis*	61	1.7
	Large scale tapirfish	*Notacanthus nasus*	60	1.7
	Shortnose snipe eel	*Serrivomer beani*	37	1.0
	Shortspine tapirfish	*Macdonaldia rostrata*	34	0.9
	Ogrefish	Melamphaidae	32	0.9
	Common grenadier	*Nezumia bairdii*	29	0.8
	Black herring	*Bathytroctes* sp	23	0.6
	Viperfish	*Chauliodus sloani*	22	0.6
	Butterfish	Stomiatidae	18	0.5

Table 4.9 Abundant Fish by Depth Zone on the Flemish Cap (EU RV Surveys, 2004-2013)

Depth Zone	Common Name	Scientific Name	% Biomass	% Abundance	% Occurrence
Shelf (0-250m)	Acadian redfish	*Sebastes fasciatus*	21.2	51.2	86.8
	Golden redfish	*Sebastes norvegicus*	27.6	39.5	58.4
	Atlantic cod	*Gadus morhua*	25.7	7.6	92.7
	American plaice	*Hippoglossoides platessoides*	2.0	0.3	92.4
	Witch flounder	*Glyptocephalus cynoglossus*	1.1	0.2	87.7
	Wolffish	*Anarhichas sp.*	0.7	0.2	74.5
	Thorny skate	*Amblyraja radiata*	0.5	0.0	58.0
Shallow Slope (250-600m)	Acadian redfish	*Sebastes fasciatus*	38.6	46.3	99.3
	Deepwater redfish	*Sebastes mentella*	27.3	32.5	90.3
	Golden redfish	*Sebastes norvegicus*	23.0	17.9	80.1
	Atlantic cod	*Gadus morhua*	6.5	1.4	63.2
	Greenland halibut	*Reinhardtius hippoglossoides*	1.5	0.4	70.9
	Spotted wolffish	*Anarhichas minor*	0.7	0.1	60.1
	Thorny skate	*Amblyraja radiata*	0.5	0.1	65.6
Middle to Deep Slope (>600 m)	Greenland halibut	*Reinhardtius hippoglossoides*	35.2	20.6	95.5
	Roundnose grenadier	*Coryphaenoides rupestris*	14.0	19.0	99.3
	Longnose eel	*Synaphobranchus kaupii*	12.9	13.2	98.9
	Blue hake	*Antimora rostrata*	9.3	12.1	63.6
	Common Grenadier	*Nezumia bairdii*	9.1	11.8	90.8
	Roughhead grenadier	*Macrourus berglax*	6.2	7.4	91.4
	Black dogfish	*Centroscyllium fabricii*	2.4	2.4	22.7
	Demon catshark	*Apristurus* sp.	2.3	0.4	94.9

Source: Nogueira et al (2017).
Percent biomass, abundance and occurrence based on 1,699 bottom trawl halls collected from 129-1,460 m.

Beyond 600 m at the middle, transition and deep slopes in the Canadian RV survey, the number of fish species required to make up 95 percent of the total catch is higher than at the shelf and shallow slope zones, indicating that abundances are similarly low across species. Lanternfish were part of shallow to deep slope assemblages, but were the dominant fish captured between 600-1,000 m depths. Roughhead and common grenadiers were also common at shallow and middle slopes, with abundances decreasing with depth. Roundnose grenadiers were captured mainly at the transition slope and were a key part of assemblages of over 1,000 m depth. These grenadier species were also prevalent at depths of greater than 600 m on the Flemish Cap. Blue hake had the highest abundances at the middle depth zone (250-600 m) in Canadian RV surveys, but was a key species in assemblages in depths of over 600 m. This species was also a key species for middle to deep slope areas of the Flemish Cap.

The Canadian RV and EU RV (Vázquez et al 2013; Nogueira et al 2017) trawl surveys were limited to shelf and slope areas less than 1,500 m in depth. Longline fishing surveys have thus been used to identify marine fish species from 700 to 3,100 m depths within the Study Area (Murua and de Cardenas 2005). Roughhead grenadier and blue hake were the most commonly captured species at these depths, followed by smalleyed rabbitfish and skates. The majority of fish catches were between 1,150-2,000 m depths with a change in species captured at over 2,000 m. Greenland halibut and roughhead grenadier

ranges were limited to areas less than 2,000 m deep and were associated with relatively warmer, less saline and more oxygenated waters of the Labrador Sea water mass. Armed grenadier was characteristic of areas over 2,000 m and was associated with more saline, less oxygenated and colder waters of the North Atlantic deep water mass (Murua and de Cardenas 2005). Blue hake, smalleyed rabbitfish and skate species were not strongly associated with these environmental parameters as they were captured across all depth ranges sampled (Murua and de Cardenas 2005).

Table 4.10 Catch Composition from Longline Surveys (1996) on the Flemish Cap, Flemish Pass and Grand Bank Slope Areas

Depth Zone	Common Name	Scientific Name	% Abundance
Middle Slope (<800 m)	Greenland halibut	*Hippoglossoides platessoides*	86.7
	Skates	Rajidae	11.9
	Other	-	1.4
Middle to Transition Slope (800-1,150 m)	Roughhead grenadier	*Macrourus berglax*	93.3
	Greenland halibut	*Hippoglossoides platessoides*	2.5
	Blue hake	*Antimora rostrata*	2.2
	Skates	Rajidae	1.1
	Black dogfish	*Centroscyllium fabricii*	0.8
Deep Slope (1,150-1,500 m)	Roughhead grenadier	*Macrourus berglax*	41.7
	Blue hake	*Antimora rostrata*	40.3
	Greenland halibut	*Hippoglossoides platessoides*	11.1
	Smalleyed rabbitfish	*Hydrolagus affinis*	3.1
	Skates	Rajidae	1.9
	Black dogfish	*Centroscyllium fabricii*	1.9
Deep Slope (1,500-2,000 m)	Blue hake	*Antimora rostrata*	63.6
	Smalleyed rabbitfish	*Hydrolagus affinis*	21.9
	Skates	Rajidae	8.1
	Roughhead grenadier	*Macrourus berglax*	6.4
Deep Slope (>2,000 m)	Armed grenadier	*Nematonurus armatus*	76.9
	Blue hake	*Antimora rostrata*	18.1
	Skates	Rajidae	5.0

Source: Murua and de Cardenas (2005).
Percent abundance based on 64 longline hauls collected from 708-3,028 m.

As detailed in the Eastern Newfoundland SEA (Amec 2014) there are resident and migratory pelagic fishes that utilize the water column within the Study Area. Abundances of resident pelagic species, including capelin, herring, and lanternfish, are reflected in the Canadian and EU RV surveys. Species like capelin may make seasonal migrations between coastal and offshore areas for spawning or overwintering whereas Lanternfish that reside in slope areas make daily vertical migrations to feed on plankton. Some species occupy pelagic marine environments for particular life history stages, including American eel and Atlantic salmon. American eel adults migrate to the Sargasso Sea to spawn and their larvae drift as plankton in the North Atlantic before migrating into freshwater areas. Conversely, Atlantic salmon spawn in freshwater rivers and migrate to sea for their growth phase. Both these species have the potential to migrate in and out of the Study Area. In pelagic longline surveys on the Grand Bank offshore areas (2002-2003), blue shark and swordfish were the most frequently captured species, sampled at less than 30 m depths with lesser catches of bigeye tuna, porbeagle and shortfin mako shark (Foster et al 2012) (Table 4.11). Large predatory fish including sharks (Hurley 1998; Campana et

al 2015), tuna and swordfish may migrate to the Study Area during the summer in response to ocean temperatures and foraging opportunities (Amec 2014). These species take advantage of highly productive northern waters in the summer and avoid the returning colder waters in the fall.

Table 4.11 Catch Composition from the Longline Surveys (2002-2003) on Offshore Grand Banks Area

Depth Zone	Common Name	Scientific Name	Total Species Catch	% Total Catch
Pelagic Waters (<30 m)	Blue shark	*Prionace glauca*	24,949	49.4
	Swordfish	*Xiphias gladius*	19,366	38.3
	Bigeye tuna	*Thunnus obesus*	1,620	3.2
	Porbeagle	*Lamna nasus*	1,311	2.6
	Shortfin mako	*Isurus oxyrinchus*	700	1.4
	Albacore tuna	*Thunnus alalunga*	558	1.1
	Lancetfishes	*Alepisaurus* spp.	346	0.7
	Bluefin tuna	*Thunnus thynnus*	313	0.6
	Skates	Rajidae	280	0.6
	Dolphinfishes	*Coryphaena* spp.	275	0.6
Source: Foster et al (2012). Total species catch and percent total catch was based on 973,734 longline hooks.				

Key Species Distributions

Species that make up the top 10 for measures of abundance based on Canadian RV (2008-2012) and EU RV (2004-2013) surveys (Nogueira et al 2017) are described below. Distribution maps are presented from data available from these surveys where available. These species also represent the main fish species observed in the Study Area and many are of commercial importance.

Table 4.12 Top 10 Species within the Study Area based on Canadian RV (2008-2012) and EU RV (2004-2013) Surveys

Survey	Common Name	Scientific Name	Total Catch	% Total Catch
Canadian RV Survey within Project Area (2008-2012)	Capelin	*Mallotus villosus*	523,473	31.5
	Sand lance	*Ammodytes dubius*	494,390	29.8
	Deepwater redfish	*Sebastes mentella*	355,139	21.4
	Sculpins (Triglops)	*Triglops* sp.	46,077	2.8
	American plaice	*Hippoglossoides platessoides*	43,016	2.6
	Lanternfish	Myctophidae	42,889	2.6
	Yellowtail flounder	*Limanda ferruginea*	16,364	1.0
	Atlantic cod	*Gadus morhua*	14,114	0.9
	Roughhead grenadier	*Macrourus berglax*	12,718	0.8
	Hookear sculpin	*Artediellus* sp.	11,916	0.7
EU RV Survey on the Flemish Cap (2004-2013)[1]	Acadian Redfish	*Sebastes fasciatus*	1,781,944	34.0
	Golden redfish	*Sebastes norvegicus*	1,345,832	25.7
	Deepwater redfish	*Sebastes mentella*	1,043,142	19.9
	Atlantic cod	*Gadus morhua*	144,426	2.8
	Blue hake	*Antimora rostrata*	43,607	0.8
	Roundnose grenadier	*Coryphaenoides rupestris*	39,584	0.8
	Greenland halibut	*Reinhardtius hippoglossoides*	36,075	0.7

Survey	Common Name	Scientific Name	Total Catch	% Total Catch
	Longnose eel	*Synaphobranchus kaupii*	27,562	0.5
	Roughhead grenadier	*Macrourus berglax*	17,631	0.3
	Black dogfish	*Centroscyllium fabricii*	5,098	0.1
[1]Nogueira et al (2017)				

Capelin

Capelin are a small, commercially harvested fish that feed on zooplankton. They migrate in large aggregations from offshore areas to inshore spawning grounds (Scott and Scott 1988). As they are an abundant and important food source for a multitude of species (fish, birds and marine mammals), they are considered a key element in the marine ecosystem (Gomes et al 1992; Davoren and Montevecchi 2003; Rose 2005; Templeman 2010; Dawe et al 2012; Buren et al 2014). Capelin represented 31.5 percent of the fish in the Canadian RV Surveys for abundance (Figure 4.25). They are found in greatest abundance in the Flemish Pass and along the Bonavista Corridor, and are much less common in the southwest corner of the Study Area and along the deep slope. However, capelin are typically associated with cold water and can quickly alter their distributions to changing temperature conditions (Rose 2005).

Sand Lance

Sand lance are small, planktivorous schooling fish (Scott and Scott 1988) that are a critical part of the food web in parts of the Study Area. Although not commercially fished themselves, they serve as prey for other valued species such as Atlantic cod, American plaice and Yellowtail flounder (Gomes et al 1992). Of the species captured in Canadian RV Surveys, they were second most abundant, representing approximately 29.8 percent of fish captured as shown in Table 4.12. Within the surveyed portion of the Study Area, sand lance was found primarily over the Grand Bank (Figure 4.26). This species was noticeably absent from areas north of the Grand Bank.

Figure 4.25 Distribution of Capelin in the Study Area (Canadian RV Surveys, 2008-2012)

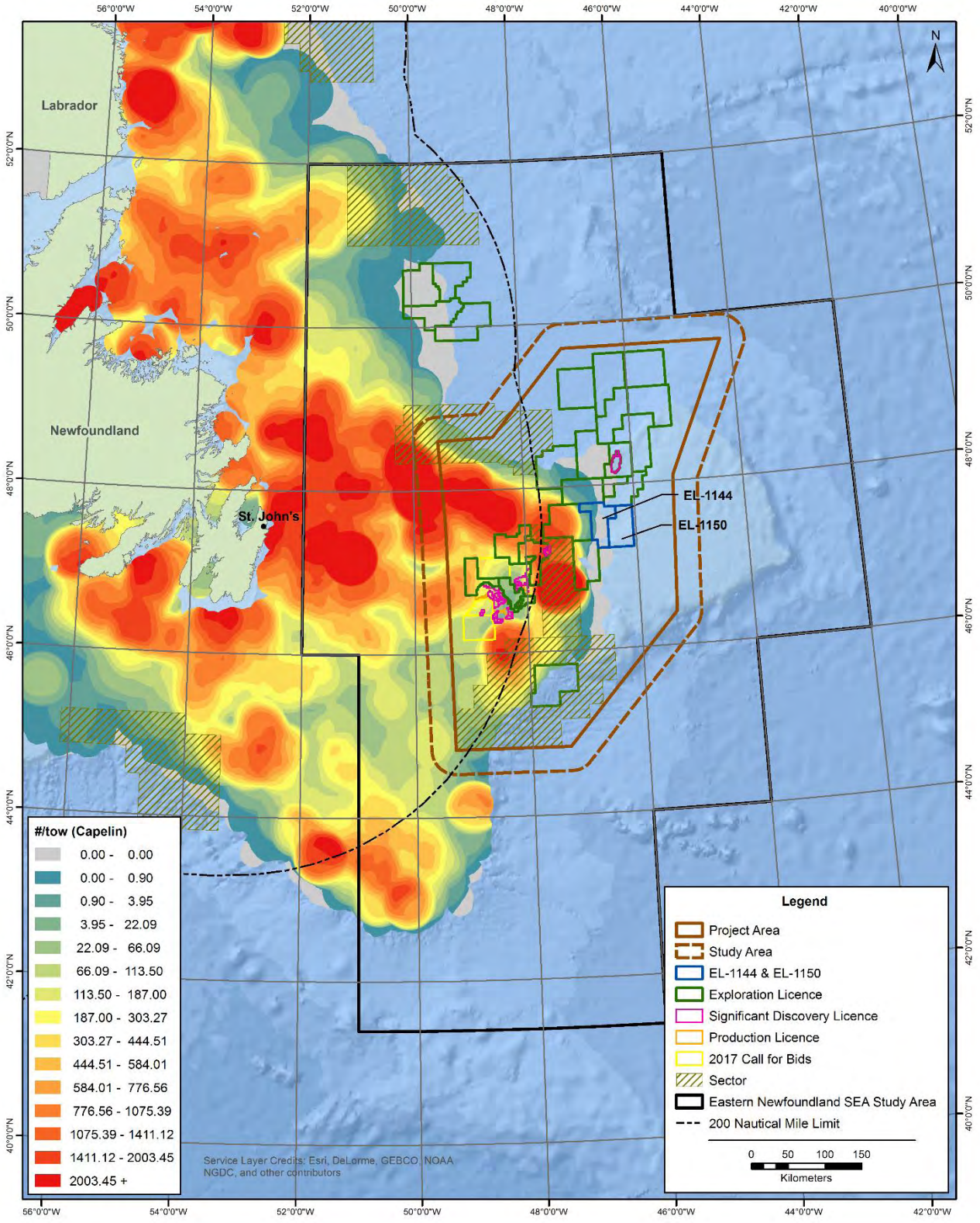
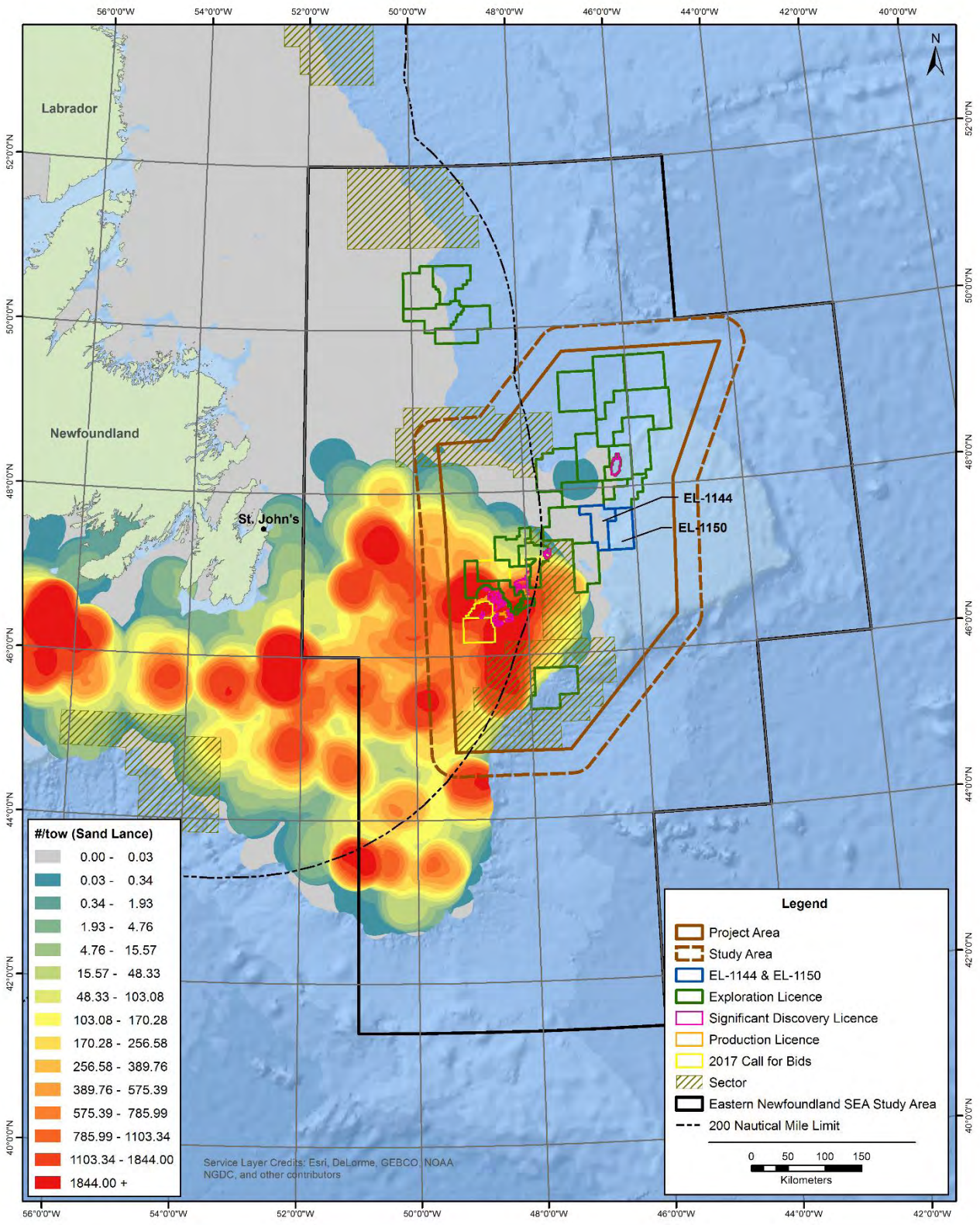


Figure 4.26 Distribution of Sand Lance in the Study Area (Canadian RV Surveys, 2008-2012)



Redfish (Acadian, Deepwater, Golden)

Three species of redfish were captured within the Study Area, including Acadian, Deepwater and Golden redfish. In the Canadian RV surveys, deepwater redfish was the dominant redfish species captured and represented 21.4 percent of the total catch (Table 4.12, Figure 4.27). This species was a main species of shelf assemblages in the Canadian RV surveys, but was a main species of shallow slope assemblages in the EU RV surveys. Redfish species were well represented in the EU RV surveys with all three species comprising almost 80 percent of total catches on the Flemish Cap (Figure 4.28). Acadian redfish have a depth range of 138-1,206 m and had the highest abundance on the Flemish Cap, as well as being a key species in shelf and shallow slope assemblages. Golden redfish has the smallest depth range (130-631 m) of the three species and was another key species in shelf and shallow slope assemblages on the Flemish Cap. Redfish species are long lived (40-75 years in age) commercially harvested species that are associated with the slopes of the Newfoundland Shelf, the Flemish Pass and Flemish Cap. Redfish engage in nocturnal vertical migrations to feed on zooplankton and fish (Scott and Scott 1988; Templeman 2010) but are not known to undertake the seasonal migrations exhibited by many shelf species. The redfish stock in the Study Area are considered to be in poor condition and consequently are listed as Threatened by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) (COSEWIC 2010a). Exploitation (northern portions of the Study Area) and environmental conditions (northern and southern portions) are affecting stock health (Devine and Haedrich 2011).

Yellowtail Flounder

Yellowtail flounder are a flatfish associated with warm, shallow, offshore banks (Scott and Scott 1988; Gomes et al 1992). The distribution of this commercially valuable species is focused in the shallow, southwestern portion of the Study Area. In contrast, individuals are at low abundance from the Flemish Pass and the Newfoundland Shelf north of Bonavista (Figure 4.29). The species was considered to be at low levels in the 1990s but is one of the few groundfish species that has fully recovered after its collapse (Brodie et al 2010; Templeman 2010). In Canadian RV Surveys of the Study Area, yellowtail comprised only 1.0 percent of the individuals captured.

American Plaice

American plaice are a commercially important flatfish that are relatively widespread and abundant (2.6 percent of Canadian RV Survey abundance; Figure 4.30) through much of the shelf areas of the Study Area, including shallow portions of the Flemish Cap (Figure 4.31) (Casas and Gonzáles-Troncoso 2013). Their widespread distribution is partially attributed to their tolerance of cold water (Scott and Scott 1988; Morgan and Brodie 1991). Canadian RV Survey data show them occupying habitats such as the Bonavista Corridor in high abundance, but also in shallow areas of the Grand Bank that are not used as frequently by other species. This demersal species feeds on a variety of invertebrates and fish (Scott and Scott 1988) and is a prey source for larger fish such as cod and sharks. While adults are not known to undertake significant migrations, eggs and larvae are dispersed more widely by the currents (Scott and Scott 1988; Frank et al 1992). American plaice once supported the largest flatfish fishery in the world. Unfortunately, like several other commercially exploited groundfish species in the Study Area, the stock collapsed to a fraction of its former abundance. It has since been listed as Threatened by COSEWIC and shows few signs of recovery on the Flemish Cap (Nogueira et al 2017), unlike some other collapsed stocks (e.g. yellowtail flounder; Brodie et al 2010). Nogueira et al (2016) indicated that there is some evidence for recovery of American plaice on the Newfoundland shelf.

Figure 4.27 Distribution of Redfish in the Study Area (Canadian RV Surveys, 2008-2012)

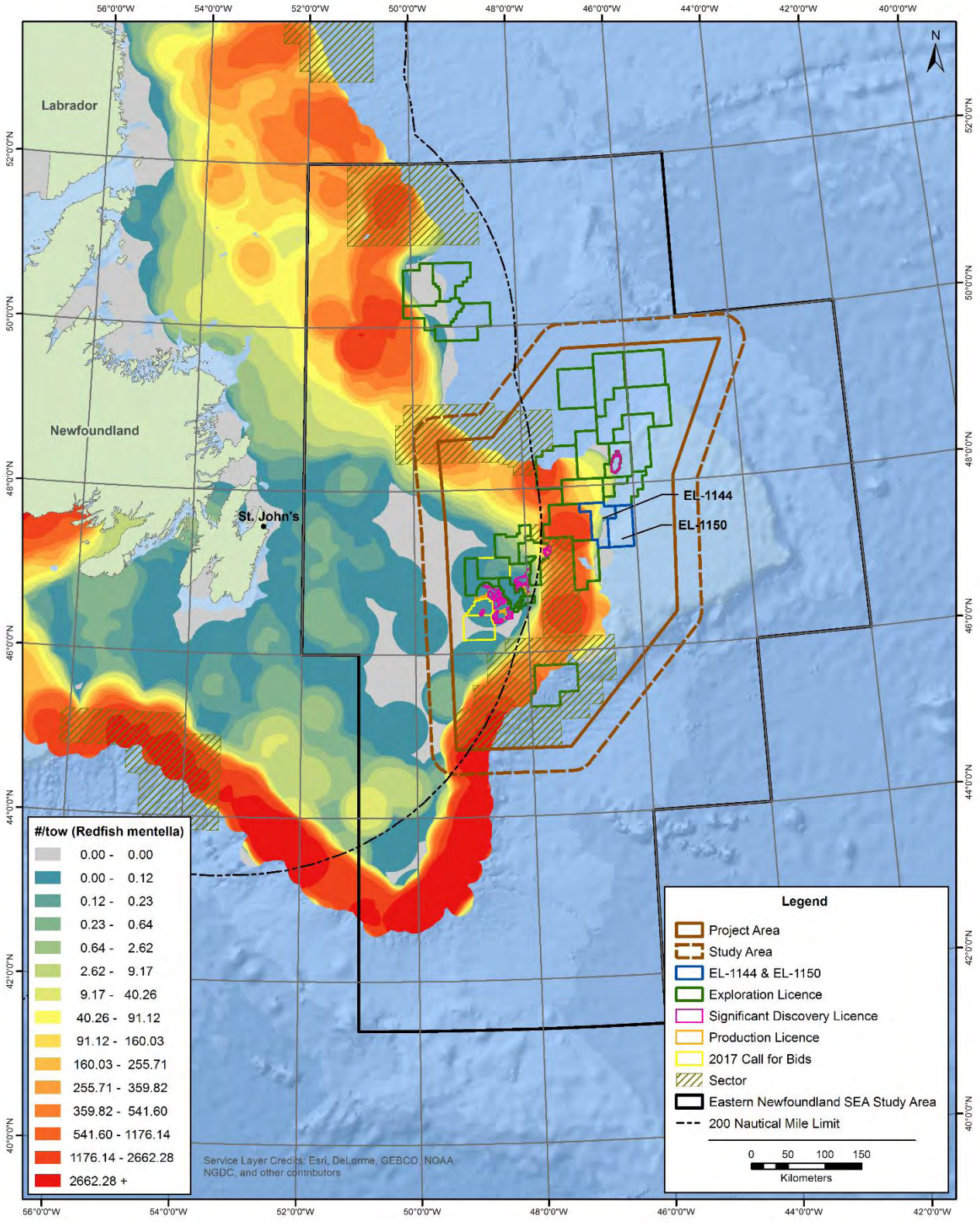


Figure 4.28 Distribution of Redfish on the Flemish Cap (EU RV Surveys, 2012)

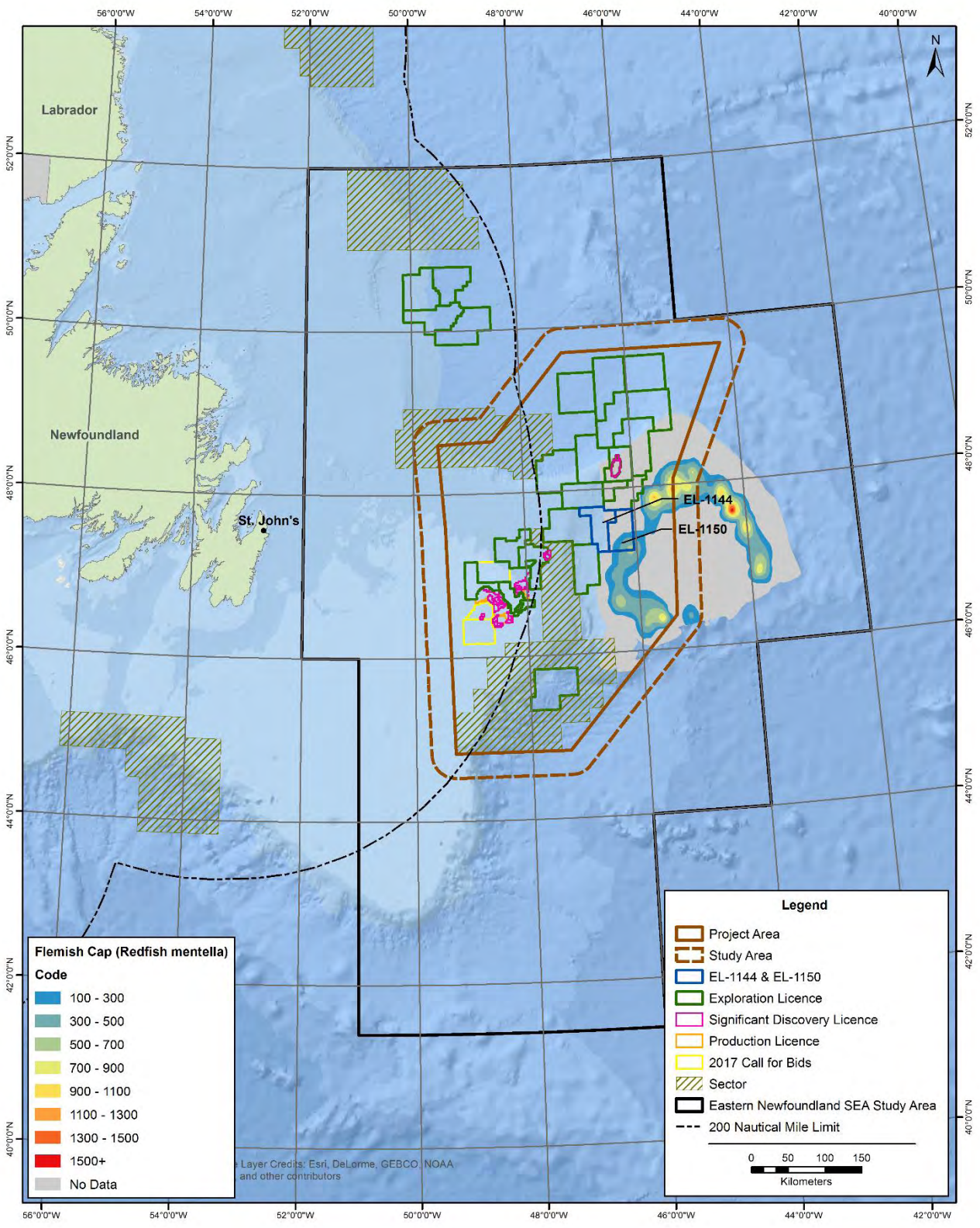


Figure 4.29 Distribution of Yellowtail Flounder in the Study Area (Canadian RV Surveys, 2008-2012)

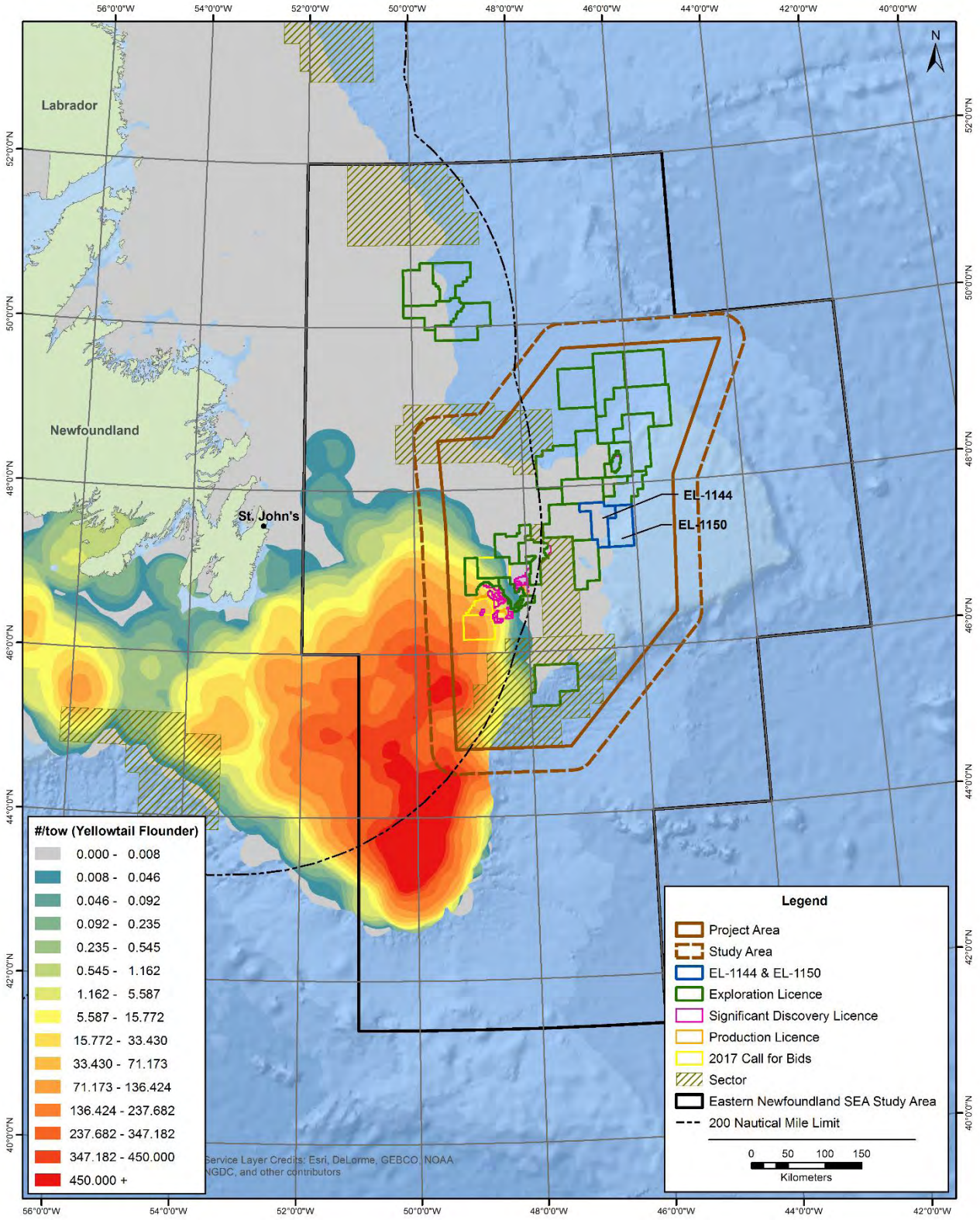


Figure 4.30 Distribution of American Plaice in the Study Area (Canadian RV Surveys, 2008-2012)

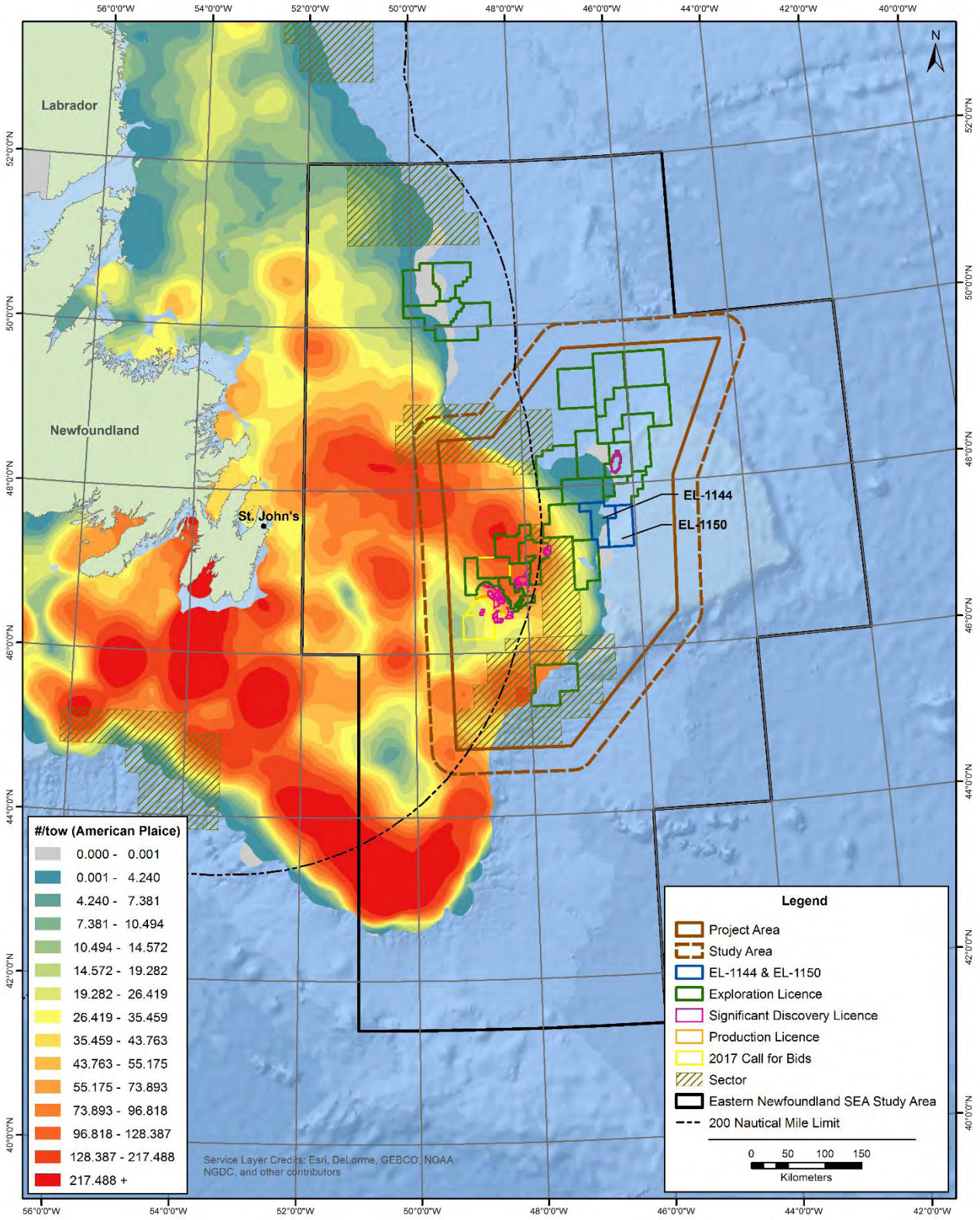
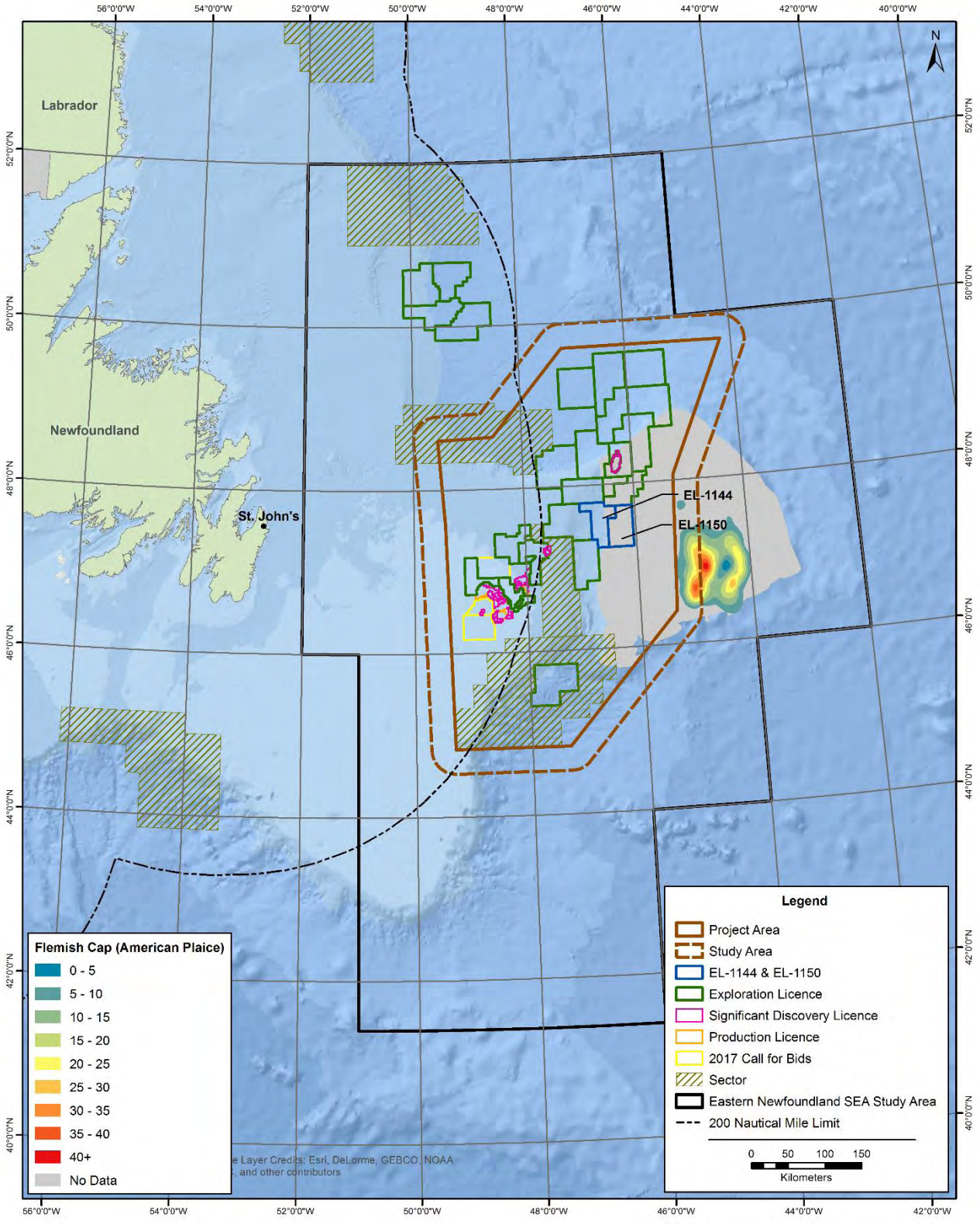


Figure 4.31 Distribution of American Plaice on the Flemish Cap (EU RV Surveys, 2012)



Greenland Halibut

Greenland halibut are a commercially important deepwater flatfish with a depth range of less than 2,000 m and peak abundances from 1,300-1,600 m (Murua and de Cardenas 2005). This species spends considerable time feeding pelagically on a variety of fish and invertebrates (Morgan et al 2013), including commercially important Atlantic cod, capelin, redfish, shrimp and squid. This species also inhabits progressively deeper waters as they age (Bowering and Chumakov 1989). Within the Study Area, Greenland halibut abundances are highest along the slopes of the northeastern edge of the Newfoundland Shelf, and to a lesser degree, in the Flemish Pass. This species contributed less than one percent of fish abundance in both the Canadian and EU RV surveys (Figures 4.32 and 4.33).

Sculpins (Triglops sp.)

Small sculpins are found across much of the Canadian RV surveyed portions of the Study Area, particularly in the Bonavista Corridor and the northern and eastern extents of the Grand Bank (Figure 4.34). Its lowest abundance occurs near the deep water survey extent within the EEZ and they are not expected to occur in high abundance in most areas beyond the EEZ. *Triglops* sp. are not well represented in Flemish Cap surveys from 2003-2012 (Vázquez et al 2013). It is a morphologically small species that ranks higher relative to other Study Area species in abundance (2.8 percent), but their ecology is poorly understood (Scott and Scott 1988).

Lanternfish

The lanternfish are a small, pelagic fish family that are widespread in deep waters and characterized by having light producing organs on their bodies (Scott and Scott 1988). They serve an important ecological role in the systems they inhabit as prey for commercially valued species such as Atlantic cod, hake, tunas, salmon and marine mammals (Scott and Scott 1988). This characterization is corroborated by Canadian RV Surveys, which show a near absence in shallow areas on the Grand Bank and the highest abundances at the deep water margins of the surveyed area (particularly in the Flemish Pass). As the Canadian RV Survey program does not capture areas beyond the continental slope, the importance of this species in the Study Area is most likely underrepresented (Figure 4.35). This species comprises 2.6 percent of overall fish abundance within the Study Area as reported in the Canadian RV survey (Table 4.12).

Atlantic Cod

Atlantic cod dominated the groundfish fishery for centuries and has long been associated commercially and culturally with Newfoundland (COSEWIC 2010b), but poor environmental conditions and excessive fishing caused the collapse of the stock (Worm and Myers 2003; Dawe et al 2012). The stock coinciding with the Study Area remains a small part (less than three percent) of historical levels and is listed as Endangered by COSEWIC (COSEWIC 2010b). Atlantic cod are showing signs of recovery after two decades of restricted fishing (Koen-Alonso et al 2010; Nogueira et al 2014). They are most prevalent in the northwestern (vicinity of the Bonavista Corridor) and southwestern (eastern slope of the Grand Banks) corners of the Study Area and in the Flemish Pass (Figure 4.36). EU RV surveys on the Flemish Cap show Atlantic cod's distribution largely restricted to the shallow waters (less than 250 m) of the Cap (Figure 4.37; Nogueira et al 2014, 2017). In the Study Area, Atlantic cod comprised less than one percent of the total catch within the Canadian RV surveys and 2.8 percent in the EU RV surveys (Table 4.12).

Figure 4.32 Distribution of Greenland Halibut in the Study Area (Canadian RV Surveys, 2008-2012)

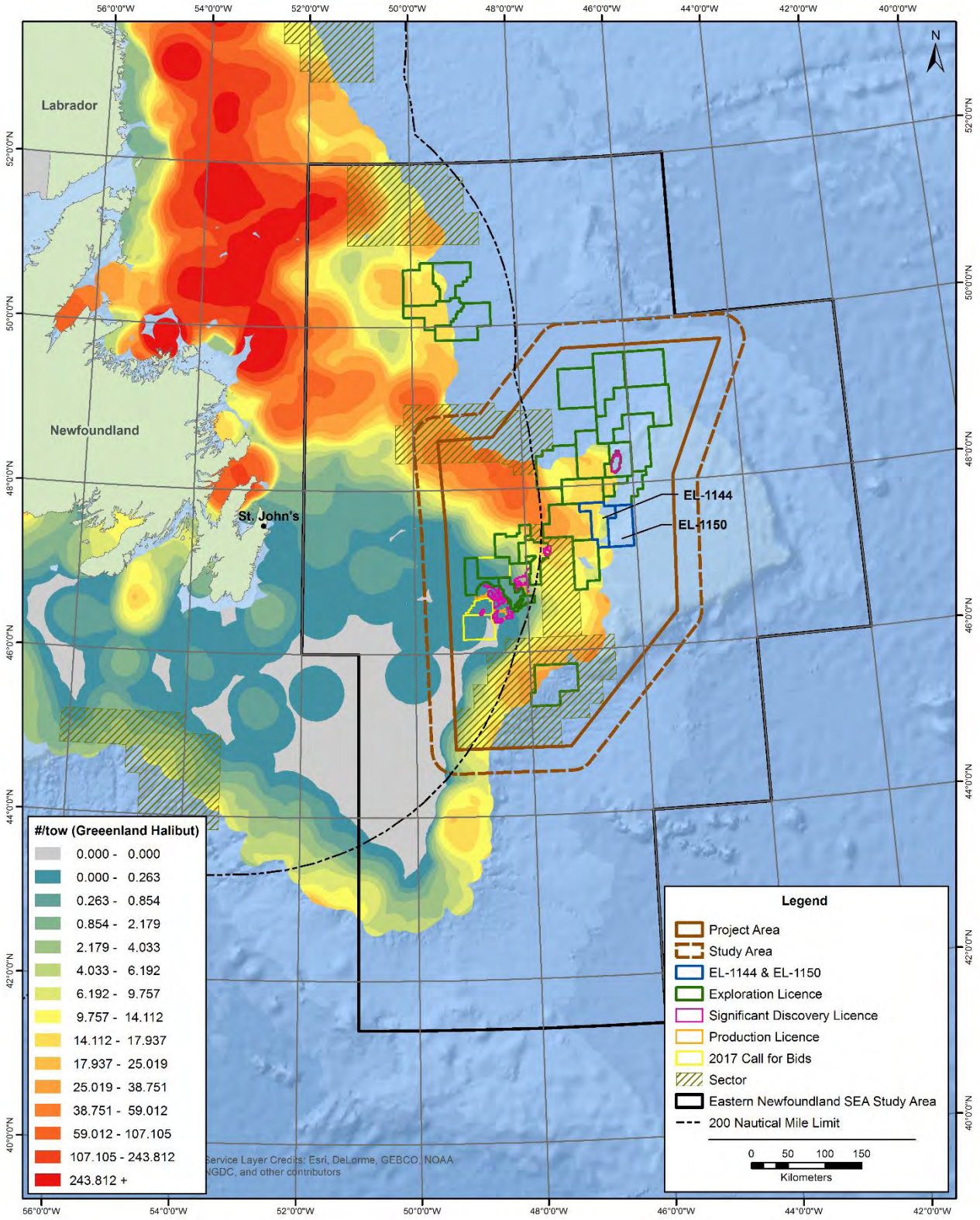


Figure 4.33 Distribution of Greenland Halibut on the Flemish Cap (EU RV Surveys, 2012)

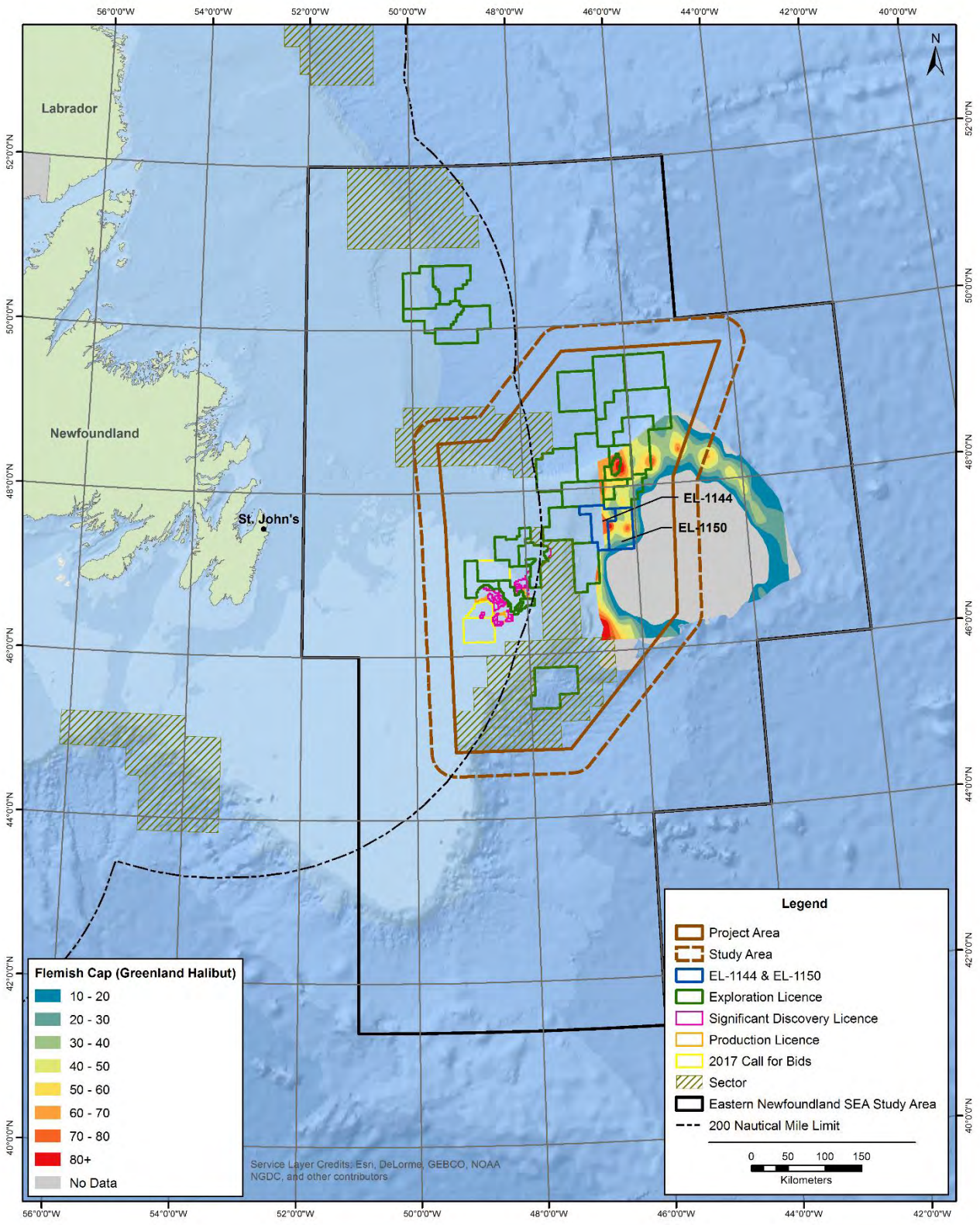


Figure 4.34 Distribution of *Triglops* Sculpins in the Study Area (Canadian RV Surveys, 2008-2012)

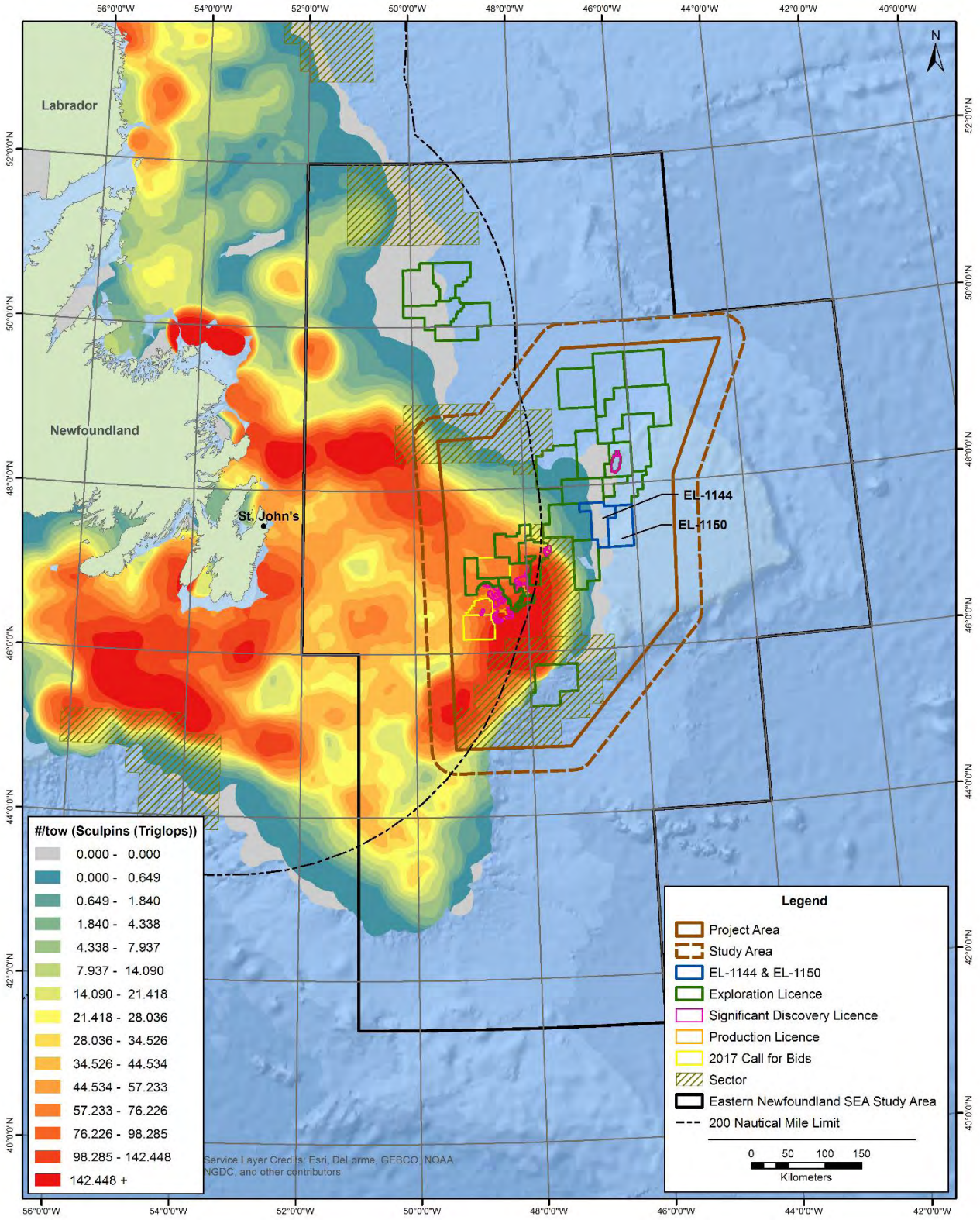


Figure 4.35 Distribution of Lanternfish in the Study Area (Canadian RV Surveys, 2008-2012)

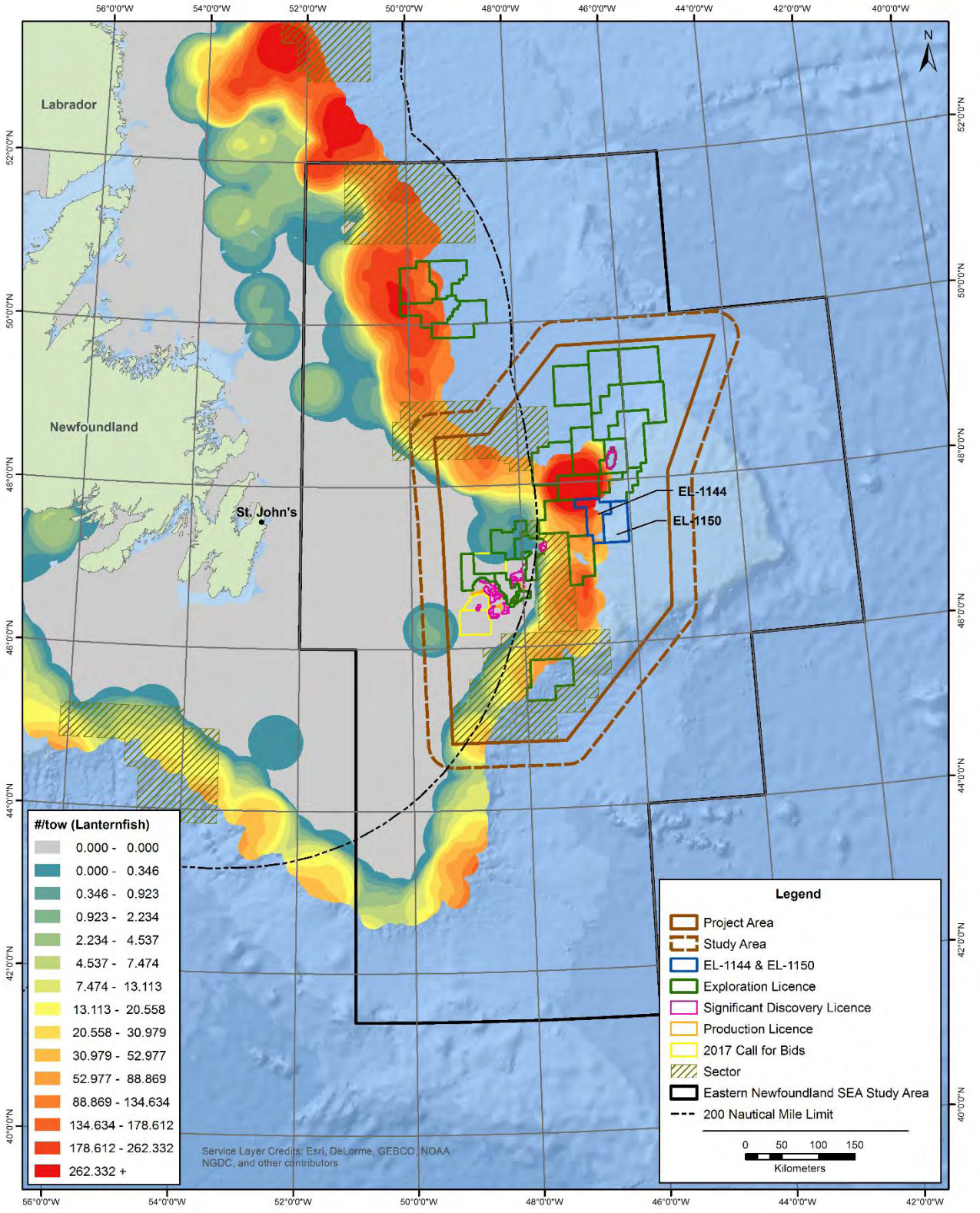


Figure 4.36 Distribution of Atlantic Cod in the Study Area (Canadian RV Surveys, 2008-2012)

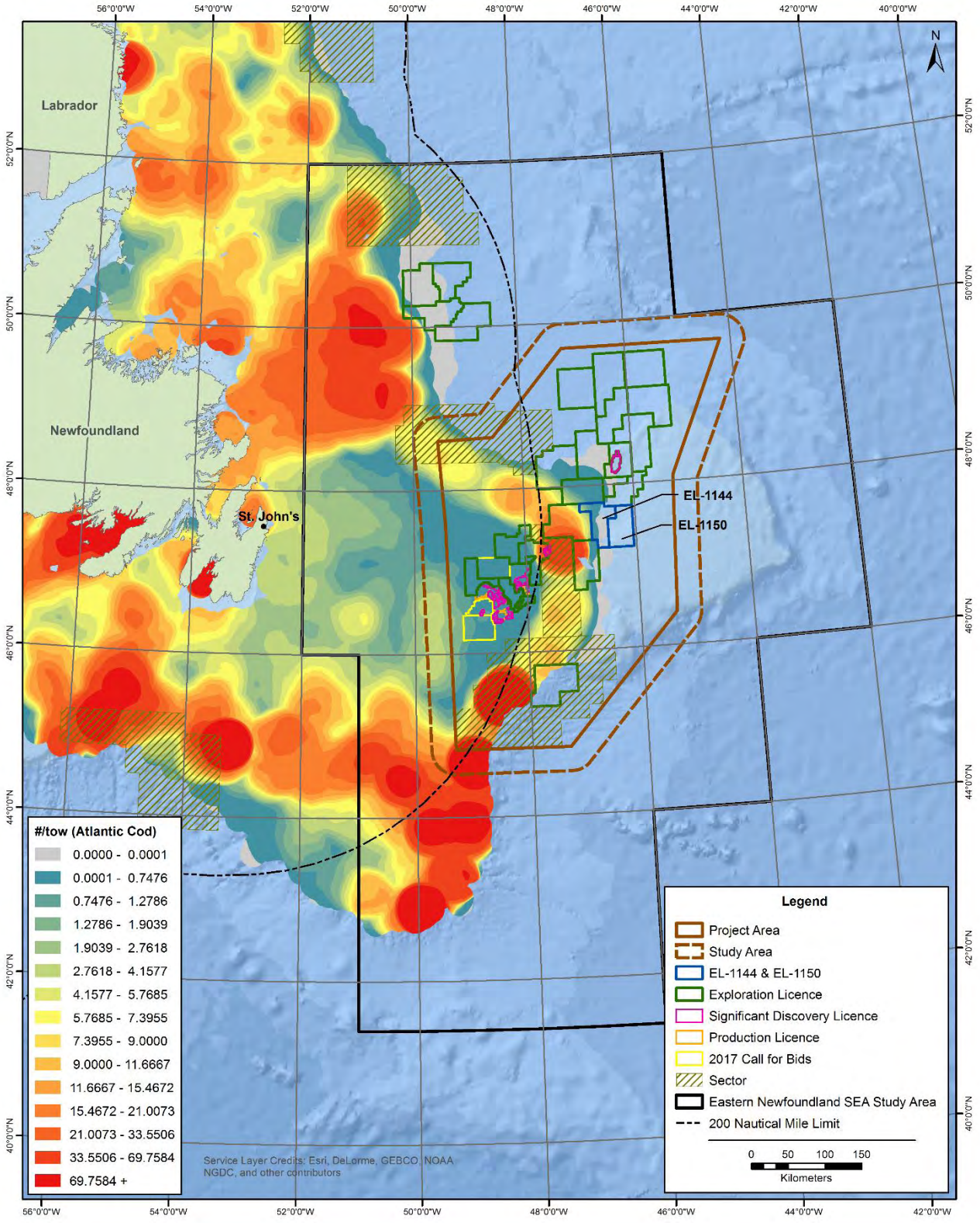
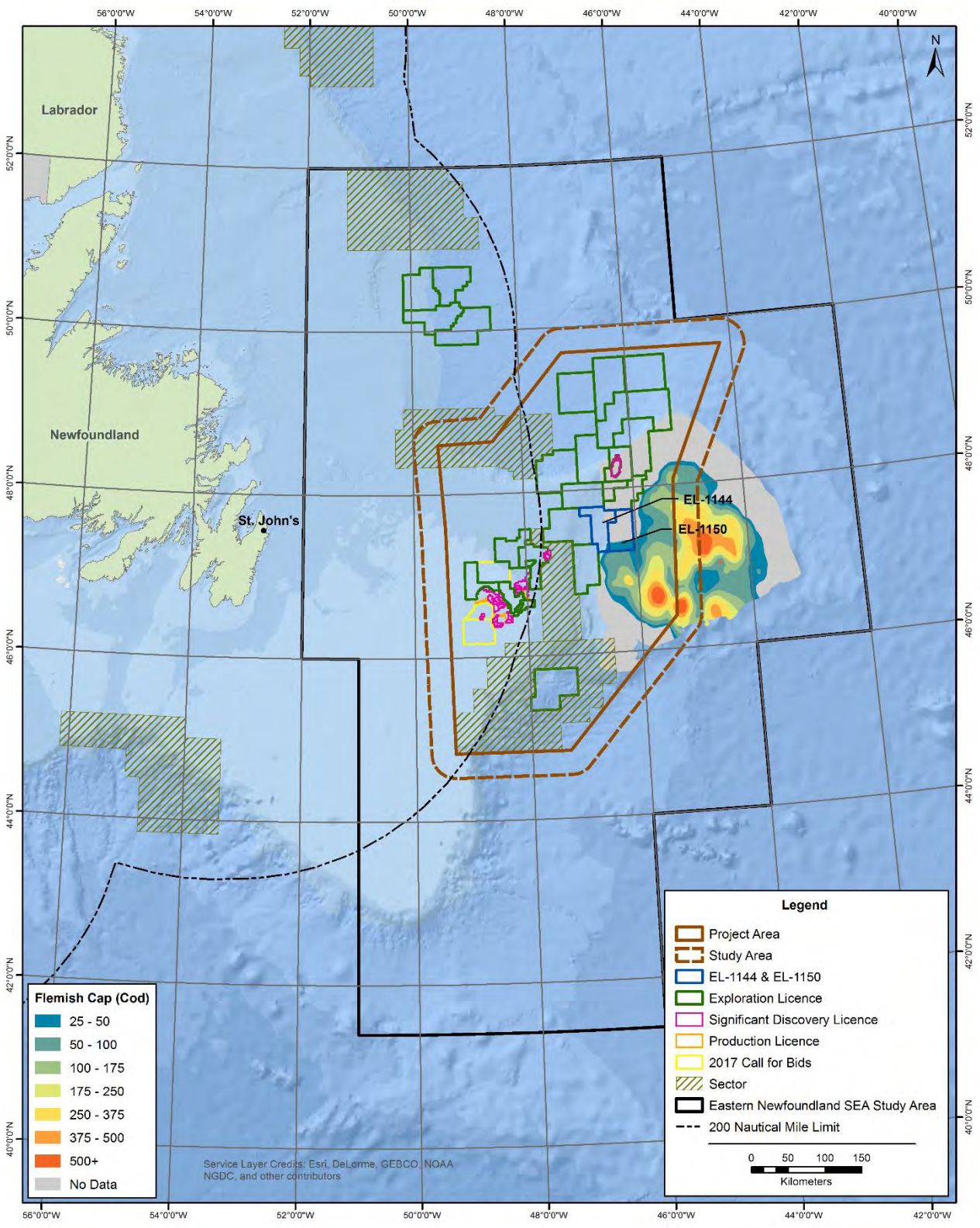


Figure 4.37 Distribution of Atlantic Cod on the Flemish Cap (EU RV Surveys, 2012)



Grenadier (Roughhead and Roundnose)

Roughhead grenadier comprised less than one percent of the total catch in the Canadian and EU RV surveys, and roundnose grenadier comprised less than one percent of the total catch in the EU RV surveys, as shown in Table 4.12. Both grenadier species are important parts of middle slope to deep slope assemblages (over 600 m) as observed in the Canadian and EU RV surveys and pelagic longline surveys. These two slow growing, deep sea species are well distributed on the continental slopes (Figures 4.38 to 4.40). Roughhead grenadiers are abundant on the Flemish Pass and Nose of the Grand Banks and roundnose grenadiers are abundant between the Flemish Cap and Nose of the Grand Banks (Figure 4.40). Grenadiers prey on benthic invertebrates and small fish and serve as prey to other piscivorous fish (Scott and Scott 1988).

Hookear Sculpin

Hookear sculpins that are present in the Study Area include Atlantic hookear sculpin and snowflake hookear sculpin. The Atlantic hookear sculpin inhabits soft bottom habitats ,whereas snowflake hookear sculpins show no known substrate preference (van Guelpen 1986). Hookear sculpins are mainly distributed in shelf areas (less than 250 m) with relatively high abundance and are rarely captured in Canadian RV surveys at depths greater than 500 m (Figure 4.41), as demonstrated by relatively high concentrations of sculpin catches on the shelf of the Grand Banks.

Blue Hake

Blue Hake are associated with mud bottoms on the slope and are distributed from 250 to over 2,000 m depths in the Study Area (Figure 4.42). They are an important part of deepwater assemblages with peak abundances between 1,300-2,200 m depths (Murua and de Cardenas 2005). Catches from Canadian RV surveys show high aggregations of blue hake on the northern and western slopes of the Flemish Cap and the northeastern slope of the Newfoundland Shelf. This species comprised less than one percent of the EU RV survey catch on the Flemish Cap.

Black Dogfish

This demersal shark feeds mainly on squid, crustaceans, jellyfish and small redfish and is distributed mainly on the slopes of the Grand Bank. This species has been observed in the Study Area at depths over 600 m, although they are a key species of transition to deep slope assemblages (1000-1,500 m) as shown in the results of the RV and longline surveys. They are a main species of the Flemish Cap surveys where they comprised less than one percent of the total catch (Figure 4.43). In the Canadian RV surveys, black dogfish has mainly been captured on the western slopes of the Flemish Cap and southern area of the Flemish Pass.

Longnose Eel

The longnose eel is distributed in northern and southern parts of the Atlantic Ocean, in the Pacific Ocean and the Gulf of Mexico. This bottom dwelling species is commonly observed on the Grand Banks with a depth range of 240-3,650 m (Baker et al 2012). It is the eighth most abundant species caught on the Flemish Cap and is a key species in middle to deep slope assemblages at over 600 m depth in the Study Area (Figure 4.44). In the Canadian RV surveys, it is predominantly captured in deep regions of the Flemish Pass or western slopes of the Flemish Cap.

Figure 4.38 Distribution of Roughhead Grenadier in the Study Area (Canadian RV Surveys, 2008-2012)

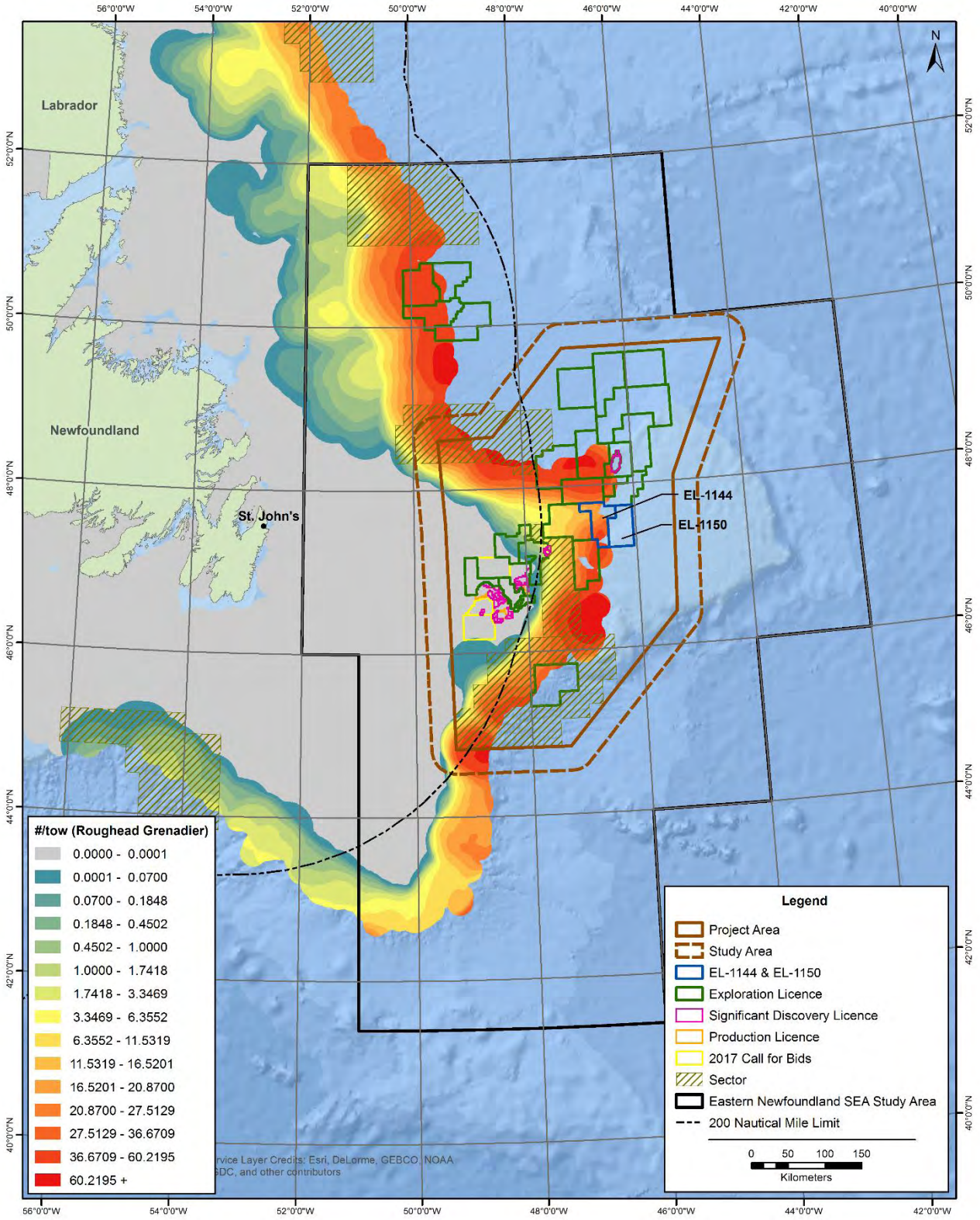


Figure 4.39 Distribution of Roughhead Grenadier on the Flemish Cap (EU RV Surveys, 2012)

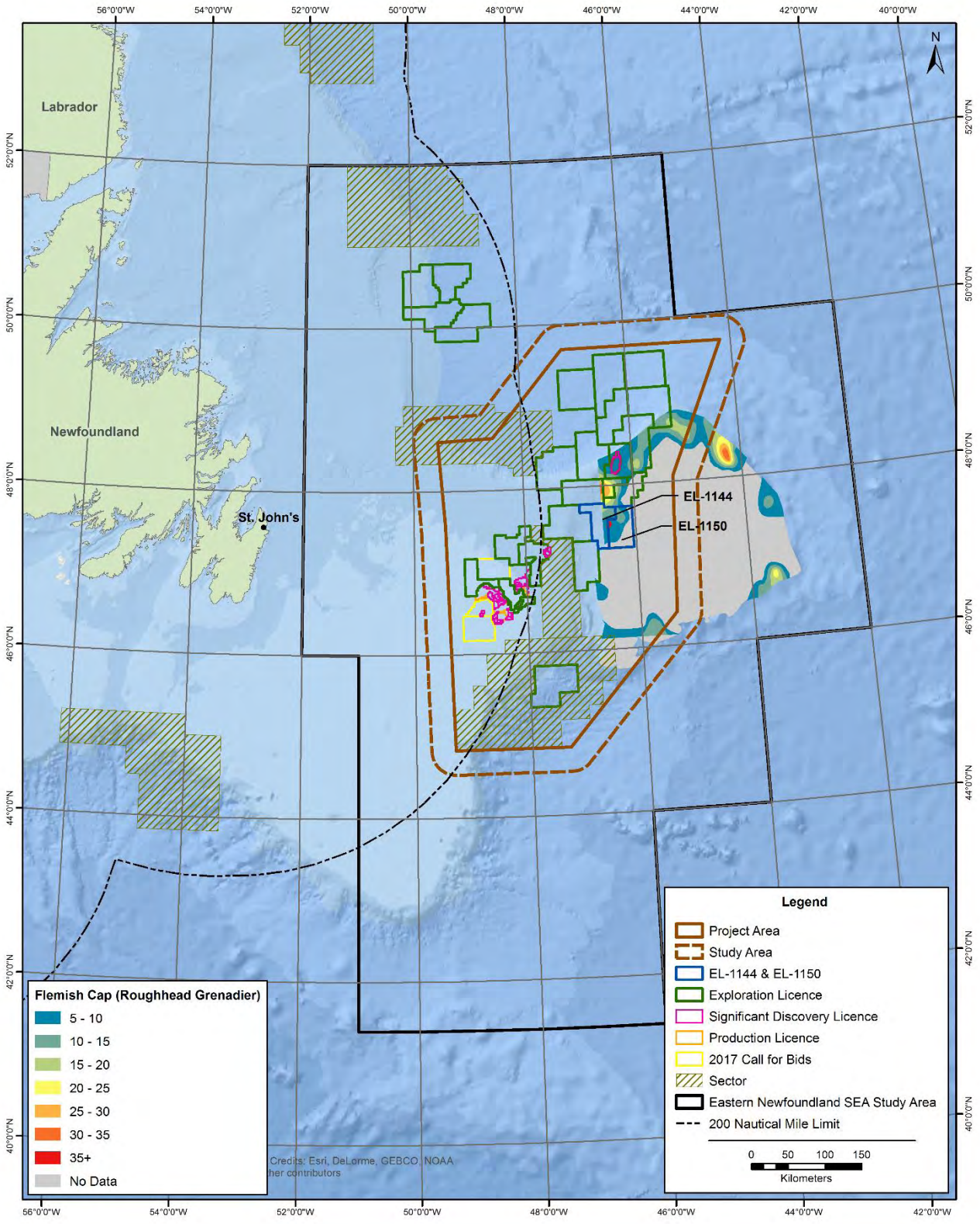


Figure 4.40 Distribution of Roundnose Grenadier in the Study Area (Canadian RV Surveys, 2008-2012)

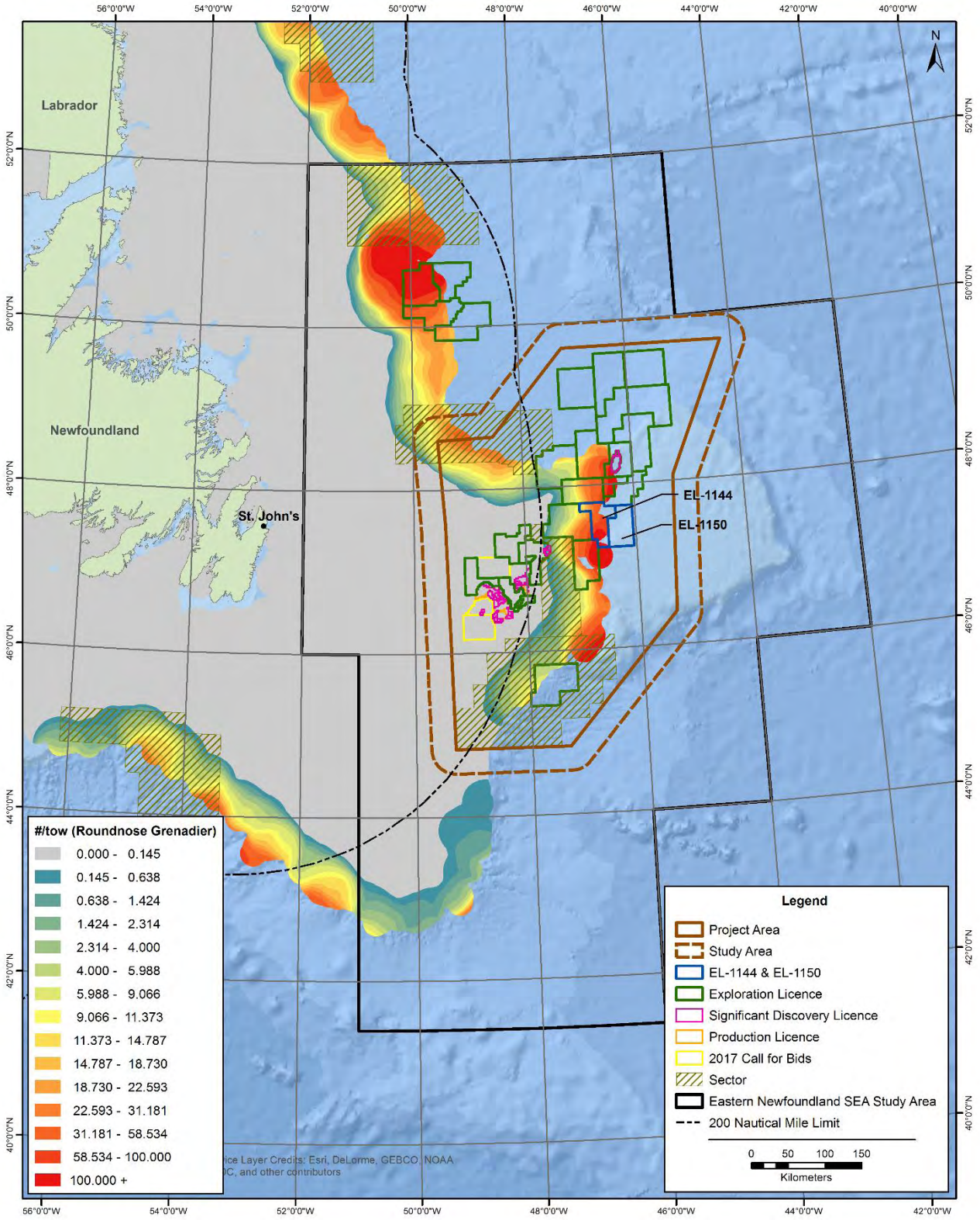


Figure 4.41 Distribution of Hookear Sculpin in the Study Area (Canadian RV Surveys, 2008-2012)

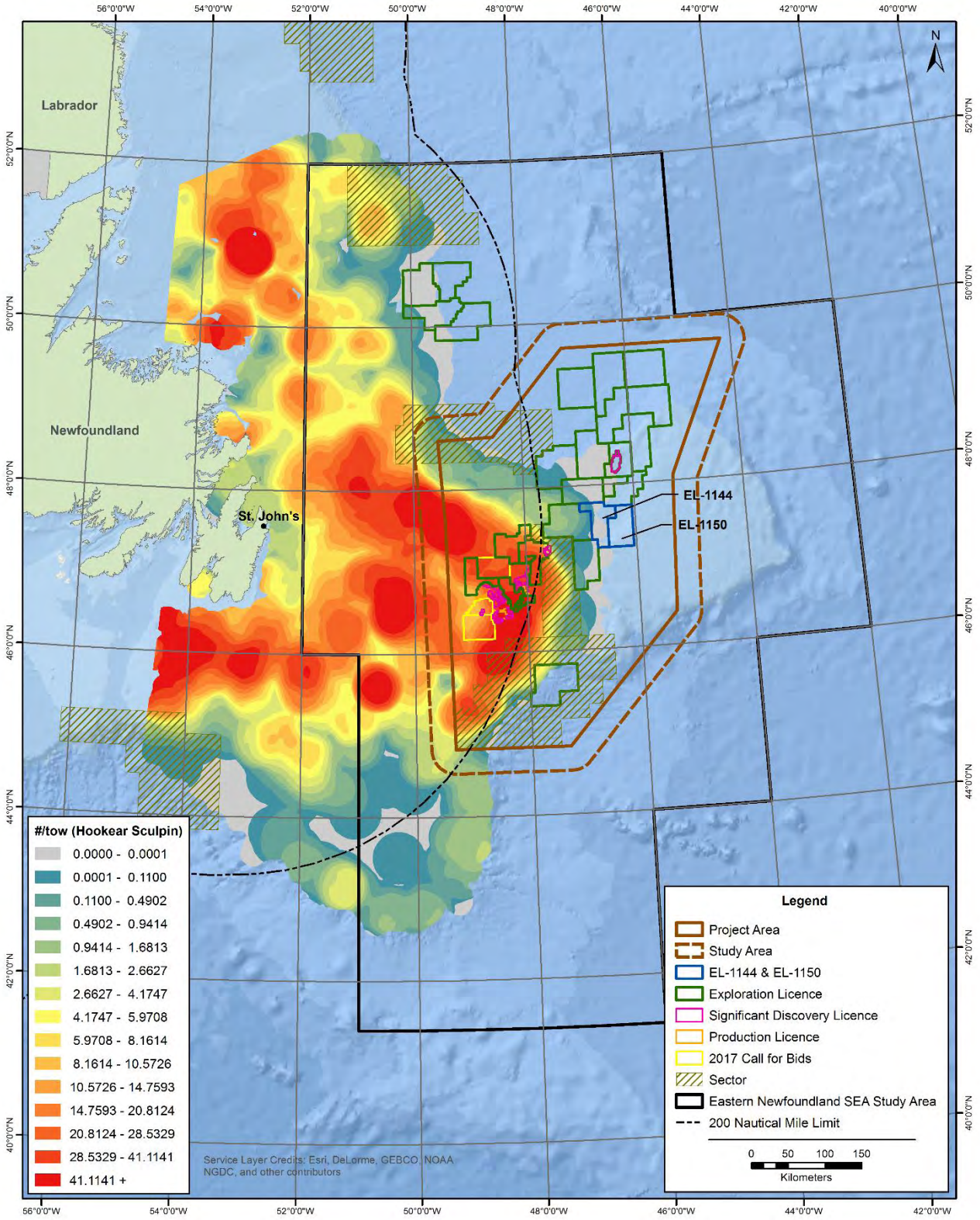


Figure 4.42 Distribution of Blue Hake in the Study Area (Canadian RV Surveys, 2008-2012)

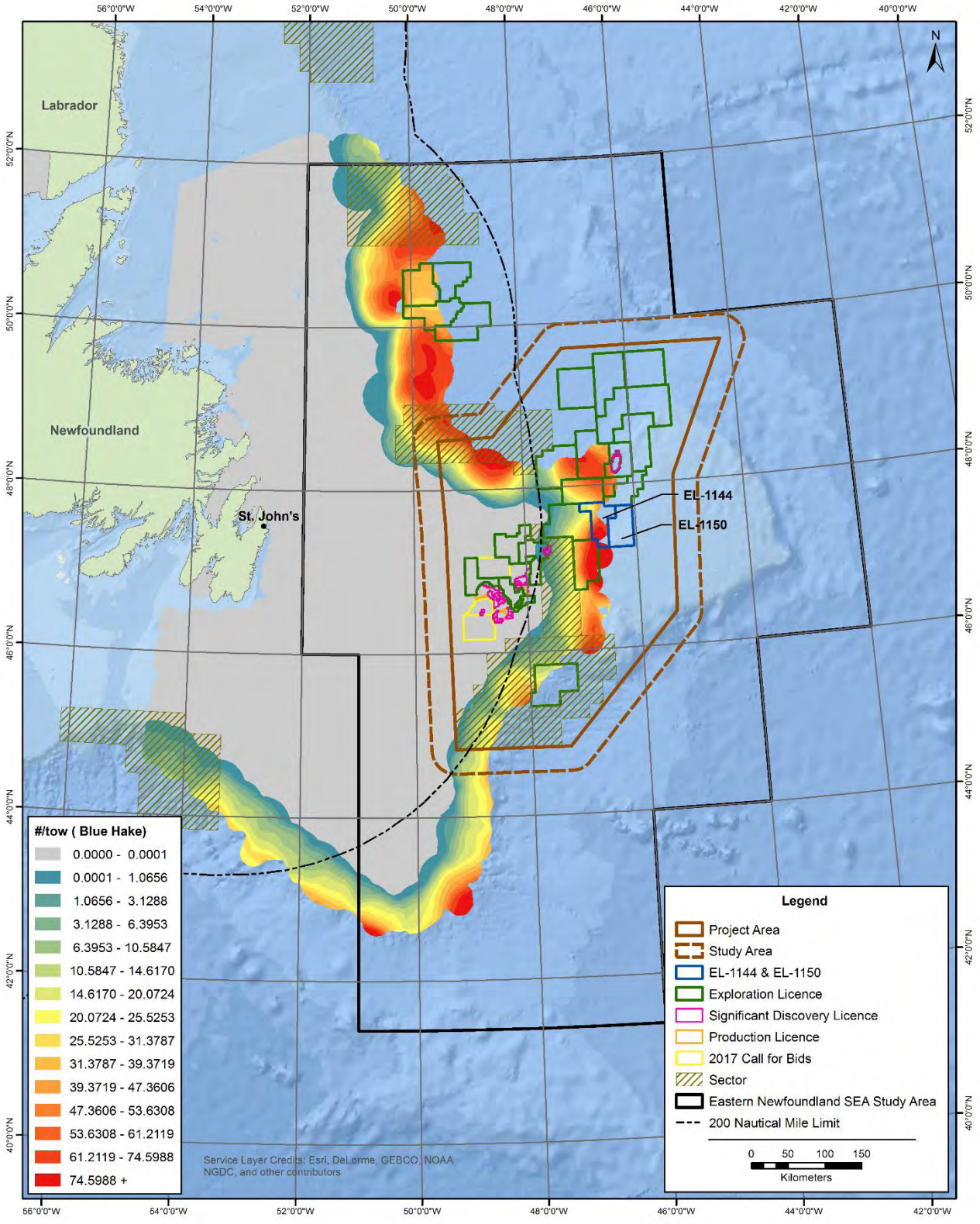


Figure 4.43 Distribution of Black Dogfish in the Study Area (Canadian RV Surveys, 2008-2012)

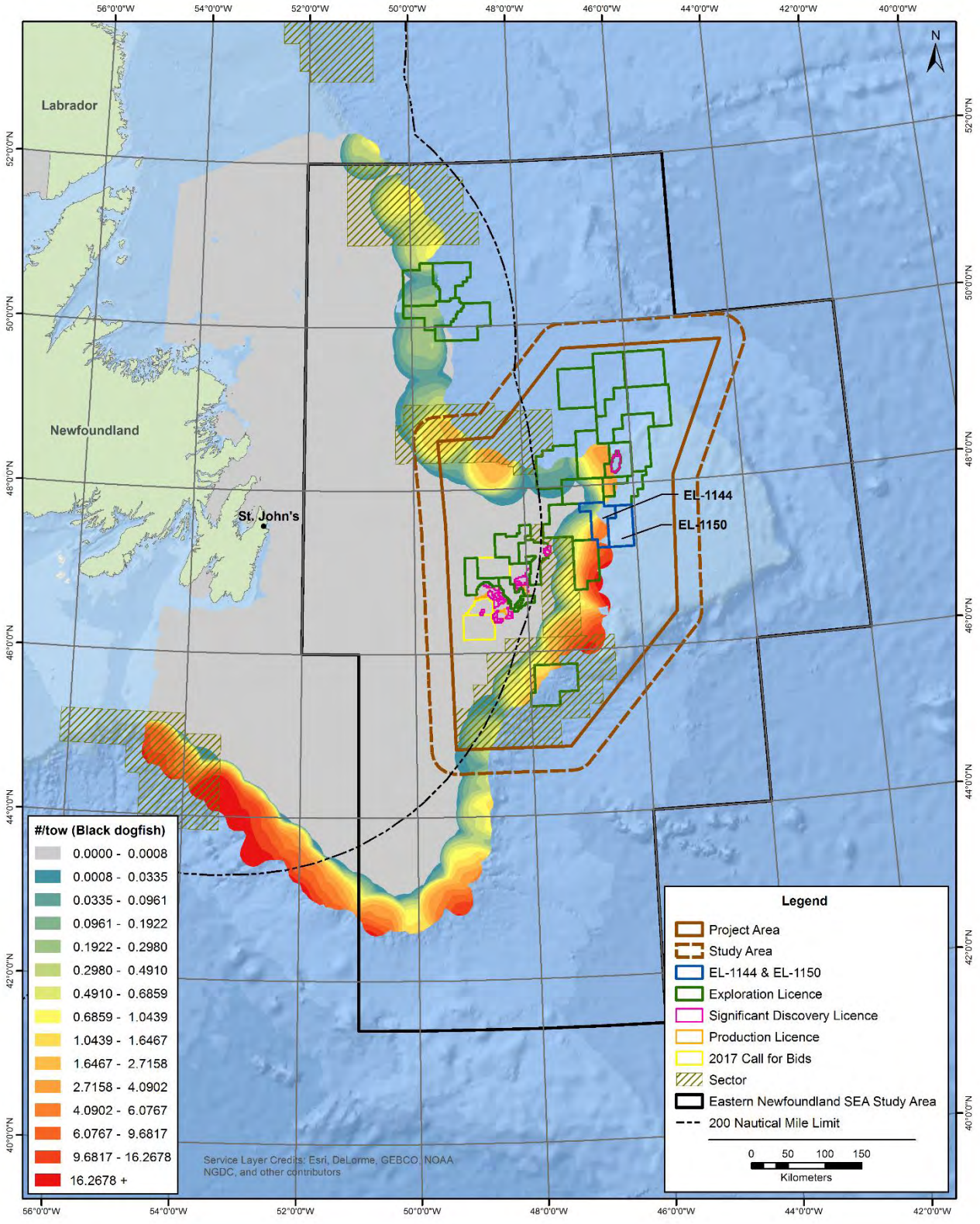
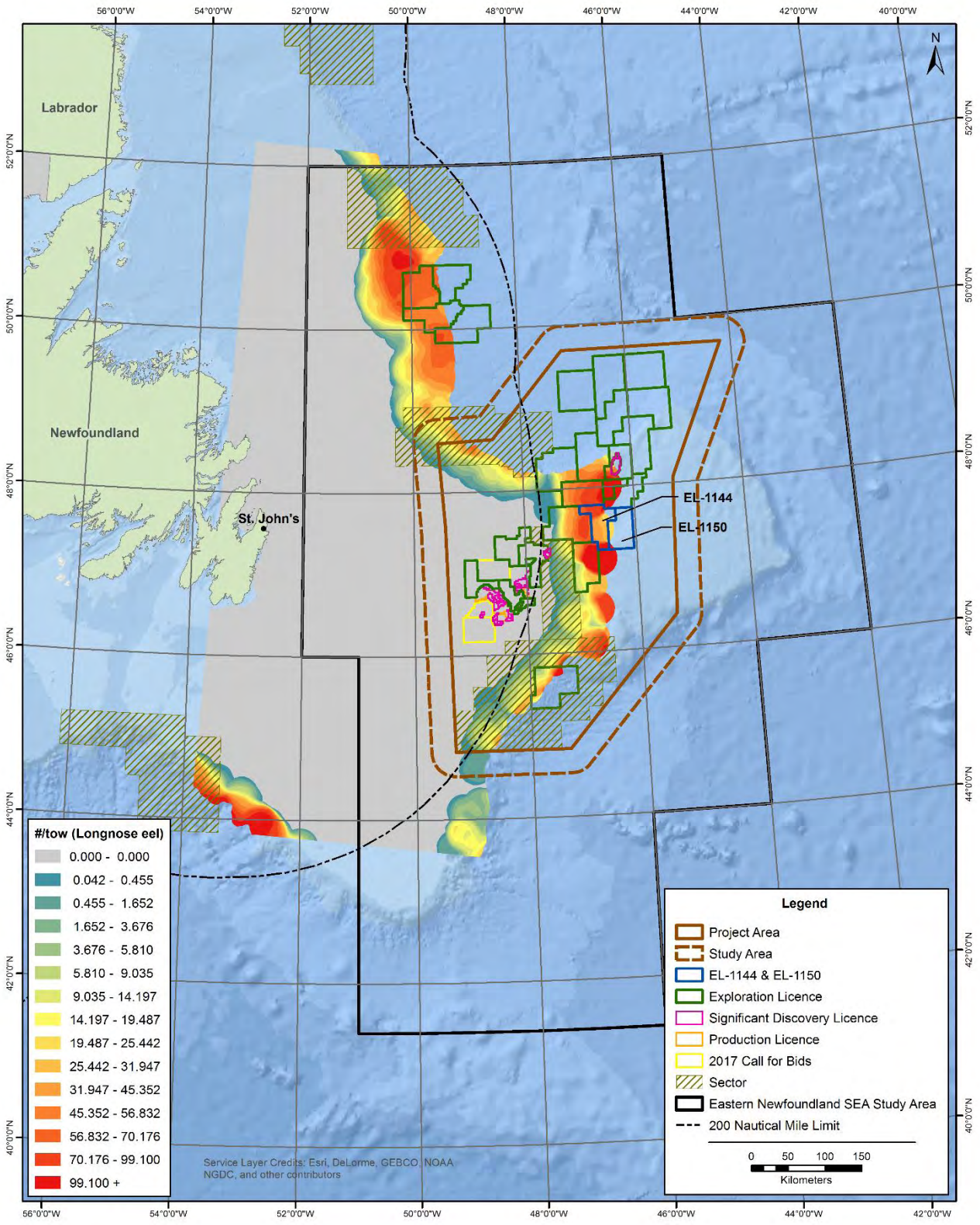


Figure 4.44 Distribution of Longnose Eel in the Study Area (Canadian RV Surveys, 2008-2012)



Spawning

The various fish species that are found in the Study Area exhibit diverse reproductive strategies that include demersal spawning (such as skates, capelin) and broadcast spawning (Atlantic cod) as well as more specialized strategies such as diadromy (Atlantic salmon, American eels) and ovivipary (species such as sharks and redfish that give birth to live young). In many cases, spawning migrations take fish species well beyond Newfoundland's offshore to freshwater rivers, more shallow waters or tropical locations, whereas others are able to fulfill their whole life cycle in the Study Area. Of those that remain, most are spring and early summer spawners. However a few spawn in winter, such as Greenland halibut and roughhead grenadier (Figure 4.45).

Figure 4.45 Spawning Periods and Reproductive Biology for Key Species

Species	Spawning Time[1]												Key Spawning Locations
	J	F	M	A	M	J	J	A	S	O	N	D	
Sand lance	■	■	■								■	■	Grand Bank[2,3]
Capelin						■	■						Southeast shoal of Grand Bank[4]
Deepwater redfish				■	■	■							Southwest Shelf Edge and Slope of Grand Bank[4,5]
Acadian redfish[5]				■	■	■							
Golden redfish[6]			■	■	■								
Yellowtail flounder				■	■	■	■						Grand Bank
American plaice				■	■	■							Grand Bank
Greenland halibut	■	■	■	■									Davis Strait
Myctophid sculpin								■	■	■	■		
Hookear sculpin[7]					■	■	■	■	■	■			
Lanternfish				■	■	■	■						
Atlantic cod[8]				■	■	■	■	■	■	■	■		Southeast shoal of Grand Bank and Virgin Rocks[4]
Blue hake[9]	■	■	■								■	■	
Roughhead grenadier	■	■	■	■									
Roundhead grenadier[10]	■	■	■	■	■	■	■	■	■	■	■	■	
Black dogfish[11]	■	■	■	■	■	■	■	■	■	■	■	■	

Sources: [1] Scott and Scott 1988; [2] Winters 1983; [3] Gilman 1994; [4] Templeman 2007; [5] COSEWIC 2010a; [6] Saborido-Rey et al 2015; [7]von Dorrien 1996; [8]COSEWIC 2010b; [9]White et al 2011; [10]COSEWIC 2008; [11]Jakobsdóttir 1998

Migration Patterns

Fish migration in temperate latitudes is common, allowing individuals to seek out seasonally abundant resources, avoid harsh environmental conditions and/or aggregate for activities such as spawning (Dingle and Drake 2007). Key migration strategies used by fish found in the Study Area are described in the Eastern Newfoundland SEA (Amec 2014) and include:

- Migrations from offshore wintering habitats to shallow coastal areas in summer (cod and capelin);
- Summer feeding migrations from southerly latitudes into the Study Area by large warm water pelagic species such as tunas, swordfish and a variety of sharks;
- Migrations of freshwater spawners like Atlantic salmon, which often transit through the Study Area between offshore feeding migrations and their natal rivers;
- Catadromous migrations of American eel, that may pass through offshore environments as they migrate between freshwater rearing environments and the Sargasso Sea spawning areas; and
- Movements within offshore habitats that can be exhibited by deep water species (such as redfish, wolffish and Greenland halibut) and some stock components of other species (including inshore populations of Atlantic cod).

An important consideration of migratory species is therefore that their movements may extend well beyond the Study Area. For example, Atlantic salmon populations that have to migrate through the Study Area could originate from rivers on the south coast of Newfoundland, the Maritimes or even the northeast United States (COSEWIC 2010c). Large pelagics (such as sharks) could have migration pathways that carry them across large portions of the Atlantic Ocean (Ocearch 2017).

Some migrations are conducted across wide areas of the Study Area, such as inshore-offshore migrations, whereas in other cases some generalized migration corridors can be identified. These include:

- Warm, deep water channels that are used to access inshore areas (such as the Bonavista Corridor); and
- The Southern Grand Bank, which likely experiences traffic from pelagics migrating to and from southerly latitudes.

4.2.1.8 Fish Species at Risk and Otherwise of Special Conservation Concern

Species of conservation concern (SOCC) are identified by “arm’s length” conservation organizations such as COSEWIC and the International Union for the Conservation of Nature (IUCN). Some of these species are provided with legislative protection within Canadian (federal *Species at Risk Act - SARA*) and provincial (*Newfoundland and Labrador Endangered Species Act - NL ESA*) jurisdictions.

Within the Study Area, 30 species have been identified as SOCC with some species having overlapping designations under COSEWIC and IUCN. Currently 23 species have been identified by COSEWIC and 23 species have been identified on the IUCN Redlist for the Study Area (Table 4.13). Several COSEWIC and IUCN assessed species, including large migratory pelagics, may never have occurred in great densities in the Study Area as it is peripheral to their typical range. Other listed species remain common, including American plaice, Atlantic cod, and redfish, but have experienced population declines, particularly during the groundfish collapse of the early 1990s. There are currently four *SARA* listed and one *NL ESA* listed species that may occur within the Study Area, including three species of wolffish, the white shark, and the American eel (Table 4.13).

Table 4.13 Fish Species at Risk or Otherwise of Special Conservation Concern

Family	Species		Status/Designation[1]			
	Common Name	Scientific Name	*NL ESA*	*SARA* Status (Schedule 1)	COSEWIC Designation	IUCN
Anarhichadidae	Atlantic wolffish	*Anarhichas lupus*		SC	SC	
Anarhichadidae	Northern wolffish	*Anarhichas denticulatus*		T	T	
Anarhichadidae	Spotted wolffish	*Anarhichas minor*		T	T	
Anguillidae	American eel	*Anguilla rostrata*	V		T	E
Carcharhinidae	Blue shark	*Prionace glauca*			NR	NT
Cetorhinidae	Basking shark	*Cetorhinus maximus*			SC	V
Gadidae	Atlantic cod (Newfoundland and Labrador population)	*Gadus morhua*			E	V
Gadidae	Cusk	*Brosme brosme*			E	
Gadidae	Haddock	*Melanogrammus aeglefinus*				V
Lamnidae	Porbeagle	*Lamna nasus*			E	V
Lamnidae	Shortfin mako	*Isurus oxyrinchus*			T	V
Lamnidae	White shark	*Carcharodon carcharias*		E	E	V
Macrouridae	Roughhead grenadier	*Macrourus berglax*			SC	
Macrouridae	Roundnose grenadier	*Coryphaenoides rupestris*			E	CE
Phycidae	White hake (Atlantic and Northern Gulf of St. Lawrence population)	*Urophycis tenuis*			T	
Pleuronectidae	American plaice (Newfoundland and Labrador population)	*Hippoglossoides platessoides*			T	
Pleuronectidae	Atlantic halibut	*Hippoglossus hippoglossus*				E
Rajidae	Barndoor skate	*Dipturus laevis*				E
Rajidae	Little skate	*Leucoraja erinacea*				NT
Rajidae	Smooth skate (Funk Island Deep population)	*Malacoraja senta*			E	E
Rajidae	Spinytail skate	*Bathyraja spinicauda*				NT

Family	Species		Status/Designation[1]			
	Common Name	Scientific Name	*NL ESA*	*SARA* Status (Schedule 1)	COSEWIC Designation	IUCN
Rajidae	Thorny skate	*Amblyraja radiata*			SC	V
Rajidae	Winter Skate (Eastern Scotian Shelf – Newfoundland)	*Leucoraja ocellata*			E	E
Salmonidae	Atlantic salmon (South Newfoundland Population; Outer Bay of Fundy population)	*Salmo salar*			T; E	LC
Scombridae	Albacore tuna	*Thunnus alalunga*				NT
Scombridae	Atlantic bluefin tuna	*Thunnus thynnus*			E	E
Scombridae	Bigeye tuna	*Thunnus obesus*				V
Scorpaenidae	Acadian redfish (Atlantic population)	*Sebastes fasciatus*			T	E
Scorpaenidae	Deepwater redfish (Northern population)	*Sebastes mentella*			T	LC
Squalidae	Spiny dogfish	*Squalus acanthias*			SC	V

[1] Not at Risk (NR), Least Concern (LC), Vulnerable (V), Near Threatened (NT), Special Concern (SC), Threatened (T), Endangered (E), Critically Endangered (CE)

Striped, northern and spotted wolffish have either “special concern” or “threatened” designations under the *SARA*. All three species are slow growing and long lived, characteristics that limit their recovery potential from stressors including bycatch mortality or habitat alteration. Populations of all three species have declined in Canadian waters since the 1980s due mainly to commercial fishing bycatch mortality. However there has been a small upward trend since the mid 1990s (COSEWIC 2012a, 2012b, 2012c). Proposed measures to increase population levels and distributions as part of the Recovery Strategy and Management Plans include increasing research on each species, protecting habitat, monitoring and mitigating human impacts (Kulka et al 2007). Habitat requirements and preferences differ considerably across these three species. Striped wolffish generally frequent depths of less than 100 m with peak abundance around 250 m depths and below the thermocline (COSEWIC 2012a). Juveniles and adults of this species generally inhabit areas of rocky and sandy bottoms and require caves or boulders for spawning (COSEWIC 2012a). Spotted wolffish mainly frequent intermediate water depths (200-750 m) with no apparent substrate type preferences (COSEWIC 2012b). Northern wolffish have a wide depth range (38-1,504 m), but tend to occupy pelagic areas more than the other two wolffish species and are associated with sand and shell substrates (COSEWIC 2012c).

The Canadian RV Survey data support the scientific literature conclusions for wolffish distributions, including that the northern wolffish was typically distributed in deeper waters (Figures 4.46). Areas of high abundance for all three species were associated with deep slope areas and the Flemish Pass. However, the striped wolffish (Figures 4.47) was more widespread, occurring in many areas of the continental shelf at lower abundance. An area of high spotted wolffish concentration was observed in the Bonavista Corridor (Figures 4.48).

Figure 4.46 Distribution of Northern (Broadhead) Wolffish in the Study Area (Canadian RV Surveys, 2008-2012)

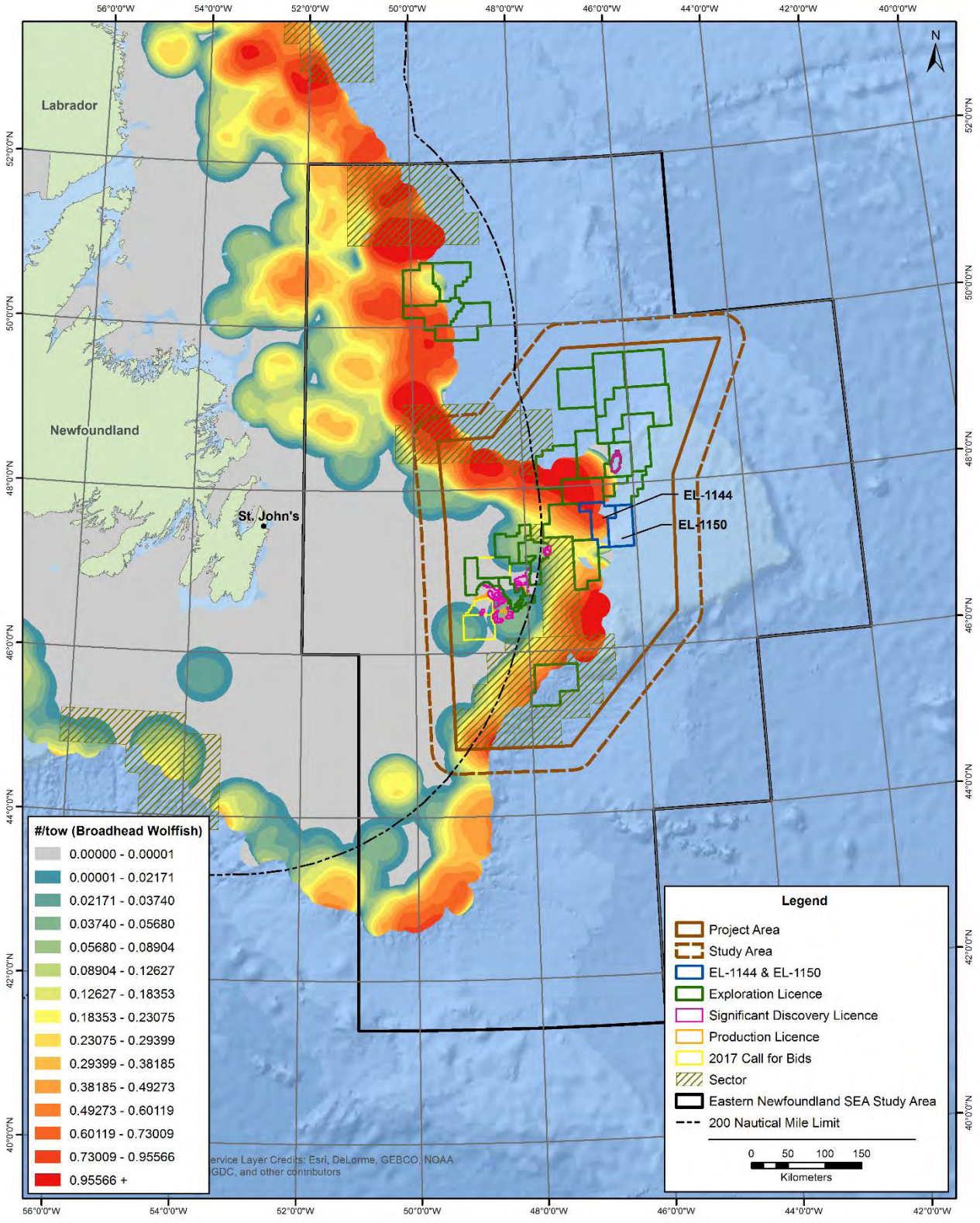


Figure 4.47 Distribution of Striped Wolffish in the Study Area (Canadian RV Surveys, 2008-2012)

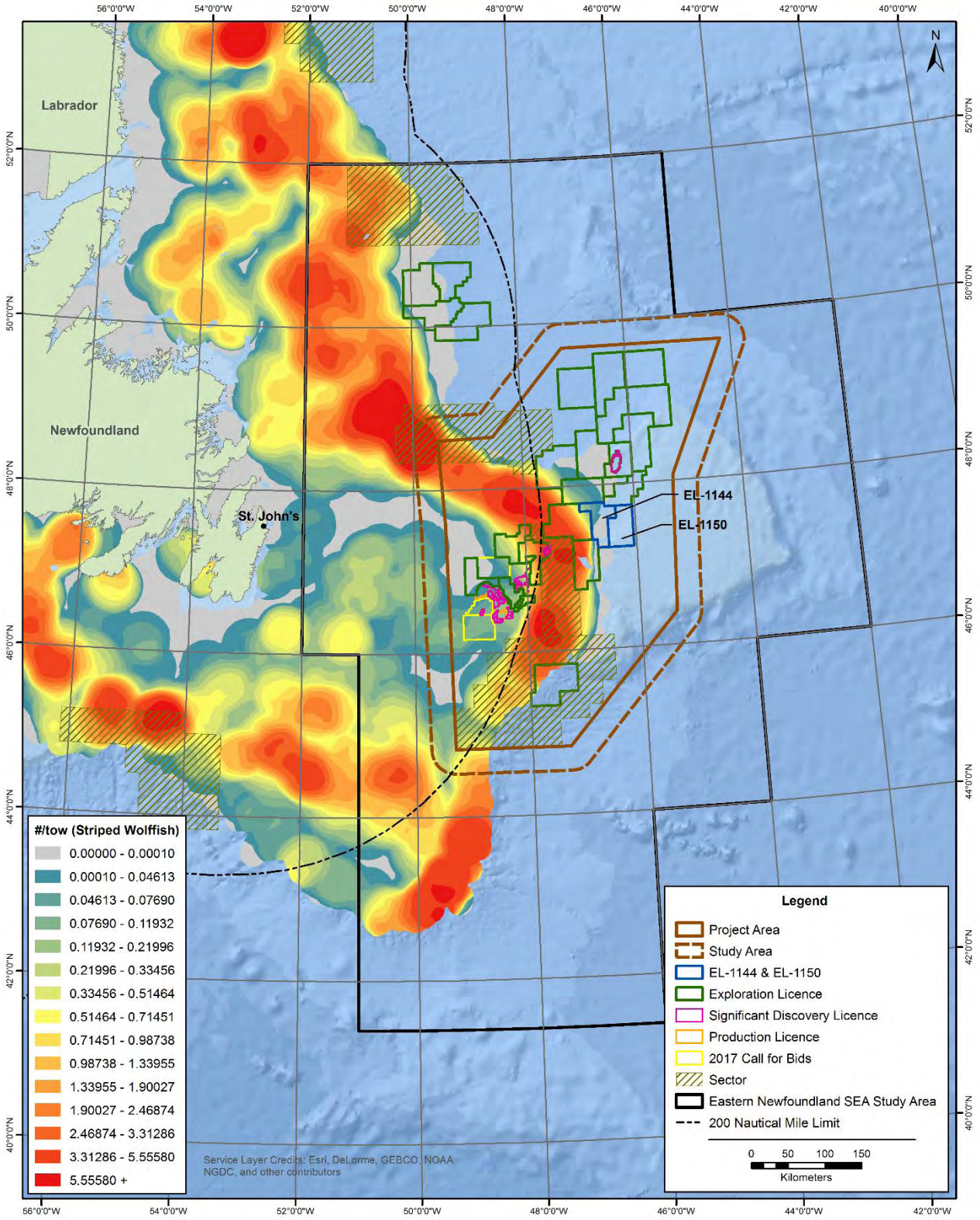
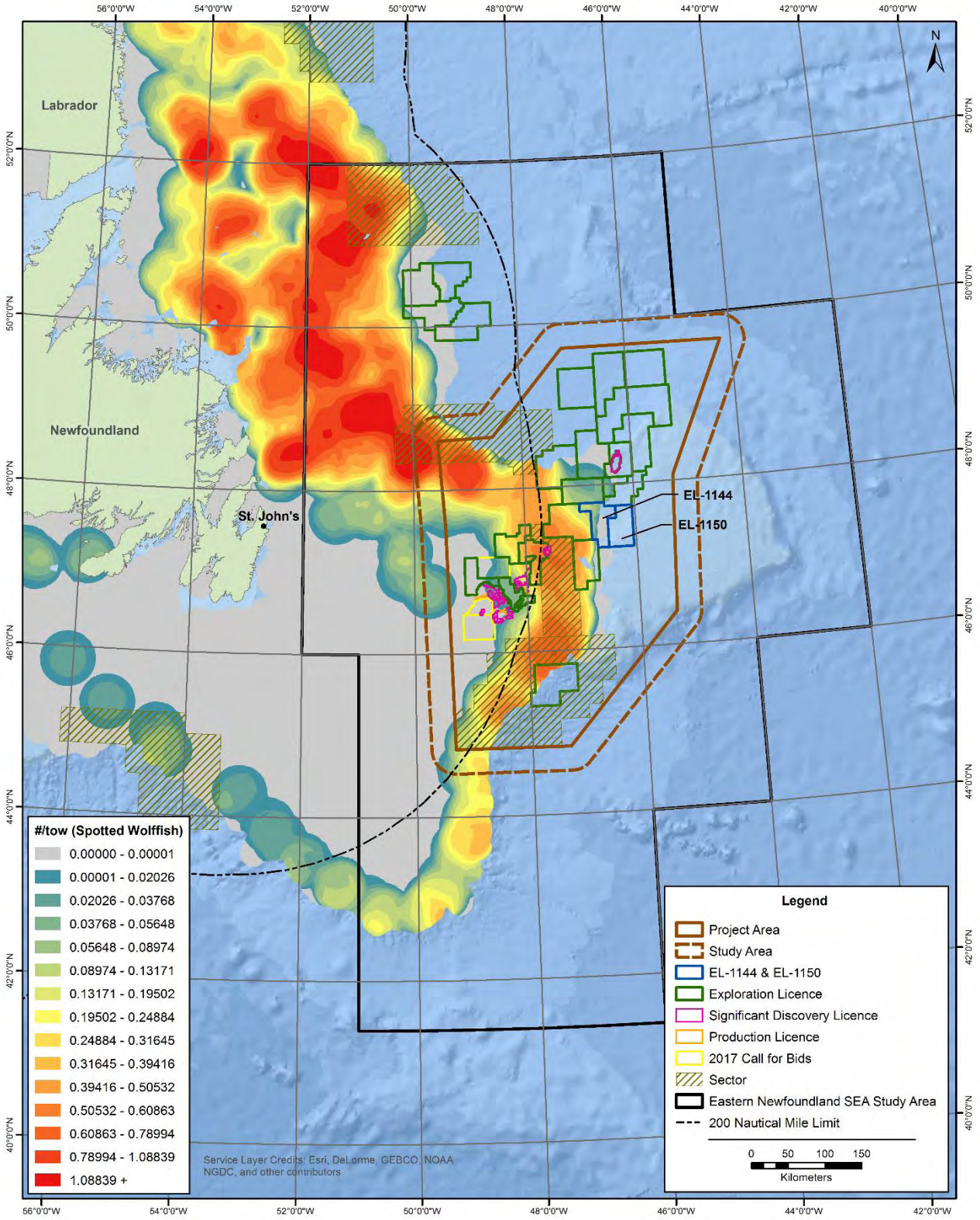


Figure 4.48 Distribution of Spotted Wolffish in the Study Area (Canadian RV Surveys, 2008-2012)



American eels are a catadromous species that spawns in the marine environments and migrates to freshwater environments for rearing and growth. This species is listed as “vulnerable” under the *NL ESA*. Adult American eels migrate from freshwater environments to the Sargasso Sea off Bermuda to spawn and adults die shortly after reproduction (Figure 4.49). The resulting eggs and larvae drift passively on the Gulf Stream to coastal areas of North America, where they migrate into freshwater lakes and rivers. Pelagic larval and adult stages may drift through the Study Area during their migrations. American eels are part of large panmictic population with little genetic differentiation between eels from various locations (Cairns et al 2014). Threats to eel populations include barriers to freshwater migration and habitat fragmentation, contaminants, parasites and shifting environmental conditions (COSEWIC 2012d).

The white shark is listed as “endangered” under the *SARA*. It inhabits inshore and offshore waters and the intertidal zone to continental slopes (COSEWIC 2006a) and is distributed in sub-polar to tropical seas. White sharks have been observed from Newfoundland and the Grand Banks, including the Study Area, to the Gulf of Mexico, but they are primarily distributed off the eastern coast of the US (Curtis et al 2014). Their distribution ranges are seasonal, with sharks frequenting areas off the southeastern US in winter months and expansion to northern parts of their range in the spring to summer (Curtis et al 2014). Recent tracking programs have showed that white sharks may migrate through or nearby the Study Area (Figure 4.50). A directed fishery for this species is not conducted in Canadian waters, but bycatch mortality remains a threat to this species.

4.2.1.9 Aquatic Invasive Species

Invasive species threaten ecosystems around the globe (Molnar et al 2008). Their capacity for rapid population growth can disrupt ecosystems and their native species through processes that include predation, competition or habitat alteration. Such species can also have negative economic effects by affecting fisheries, fouling marine infrastructure and even altering human health (Molnar et al 2008). Consequently, within the Study Area, invasive species are a concern to local fishermen (Amec 2014), where increased industrial traffic serves as a potential vector for invasive species (McKenzie et al 2010; Benoit et al 2012). Seven invasive species have been identified in the Newfoundland Shelf, including: the European green crab, the Japanese skeleton shrimp, the golden star tunicate, the violet tunicate, the vase tunicate, the coffin box bryozoans and oyster thief algae. These species are generally thought to have greater effects on benthic coastal communities compared to the open ocean environments that characterize the Study Area (Templeman 2010).