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Estimation of Pelagic Shark Bycatch and Associated Mortality in Canadian Atlantic Fisheries

Estimation des captures accessoires de requins pélagiques et de la mortalité connexe dans les pêches canadiennes de l'Atlantique

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ABSTRACT

The estimation of pelagic shark bycatch, discards and discard mortality was an objective of both the *Workplan to Address Incidental Catch in Canadian Large Pelagic Fisheries* and the associated Regional Advisory Process meeting (held 11-12 July, 2011). In addition to quantifying all sources of bycatch for porbeagle (*Lamna nasus*), shortfin mako (*Isurus oxyrinchus*), and blue shark (*Prionace glauca*), we used documented or inferred capture and post-release mortality rates to estimate total discard mortality, and tested the key assumptions underlying the use of observer data to estimate fishery-scale discards. Annual estimates of shark discards by fishery indicated that the swordfish/tuna fishery accounted for 58% of 57 mt of porbeagle discards, 70% of 23 mt of mako discards, and 99% of 1414 mt of blue shark discards in 2010. Aggregated across all fisheries, an estimated 29 mt of non-retained porbeagle died from fishing-related causes in 2010, which is equivalent to 35% of reported landings. A total of 11 mt of non-retained mako did not survive fishing in 2010, which is equivalent to 29% of the reported landings. Discarded blue sharks which did not survive fishing totalled 495 mt in 2010, which far exceeded landings. Based on tests of accuracy of the bycatch estimation method, the bycatch and discard amounts for these shark species are expected to be reasonably close to reality. Porbeagle bycatch is largely limited to Emerald Basin and the edge of the Scotian Shelf, but bycatches of mako and blue shark are more broadly representative of the distribution of the pelagic longline fishery in the northwest Atlantic.

RÉSUMÉ

L’estimation des captures accessoires et des rejets de requins pélagiques ainsi que de la mortalité due à ces rejets était un objectif du document intitulé *Workplan to Address Incidental Catch in Canadian Large Pelagic Fisheries* et de la réunion connexe tenue dans le cadre du Processus de consultation régional (les 11 et 12 juillet 2011). En plus de quantifier toutes les sources de captures accessoires de requins-taupes communs (*Lamna nasus*), de requins-taupes bleus (*Isurus oxyrinchus*) et de requins bleus (*Prionace glauca*), nous nous sommes fondés sur les captures et les taux de mortalité après remise à l’eau, documentés ou inférés, pour estimer la mortalité totale par rejets et avons vérifié les principales hypothèses qui sous-tendent l’utilisation des données des observateurs pour estimer les rejets à l’échelle des pêches. Il ressort des estimations annuelles des rejets de requins par les pêcheurs que la pêche de l’espadon et des thons a produit 58 % des 57 tm de requins-taupes communs rejetés, 70 % des 23 tm de requins-taupes bleus rejetés et 99 % des 1 414 tm de requins bleus rejetés en 2010. Si on considère l’ensemble des pêches, on estime à 29 tm les requins-taupes communs non gardés qui sont morts de causes liées à la pêche en 2010, ce qui équivaut à 35 % des débarquements déclarés. En tout, 11 tm de requins-taupes bleus non gardés n’ont pas survécu à la pêche en 2010, soit l’équivalent de 29 % des débarquements déclarés. Les requins bleus rejetés qui n’ont pas survécu à la pêche totalisaient 495 tm en 2010, ce qui est bien supérieur aux débarquements. D’après les vérifications d’exactitude de la méthode d’estimation des captures accessoires, les quantités de captures accessoires et de rejets indiquées pour ces espèces de requin devraient être suffisamment proches de la réalité. Les captures accessoires de requins-taupes communs se limitent en grande part au bassin Émeraude et au bord du plateau néo-écossais, tandis que les captures accessoires de requins-taupes bleus et de requins bleus reflètent plus largement la répartition de la pêche à la palangre pélagique dans l’Atlantique Nord-Ouest.

INTRODUCTION

Fishing gear can often be non-selective with respect to the species captured, resulting in the capture of both the target species and other non-target species. Where the non-target species is considered commercially valuable, bycatch is usually retained and used, and thus is not necessarily harmful. However, bycatch of non-commercial species or unretained individuals can lead to their injury or death, either during capture (eg- immediate or hooking mortality) or after release (Lewison et al. 2004). Marine mega-fauna such as sea turtles, seabirds, sharks and marine mammals appear to be particularly susceptible to bycatch mortality in fishing gear, but bycatch and discarding of less charismatic fish species is also viewed as a global problem (Harrington et al. 2005). Sharks are often the most frequently discarded category in longline fisheries for highly migratory pelagic species such as tuna and swordfish (Lewison et al. 2004, Harrington et al. 2005).

Three pelagic shark species are caught regularly in large pelagic fishing gear in the waters off of Atlantic Canada: porbeagle (*Lamna nasus*), shortfin mako (*Isurus oxyrinchus*) and blue shark (*Prionace glauca*). Porbeagle is caught both in a small directed fishery and as bycatch in other large pelagic fisheries, while shortfin mako and blue shark are both caught as bycatch and are considered as valued and undesired/discarded, respectively.

Recent stock assessments for porbeagle (Campana et al. 2010), mako (Fowler and Campana 2009a) and blue shark (Fowler and Campana 2009b) all acknowledge the existence of substantial bycatch and discards of pelagic shark species in Canadian waters, but previous attempts to quantify all sources of bycatch and fishing-induced mortality (capture and post-release) have been incomplete. Both the *Workplan to Address Incidental Catch in Canadian Large Pelagic Fisheries* and the associated Regional Advisory Process meeting (held 11-12 July 2011) identified key objectives associated with the estimation of discards and post-release mortality of large pelagic sharks. Therefore, the objectives of this analysis are to: 1) quantify all sources of porbeagle, mako and blue shark bycatch, from all fishing gears; 2) use documented or inferred capture and post-release mortality rates to estimate total discard mortality; 3) examine and test the key assumptions underlying the use of observer data to estimate fishery-scale discards; and 4) map the distribution of discarded pelagic shark bycatch in relation to observed and reported catch.

Methods Used for Estimation of Total Shark Bycatch

The Scotia-Fundy Observer Program (SFOP) has maintained 100% coverage of foreign fisheries in the Canadian zone since 1987, thus allowing accurate determinations of foreign shark catch and bycatch. Since 1999 however, essentially all pelagic shark catch and bycatch has been by Canadian vessels, for which observer coverage has been substantially less (on the order of 5% for the large pelagic fishery, and considerably less for groundfisheries). To determine the magnitude of the shark bycatch in each of the Atlantic Canadian fisheries, the bycatch of each of the pelagic shark species (porbeagle, shortfin mako and blue) was estimated by fishery, quarter and year from Scotia-Fundy Observer Program (SFOP) observations made between 1996-2010. The observed bycatch proportion in each fishery/quarter/year cell was calculated as the weight of each discarded shark species relative to the weight of the observed kept target catch. After first confirming the absence of temporal trends in the bycatch proportion (see below), the weighted mean proportion (weighted by number of observed sets) across the years 1996-2010 was scaled up to that of the entire fishery by multipling by the quarterly landings of the target fishery (as reported to ZIF or MARFIS) to estimate total discards by fishery, quarter and year. Therefore, each quarter and fishery was characterized by a unique bycatch proportion, but this proportion was maintained for all years. This method of bycatch

estimation is less susceptible to sampling variability or poor sampling than is the year by year method. The assumption that there were no temporal trends in bycatch proportions was tested by plotting the time series for each fishery and quarter.

Use of the summed target catch (as opposed to an individual species) in the discard estimation avoided problems associated with the species sought being unknown, although previous analyses by individual species sought provided comparable results (Campana et al. 2002). Bycatch was estimated separately for both discarded and retained shark bycatch. Shark bycatch was estimated for each of the following target fisheries: pelagic longline for swordfish and non-bluefin tuna; pelagic longline for porbeagle; groundfish longline; groundfish gillnet; groundfish otter trawl. Shark bycatch in the bluefin tuna fishery was previously found to be about 50 mt in recent years (Campana et al. 2005), and thus was not considered further here. Subsequent references in this document to the swordfish/tuna fishery refers to swordfish and all tuna species other than bluefin.

Since some Canadian pelagic longline vessels routinely remove blue sharks (or cut off the leader) before they reach the deck, it can be difficult to estimate or record any component of the catch which is not brought onto deck before discarding, such as blue sharks. This was particularly true for the years prior to 1999, for which many observers reported zero blue sharks across all trips (see Results). However, observer records for more recent years have usually taken account of sharks not brought on deck. Therefore, the bycatch estimations reported here have assumed that all blue shark catches, including sets reporting zero blue sharks, are accurately reported. This assumption probably underestimates blue shark catches prior to 1999.

Mortality due to fishing can be partitioned into landed catch, capture mortality (fish that are dead upon retrieval of the fishing gear), and post-release mortality (mortality which occurs after the fish is returned alive to the water). Landed catch is usually known, and capture mortality can be recorded by scientific staff or observers. However, post-release mortality is unknown unless experimentally determined, such as through the use of archival satellite popup tags. Post-release mortality of blue sharks has been accurately measured at 19% for live releases tagged with popup tags (Campana et al. 2009). Capture (hooking) mortality of blue sharks has been measured at 20% by scientific staff, and at 12% by observers, with the explanation for the difference discussed by Campana et al. (2009). Since the capture and post-release mortality rates are non-additive, the total mortality of non-retained blue sharks would be 35% using the scientific observations, or 29% using the observer estimates. Post-release mortality of shortfin mako and porbeagle sharks has not yet been measured, and was assumed to be somewhat higher than that of blue sharks (which appear to be a hardier species). A total mortality of 50% (capture + post-release) was assumed for non-retained mako and porbeagle sharks.

Discard Estimates for Large Pelagic Sharks

Observer records were available for most fisheries/quarters/years, but were absent or sporadic when overall catches were low. Based on the proportion of the reported fishery catch which was observed each quarter, the observed catch accounted for 10% of the total swordfish/tuna pelagic longline catch, 7% of the directed longline porbeagle fishery, 6% of the groundfish longline fishery, 2% of the groundfish gillnet fishery, and 11% of the groundfish OTB fishery. These percentages do not include reported catches for cells for which there were no observer entries, which means that the actual observer coverage percentages could be lower than shown.

Discards of both porbeagle (Table 1) and shortfin mako (Table 2) tended to be highest during the third quarter of the swordfish/tuna fishery, but averaged less than 10 mt per quarter/year in each of the other fisheries. In contrast, discards of blue shark averaged more than 10 mt per quarter/year in the 2nd, 3rd and 4th quarters of the swordfish/tuna fishery, and in the 3rd quarter of the groundfish longline fishery (Table 3).

The spatial distribution of porbeagle discards was not representative of the overall swordfish/tuna fishery, with the discards being most prevalent in Emerald Basin and along the edge of the Scotian Shelf (Fig. 1). The discards of mako were more widely dispersed, and did not differ appreciably from that of the pelagic longline fishery (Fig. 2). Blue shark discards were also broadly dispersed, although the observed discards seemed to be most concentrated in Emerald Basin, along the edge of the entire continental shelf, and in southwestern offshore waters (Fig. 3).

Annual estimates of shark discards by fishery indicated that the swordfish/tuna fishery accounted for 58% of the porbeagle discards, 70% of the mako discards, and 99% of the blue shark discards in 2010 (Table 4). However, the groundfish OTB fishery has discarded an average of more than 20 mt of porbeagle annually since 1996, while the groundfish longline fishery has discarded an average of 19 mt of blue shark annually.

Aggregated across fisheries, an estimated 29 mt of non-retained porbeagle died from fishing-related causes in 2010, which is equivalent to 35% of reported landings (Table 4). A total of 11 mt of non-retained mako did not survive fishing in 2010, which is equivalent to 29% of the reported landings. Discarded blue sharks which did not survive fishing totalled 495 mt in 2010, which far exceeded landings.

Tests of Assumptions Underlying Shark Discard Estimates

Most regional fisheries management organizations (such as ICCAT) estimate discards using the same basic method applied here: by calculating the weight ratio of the discard species relative to the target species, and then scaling to the total reported landings of the target species. The more detailed discard calculations reported here were first stratified by fishing quarter and fishery, thus improving upon precision. Nevertheless, any use of the weight ratio estimator for discards makes several basic assumptions, each of which are examined below.

Many of the previous estimates of shark discards in the swordfish/tuna fishery assumed that sets in which no blue sharks were recorded by observers reflected lack of recording, due to sharks being cut off before being brought on deck, rather than lack of sharks (eg., Campana et al. 2004). Discard estimates based on records with zero shark catches would therefore incorrectly, and perhaps grossly, underestimate the magnitude of the shark discards. Carruthers and Neis (2011) criticised this approach and suggested that the incorrect recording of sets with zero blue sharks was limited to observers prior to 1999. To test this interpretation, we calculated the proportion of sets reporting zero blue sharks that were observed in the swordfish/tuna fishery, stratified by quarter (Fig. 4). Observed sets prior to 1998 reported that more than 50% of the sets contained no blue sharks, which is biologically implausible. On the other hand, more recent observed sets reported about 6% of the sets contained zero blue sharks, with no apparent trend since 1998 (Fig. 4). Since a 6% absence rate is very plausible, all discard calculations reported in this document assume that the entire time series of observed sets is accurate, whether or not it included sets with zero sharks. Inclusion of the years 1996-1997 (with their erroneous zero shark sets) in the overall mean discard weight ratio estimator implies that mean discard ratios may be slightly underestimated.

A second assumption of our use of the weight ratio estimator is that our use of an aggregated target species (swordfish + tuna other than bluefin) is superior, or at least not worse, than the use of swordfish alone. Carruthers and Neis (2011) criticised this assumption on the basis of a perceived long-term shift in the target species of the large pelagic fishery, away from swordfish (which are often associated with blue sharks) and towards tuna (which are less often associated with blue sharks). If their criticism is correct, there should be a long-term trend in the blue shark bycatch ratio. More specifically, there should be a long-term negative trend to lower blue shark bycatch ratios, reflecting the greater preponderance of tuna-directed sets. To test this assumption, we plotted the time trends in the blue shark bycatch ratio relative to swordfish+tuna for each quarter. There was no evidence, either statistically or graphically, of a negative trend in any of the time series (Fig. 5). Indeed, there may have been a slight upwards trend in some of the quarters. Therefore, our use of an aggregated target species appears to be justified.

The accuracy of the discard weight ratio method for estimating total shark bycatch can be tested for high value discard species such as shortfin mako. Total estimated shortfin mako retained catch was estimated using the bycatch ratio method applied to observed, retained (rather than discarded) mako bycatch in the swordfish/tuna fishery, then scaled to the reported swordfish/tuna landings (Table 5). If the ratio method is accurate, the calculation of total estimated retained mako bycatch should be similar to that of reported mako landings, despite the fact that the observer-based estimated bycatch values are completely independent of the reported landings data. The sum of the estimated mako bycatch (across all sources and fisheries) increased from 70% of reported landings in the 1990s, to 115% of reported landings since 2004, with an overall average of 91%. Therefore, despite the assumptions of the ratio method (which includes the assumption that observer coverage of swordfish-directed trips has not changed over time relative to tuna-directed trips), the bycatch ratio method provided reasonably accurate estimates of scaled total mako bycatch in the swordfish/tuna fishery. Similar accuracy would be expected of scaled discard estimates of blue and porbeagle sharks.

CONCLUSIONS

The bycatch of porbeagle, shortfin mako and blue sharks is largest in the large pelagic longline fishery, with smaller bycatch amounts having been estimated for other fisheries in Atlantic Canada. The bycatch of blue sharks far exceeds that of the other pelagic shark species, and is almost completely discarded, whereas significant proportions of the more valued mako and porbeagle bycatch are retained. In recent years, the discarded bycatch of both porbeagle and makos has increased to significant proportions of the landed catch, in part because of increased efforts by the pelagic longline fishery to release live sharks. Nevertheless, the combination of increased mortality associated with capture and post-release mortality, summed across all fisheries, implies that about 30 mt of discarded porbeagle, 10 mt of discarded mako and 500 mt of discarded blue shark can be expected to die annually from activities associated with commercial fishing. Based on tests of accuracy of the bycatch estimation method, the bycatch amounts for these shark species are expected to be reasonably close to reality. Porbeagle bycatch is largely limited to Emerald Basin and the edge of the Scotian Shelf, but bycatches of mako and blue shark are more broadly representative of the distribution of the pelagic longline fishery in the northwest Atlantic.

Given that pelagic shark bycatch and discarding is a likely by-product of commercial fishing for at least the near future, some efforts should be made to incorporate estimates of discard mortality into the stock assessments of all three pelagic shark species, thus leaving fisheries managers with better options for addressing bycatch and discards.

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Table 1. Observed and estimated porbeagle bycatch and discards by quarter and fishery, 1996-2010.

Fishery **Pelagic longline for tuna and swordfish (not shark)** **DISCARDS (mt)**

QUARTILE		1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
1																
	Swordfish&tuna kept catch from IOP															
	Porbeagle discard catch from IOP															
	Porbeagle discard /swordfish&tuna kept ratio															
	Mean porbeagle discard/swordfish&tuna kept ratio															
	Swordfish&tuna catch from MARFIS															
	Estimated Discard Porbeagle catch in swordfish&tuna fishery															
QUARTILE		1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
2																
	Swordfish&tuna kept catch from IOP	10.4			3.2	18.6	18.7	27.6	11.9	22.6	8.2	11.3	11.8	6.1	4.4	17.8
	Porbeagle discard catch from IOP	0.0			0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.0	0.0	0.0	1.5
	Porbeagle discard /swordfish&tuna kept ratio	0.00			0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.00	0.00	0.00	0.08
	Mean porbeagle discard/swordfish&tuna kept ratio	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
	Swordfish&tuna catch from MARFIS	63	85	71	111	114	192	75	65	109	178	107	125	174	125	169
	Estimated Discard Porbeagle catch in swordfish&tuna fishery	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1
QUARTILE		1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
3																
	Swordfish&tuna kept catch from IOP	35.5	100.5	82.4	50.7	23.5	115.7	301.4	122.2	50.2	85.1	85.1	81.4	73.1	113.7	101.9
	Porbeagle discard catch from IOP	0.2	0.1	0.2	2.0	0.9	3.8	1.0	2.0	0.6	1.2	2.1	2.3	0.6	1.2	5.6
	Porbeagle discard /swordfish&tuna kept ratio	0.01	0.00	0.00	0.04	0.04	0.03	0.00	0.02	0.01	0.01	0.02	0.03	0.01	0.01	0.05
	Mean porbeagle discard/swordfish&tuna kept ratio	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02
	Swordfish&tuna catch from MARFIS	731	1022	784	879	823	860	1017	976	1243	1488	1426	1284	1151	1046	1170
	Estimated Discard Porbeagle catch in swordfish&tuna fishery	14	20	15	17	16	17	20	19	24	29	28	25	23	21	23
QUARTILE		1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
4																
	Swordfish&tuna kept catch from IOP	1.5	3.9	13.4	73.8	23.3	40.6	91.5	16.1	2.8	0.9	61.0	6.6	4.0	7.6	41.9
	Porbeagle discard catch from IOP	0.0	0.0	0.0	0.1	0.0	0.1	1.7	1.6	0.5	0.1	1.3	0.5	0.9	0.2	0.8
	Porbeagle discard /swordfish&tuna kept ratio	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.10	0.18	0.06	0.02	0.07	0.23	0.03	0.02
	Mean porbeagle discard/swordfish&tuna kept ratio	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05
	Swordfish&tuna catch from MARFIS	94	104	120	74	41	38	152	227	204	185	191	148	127	104	170
	Estimated Discard Porbeagle catch in swordfish&tuna fishery	5	5	6	4	2	2	7	11	10	9	9	7	6	5	8

Fishery **Directed porbeagle LL** **DISCARDS (mt)**

QUARTILE		1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
1																
	Porbeagle kept catch from IOP	112.2	70.5													
	Porbeagle discard catch from IOP	0.5	0.0													
	Porbeagle discard /porbeagle kept ratio	0.00	0.00													
	Mean porbeagle discard/porbeagle kept ratio	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Porbeagle catch from MARFIS	122	98	98	160	97	21	2	1	17	1	29	1	23	2	9
	Estimated Discard Porbeagle catch in porbeagle fishery	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
QUARTILE		1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
2																
	Porbeagle kept catch from IOP	15.0	7.5					117.0		5.8	4.0					2.2
	Porbeagle discard catch from IOP	0.0	0.0					1.0		0.0	0.0					0.2
	Porbeagle discard /porbeagle kept ratio	0.00	0.00					0.01		0.00	0.00					0.08
	Mean porbeagle discard/porbeagle kept ratio	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
	Porbeagle catch from MARFIS	412	656	582	622	556	457	146	88	142	142	83	49	67	30	17
	Estimated Discard Porbeagle catch in porbeagle fishery	6	10	9	9	8	7	2	1	2	2	1	1	1	0	0
QUARTILE		1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
3																
	Porbeagle kept catch from IOP	69.0														
	Porbeagle discard catch from IOP	0.0														
	Porbeagle discard /porbeagle kept ratio	0.00														
	Mean porbeagle discard/porbeagle kept ratio	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Porbeagle catch from MARFIS	140	242	45	8	96	11	25	21	37	42	45	25	18	10	25
	Estimated Discard Porbeagle catch in porbeagle fishery	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
QUARTILE		1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
4																
	Porbeagle kept catch from IOP	28.7						15.2								
	Porbeagle discard catch from IOP	0.0						0.2								
	Porbeagle discard /porbeagle kept ratio	0.00						0.01								
	Mean porbeagle discard/porbeagle kept ratio	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
	Porbeagle catch from MARFIS	335	215	180	151	132	1	40	16	11	7	24	8	9	8	14
	Estimated Discard Porbeagle catch in porbeagle fishery	2	1	1	1	1	0	0	0	0	0	0	0	0	0	0

Table 1 – cont'd. Mean discard ratios of <0.005 have been rounded to 0 for display purposes only.

Fishery **Groundfish LL (major groundfish species only eg- cod, haddock, pollock, redfish, flounder, silver hake)** **DISCARDS (mt)**

QUARTILE		1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
1																
	Groundfish kept catch from IOP	119.6	53.8	127.8	88.6	276.4	113.2	86.8	78.6	63.9	65.1	45.0	54.7	132.3	203.0	18.1
	Porbeagle discard catch from IOP	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.0
	Porbeagle discard /groundfish kept ratio	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Mean porbeagle discard/groundfish kept ratio	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Groundfish catch from MARFIS	614	682	733	499	1540	1422	1024	1064	789	516	650	725	806	682	742
	Estimated Discard Porbeagle catch in groundfish fishery	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
QUARTILE		1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
2																
	Groundfish kept catch from IOP	7.2	121.3	113.7	32.9	62.1	88.4	72.3	87.9	26.1	14.4	30.2	212.9	76.8	33.0	126.1
	Porbeagle discard catch from IOP	0.0	0.0	0.0	0.0	0.0	0.5	0.0	0.2	0.0	0.0	0.0	0.0	0.1	0.0	1.5
	Porbeagle discard /groundfish kept ratio	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01
	Mean porbeagle discard/groundfish kept ratio	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Groundfish catch from MARFIS	1573	1278	1277	1033	863	977	720	839	668	644	537	876	678	565	632
	Estimated Discard Porbeagle catch in groundfish fishery	2	2	2	1	1	1	1	1	1	1	1	1	1	1	1
QUARTILE		1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
3																
	Groundfish kept catch from IOP	198.7	154.3	43.7	119.7	261.1	140.5	108.8	126.6	149.9	182.5	165.7	156.8	462.3	449.4	418.4
	Porbeagle discard catch from IOP	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.2	0.1	0.0	0.2	0.3
	Porbeagle discard /groundfish kept ratio	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Mean porbeagle discard/groundfish kept ratio	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Groundfish catch from MARFIS	3973	4857	4913	4675	4432	4445	4571	4331	3808	3965	4891	4829	4890	4190	4556
	Estimated Discard Porbeagle catch in groundfish fishery	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
QUARTILE		1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
4																
	Groundfish kept catch from IOP	84.5	20.9	127.8	53.4	139.1	130.6	42.3	145.5	251.1	21.6	55.3	106.5	211.4	73.3	55.1
	Porbeagle discard catch from IOP	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1
	Porbeagle discard /groundfish kept ratio	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Mean porbeagle discard/groundfish kept ratio	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Groundfish catch from MARFIS	2701	2764	2380	1780	1582	2178	1928	2021	1564	1510	1366	1459	1758	1584	1368
	Estimated Discard Porbeagle catch in groundfish fishery	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fishery **Groundfish gillnet** **DISCARDS (mt)**

QUARTILE		1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
1																
	Groundfish kept catch from IOP							0.7		6.9	8.9					
	Porbeagle discard catch from IOP							0.0		0.1	0.0					
	Porbeagle discard /groundfish kept ratio							0.00		0.01	0.00					
	Mean porbeagle discard/groundfish kept ratio	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Groundfish catch from MARFIS	0	0	17	14	175	140	227	303	234	140	112	17	30	2	12
	Estimated Discard Porbeagle catch in groundfish fishery	0	0	0	0	1	1	1	1	1	1	0	0	0	0	0
QUARTILE		1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
2																
	Groundfish kept catch from IOP	20.6	31.8	4.8				23.5		25.2	2.4	16.0		8.8		36.3
	Porbeagle discard catch from IOP	0.0	0.0	0.0				0.0		0.0	0.0	0.0		0.0		0.0
	Porbeagle discard /groundfish kept ratio	0.00	0.00	0.00				0.00		0.00	0.00	0.00		0.00		0.00
	Mean porbeagle discard/groundfish kept ratio	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Groundfish catch from MARFIS	672	1214	1294	719	666	657	813	637	1013	631	401	285	347	128	297
	Estimated Discard Porbeagle catch in groundfish fishery	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
QUARTILE		1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
3																
	Groundfish kept catch from IOP	56.3	18.7	37.3	29.3	16.4	36.0	15.7	47.6	37.2	23.7	96.3		23.0	42.2	21.7
	Porbeagle discard catch from IOP	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0		0.0	0.0	0.0
	Porbeagle discard /groundfish kept ratio	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00		0.00	0.00	0.00
	Mean porbeagle discard/groundfish kept ratio	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Groundfish catch from MARFIS	2152	2960	3036	2114	1832	2217	1878	2129	2222	1771	1204	1547	1401	1568	1295
	Estimated Discard Porbeagle catch in groundfish fishery	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
QUARTILE		1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
4																
	Groundfish kept catch from IOP					10.2	19.9	5.7	9.3	4.3	2.6	46.9				
	Porbeagle discard catch from IOP					0.0	0.0	0.0	0.4	0.0	0.0	0.0				
	Porbeagle discard /groundfish kept ratio					0.00	0.00	0.00	0.04	0.00	0.00	0.00				
	Mean porbeagle discard/groundfish kept ratio	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
	Groundfish catch from MARFIS	342	695	528	433	447	374	204	474	349	313	112	146	113	285	98
	Estimated Discard Porbeagle catch in groundfish fishery	2	4	3	3	3	2	1	3	2	2	1	1	1	2	1

Table 1 – cont'd. Mean discard ratios of <0.005 have been rounded to 0 for display purposes only.

Fishery **Groundfish OTB** **DISCARDS (mt)**

QUARTILE		1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
1																
	Groundfish kept catch from IOP	1406.2	2112.0	318.4	681.3	884.2	1090.1	1553.3	558.4	263.9	1483.4	1342.2	1985.7	3001.8	1058.5	1939.6
	Porbeagle discard catch from IOP	0.2	0.0	0.0	0.4	0.0	0.0	0.0	0.0	0.0	0.4	0.7	1.9	1.3	0.4	1.5
	Porbeagle discard /groundfish kept ratio	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Mean porbeagle discard/groundfish kept ratio	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Groundfish catch from MARFIS	4984	5762	8435	5992	10023	12032	10069	9173	9134	11631	10071	10676	11287	12235	11759
	Estimated Discard Porbeagle catch in groundfish fishery	1	2	2	2	3	3	3	3	3	3	3	3	3	3	3
QUARTILE		1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
2																
	Groundfish kept catch from IOP	2378.6	503.5	758.0	953.4	1143.4	1796.5	1442.0	2159.4	1151.9	905.3	1361.7	2121.7	1365.7	1001.9	1218.5
	Porbeagle discard catch from IOP	0.0	0.0	0.0	0.1	0.0	0.5	0.2	1.6	0.1	0.0	1.2	4.4	1.6	1.9	5.7
	Porbeagle discard /groundfish kept ratio	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Mean porbeagle discard/groundfish kept ratio	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Groundfish catch from MARFIS	10427	11125	16562	12203	12160	14435	14724	11968	12499	11840	8661	10150	10155	10043	11217
	Estimated Discard Porbeagle catch in groundfish fishery	8	9	13	10	10	12	12	10	10	9	7	8	8	8	9
QUARTILE		1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
3																
	Groundfish kept catch from IOP	1037.4	858.8	1090.3	1097.3	1214.1	1001.4	1013.9	842.6	869.2	1107.1	1445.9	6088.2	1291.6	1392.5	1394.2
	Porbeagle discard catch from IOP	0.0	0.0	0.0	0.0	0.3	0.0	0.8	0.7	0.2	0.4	1.5	12.6	0.6	1.1	2.5
	Porbeagle discard /groundfish kept ratio	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Mean porbeagle discard/groundfish kept ratio	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Groundfish catch from MARFIS	31063	26004	20242	17501	12939	15593	15146	13332	13715	14441	13172	13309	12936	14547	13170
	Estimated Discard Porbeagle catch in groundfish fishery	18	15	12	10	8	9	9	8	8	8	8	8	8	8	8
QUARTILE		1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
4																
	Groundfish kept catch from IOP	2142.9	637.2	1306.5	1322.9	909.3	823.1	658.2	619.2	441.1	148.9	1040.3	2015.1	1054.6	833.0	741.0
	Porbeagle discard catch from IOP	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.2	0.7	0.1	0.2	0.8
	Porbeagle discard /groundfish kept ratio	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Mean porbeagle discard/groundfish kept ratio	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Groundfish catch from MARFIS	10119	7861	11582	10296	10137	12141	10078	9891	9163	8578	8673	8559	8440	9409	7728
	Estimated Discard Porbeagle catch in groundfish fishery	1	1	2	1	1	2	1	1	1	1	1	1	1	1	1

Table 2. Observed and estimated shortfin mako bycatch and discards by quarter and fishery,1996-2010. Discards in the porbeagle, gillnet and groundfish longline were <1 mt each year and are not shown. Mean discard ratios of <0.005 have been rounded to 0 for display purposes only.

Fishery **Pelagic longline for tuna and swordfish (not shark)** **DISCARDS (mt)**

QUARTILE 1		1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
	Swordfish&tuna kept catch from IOP															
	Shortfin Mako discard catch from IOP															
	Shortfin Mako discard/swordfish&tuna kept ratio															
	Mean shortfin mako discard/swordfish&tuna kept ratio															
	Swordfish&tuna catch from MARFIS															
	Estimated Discard Shortfin Mako catch in swordfish&tuna fishery															
QUARTILE 2		1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
	Swordfish&tuna kept catch from IOP	10.4			3.2	18.6	18.7	27.6	11.9	22.6	8.2	11.3	11.8	6.1	4.4	17.8
	Shortfin Mako discard catch from IOP	0.2			0.0	0.2	0.0	0.5	0.1	0.2	0.1	0.2	0.3	0.0	0.2	1.0
	Shortfin Mako discard/swordfish&tuna kept ratio	0.01			0.01	0.01	0.00	0.02	0.00	0.01	0.01	0.01	0.03	0.00	0.04	0.06
	Mean shortfin mako discard/swordfish&tuna kept ratio	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02
	Swordfish&tuna catch from MARFIS	63	85	71	111	114	192	75	65	109	178	107	125	174	125	169
	Estimated Discard Shortfin Mako catch in swordfish&tuna fishery	1	1	1	2	2	3	1	1	2	3	2	2	3	2	3
QUARTILE 3		1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
	Swordfish&tuna kept catch from IOP	35.5	100.5	82.4	50.7	23.5	115.7	301.4	122.2	50.2	85.1	85.1	81.4	73.1	113.7	101.9
	Shortfin Mako discard catch from IOP	0.0	0.1	1.3	0.3	0.4	1.1	1.0	0.5	0.7	1.1	1.4	1.5	0.4	1.0	0.6
	Shortfin Mako discard/swordfish&tuna kept ratio	0.00	0.00	0.02	0.00	0.02	0.01	0.00	0.00	0.01	0.01	0.02	0.02	0.01	0.01	0.01
	Mean shortfin mako discard/swordfish&tuna kept ratio	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
	Swordfish&tuna catch from MARFIS	731	1022	784	879	823	860	1017	976	1243	1488	1426	1284	1151	1046	1170
	Estimated Discard Shortfin Mako catch in swordfish&tuna fishery	7	10	7	8	8	8	10	9	12	14	13	12	11	10	11
QUARTILE 4		1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
	Swordfish&tuna kept catch from IOP	1.5	3.9	13.4	73.8	23.3	40.6	91.5	16.1	2.8	0.9	61.0	6.6	4.0	7.6	41.9
	Shortfin Mako discard catch from IOP	0.0	0.0	0.1	0.1	0.3	0.5	0.1	0.2	0.0	0.0	0.4	0.0	0.5	0.1	0.1
	Shortfin Mako discard/swordfish&tuna kept ratio	0.00	0.00	0.01	0.00	0.01	0.01	0.00	0.01	0.00	0.00	0.01	0.00	0.13	0.01	0.00
	Mean shortfin mako discard/swordfish&tuna kept ratio	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
	Swordfish&tuna catch from MARFIS	94	104	120	74	41	38	152	227	204	185	191	148	127	104	170
	Estimated Discard Shortfin Mako catch in swordfish&tuna fishery	1	1	2	1	1	0	2	3	3	2	2	2	2	1	2

Groundfish OTB **DISCARDS (mt)**

QUARTILE 1		1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
	Groundfish kept catch from IOP	1406.2	2112.0	318.4	681.3	884.2	1090.1	1553.3	558.4	263.9	1483.4	1342.2	1985.7	3001.8	1058.5	1939.6
	Shortfin Mako discard catch from IOP	0.6	0.0	0.0	0.0	0.0	0.2	0.1	0.0	0.0	0.0	0.2	1.0	0.0	0.0	0.2
	Shortfin Mako discard /groundfish kept ratio	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Mean shortfin mako discard/groundfish kept ratio	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Groundfish catch from MARFIS	4984	5762	8435	5992	10023	12032	10069	9173	9134	11631	10071	10676	11287	12235	11759
	Estimated Discard Shortfin Mako catch in groundfish fishery	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1
QUARTILE 2		1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
	Groundfish kept catch from IOP	2378.6	503.5	758.0	953.4	1143.4	1796.5	1442.0	2159.4	1151.9	905.3	1361.7	2121.7	1365.7	1001.9	1218.5
	Shortfin Mako discard catch from IOP	0.0	0.0	0.0	0.5	0.0	0.0	0.5	0.0	0.0	0.4	0.9	2.6	0.3	0.3	0.3
	Shortfin Mako discard /groundfish kept ratio	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Mean shortfin mako discard/groundfish kept ratio	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Groundfish catch from MARFIS	10427	11125	16562	12203	12160	14435	14724	11968	12499	11840	8661	10150	10155	10043	11217
	Estimated Discard Shortfin Mako catch in groundfish fishery	3	3	4	3	3	4	4	3	3	3	2	3	3	3	3
QUARTILE 3		1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
	Groundfish kept catch from IOP	1037.4	858.8	1090.3	1097.3	1214.1	1001.4	1013.9	842.6	869.2	1107.1	1445.9	6088.2	1291.6	1392.5	1394.2
	Shortfin Mako discard catch from IOP	0.0	0.0	0.0	0.0	0.0	0.2	0.0	0.0	0.0	0.0	0.0	4.4	0.0	0.4	0.5
	Shortfin Mako discard /groundfish kept ratio	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Mean shortfin mako discard/groundfish kept ratio	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Groundfish catch from MARFIS	31063	26004	20242	17501	12939	15593	15146	13332	13715	14441	13172	13309	12936	14547	13170
	Estimated Discard Shortfin Mako catch in groundfish fishery	3	3	2	2	1	2	2	1	1	1	1	1	1	1	1
QUARTILE 4		1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
	Groundfish kept catch from IOP	2142.9	637.2	1306.5	1322.9	909.3	823.1	658.2	619.2	441.1	148.9	1040.3	2015.1	1054.6	833.0	741.0
	Shortfin Mako discard catch from IOP	0.0	0.0	0.0	0.0	0.0	0.1	0.3	0.0	0.0	0.0	0.3	0.0	0.0	0.0	0.0
	Shortfin Mako discard /groundfish kept ratio	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Mean shortfin mako discard/groundfish kept ratio	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Groundfish catch from MARFIS	10119	7861	11582	10296	10137	12141	10078	9891	9163	8578	8673	8559	8440	9409	7728
	Estimated Discard Shortfin Mako catch in groundfish fishery	1	0	1	1	1	1	1	1	1	1	1	1	1	1	0

Table 3. Observed and estimated blue shark bycatch and discards by quarter and fishery,1996-2010. Mean discard ratios of <0.005 have been rounded to 0 for display purposes only.

Pelagic longline for tuna and swordfish (not shark) **DISCARDS (mt)**

QUARTILE 1		1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
	Swordfish&tuna kept catch from IOP															
	Blue Shark discard catch from IOP															
	Blue Shark discard/swordfish&tuna kept ratio															
	Mean blue shark discard/swordfish&tuna kept ratio															
	Swordfish&tuna catch from MARFIS															
	Estimated Discard Blue Shark catch in swordfish&tuna fishery															
QUARTILE 2		1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
	Swordfish&tuna kept catch from IOP	10.4			3.2	18.6	18.7	27.6	11.9	22.6	8.2	11.3	11.8	6.1	4.4	17.8
	Blue Shark discard catch from IOP	18.5			0.2	11.4	10.3	44.9	14.6	12.7	3.0	10.7	4.1	3.4	1.0	26.8
	Blue Shark discard/swordfish&tuna kept ratio	1.78			0.08	0.62	0.55	1.63	1.23	0.56	0.36	0.94	0.35	0.56	0.23	1.51
	Mean blue shark discard/swordfish&tuna kept ratio	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80
	Swordfish&tuna catch from MARFIS	63	85	71	111	114	192	75	65	109	178	107	125	174	125	169
	Estimated Discard Blue Shark catch in swordfish&tuna fish	50	68	57	88	91	154	60	52	87	142	85	100	139	100	135
QUARTILE 3		1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
	Swordfish&tuna kept catch from IOP	35.5	100.5	82.4	50.7	23.5	115.7	301.4	122.2	50.2	85.1	85.1	81.4	73.1	113.7	101.9
	Blue Shark discard catch from IOP	12.7	22.4	152.9	27.6	34.8	66.3	110.3	63.6	32.7	48.7	37.8	67.3	68.4	84.0	141.1
	Blue Shark discard/swordfish&tuna kept ratio	0.36	0.22	1.86	0.54	1.48	0.57	0.37	0.52	0.65	0.57	0.44	0.83	0.94	0.74	1.38
	Mean blue shark discard/swordfish&tuna kept ratio	0.76	0.76	0.76	0.76	0.76	0.76	0.76	0.76	0.76	0.76	0.76	0.76	0.76	0.76	0.76
	Swordfish&tuna catch from MARFIS	731	1022	784	879	823	860	1017	976	1243	1488	1426	1284	1151	1046	1170
	Estimated Discard Blue Shark catch in swordfish&tuna fish	559	782	600	672	630	658	778	747	951	1138	1091	982	880	800	894
QUARTILE 4		1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
	Swordfish&tuna kept catch from IOP	1.5	3.9	13.4	73.8	23.3	40.6	91.5	16.1	2.8	0.9	61.0	6.6	4.0	7.6	41.9
	Blue Shark discard catch from IOP	0.0	0.2	55.3	154.1	21.1	89.8	67.4	5.7	12.5	4.5	90.9	7.8	18.1	18.7	112.7
	Blue Shark discard/swordfish&tuna kept ratio	0.00	0.05	4.14	2.09	0.91	2.21	0.74	0.35	4.40	5.02	1.49	1.18	4.56	2.46	2.69
	Mean blue shark discard/swordfish&tuna kept ratio	2.15	2.15	2.15	2.15	2.15	2.15	2.15	2.15	2.15	2.15	2.15	2.15	2.15	2.15	2.15
	Swordfish&tuna catch from MARFIS	94	104	120	74	41	38	152	227	204	185	191	148	127	104	170
	Estimated Discard Blue Shark catch in swordfish&tuna fish	202	223	258	158	89	82	328	489	438	398	410	319	274	223	365

Directed porbeagle LL **DISCARDS (mt)**

QUARTILE 1		1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
	Porbeagle kept catch from IOP	112.2	70.5													
	Blue Shark discard catch from IOP	2.5	0.0													
	Blue Shark discard/porbeagle kept ratio	0.02	0.00													
	Mean blue shark discard/porbeagle kept ratio	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
	Porbeagle catch from MARFIS	122	98	98	160	97	21	2	1	17	1	29	1	23	2	9
	Estimated Discard Blue Shark catch in Porbeagle fishery	1	1	1	2	1	0	0	0	0	0	0	0	0	0	0
QUARTILE 2		1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
	Porbeagle kept catch from IOP	15.0	7.5					117.0		5.8	4.0					2.2
	Blue Shark discard catch from IOP	0.0	0.0					2.9		0.0	0.0					0.0
	Blue Shark discard/porbeagle kept ratio	0.00	0.00					0.02		0.00	0.00					0.00
	Mean blue shark discard/porbeagle kept ratio	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Porbeagle catch from MARFIS	412	656	582	622	556	457	146	88	142	142	83	49	67	30	17
	Estimated Discard Blue Shark catch in Porbeagle fishery	2	3	2	3	2	2	1	0	1	1	0	0	0	0	0
QUARTILE 3		1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
	Porbeagle kept catch from IOP	69.0														
	Blue Shark discard catch from IOP	0.0						0.0								
	Blue Shark discard/porbeagle kept ratio	0.00														
	Mean blue shark discard/porbeagle kept ratio	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Porbeagle catch from MARFIS	140	242	45	8	96	11	25	21	37	42	45	25	18	10	25
	Estimated Discard Blue Shark catch in Porbeagle fishery	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
QUARTILE 4		1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
	Porbeagle kept catch from IOP	28.7						15.2								
	Blue Shark discard catch from IOP	0.0						0.0								
	Blue Shark discard/porbeagle kept ratio	0.00						0.00								
	Mean blue shark discard/porbeagle kept ratio	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Porbeagle catch from MARFIS	335	215	180	151	132	1	40	16	11	7	24	8	9	8	14
	Estimated Discard Blue Shark catch in Porbeagle fishery	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Table 3 – cont'd. Mean discard ratios of <0.005 have been rounded to 0 for display purposes only.

Groundfish LL (major groundfish species only eg- cod, haddock, pollock, redfish, flounder, silver hake) **DISCARDS (mt)**

QUARTILE		1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
1																
	Groundfish kept catch from IOP	119.6	53.8	127.8	88.6	276.4	113.2	86.8	78.6	63.9	65.1	45.0	54.7	132.3	203.0	18.1
	Blue Shark discard catch from IOP	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Blue Shark discard/groundfish kept ratio	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Mean blue shark discard/groundfish kept ratio	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Groundfish catch from MARFIS	614	682	733	499	1540	1422	1024	1064	789	516	650	725	806	682	742
	Estimated Discard Blue Shark catch in groundfish fishery	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
QUARTILE		1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
2																
	Groundfish kept catch from IOP	7.2	121.3	113.7	32.9	62.1	88.4	72.3	87.9	26.1	14.4	30.2	212.9	76.8	33.0	126.1
	Blue Shark discard catch from IOP	0.0	0.0	0.1	0.0	0.2	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0
	Blue Shark discard/groundfish kept ratio	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Mean blue shark discard/groundfish kept ratio	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Groundfish catch from MARFIS	1573	1278	1277	1033	863	977	720	839	668	644	537	876	678	565	632
	Estimated Discard Blue Shark catch in groundfish fishery	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0
QUARTILE		1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
3																
	Groundfish kept catch from IOP	198.7	154.3	43.7	119.7	261.1	140.5	108.8	126.6	149.9	182.5	165.7	156.8	462.3	449.4	418.4
	Blue Shark discard catch from IOP	1.6	1.0	0.0	1.3	0.9	0.1	0.9	0.5	0.3	0.1	0.2	0.1	1.2	0.8	1.2
	Blue Shark discard/groundfish kept ratio	0.01	0.01	0.00	0.01	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Mean blue shark discard/groundfish kept ratio	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Groundfish catch from MARFIS	3973	4857	4913	4675	4432	4445	4571	4331	3808	3965	4891	4829	4890	4190	4556
	Estimated Discard Blue Shark catch in groundfish fishery	14	17	18	17	16	16	16	16	14	14	18	17	18	15	16
QUARTILE		1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
4																
	Groundfish kept catch from IOP	84.5	20.9	127.8	53.4	139.1	130.6	42.3	145.5	251.1	21.6	55.3	106.5	211.4	73.3	55.1
	Blue Shark discard catch from IOP	0.3	0.0	0.0	0.3	0.2	0.6	0.0	0.2	0.1	0.0	0.1	0.0	0.1	0.1	0.0
	Blue Shark discard/groundfish kept ratio	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Mean blue shark discard/groundfish kept ratio	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Groundfish catch from MARFIS	2701	2764	2380	1780	1582	2178	1928	2021	1564	1510	1366	1459	1758	1584	1368
	Estimated Discard Blue Shark catch in groundfish fishery	4	4	3	2	2	3	3	3	2	2	2	2	2	2	2

Groundfish gillnet **DISCARDS (mt)**

QUARTILE		1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
1																
	Groundfish kept catch from IOP							0.7		6.9	8.9					
	Blue Shark discard catch from IOP							0.0		0.0	0.0					
	Blue Shark discard/groundfish kept ratio							0.00		0.00	0.00					
	Mean blue shark discard/groundfish kept ratio	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Groundfish catch from MARFIS	0	0	17	14	175	140	227	303	234	140	112	17	30	2	12
	Estimated Discard Blue Shark catch in groundfish fishery	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
QUARTILE		1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
2																
	Groundfish kept catch from IOP	20.6	31.8	4.8				23.5		25.2	2.4	16.0		8.8		36.3
	Blue Shark discard catch from IOP	0.0	0.0	0.0				0.0		0.0	0.0	0.0		0.0		0.0
	Blue Shark discard/groundfish kept ratio	0.00	0.00	0.00				0.00		0.00	0.00	0.00		0.00		0.00
	Mean blue shark discard/groundfish kept ratio	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Groundfish catch from MARFIS	672	1214	1294	719	666	657	813	637	1013	631	401	285	347	128	297
	Estimated Discard Blue Shark catch in groundfish fishery	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
QUARTILE		1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
3																
	Groundfish kept catch from IOP	56.3	18.7	37.3	29.3	16.4	36.0	15.7	47.6	37.2	23.7	96.3		23.0	42.2	21.7
	Blue Shark discard catch from IOP	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0		0.0	0.0	0.0
	Blue Shark discard/groundfish kept ratio	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00		0.00	0.00	0.00
	Mean blue shark discard/groundfish kept ratio	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Groundfish catch from MARFIS	2152	2960	3036	2114	1832	2217	1878	2129	2222	1771	1204	1547	1401	1568	1295
	Estimated Discard Blue Shark catch in groundfish fishery	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0
QUARTILE		1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
4																
	Groundfish kept catch from IOP					10.2	19.9	5.7	9.3	4.3	2.6	46.9				
	Blue Shark discard catch from IOP					0.0	0.0	0.0	0.0	0.0	0.0	0.0				
	Blue Shark discard/groundfish kept ratio					0.00	0.00	0.00	0.00	0.00	0.00	0.00				
	Mean blue shark discard/groundfish kept ratio	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Groundfish catch from MARFIS	342	695	528	433	447	374	204	474	349	313	112	146	113	285	98
	Estimated Discard Blue Shark catch in groundfish fishery	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Table 3 – cont'd. Mean discard ratios of <0.005 have been rounded to 0 for display purposes only.

Groundfish OTB **DISCARDS (mt)**

QUARTILE		1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
1																
	Groundfish kept catch from IOP	1406.2	2112.0	318.4	681.3	884.2	1090.1	1553.3	558.4	263.9	1483.4	1342.2	1985.7	3001.8	1058.5	1939.6
	Blue Shark discard catch from IOP	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.1	0.0
	Blue Shark discard/groundfish kept ratio	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Mean blue shark discard/groundfish kept ratio	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Groundfish catch from MARFIS	4984	5762	8435	5992	10023	12032	10069	9173	9134	11631	10071	10676	11287	12235	11759
	Estimated Discard Blue Shark catch in groundfish fishery	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
QUARTILE		**1996**	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**
2																
	Groundfish kept catch from IOP	2378.6	503.5	758.0	953.4	1143.4	1796.5	1442.0	2159.4	1151.9	905.3	1361.7	2121.7	1365.7	1001.9	1218.5
	Blue Shark discard catch from IOP	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0
	Blue Shark discard/groundfish kept ratio	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Mean blue shark discard/groundfish kept ratio	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Groundfish catch from MARFIS	10427	11125	16562	12203	12160	14435	14724	11968	12499	11840	8661	10150	10155	10043	11217
	Estimated Discard Blue Shark catch in groundfish fishery	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
QUARTILE		**1996**	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**
3																
	Groundfish kept catch from IOP	1037.4	858.8	1090.3	1097.3	1214.1	1001.4	1013.9	842.6	869.2	1107.1	1445.9	6088.2	1291.6	1392.5	1394.2
	Blue Shark discard catch from IOP	0.1	0.0	0.1	0.1	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.6	0.0	0.0	0.2
	Blue Shark discard/groundfish kept ratio	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Mean blue shark discard/groundfish kept ratio	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Groundfish catch from MARFIS	31063	26004	20242	17501	12939	15593	15146	13332	13715	14441	13172	13309	12936	14547	13170
	Estimated Discard Blue Shark catch in groundfish fishery	**1**	**1**	**1**	**1**	**0**	**1**	**1**	**0**	**0**	**1**	**0**	**0**	**0**	**1**	**0**
QUARTILE		**1996**	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**
4																
	Groundfish kept catch from IOP	2142.9	637.2	1306.5	1322.9	909.3	823.1	658.2	619.2	441.1	148.9	1040.3	2015.1	1054.6	833.0	741.0
	Blue Shark discard catch from IOP	0.0	0.1	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Blue Shark discard/groundfish kept ratio	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Mean blue shark discard/groundfish kept ratio	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Groundfish catch from MARFIS	10119	7861	11582	10296	10137	12141	10078	9891	9163	8578	8673	8559	8440	9409	7728
	Estimated Discard Blue Shark catch in groundfish fishery	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**

Table 4. Summary of shark bycatch, discards and discard mortality by fishery, 1996-2010. Discard catch refers to discards which are either alive or dead, while post-release mortality refers to sharks which are discarded alive but subsequently die.

Discards (mt)

	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
Estimated Total Catch	1107	1324	1015	1036	980	591	330	257	336	314	293	181	209	134	161
Estimated Discard Catch	63	72	68	61	56	59	60	61	65	69	62	58	55	53	57
Estimated Post-release Mortality	32	36	34	31	28	30	30	30	32	35	31	29	27	26	29
Reported Landings	1014	1223	916	951	884	497	225	139	219	203	190	93	125	62	83
Estimated Total Catch	58	76	64	66	62	72	73	74	88	104	94	88	85	75	87
Estimated Discard Catch	17	21	20	19	18	20	21	20	23	27	24	23	22	20	23
Estimated Post-release Mortality	9	10	10	9	9	10	10	10	12	13	12	11	11	10	11
Reported Landings	60	101	57	53	55	57	67	66	70	86	67	69	44	49	38
Estimated Total Catch	844	1113	949	952	842	926	1192	1312	1501	1706	1615	1428	1323	1148	1422
Estimated Discard Catch	834	1100	942	945	832	917	1187	1308	1495	1696	1608	1422	1315	1142	1414
Estimated Post-release Mortality	292	385	330	331	291	321	416	458	523	594	563	498	460	400	495
Reported Landings	9	5	2	52	18	0	2	6	0	0	0	0	0	0	0

Discards (mt)

	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
Swordfish and Tuna LL	19	26	22	22	19	20	28	31	35	40	38	33	30	27	33
Porbeagle LL	8	11	10	10	9	7	2	1	2	2	1	1	1	0	0
Groundfish LL	4	4	4	3	3	3	3	3	2	2	2	3	3	2	2
Groundfish Gillnet	2	5	4	3	4	3	2	4	3	3	1	1	1	2	1
Groundfish OTB	29	27	29	23	21	26	25	21	22	22	19	20	20	21	21
Total	63	72	68	61	56	59	60	61	65	69	62	58	55	53	57
Swordfish and Tuna LL	9	12	10	11	10	12	13	13	16	19	18	16	15	13	16
Porbeagle LL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Groundfish LL	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Groundfish Gillnet	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0
Groundfish OTB	7	7	8	6	6	7	7	6	6	6	5	6	6	6	6
Total	17	21	20	19	18	20	21	20	23	27	24	23	22	20	23
Swordfish and Tuna LL	811	1073	915	919	809	894	1166	1288	1476	1678	1586	1401	1293	1123	1394
Porbeagle LL	3	4	3	4	3	2	1	0	1	1	1	0	1	0	0
Groundfish LL	19	22	21	20	19	19	19	19	16	17	20	20	20	17	19
Groundfish Gillnet	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0
Groundfish OTB	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Total	834	1100	942	945	832	917	1187	1308	1495	1696	1608	1422	1315	1142	1414

Table 5. Test of the assumption that the bycatch weight ratio estimator using the observed shark bycatch relative to the summed observed swordfish/tuna weight can be used to provide an accurate indicator of total species bycatch. Estimated shortfin mako retained catch from all sources and fisheries (using the bycatch ratio) averages 90% of total reported landings.

	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
Estimated kept + discards	58	76	64	66	62	72	73	74	88	104	94	88	85	75	87
Estimated discards	17	21	20	19	18	20	21	20	23	27	24	23	22	20	23
Estimated kept	41	55	45	47	45	52	53	53	65	78	70	65	63	55	65
Total reported landings	60	80	71	69	62	70	79	66	70	85	67	69	44	49	38
Proportion: estimated kept to reported landings	**0.7**	**0.7**	**0.6**	**0.7**	**0.7**	**0.7**	**0.7**	**0.8**	**0.9**	**0.9**	**1.0**	**0.9**	**1.4**	**1.1**	**1.7**

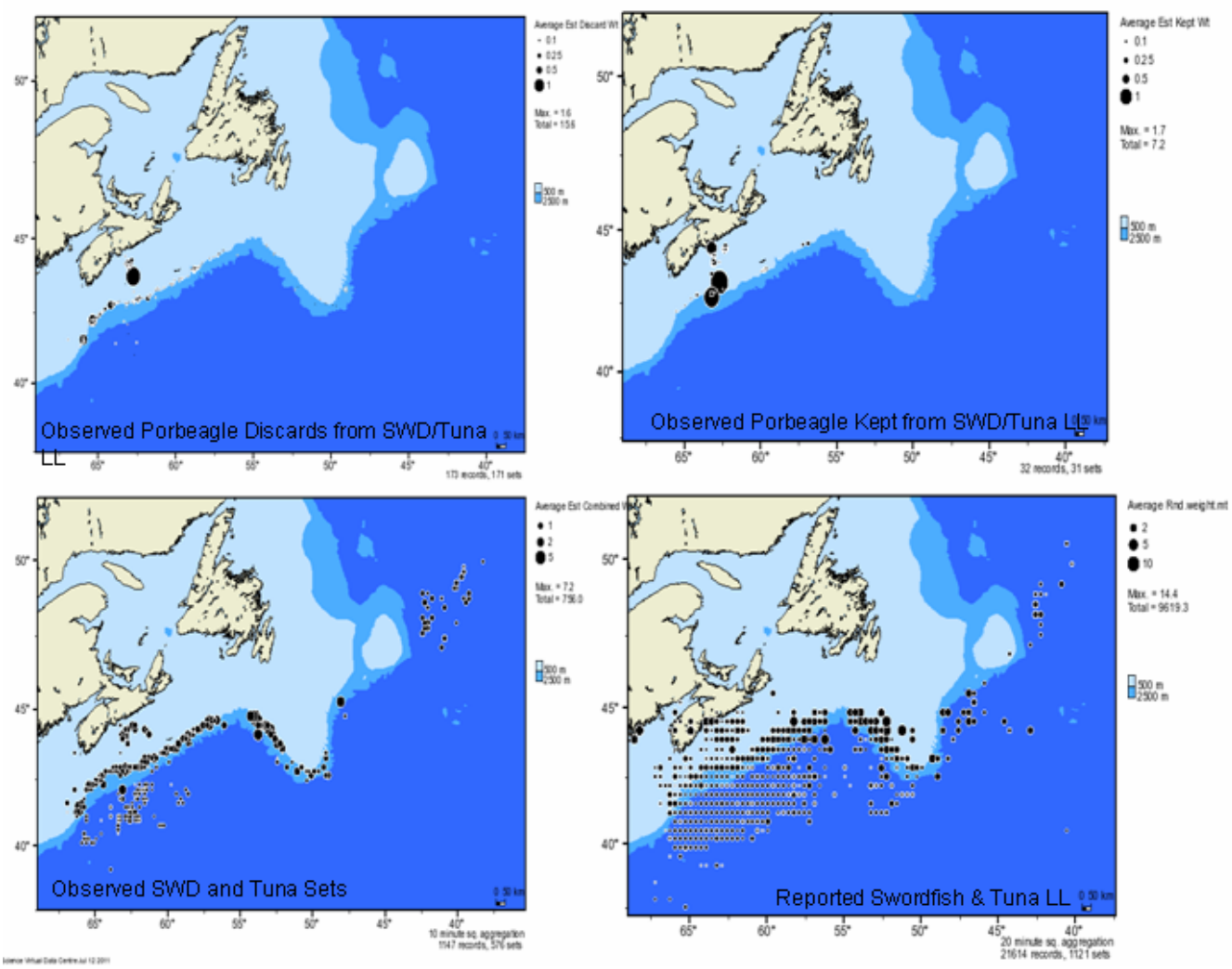


Fig. 1. Spatial distribution of observed porbeagle catch and discards compared to that of the commercial fishery for swordfish and tuna, 3rd quarter 2003-2010. Porbeagle discards appear to be spatially restricted compared to the overall fishery.

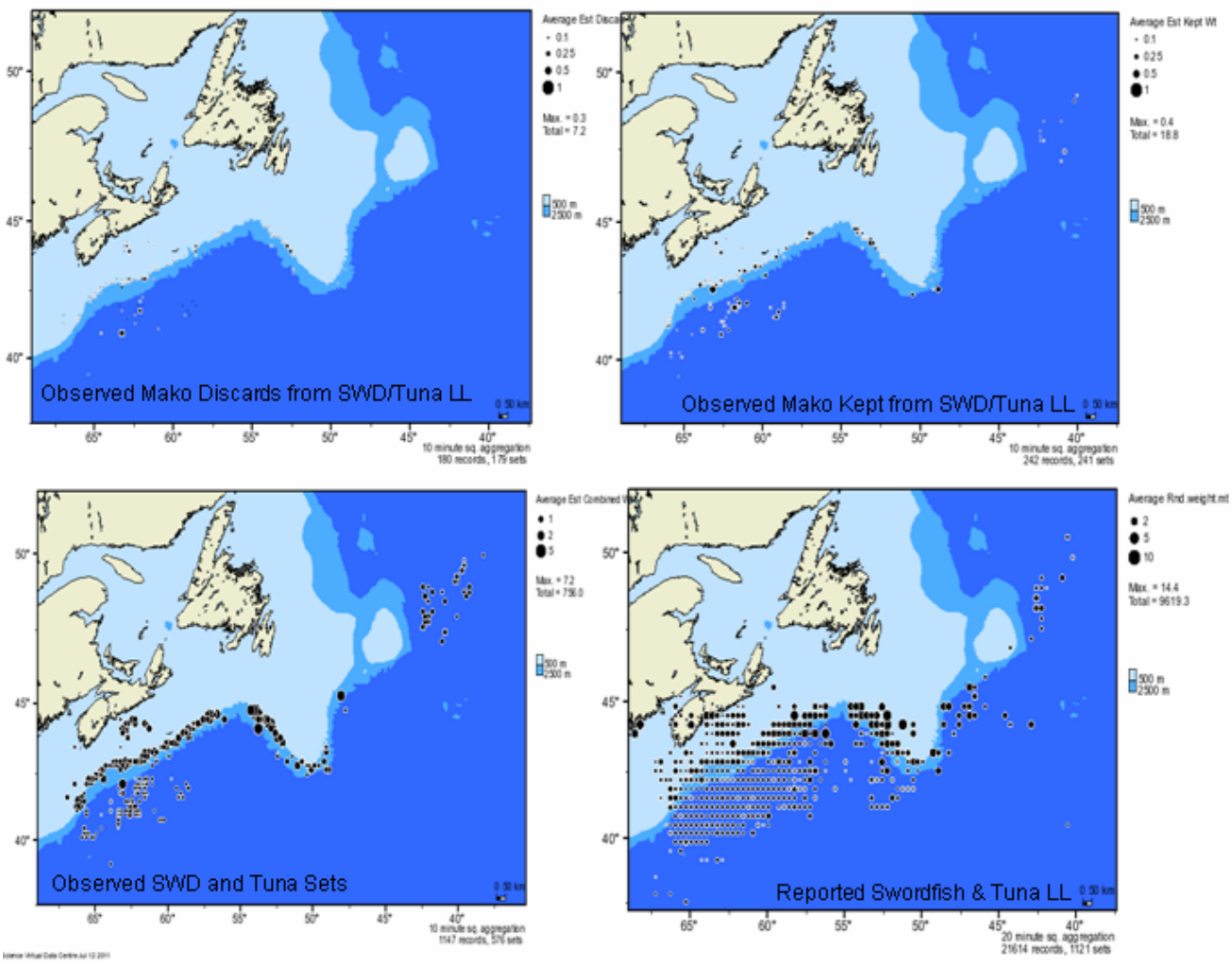


Fig. 2. Spatial distribution of observed shortfin mako catch and discards compared to that of the commercial fishery for swordfish and tuna, 3rd quarter 2003-2010. Mako discards appear to be broadly representative of the overall fishery.

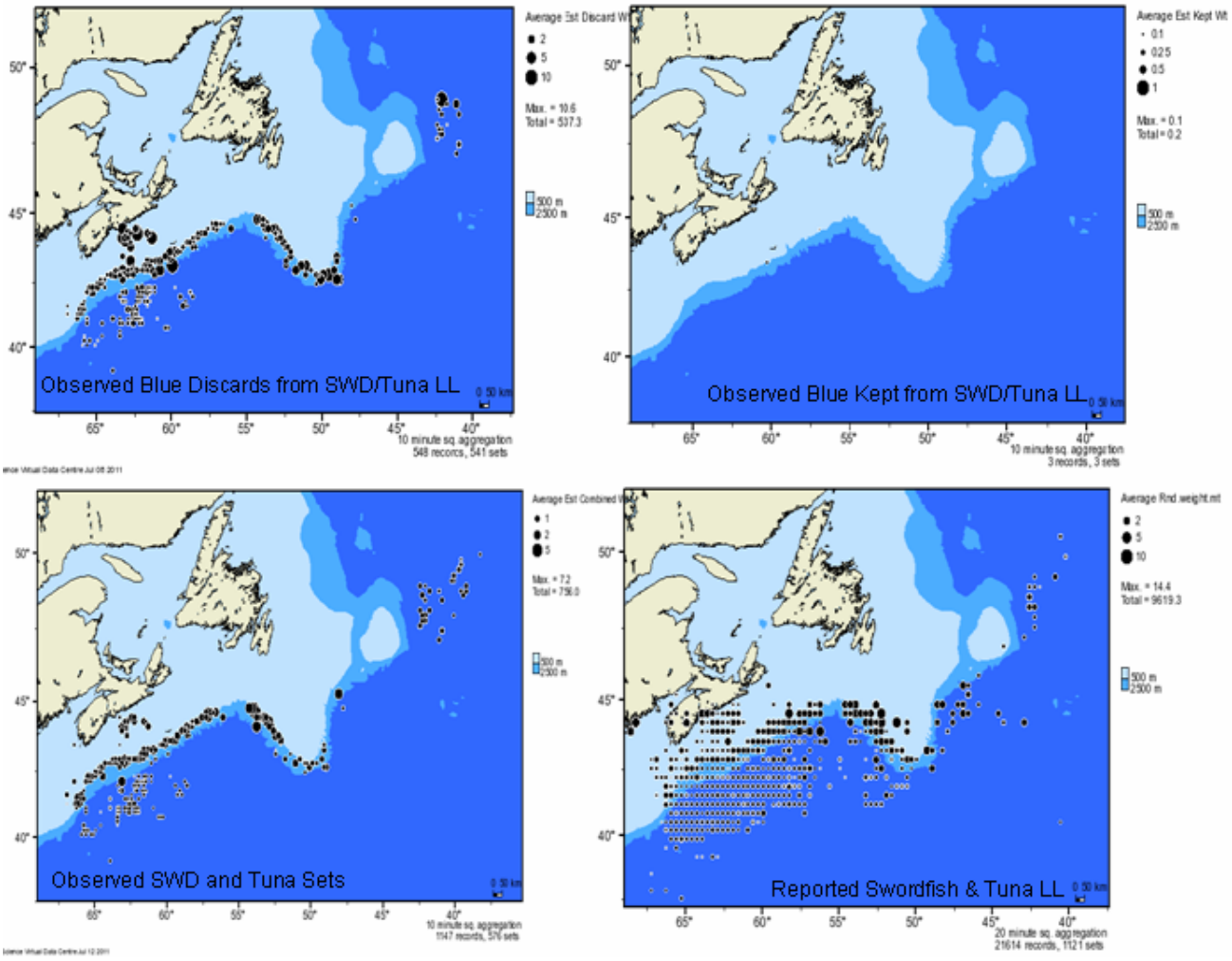
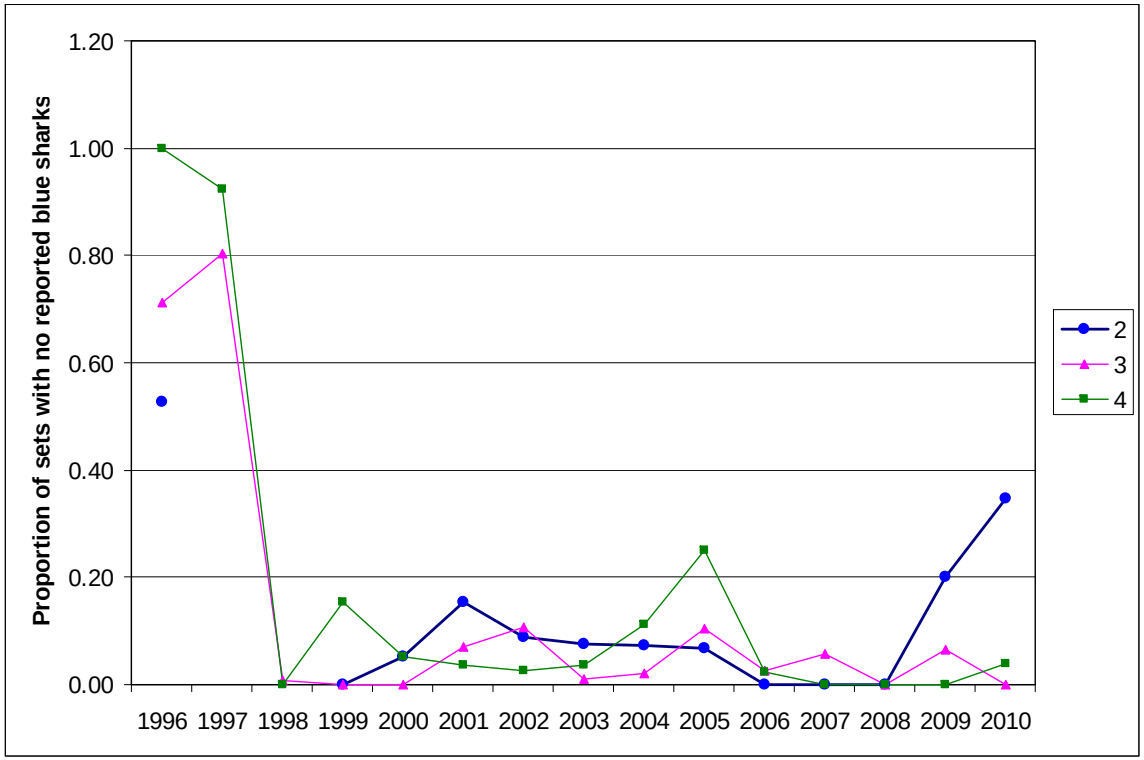


Fig. 3. Spatial distribution of observed blue shark catch and discards compared to that of the commercial fishery for swordfish and tuna, 3rd quarter 2003-2010. Blue shark discards appear to be spatially restricted compared to the overall fishery.



Ratio of 0 sets (no blue shark to tot num sets by year and quarter, directed LL)

Quarter		1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
2	Tot 0 sets (no blue shark)	20			0	1	4	6	1	2	1	0	0	0	2	8
	Tot # sets	38			1	19	26	67	13	27	15	12	10	4	10	23
	ratio (0/total)	0.53			0.00	0.05	0.15	0.09	0.08	0.07	0.07	0.00	0.00	0.00	0.20	0.35
3	Tot 0 sets (no blue shark)	99	139	1	0	0	11	23	1	1	9	2	4	0	7	0
	Tot # sets	139	173	133	40	39	159	215	92	46	87	79	71	45	108	61
	ratio (0/total)	0.71	0.80	0.01	0.00	0.00	0.07	0.11	0.01	0.02	0.10	0.03	0.06	0.00	0.06	0.00
4	Tot 0 sets (no blue shark)	7	12	0	9	3	4	2	1	1	1	1	0	0	0	1
	Tot # sets	7	13	31	58	57	112	78	27	9	4	43	7	3	5	25
	ratio (0/total)	1.00	0.92	0.00	0.16	0.05	0.04	0.03	0.04	0.11	0.25	0.02	0.00	0.00	0.00	0.04

Fig. 4. Proportion of observed sets in each quarter of the large pelagic fishery for swordfish/tuna in which the observer reported zero blue sharks, 1996-2010. The high proportion in the early years of the time series suggests that the assumption of all sharks being reported does not appear to be met for the years prior to 1998.

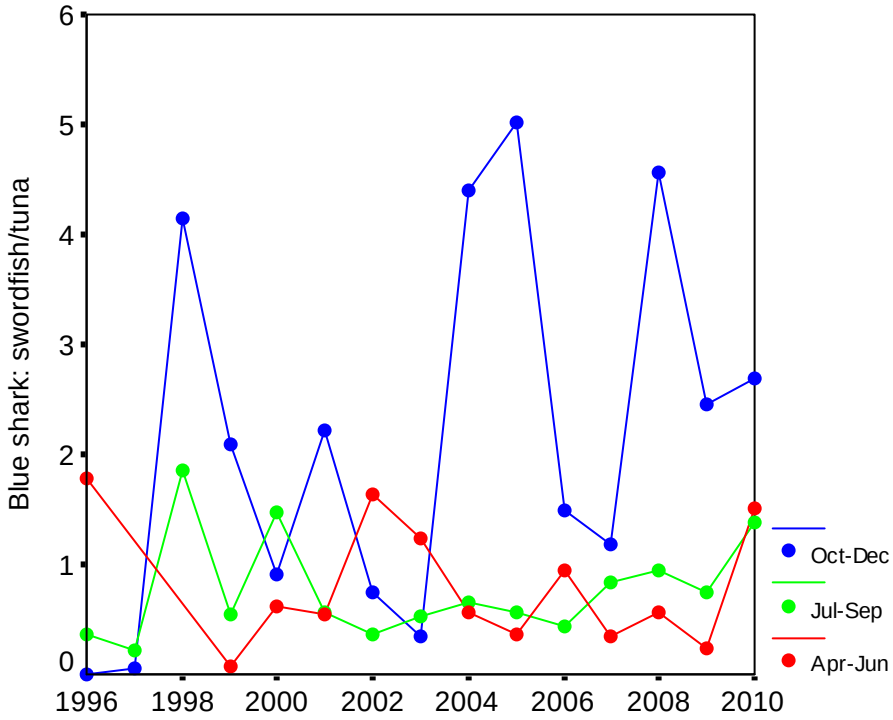


Fig. 5. Bycatch ratio of blue sharks to targeted swordfish/tuna in observed sets by quarter, 1996-2010. The absence of a trend after 1998 suggests that the use of combined swordfish+tuna in the bycatch ratio is not confounded by a long-term shift towards a tuna fishery characterized by fewer blue sharks than in the swordfish fishery.