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Overview of Discards from Canadian Commercial Groundfish Fisheries in Northwest Atlantic Fisheries Organization (NAFO) Divisions 4X5Yb for 2007-2011

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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.

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ABSTRACT

Discards from Canadian commercial groundfish fisheries in Northwest Atlantic Fisheries Organization Divisions 4X5Yb were characterized for the period 2007-2011. The results were compared to discards calculated for a variety of fisheries conducted in Fisheries and Oceans Canada's Maritimes Region from 2002-2006. The discards between periods were estimated using the same methodology, which is based on at-sea observations that were scaled to the total catch of each fishery by weight. There may be considerable bias in estimated discards due to issues with the spatial representativeness of the observer coverage, and low levels of observer coverage (ranging from 0 to 11%), particularly for discarded species that are rarely caught. In addition, given the variable and poorly understood mortality of discarded bycatch, this report only calculates total discards and does not adjust for post-release survival or mortality. These discard estimates are only intended for making broad comparisons. Despite some limitations, this type of broad comparison of discards across fisheries and years can be helpful in identifying potential conservation concerns, as well as providing a basis for triage by resource managers.

Aperçu des rejets de poisson de fond liés aux pêches commerciales canadiennes dans les divisions 4X5Yb de l'Organisation des pêches de l'Atlantique Nord-Ouest entre 2007 et 2011

RÉSUMÉ

Les rejets de poisson de fond liés aux pêches commerciales canadiennes dans les divisions 4X5Yb de l'Organisation des pêches de l'Atlantique Nord-Ouest (OPANO) ont été caractérisés pour la période allant de 2007 à 2011. Les résultats ont été comparés aux taux de rejets calculés pour une variété de pêches menées dans la région des Maritimes de Pêches et Océans Canada de 2002 à 2006. Les taux de rejets entre les périodes ont été estimés à l'aide de la même méthode, qui est fondée sur la comparaison des observations en mer par rapport au total des prises pour chaque pêche, en fonction du poids. Les estimations de rejets peuvent faire l'objet d'un biais considérable en raison des problèmes liés à la représentativité spatiale de la couverture par les observateurs et des faibles niveaux de surveillance par des observateurs (de 0 % à 11 %), en particulier pour les espèces rejetées qui sont rarement capturées. De plus, en raison des variables et de la mauvaise compréhension du taux de mortalité des prises accessoires rejetées, le présent rapport ne calcule que les rejets totaux; il ne tient pas compte des taux de survie ou de mortalité après la remise à l'eau. Ces estimations de rejet sont uniquement destinées à l'établissement de comparaisons générales. En dépit de certaines contraintes, ce type de comparaison générale des rejets dans plusieurs pêches et sur plusieurs années peut être utile pour déterminer les préoccupations potentielles en matière de conservation, ainsi que pour fournir une valeur de base pour le triage effectué par les gestionnaires des ressources.

INTRODUCTION

Bycatch is recognized as a problem inherent within most fisheries (Davies et al. 2009; Davis 2002; Gillis et al. 1995; Alverson et al. 1994). It refers to the capture of non-target organisms, whether they are retained or discarded (Gavaris et al. 2010; Davies et al. 2009; Alverson et al. 1994). The retained portion of bycatch is termed incidental catch, whereas the discarded portion is identified as discards (Alverson et al. 1994). Discards consist of species that are not harvested commercially and prohibited species, as well as some harvestable species. The latter may be discarded to comply with management regulations such as size limits or license restrictions or, alternatively, may be discarded illegally in an attempt to improve catch composition through high-grading (Gavaris et al. 2010; Davis 2002; Gillis et al. 1995; Alverson et al. 1994).

Management and conservation practices require reliable estimates of total mortality generated by commercial fishing – both landed catch and discards that die (Gavaris et al. 2010). Although discarded organisms may survive post-release, discard mortality rates are poorly studied even though losses are expected to be considerable (Gavaris et al. 2010; Davis 2002; Gillis et al. 1995). The mortality of discards depends on fishing method, tow duration, individual condition, the species caught and a number of other factors (Davis 2002). For example, redfish (*Sebastes spp.*) have a closed swim bladder that expands uncontrollably when these fish are brought to the surface quickly from depth. As such, discarded redfish have been attributed a mortality rate approaching 100% (COSEWIC 2009; Rummer and Bennett 2005; Starr et al. 2002). On the other hand, the survival of species that lack swim bladders can vary considerably. Notably, the survival rate of undersized Atlantic Halibut (*Hippoglossus hippoglossus*) has been documented as 35% from trawls and 77% from longline fisheries for 48 hours following discarding (Neilson et al. 1989). Given the variable and poorly understood mortality of discarded bycatch, this report only calculates total discards and does not adjust for possible post-release survival.

Although retained landings can be monitored effectively via dockside monitoring programs, the only reliable means of estimating discards is through direct observation of fishing activities, by employing at-sea observers or electronic monitoring systems (Benoît and Allard 2009; Babcock et al. 2003; Furlong and Martin 2000; Karp and McElderry 1999; Kulka and Waldron 1983). It is commonly held that 100% observer coverage would be ideal, but prohibitive costs result in fisheries having considerably lower coverage (Benoît and Allard 2009). Observer coverage of fisheries can vary by type of fishery, region or even year. In general, a lower level of observer coverage results in a higher level of error in bycatch estimation (Karp and McElderry 1999). In a report from the Pew Institute of Ocean Science at the University of Miami, Babcock et al. (2003) suggested that coverage of at least 20% is necessary for estimates of bycatch of common species, while more than 50% coverage would be needed for rare species based on a literature review and simulation studies.

The purpose of this study is to characterize the discards, by species and weight, from Canadian commercial groundfish fisheries conducted in the Northwest Atlantic Fisheries Organization (NAFO) Divisions 4X and 5Yb from 2007 to 2011 (Figure 1). This study is a continuation of the Gavaris et al. (2010) overview of discards from the period 2002 through 2006 and includes the period of April 2010 to March 2011, when additional funding for observer coverage was provided by Fisheries and Oceans Canada's (DFO's) Species at Risk program.

METHODS

FISHERY MONITORING AND ASSIGNING A FISHERY

The groundfish fisheries in NAFO Divisions 4X and 5Yb are licensed by DFO. Fisheries participants record their activity, retained catches and weighed landings and submit the information to DFO Maritimes Region for entry into the Maritimes Fisheries Information System (MARFIS). The MARFIS database represents a complete census of almost all commercial fishing activities in the DFO Maritimes region (Gavaris et al. 2010).

The documents submitted by fisheries participants do not include estimates of discarded catches. This gap is addressed by at-sea observer data. Observers record the nature and location of fishing activities and the catches of both retained and discarded species (Gavaris et al. 2010). The observer data is recorded by DFO Maritimes Region in the Industry Surveys Database (ISDB). There are several potential biases in observer data (for a discussion of biases, see Benoît and Allard 2009; Babcock et al. 2003; Furlong and Martin 2000; and Liggins et al.1997). For the purposes of this study, cases that did not reflect regular fishing activities, such as observed trips that were part of scientific surveys, were removed. Therefore, the at-sea deployments included in the analysis should be representative (Gavaris et al. 2010).

The quantity and composition of the bycatch caught in the groundfish fishery are influenced by a variety of factors, including the type of fishery, the gear used, the date fished, and the location fished (Gavaris et al. 2010). To minimize the variation introduced by these factors, discard calculations were performed by fishery, year, and area. In Gavaris et al. (2010), the calculations were conducted by calendar year rather than fishery year. For comparison purposes, this method has also been adopted in the current study. Although it is possible that seasonal variation in bycatch exists (Smith and Baird 2005; Ortiz et al. 2000; Julian and Beeson 1998), limited observer coverage and small sample size prevented resolution to a finer temporal scale in most years. Annual discard estimates were calculated for 2007 to 2011. These were supplemented with discard estimates by quarter for some fisheries in 2010 and 2011 when there was higher observer coverage. The quarters examined in 2010 and 2011 were:

1) January 1 to March 3;
2) April 1 to June 30;
3) July 1 to September 30; and
4) October 1 to December 31.

Both area fished and date fished are recorded in the MARFIS database. For this study, groundfish fisheries were identified by the type of species licensed for landing and the fishing gear used in the same way as reported in Gavaris et al. (2010). Although groundfish licenses authorize the landing of multiple groundfish species, some fishery subtypes can be distinguished on the basis of mesh size. For example, during the period during which the data for this study was collected, the silver hake and redfish fisheries used mesh sizes of 45-89 mm and 90-126 mm, respectively. A fishery for sculpin that operated differently from the general groundfish fishery was identified based on DFO assigned vessel number and landing dates falling within the sculpin fishery dates. Those trips lacking a recorded mesh size, or with mesh size outside the above categories, were assigned to the general groundfish bottom trawl fishery. Finally, some of the groundfish fisheries could be identified as either inshore or offshore based on license subtype. The groundfish fisheries identified in this study are presented in Table 1.

Each fishing trip, the basic unit of fishing activity, was assigned a fishery type (Gavaris et al. 2010). The *Fisheries Act* defines a fishing trip as “a voyage that commences at the time a

fishing vessel leaves a port to engage in fishing and terminates at the time fish caught during that period are off-loaded". Trip records are, therefore, associated with landing dates.

DISCARD ESTIMATION

To allow comparisons, this study used the same methodology for calculating discards as Gavaris et al. (2010). By combining observer data from ISDB with fishery data from MARFIS, it was possible to estimate the weight of discards by species, area and year. These estimates were based on the formula:

$$\textbf{DISCARDS} = \textbf{LANDINGS}\ (\textbf{discards}/\textbf{landings})$$

where **DISCARDS** are the total estimated discards of species A, **LANDINGS** are the total landings of all species, **discards** are the observed discards of species A, and **landings** are the observed landings of all species.

In order to perform calculations based on this formula, it was necessary to first match ISDB and MARFIS records, and then to tally total landings, observed landings and observed discards. The data from the two databases were matched based on the DFO assigned vessel number, the landed date and the gear type used. It is important to note that the gear codes differ between the MARFIS and ISDB databases; the associations used to match gear types are presented in Table 2. Occasionally, ISDB landed dates did not match MARFIS landed dates. In such instances, matching was attempted based on dates fished rather than landed dates. After such corrections, the percentage of ISDB trip records that could not be matched to MARFIS records was 5%, 7%, 16%, 11%, and 7% for 2007 through 2011, respectively. These percentages are slightly higher than they were for 2002 to 2006 (6%, 4%, 5%, 5%, and 5%; Gavaris et al. 2010).

The values for total landings of all species (**LANDINGS**) and observed landings of all species (**landings**) were both derived from MARFIS so that potential inconsistencies in methods between the databases would not influence results. While **LANDINGS** was the sum of all landings for a fishery, **landings** was simply the sum of the landings from observed trips in a fishery. The observed discards (**discards**) were derived from the ISDB. The value **discards** represents the estimated weight of all discards on a trip, even if operational constraints prevented an observer from observing all sets on a trip. In cases where the entire trip was not observed, the discards from the witnessed portion of the trip were extrapolated to the entire trip, using the following formula:

$$\textbf{discards} = \textbf{duration}\ (\textbf{discards}_{\textbf{witnessed}} / \textbf{duration}_{\textbf{witnessed}})$$

where **duration** is the total duration of the trip, $\textbf{discards}_{\textbf{witnessed}}$ is the discards recorded by the observer during observed portions of the trip and $\textbf{duration}_{\textbf{witnessed}}$ is the duration of the trip that was witnessed by the observer. Both the witnessed and the total trip duration for observed trips were retrieved from the ISDB records, ensuring consistency. Percent observer coverage by year is reported as the percent of trips with an observer.

REPRESENTATIVENESS

One concern with the use of observer data is whether observed trips are representative of all trips in a fishery. Except in rare cases, the intent is to deploy observers to the fishery in a random manner to ensure that data collected are representative and there are many strategies to achieve this goal (see Benoît and Allard 2009; Furlong and Martin 2000). Spatial bias is one of the most common biases in the deployment of observers (Benoît and Allard 2009). In this study, the distribution of all fishing activities was mapped and compared to the observed subset to determine whether observed trips provided a spatially representative sample of all fishing trips. Chi-square goodness-of-fit tests were used to determine whether the distribution of

observed trips differed from the distribution of all trips (i.e. the expected distribution) as per Hanke et al. (2011).

RESULTS AND DISCUSSION

Observer coverage of the commercial fisheries in 4X and 5Yb varied considerably between 2007 and 2011. The coverage by year and fishery is given in Table 3. The higher observer coverage in 2010 (9.8% trawl fishery, 5.7% longline) and 2011 (10.7% trawl fishery, 4.3% longline) was due to the additional funding for observer coverage in these fleets provided through Species at Risk funds.

DISCARDS BY YEAR AND FISHERY

Estimated discards for 2007 to 2011 are tabulated in Appendices 1 through 4 to support the comparisons made in this document. It is important to note that the bycatch estimates are extrapolated from a small proportion of observed trips and, therefore, may be biased, particularly in the case of species that are rarely encountered. As such, discard estimates should be considered critically, and are more appropriately used for relative comparisons rather than distinct estimates.

Species were classified into one of three categories: licensed species, species of potential concern, and other species. Species of 'potential concern' were defined for this study as those listed by the *Species at Risk Act* (SARA) or recommended for listing by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC). The species with the highest discard weights in each of these categories are illustrated in Figure 2. For all groundfish fisheries combined, the licensed species discarded in the highest quantities were spiny dogfish, American Lobster, Atlantic Halibut, Atlantic Rock Crab, sculpin, Jonah crab, and American Shad. Of these species, spiny dogfish were discarded most consistently and in the greatest quantity, with an average of 936 metric tonnes (mt) discarded per year from 2007 to 2011 (range: 286 mt in 2010 to 1479 mt in 2011) (Figure 2a). Spiny dogfish were also the most consistently discarded licensed species from 2002 to 2006 along with American Lobster, Atlantic Halibut, Jonah crab, sculpin and Atlantic Rock Crab (Gavaris et al. 2010).

The species of potential concern that were discarded in the highest quantities by weight for all groundfish fisheries combined were barndoor, winter and thorny skates, cusk, white hake, and porbeagle sharks. On a few occasions, basking sharks were also discarded (Figure 2b). Barndoor skates were most consistently discarded, while basking sharks accounted for the greatest weight of discards among species of potential concern. This result reflects one of the problems with extrapolating discards from observed trips to the entire fishery; namely that the bycatch of large but rarely encountered species may be overestimated. In this case, basking sharks were observed on only four occasions between 2007 and 2011 in three different fisheries, but when the weight was extrapolated to the entire fishery it represented a significant, and likely misleading, tonnage. Trends in discards of species of potential concern were similar in the earlier report (years 2002 to 2006), with thorny, barndoor and winter skates being the species most consistently discarded in large quantities (Gavaris et al. 2010). However, the calculated basking shark discards were considerably lower than from 2002 to 2006, with less than 100 mt discarded.

Finally, of species that did not fall into the licensed or potential concern category, starfish and other species of skates were most discarded (Figure 2c), while, in the earlier period (2002 to 2006), other skates, other dogfish and starfish were the most discarded species in this third category (Gavaris et al. 2010). Further details for selected species are shown by fishery in Figures 3 to 5, and the estimates are tabulated in Appendices 1 to 4.

Trends in the estimation of species discarded differed by fishery (Figures 6 and 7). For example, spiny dogfish was the licensed species that was discarded in the greatest quantity in the groundfish bottom trawl, both onshore and offshore, as well as in the onshore and offshore redfish bottom trawl. The licensed species with the greatest discards in the gillnet fishery and sculpin bottom trawl was American Lobster, while in the silver hake trawl and longline fisheries, the most discarded species were alewife and American Halibut, respectively (Figure 6). In the earlier period from 2002 to 2006, spiny dogfish were discarded in greatest quantity in the onshore and offshore groundfish bottom trawl and redfish bottom trawl fisheries, as well as in the gillnet, longline, and silver hake trawl fisheries (Gavaris et al. 2010).

The species of potential concern that were discarded in greatest quantity also differed by fishery (Figure 7). From 2007 to 2011, basking shark, winter skate, barndoor skate, and smooth skate were the species that were discarded in greatest quantity: basking sharks in the groundfish bottom trawl and gillnet fisheries, winter skates in the offshore groundfish bottom trawl, barndoor skates in the longline, silver hake trawl, and onshore and offshore redfish trawl fisheries, and smooth skates in the sculpin bottom trawl (Figure 7). Trends in discards of species of potential concern from 2002 to 2006 were similar (Gavaris et al. 2010).

For species assigned to the ‘other species’ category from 2007 to 2011, discard quantities of little skate were highest in the groundfish bottom trawl, unidentified skates were highest in the offshore groundfish bottom trawl, longline and offshore redfish trawl fisheries, starfish were highest in the gillnet, shortfin squid were highest in the silver hake trawl, brown rockweed was highest in the sculpin trawl and black dogfish were highest in the redfish bottom trawl (Appendices 1 to 4). Other skate discards dominated from 2002 to 2006 in a number of fisheries, among the other discards category: onshore and offshore groundfish trawls, longline, silver hake trawl, sculpin trawl, and onshore redfish trawl fisheries. The species that dominated discards of the ‘other species’ category in the gillnet and offshore redfish trawl fisheries between 2002 and 2006 were sturgeon (i.e. Atlantic and shortnose) and dolphins, respectively.

Overall, the greatest discards of licensed species occurred in the groundfish bottom trawl fishery (>2000 mt), while the discards of species of potential concern were highest in the groundfish longline fishery (>1000 mt), followed by the groundfish bottom trawl fishery (>800 mt). The trends are different when individual years are considered. Notably, discards of licensed species were highest in the redfish bottom trawl fishery in 2007, in the groundfish bottom trawl fishery in 2008, in the gillnet fishery in 2009, in the offshore redfish bottom trawl fishery in 2010, and were relatively low in all fisheries in 2011. Species of potential concern were discarded in greatest quantity in the groundfish bottom trawl fishery in 2007 and 2008 and in the groundfish longline fishery in all other years.

DISCARDS BY QUARTER

During 2010 and 2011, when there was enhanced observer coverage, only four of the groundfish fisheries analysed for this report had trips in all four quarters: the groundfish bottom trawl, longline, and inshore and offshore redfish bottom trawl fisheries. As the number of trips differed considerably by quarter, discards were standardized by dividing by the number of trips. In 2010, the discards of licensed species were generally highest in the first quarter for the groundfish bottom trawl fishery, whereas in 2011 discards in this fishery tended to be highest in the second and fourth quarters (Figure 8). In the longline fishery, discards were highest in the first quarter in 2010 and in the fourth quarter in 2011 (Figure 9). Discards were highest in the second quarter in both 2010 and 2011 for the inshore redfish bottom trawl fishery (Figure 10). Discards from the offshore redfish bottom trawl fishery showed no trend by quarter (Figure 11). There were no trends in the quarterly discards of species of potential concern in the groundfish bottom trawl fishery (Figure 12). Discards of species of potential concern in the longline fishery

were highest in the third and fourth quarters (Figure 13). There were no consistent trends in the quarterly discards of species of potential concern from either the inshore or offshore redfish bottom trawl fisheries (Figures 14 and 15).

REPRESENTATIVENESS

Within 4X and 5Yb, both the ISDB and MARFIS trip entries were recorded down to the subarea level and could accordingly be compared. These areas are 4XL, 4XM, 4XN, 4XO, 4XP, 4XQ, 4XR, 4XS, 4XX, and 5Yb (Figure 1). There was strong evidence for rejecting the null hypothesis that the number of observed trips was proportional to the total fishing in each of the fishing areas in several of the years examined. Notably, the Chi-square analyses supported rejection of the null for the years 2007, 2008, 2009 and 2011 (2007: χ^2=88.7, p<0.0001; 2008: χ^2=41.9, p<0.0001; 2009: χ^2=26.6, p=0.0030; 2011: χ^2=29.2, p=0.0012). There was no evidence to support rejection of the null hypothesis in 2010 (χ^2=15.7, p=0.1085). This indicates that the distribution of observed trawl, longline and gillnet trips across subareas was not representative of the distribution of all such trips in those areas for four out of five years tested, indicating that there may be bias in the calculations of discards. The spatial distribution of observer coverage appeared to be spatially representative only in 2010 when there was a higher level of coverage. The distributions of both observed and unobserved fishing trip sets by gear type and year are presented in Figures 16 to 30.

SUMMARY

The discards from Canadian commercial groundfish fisheries in NAFO Divisions 4X5Yb were characterized for the period 2007 to 2011. The discard estimates were intended for making broad comparisons and informing management of potential conservation concerns. It provides an update on the analysis of Gavaris et al. (2010). The estimated discards relied on at-sea observations and were extrapolated to reflect the entire fishery. Given the low level of observer coverage (ranging from 0% to 11%), there may be considerable bias in estimated discards. For example, discards of large but rarely encountered species, such as basking sharks, are likely to be overestimated upon extrapolation, and the discarding of some rarely caught species may be missed entirely.

Discarding has long been recognized as a source of fishing mortality, but the focus on its importance and its inclusion in stock assessments and fisheries management decisions is relatively new. Whereas the numbers in this study should not be considered precise estimates because of the issues of limited coverage, broad comparisons of the estimates of discards across fisheries can be used to identify potential conservation concerns. As such, they can provide a basis for triage by resource managers, including identifying fisheries that may require additional observer coverage. According to Gavaris et al. (2010), the first step in such a triage is to identify species with the highest discards. On the basis of the analysis presented in this document, in 4X5Yb, the species that are discarded at the highest levels are spiny dogfish (in the inshore and offshore bottom trawl and redfish trawl fisheries), American Lobster (in the gillnet and bottom trawl fisheries), Atlantic Halibut (in the longline and bottom trawl fisheries), barndoor skate (in the longline fishery), winter skate (in the bottom trawl fishery) and cusk (in the longline fishery).

REFERENCES CITED

Alverson, D.L., Freeberg, M.H., Murawski, S.A., and Pope, J.G. 1994. A global assessment of fisheries bycatch and discards. FAO Fish. Tech. Pap. 339. 233 p.

Babcock, E.A., Pikitch, E.K., and Hudson, C.G. 2003. How much observer coverage is enough to adequately estimate bycatch? Report of the Pew Institute for Ocean Science, Rosenstiel School of Marine and Atmospheric Science, University of Miami, Miami, FL. 36 p.

Benoît, H.P., and Allard, J. 2009. Can the data from at-sea observer surveys be used to make general inferences about catch composition and discards? Can. J. Fish. Aquat. Sci. 66: 2025-2039.

COSEWIC. 2009. COSEWIC Assessment and status report on the darkblotched rockfish *Sebastes crameri* in Canada. COSEWIC. vii + 48 p.

Davies, R.W.D., Cripps, S.J., Nickson, A., and Porter, G. 2009. Defining and estimating global marine fisheries bycatch. Mar. Pol. 33: 661-672.

Davis, M.W. 2002. Key principles for understanding fish bycatch discard mortality. Can. J. Fish. Aquat. Sci. 59: 1834-1843.

Furlong, W.J., and Martin, P.M. 2000. Observer deployment in the fishery and regulatory self-enforcement. *In* Proceedings of the 10th Biennieal Conference of the International Institute of Fisheries Economics and Trade, Corvallis. Edited by Richard S. Johnston. 9 p. (Last accessed 17 July 2015).

Gavaris, S., Clark, K.J., Hanke, A.R., Purchase, C.F., and Gale, J. 2010. Overview of discards from Canadian commercial fisheries in NAFO divisions 4V, 4W, 4X, 5Y and 5Z for 2002-2006. Can. Tech. Rep. Fish. Aquat. Sci. 2873. 112 p.

Gillis, D.M., Peterman, R.M., and Pikitch, E.K. 1995. Implications of trip regulations for high-grading: A model of the behaviour of fishermen. Can. J. Fish. Aquat. Sci. 52(2): 40-415.

Hanke, A.R., Andrushchenko, I., and Croft, G. 2011. Observer coverage of the Atlantic Canadian swordfish and other tuna longline fishery: An assessment of current practices and alternative methods. DFO Can. Sci. Advis. Sec. Res. Doc. 2011/028.

Julian, F., and Beeson, M. 1998. Estimates of marine mammal, turtle, and seabird mortality for two California gillnet fisheries: 1990-1995. Fish. Bull. 96: 271-284.

Liggins, G.W., Bradley, M.J., and Kennelly, S.J. 1997. Detection of bias in observer-based estimates of retained and discarded catches from a multispecies trawl fishery. Fish. Res. 32(2): 133-147.

Karp, W.A., and McElderry, H. 1999. Catch monitoring by fisheries observers in the United States and Canada. *In* Proceedings of the International Conference on Integrated Fisheries Monitoring, Sydney, Australia, 1-5 February 1999. Edited by C.P. Nolan. FAO, Rome, Italy. pp. 261-284.

Kulka, D.W., and Waldron, D. 1983. The Atlantic observer programs – A discussion of sampling from commercial catches at-sea. *In* Sampling Commercial Catches Of Marine Fish And Invertebrates. Edited by W.G. Doubleday and D. Rivard. Can. Spec. Publ. Fish. Aquat. Sci. 66: 255-262.

Neilson, J.D., Waiwood, K.G., and Smith, S.J. 1989. Survival of Atlantic halibut (*Hippoglossus hippoglossus*) caught by longline and otter trawl gear. Can. J. Fish. Aquat. Sci. 46(5): 887-897.

Ortiz, M., Legault, C.M., and Ehrhardt, N.M. 2000. An alternative method for estimating bycatch from the U.S. shrimp trawl fishery in the Gulf of Mexico, 1972-1995. Fish. Bull. 98: 583-599.

Rummer, J.L., and Bennett, W.A. 2005. Physiological effects of swim bladder overexpansion and catastrophic decompression on red snapper. Trans. Amer. Fish. Soc. 134(6): 1457-1470.

Smith, M.H., and Baird, S.J. 2005. Representativeness of past observer coverage, and future coverage required for estimation of New Zealand sea lion (*Phocarctos hookeri*) captures in the SQU 6T fishery. NZ Fish. Asses. Rep. 2005/5. 39 p.

Starr, R.M., Heine, J.N., Felton, J.M, and Cailliet, G.M. 2002. Movements of bocaccio (*Sebastes paucispinis*) and greenspotted (*S. chlorostictus*) rockfishes in a Monterey submarine canyon: Implications for the design of marine reserves. Fish. Bull. 100: 324-337.

TABLES

Table 1. List of Canadian commercial licensed fisheries of interest operating in NAFO Divisions 4X, 5Yb and 5Z. Offshore sectors are identified by their license. Mesh size was used to distinguish some groundfish fisheries.

Fishery Code	Fishery	Description
GRO01	GRO-OTB	Groundfish bottom trawl
GRO02	GRO-OTB-OF	Groundfish bottom trawl offshore
GRO07	GRO-LLS	Groundfish longline
GRO08	GRO-LHP	Groundfish handline
GRO12	GRO-GNS	Groundfish gillnet
GRO14	HKS-OTB[1]	Silver Hake trawl
GRO15	RED-OTB[2]	Redfish bottom trawl
GRO16	RED-OTB-OF[2]	Redfish bottom trawl offshore
GRO17	SKW-OTB	Winter Skate bottom trawl
GRO18	SCU-OTB[3]	Sculpin bottom trawl

Note:
[1] 45-89 mm mesh.
[2] 90-126 mm mesh.
[3] Specific license holders fishing between April 15 and May 31 with <90 mm mesh.

Table 2. Association of gear codes in the MARFIS and ISDB databases that was used to assist with or confirm trip matches. There is not a one-to-one relationship with multiple ISDB codes corresponding to a single MARFIS code and vice versa. (From Gavaris et al. 2010).

ISDB		MARFIS	
Code	Description	Code	Description
12	BOTTOM OTTER TRAWL (STERN)	12	OTTER TRAWL, STERN
41	SET GILLNETS	41	GILL NET (SET OR FIXED)
50	LONGLINE (TYPE NOT SPECIFIED)	51	LONGLINE
51	SET LINES (BOTTOM OR NEAR BOTTTOM)	51	LONGLINE
52	DRIFT LINES (DRIFTING LONGLINE)	51	LONGLINE

Table 3. Percent observer coverage of commercial fisheries in 4X and 5Yb from 2007 to 2011. (SE indicates standard error).

Year	Trawl	Gillnet	Longline
2007	2.4	0.0	1.8
2008	2.5	1.8	2.1
2009	4.1	0.1	2.5
2010	9.8	0.8	5.7
2011	10.7	0.3	4.3
Average ± SE	5.9 ± 1.8	0.6 ± 0.3	3.3 ± 0.7

FIGURES

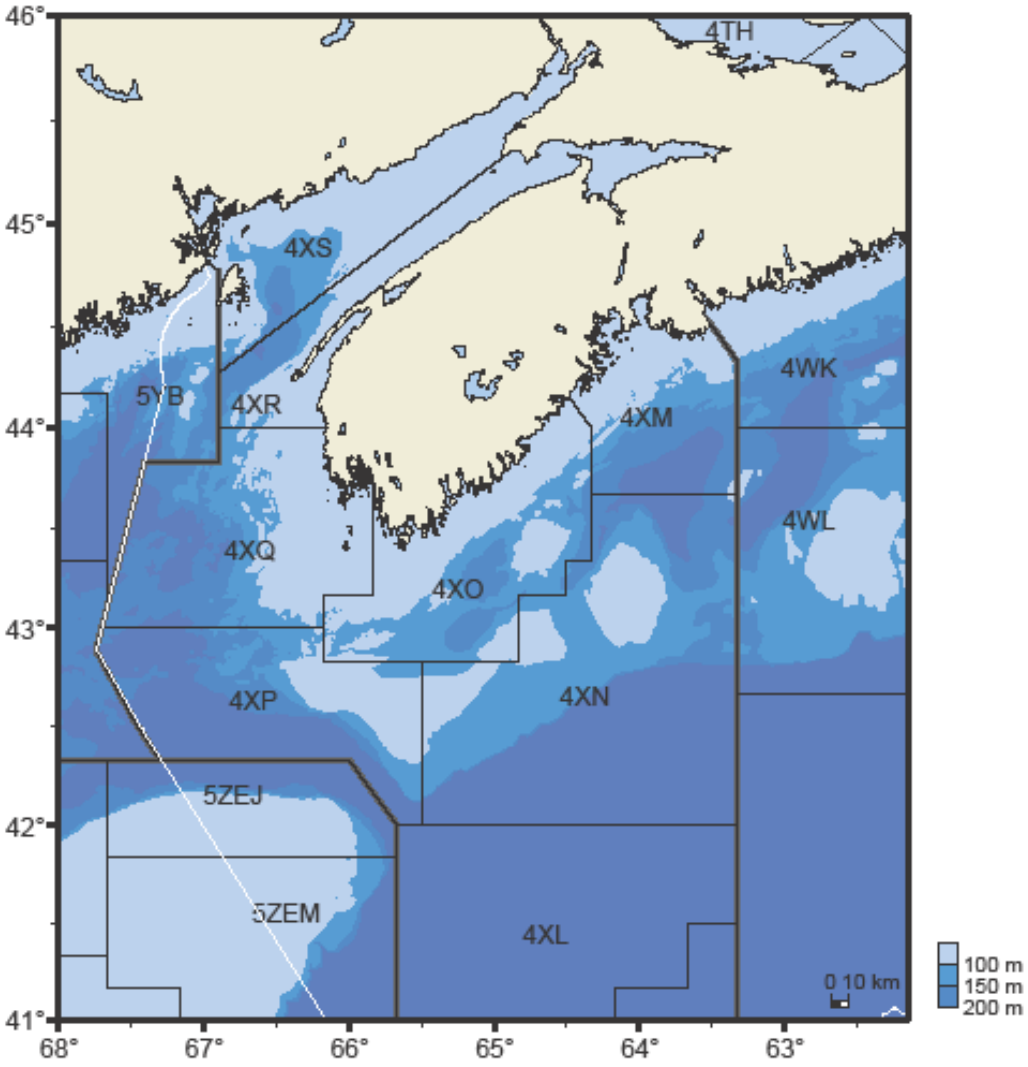

Figure 1. Map of the Maritimes Region showing NAFO Divisions and Subdivisions.

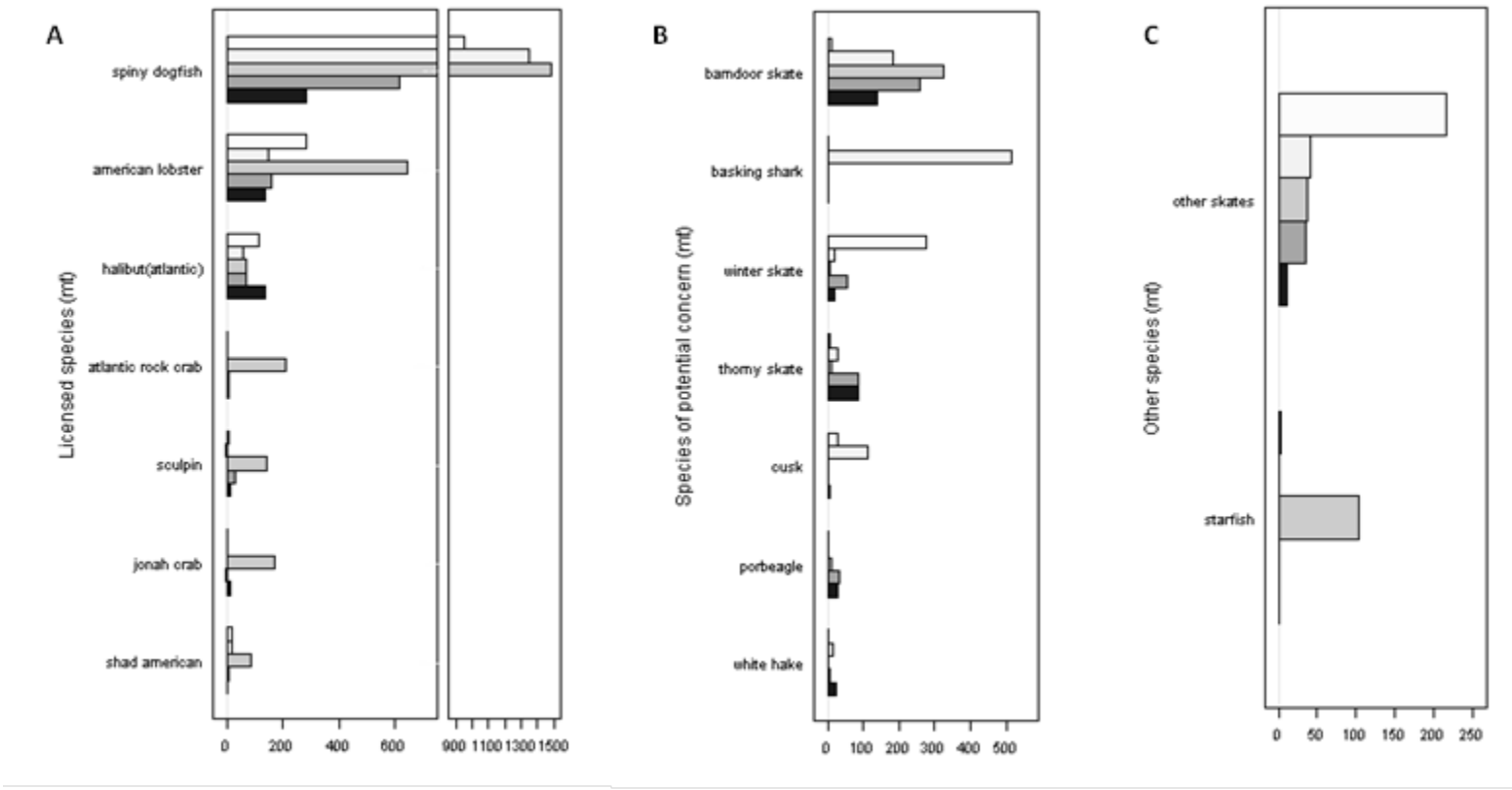

Figure 2. The most frequent discards (by weight in metric tonnes) of a) licensed species, b) species of potential concern, and c) other species in the groundfish fisheries in 4X5Yb between 2007 and 2011. The range of shades represent different years, with the palest being 2007 and the darkest being 2011.

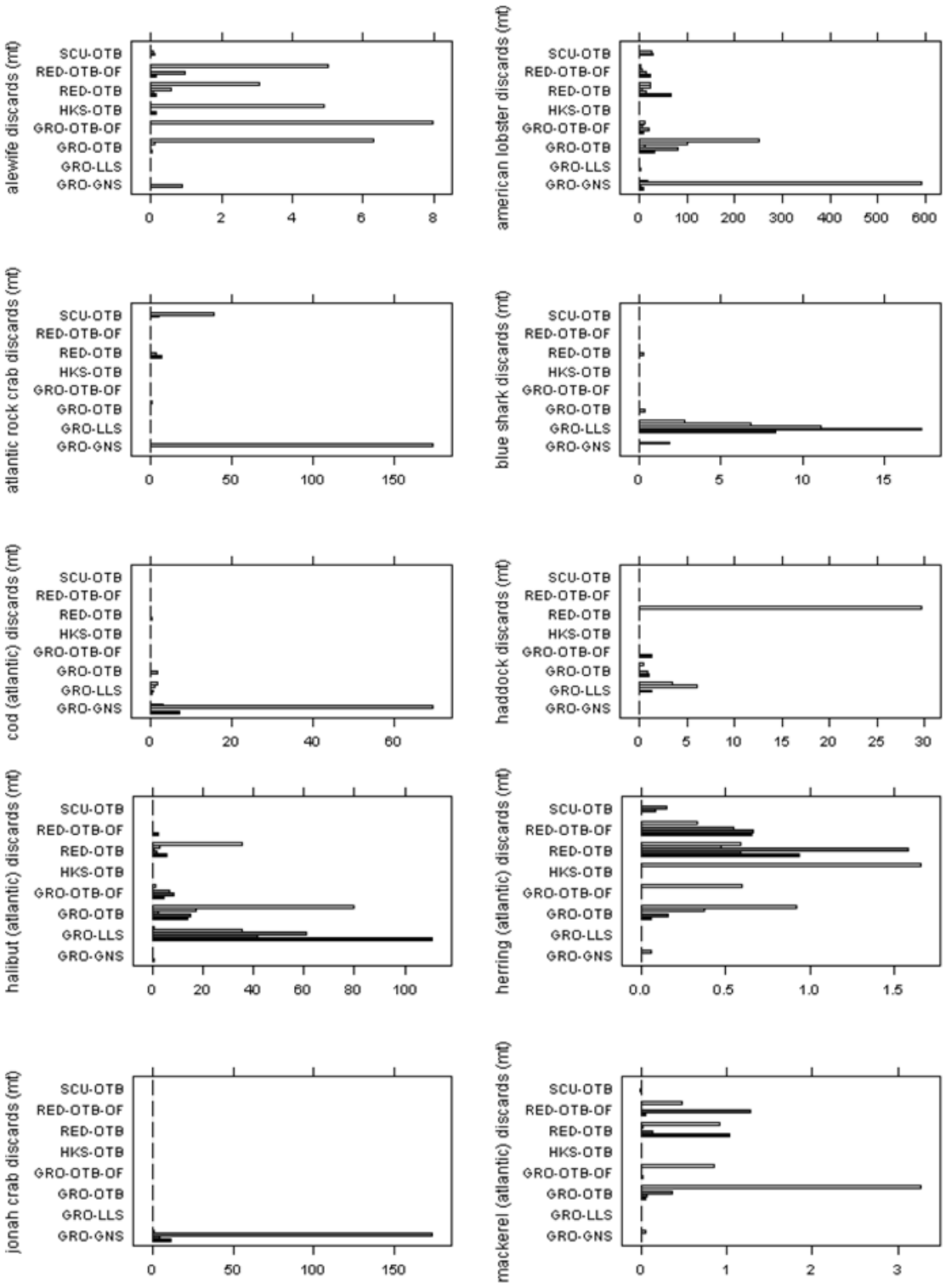

Figure 3. Estimated discards (in metric tonnes) of licensed species in 4X5Yb by fishery. The five bars represent years, with the palest bars being 2007 and the darkest being 2011.

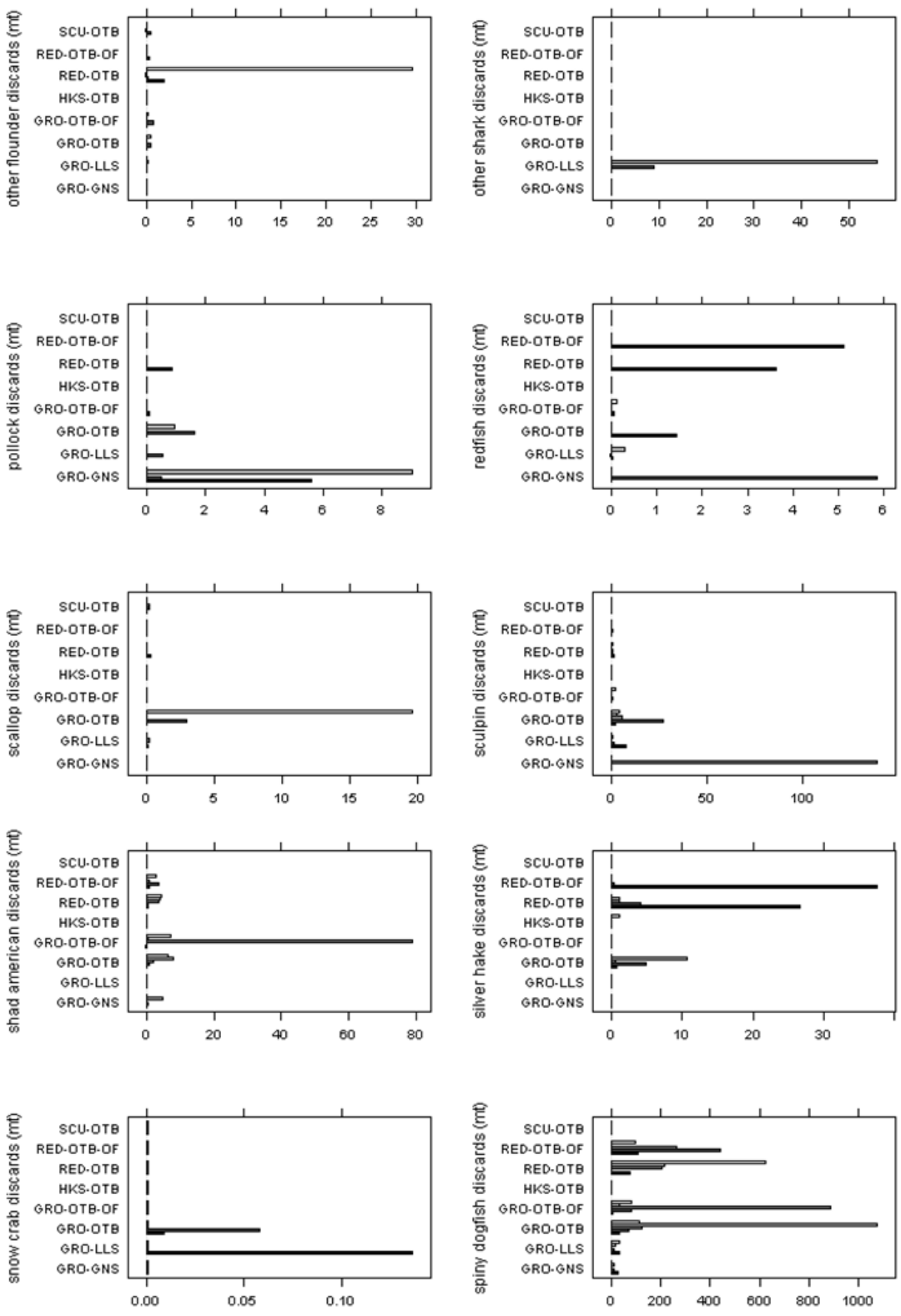

Figure 3 (Continued). Estimated discards (in metric tonnes) of licensed species in 4X5Yb by fishery. The five bars represent years, with the palest bars being 2007 and the darkest being 2011.

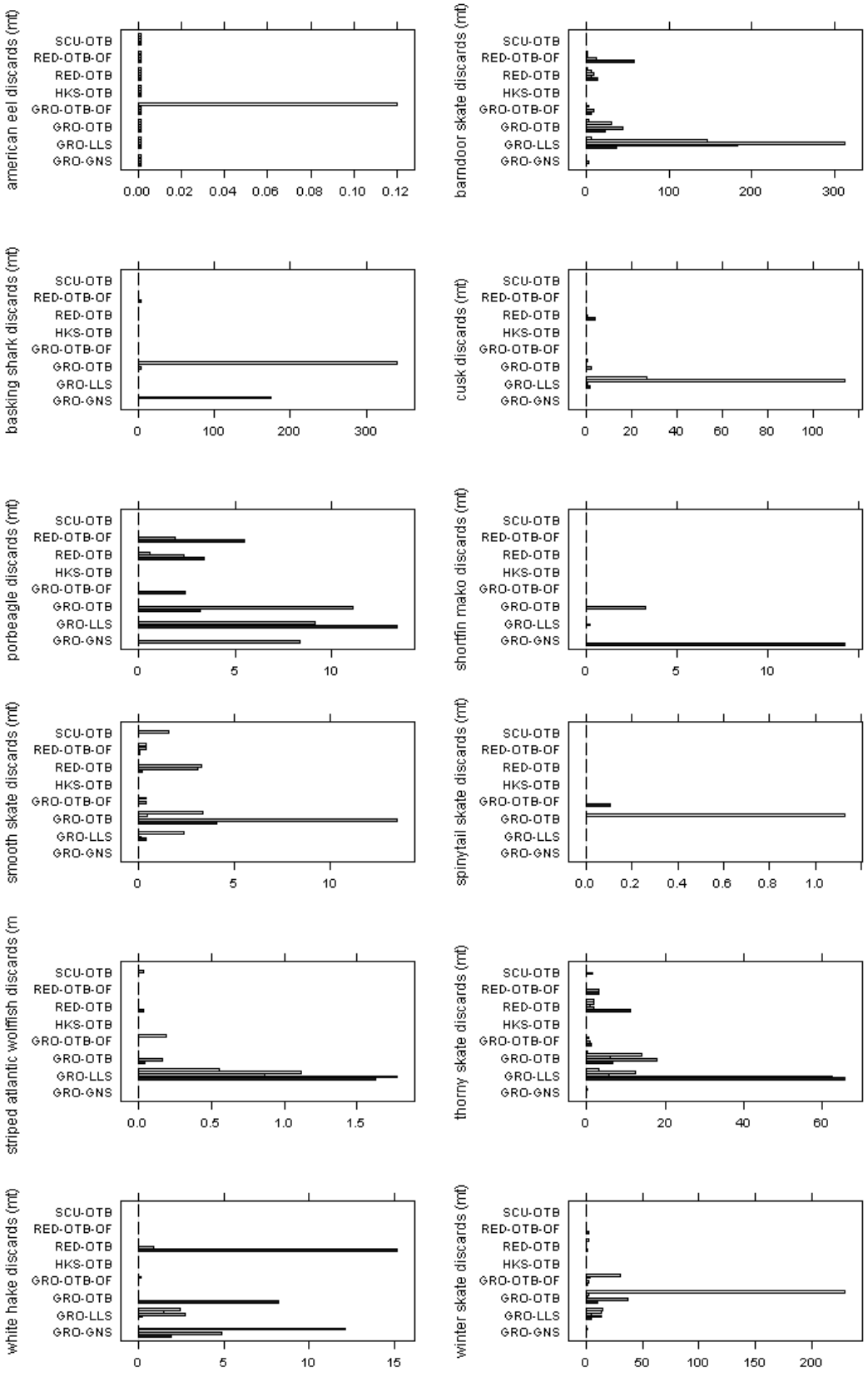

Figure 4. Estimated discards (in metric tonnes) of species of potential concern in 4X5Yb by fishery. The five bars represent years, with the palest bars being 2007 and the darkest being 2011.

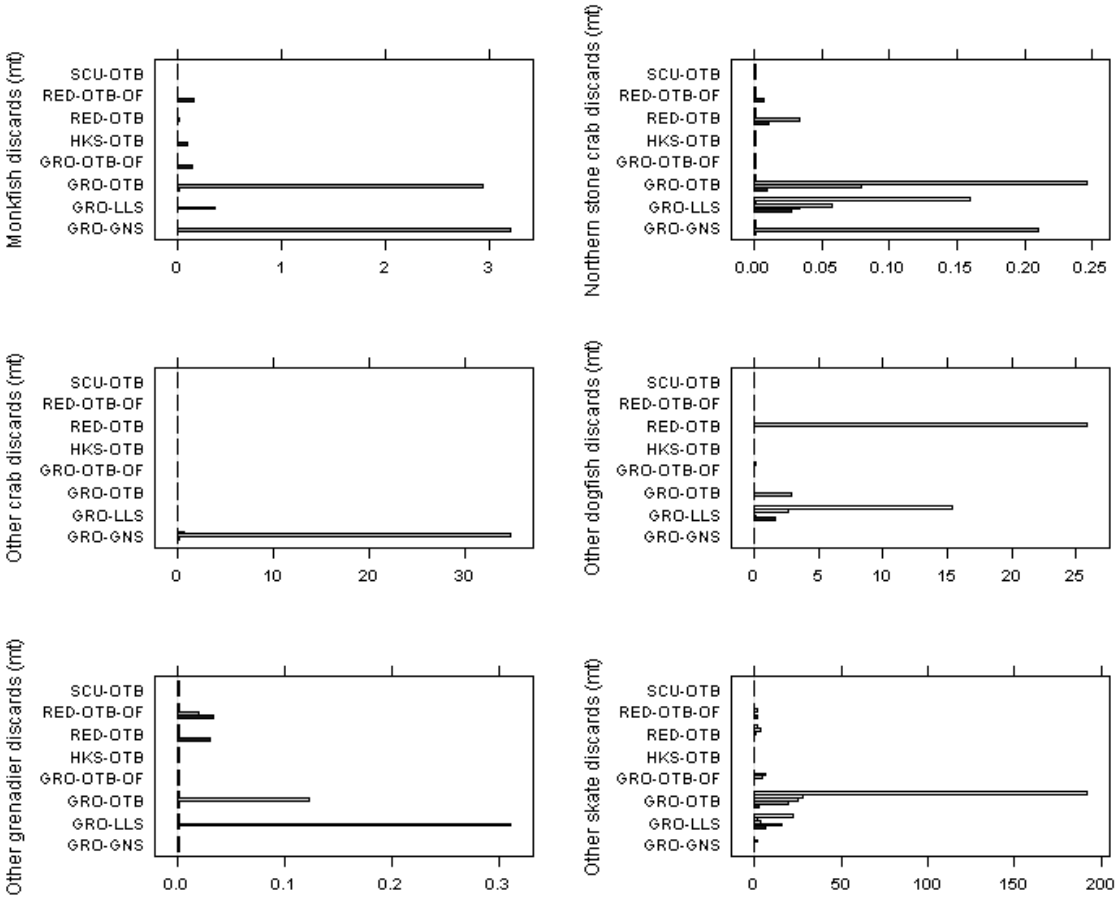

Figure 5. Estimated discards (in metric tonnes) of other species (neither licensed or of potential concern) in 4X5Yb by fishery. The five bars represent years, with the palest bars being 2007 and the darkest being 2011.

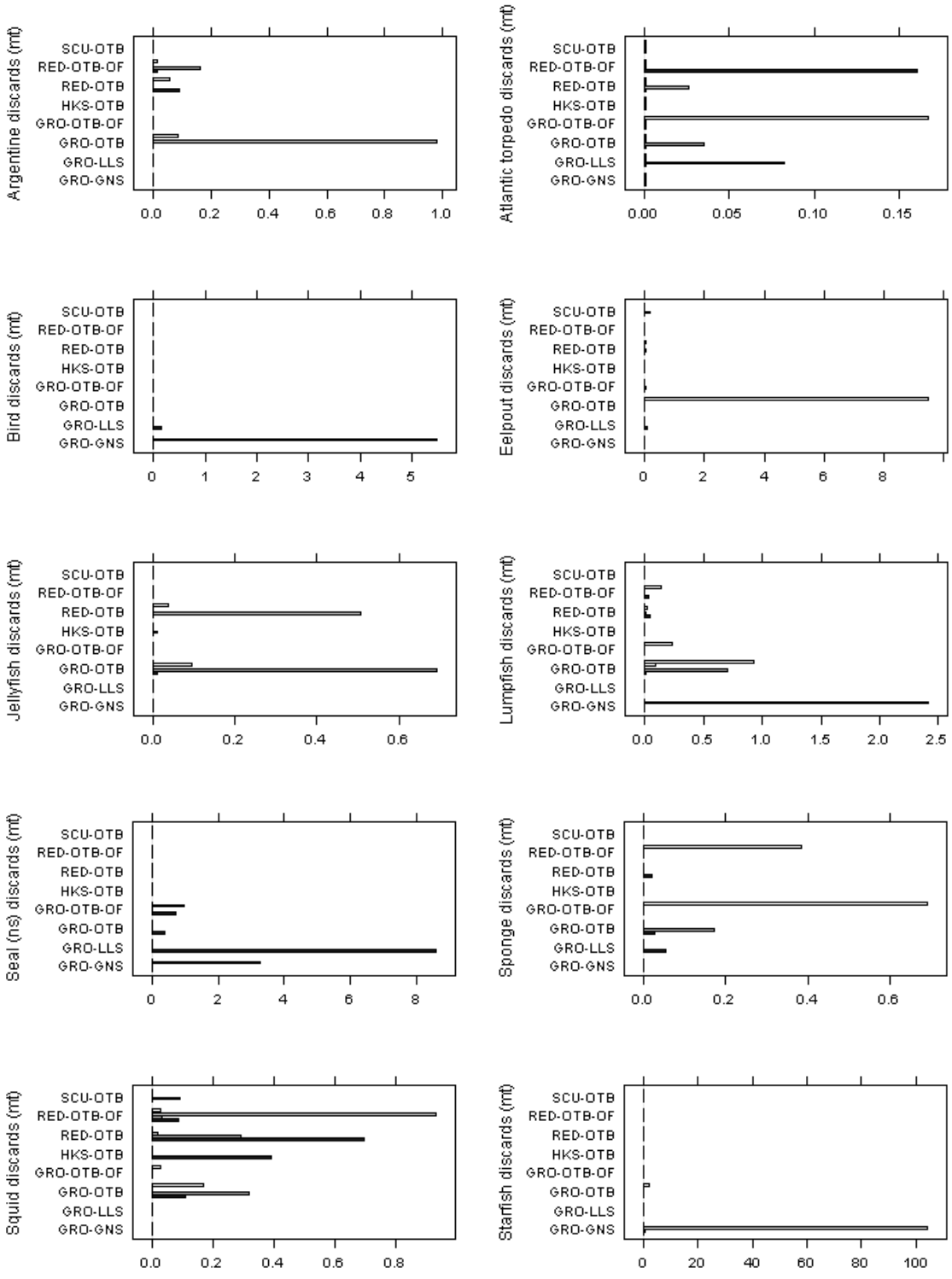

Figure 5 (Continued). Estimated discards (in metric tonnes) of other species (neither licensed or of potential concern) in 4X5Yb by fishery. The five bars represent years, with the palest bars being 2007 and the darkest being 2011.

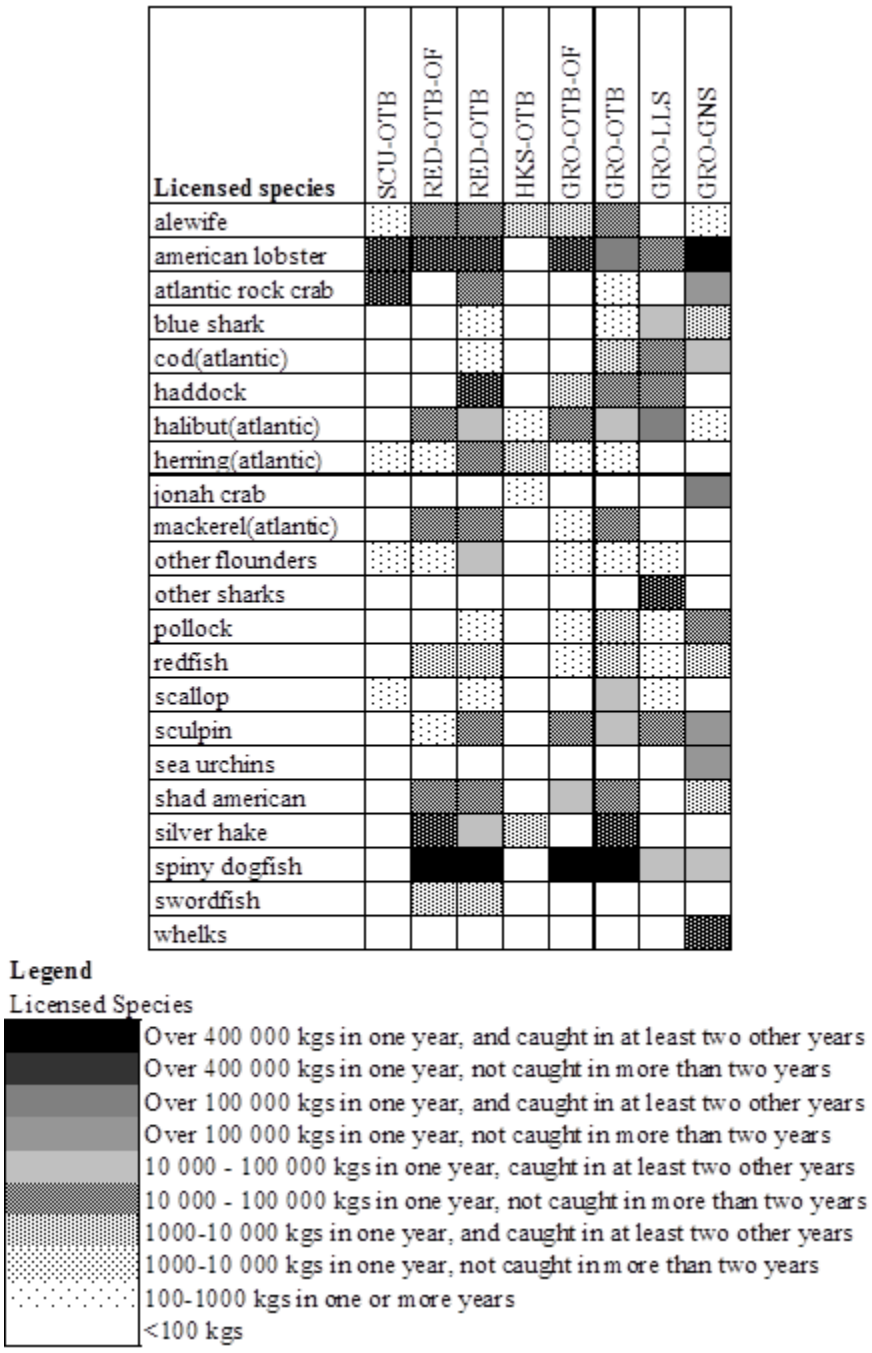

Figure 6. Summary of important discards in 4X5Yb of licensed species with contributing fisheries indicated.

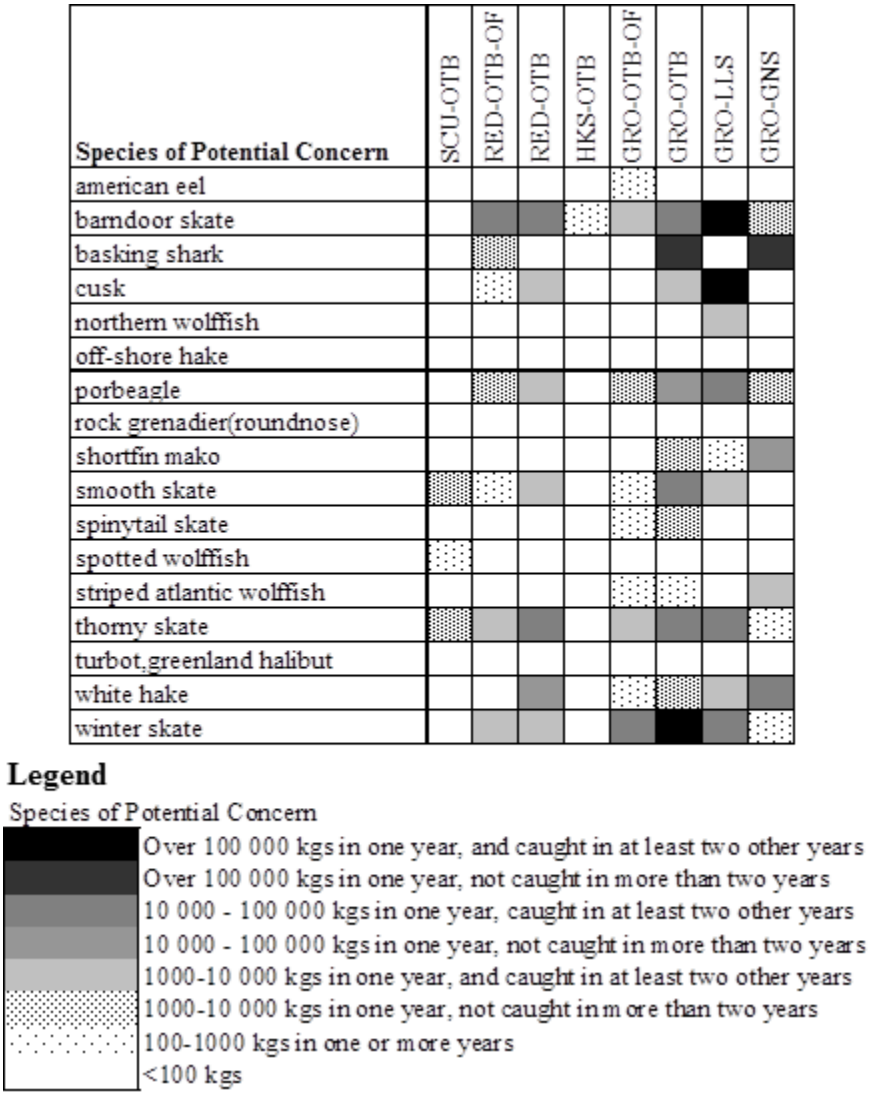

Figure 7. Summary of important discards in 4X5Yb of species of potential concern with contributing fisheries indicated.

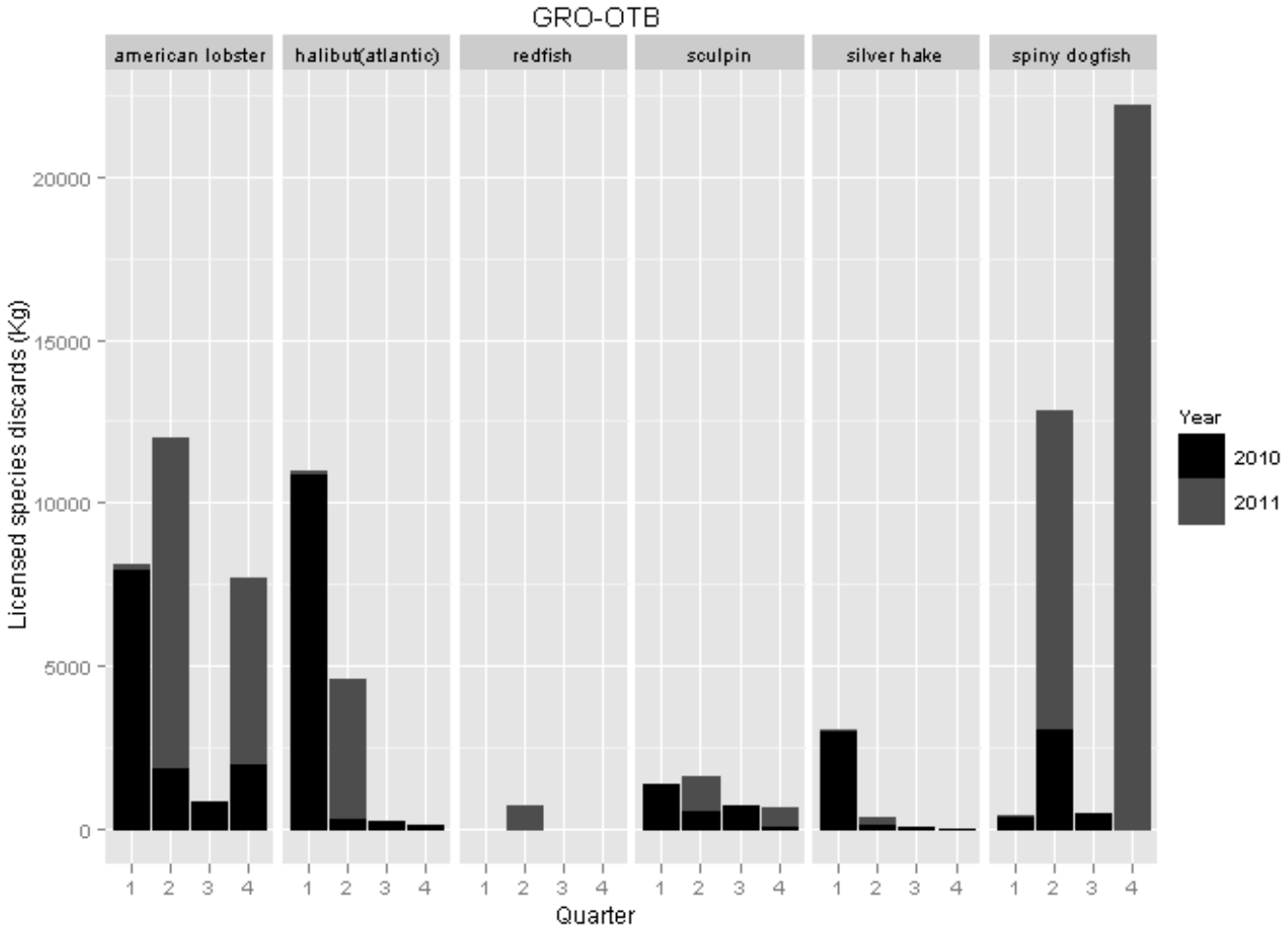

Figure 8. Estimated discards (in kg) of important licensed species by quarter in the groundfish bottom trawl fishery.

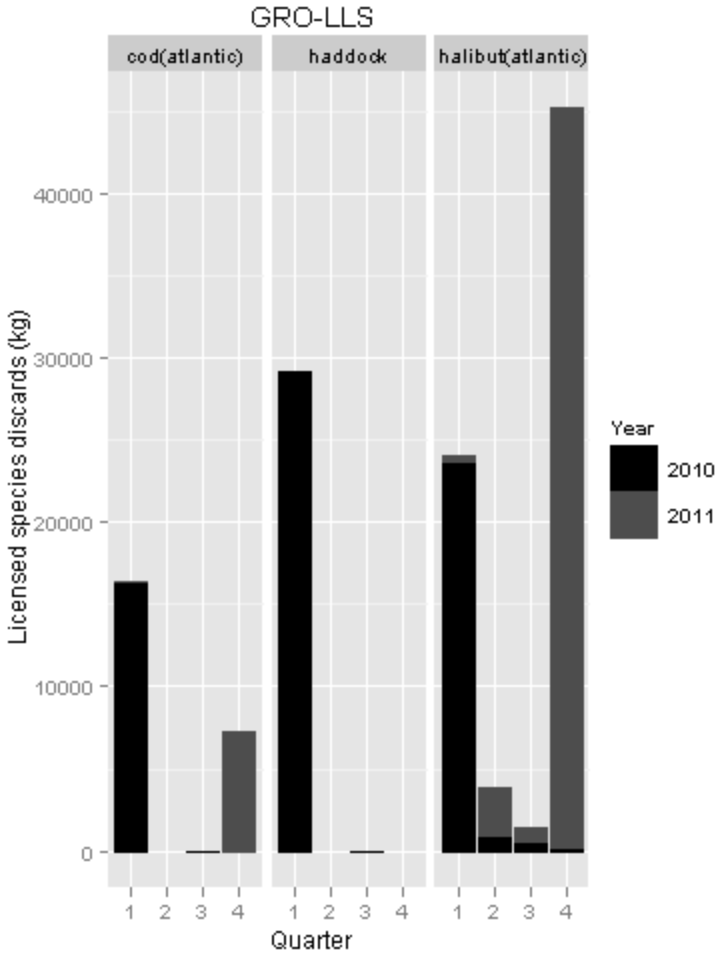

Figure 9. Estimated discards (in kg) of important licensed species by quarter in the groundfish longline fishery.

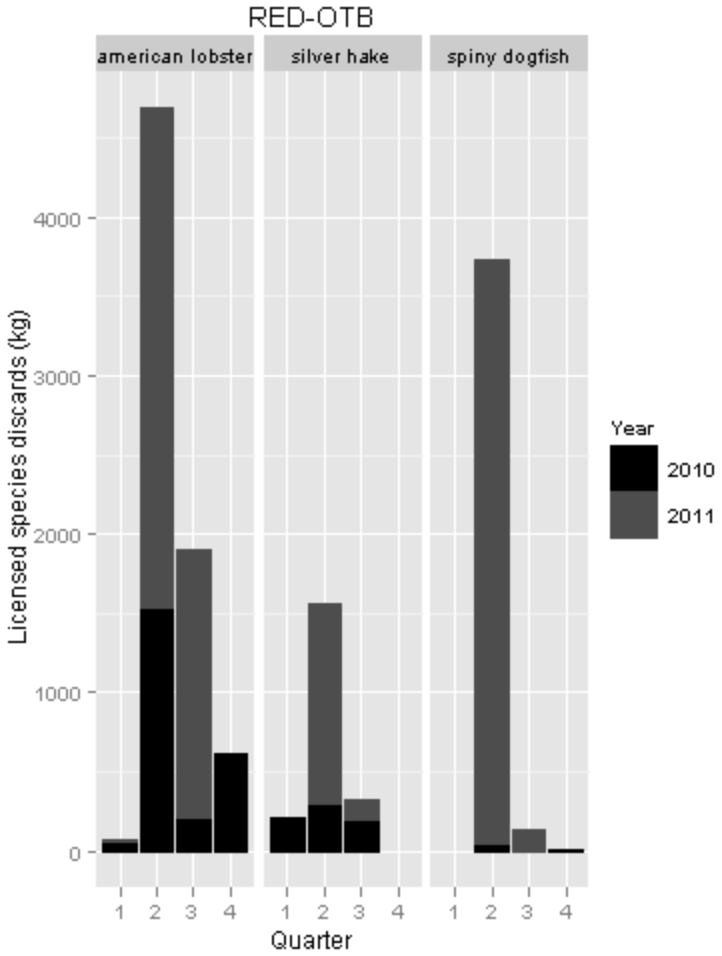

Figure 10. Estimated discards (in kg) of important licensed species by quarter in the onshore redfish bottom trawl fishery.

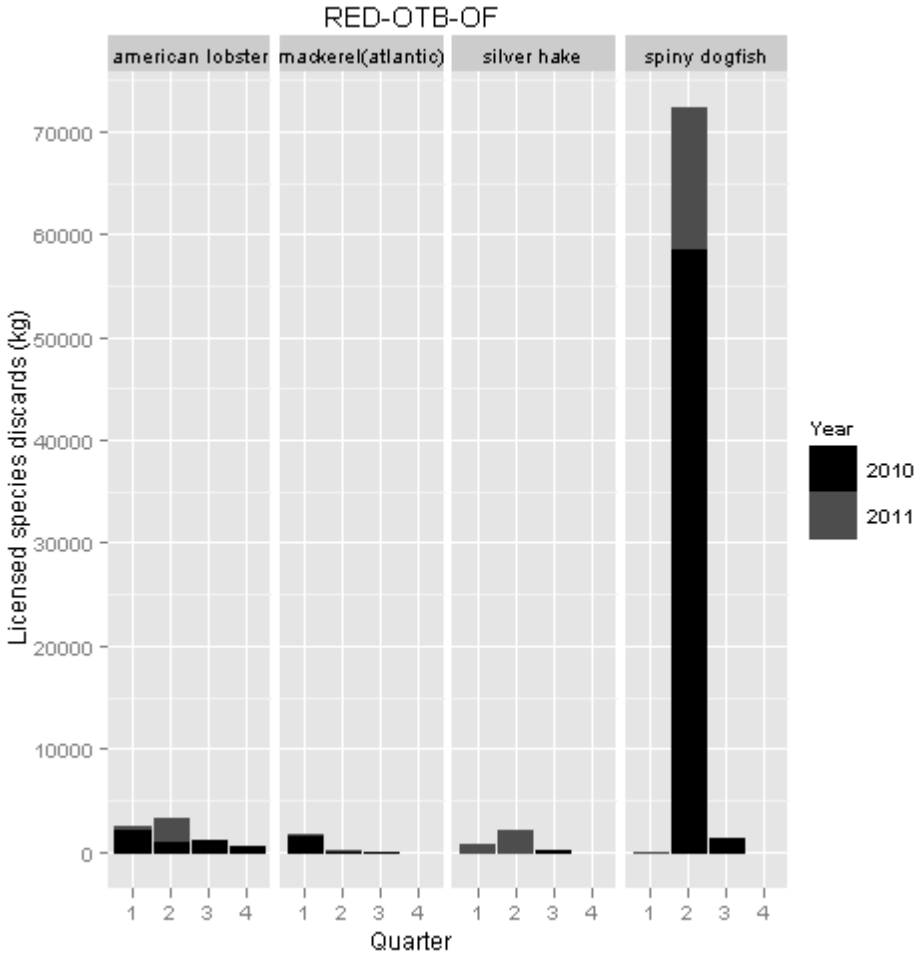

Figure 11. Estimated discards (in kg) of important licensed species by quarter in the offshore redfish bottom trawl fishery.

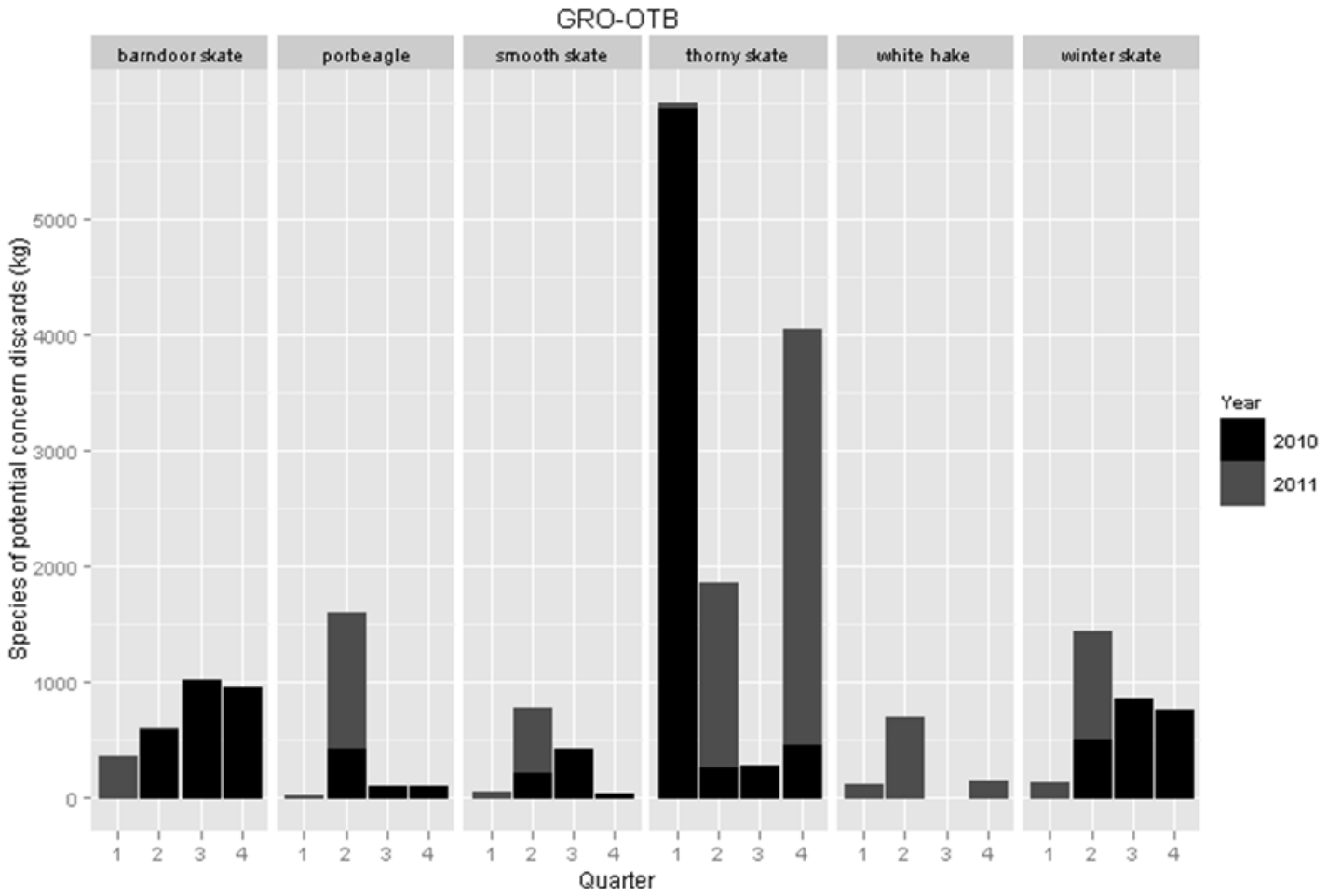

Figure 12. Estimated discards (in kg) of important species of potential concern by quarter in the groundfish bottom trawl fishery.

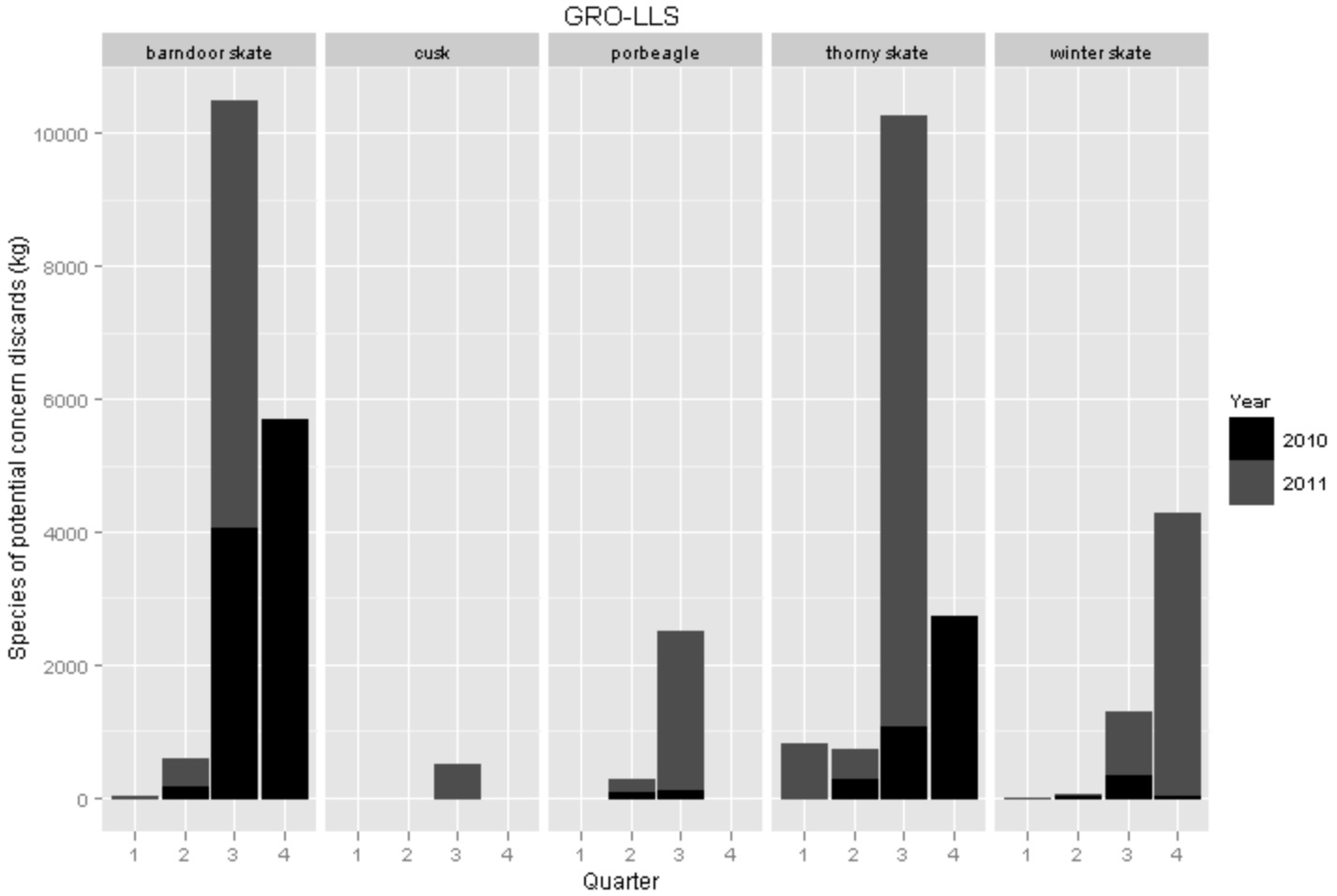

Figure 13. Estimated discards (in kg) of important species of potential concern by quarter in the groundfish longline fishery.

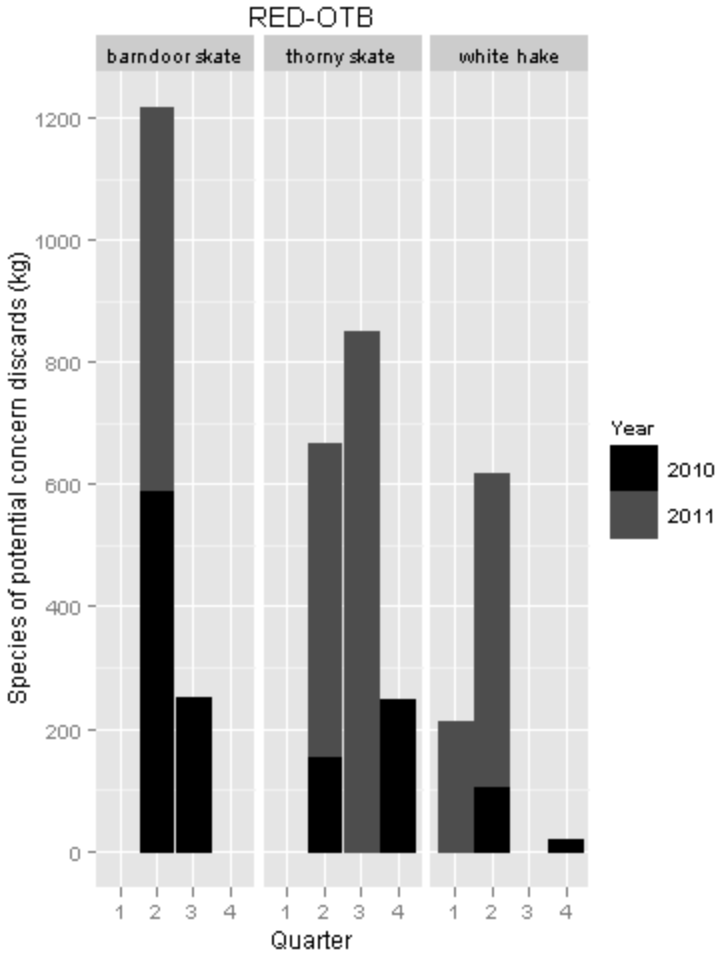

Figure 14. Estimated discards (in kg) of important species of potential concern by quarter in the onshore redfish bottom trawl fishery.

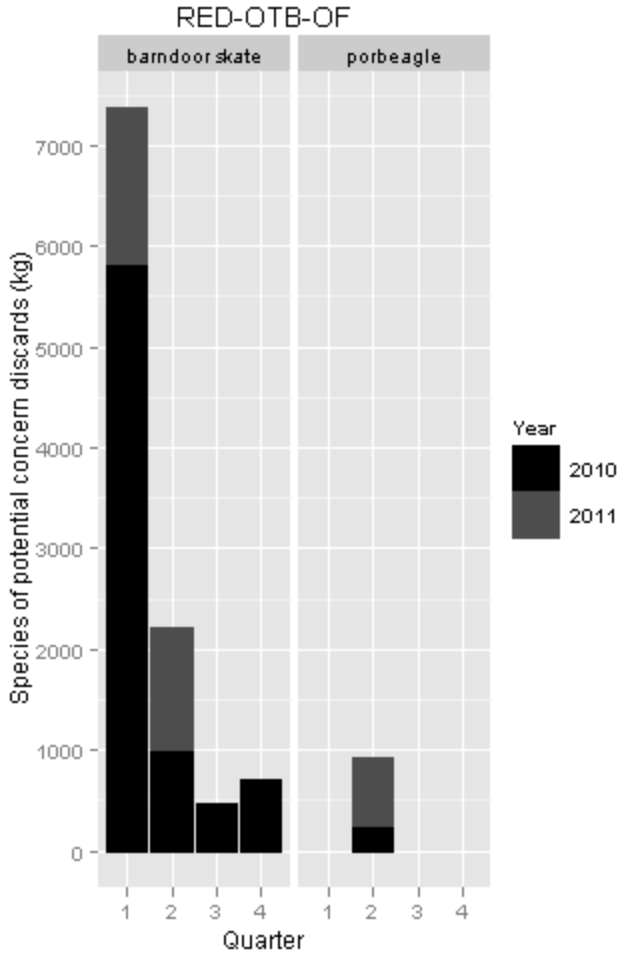

Figure 15. Estimated discards (in kg) of important species of potential concern by quarter in the offshore redfish bottom trawl fishery.

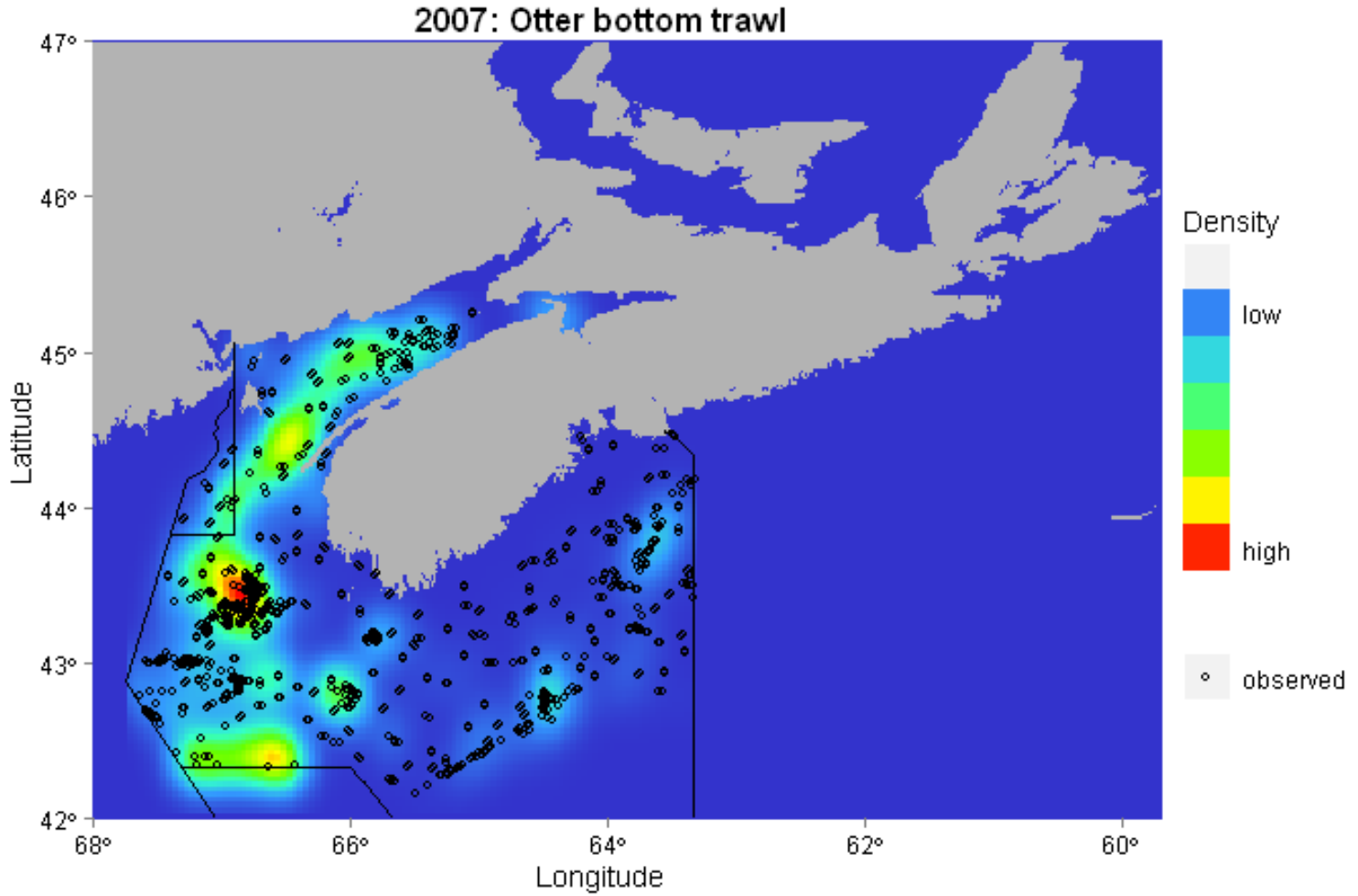

Figure 16. Distribution of fishing effort in 4X5Yb in the groundfish trawl fisheries in 2007. The colour scale represents the density of all trips (in MARFIS), while open points represent observed trips (extracted from ISDB).

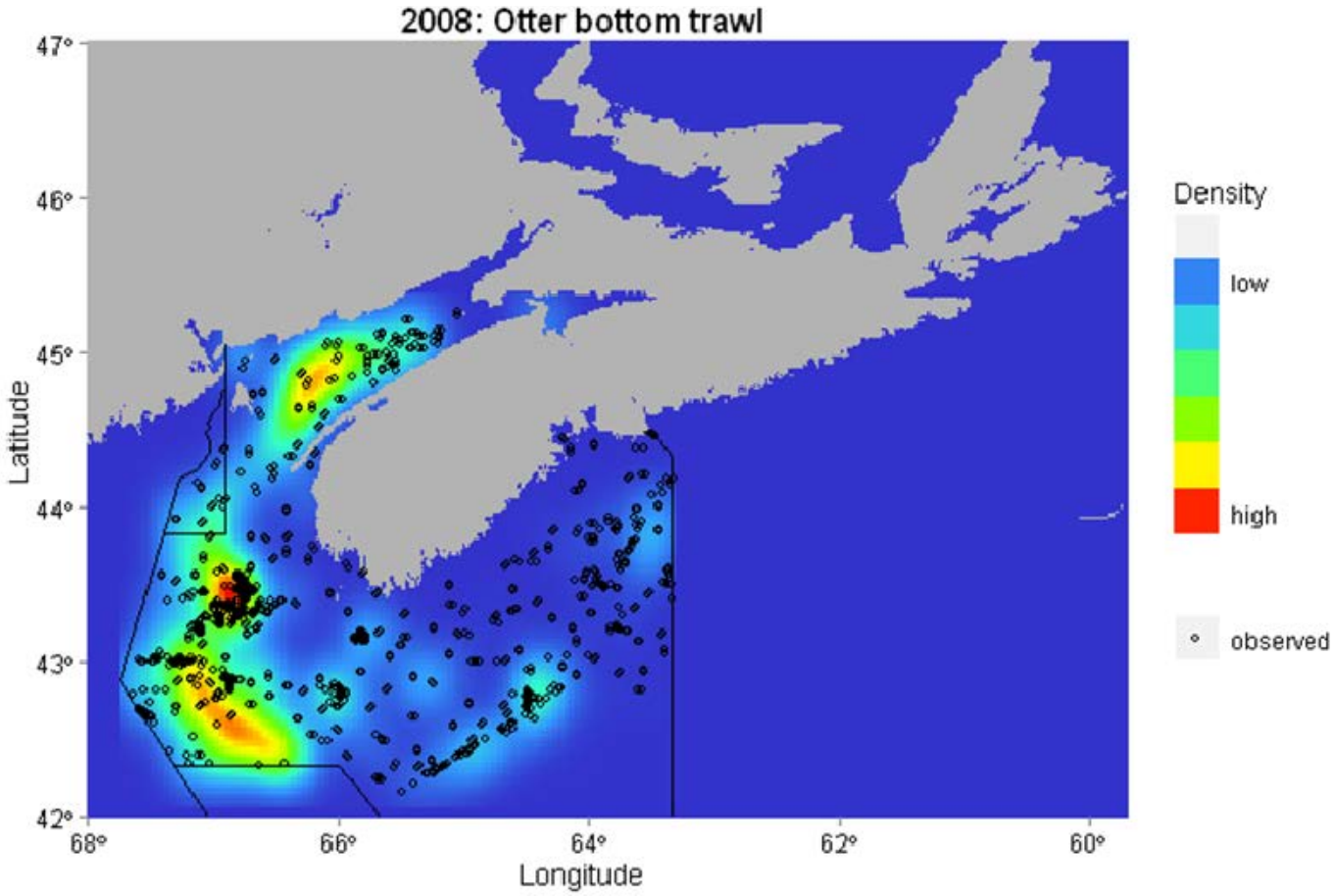

Figure 17. Distribution of fishing effort in 4X5Yb in the groundfish trawl fisheries in 2008. The colour scale represents the density of all trips (in MARFIS), while open points represent observed trips (extracted from ISDB).

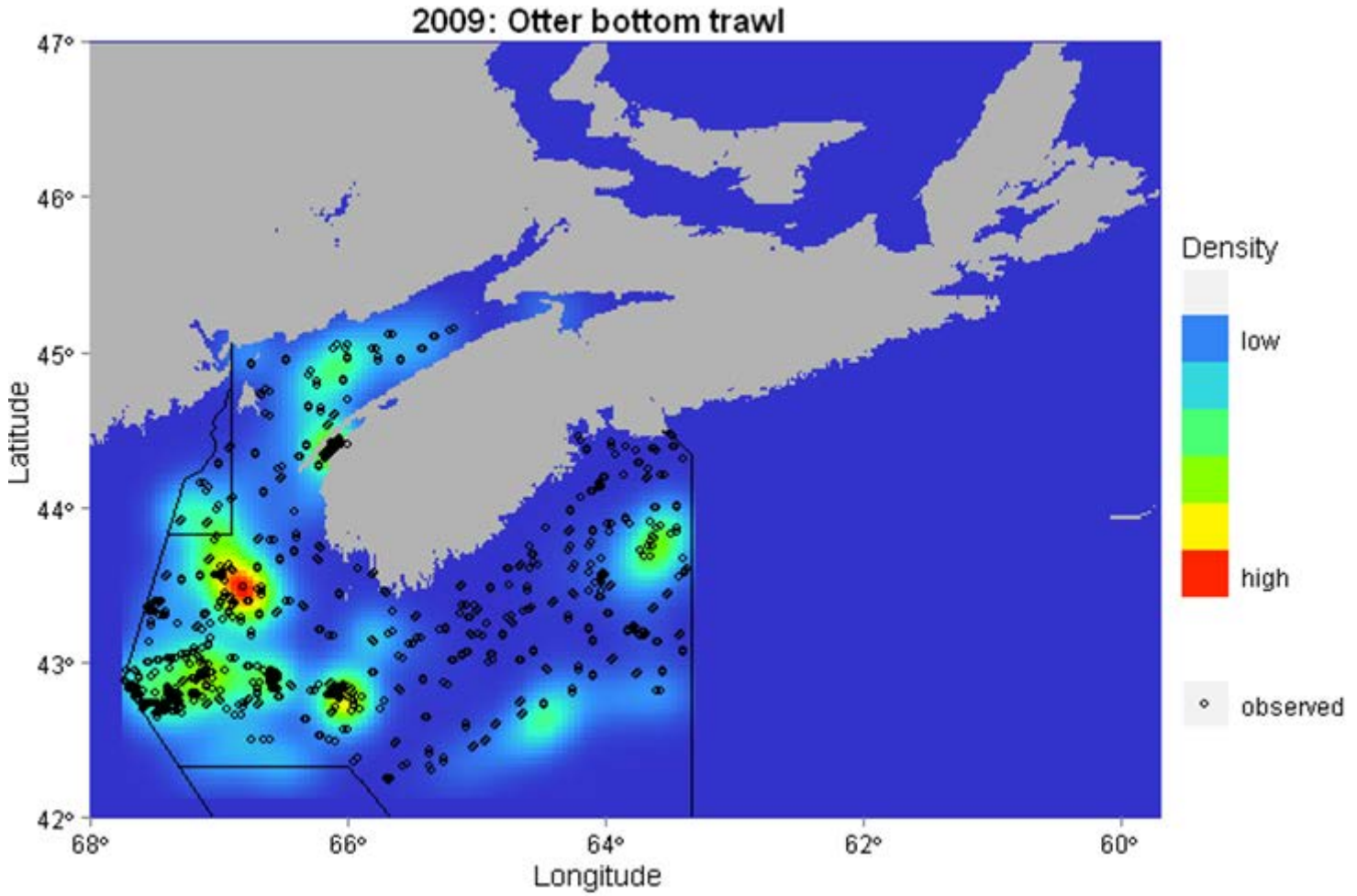

Figure 18. Distribution of fishing effort in 4X5Yb in the groundfish trawl fisheries in 2009. The colour scale represents the density of all trips (in MARFIS), while open points represent observed trips (extracted from ISDB).

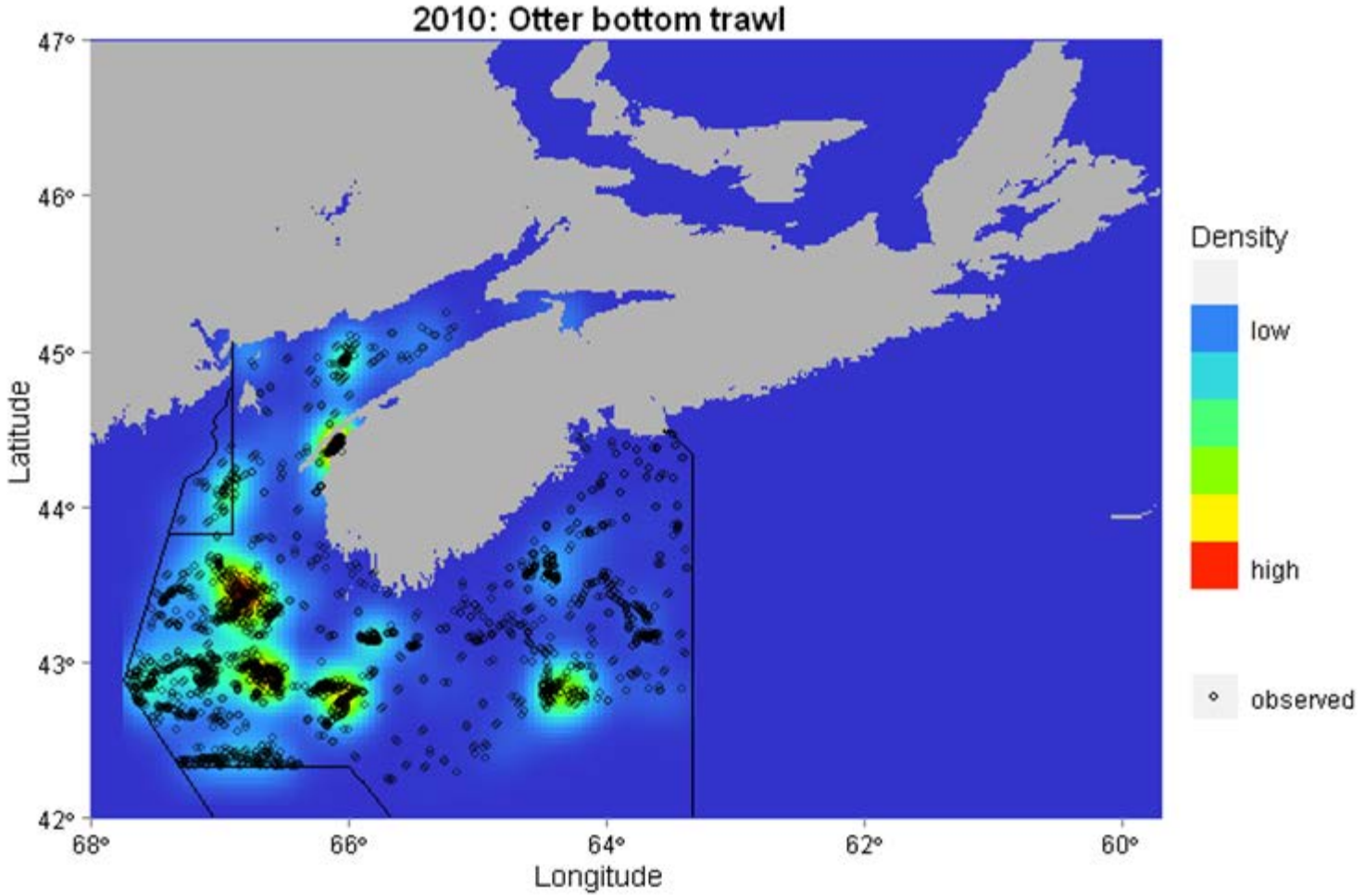

Figure 19. Distribution of fishing effort in 4X5Yb in the groundfish trawl fisheries in 2010. The colour scale represents the density of all trips (in MARFIS), while open points represent observed trips (extracted from ISDB).

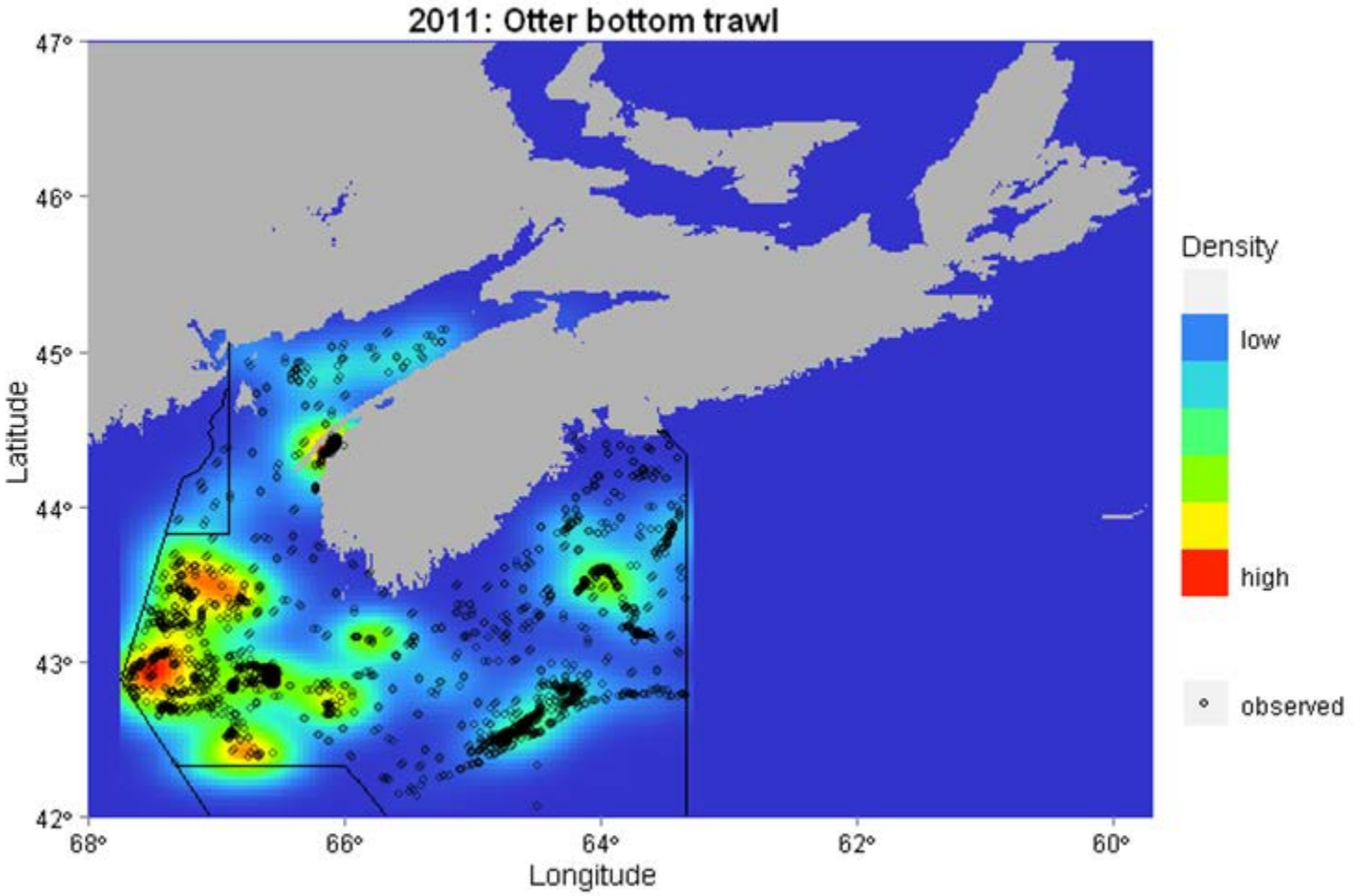

Figure 20. Distribution of fishing effort in 4X5Yb in the groundfish trawl fisheries in 2011. The colour scale represents the density of all trips (in MARFIS), while open points represent observed trips (extracted from ISDB).

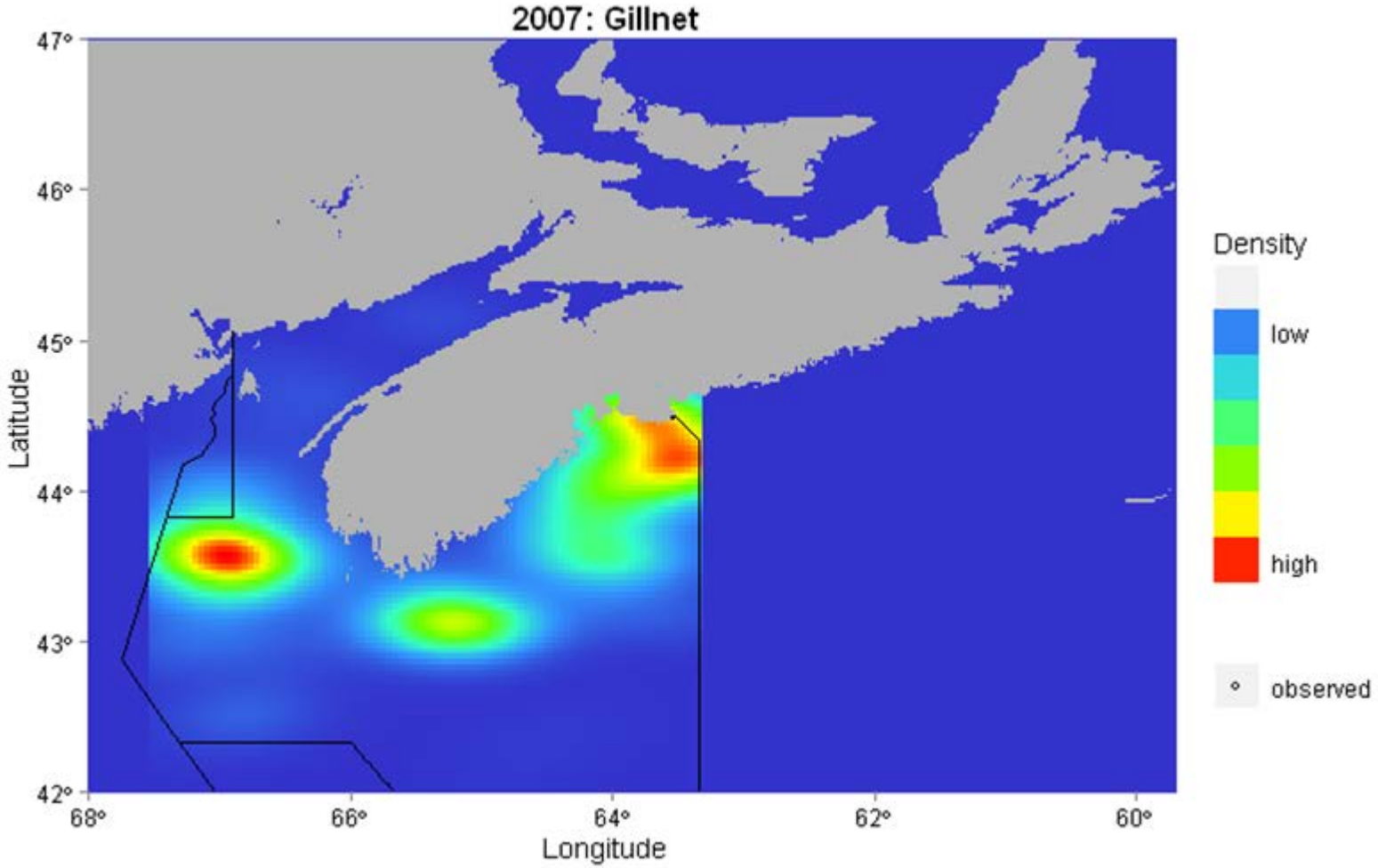

Figure 21. Distribution of fishing effort in 4X5Yb in the groundfish gillnet fisheries in 2007. The colour scale represents the density of all trips (in MARFIS). There were no observed trips.

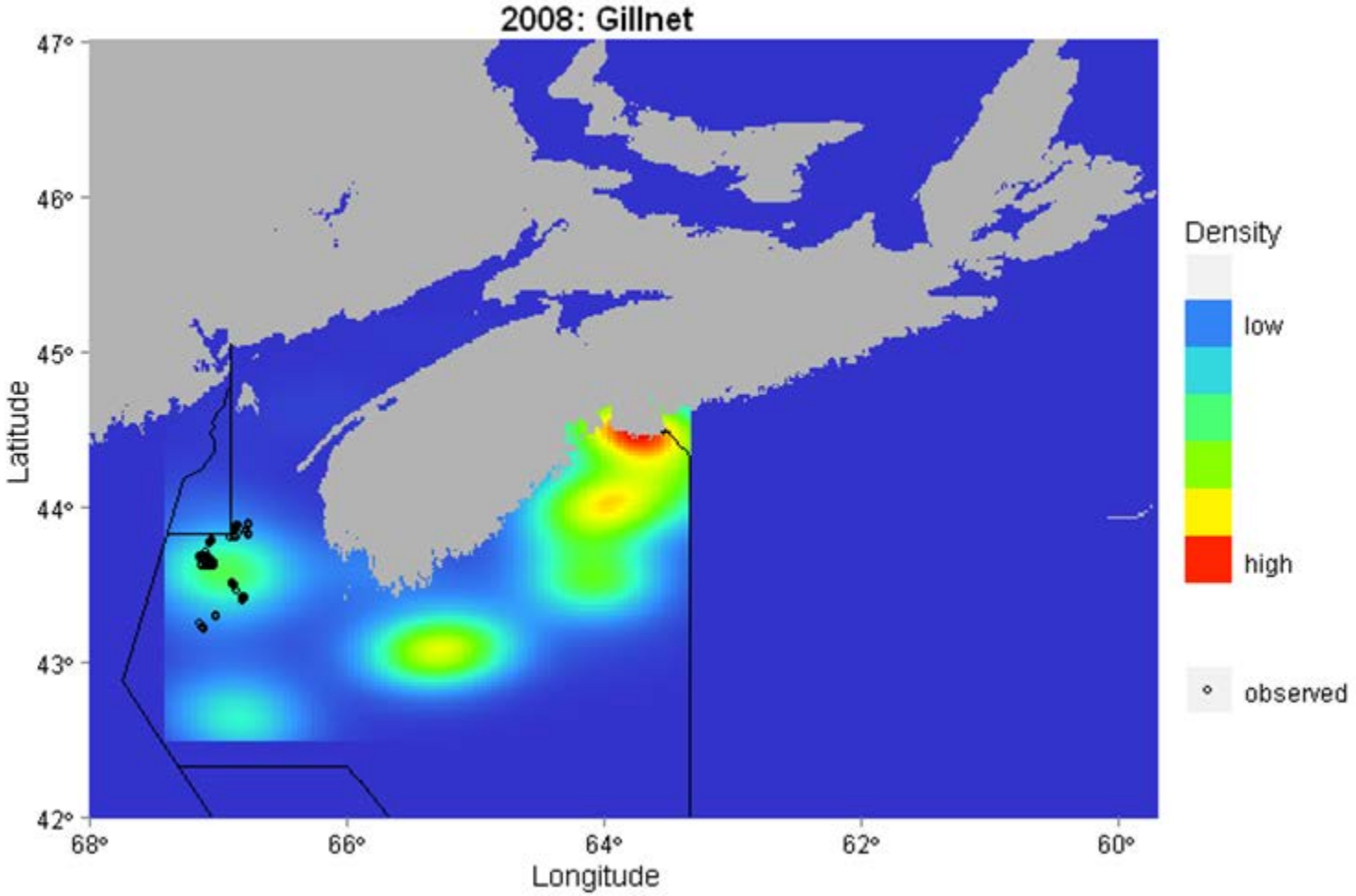

Figure 22. Distribution of fishing effort in 4X5Yb in the groundfish gillnet fisheries in 2008. The colour scale represents the density of all trips (in MARFIS), while open points represent observed trips (extracted from ISDB).

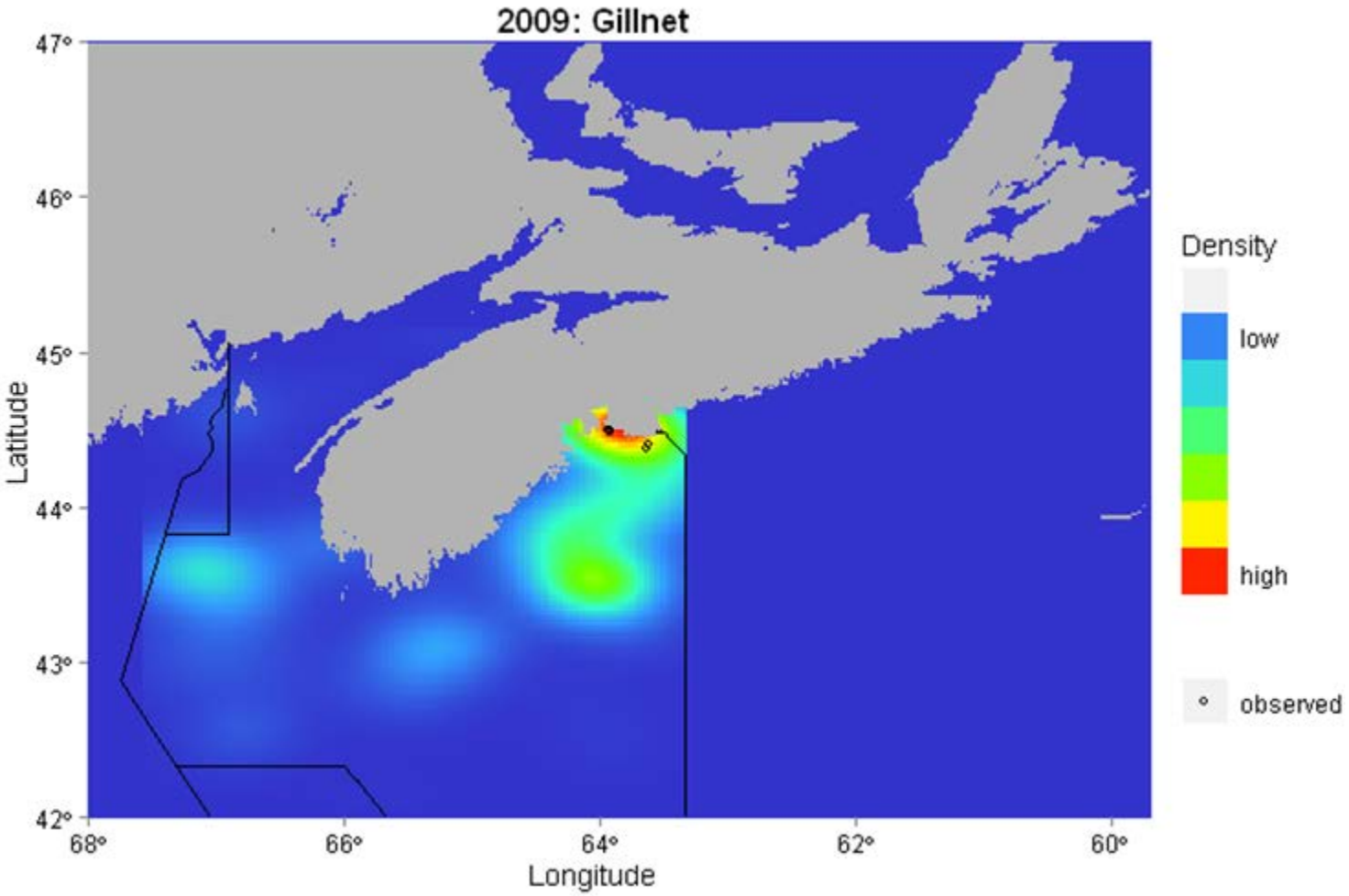

Figure 23. Distribution of fishing effort in 4X5Yb in the groundfish gillnet fisheries in 2009. The colour scale represents the density of all trips (in MARFIS), while open points represent observed trips (extracted from ISDB).

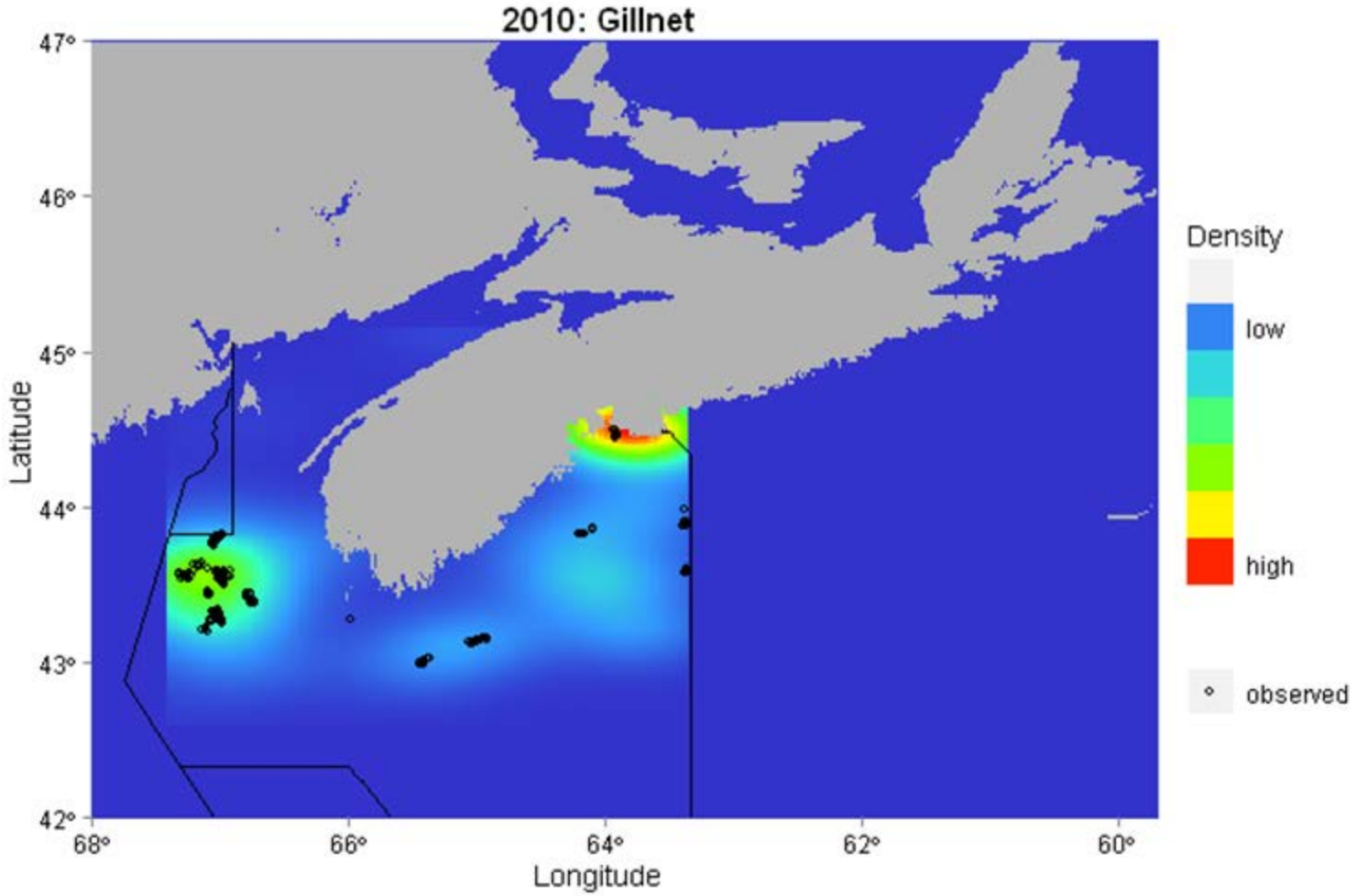

Figure 24. Distribution of fishing effort in 4X5Yb in the groundfish gillnet fisheries in 2010. The colour scale represents the density of all trips (in MARFIS), while open points represent observed trips (extracted from ISDB).

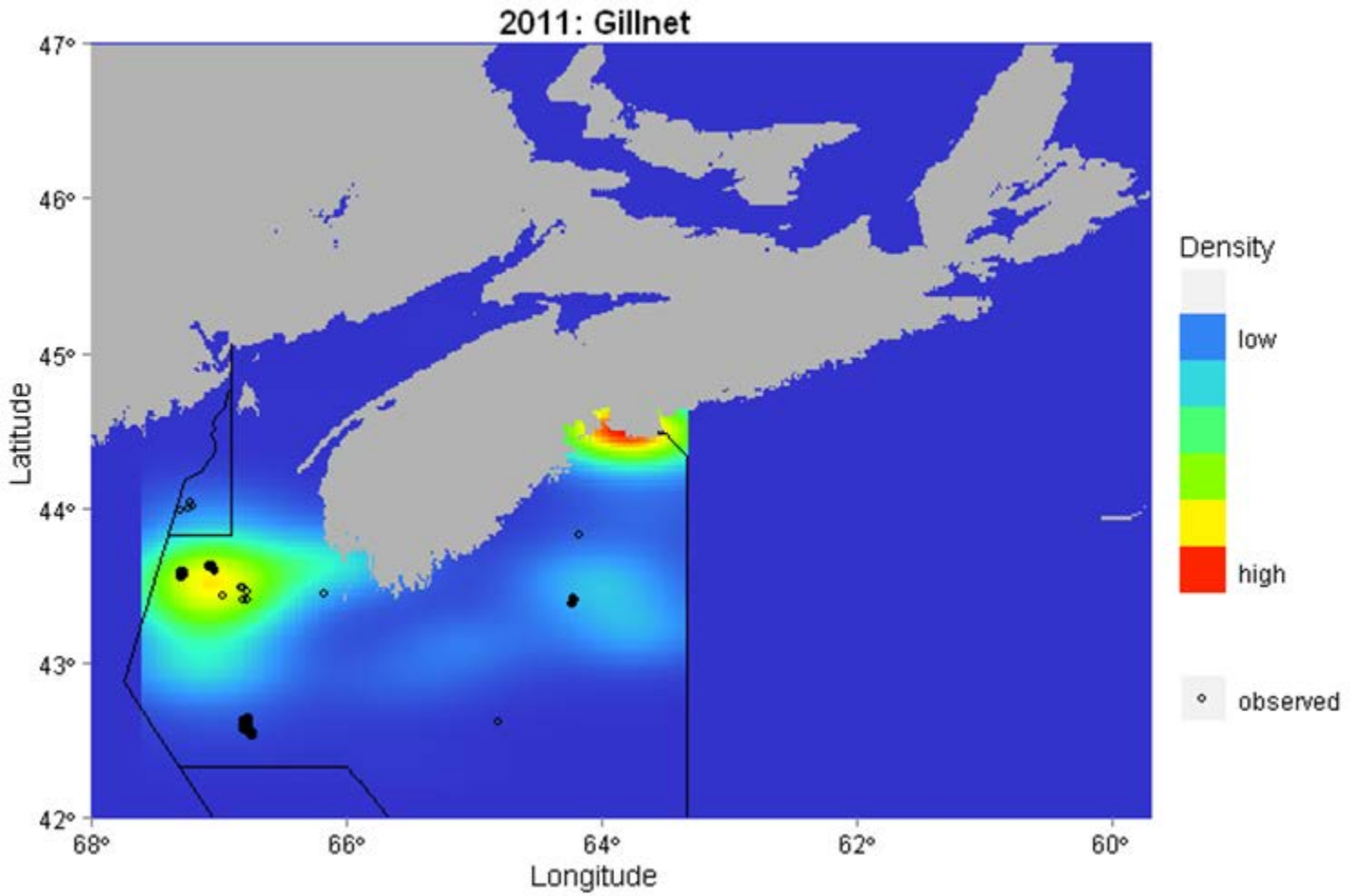

Figure 25. Distribution of fishing effort in 4X5Yb in the groundfish gillnet fisheries in 2011. The colour scale represents the density of all trips (in MARFIS), while open points represent observed trips (extracted from ISDB).

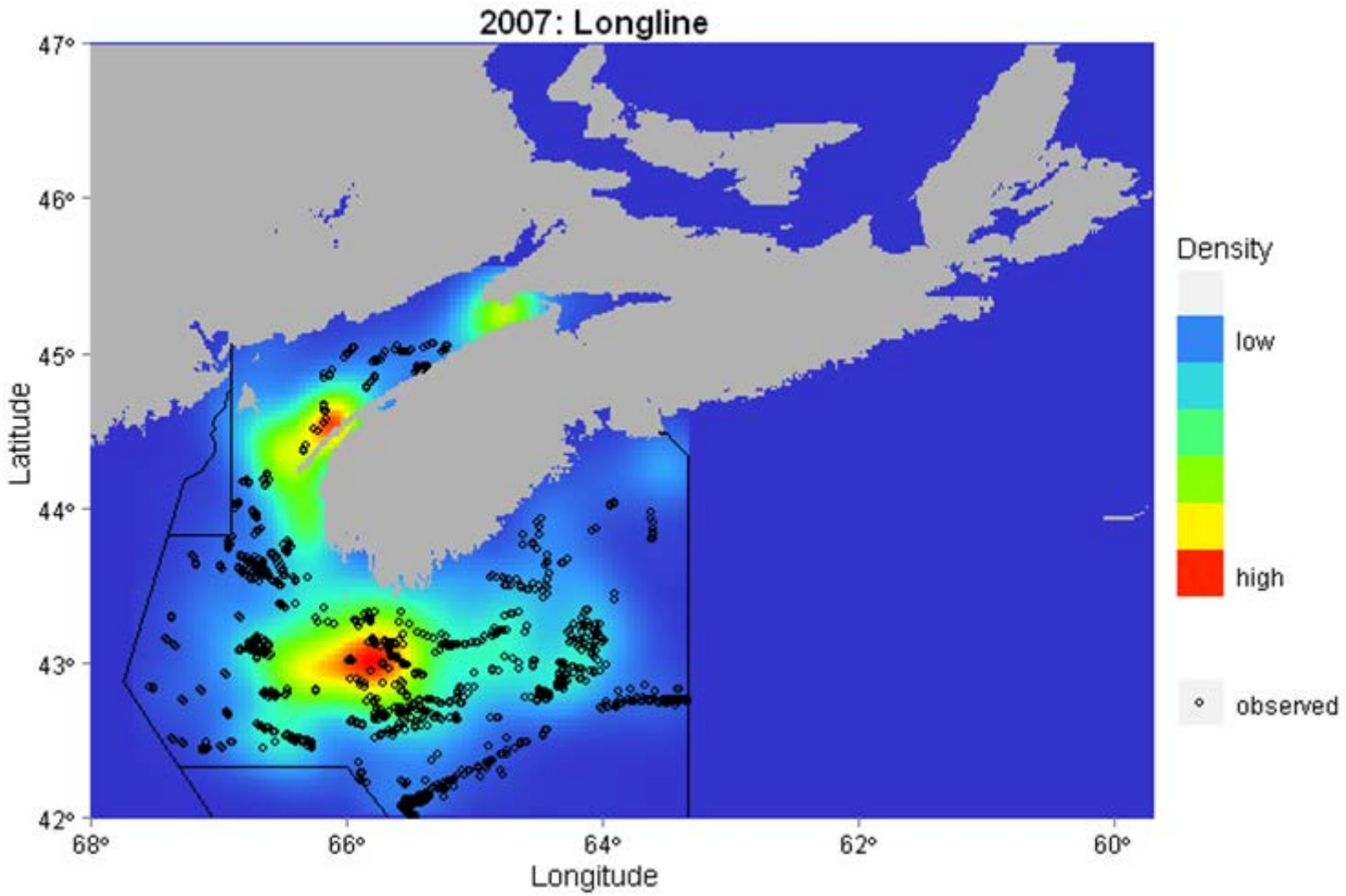

Figure 26. Distribution of fishing effort in 4X5Yb in the groundfish longline fisheries in 2007. The colour scale represents the density of all trips (in MARFIS), while open points represent observed trips (extracted from ISDB).

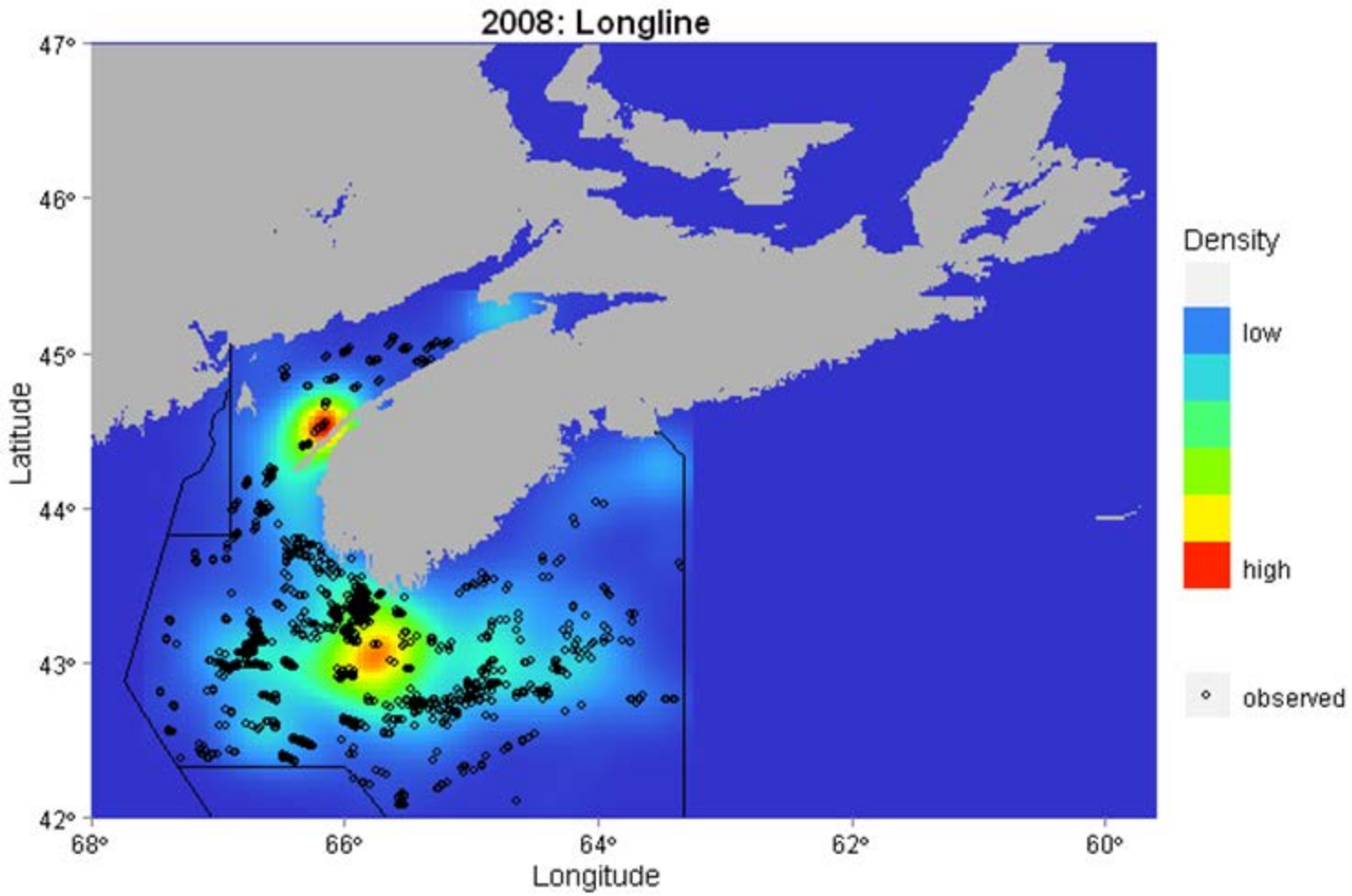

Figure 27. Distribution of fishing effort in 4X5Yb in the groundfish longline fisheries in 2008. The colour scale represents the density of all trips (in MARFIS), while open points represent observed trips (extracted from ISDB).

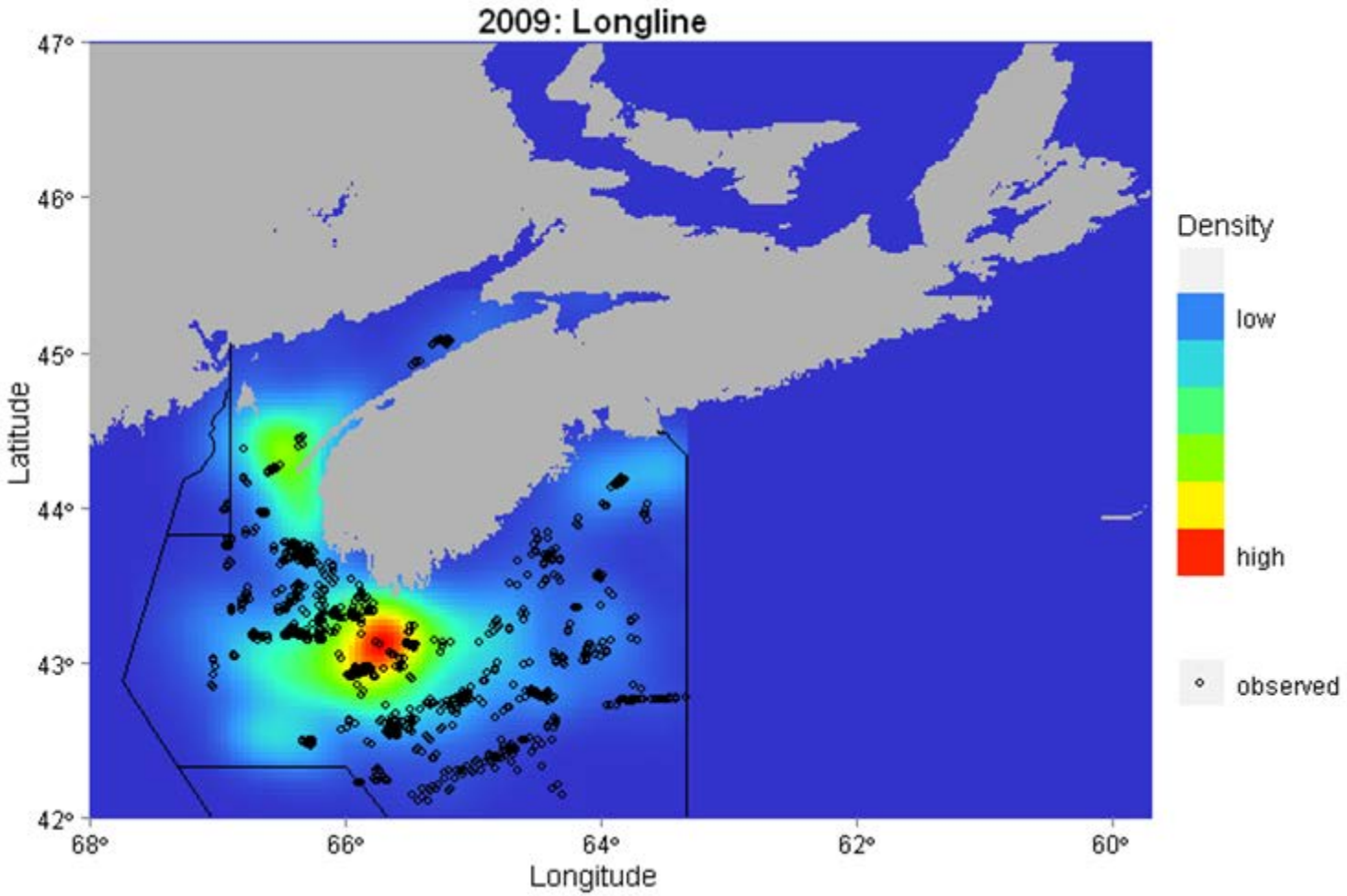

Figure 28. Distribution of fishing effort in 4X5Yb in the groundfish longline fisheries in 2009. The colour scale represents the density of all trips (in MARFIS), while open points represent observed trips (extracted from ISDB).

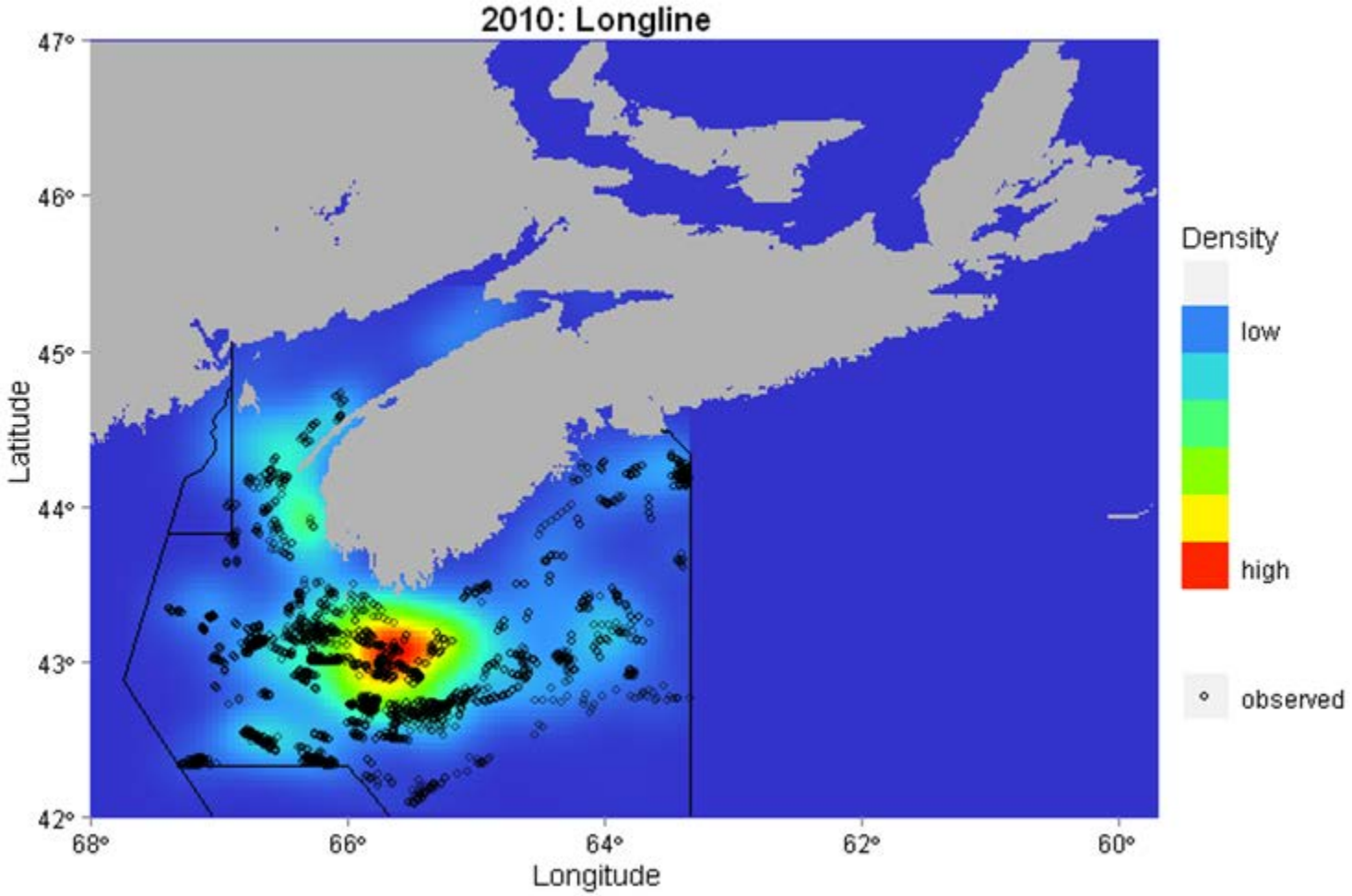

Figure 29. Distribution of fishing effort in 4X5Yb in the groundfish longline fisheries in 2010. The colour scale represents the density of all trips (in MARFIS), while open points represent observed trips (extracted from ISDB).

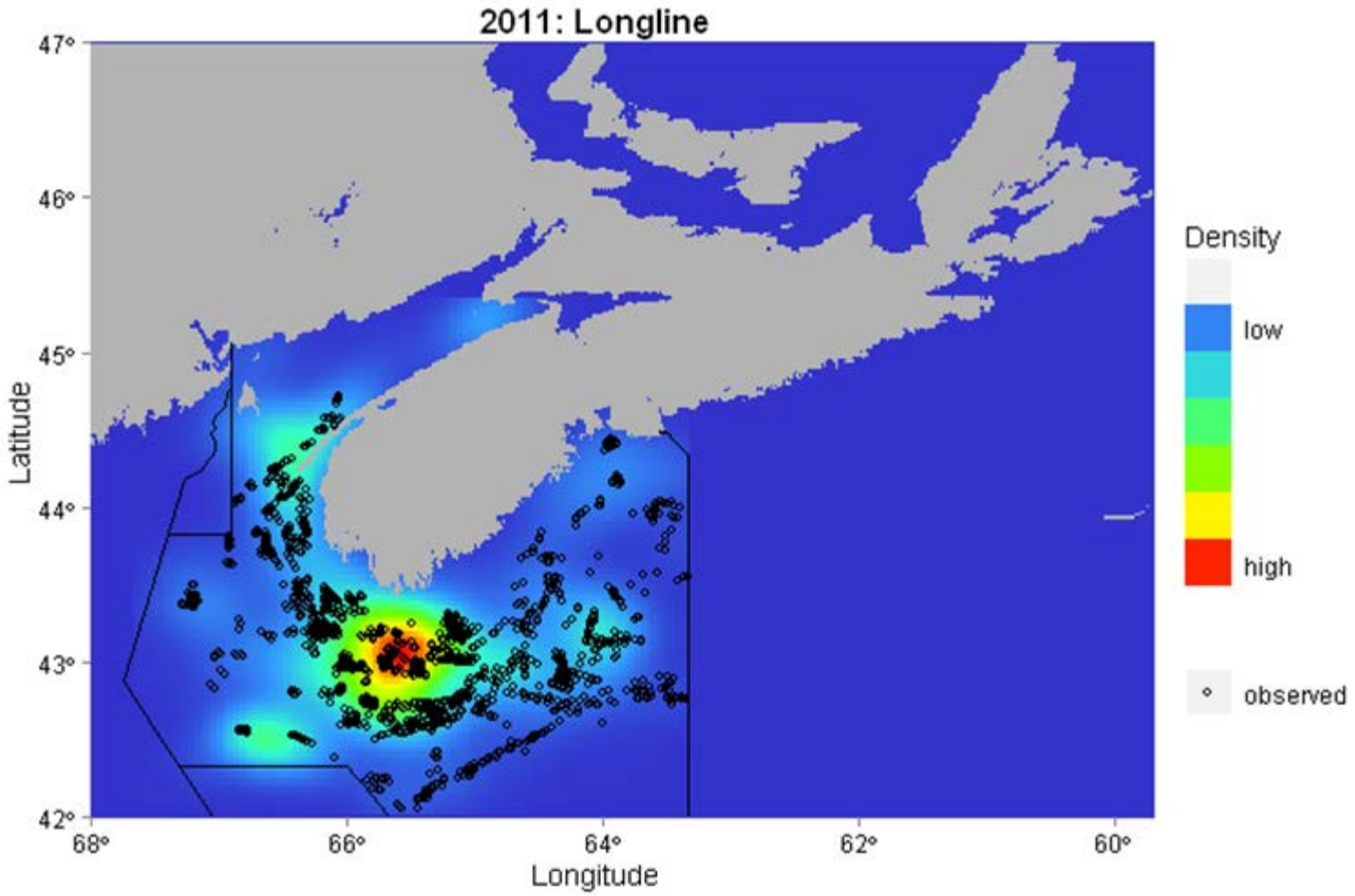

Figure 30. Distribution of fishing effort in 4X5Yb in the groundfish longline fisheries in 2011. The colour scale represents the density of all trips (in MARFIS), while open points represent observed trips (extracted from ISDB).

APPENDICES

APPENDIX 1

Table A1. Discards (kg) of licensed species in 4X5Yb by fishery and year to support the broad comparisons made in this analysis. Estimates should not be construed as definitive or accepted uncritically. A dash (-) indicates no data.

Species	Fishery	2007	2008	2009	2010	2011
Alewife	GRO-GNS	-	-	-	905	-
	GRO-OTB	6289	94	-	-	17
	GRO-OTB-OF	7965	-	-	-	-
	HKS-OTB	-	4892	-	-	129
	RED-OTB	3053	-	570	83	145
	RED-OTB-OF	5017	-	-	972	141
	SCU-OTB	-	-	53	113	-
American Lobster	GRO-GNS	-	17685	590471	2645	7481
	GRO-LLS	-	298	230	569	2054
	GRO-OTB	249811	99336	11738	79329	32568
	GRO-OTB-OF	10890	9439	3909	18794	7744
	HKS-OTB	56	-	-	-	-
	RED-OTB	23246	22382	6728	14730	67155
	RED-OTB-OF	1818	-	5425	13732	21969
	SCU-OTB	-	-	25016	27430	-
Atlantic Rock Crab	GRO-GNS	-	-	173668	278	-
	GRO-LLS	-	-	-	16	-
	GRO-OTB	1090	-	-	23	135
	RED-OTB	-	-	18	3140	6786
	RED-OTB-OF	-	-	-	19	-
	SCU-OTB	-	-	39097	5204	-
Blue Shark	GRO-GNS	-	1862	-	-	-
	GRO-LLS	2781	6784	11097	17269	8378
	GRO-OTB	-	-	-	306	-
	RED-OTB	-	-	-	224	-
Cod(Atlantic)	GRO-GNS	-	2957	69467	-	7165
	GRO-LLS	1669	820	57	781	378
	GRO-OTB	-	-	-	1631	-
	RED-OTB	-	-	-	-	405
	SCU-OTB	-	-	6	23	-
Haddock	GRO-LLS	3496	6038	-	1317	-
	GRO-OTB	419	-	-	842	1052
	GRO-OTB-OF	-	-	-	-	1217
	RED-OTB	29646	-	-	-	29
	RED-OTB-OF	-	-	-	-	32
Halibut (Atlantic)	GRO-GNS	-	-	-	-	843
	GRO-LLS	556	35633	61047	41352	110779
	GRO-OTB	79611	17353	2445	15238	13949
	GRO-OTB-OF	1379	103	6732	8423	4597
	HKS-OTB	-	176	-	-	162
	RED-OTB	35660	2882	374	1822	5427
	RED-OTB-OF	173	-	-	243	2217
	SCU-OTB	-	-	53	38	-

Species	Fishery	2007	2008	2009	2010	2011
Herring (Atlantic)	GRO-GNS	-	55	-	-	-
	GRO-OTB	922	375	-	15559	59
	GRO-OTB-OF	594	-	-	-	-
	HKS-OTB	1658	-	-	-	-
	RED-OTB	589	472	1584	588	935
	RED-OTB-OF	332	-	545	663	654
	SCU-OTB	-	-	147	83	-
Jonah Crab	GRO-GNS	-	821	173668	4455	11696
	GRO-LLS	-	-	-	16	27
	GRO-OTB	-	-	-	78	-
	HKS-OTB	-	309	-	-	-
	RED-OTB	-	-	-	-	19
	RED-OTB-OF	-	-	-	9	-
	SCU-OTB	-	-	-	8	-
Mackerel (Atlantic)	GRO-GNS	-	55	-	-	-
	GRO-OTB	3270	-	367	68	50
	GRO-OTB-OF	856	-	-	-	10
	RED-OTB	920	25	-	139	1031
	RED-OTB-OF	478	-	-	1281	45
	SCU-OTB	-	-	6	8	-
Other Flounders	GRO-LLS	-	224	-	-	-
	GRO-OTB	419	-	-	528	55
	GRO-OTB-OF	166	-	-	738	66
	HKS-OTB	-	-	-	-	65
	RED-OTB	29646	-	89	141	1928
	RED-OTB-OF	-	-	-	-	308
	SCU-OTB	-	-	82	505	-
Other Sharks	GRO-LLS	-	55909	-	8944	-
Pollock	GRO-GNS	-	9034	-	487	5584
	GRO-LLS	-	-	-	537	-
	GRO-OTB	-	938	-	1621	-
	GRO-OTB-OF	-	-	-	-	116
	RED-OTB	-	-	-	-	868
	RED-OTB-OF	-	-	-	-	19
Redfish	GRO-GNS	-	-	-	5848	-
	GRO-LLS	-	298	-	16	27
	GRO-OTB	-	-	-	-	1447
	GRO-OTB-OF	119	-	-	-	66
	RED-OTB	-	-	-	-	3615
	RED-OTB-OF	-	-	-	-	5108
Scallop	GRO-LLS	-	-	230	16	108
	GRO-OTB	19622	-	-	2946	17
	RED-OTB	-	-	-	-	289
	SCU-OTB	-	-	217	211	-
Sculpin	GRO-GNS	-	55	138934	-	-
	GRO-LLS	79	1044	172	1740	7432
	GRO-OTB	4003	2533	5869	27284	2364
	GRO-OTB-OF	2116	17	-	944	152
	RED-OTB	662	199	819	928	1465
	RED-OTB-OF	-	-	-	897	96
Sea Urchins	GRO-GNS	-	-	104201	-	-

Species	Fishery	2007	2008	2009	2010	2011
Shad (American)	GRO-GNS	-	4654	-	487	-
	GRO-OTB	6457	7973	2201	764	34
	GRO-OTB-OF	7062	497	79043	177	248
	RED-OTB	4303	3950	3453	323	395
	RED-OTB-OF	2840	-	780	3522	679
Silver Hake	GRO-GNS	-	55	-	-	-
	GRO-OTB	-	10787	611	4804	799
	GRO-OTB-OF	-	-	-	44	25
	RED-OTB	74	1168	1192	4101	26642
	RED-OTB-OF	-	-	-	402	37517
Spiny Dogfish	GRO-GNS	-	9198	-	12252	26025
	GRO-LLS	35357	17891	1092	9529	32512
	GRO-OTB	114573	1075340	122516	69676	33971
	GRO-OTB-OF	80296	33232	888365	81254	5213
	RED-OTB	624143	214255	204196	389	77816
	RED-OTB-OF	97757	-	263122	442100	110225
Swordfish	GRO-GNS	-	-	1620	-	-
	GRO-LLS	-	-	-	1401	-
Whelks	RED-OTB-OF	-	-	34734	-	-

APPENDIX 2

Table A2. Discards (kg) of species of potential concern in 4X5Yb by fishery and year to support the broad comparisons made in this analysis. Estimates should not be construed as definitive or accepted uncritically. A dash (-) indicates no data.

Species	Fishery	2007	2008	2009	2010	2011
American Eel	GRO-OTB-OF	119	-	-	-	-
Barndoor Skate	GRO-GNS	-	-	-	2576	-
	GRO-LLS	5562	146779	312113	183212	36620
	GRO-OTB	3354	29923	-	43804	22951
	GRO-OTB-OF	166	3203	-	9043	6531
	HKS-OTB	-	-	-	-	243
	RED-OTB	1361	5440	9166	6031	13128
	RED-OTB-OF	1301	-	1271	12176	57269
	SCU-OTB	-	-	6	-	-
Basking Shark	GRO-GNS	-	174223	-	-	-
	GRO-OTB	-	340406	-	2572	-
	RED-OTB-OF	-	-	-	-	2564
Cusk	GRO-LLS	26299	113532	287	49	1811
	GRO-OTB	252	-	-	2141	25
	GRO-OTB-OF	-	34	-	-	20
	RED-OTB	-	-	53	591	3952
	RED-OTB-OF	-	-	-	112	-
Northern Wolffish	GRO-LLS	2543	2162	-	-	811
	GRO-OTB	-	-	-	-	34
Off-shore Hake	RED-OTB-OF	-	-	-	47	-
Porbeagle	GRO-GNS	-	-	-	8354	-
	GRO-LLS	-	-	9142	7057	13351
	GRO-OTB	-	-	-	11057	3182
	GRO-OTB-OF	-	-	-	-	2404
	RED-OTB	-	-	605	2355	3374
	RED-OTB-OF	-	-		1909	5492
Rock Grenadier(Roundnose)	GRO-GNS	-	-	-	70	-
	GRO-OTB	-	-	-	11	-
	RED-OTB	-	-	-	17	-
	RED-OTB-OF	-	-	-	9	-
Shortfin Mako	GRO-GNS	-	-	-	-	14224
	GRO-LLS	-	-	-	179	-
	GRO-OTB	-	-	-	3285	-
Smooth Skate	GRO-LLS	-	2385	-	114	405
	GRO-OTB	3354	469	-	13493	4047
	GRO-OTB-OF	-	411	-	354	-
	RED-OTB	-	-	3310	3073	174
	RED-OTB-OF	398	-	363	37	83
	SCU-OTB	-	-	1572	-	-
Spinytail Skate	GRO-OTB	-	1126	-	-	-
	GRO-OTB-OF	-	-	-	-	101
Spotted Wolffish	GRO-LLS	-	-	-	-	81
	SCU-OTB	-	-	111	-	-
Striped Atlantic Wolffish	GRO-LLS	556	1118	862	1772	1622
	GRO-OTB	-	-	-	159	42
	GRO-OTB-OF	190	-	-	-	-
	RED-OTB	-	-	-	-	29
	SCU-OTB	-	-	35	-	-

Species	Fishery	2007	2008	2009	2010	2011
Thorny Skate	GRO-GNS	-	383	-	70	105
	GRO-LLS	3099	12598	5692	62523	65646
	GRO-OTB	145	14164	6114	18016	6661
	GRO-OTB-OF	-	719	-	1018	1379
	RED-OTB	1821	1987	908	1845	11037
	RED-OTB-OF	-	-	86	3140	3166
	SCU-OTB	-	-	29	1418	-
Turbot (Greenland Halibut)	GRO-OTB	-	-	-	57	-
	GRO-OTB-OF	-	-	-	-	10
	RED-OTB	-	-	-	17	67
White Hake	GRO-GNS	-	12155	-	4873	1897
	GRO-LLS	2463	1491	2693	244	-
	GRO-OTB	-	-	-	-	8169
	GRO-OTB-OF	-	154	-	-	-
	RED-OTB	-	-	-	852	15153
	SCU-OTB	-	-	6	-	-
Winter Skate	GRO-GNS	-	383	-	-	-
	GRO-LLS	14302	13418	4830	13610	3784
	GRO-OTB	229259	2064	611	36516	10357
	GRP-OTB-OF	29579	3101	-	2124	793
	RED-OTB	2483	50	-	340	771
	RED-OTB-OF	27	-	-	140	2288
	SCU-OTB	-	-	-	8	-

APPENDIX 3

Table A3. Discards (kg) in different fisheries in 4X5Yb by licensed species and year to support the broad comparisons made in this analysis. Estimates should not be construed as definitive or accepted uncritically. A dash (-) indicates no data.

Fishery	Species	2007	2008	2009	2010	2011
GRO-GNS	Alewife	-	-	-	905	-
	American Lobster	-	17685	590471	2645	7481
	Atlantic Rock Crab	-		173668	278	-
	Blue Shark	-	1862	-	-	-
	Cod(Atlantic)	-	2957	69467	-	7165
	Halibut(Atlantic)	-	-	-	-	843
	Herring(Atlantic)	-	55	-	-	-
	Jonah Crab	-	821	173668	4455	11696
	Mackerel(Atlantic)	-	55	-	-	-
	Pollock	-	9034	-	487	5584
	Redfish	-	-	-	5848	-
	Sculpin	-	55	138934	-	-
	Sea Urchins	-	-	104201	-	-
	Shad(American)	-	4654	-	487	-
	Silver Hake	-	55	-	-	-
	Spiny Dogfish	-	9198	-	12252	26025
	Whelks	-	-	34734	-	-
GRO-LLS	American Lobster	-	298	230	569	2054
	Atlantic Rock Crab	-	-	-	16	-
	Blue Shark	2781	6784	11097	17269	8378
	Cod(Atlantic)	1669	820	57	781	378
	Haddock	3496	6038		1317	
	Halibut(Atlantic)	556	35633	61047	41352	110779
	Jonah Crab	-	-	-	16	27
	Other Flounders	-	224	-	-	-
	Other Sharks	-	55909	-	8944	-
	Pollock	-	-	-	537	-
	Redfish	-	298	-	16	27
	Scallop	-	-	230	16	108
	Sculpin	79	1044	172	1740	7432
	Spiny Dogfish	35357	17891	1092	9529	32512
GRO-OTB	Alewife	6289	94	-	-	17
	American Lobster	249811	99336	11738	79329	32568
	Atlantic Rock Crab	1090	-	-	23	135
	Blue Shark	-	-	-	306	-
	Cod(Atlantic)	-	-	-	1631	-
	Haddock	419			842	1052
	Halibut(Atlantic)	79611	17353	2445	15238	13949
	Herring(Atlantic)	922	375	-	159	59
	Jonah Crab	-	-	-	78	-
	Mackerel(Atlantic)	3270	-	367	68	50
	Other flounders	419	-	-	528	55
	Pollock	-	938	-	1621	-
	Redfish	-	-	-	-	1447
	Scallop	19622	-	-	2946	17
	Sculpin	4003	2533	5869	27284	2364
	Shad(American)	6457	7973	2201	764	34
	Silver Hake	-	10787	611	4804	799
	Spiny Dogfish	114573	1075340	122516	69676	33971

Fishery	Species	2007	2008	2009	2010	2011
GRO-OTB-OF	Alewife	7965	-	-	-	-
	American Lobster	10890	9439	3909	18794	7744
	Haddock	-	-	-	-	1217
	Halibut(Atlantic)	1379	103	6732	8423	4597
	Herring(Atlantic)	594	-	-	-	-
	Mackerel(Atlantic)	856	-	-	-	10
	Other Flounders	166	-	-	738	66
	Pollock	-	-	-	-	116
	Redfish	119	-	-	-	66
	Sculpin	2116	17	-	944	152
	Shad(American)	7062	497	79043	177	248
	Silver Hake	-	-	-	44	25
	Spiny Dogfish	80296	33232	888365	81254	5213
HKS-OTB	Alewife	-	4892	-	-	129
	American Lobster	56	-	-	-	-
	Halibut(American)	-	176	-	-	162
	Herring(Atlantic)	1658	-	-	-	-
	Jonah Crab	-	309	-	-	-
	Other Flounders	-	-	-	-	65
	Silver Hake	1118	-	-	-	-
RED-OTB	Alewife	3053	-	570	83	145
	American Lobster	23246	22382	6728	14730	67155
	Atlantic Rock Crab	-	-	18	3140	6786
	Blue Shark	-	-	-	224	-
	Cod(Atlantic)	-	-	-	-	405
	Haddock	29646		-	-	29
	Halibut(Atlantic)	35660	2882	374	1822	5427
	Herring(Atlantic)	589	472	1584	588	935
	Jonah Crab	-	-	-	-	19
	Mackerel(Atlantic)	920	25	-	139	1031
	Other Flounders	29646	-	89	141	1928
	Pollock	-	-	-	-	868
	Redfish	-	-	-	-	3615
	Scallop	-	-	-	-	289
	Sculpin	662	199	819	928	1465
	Shad(American)	4303	3950	3453	323	395
	Silver Hake	74	1168	1192	4101	26642
	Spiny Dogfish	624143	214255	204196	389	77816
	Swordfish	-	-	1620	-	-
RED-OTB-OF	Alewife	5017	-	-	972	141
	American Lobster	1818	-	5425	13732	21969
	Atlantic Rock Crab	-	-	-	19	-
	Haddock	-	-	-	-	32
	Halibut(American)	173	-	-	243	2217
	Herring(Atlantic)	332	-	545	663	654
	Jonah Crab	-	-	-	9	-
	Mackerel(Atlantic)	478	-	-	1281	45
	Other Flounders	-	-	-	-	308
	Pollock	-	-	-	-	19
	Redfish	-	-	-	-	5108
	Sculpin	-	-	-	897	96
	Shad(American)	2840	-	780	3522	679
	Silver Hake	-	-	-	402	37517
	Spiny Dogfish	97757	-	263122	442100	110225
	Swordfish	-	-	-	1401	-

Fishery	Species	2007	2008	2009	2010	2011
SCU-OTB	Alewife	-	-	53	113	-
	American Lobster	-	-	25016	27430	-
	Atlantic Rock Crab	-	-	39097	5204	-
	Cod(Atlantic)	-	-	6	23	-
	Halibut(Atlantic)	-	-	53	38	-
	Herring(Atlantic)	-	-	147	83	-
	Jonah crab	-	-	-	8	-
	Mackerel(Atlantic)	-	-	6	8	-
	Other Flounders	-	-	82	505	-
	Scallop	-	-	217	211	-

APPENDIX 4

Table A4. Discards (kg) in different fisheries in 4X5Yb by species of potential concern and year to support the broad comparisons made in this analysis. Estimates should not be construed as definitive or accepted uncritically. A dash (-) indicates no data.

Fishery	Species	2007	2008	2009	2010	2011
GRO-GNS	Barndoor Skate	-	-	-	2576	-
	Basking Shark	-	174223	-	-	-
	Porbeagle	-	-	-	8354	-
	Rock Grenadier(Roundnose)	-	-	-	70	-
	Shortfin Mako	-	-	-	-	14224
	Thorny Skate	-	383	-	70	105
	White Hake	-	12155	-	4873	1897
	Winter Skate	-	383	-	-	-
GRO-LLS	Barndoor Skate	5562	146779	312113	183212	36620
	Cusk	26299	113532	287	49	1811
	Northern Wolffish	2543	2162	-	-	811
	Porbeagle	-	-	9142	7057	13351
	Shortfin Mako	-	-	-	179	-
	Smooth Skate	-	2385	-	114	405
	Spotted Wolffish	-	-	-	-	81
	Striped Atlantic Wolffish	556	1118	862	1772	1622
	Thorny Skate	3099	12598	5692	62523	65646
	White Hake	2463	1491	2693	244	-
	Winter Skate	14302	13418	4830	13610	3784
GRO-OTB	Barndoor Skate	3354	29923	-	43804	22951
	Basking Shark	-	340406	-	2572	-
	Cusk	252	-	-	2141	25
	Northern Wolffish	-	-	-		34
	Porbeagle	-	-	-	11057	3182
	Rock Grenadier(Roundnose)	-	-	-	11	-
	Shortfin Mako	-	-	-	3285	-
	Smooth Skate	3354	469	-	13493	4047
	Spinytail Skate	-	1126	-	-	-
	Striped Atlantic Wolffish	-	-	-	159	42
	Thorny Skate	145	14164	6114	18016	6661
	Turbot,Greenland Halibut	-	-	-	57	-
	White Hake	-	-	-	-	8169
	Winter Skate	229259	2064	611	36516	10357
GRO-OTB-OF	American Eel	119	-	-	-	-
	Barndoor Skate	166	3203	-	9043	6531
	Cusk	-	34	-	-	20
	Porbeagle	-	-	-	-	2404
	Smooth Skate	-	411	-	354	-
	Spinytail Skate	-	-	-	-	101
	Striped Atlantic Wolffish	190	-	-	-	-
	Thorny Skate	-	719	-	1018	1379
	Turbot,Greenland Halibut	-		-	-	10
	White Hake	-	154	-	-	-
	Winter Skate	29579	3101	-	2124	793
HKS-OTB	Barndoor Skate	-	-	-	-	243

Fishery	Species	2007	2008	2009	2010	2011
RED-OTB	Barndoor Skate	1361	5440	9166	6031	13128
	Cusk	-	-	53	591	3952
	Porbeagle	-	-	605	2355	3374
	Rock Grenadier(Roundnose)	-	-	-	17	-
	Smooth Skate	-	-	3310	3073	174
	Striped Atlantic Wolffish	-	-	-	-	29
	Thorny Skate	1821	1987	908	1845	11037
	Turbot,Greenland Halibut	-	-	-	17	67
	White Hake	-	-	-	852	15153
	Winter Skate	2483	50	-	340	771
RED-OTB-OF	Barndoor Skate	1301	-	1271	12176	57269
	Basking Shark	-	-	-	-	2564
	Cusk	-	-	-	112	-
	Off-shore Hake	-	-	-	47	-
	Porbeagle	-	-	-	1909	5492
	Rock Grenadier(Roundnose)	-	-	-	9	-
	Smooth Skate	398	-	363	37	83
	Thorny Skate	-	-	86	3140	3166
	Winter Skate	27	-	-	140	2288
SCU-OTB	Barndoor Skate	-	-	6	-	-
	Smooth Skate	-	-	1572	-	-
	Spotted Wolffish	-	-	111	-	-
	Striped Atlantic Wolffish	-	-	35	-	-
	Thorny Skate	-	-	29	1418	-
	White Hake	-	-	6	-	-
	Winter Skate	-	-	-	8	-