Maritimes Region Longline and Trap Fisheries Footprint Mapping for Marine Spatial Planning and Risk Assessment

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2019

Canadian Technical Report of Fisheries and Aquatic Sciences 3293

Canadian Technical Report of Fisheries and Aquatic Sciences

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Rapport technique canadien des sciences halieutiques et aquatiques

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Les numéros 1 à 456 de cette série ont été publiés à titre de Rapports techniques de l’Office des recherches sur les pêcheries du Canada. Les numéros 457 à 714 sont parus à titre de Rapports techniques de la Direction générale de la recherche et du développement, Service des pêches et de la mer, ministère de l’Environnement. Les numéros 715 à 924 ont été publiés à titre de Rapports techniques du Service des pêches et de la mer, ministère des Pêches et de l’Environnement. Le nom actuel de la série a été établi lors de la parution du numéro 925.

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Cat. No. Fs97-6/3293E-PDF
ISBN 978-0-660-29348-6 ISSN 1488-5379

Correct citation for this publication:

S. Butler, D. Ibarra and S. Coffen-Smout, 2019. Maritimes Region Longline and Trap Fisheries Footprint Mapping for Marine Spatial Planning and Risk Assessment. *Can. Tech. Rep. Fish. Aquat. Sci*. 3293: v + 30 p.

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This report shows commercial fishery footprint maps for directed fisheries using bottom and pelagic longlines for groundfish and large pelagics respectively, and traps for hagfish, LFA 41 and Grey Zone lobster, snow crab, and other crab on the Scotian Shelf, the Bay of Fundy, and Georges Bank in NAFO Divisions 4VWX and Canadian portions of 5Y and 5Z. Bottom longline and trap fishery maps aggregate commercial logbook effort (bottom longline soak time and logbook entries) per 2-minute grid cell using 2002–2017 data. Pelagic longline maps aggregate speed-filtered vessel monitoring system (VMS) track lines as vessel minutes per km^2 using 2003–2018 data. The following maps are publicly available and included in the report for multiple applications in marine spatial planning and ecological risk assessment: 1) multi-year and quarterly composite maps and data layers aggregating fishery footprints for bottom longline and trap gear, and 2) yearly and monthly composite maps and data layers for pelagic longline. Yearly maps and data layers for bottom longline and trap gear were also produced for internal use and management-related decision making. These maps may be compared with 1999–2003 landings maps in the DFO publication *The Scotian Shelf: An Atlas of Human Activities* (DFO, 2005) and with 2010–2014 landings maps in a fisheries atlas (Butler and Coffen-Smout, 2017).

RÉSUMÉ

S. Butler, D. Ibarra and S. Coffen-Smout, 2019. Maritimes Region Longline and Trap Fisheries Footprint Mapping for Marine Spatial Planning and Risk Assessment. Can. Tech. Rep. Fish. Aquat. Sci. 3293: v + 30 p.

Le présent rapport présente des cartes de l'empreinte de la pêche commerciale pour la pêche dirigée à la palangre de fond et à la palangre pélagique pour les poissons de fond et les grands poissons pélagiques respectivement, et de la pêche au casier pour la myxine, le homard de la zone grise et de la zone de pêche du homard 41 ainsi que le crabe des neiges et d'autres crabes sur la plate-forme Néo-Écossaise, dans la baie de Fundy et dans le banc de Georges dans les divisions 4VWX et dans les portions canadiennes des divisions 5Y et 5Z de l'Organisation des pêches de l'Atlantique Nord-Ouest. Les cartes de la pêche à la palangre de fond et de la pêche au casier illustrent l'effort global de pêche commerciale dans le journal de bord (temps d'immersion de la palangre de fond et saisies du journal de bord) par maille de 2 minutes en utilisant les données de 2002–2017. Les cartes de la pêche à la palangre pélagique regroupent les tracés du système de surveillance des navires (SSN), dont la vitesse est exprimée en minutes par km2 à l'aide des données de 2003–2018. Les cartes suivantes sont accessibles au public et incluses dans le rapport pour de multiples usages en matière de planification spatiale marine et d'évaluation des risques écologiques : 1) des cartes composites et des couches de données pluriannuelles et trimestrielles regroupant les empreintes de pêche à la palangre de fond et au casier, et 2) des cartes composites et des couches de données annuelles et mensuelles pour la palangre pélagique. Des cartes et des couches de données annuelles pour la palangre de fond et les casiers ont également été produites à des fins d'usage en interne et de prise de décisions en matière de gestion. Ces cartes peuvent être comparées aux cartes des débarquements de 1999–2003 présentées dans la publication du MPO intitulée *La plate-forme Néo-Écossaise : atlas des activités humaines* (MPO, 2005) et aux cartes des débarquements de 2010–2014 dans un atlas des pêches (Butler et Coffen-Smout, 2017).

INTRODUCTION

The commercial fishery footprint maps in this report are for directed fisheries using bottom and pelagic longlines for groundfish and large pelagics respectively, as well as trap gear for hagfish, LFA 41 and Grey Zone lobster, snow crab and other crab[1] on the Scotian Shelf, the Bay of Fundy, and Georges Bank in NAFO Divisions 4VWX and Canadian portions of 5Y and 5Z. Bottom longline and trap fishery maps aggregate commercial logbook effort (bottom longline soak time and logbook entries) per 2 x 2-minute grid cell using 2002–2017 data. Pelagic longline maps in the report aggregate speed-filtered vessel monitoring system (VMS) track lines as vessel minutes per km^2 using 2003–2018 data.

Data sources include the regional commercial logbook database maintained by DFO Policy and Economics Branch, i.e., the Maritime Fishery Information System (MARFIS) database in Maritimes Region. VMS data is sourced from the VMS Centre of Expertise database in DFO's Newfoundland and Labrador Region.

Variables in the logbook dataset included: catch latitude and longitude, species landed, live weight, date caught, NAFO unit area, DFO region, gear code and class, vessel ID, trip ID, licence ID, and fisher ID. Erroneous data were not removed from datasets to address incorrect geo-references, e.g., sets on land that are masked by land and bottom fisheries in depths > 1,500 m. Variables in the VMS dataset included: vessel ID, date, time, and latitude and longitude. In addition to yearly maps that are not for public distribution, multi-year, quarterly, or monthly composite maps and data layers that aggregate fishery footprints for each map series are publicly available and included in this report. These spatial depictions of fishing activity do not represent biological distributions of species as species' range distributions are broader than fishery footprints and management measures influence the fishing effort distribution.

These maps may be used for decision making in coastal and oceans management, including marine spatial planning and ecological risk assessment. Management applications may include mitigating human use conflicts, informing Marine Stewardship Council certification processes, marine conservation planning, and assessing ecological risks and threats to species at risk. The maps may be compared with 1999–2003 landings maps in the DFO publication *The Scotian Shelf: An Atlas of Human Activities* (DFO, 2005) and with 2010–2014 landings maps in a fisheries atlas (Butler and Coffen-Smout, 2017).

METHODS

Fisheries Mapping Methodology

Fisheries footprint maps for bottom longline (BLL) gear were produced using commercial logbook data and observer data, while pelagic longline (PLL) fishing footprint maps for untended, drifting pelagic longline gear were produced using vessel monitoring system (VMS) data. Footprint maps of trap-gear fisheries for snow crab, other crab, LFA 41 and Grey Zone lobster, and hagfish were produced using commercial logbook data. Groundfish gillnet footprint maps were not included in this report; however, a five-year composite gillnet landings map is published in Butler and Coffen-Smout (2017) showing a footprint off southwestern Nova Scotia and in the Gulf of Maine.

Identification of Targeted Species in Logbook Data

Fisheries logbook data (2002–2017) from DFO's Maritimes Region was first processed to extract logbook entries for five fixed-gear fisheries (i.e., BLL, snow crab, other crab, LFA 41 and Grey Zone lobster, and hagfish). The 'other crab' category includes trap fisheries targeting Spider-Toad, Jonah, Rock, Red, and Stone-King crab species. In order to remove records where a species was not targeted (i.e., bycatch), a

[1] Other Crab includes species such as Spider-Toad crab, Jonah crab, Rock crab, Red crab, and Stone-King crab.

series of processing steps was employed. For example, a single logbook entry will often have multiple records associated with it for the different species caught. For this reason, a single record must be identified as the targeted record as to avoid double-counting. Using an approach used in past effort mapping projects (Butler and Coffen-Smout, 2017), it was assumed that the species caught with the largest total catch for a given logbook entry was the targeted species. The resulting directed records were then parsed to extract the five different fishery types.

Bottom Longline Fishery Observer Data

While the four trap fisheries (i.e., snow crab, other crab, LFA 41 and Grey Zone lobster, and hagfish) are believed to be an accurate spatial representation of the fishery, an additional analysis was completed for the bottom longline fishery to better represent the spatial footprint associated with this gear type. To obtain an estimate of the spatial footprint of longline gear in the water, as well as the typical soak time, data from the At-Sea Observer Program were analyzed. After reviewing the observer data, the 1999–2017 time period was extracted for analysis as coordinate locations were more consistently reported post-1998.

For the bottom longline fishery, information is recorded at various times when the longline is first set and then recovered. These different events include when the first hook on the longline enters the water (P1), followed by the location where the last hook enters the water (P2). This is then followed by the start location of the recovery of the longline (P3), and finally the last hook removed from the water (P4). Based on advice from DFO Science, the locations of P1 and P2 were plotted and polylines joining the two locations were generated. While a "footprint" approach was explored to make use of all four reported locations (P1-P4), the amount of error and uncertainty associated with the coordinates made this approach challenging. Furthermore, the amount of drift associated with bottom longline gear is minimal, so there was not a significant benefit to plotting all four locations (H. Stone and B. Wringe, pers. comm.).

The main goal of using the observer data was to obtain an average length between the P1-P2 locations to apply to the logbook data point locations, which represent the start of a bottom longline set (i.e., P1). Furthermore, an average soak time of gear in the water was required, which would also be applied to the logbook data records. According to DFO Science (B. Wringe, pers. comm.), the time between P2 and P3 is the best estimate of the average minimum time that gear soaks in the water.

Observer Data Cleaning

Before average values of soak time and plotted lengths could be calculated, data cleaning was completed to remove any outliers in the observer data. Using the reported length of longline associated with a given record, obvious errors in the plotted distances between P1 and P2 could more easily be identified by comparing with the reported length values. Using this approach, all plotted P1-P2 lengths less than half or greater than 1.5 times the reported length of longline were removed. This resulted in a much more normal distribution of length values, allowing us to calculate average values. While the soak time values of the observer data did not have the amount of errors associated with the plotted length values, a simple data cleaning method was employed to remove obvious outliers. Based on advice from DFO Science (B. Wringe, pers. comm.), soak times between P2 and P3 rarely exceed 24 hours. For this reason, all soak times exceeding 24 hours were removed from the dataset.

Logbook Data Limitations

Opportunities exist for errors to be introduced into fisheries landings databases, both reporting errors (e.g., wrong positions recorded in the logbook or monitoring report) and data entry errors (e.g., incorrect data entries in electronic databases). We have not removed landings data that are probably erroneous, and fixed-gear maps of trap and bottom longline fisheries should be interpreted in light of the characteristics and area-based management measures of a specific fishery. Furthermore, only one latitude and longitude position is used per reported landing. A logbook entry may represent one day of activity; however, fishing gear may cover a large area that goes well beyond the reported position. On the scale of the Scotian Shelf, using a single position to represent fishing activity is not problematic, nonetheless patterns shown in maps should be considered general patterns of activity and not an absolute determination of where fishing does or does not occur.

Random Transect Generation

Following the data cleaning process, average plotted P1-P2 lengths and soak times were calculated based on the species sought. For bottom longline observer data, the two categories of species sought were: 1) Atlantic halibut; or 2) Cod, Haddock, and Pollock. In order to apply these average values to the logbook data, a "random transect" approach was used to generate lines at random angles originating at the logbook data start set point. Based on the targeted species of the logbook data, the generated line segments were assigned the observer data average lengths based on one of the two species sought categories. For logbook entries where Atlantic halibut was targeted, the average P1-P2 length value (4,029 metres) was applied (see Figure 1). Conversely, for logbook entries where all other groundfish species were targeted, the average P1-P2 length (2,382 metres) for the 'Cod, Haddock, and Pollock' category was applied (see Figure 2).

Using the same approach as the plotted lengths, the average soak times were assigned to the logbook data according to the targeted species (9.65 and 11.78 hours for 'Atlantic halibut' and 'Cod, Haddock, and Pollock,' respectively). The two resulting transect files ('Atlantic halibut' and 'Cod, Haddock, and Pollock') were then merged together to create a single bottom longline transect file for the 2002–2017 time period.

Data Aggregation and Effort Map Production

The final step of creating the fishery effort maps was to aggregate the fisheries datasets by binning the data into 2-minute grid cells. This process was completed for the four trap fishery logbook point datasets, as well as the bottom longline transects. The grids produced included fishing activity for the entire 2002–2017 time period, quarterly maps to demonstrate the seasonal variability of the fisheries, as well as yearly maps for each of the 16 years. Quarterly maps for January-March (Q1) were not included for hagfish, other crab, and Grey Zone lobster due to the Rule of Five on data privacy not being met.[2] NAFO unit areas that fail to meet the Rule of Five on data privacy are indicated on maps as privacy screened areas. To represent fishing effort, the trap fishery grids were presented as the total number of logbook entries per grid cell due to inconsistent reporting of other effort metrics such as numbers of traps or trap hauls. While logbook data for certain trap fisheries can include other effort metrics reported (e.g., number of traps), this was underreported for specific fisheries. To represent bottom longline gear fishing effort, aggregated soak time (hrs) per grid cell was generated.

Vessel Monitoring System Data Processing

Vessel Monitoring System (VMS) data from 2003 to 2018 were used to estimate the density of longliners engaged in fishing as a proxy for the pelagic longline fishing footprint in DFO's Maritimes Region. The VMS data were initially filtered to only include pelagic longliners, and subsequently filtered to only include vessels moving at speeds consistent with fishing-like behaviour. The filtered VMS data were interpolated to estimate vessel positions between hourly detections and then projected onto a 0.01 degrees regular grid to estimate fishing vessel density. VMS data along Nova Scotia's Atlantic coastline were

[2] The Rule of Five on data privacy states that fisheries data and data products (e.g., maps) are not to be shared without consent for fisheries where there are less than five different Fisher IDs, Licence IDs, or vessel registration numbers (VRNs) in any one geographic area during the timeframes displayed in map products.

removed from three exclusion zones where rod and reel gear were incorrectly coded in the database as pelagic longline gear. The coastal areas where VMS data were removed are: 1) the Bluefin Exclusion Zone enclosed by Nova Scotia's coastline from Clark's Harbour/Barrington Passage in Shelburne County to Liscomb Harbour in Guysborough County, 2) NAFO division 4Wd off Chedabucto Bay from Port Bickerton in Guysborough County to Fourchu in Richmond County, and 3) Zone 2 (Bay of Fundy) of the Fishing Zones of Canada where swordfish licence holders are restricted from activity.[3]

Pelagic Longline Filter

We cross-referenced VMS data with data from the Maritimes Fishery Information System (MARFIS) logbook database to identify vessels using pelagic longlines. We used the vessel registration number (VRN) from the VMS data to query the hail-out table in the MARFIS database. The temporal extent of each query spanned from 2 days before the first VMS data point in each month, to 2 days after the last data point in each month. The gear reported in the MARFIS hail-out table can be ambiguous since vessels often have licences for several gear types and fishers do not have to log which gear is used in each trip. Therefore, we used landed species as a proxy for gear type, i.e., we assumed that all landings for tunas or swordfish were the result of pelagic longlines. The VMS data were filtered to only include data matching trips that produced tunas or swordfish. Note that a small fraction of tuna landings use rod and reel, but they are restricted to specific coastal zones and thus we eliminated those data as noted above.

Speed Filter

We used apparent speed to discriminate VMS data produced by vessels engaged in fishing activity from other non-fishing activity (i.e., transiting, drifting, docked, anchored, etc.). Apparent speed was calculated from the computed distance and computed elapsed time between pairs of hourly VMS data points. Data points where the apparent speed was between 0.5 and 4.5 knots were considered to be engaged in fishing activity. Data points with apparent speeds slower than 0.5 knots or faster than 4.5 knots were discarded.

Interpolation and Estimation of Heatmaps of Vessel Density

The filtered VMS data were projected onto a 0.01 degree regular grid to estimate heatmaps of vessel density (units: Vessel minutes per km^2). Vessel density was estimated by dividing the number of minutes spent by vessels in a grid cell by the grid cell area. However, because VMS data are normally logged at hourly intervals, subsequent VMS detections often occurred several grid cells apart, thus resulting in "noisy" heatmaps. Therefore, we linearly interpolated between pairs of VMS detections to ensure that vessel density was also calculated in all grid cells between each pair. However, we did not interpolate between pairs of detections if they were separated in time by more than 1 day, or if they were separated in space by more than 74 kilometers (i.e., distance traveled in 1 hour by a vessel cruising at 40 knots). Each month of VMS data was condensed into one gridded file of vessel density. These gridded files were then combined to produce average density maps for each month in all 16 years (i.e., monthly composites), average density maps for each year (i.e., yearly composites), and an average density map for the entire dataset (i.e., 16 years of data). The number of unique vessels in each monthly and yearly composite map was computed to verify that each map included data from at least five vessels to comply with DFO's Rule of Five to maintain privacy of personal or third party information.[4] No pelagic longline fishing occurred from January to March during any year. The only monthly composite map that did not meet the Rule of Five on data privacy was for April, which has been omitted from the maps in this report. All yearly composite maps met the Rule of Five and, on average, there were 46 unique fishing vessels in each yearly composite map over the 16-year period.

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[3] The coordinates and timing of the two pelagic longline exclusion zones are listed in Appendix 4 of the Swordfish Integrated Fishery Management Plan, available online: <http://www.dfo-mpo.gc.ca/fm-gp/peches-fisheries/ifmp-gmp/swordfish-espadon/NEW-swordfish-2013-espado-eng.htm>. Coordinates for Zone 2 (Bay of Fundy) in the Fishing Zones of Canada are online: <https://laws-lois.justice.gc.ca/eng/regulations/C.R.C.,_c._1547/index.html>.
[4] See Rule of Five, n. 2 above.

DISCUSSION

Bottom longline fishery footprints are shown as soak time (hrs) in a 16-year composite map in Figure 3 and as quarterly footprints in Figures 4 to 7. Hagfish trap fishery footprints are represented by the number of logbook entries for all 16 years and as quarterlies in Figures 8 to 11. While there was limited hagfish trap fishing during January-March (Q1) over several years, the Q1 hagfish map did not meet the Rule of Five on data privacy and was excluded from the report.

The lobster fishery footprint in Lobster Fishing Area 41 (LFA 41) and in the Grey Zone at the entrance to the Bay of Fundy is shown in Figure 12. Grey Zone quarterly footprints for lobster in Q2, Q3 and Q4 are shown in Figures 13 to 15. The Grey Zone lobster fishery map for Q1 was excluded due to the absence of data (and a fishery) during January to March. The Grey Zone quarterlies in Figures 13 to 15 exclude LFA 41 data due to the consent of the licence holder being withheld on quarterly data footprints in the offshore lobster fishery. U.S.-based fishers from Maine also target lobster in the Grey Zone, but no U.S. effort data were included in this analysis.

The other crab trap fishery footprint for Spider-Toad crab, Jonah crab, Rock crab, Red crab, and Stone-King crab is shown for all years in Figures 16 and for three quarterlies in Figures 17 to 19. While there was limited fishing for other crab during January-March (Q1) over multiple years, the other crab map for Q1 did not meet the Rule of Five on data privacy and was excluded from the report. The Snow crab trap fishery footprint is represented in Figure 20 for all 16 years and in Figures 21 to 24 for the four quarterlies.

An aggregated 16-year pelagic longline fishery footprint is depicted in Figure 25 and the sixteen yearly footprints are shown in Figures 26 to 41. Eight monthly composites of the pelagic longline fishery footprint are shown in Figures 42 to 49. As noted above, the pelagic longline monthly composite for April did not meet the Rule of Five and was excluded from the report. There was no pelagic longline activity during January to March in any of the 16 years of VMS or logbook data.

The quarterly composite maps are effective at depicting changing seasonality of fixed-gear fisheries using bottom longline and trap gear on the Scotian Shelf and in the Bay of Fundy. The May to December pelagic longline monthly composite maps show spatially shifting effort distributions as a function of migrating targeted tunas and swordfish following warming ocean temperatures on and beyond the Scotian Shelf. It is anticipated that the longline and trap gear fishery footprints in this report will be important data layers for marine spatial planning, risk assessments of species at risk, as well as for broader decision support in integrated oceans management.

ACKNOWLEDGEMENTS

The authors thank Mike McMahon, Heath Stone, and Brendan Wringe for data-related advice and Alex Dalton, Sean Smith, and Carl MacDonald for peer reviewing the report. We acknowledge the assistance of Statistics staff from DFO Maritimes Region to acquire commercial fisheries logbook data. VMS data were sourced from the VMS Centre of Expertise in DFO's Newfoundland and Labrador Region.

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DFO, 2005. *The Scotian Shelf: An Atlas of Human Activities*. http://waves-vagues.dfo-mpo.gc.ca/Library/321387.pdf

FISHERIES FOOTPRINT MAPS

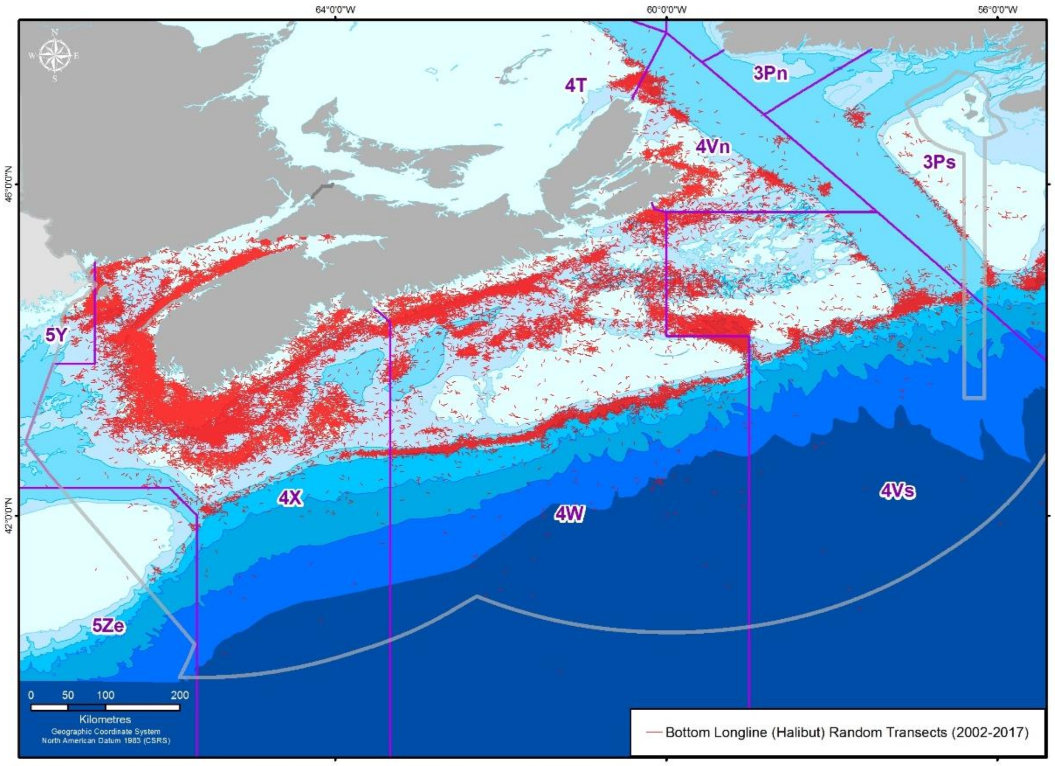

Figure 1.–Random transects for bottom longline targeting Atlantic Halibut, 2002-2017.

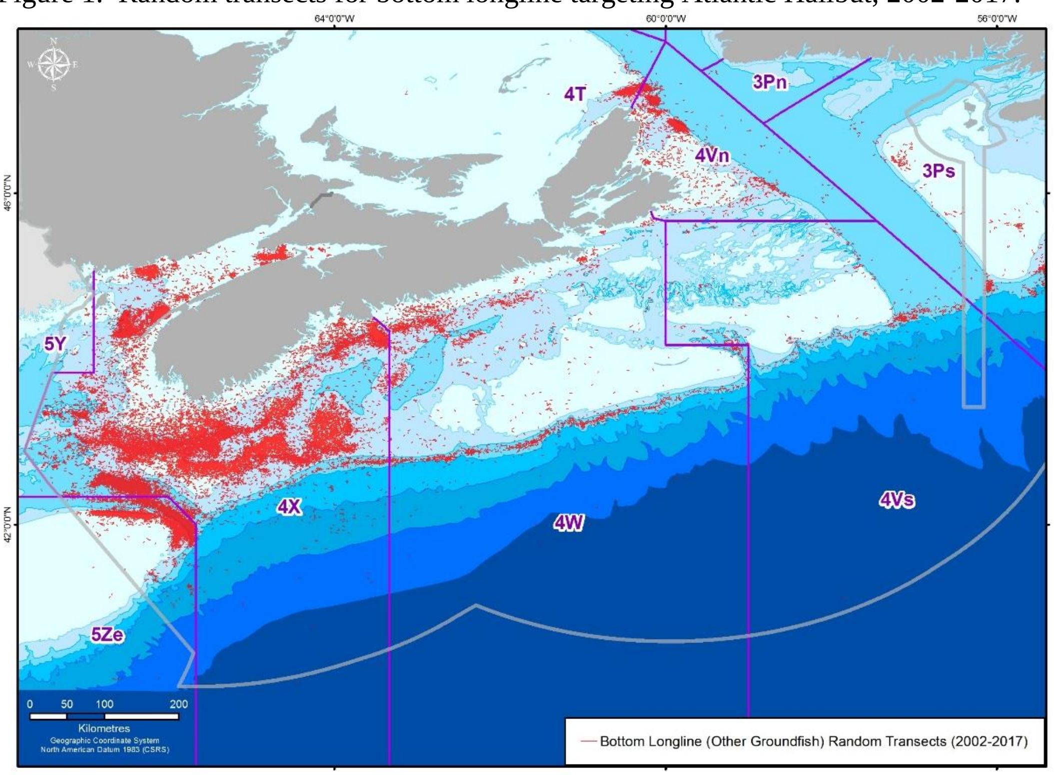

Figure 2.–Random transects for bottom longline targeting Other Groundfish, 2002-2017.

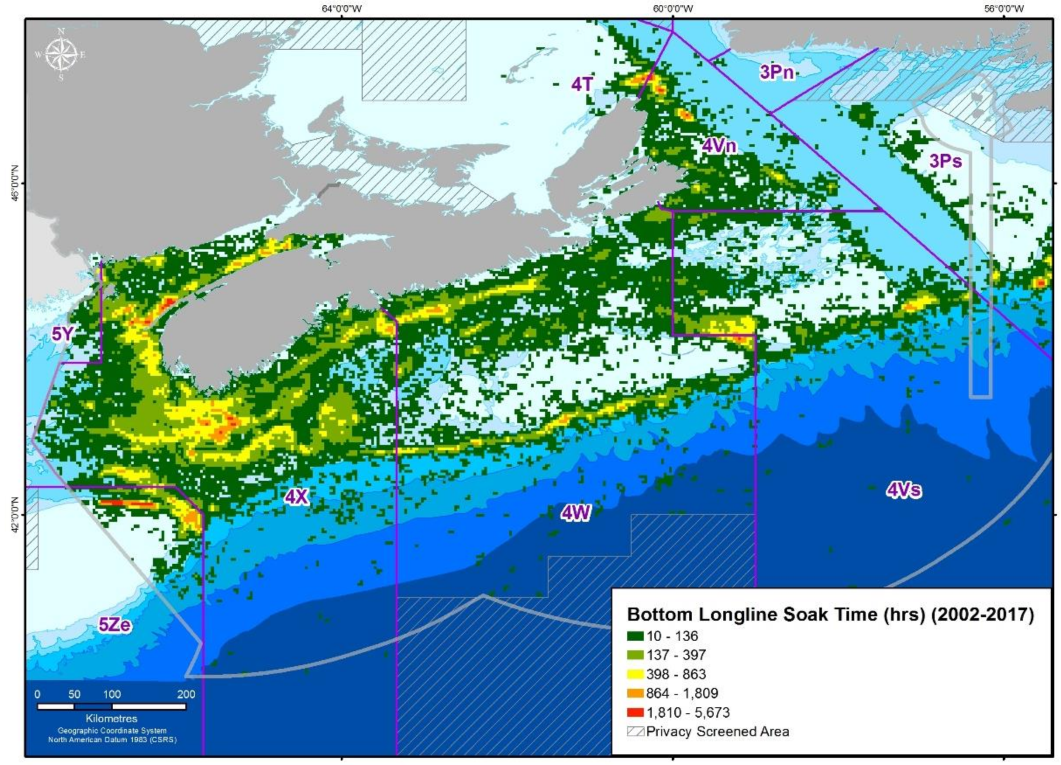

Figure 3.–Bottom longline soak time (hrs), 2002-2017.

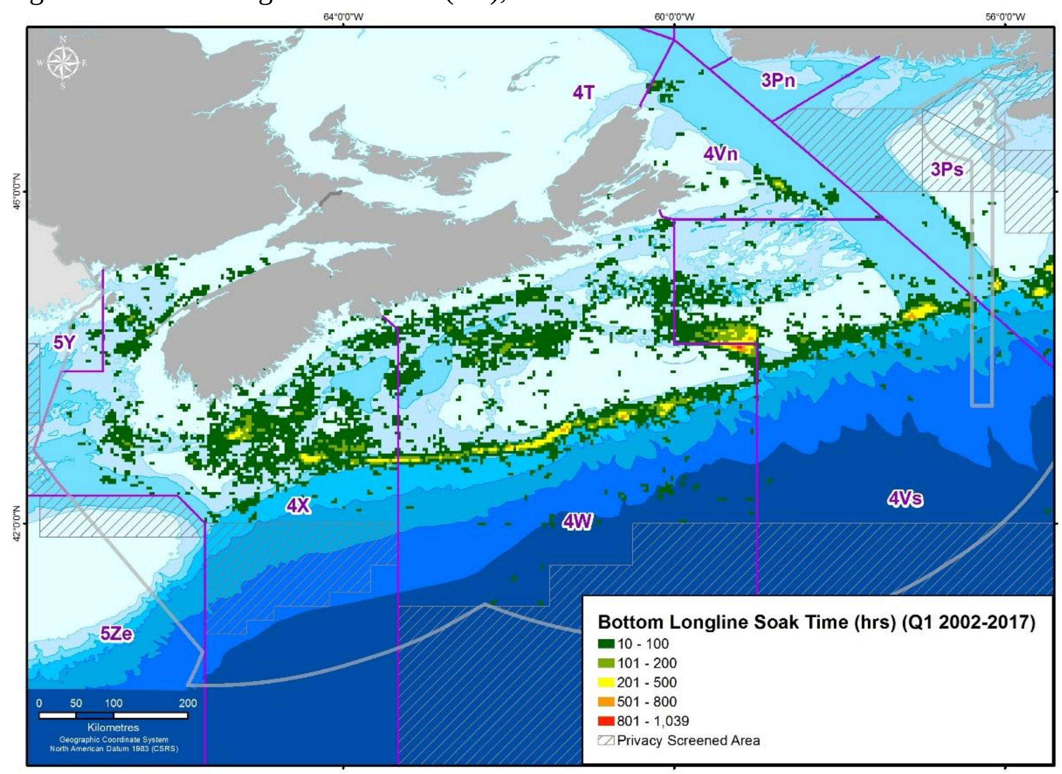

Figure 4.–Bottom longline soak time (hrs), Q1 2002-2017.

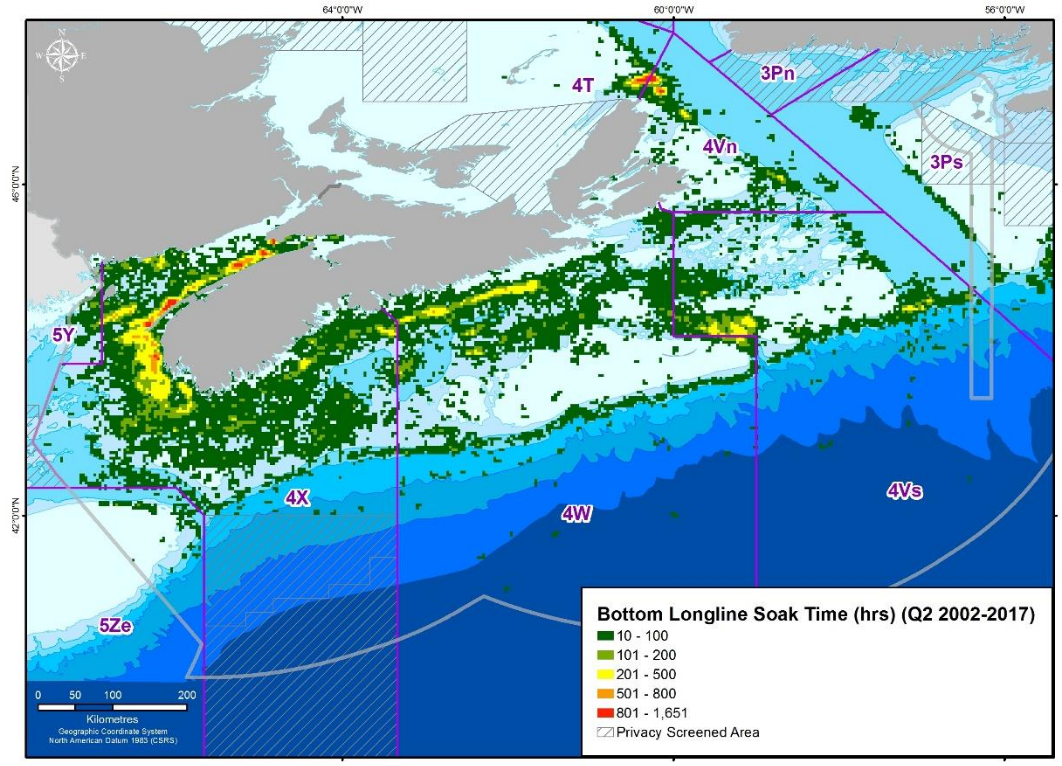

Figure 5.–Bottom longline soak time (hrs), Q2 2002-2017.

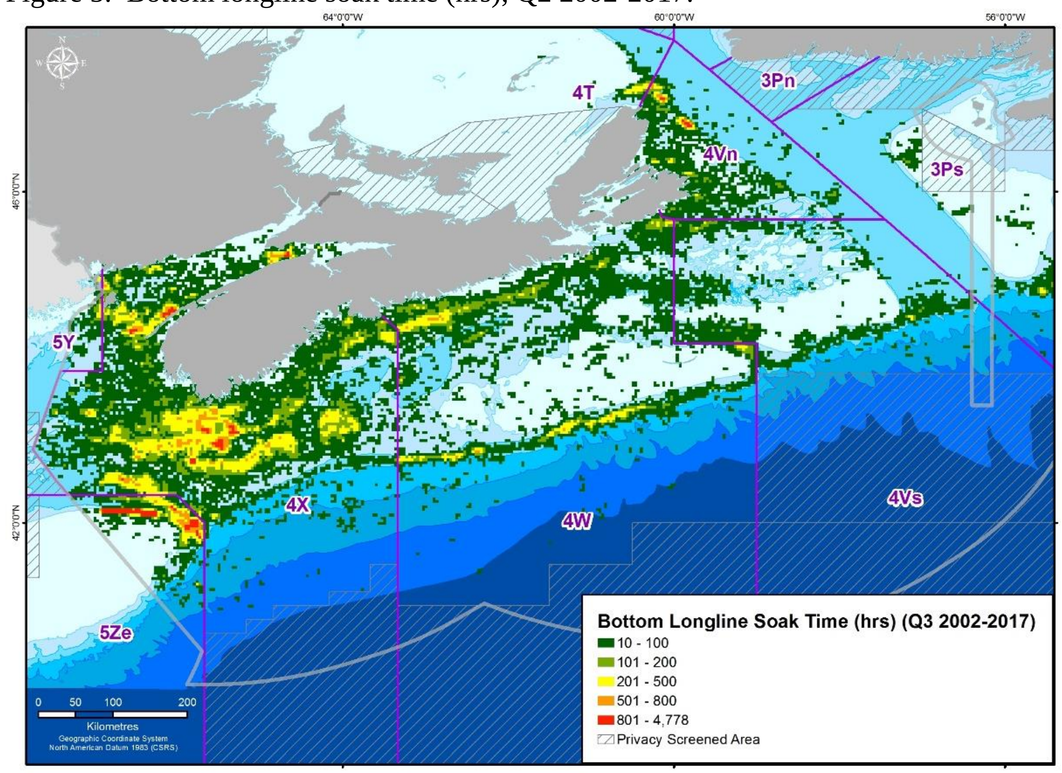

Figure 6.–Bottom longline soak time (hrs), Q3 2002-2017.

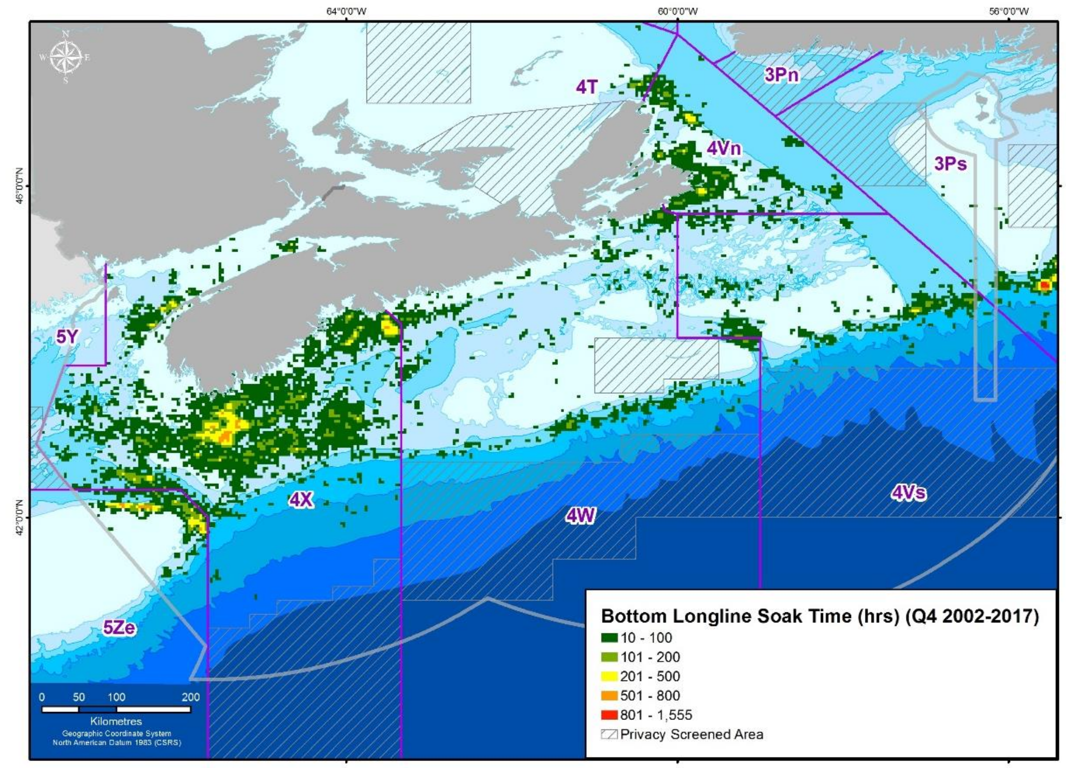

Figure 7.–Bottom longline soak time (hrs), Q4 2002-2017.

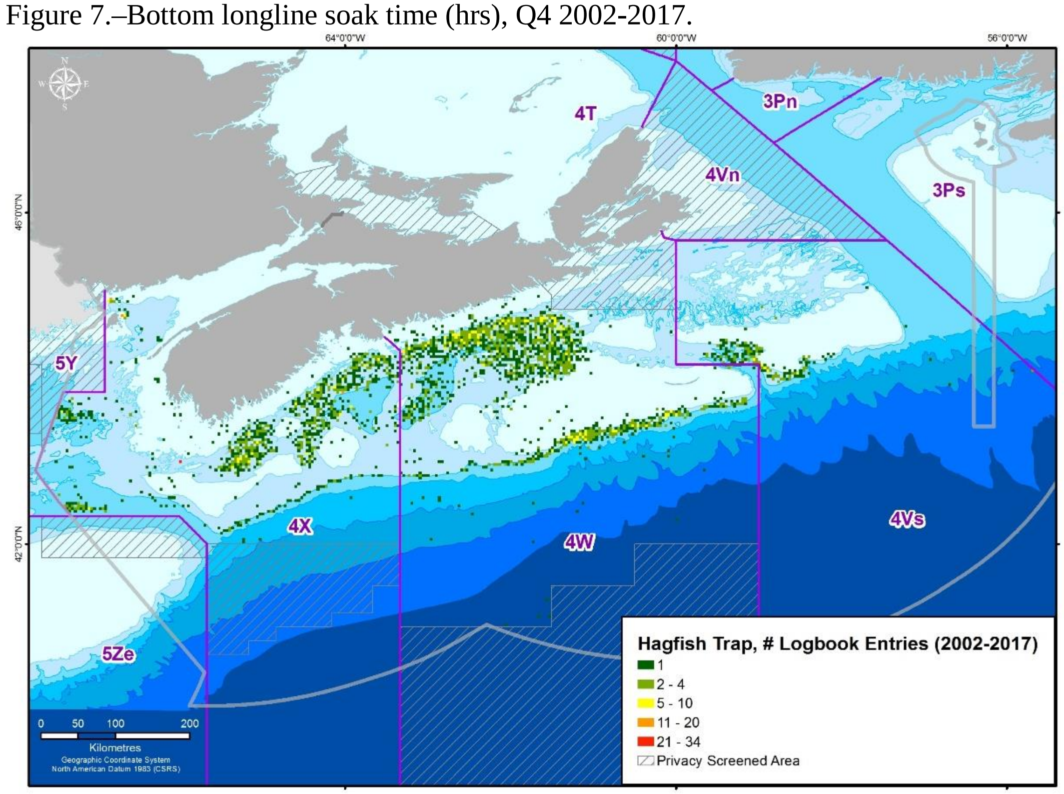

Figure 8.–Hagfish trap, number of logbook entries, 2002-2017.

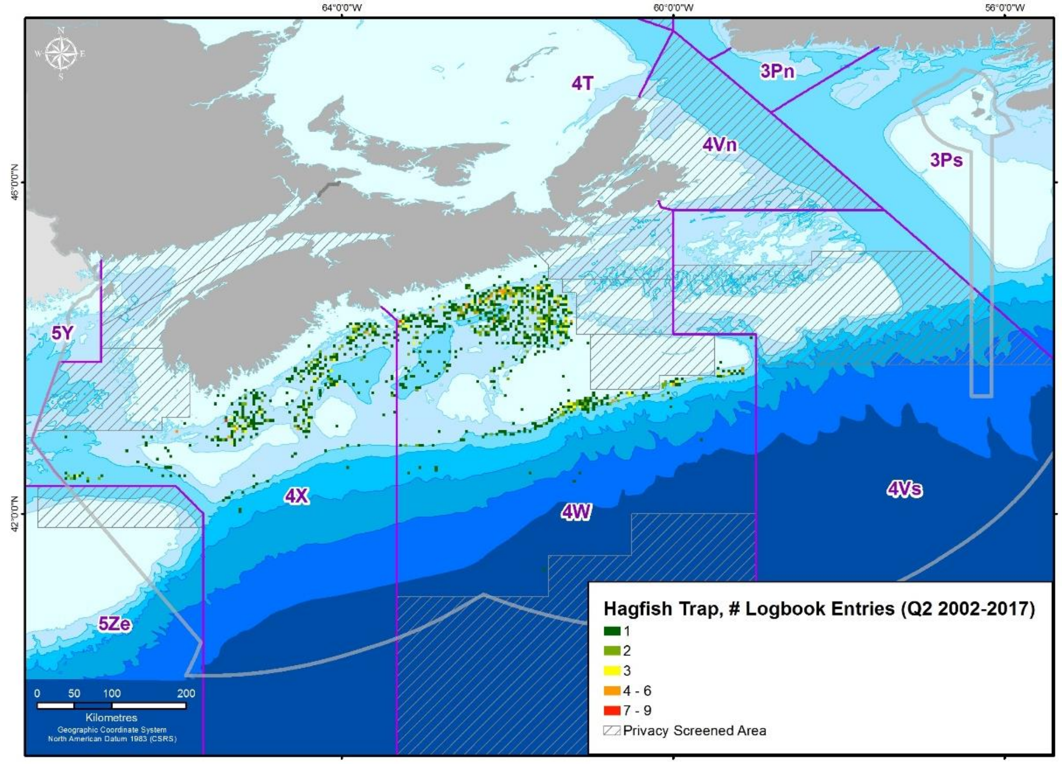

Figure 9.–Hagfish trap, number of logbook entries, Q2 2002-2017.

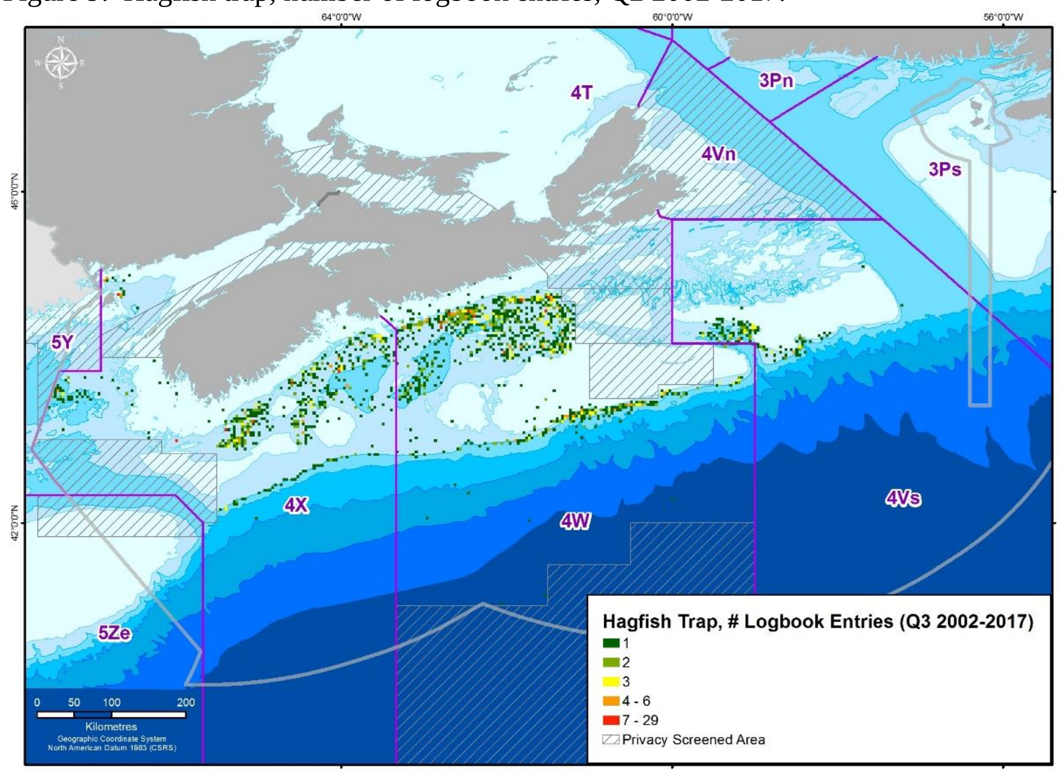

Figure 10.–Hagfish trap, number of logbook entries, Q3 2002-2017.

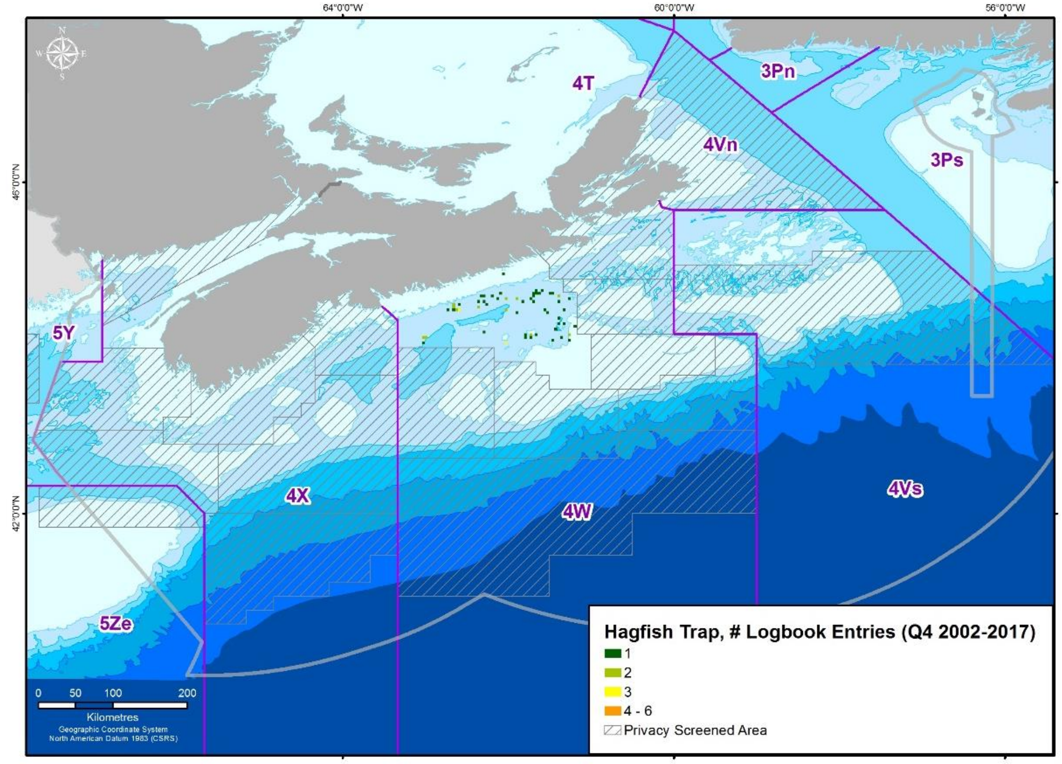

Figure 11.–Hagfish trap, number of logbook entries, Q4 2002-2017.

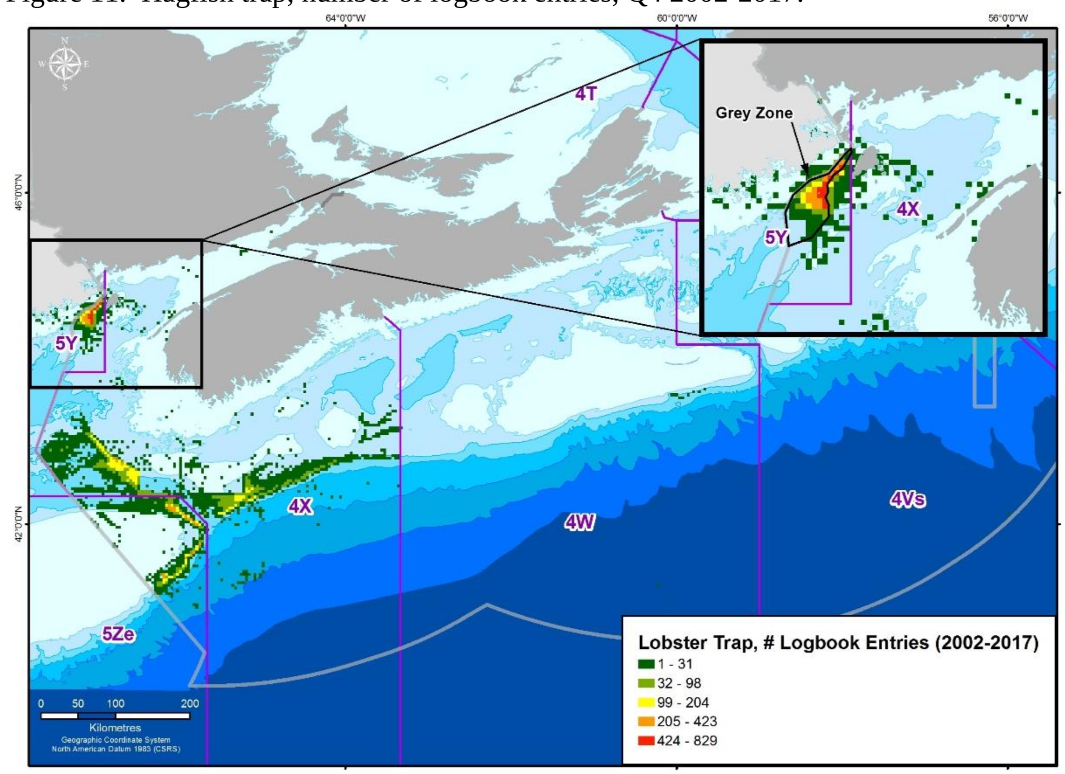

Figure 12.–LFA 41 and Grey Zone lobster trap, number of logbook entries, 2002-2017.

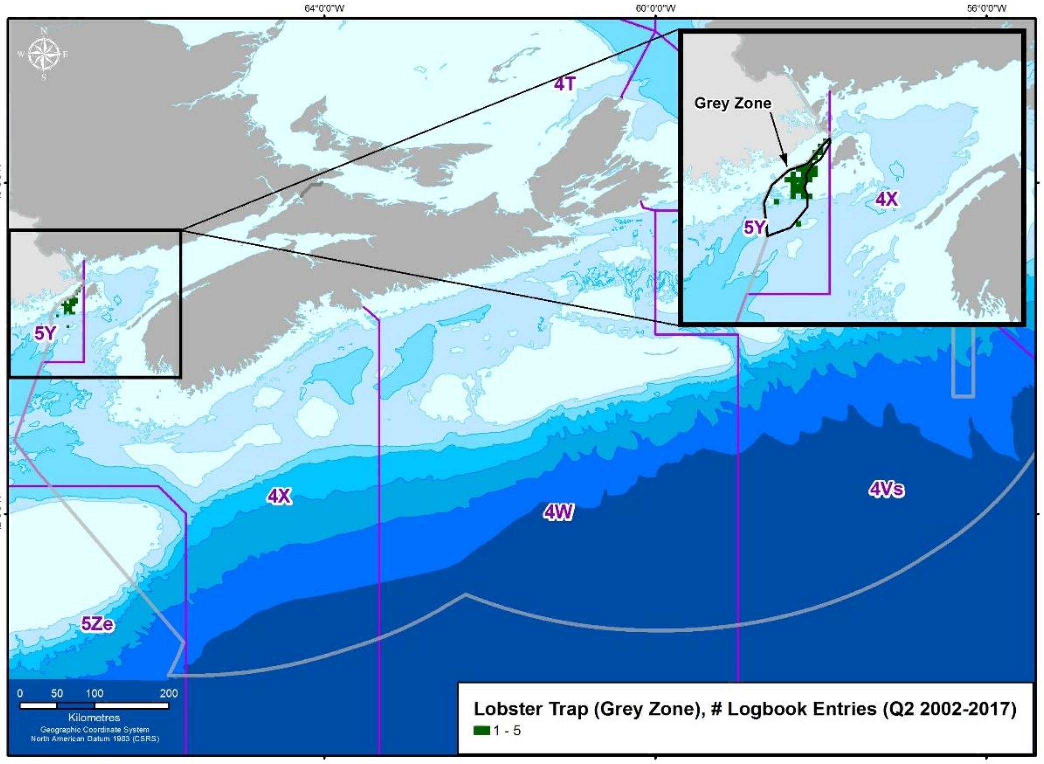

Figure 13.–Grey Zone lobster trap, number of logbook entries, Q2 2002-2017. Consent was withheld by the licence holder for LFA 41 data in the offshore.

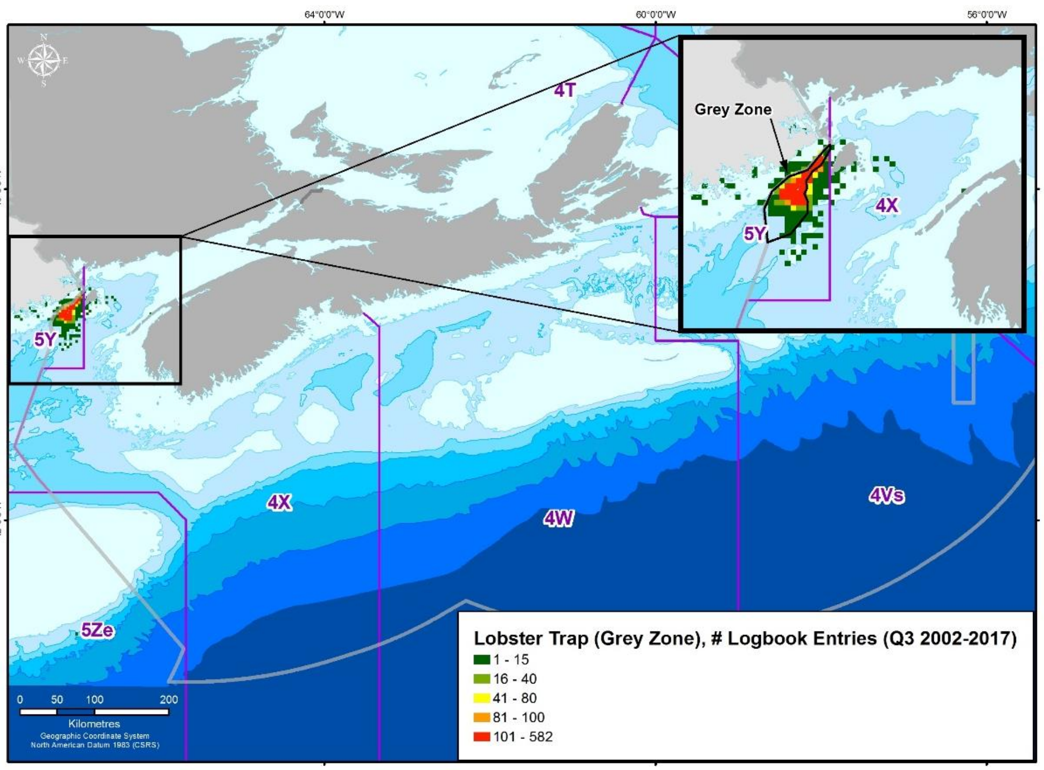

Figure 14.–Grey Zone lobster trap, number of logbook entries, Q3 2002-2017. Consent was withheld by the licence holder for LFA 41 data in the offshore.

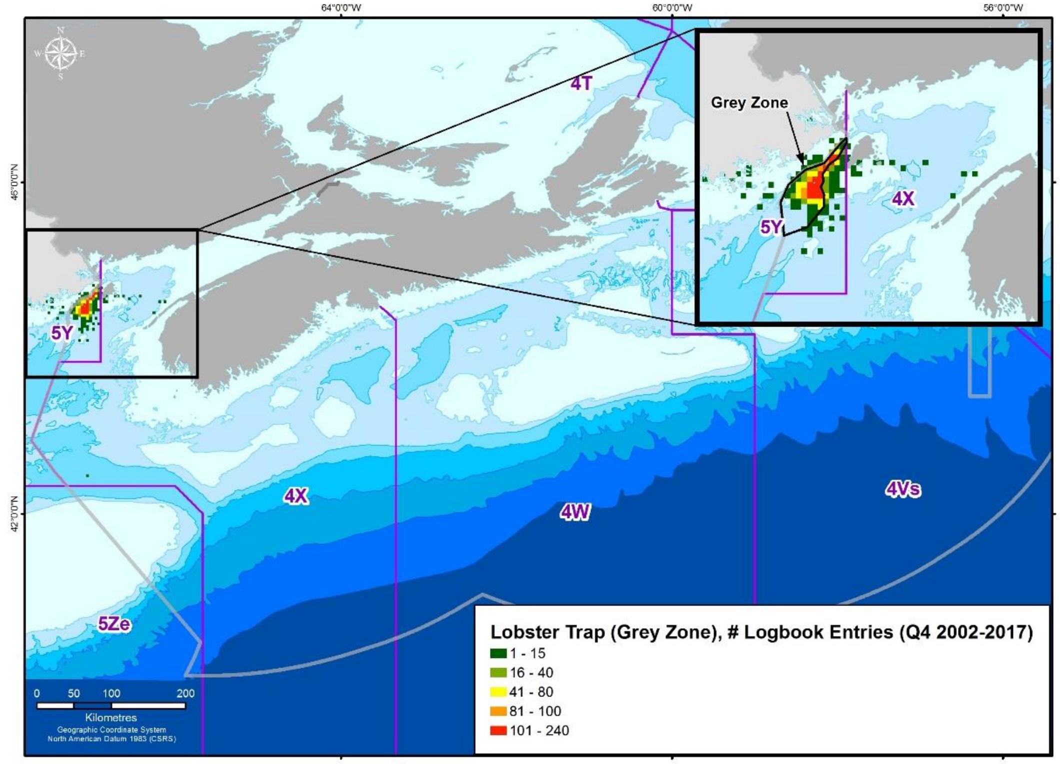

Figure 15.–Grey Zone lobster trap, number of logbook entries, Q4 2002-2017. Consent was withheld by the licence holder for LFA 41 data in the offshore.

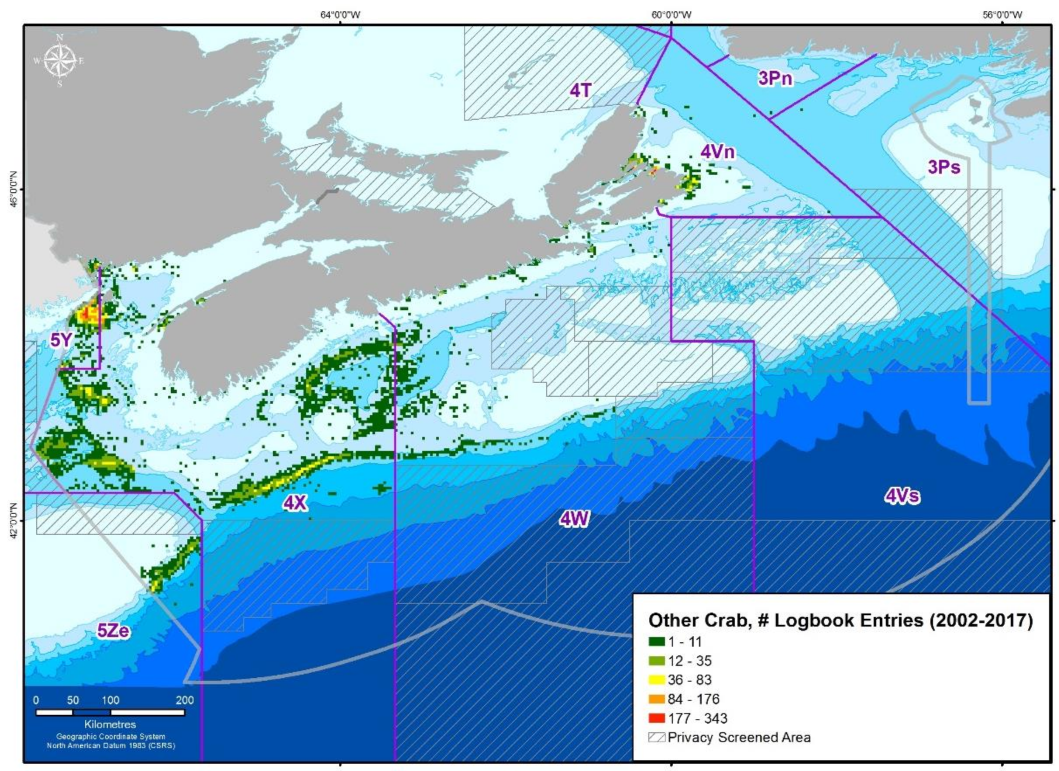

Figure 16.–Other crab trap, number of logbook entries, 2002-2017.

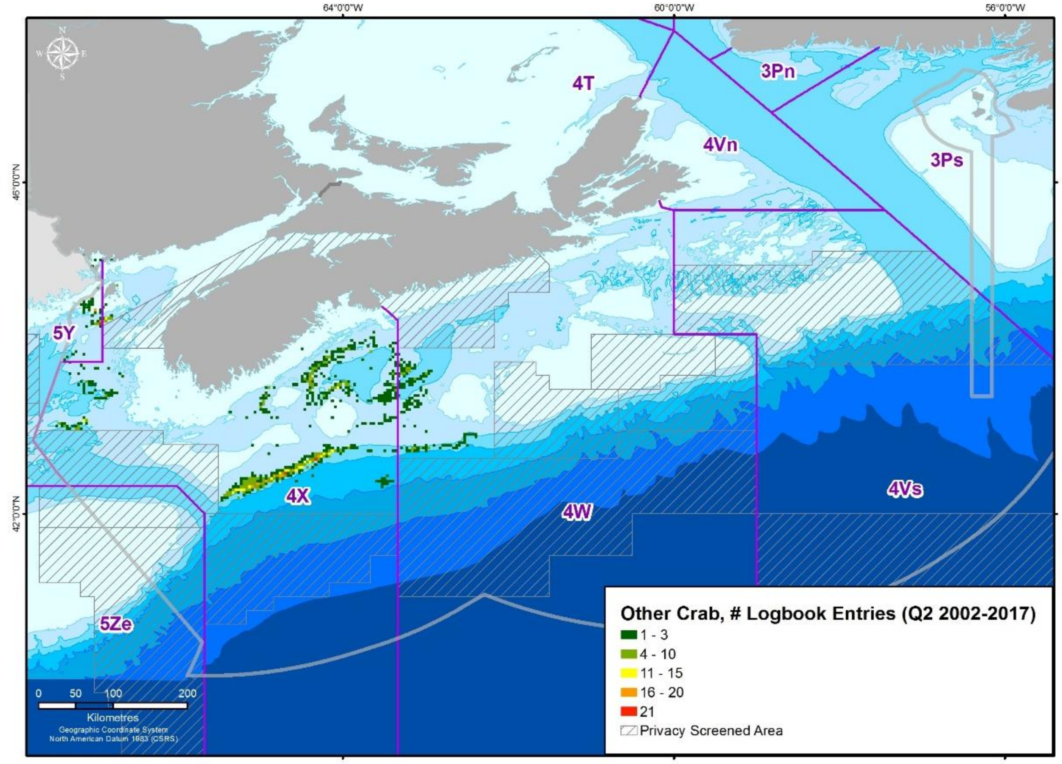

Figure 17.–Other crab trap, number of logbook entries, Q2 2002-2017.

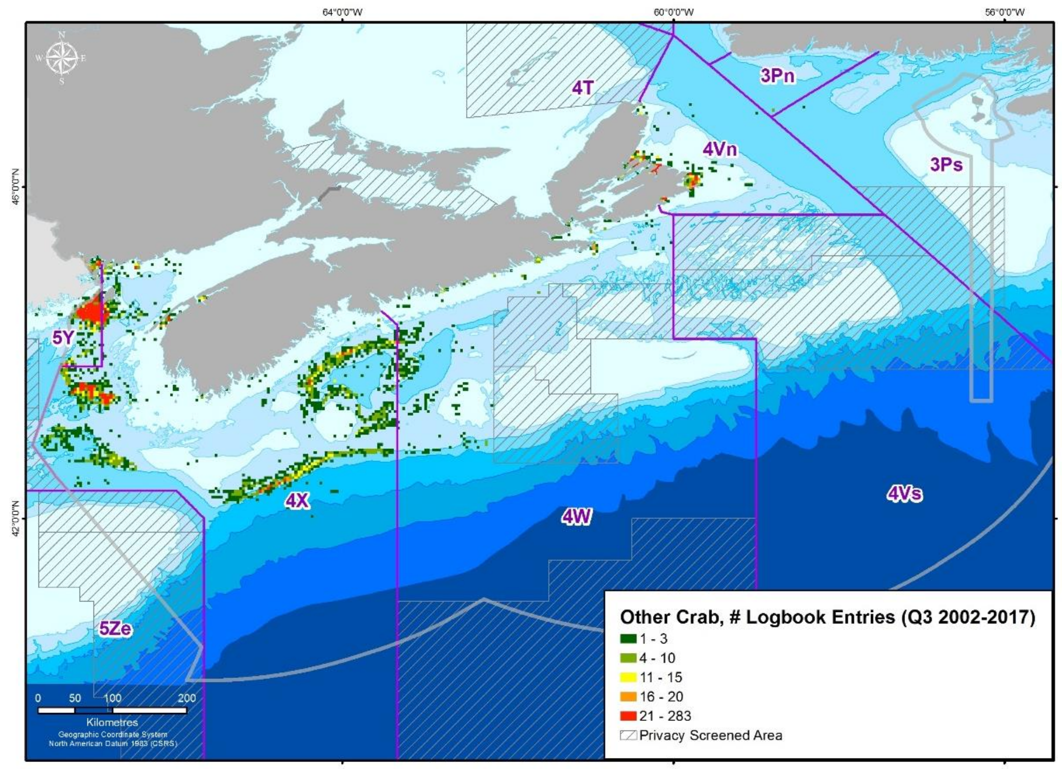

Figure 18.–Other crab trap, number of logbook entries, Q3 2002-2017.

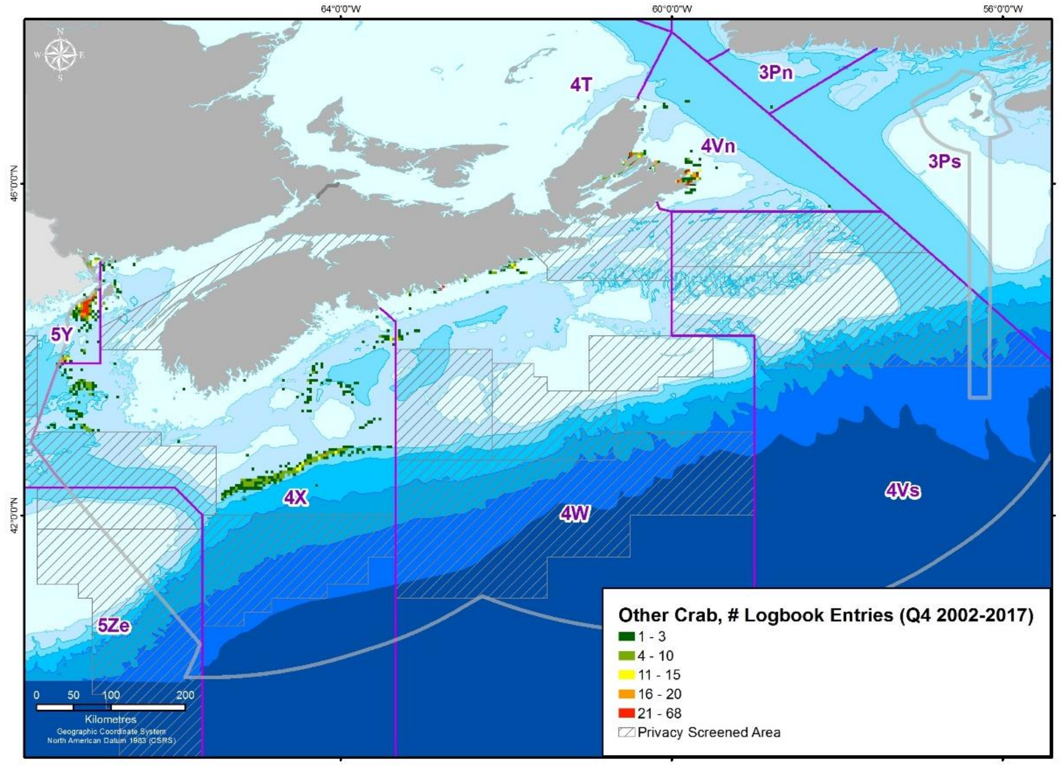

Figure 19.–Other crab trap, number of logbook entries, Q4 2002-2017.

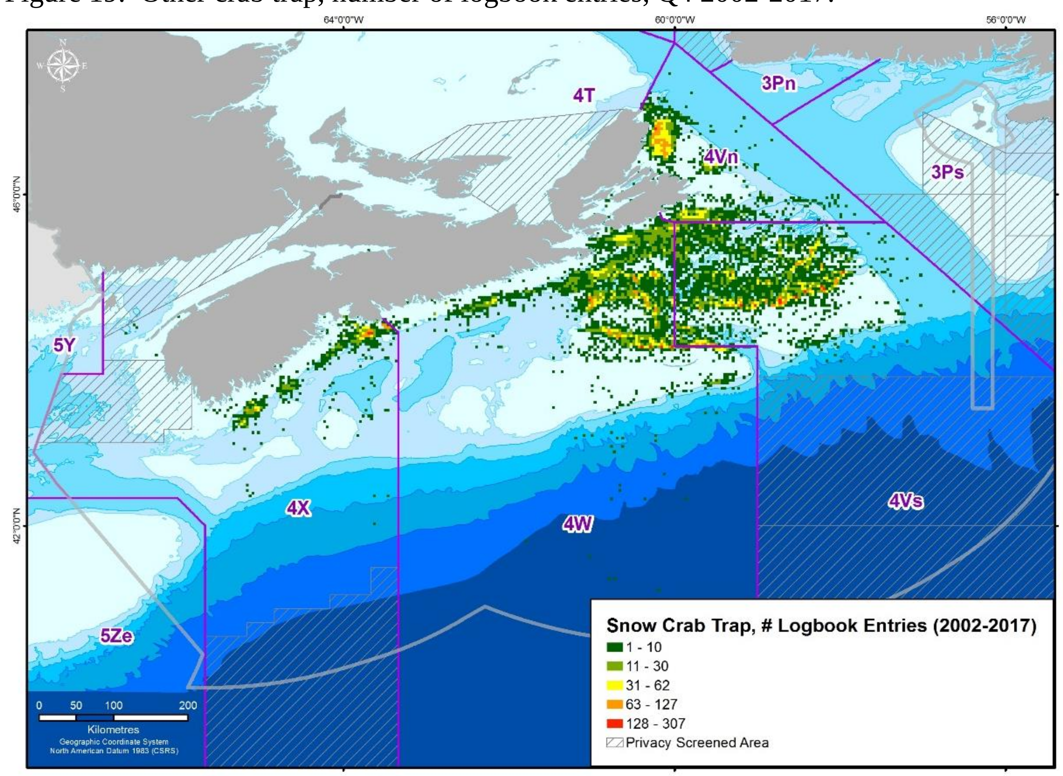

Figure 20.–Snow crab trap, number of logbook entries, 2002-2017.

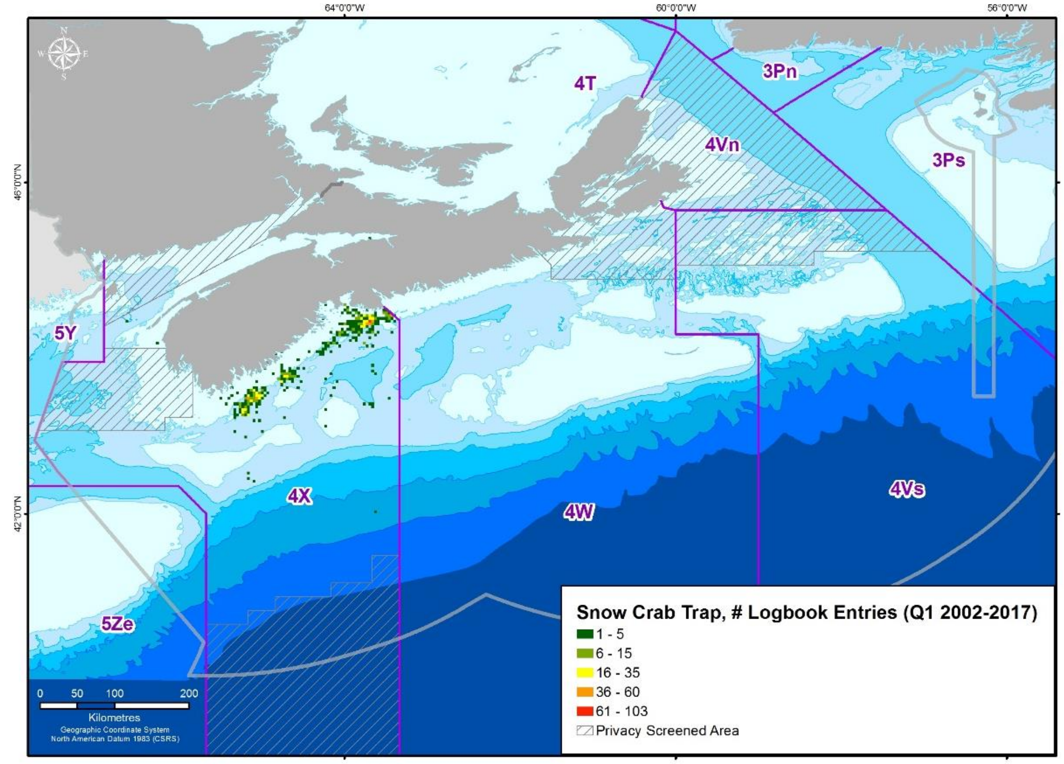

Figure 21.–Snow crab trap, number of logbook entries, Q1 2002-2017.

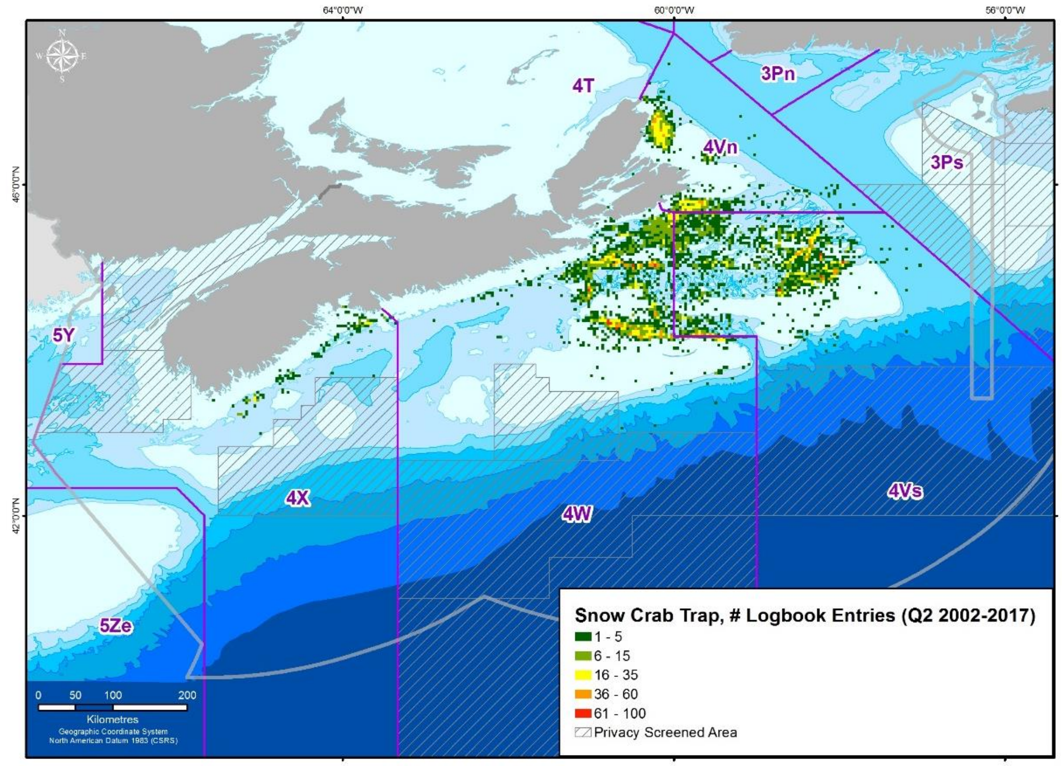

Figure 22.–Snow crab trap, number of logbook entries, Q2 2002-2017.

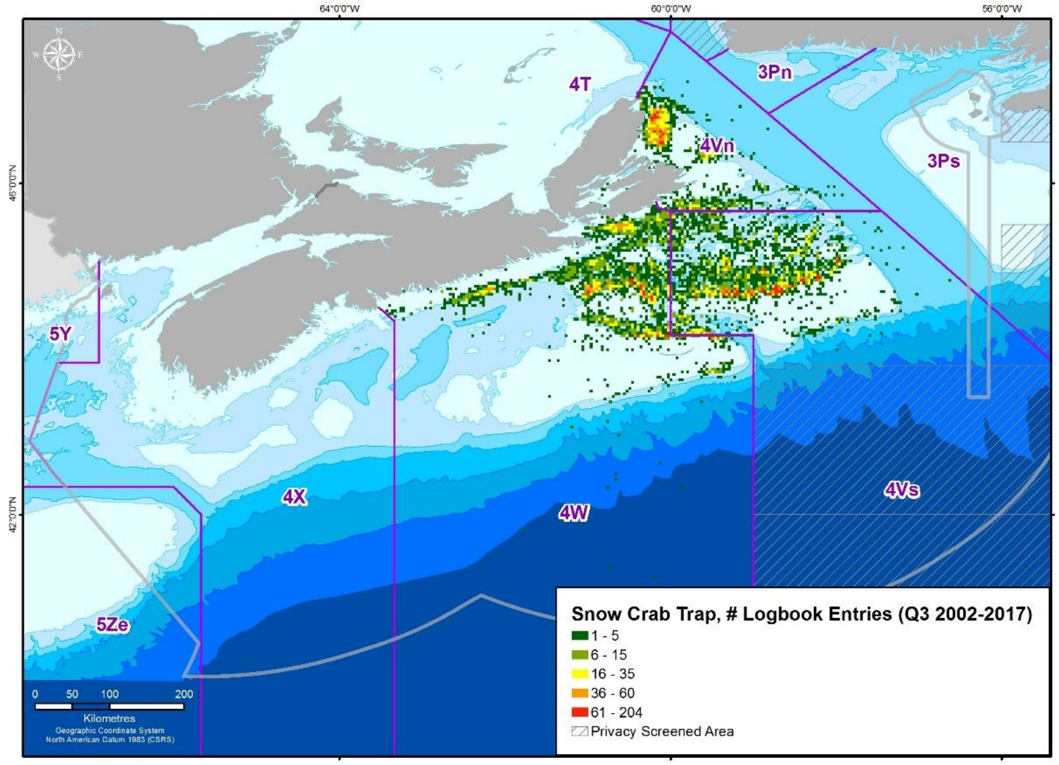

Figure 23.–Snow crab trap, number of logbook entries, Q3 2002-2017.

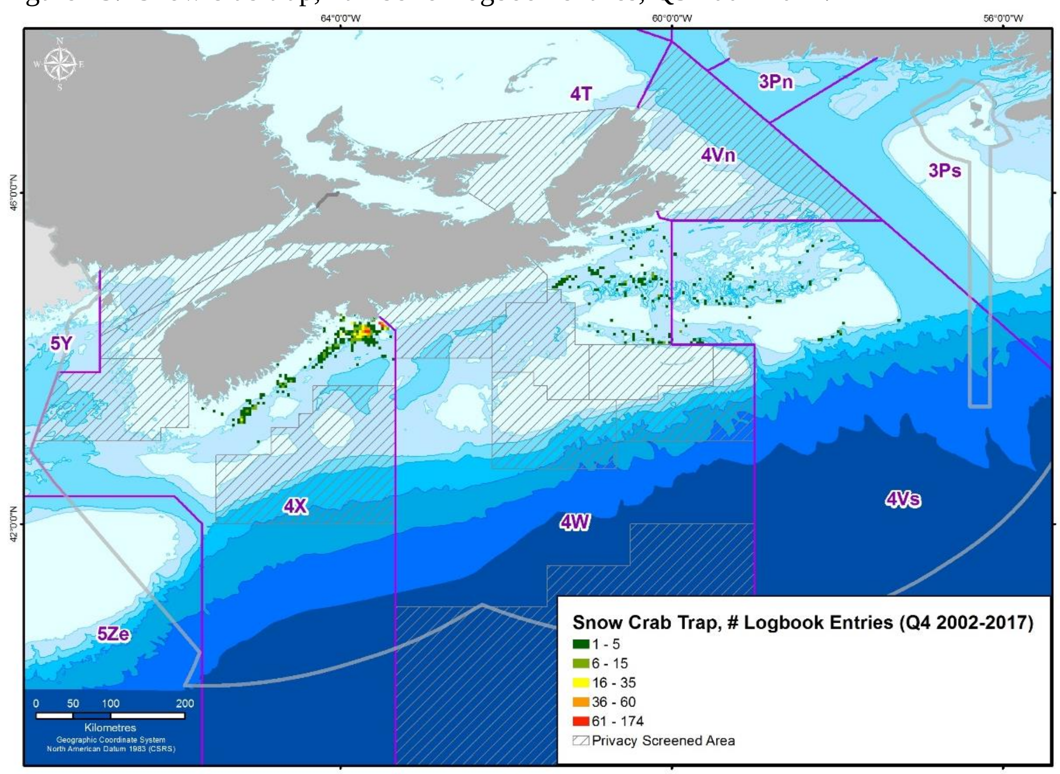

Figure 24.–Snow crab trap, number of logbook entries, Q4 2002-2017.

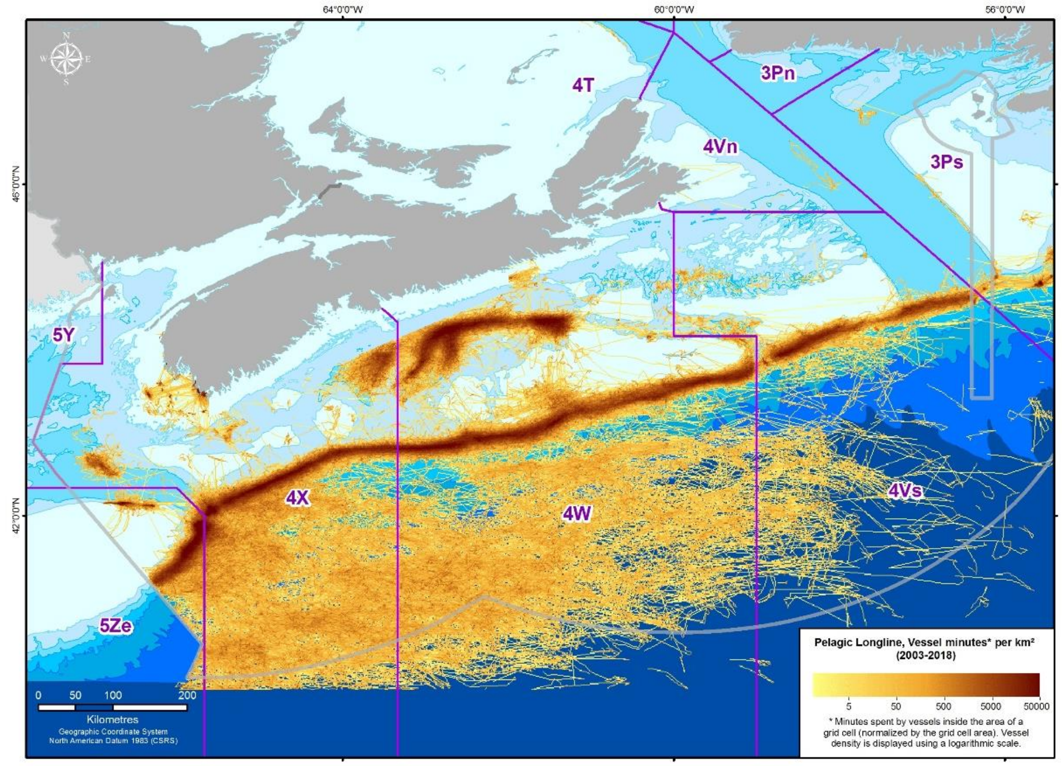

Figure 25.–Pelagic longline, vessel minutes per km^2, 2003-2018.

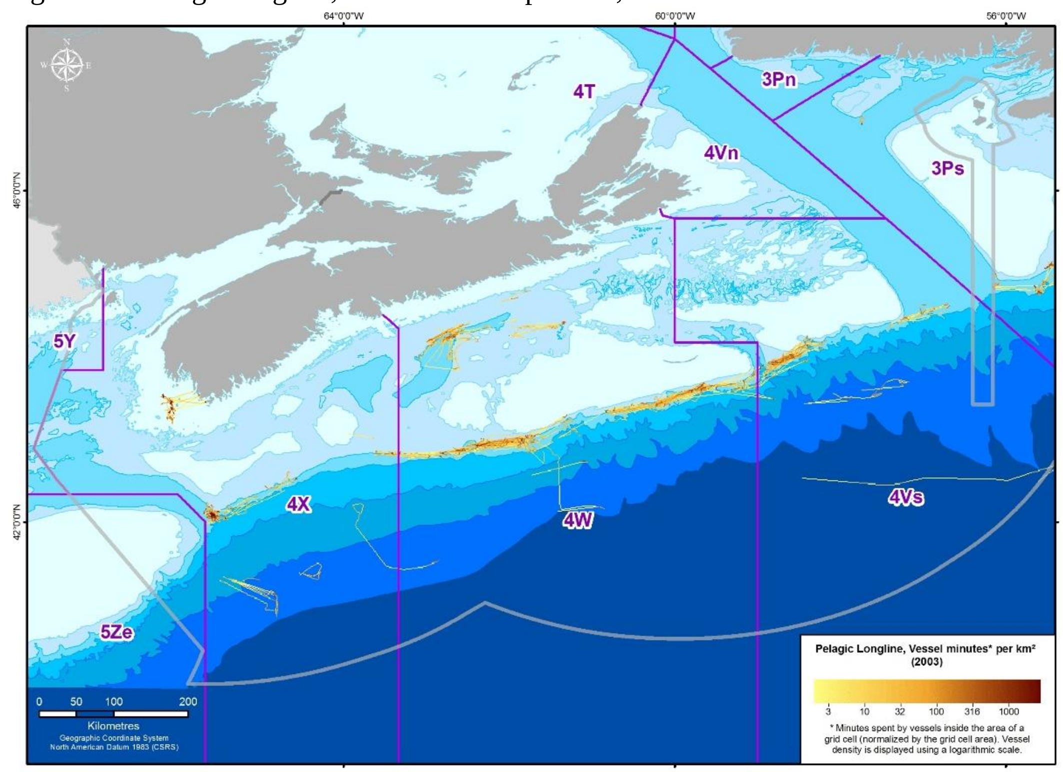

Figure 26.–Pelagic longline, vessel minutes per km^2, 2003.

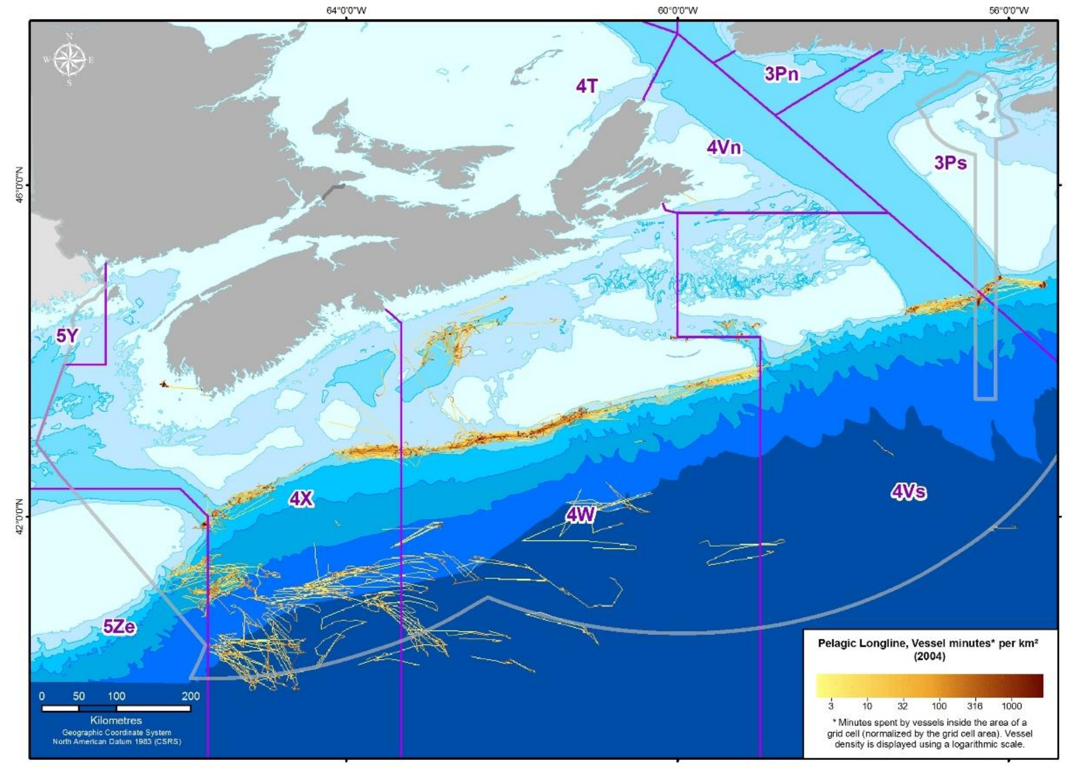

Figure 27.–Pelagic longline, vessel minutes per km^2, 2004.

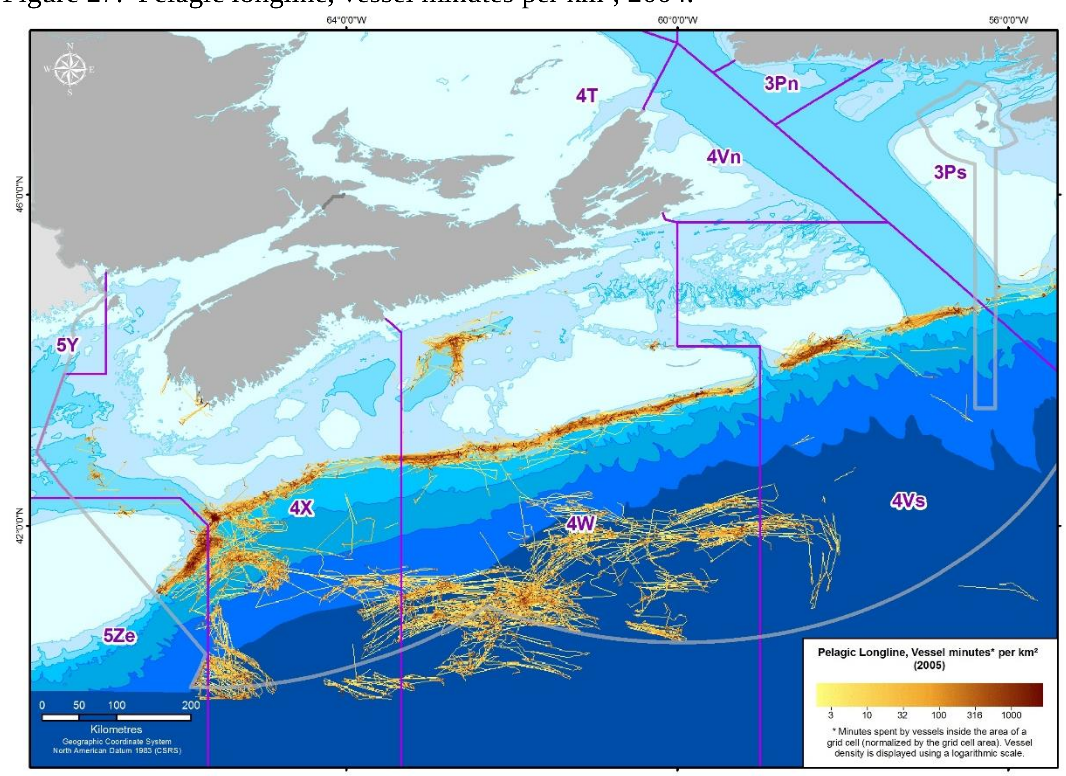

Figure 28.–Pelagic longline, vessel minutes per km^2, 2005.

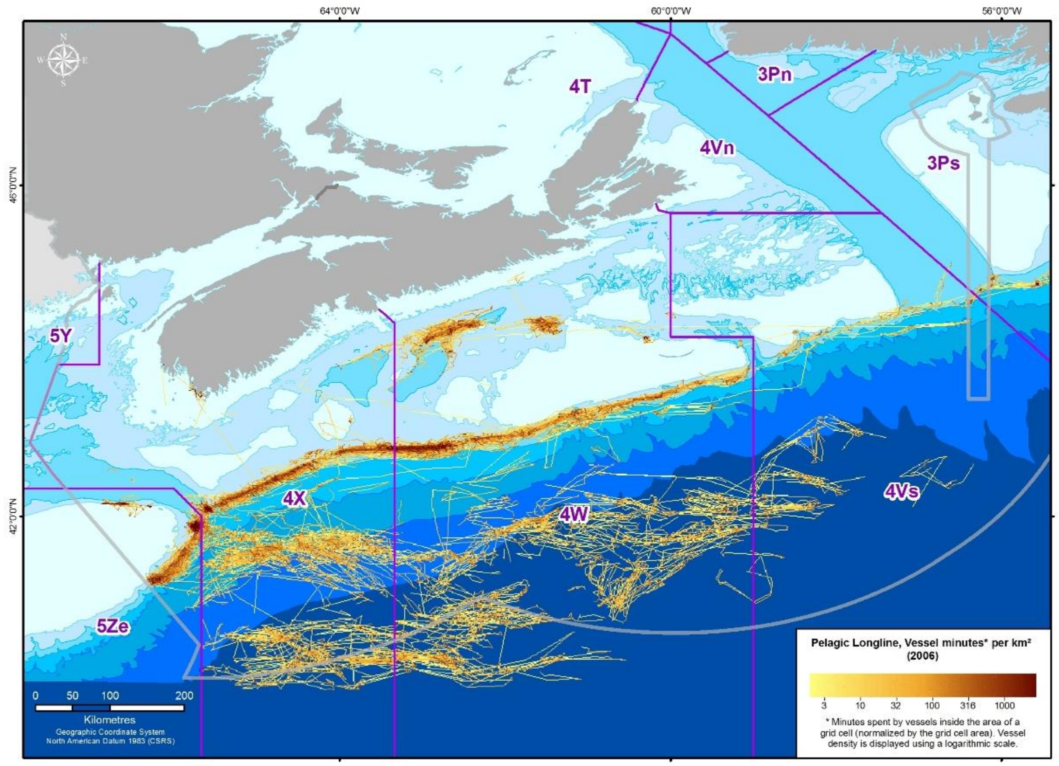

Figure 29.–Pelagic longline, vessel minutes per km^2, 2006.

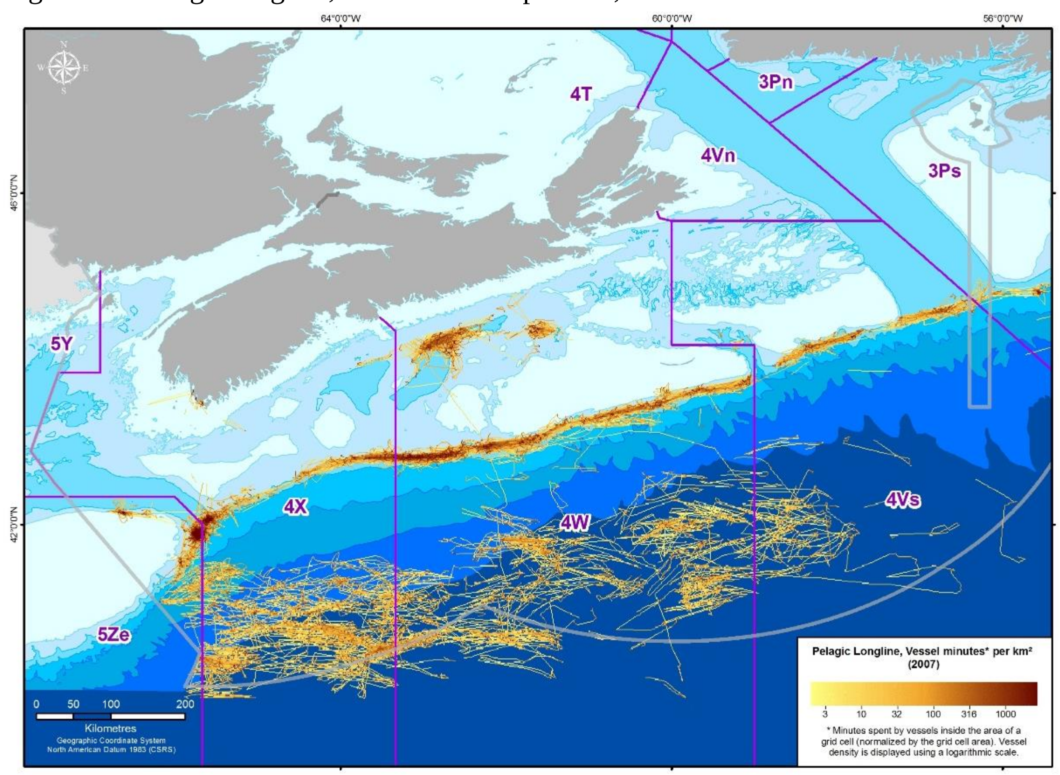

Figure 30.–Pelagic longline, vessel minutes per km^2, 2007.

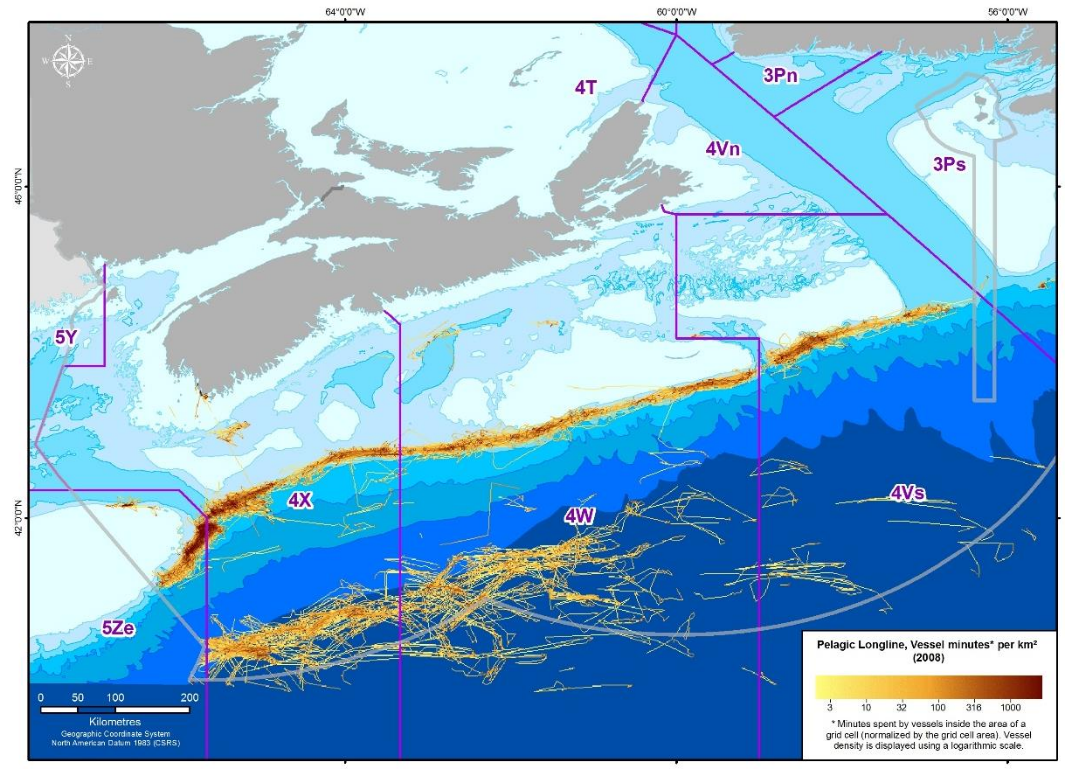

Figure 31.–Pelagic longline, vessel minutes per km^2, 2008.

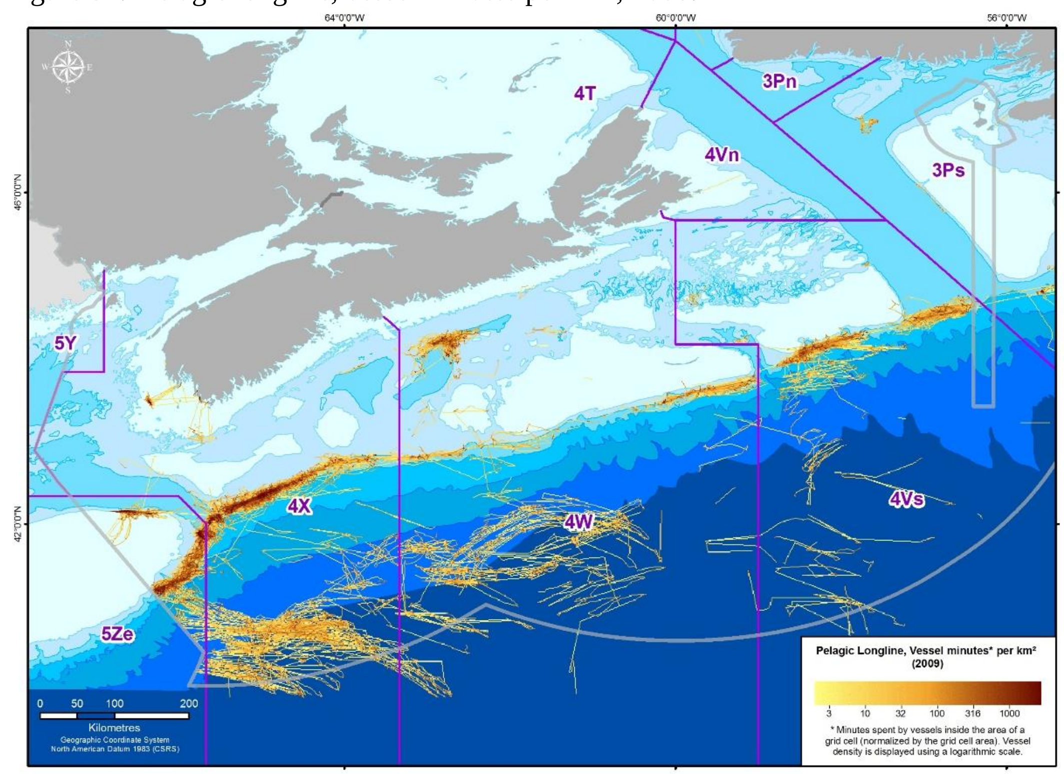

Figure 32.–Pelagic longline, vessel minutes per km^2, 2009.

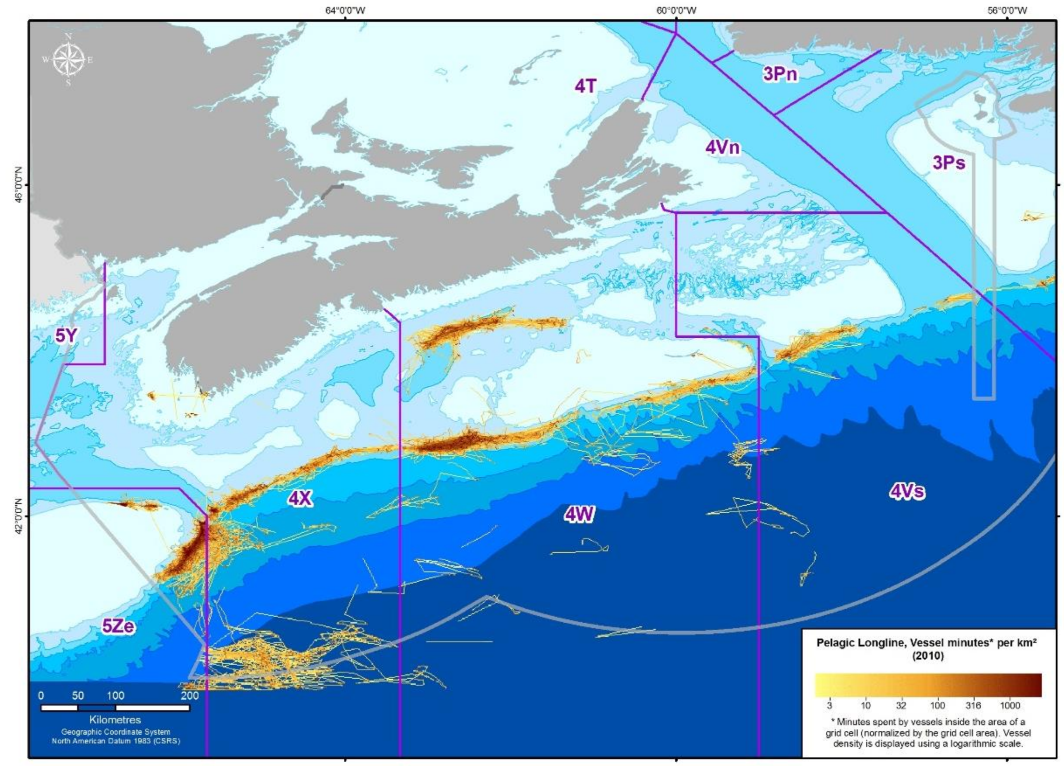

Figure 33.–Pelagic longline, vessel minutes per km^2, 2010.

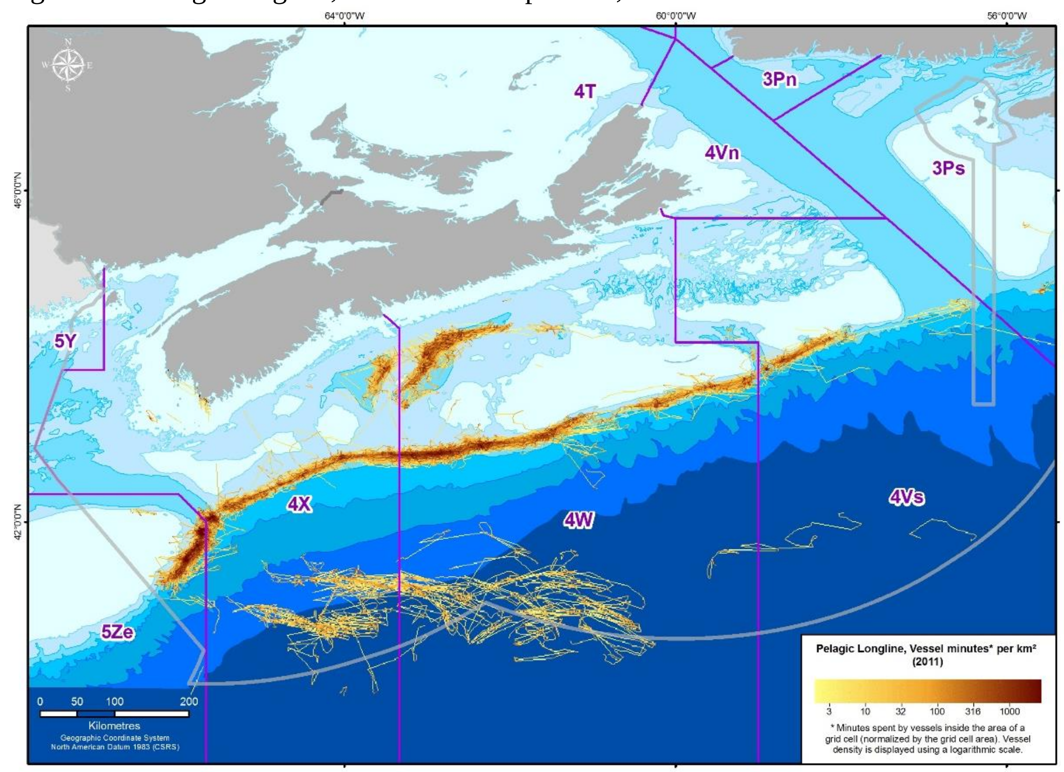

Figure 34.–Pelagic longline, vessel minutes per km^2, 2011.

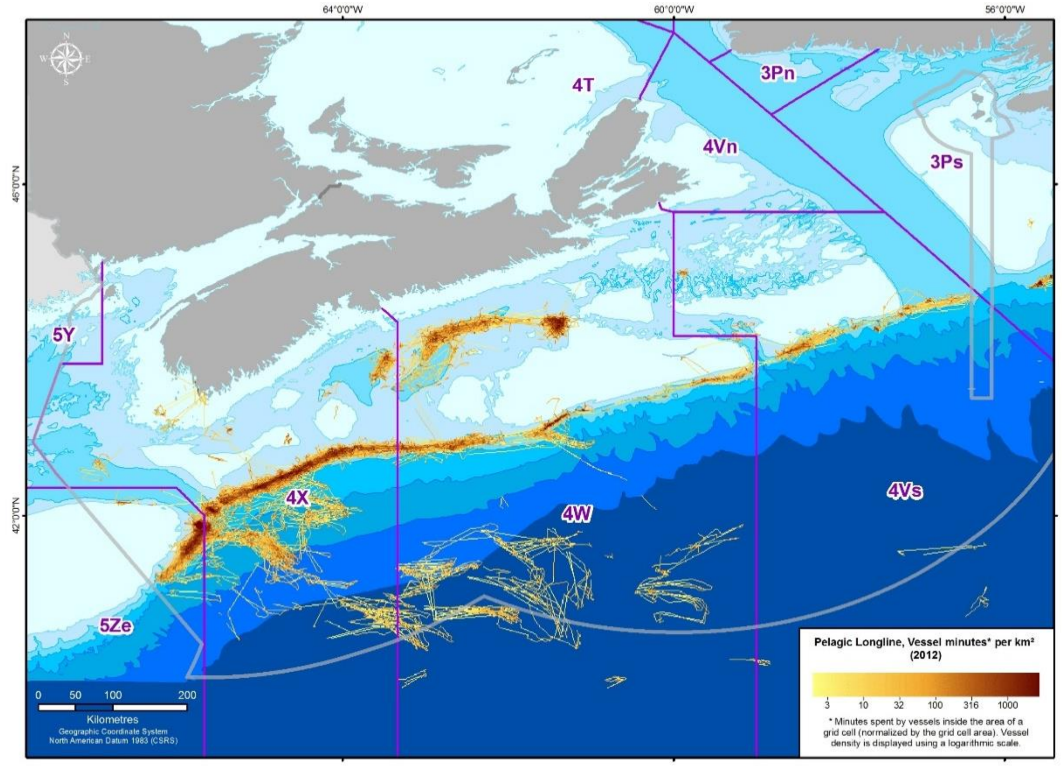

Figure 35.–Pelagic longline, vessel minutes per km^2, 2012.

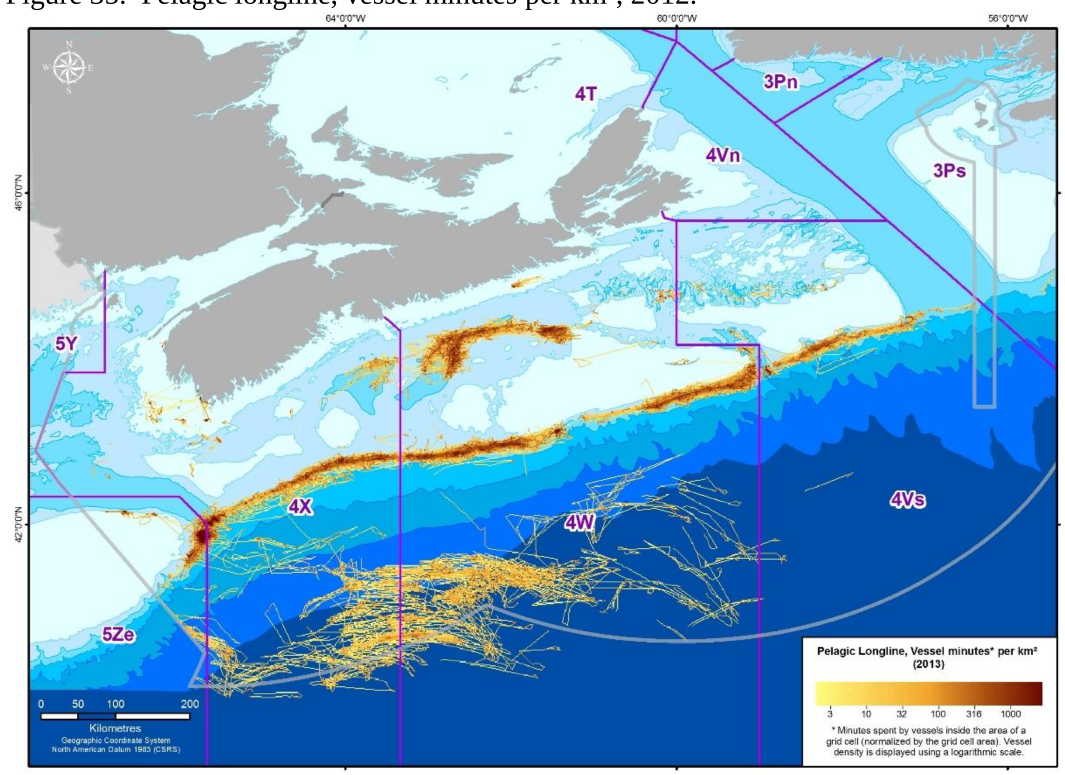

Figure 36.–Pelagic longline, vessel minutes per km^2, 2013.

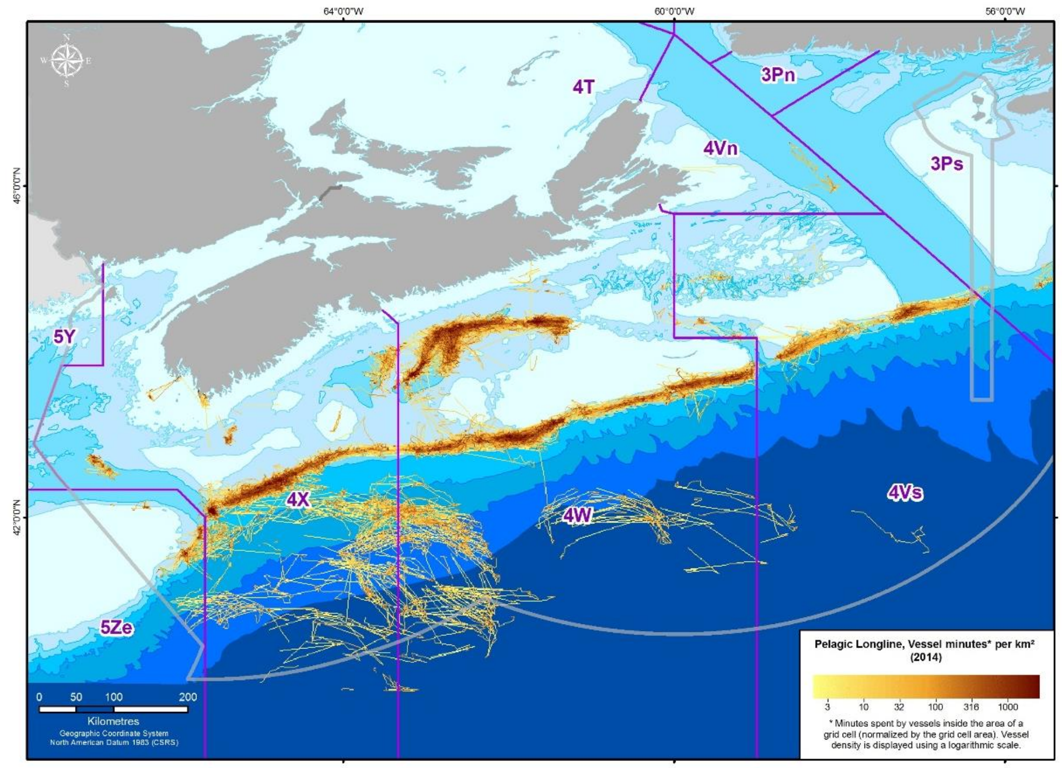

Figure 37.–Pelagic longline, vessel minutes per km^2, 2014.

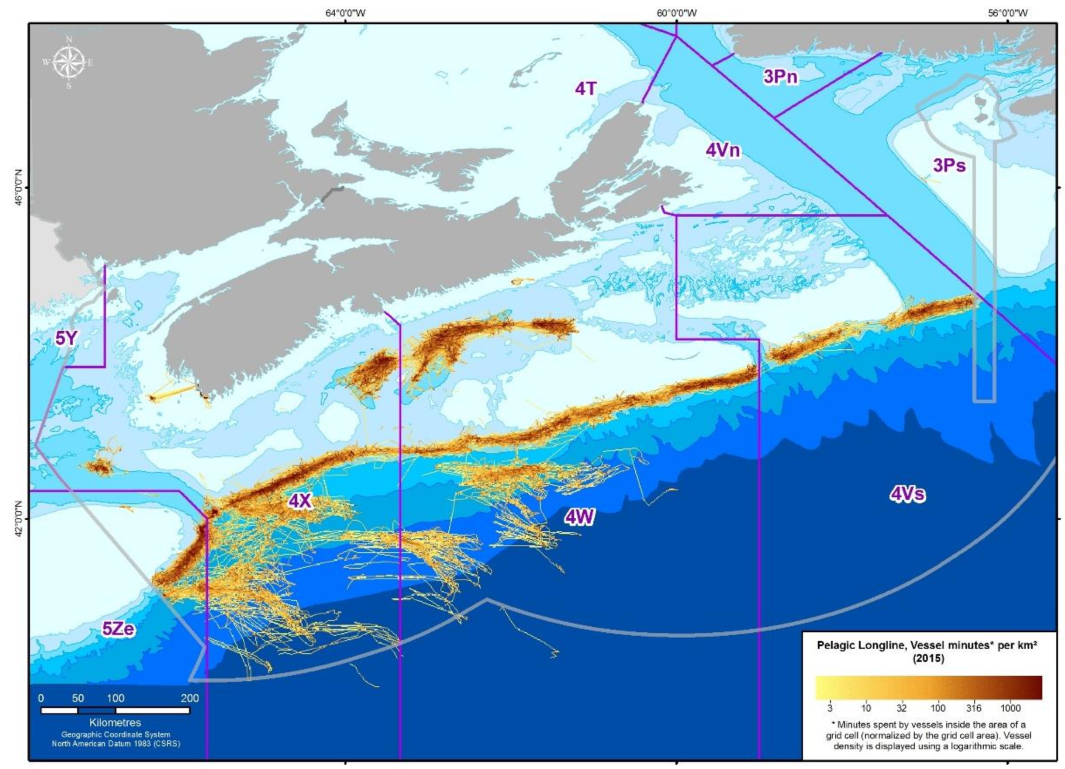

Figure 38.–Pelagic longline, vessel minutes per km^2, 2015.

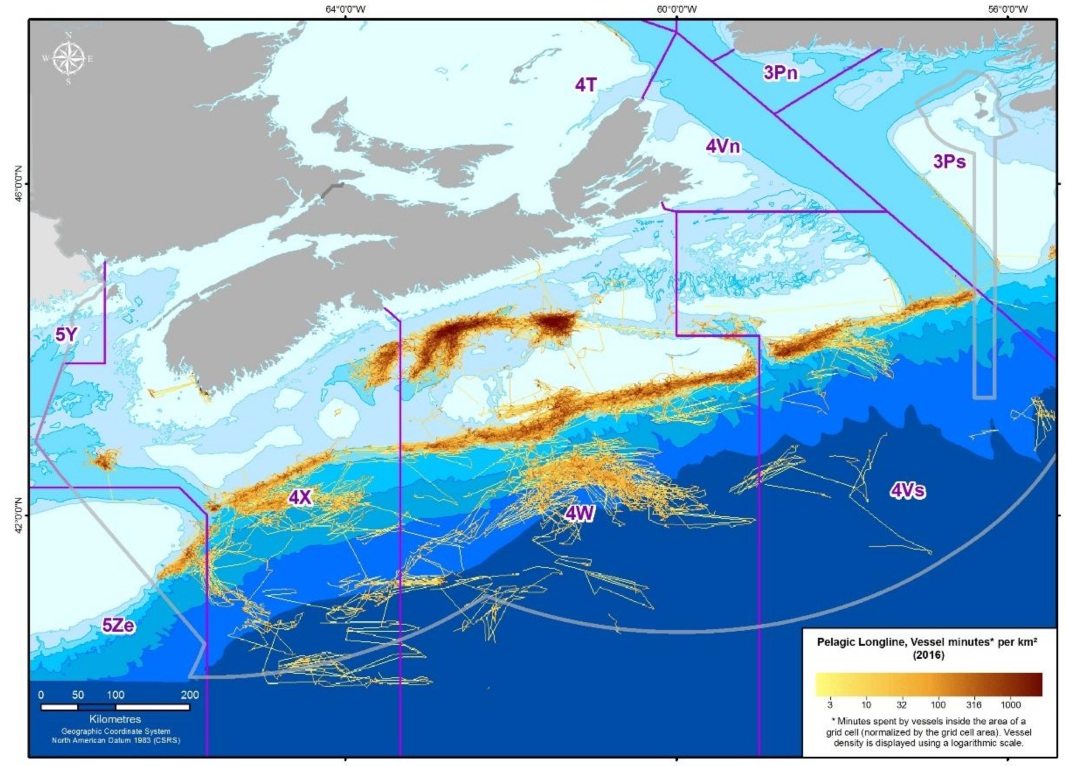

Figure 39.–Pelagic longline, vessel minutes per km^2, 2016.

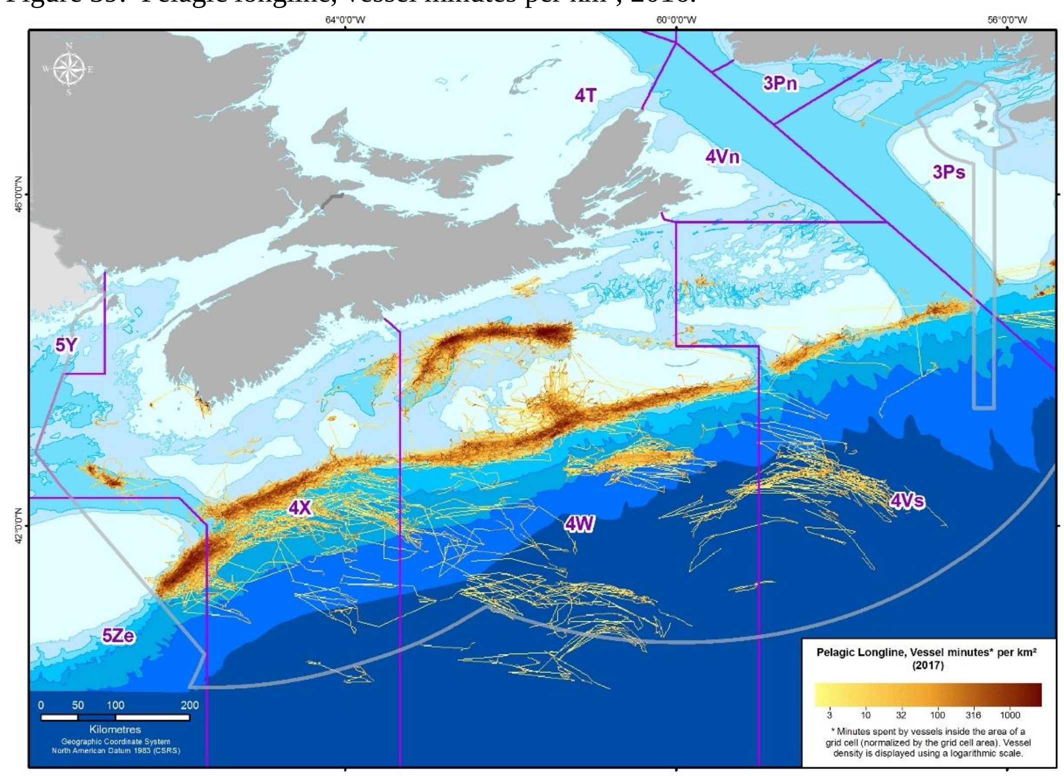

Figure 40.–Pelagic longline, vessel minutes per km^2, 2017.

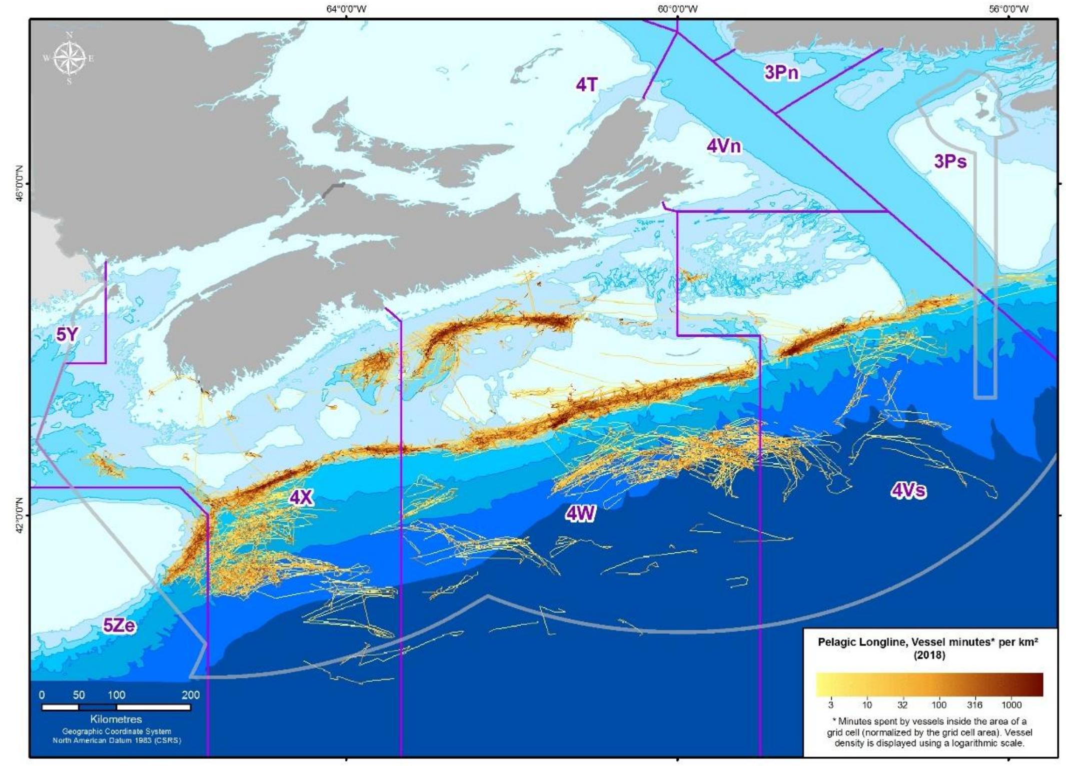

Figure 41.–Pelagic longline, vessel minutes per km^2, 2018.

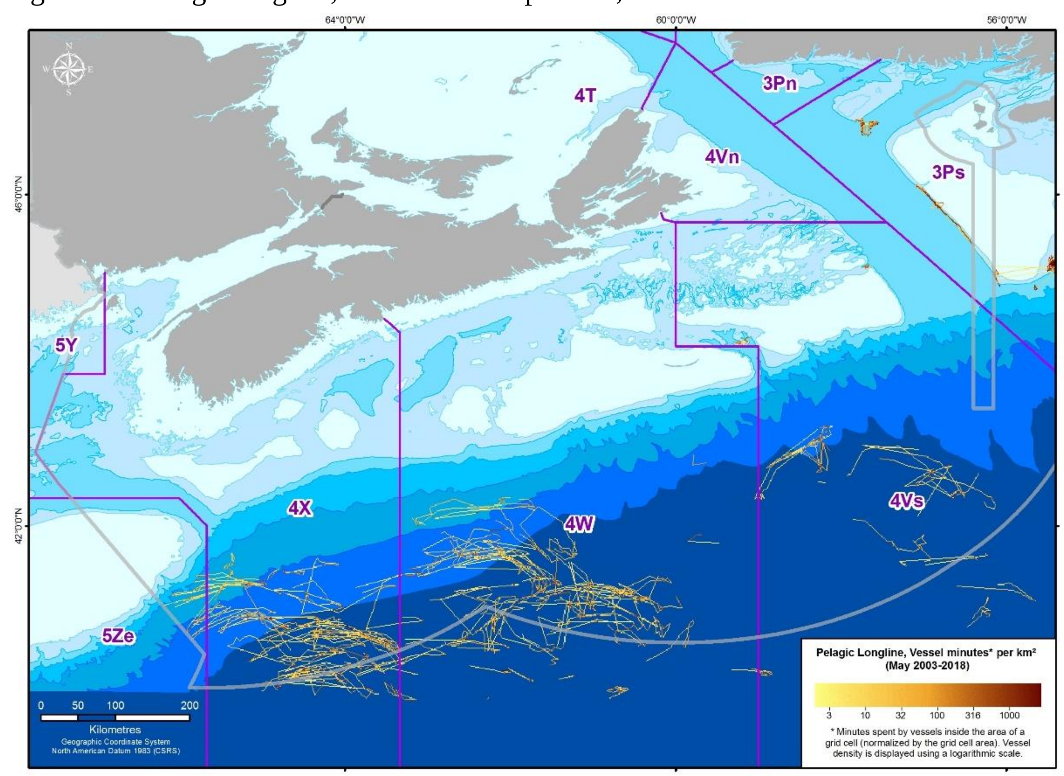

Figure 42.–Pelagic longline, vessel minutes per km^2, May composite, 2003-2018.

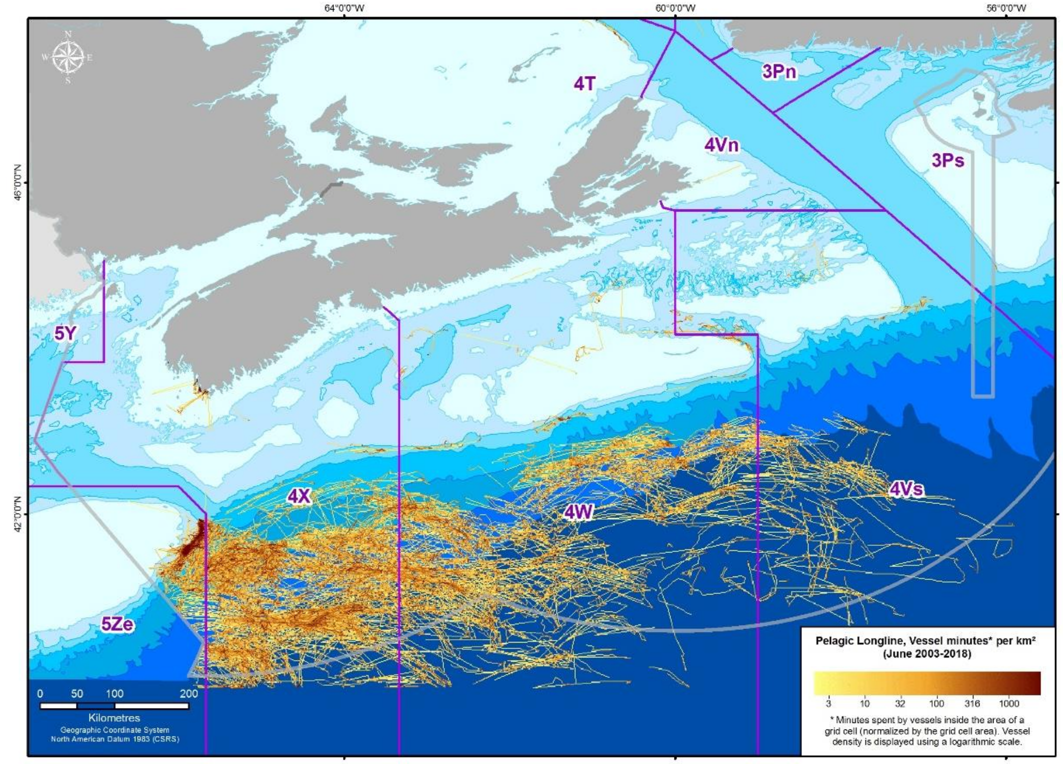

Figure 43.– Pelagic longline, vessel minutes per km^2, June composite, 2003-2018.

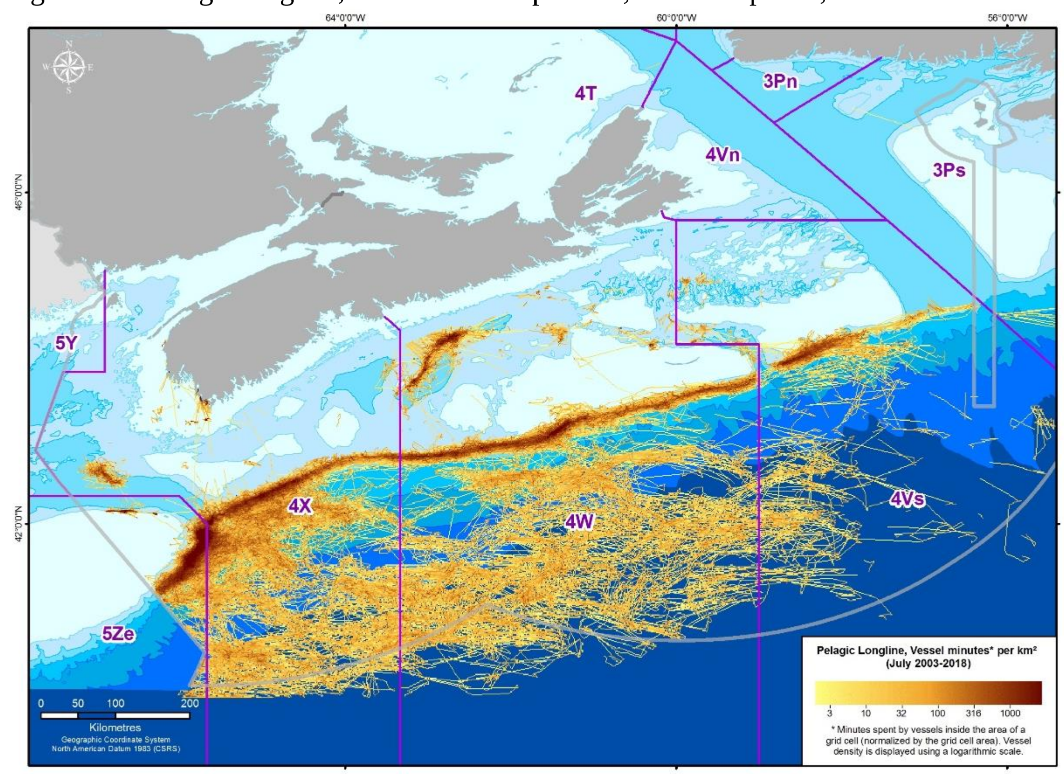

Figure 44.– Pelagic longline, vessel minutes per km^2, July composite, 2003-2018.

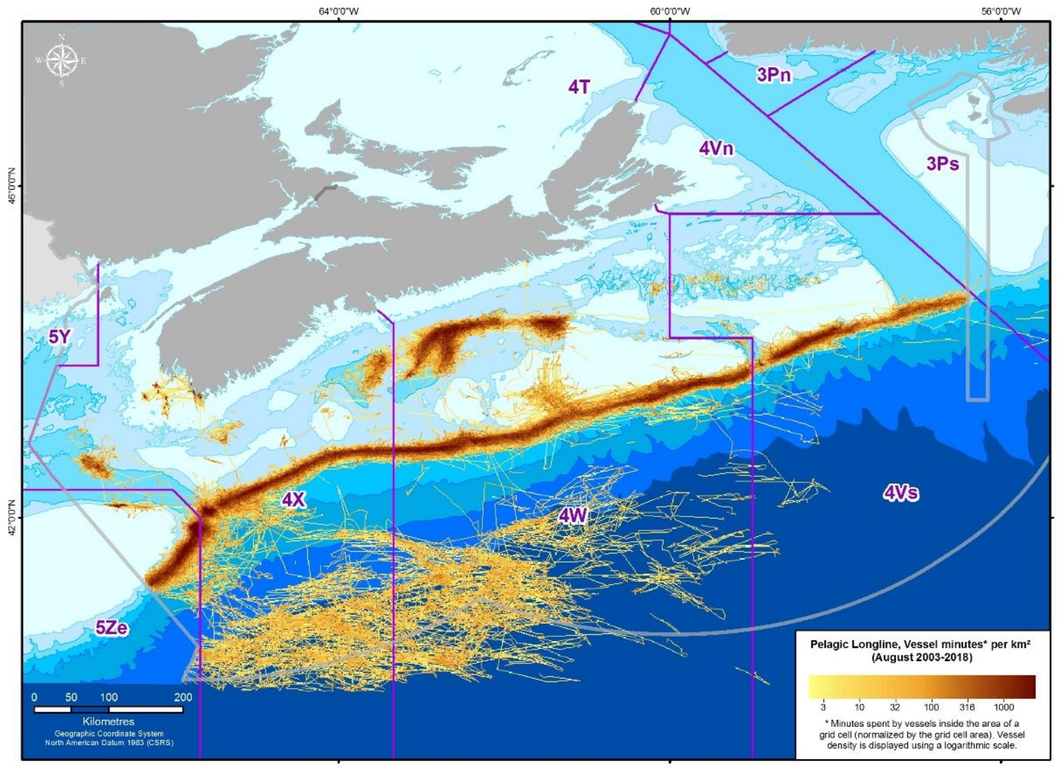

Figure 45.–Pelagic longline, vessel minutes per km^2, August composite, 2003-2018.

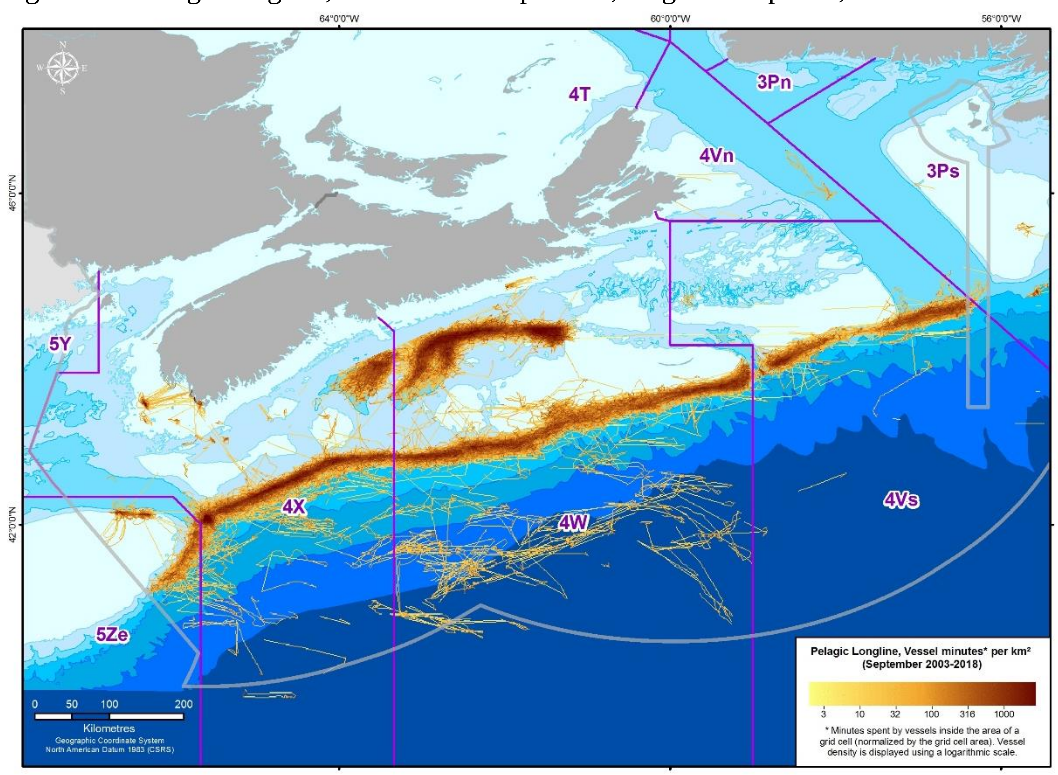

Figure 46.–Pelagic longline, vessel minutes per km^2, September composite, 2003-2018.

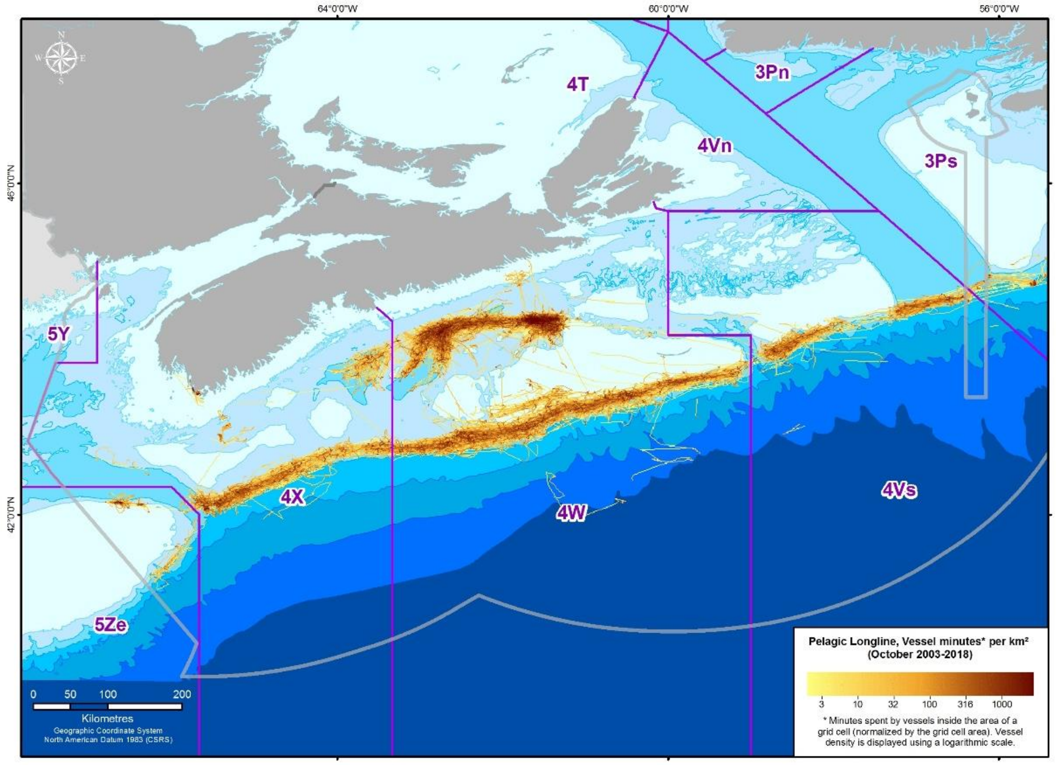

Figure 47.–Pelagic longline, vessel minutes per km^2, October composite, 2003-2018.

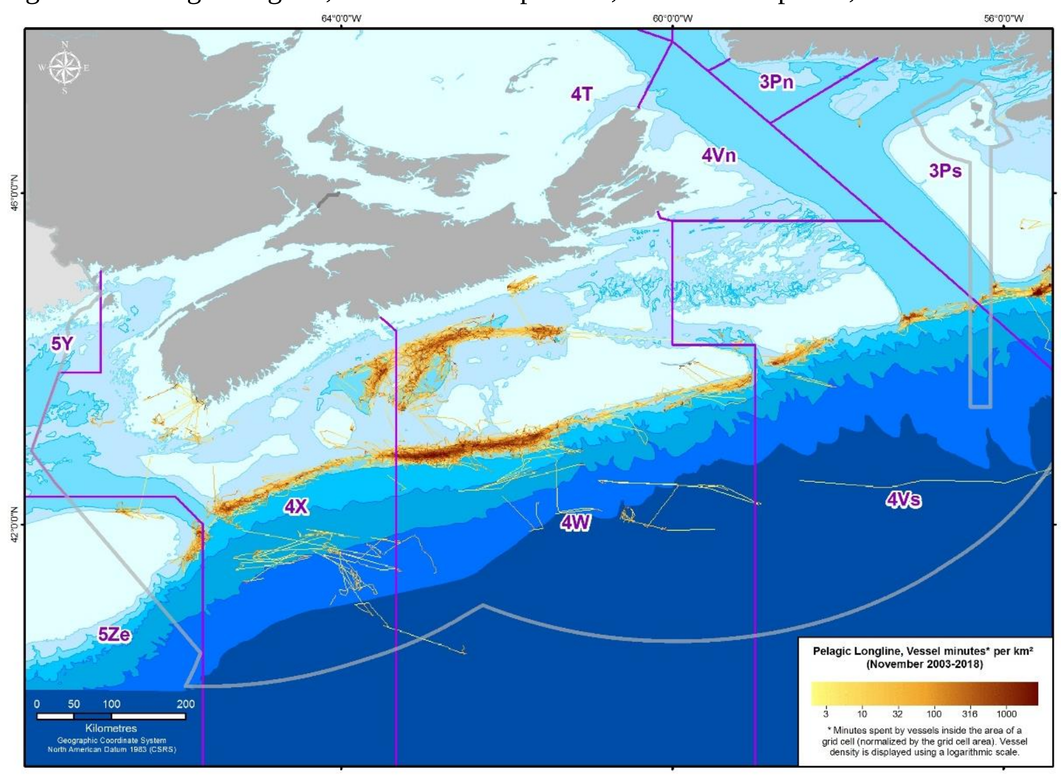

Figure 48.–Pelagic longline, vessel minutes per km^2, November composite, 2003-2018.

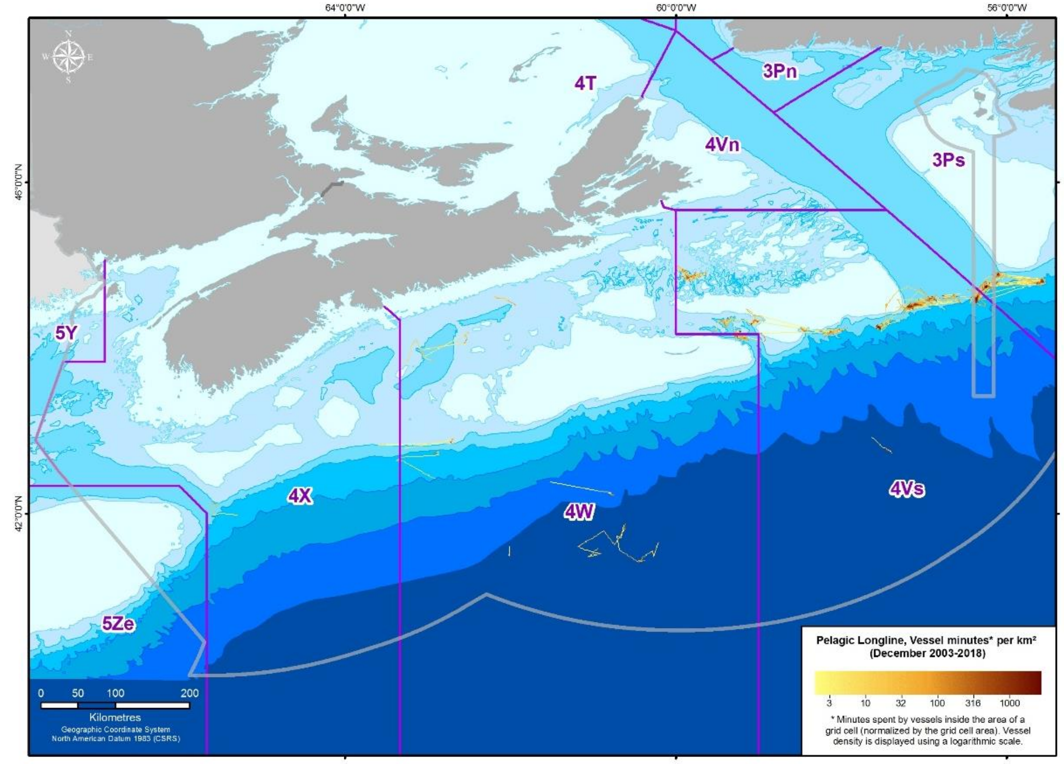

Figure 49.–Pelagic longline, vessel minutes per km^2, December composite, 2003-2018.