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Assessment of the Recovery Potential of Shortfin Mako Sharks in Atlantic Canada

Évaluation du potentiel de rétablissement du requin-taupe bleu au Canada atlantique

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ABSTRACT

International indices indicate that shortfin mako (*Isurus oxyrinchus*) population abundance in the North Atlantic has declined since the 1970s, but has been relatively stable since the late 1980s. Catch rate statistics from the Canadian pelagic longline fleet also indicated relatively stable bycatch rates since the late 1980s, but analysis of median size trends suggests there has been a decline in the abundance of larger shortfin makos in the Canadian fishery since 1998. Reference points to characterize recovery have not been developed for shortfin mako, but one half the virgin spawning stock biomass (SSB_0) is proposed as a potential target. Canadian catch accounts for only a small percentage (at most 2-3%) of the North Atlantic catch, indicating that bycatch by foreign fleets in the North Atlantic is the most significant source of mortality for the population. Thus, international efforts will be needed to reduce cumulative impacts and promote recovery. Live release of makos and a maximum annual catch limit of 100t are precautionary measures that could be used to reduce mortality. Uncertainty around estimates of the current population size and trajectory is the main reason that population abundance relative to the recovery target is poorly estimated. Monitoring shortfin mako population status in Canadian waters through a fishery-independent shark survey is recommended as a means for obtaining more accurate population estimates.

RÉSUMÉ

Les indices internationaux indiquent que l'abondance de la population de requins-taupes bleus (*Isurus oxyrinchus*) dans l'Atlantique Nord a décliné depuis les années 1970, mais qu'elle est restée relativement stable depuis la fin des années 1980. Les statistiques sur les taux de prises par la flotte canadienne de palangriers pélagiques indiquent également un taux de prises accessoires relativement stable depuis la fin des années 1980, mais des analyses des tendances relatives à la taille moyenne donnent à penser qu'il y a eu un déclin de l'abondance des plus gros requins-taupes bleus dans les pêches canadiennes depuis 1998. On n'a pas élaboré de points de référence permettant de caractériser le rétablissement du requin-taupe bleu, mais la moitié de la biomasse du stock reproducteur vierge (SSB0) est proposée comme une cible potentielle. Les prises canadiennes ne représentent qu'un faible pourcentage (au mieux 2 à 3 %) de l'ensemble des prises dans l'Atlantique Nord, ce qui indique que les prises accessoires par des flottes étrangères dans cette région de l'océan sont la source de mortalité la plus importante pour la population. Ainsi, il faudra consentir des efforts internationaux pour réduire les impacts cumulatifs et promouvoir le rétablissement de l'espèce. Le repeuplement et une limite annuelle maximale de prises de 100 t sont des mesures de précaution qui pourraient être utilisées pour réduire l'effet de la mortalité. La raison principale pour laquelle l'abondance de la population par rapport à la cible de rétablissement est mal estimée est l'incertitude entourant les estimations de la taille actuelle de la population et sa trajectoire. On recommande de suivre l'état de la population de requins-taupes bleus dans les eaux canadiennes par l'intermédiaire d'un relevé indépendant des pêches, lequel nous permettra obtenir des estimations plus précises de la population.

INTRODUCTION

The shortfin mako shark (*Isurus oxyrinchus)* is a large temperate and tropical pelagic shark species of the family Lamnidae that occurs in the Atlantic, Pacific and Indian oceans. In Canadian waters, the shortfin mako shark is most closely associated with warm waters such as in and around the Gulf Stream. It has been recorded from Georges and Browns Bank, along the continental shelf of Nova Scotia, the Grand Banks and even into the Gulf of St. Lawrence (Templeman 1963). In Canadian waters these sharks are not abundant, due to their preference for warm waters, but neither are they uncommon. The species is highly migratory, with tagging results suggesting that there is a single well-mixed population in the North Atlantic (Casey and Kohler 1992). Atlantic Canada represents the northern extension of their range, and most of their population is believed to reside in more temperate waters.

The status of the mako shark population in Canadian waters was assessed for the first time in 2004 (Campana et al. 2004, 2005). Non-restrictive catch guidelines of 250t have been in place since 1995, but these guidelines were not based on any scientific advice. O'Boyle et al. (1996) provided a brief summary of catches. Based on an analysis of U.S. pelagic longline logbooks fishing outside of Canadian waters, Baum et al. (2003) suggested that the North Atlantic population had declined since 1986. An initial attempt to prepare a North Atlantic-wide stock assessment of shortfin makos also suggested that the population may have declined, but the assessment was hampered by poor data quality, and the conclusion was considered to be very provisional (ICCAT 2005a). The most recent stock assessment for shortfin makos in Atlantic Canadian waters concluded that makos in Canada represent the margins of the distribution of the population, and are fished most heavily outside of the Canadian EEZ (Campana et al. 2004, 2005). Given the bycatch nature of the fishery in Canada, it appeared unlikely that current exploitation rates in Canada were having an appreciable impact on the population. Nevertheless, there were some signs that the population was declining in abundance, implying that continued monitoring was warranted.

In April 2006, the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) designated the shortfin mako as Threatened, and recommended that it be listed under Schedule 1 of Canada's Species at Risk Act (SARA). If listed, activities that would harm the species would be prohibited and a recovery plan would be required. Before the listing decision is made, decisions on permitting incidental harm and in support of recovery planning need to be made.

The present document provides an up-to-date summary of current population status and recovery potential for shortfin mako. The basis for the document is an analysis of available data to the end of 2005, including an evaluation of population status in international waters. The document concludes by identifying sources of human-induced mortality for which incidental harm permits could be considered.

Species Biology

Shortfin mako (*Isurus oxyrinchus*) is one of two shark species in the genus *Isurus* and one of five species in the family Lamnidae or mackerel sharks. Since longfin makos are rare in Canadian waters, misidentifications within the genus have probably been minimal, but in Atlantic Canada, shortfin makos have at times been misidentified as porbeagle shark.

Microsatellite DNA studies on shortfin makos suggest that populations observed on both the Atlantic and Pacific coast of Canada comprise part of a global population, whereas mitochondrial DNA research suggests sex-biased dispersal. Schrey and Heist (2003) concluded that females are likely more philopatric based on differences in the maternally inherited mtDNA and that males disperse more widely based on weak differentiation in nuclear DNA markers. Although evidence is not fully conclusive for shortfin makos, this sort of sex-biased dispersal has been reported for other shark species.

Shortfin makos are known to migrate over long distances throughout the north Atlantic. A Canadian study conducted between 1961 and 1980 (Burnett et al. 1987) revealed that some mako sharks migrate between continental shelf and offshore waters, and between Canadian and U.S. waters. A more extensive study conducted by the U.S. National Marine Fisheries Service (NMFS) between 1962 and 1993 also found that shortfin makos migrate over long distances (>500 km; Kohler et al. 1998) (Figure 1). In Canadian Atlantic waters, the shortfin mako is typically associated with warm waters such as those associated with the Gulf Stream (Figure 2). They have been recorded from Georges and Browns Bank, along the continental shelf of Nova Scotia, the Grand Banks off Newfoundland and into the Gulf of St. Lawrence (Templeman 1963). Shortfin makos in Atlantic Canada are considered to make up no more than 2-3% of the Atlantic population (which is the Designatable Unit (DU)).

Shortfin makos prefer temperate to tropical waters with temperatures between 17-22°C. They occur from the surface to 500 m depths and typically well offshore, but shortfin makos have occasionally been observed in littoral zones. They feed on fish and marine mammals.

Shortfin makos are ovoviviparous and have a 15-18 month gestation period and an estimated 3 year parturition cycle. Females give birth to an average of 11 young every 3 yr. Males reach sexual maturity in 7-9 yr at lengths between 2.0-2.2 m, but females do not mature until they are 19-21 yr old and between 2.7 – 3.0 m in length. Growth rate is moderate compared to other shark species (Figure 3). These life history characteristics imply that makos are somewhat more productive as a species than are porbeagle, but less productive than blue sharks. Mature females and young of the year are rarely caught in Canadian waters (Figure 4).

The longevity of shortfin makos in the Northwest Atlantic has been demonstrated to be at least 24 years (Campana et al. 2002), with a theoretical maximum age as high as 45 years (Cailliet and Bedford 1983). The instantaneous rate of natural mortality has been estimated at 0.16 and estimated generation length is at least 14 years.

ASSESSMENT AND ANALYSIS

<u>Stock Trends and Current Status</u>

There are no shark surveys or fishery-independent surveys for shortfin mako in Canadian waters. Therefore, all abundance indices are based on data from commercial or recreational fisheries.

Previous research into shortfin mako abundance trends in Canadian waters was limited to a single study by Campana et al. (2004). This earlier catch rate series was modified slightly (analyzed at the trip level, rather than the set level) and then updated to 2005 for the purposes of this assessment. The standardized catch rate model (gamma error distribution) was based on observer data of Japanese pelagic longline fisheries targeting bigeye tuna on the Scotian Shelf in the fourth quarter between 1987 and 1999, and Canadian commercial logbook data from swordfish-directed sets on the Scotian Shelf in the third quarter between 1996 and 2005, where at least one mako was recorded within a trip. The standardized catch rate index showed no evidence of a significant change in abundance between 1988 and 2005 (Figure 5). However, due to small sample size and high variance, this analysis would have been unable to detect anything other than a severe change.

The time series of median size of shortfin mako in the Canadian catch was used as an indicator of the degree of exploitation (Campana et al. 2004). A plot of median fork length from 1986 through 1996 indicated a gradually and significantly increasing trend ($r^2 = 0.58$, $p < 0.01$) in the Japanese fishery (Figure 6). However, there were insufficient data to extend the Japanese trend beyond 1996. In the Canadian fishery, the median size of shortfin makos in the Atlantic Canadian fishery declined between 1998 and 2005, albeit non-significantly ($p>0.10$). When the 1996 and 1997 outliers are excluded, the decline in median fork length is statistically significant ($p<0.05$). Since there is little overlap in the time series for the two countries, it is difficult to determine if the disparate trends reflect targeting of different groups of shortfin mako or a real change in trend. However, the recent decline in the mean size in the Canadian fishery suggests a decline in abundance of larger shortfin makos.

The number and distribution of shortfin makos in Canadian waters varies seasonally due to seasonal migrations. Summing across the annual distributional range (Gulf of Maine, Scotian Shelf, southern Newfoundland, Gulf of St. Lawrence) gives a total area of potentially occupied waters in Canada of about 1,200,000 km^2. The current area of occupancy, represented by frequent sightings or captures, is probably less than 800,000 km^2 (Figure 2). There is no suggestion of a change in extent of occupancy or occurrence since 1989, nor is there evidence suggesting a fragmentation of the population (Campana et al. 2004). There are no known breeding areas in Canadian waters. Although an estimate of the proportion of mature animals in Canadian waters has been derived (Wallace et al. 2005), there are no reliable means for estimating the total abundance of mature individuals in Canadian waters, as the total population in Canadian waters is unknown.

Because shortfin mako in Atlantic Canadian waters represent the margins of their distribution, catch rate trends in Canadian waters may be influenced by factors other than abundance. For this reason, analyses representing a larger spatial scale present a more accurate picture of the population. Pelagic longline catch rates in the Northwest Atlantic based on U.S. logbooks suggested a 40% decline in abundance since 1986 (Baum et al. 2003) (Figure 7). However, this trend needs to be interpreted with caution because the analysis was not based on the full range of available international data (Burgess et al. 2005).

An ICCAT analysis of catch rate trends from several countries in the North Atlantic concluded that shortfin mako abundance may have declined by about 35% between 1971-2003 (ICCAT 2005) (Figure 8). Current spawning stock biomass relative to pre-exploitation conditions (SSB/SSB_0) was estimated to be about 0.32 (ICCAT 2005b), below the 0.50 level that would be expected at maximum sustainable yield (MSY). Due to concerns over the quantity and quality of the information that was available, the assessment was described as very preliminary and the current status uncertain (ICCAT 2005b).

Recovery Targets

Reference points to characterize recovery have not been developed for shortfin mako. One possible recovery target is that proposed by ICCAT (2005b): one half the virgin spawning stock biomass (SSB_0). Although this is a very cautious recovery target, and there is large uncertainty associated with virgin biomass estimates, it is consistent with the Cautious-Healthy boundary of the Precautionary Approach Framework being established by the Department of Fisheries and Oceans (Department of Fisheries and Oceans 2005).

Recovery Potential

Based on life history characteristics, the recovery potential of shortfin makos appears to be better than that of porbeagle, but not as good as that of blue shark.

Given the small percentage (at most 2-3%) of the population in Canadian waters, recovery targets will not be reached without a reduction in shortfin mako bycatch by international fisheries (e.g., Spain, Portugal, U.S.). Effort in the Canadian pelagic longline fishery has not increased as it appears to have elsewhere in the North Atlantic (Figure 9); although Canadian effort peaked in the mid-1990s, it has been declining steadily to the present and is currently near the lowest levels observed since 1994 (Figure 10). The low fishing effort in the 1970s and 1980s was due to concerns about mercury levels in swordfish.

It appears unlikely that a reduction in bycatch of shortfin makos by the Canadian pelagic longline fishery would have any detectable or biologically significant influence on the population. The percentage of the total North Atlantic mako catch accounted for by the Canadian fishery has declined since 1995 and is now only about 2% (Figure 11). International efforts to reduce cumulative impacts are required to promote recovery.

Sources of Uncertainty

Although it is known to be small, the percentage of the mako population found in Canadian waters is unknown. The relationship between abundance trends in Canadian waters and overall population abundance is also unknown.

In the absence of historical baseline population abundance information, it is difficult to estimate recovery targets.

There is considerable uncertainty around estimates of the current population size and trajectory. Population abundance relative to the recovery target is poorly estimated.

Although mako sharks are suspected to have high levels of contaminants in their tissues, the effects of these contaminants are unknown.

ALLOWABLE HARM / PROVISIONS OF RECOVERY PLAN

High exploitation rate is the only known cause for the apparent decline in shortfin mako population abundance.

There is no directed fishery for shortfin makos in Canadian waters. Landings reported from Canadian vessels have averaged between 70t and 80t per year from 1998 to 2004, with a slight increase to 96t in 2005 (Table 1). Mako typically make up less than 2-3% of the pelagic longline catch by weight, with relatively little discarding. Most Canadian bycatch is taken by Scotia-Fundy vessels in pelagic longline fisheries for swordfish and fixed gear groundfish fisheries (Tables 2 and 3). Since 1999, there have been no international longline fisheries in Canadian waters. Recreational catches of shortfin makos are minor with only a few sharks landed per year.

Nominal landings of shortfin makos in the North Atlantic averaged about 2900 t annually since 1997 (Table 1). These landings are believed to be underestimates due to underreporting by some foreign fleets. Thus, the Canadian catch is at most 2-3% of the total.

Estimates of allowable harm could not be calculated. Both catches and fishing effort by the Canadian pelagic longline fishery peaked in the mid-1990s, with no apparent effect on population status. However, it would be prudent not to exceed the roughly 100t average catch of these years. Catch levels at or below these values are unlikely to have a detectable or biologically significant effect on population recovery. However, live release of all commercially-captured makos would be an obvious precautionary measure to reduce mortality. There are neither mating areas nor nursery grounds in Canadian waters, so there are no sensitive habitats to protect.

As top predators, shortfin makos bioaccumulate chlorinated hydrocarbons and other contaminants in their tissues. Although it is possible that these contaminants are having an adverse effect on mako shark physiology, our understanding is insufficient to suggest a means through which this contaminant load could be minimized.

Currently, the ability to monitor population status is dependent upon commercial catch rates, which is a fishery-dependent activity. A fishery-independent shark survey could provide an index of abundance for makos and other sharks and thus assist in the monitoring of population recovery. Such a survey would also detect any changes in the proportion of the mako population resident in Canadian waters.

CONCLUSIONS AND ADVICE

Population abundance in the North Atlantic has declined since the 1970s, but has been relatively stable since the late 1980s. Trends in median size indicate that there has been a decline in abundance of larger shortfin makos in the Canadian fishery since 1998.

Shortfin mako bycatch by foreign fleets in the North Atlantic are the most significant source of mortality for the population. While it is unlikely that a reduction in bycatch of shortfin makos by the Canadian pelagic longline fishery would have any detectable or biologically significant influence on the population, it would be prudent not to exceed 100t annually. International efforts to reduce cumulative impacts are required to promote recovery.

As a precautionary measure, commercially-caught makos could be released alive as a measure to reduce mortality.

Monitoring of mako population status in Canadian waters would require a fishery-independent shark survey, plus length and sex measurements of the catch.

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Table 1. Reported mako shark landings (mt) by country.

	Canadian Atlantic (NAFO Areas 2 - 5)					Northwest Atlantic				North Atlantic
Year	Canada	Faroe Is	Japan	Other	Total	Japan	USA	Other	Unspecified pelagic sharks	
1979			0		0					
1980		2	0		2					
1981			1		1					
1982			0		0	226				
1983			5		5	85				
1984			1		1	213				
1985						214				
1986			2		2	231				
1987			10		10	232				
1988		0	17		18	168				
1989		1	13		14	176				
1990		5	8		13	140	268			601
1991		2	14		16	198	210			712
1992		2	29		31	345	250			835
1993	4	0	16		20	553	824			2273
1994	142		21		164	450	508			1685
1995	111		4		115	397	1574			2840
1996	67		5		72	252	342	1		1287
1997	110		2		112	100	332	1		3432
1998	71		1	0	72	107	145	2		2878
1999	70		2		72	123	69	3		2625
2000	79				79	83	290			2349
2001	70				70	116	360			2620
2002	79			1	79		388			2939
2003	74				74		114	10		3519
2004	81				81		219	186		2916
2005	96				96	na	na	na		na

Notes: Canada is from DFO Zonal Statistics File, except for 2003-2005 where SF is from MARFIS plus other regional data
Japan, Faroes, other countries in Canadian Atlantic are from Scotia-Fundy & NF IOP (excludes discards)
NW Atlantic landings from countries other than Japan are from ICCAT statistics for area 92
Japan in NW Atlantic represents nominal catch of unspecified sharks and rays from FAO Statistics (2001)
North Atlantic landings from ICCAT statistics for Atlantic Shark Stock (1990-2005) including sport and rod and reel catches,
Japanese catches from FA0 Statistics (2001) used for North Atlantic totals when unreported in ICCAT database (all years except 1996 and 1997)

Table 2. Canadian mako shark landings (mt) by fishery.

Year	Porbeagle fishery	Swordfish fishery	Tuna fishery	Unspecified pelagic fishery	Groundfish bycatch	Fishery not recorded	Mako Total
1991	0	0	0	0	0	0	0
1992	0	0	0	0	0	0	0
1993	0	0	0	0	3	0	3
1994	0	63	5	49	14	11	141
1995	0	56	9	23	20	3	112
1996	1	33	7	13	10	3	67
1997	2	53	14	21	15	4	109
1998	0	40	5	7	18	0	70
1999	1	34	7	8	21	0	71
2000	0	30	15	10	24	0	79
2001	0	33	15	7	15	0	70
2002	0	32	13	11	22	0	78
2003	0	49	8	2	15	0	74
2004	1	45	18	0	18	0	81
2005	0	56	13	1	25	0	96

1991 - 2002 from ZIF
2003 - 2005 SF from MARFIS plus other regional data

Table 3. Canadian landings (mt) of mako shark by fishing gear, area and year.

Year	Region	Longline	Handline	Gillnet	Otter trawl	Other	Derby	Subarea total	Annual total
1993	Scotia-Fundy			0.3				0	4
	NF	1.1		2.3		0.1		4	
	Quebec							0	
	Gulf							0	
1994	Scotia-Fundy	117.6	2.3	9.5	1.7	0.1		131	142
	NF	6.5		4.5				11	
	Quebec		0.2					0	
	Gulf							0	
1995	Scotia-Fundy	88.0	0.2	13.4	0.7	0.5		103	111
	NF	5.9		2.4				8	
	Quebec							0	
	Gulf	0.1						0	
1996	Scotia-Fundy	50.5	0.3	7.8	1.0			60	68
	NF	5.6		2.3				8	
	Quebec						0.0	0	
	Gulf							0	
1997	Scotia-Fundy	90.2	0.2	9.3	1.5			101	110
	NF	4.0		4.0	0.1			8	
	Quebec							0	
	Gulf	0.2						0	
1998	Scotia-Fundy	46.2	0.2	8.0	2.2	0.6		57	71
	NF	9.5		4.0				14	
	Quebec							0	
	Gulf	0.2						0	
1999	Scotia-Fundy	45.8		4.8	1.8	0.7		53	70
	NF	7.8	0.1	9.2	0.1			17	
	Quebec	0.0						0	
	Gulf	0.1						0	
2000	Scotia-Fundy	48.2	0.1	5.3	0.4	0.8		55	80
	NF	10.7		12.9	0.1	0.5		24	
	Quebec	0.0					0.3	0	
	Gulf	0.1					0.2	0	
2001	Scotia-Fundy	51.2	0.2	5.2	0.2	0.4		57	70
	NF	8.6		3.6	0.1			12	
	Quebec	0.0	0.1	0.2		0.0		0	
	Gulf	0.0				0.1		0	
2002	Scotia-Fundy	54.3	0.3	9.8	0.8	1.3		67	79
	NF	6.4	0.1	4.5				11	
	Quebec			0.1				0	
	Gulf	0.8		0.2		0.1	0.7	2	
2003	Scotia-Fundy	57.6	0.2	6.8	0.5	1.4		67	74
	NF	6.0		1.4		0.1		8	
	Quebec	0.0						0	
	Gulf							0	
2004	Scotia-Fundy	62.1	0.2	6.8	0.1	1.0		70	81
	NF	8.0		3.0				11	
	Quebec							0	
	Gulf	0.2						0	
2005	Scotia-Fundy	71.3	0.5	11.9	0.9	0.9		86	96
	NF	5.3		4.4	0.1			10	
	Quebec							0	
	Gulf	0.4						0	

1991 - 2002 from ZIF
2003 - 2005 SF from MARFIS plus other regional data

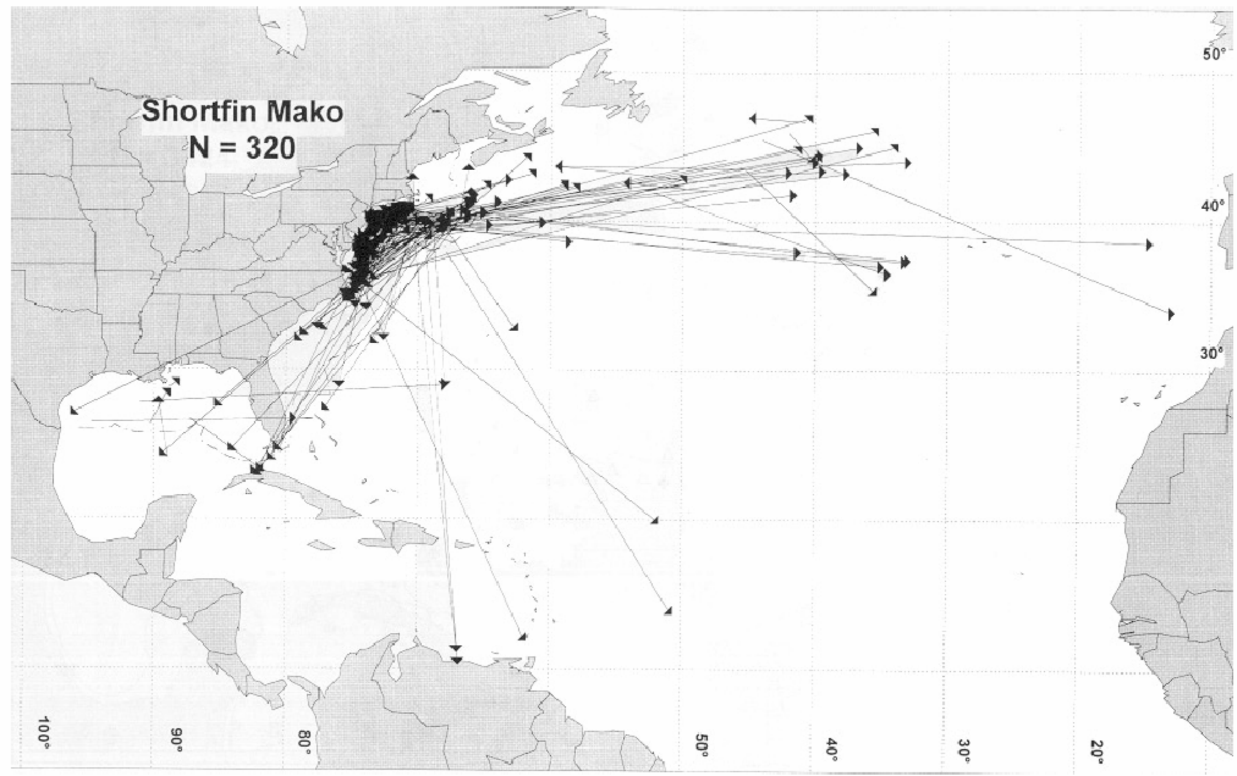

Figure 1. Recaptures of shortfin makos tagged by the NMFS Shark Tagging Program. Figure adapted from Fig. 38 of Kohler et al. (Mar. Fish. Rev. 60:1-87 (1998)).

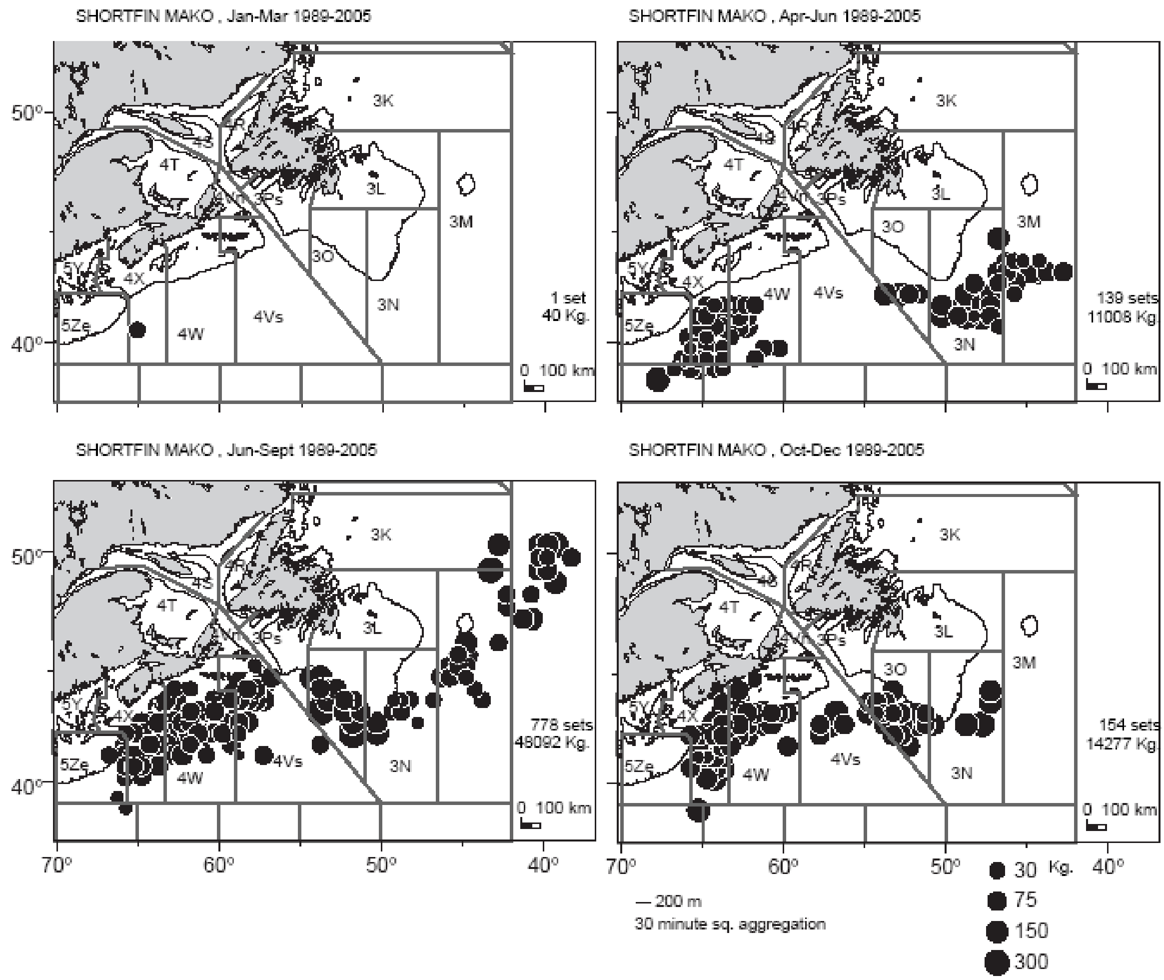

Figure 2. Distribution of shortfin mako in Atlantic Canada based on recorded catch (kg) from the International Observer Program database by quarter from 1989 to 2005. The 200 m depth contour is shown.

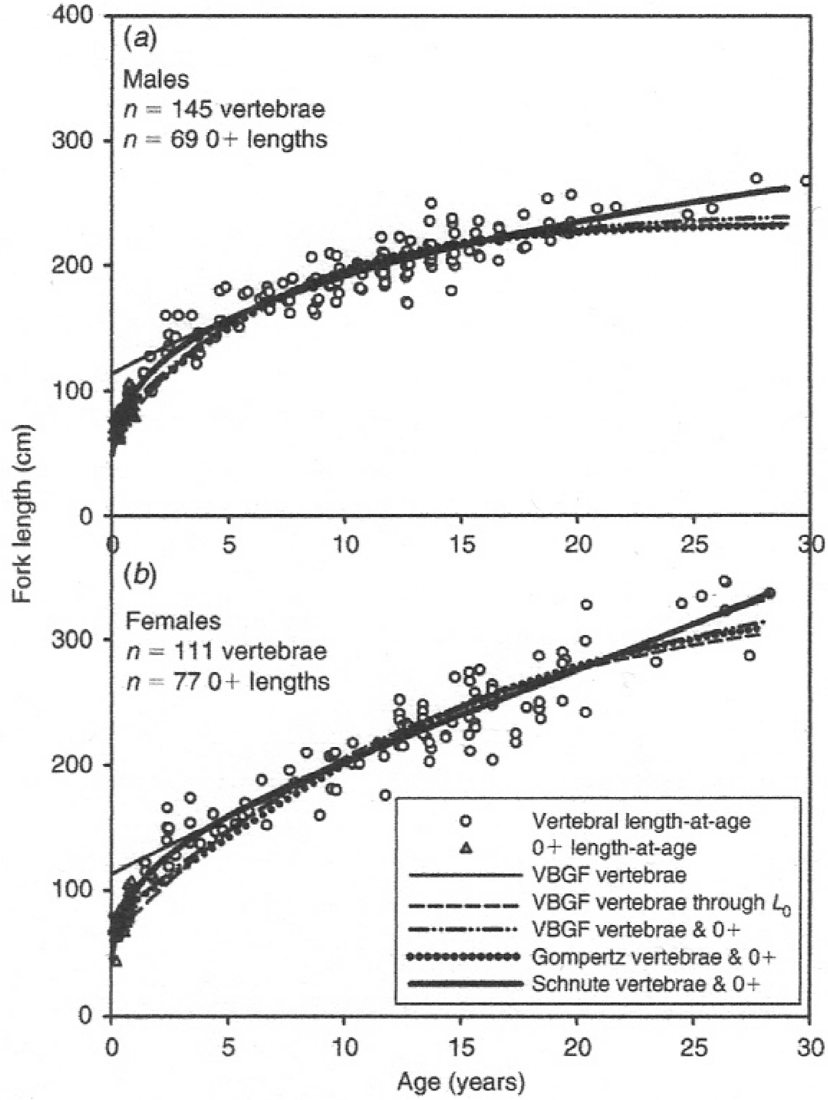

Figure 3. Growth curves fitted to length-at-age data fitted derived from vertebrae and known age 0+ sharks for (a) male and (b) female shortfin mako sharks;VBGF = von Bertalanffy growth model (from Bishop et al. 2006).

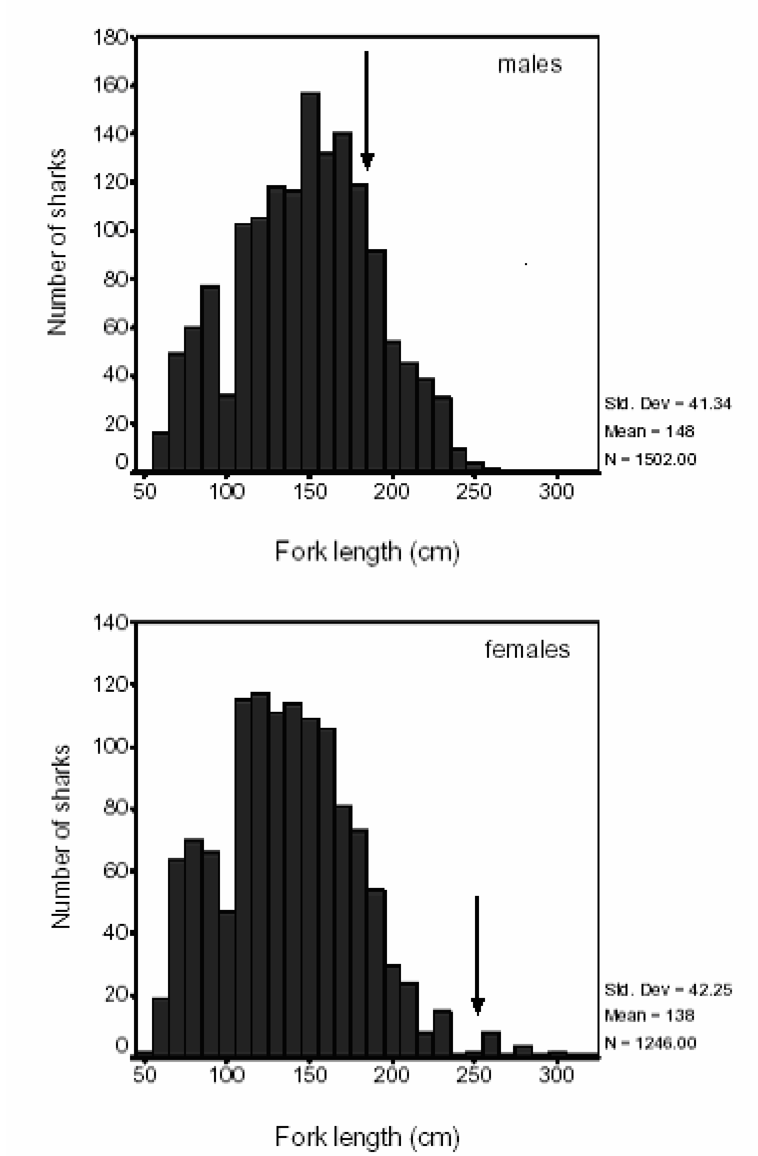

Figure 4. Length frequency histograms of male and female shortfin mako sharks (year, area and season combined) from Observer data collected from 1979-2002 from the waters around Newfoundland, the Scotian Shelf, and off southern Nova Scotia. Length at maturity (fork length) for females is between 250-280 cm and males 185-205 cm. Arrow represents minimum length at maturity. Figure from Campana et al. (2004).

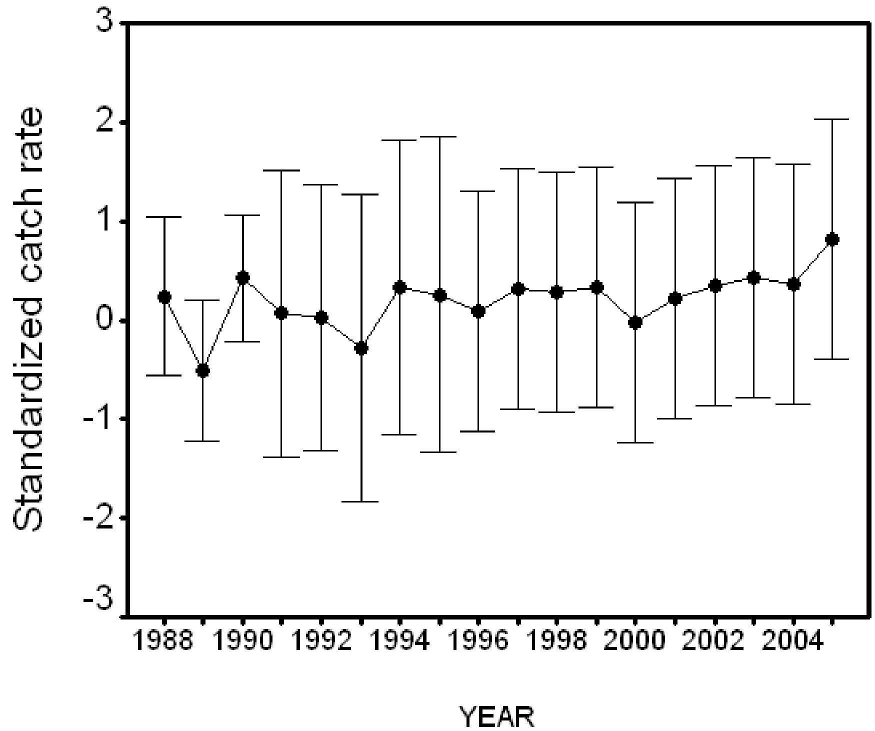

Figure 5. Standardized trip-level catch rate (kg/hook) of shortfin mako sharks caught by pelagic longliners on the Scotian Shelf between 1988 and 2005. Data were restricted to Japanese longliners targeting bigeye tuna between Oct-Dec of 1987-99 and Canadian longliners targeting swordfish between July-Sept of 1996-2005. The GLM model was fit to non-zero trips using a gamma error distribution and with Year and Vessel as factors. Error bars represent 1 SE around the mean.

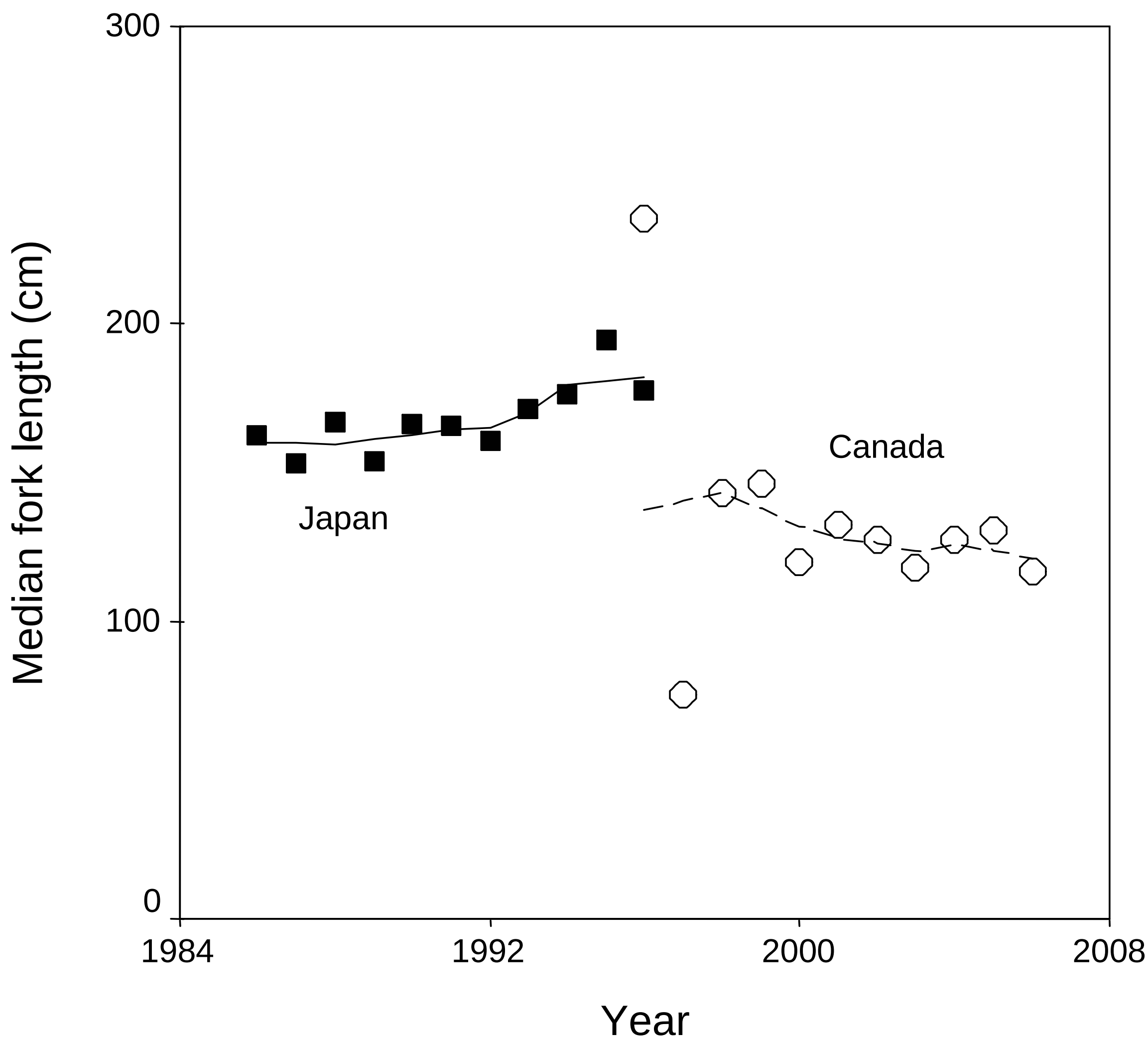

Figure 6. Long-term changes in the median fork length of makos caught by Japanese (solid squares) and Canadian (open circles) pelagic longliners. LOESS curves have been fit to the trends.

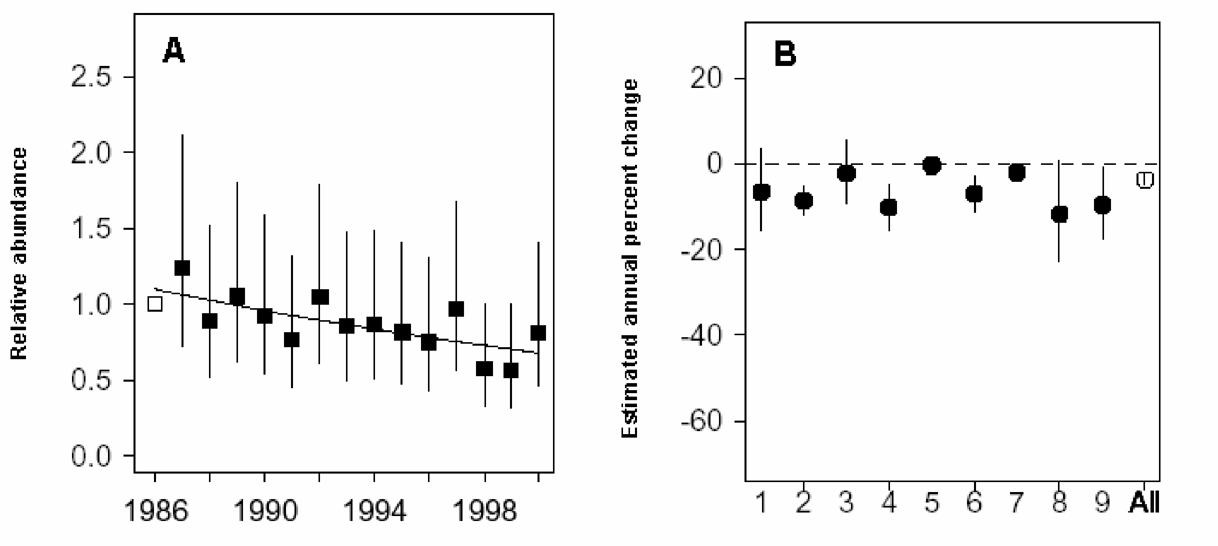

Figure 7. A. Relative abundance of shortfin mako in the west Atlantic indicated by an analysis of U.S. commercial longline fishery logbook from 1986-2000. The fitted model showed a decline of 40%; (B) estimated annual rate of change for nine assessment areas and total. Areas 6 and 7 refer to the areas south of Nova Scotia and around the Grand Banks, respectively. From Baum et al. 2003.

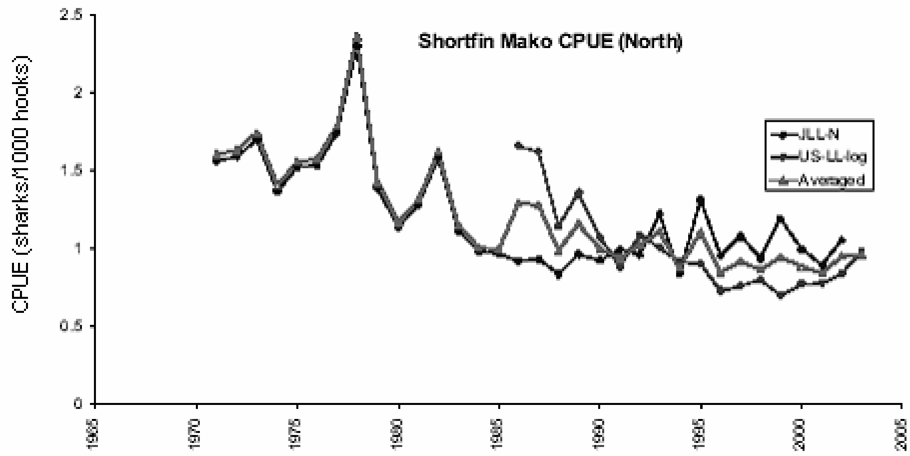

Figure 8. Indexed CPUE of shortfin mako in the North Atlantic from the Japanese longline fleet (JLL) and United States longline fleet (USLL). Source: ICCAT 2005a.

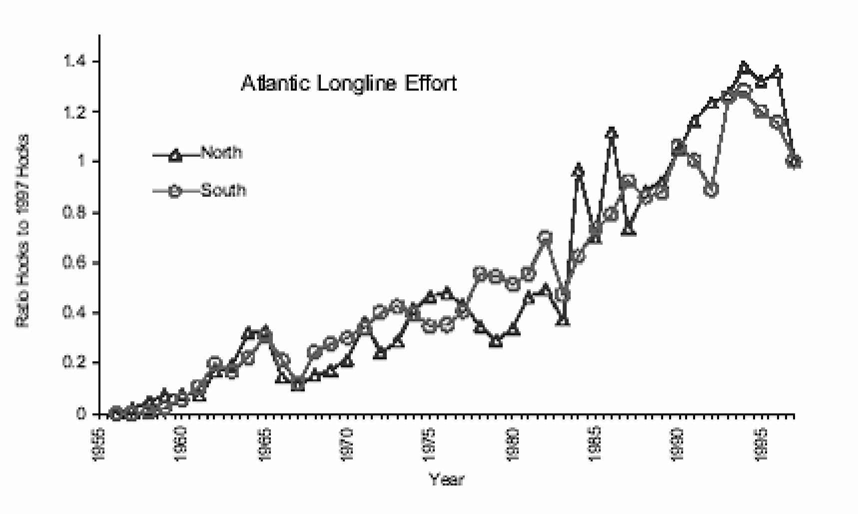

Figure 9. Trend in effort for the North Atlantic longline fleet (1956-1997). Source: ICCAT 2005a.

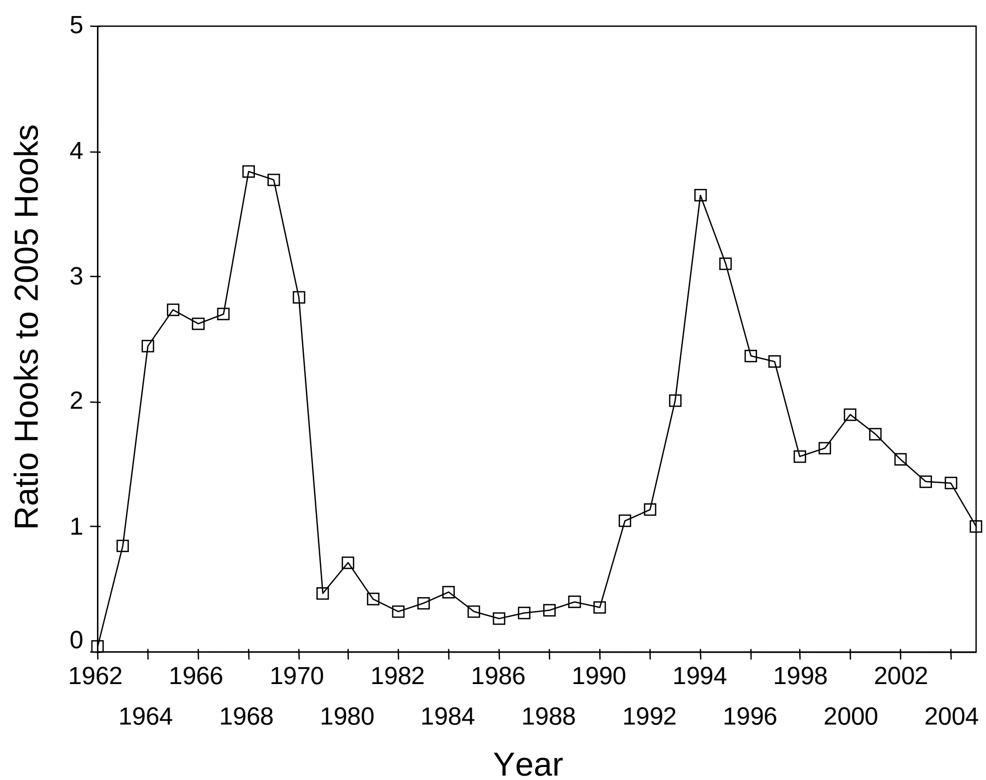

Figure 10. Trend in effort for the Canadian North Atlantic longline fleet (1962-2005).

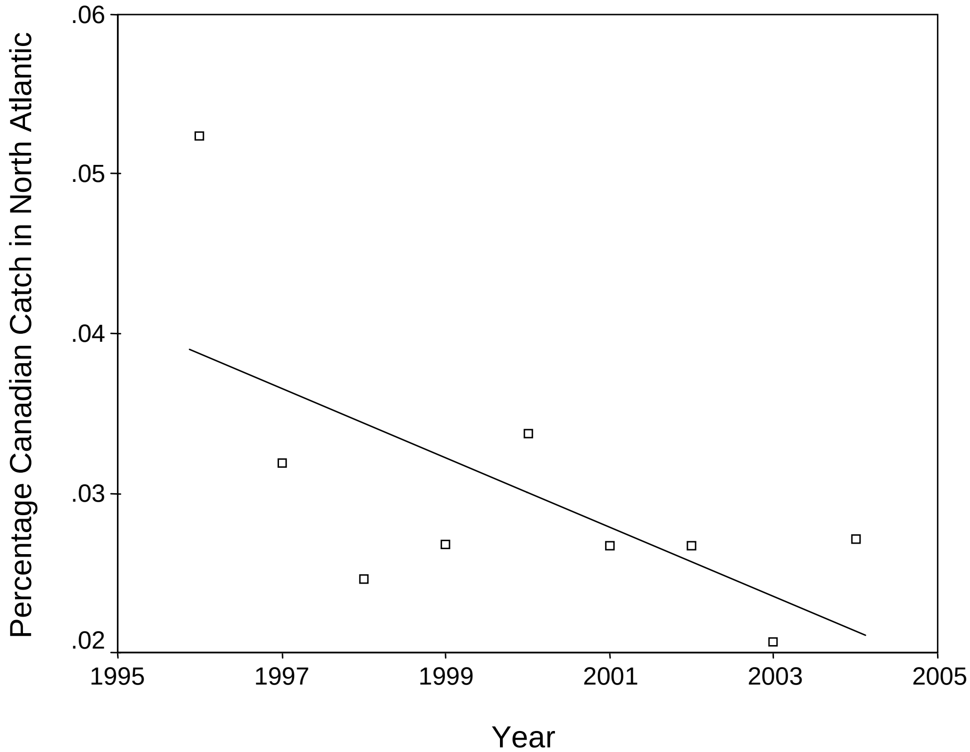

Figure 11. Percentage of total catch in the North Atlantic captured by the Canadian pelagic longline fishery from 1996-2004 (linear regression, r^2 = 0.34, p=0.06).