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Observations on Shortfin Mako Shark (*Isurus oxyrinchus*) in the North Atlantic

by

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[1]La présente série documente les bases scientifiques des évaluations des ressources halieutiques sur la côte atlantique du Canada. Elle traite des problèmes courants selon les échéanciers dictés. Les documents qu'elle contient ne doivent pas être considérés comme des énoncés définitifs sur les sujets traités, mais plutôt comme des rapports d'étape sur les études en cours.

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Abstract

Shortfin mako are caught as a by-catch to a number of fisheries, primarily that of tuna and swordfish. It only occurs incidentally in Canadian waters, being a warm water species. There is very little documentation of the catches and the effort in this fishery. Consequently, the Precautionary Catch Level of 250t set in 1995 as part of the Shark Management Plan was not based on biological assessment. Shortfin mako are at the northern limit of their range, associated with the warm water of the Gulf Stream. It is therefore unlikely that a directed fishery for this species in Canadian waters is feasible. Also, a directed fishery for it would likely result in significant by-catches of swordfish and possibly bluefin tuna.

Résumé

Le mako à nageoires courtes est une prise accidentelle d'un certain nombre de pêches, en particulier du thon et de l'espadon. Comme peu de données sur les prises et l'effort sur cette espèce sont disponibles, le quota prudent de 250 t donné dans le Plan de gestion 1995 du requin n'était pas basé sur une évaluation biologique. Ce requin, préférant les eaux chaudes du Gulf Stream, se retrouve rarement dans les eaux canadiennes, où il atteint la limite nord de son aire de répartition. Il est donc peu probable qu'une pêche dirigée de l'espèce soit possible, pêche qui donnerait probablement lieu à d'importantes prises accessoires d'espadon et peut-être de thon rouge.

Introduction

The family Lamnidae is represented by three genera and four species in the North Atlantic (Compagno, 1984):

Porbeagle shark (Lamna nasus)
Shortfin mako shark (Isurus oxyrhincus)
Longfin mako shark (Isurus paucus)
Great white shark (Carcharodon carcharias)

The shortfin mako is a warm water species that only occasionally occurs off Canada. The longfin mako, first described in 1966, also a warm water species, has thus far not been reported in this area. The porbeagle shark is a cold-temperate species that occurs in the North Atlantic, South Atlantic and South Pacific areas. Finally, the great white is a more solitary animal and rarely strays into Canadian Atlantic waters.

Prior to 1994, DFO did not have an active program of research on sharks. Increasing interest by industry to exploit sharks - particularly porbeagle, blue and mako - stimulated the Marine Fish Division at BIO to initiate a modest research and assessment effort on sharks. The first status reports on these three species were produced in June 1995 (Anon.,1995). In the fall of 1995, it was decided to form an Elasmobranch Assessment team (Table 1) which would undertake producing the Research Documents and Stock Status Reports (SSRs) for porbeagle, blue and shortfin mako sharks as part of the Maritimes' Regional Advisory Process (RAP). The team met formally three times during January - April 1996 to review prepared material and compile the reports.

This report summarizes the information compiled by the team on shortfin mako sharks in the Northwest Atlantic. The information on the biology of this species is limited. Therefore, observations on shortfin mako in the Northeast Atlantic have been used and assumed to apply to the Northwest Atlantic. Given that the research program was initiated recently, most analyses are preliminary and thus recommendations are made to further the research program. Notwithstanding the preliminary nature of the information, advice is provided to assist in making management decisions in the Canadian Zone.

Reproductive Biology

There are three modes of reproduction in sharks - oviparity, ovoviviparity, and viviparity. These modes have markedly different implications for the life history strategy of the various species of sharks. Oviparity is the most primitive condition. Sharks, such as the Catsharks, that are oviparous, lay large eggs that contain sufficient yolk to nourish the embryo throughout development and allow it to emerge fully developed. These eggs are enclosed in leathery cases that are deposited on the sea bottom, usually attached to plants and rocks. The pups of oviparous sharks are usually small, due to the limitation in yolk. Ovoviviparity (aplacental viviparity) is the most common mode of reproduction. The eggs develop into embryos within in the uterus, and are nourished by yolk stored in the yolk sack, without forming a placental connection with the mother. In some ovoviviparous sharks, after the yolk is used up, the embryos will ingest unfertilized eggs that the mother continues to produce (oophagy). In a few species (e.g. bigeye thresher), intra-uterine cannibalism occurs and smaller embryos are also consumed. Finally, viviparity (placental viviparity) is the most advanced form. The embryos are initially nourished by yolk stored in the yolk sac. The yolk stalk elongates and the yolk sac becomes modified. In some species, the yolk sac comes into contact with the uterine wall and the embryo is nourished through a placental connection. In others, such as the blue shark, the yolk stalk becomes highly branched and the embryos obtain nourishment by absorbing nutritive secretions produced by the uterine lining of the mother.

Shortfin mako sharks are ovoviviparious. Males mature at about 195 cm TL while females mature at about 280 cm TL (Stevens, 1983), which, using the growth model of Pratt and Casey (1983) (see below), implies ages at maturity of three and seven for males and females respectively. Parturition in the Northwest Atlantic occurs in the late spring (Pratt and Casey, 1983) after a gestation period of one year. Therefore, mating occurs in the spring.

Stevens (1983) reported a range of litter sizes of 4 to 16 (average of 10) from four gravid females. Pratt and Casey (1983) noted that the difference between the age of maturity, 7, and the longevity of the female (16 years) only allows the production of 9 litters. They speculated that as the female gets older, she produces increasingly larger pups. As with the other sharks (porbeagle and blue), in the Canadian Zone, there is some question as to whether or not the reproductive cycle is of one or two years in duration.

Growth and Natural Mortality

According to Stevens (1983), total length at birth appears to be about 70 cm. This agrees well with the Von Bertalanffy growth model (figure 1) reported by Pratt and Casey (1983) for males,

$$Lt = 323*(1\text{-EXP} - 0.266*(t+1.0))$$

and for females,

$$Lt = 369*(1\text{-EXP} - 0.203*(t+1.0)$$

Pratt and Casey (1983) assumed that gestation was of one year duration, based on a number of observations, and set the value of t_0 at one. The K values of 0.203 - 0.266 indicate rapid growth for this species, the highest of the three shark species (porbeagle, blue and shortfin mako) exploited in Canadian waters.

According to Taylor (1958), who examined longevity in cod, the male's life span can be estimated as t_0 + 2.996/K or

$$1+2.996/0.266 = 12.3$$

For females, the life span is

$$1+2.996/.203 = 15.8$$

Hoenig (1983) defined longevity, t_{max}, as the age at which 0.01 of the initial population size remains. He determined the relationship between tmax and observed estimates of natural mortality, M, for a range of species as

$$Ln(M) = 1.44 - 0.982\ Ln\ (t_{max})$$

If one assumes that Taylor's (1958) estimates of life span can be used as t_{max} in Hoenig's (1983) equation, one would predict an M of 0.36 for males and 0.28 for females. These are exceptionally high rates for elasmobranchs, consistent with the high K values.

Stock Structure and Movements

Since its inception in 1962, the United States National Marine Fisheries Service (NMFS) cooperative shark tagging program has tagged over 46 species of sharks and 20 species of other fishes (Casey and Kohler, 1991). In 1994 alone, participants in the program tagged 400 shortfin and recovered 41 from 1994 and earlier releases (Casey et al, MS1995). From 1961 to 1984 Canada conducted a number of projects to tag large pelagic fishes, mainly swordfish and tunas; in a number of cases, sharks caught incidentally during these projects were also tagged (Burnett et al. 1987). During that program, 110 mako sharks were tagged, of which 5 have been recovered. In 1994 Canada initiated a shark tagging program in cooperation with recreational anglers and commercial fishers; only 1 mako has been tagged in that program.

- **It is recommended that historical and current Canadian shark tagging data sets be combined into a common database.**

- **It is recommended that the current Canadian tagging effort be continued and collaboration with other existing programs be investigated.**

Between 1962 and 1989, 2459 mako sharks were tagged by the NMFS cooperative shark tagging program, most off the northeastern United States. Slightly under 10% (231) had been recovered by 1989. Casey and Kohler (1992) synthesized the existing knowledge on mako sharks. This summary is largely derived from that report. They hypothesized that mako sharks found in the Northwest Atlantic are a single population limited to the North Atlantic and in their eastern distribution to areas west of the Mid-Atlantic Ridge.

Unlike the blue shark, the mako appears to have a narrow tolerance range between 17-22° C and prefer water temperatures near 18° C. Worthington (1959) described a persistent 250-400m thick wedge of 18° C water in the Sargasso Sea originating from the Gulf Stream. This wedge of water extends along the northern margin of the Gulf Stream as far north as the Grand Banks, then decreases in thickness until it disappears near the Mid-Atlantic Ridge. Casey and Kohler (1992) hypothesized that this water mass determines the timing and movements of the mako shark. The details of that hypothesis are summarized below.

In January, the mako is common along the western margin of the Gulf Stream with few catches being made on the continental shelf north of Cape Hatteras prior to April. As the inshore waters warm in the spring, mako sharks begin moving northward onto the continental shelf from Cape Hatteras to the Grand Banks. They remain there from June to October, then move offshore, back into the Gulf Stream and the Sargasso Sea. They do not appear to be common in Canadian waters at any time, possibly because of the limited occasions when 18° C water is on the Canadian continental shelf

This stock concept (figure 2) is based on 231 recoveries (9.4% of releases). Although the movements are presented as a clockwise movement pattern, the tag recoveries do not provide evidence of a well defined seasonal movement (Casey and Kohler, 1992). Only one recovery was made in the eastern North Atlantic. While the distribution of recoveries can be explained by the 'Sargasso Sea warm water' hypothesis, the pattern of movement is not well explained. Very small makos have been reported during summer from the Gulf of Mexico to the Grand Banks thus providing no indication of a restricted nursery area. While little is known about the reproductive biology of this species, Casey and Kohler (1992) suggested that adult females may remain far offshore in the warm water when pupping; thus the young would be distributed over a wide area. This hypothesis is similar to that for blue sharks (Casey, 1985) pertaining to the distribution of pregnant females.

- **It is recommended that monthly distribution maps of mako shark bycatch from swordfish and tuna fisheries be produced that also show the full geographic range of these fisheries.**

The Fishery

There is very little information on shortfin mako landings from the North Atlantic. FAO statistics indicate less than 100t annually caught (by the US) in the Northwest Atlantic during 1990 - 94. Landings have generally not been systematically recorded. As well, historical landings were often recorded as another species, such as mackerel shark, or large shark unspecified.

In the Northwest Atlantic, there is little directed fishing reported for shortfin mako sharks, but the species has been reported as bycatch in a number of fisheries. The largest recorded by-catches (table 2) are from the Canadian swordfish longline fishery, but the landings data for 1994 (157t) and 1995 (107t) may be unreliable. Up to and including 1991, any Canadian landings of mako sharks were recorded together with porbeagle sharks, a closely related species of similar appearance, both species being coded as mackerel sharks. During 1992 and 1993 shortfin mako and porbeagle sharks were recorded separately, but the shortfin mako component of mackerel shark landings was probably reported as unidentified shark. By 1994, those involved in the fishery began to distinguish more sharks to the species level, and identified shortfin mako sharks were being reported. There is concern, however, that a substantial proportion of the 1994-95 landings are mis-identified porbeagle sharks. For these reasons, more detail on the landings, other than that provided in table 2, are not given here.

- **It is recommended that efforts be undertaken to confirm the identification of sharks captured in the large pelagic and other fisheries.**

Shortfin mako sharks are also taken in appreciable numbers as bycatch in Japanese longline fisheries for tuna. These by-catches in Canadian waters range from 3 to 34t for the 1987-95 period. We have no data on shortfin mako shark catches outside the Canadian zone, as they are not reported, discarded, or reported as large sharks. But we assume that they represent significant by-catches in any of the Northwest Atlantic longline fisheries for swordfish and tuna.

Most of the shortfin mako shark landings occur from June to October, when Scotian Shelf and southern Grand Banks waters are warm enough for shortfin makos to venture inshore. They are not often caught very far from the Gulf Stream, rarely being taken from northerly portions of the Grand Banks or from the Gulf of St Lawrence.

The shortfin mako is a prized sportfish of importance to recreational fisheries throughout the species range, particularly those of the Atlantic coast of the United States. Interest in angling for sharks has increased in Atlantic Canada over the last few years, based primarily on blue shark catches, but shortfin makos are occasionally reported. Catches by this developing recreational fishery have not been reported.

Management History

Efforts to develop a Fisheries Management Plan for pelagic sharks in Atlantic Canada began in 1992; however pelagic sharks were not covered by Fisheries Regulations and amendments were required to the Fisheries Act. These amendments did not occur until May 1994. Between 1992 and 1994, a plan was developed through the Atlantic Large Pelagics Advisory Committee (ALPAC), the Committee that develops the Plans for the bluefin tuna and swordfish fisheries in Atlantic Canada. Following amendments to the Fisheries Act, a ban on "finning" sharks was announced in June 1994 and a Management Plan for porbeagle, shortfin mako and blue sharks was announced in July 1994. However, there were problems implementing the Plan due to interpretation of the clause that determined eligibility for a license, and thus no licenses were issued in 1994. Further dedicated industry consultation (outside of ALPAC) was conducted in March 1995 and recreational interests were included at that time. Industry consensus was reached that the rationale and restrictiveness of the Plan should be strengthened but no consensus was reached on how to regulate the recreational fishery. A revised Plan was announced in July 1995.

The 1995 Fisheries Management Plan for pelagic sharks in Atlantic Canada established precautionary catch levels for porbeagle (1500t), shortfin mako (250t) and blue (250t) sharks in the directed shark fishery; limited the number of licenses by defining eligibility criteria; specified that licenses will be exploratory; prohibited "finning"; restricted fishing gears; established seasons; restricted fishing area; limited by-catch of other species in the directed shark fishery; restricted the recreational fishery to hook and release only; and established scientific data collection.

The precautionary catch levels roughly approximate the reported landings of these species in Atlantic Canada in 1992 and were not based upon estimates of stock abundance. License eligibility criteria required active participation in the directed fishery in four of the last five years, as documented by sales records. In addition, a limited number of licenses could be issued in areas of Atlantic Canada where there had been no previous fishing effort directed at these species. Exploratory licenses are valid only for the year they are issued with no obligation that they must be issued in the future. Fins may only be sold in proportion to a maximum of five percent of dressed carcass weight aboard a vessel and fins may not remain aboard the vessel after the associated carcasses are removed. Fishing gears to be used in the directed fishery were limited to longline, handline or rod and reel gear for commercial licenses and to rod and reel only for recreational licenses. The Plan included provision for restricting fishing seasons although there were no restrictions imposed in 1995. Vessels less than 20m in length were restricted to home areas by the Sector Management Policy of the Department of Fisheries and Oceans, and specific time/area closures were implemented for all vessels to limit by-catches of bluefin tuna and small swordfish, where these are known to be a problem. Recreational licenses were limited to hook and release until such time as suitable criteria were developed which might allow for the retention of sharks by recreational anglers. These criteria have not yet been developed. The Plan made provision for the collection of catch and effort data, through completion and submission of logbooks, and for collection of sampling data (species, sex, length, weight) for each shark landed, through a dockside monitoring program.

The Resource

There are uncertainties concerning the stock area of this species, and its biology is poorly understood. Also landings data are incomplete, and proper identification of shark species remains a problem. Until we resolve these issues, estimation of stock abundance and trends is not possible.

Outlook

There is very limited information for shortfin makos on which to base harvest advice. Sequential Population Analysis (SPA) and Yield Per Recruit (YPR) models, as applied in the groundfish stock assessments, cannot be used here due to the lack of time series of age-based information on the commercial catch and population. However, some idea of the sensitivity of this resource to exploitation can be obtained from use of the equilibrium model of Brander (1981), which is a modification of that of Holden (1974).

For a stock to maintain its abundance, every mature female must on average produce one mature female during its life. Now the lifetime net fecundity (LNF) is simply a product of the annual net fecundity (ANF) and the years of spawning (YOS) or

$$LNF = ANF * YOS$$

For stock replacement, the LNF must equal one. Under this condition, the annual net fecundity can be calculated as

$$ANF = LNF/YOS = 1/YOS$$

If Z is the annual instantaneous rate of total mortality, it can be shown that the YOS can be approximated as 1/Z years (Brander, 1981). Thus, for replacement, the annual net fecundity must equal the instantaneous total mortality, or

$$ANF = Z$$

Brander (1981) expressed this relationship as

$$Z_m = (E/2) * \exp(- Z_i * t_m)$$

where

Z_m is the total mortality on the mature fish

Z_i is the total mortality on the immature fish

E is the litter size, which is divided by two to provide the estimate for females

t_m is the average age of first maturity of a female

Thus, if we know the annual gross fecundity, E, and the age of first maturity, t_m, we can estimate the mortality at which the population will exactly replace itself on average. In addition, we can examine the ratio of the mortality on the immature and mature individuals to see what impact this has on the population.

Figure 3 shows the relationship between Z_i and Z_m, using E of five and tm of seven. This assumes that the average litter size is 10 and that this is produced every second year. All combinations of Zi and Zm to the right of the curve are unsustainable. If we assume that Hoenig's (1983) estimate of natural mortality, 0.28, for females is correct, and that the mortality of the immature individuals is about this level, then the mortality on the adults could go as high as 0.35. These calculations are very sensitive to the estimates of E and tm. The assumption of the natural mortality is very sensitive to the estimate of longevity. If the reproductive cycle is annual, and not biannual, as assumed above, then E would be 10 and not five. The 'allowable' Zm values would double. As well, increasing tm by one year to 8 decreases the replacement Zm to 0.27, which is below the estimate of natural mortality. The following table summarizes the replacement Zm values for a range of E and tm, under the assumption that Zi equals the natural mortality, 0.28.

Age of First Maturity	**Gross Annual Fecundity, E**	
tm	**5 (two year cycle)**	**10 (one year cycle)**
6	0.47	0.93
7	0.35	0.70
8	0.27	0.53

It is evident that at tm = 8 and E = 5, a fishery becomes problematical. In all other cases, a fishery is a possibility, although it has to be kept in mind that this would apply to the entire stock area.

It is not possible to make recommendations concerning harvest levels for this resource with the information available. The precautionary catch level of 250t in the 1995 Shark Management Plan is not based on an estimate of stock abundance. The species is at the northern limit of its range, associated with warm water of the Gulf Stream. Therefore, it is unlikely that a directed fishery for shortfin mako shark in Canadian Atlantic waters is feasible. Also, this shark is part of a large pelagic species complex that includes other large sharks, tunas, swordfish and billfishes. It has been shown that the shortfin mako is closely associated with swordfish. A directed fishery for shortfin mako would likely result in high by-catch levels of swordfish and possibly of bluefin tuna.

It is possible that shortfin mako and porbeagle sharks are not being identified correctly by fishermen and in the marketplace. Criteria should be developed that will permit better discrimination between these two species in the landing statistics. In addition, any fishery must have a comprehensive scientific component to collect the information needed to fill in the crucial gaps in our knowledge.

Finally, the stock area of this species extends beyond the Canadian zone. Management of this resource will require international cooperation.

Summary of Research Recommendations

Throughout this document, recommendations have been made to fill knowledge gaps and thus lead to improved assessment in the long term. Here, these recommendations are prioritized to allow for a logical and coherent implementation of these recommendations.

The first recommendation relates to the collection and processing of information from the historical and current fishery:

1. It is recommended that efforts be undertaken to confirm the identification of sharks captured in the large pelagic and other fisheries.

The second recommendation relates to analyses of existing data to elucidate the trends in abundance:

2. It is recommended that monthly distribution maps of mako shark bycatch from swordfish and tuna fisheries be produced that also show the full geographic range of these fisheries.

The next two recommendations relate to studies on the shortfin mako's life history:

3. It is recommended that historical and current Canadian shark tagging data sets be combined into a common database.

4. It is recommended that the current Canadian tagging effort be continued and collaboration with other existing programs be investigated.

References

Anon. 1995. Scotia-Fundy Spring 1995 Stock Status Report for Pelagics, Invertebrates and Marine Mammals. DFO Atl. Fish. Scotia-Fundy Reg. SSR 95/1.

Bertalanffy, L. von, 1938. A quantitative theory of organic growth (inquiries on growth laws II). Hum. Biol., 10(2): 181-213.

Bigelow, H.B. and Schroeder, W.C. 1948. Fishes of the Western North Atlantic (cyclostomes and sharks). Memoir Sears Foundation for Marine Research. 1 (1): 576pp.

Brander, K. 1981. Disappearance of Common Skate Raja batis from Iris Sea. Nature. 290: 48 - 49.

Burnett, C.D., J.S. Beckett, C.A. Dickson, P.F.C. Hurley and T.D. Iles. 1987. A summary of releases and recaptures in the Canadian large pelagic fish tagging program 1961-86. Can. Rep. Fish. Aquat. Sci. 673: iii + 99p.

Casey, J.G., and J.J. Hoey. 1985. Estimated catches of large sharks by U.S. recreational fishermen in the Atlantic and Gulf of Mexico. In 'Shark catches from selected fisheries off the U.S. east coast. NOAA Technical Report NMFS SSRF No. 31, pp. 15 -19.

Casey, J.G., L.J. Natanson, H.W. Pratt, Jr., R. Briggs, P.A. Turner and N.E. Kohler. MS 1995. The shark tagger 1994 summary: Newsletter of the cooperative shark tagging program. US Dept. Commerce. NMFS. Northeast Fisheries Science Center, Narraganset, R.I.

Casey, J.G., and N.E. Kohler. 1991. Long distance movements of Atlantic sharks from the NMFS cooperative shark tagging program. pp. 87-91. *In* S.H. Gruber (ed.). Discovering Sharks. American Littoral Society. N.J.

Casey, J.G., and N.E. Kohler. 1992. Tagging studies on the shortfin mako shark (*Isurus oxyrinchus*) in the western north Atlantic. Aust. J. Mar. Freshwater Res. 43: 45-60.
Worthington, L.V. 1959. The 18_ water in the Sargasso Sea. Deep-Sea Research 5: 297-305.

Compagno, L.J.V. 1984. FAO Species Catalogue. Vol. 4. Sharks of the World. An Annotated and Illustrated Catalogue of Shark Species known to date. Part 1. Hexanchiformes to Lamniformes. FAO Fisheries Synopsis. (125) 4: Pt 1: 249 pp.

Hoenig, J.M. 1983. Empirical Use of Longevity Data to Estimate Mortality Rates. Fish. Bull (US). 81: 898 - 902.

Hoenig, J. M.and S.H. Gruber. 1990. Life-History Patterns in the Elasmobranchs: Implications for Fsiheries Management. *In* H.L. Pratt, S.H. Gruber and T. Tanaka [ed.] Elasmobranchs as Living Resources: Advances in the Biology, Ecology, Systematics, and the Status of the Fisheries. NOAA Tech. Rep. NMFS 90.

Hoey. J.J. 1983. Analysis of longline fishing effort for apex predators (swordfish, shark, and tuna) in the western North Atlantic and Gulf of Mexico. PhD. Dissertation, Univ. Of Rhode Is., Kingston. 288pp.

Holden, M.J. 1974. Problems in the Rational Exploitation of Elasmobranch Populations and Some Suggested Solutions. In F.R. Harden Jone's [ed] Sea Fisheries Research. Elek Science. London.

Mejuto, J. 1985. Associated catches of sharks, Prionace glauca, Isurus oxyrinchus, and Lamna nasus, with NW and N Spanish swordfish fishery, in 1984. ICES C.M. Doc. No. H42: 1 - 16.

Mejuto, J., and A.E. Garces. 1984. Shortfin mako, Isurus oxyrinchus, and porbeagle, Lamna nasus, associated with longline swordfish fishery in NW and N Spain. ICES C.M. Doc. No. G72: 1 - 10.

Mejuto, J., and S. Iglesias. 1987. Compana comercial de prospeccion de abundancia de pez espada, Xiphias gladius L., y especies asociadas, en areas proximas a Grand Banks. ICCAT SCRS., pp. 1 -10.

Pratt, H.L. and J.G. Casey. 1983. Age and Growth of the Shortfin Mako, Isurus oxyrinchus, Using Four Methods. Can. J. Fish. Aquat. Sci. 40:1944 - 1957.

Stevens, J.D. 1983. Observations on Reproduction in the Shortfin Mako, Isurus oxyrinchus. Copeia. 1:126-130.

Taylor, C.C. 1958. Cod Growth and Temperature. J. Cons. Inter. Explor. Mer. 23: 366 - 370.

Worthington, L.V. 1959. The 18^0 C water in the Sargasso Sea. Deep Sea Research. 5: 297 - 305.

Table 1. Members of the Maritimes Region RAP Elasmobranch Assessment Team

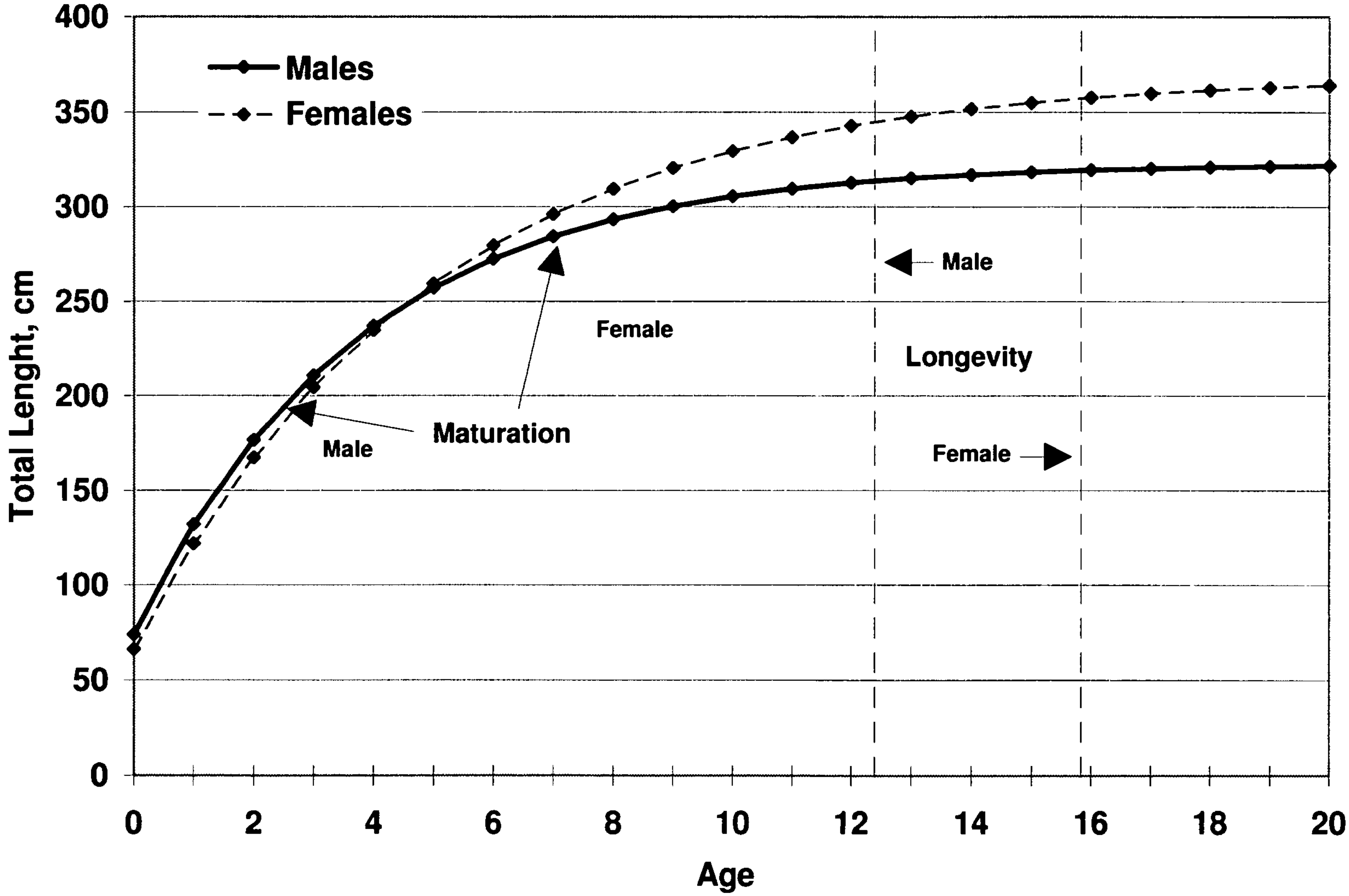
Member	Expertise	Affiliation	Telephone No.
Comeau, P.	Shark Catch Rates	MFD,BIO,DFO	902-426-4136
Crawford, R.	Shark Recreational Fishery	Dep of Fisheries, NS	902-424-0350
Fowler, M.	Shark Fishery Statistics and CPUE Analysis	MFD,BIO,DFO	902-426-3529
Frank ,K.	Elasmobranch Life History	MFD,BIO,DFO	902-426-3498
Hurlbut, T.	Spiny Dogfish Biology and Assessment	MFD, GFC, DFO	506-851-6216
Hurley, P.	Shark Reproduction and Biology	MFD,BIO,DFO	902-426-3520
Jones, C.	Shark Management	FMB, MC, DFO	902-426-1782
McRuer, J.	Spiny Dogfish Biology and Assessment	MFD,BIO,DFO	902-426-3585
O'Boyle (Chair), R.	Shark Population Models	MFD,BIO,DFO	902-426-4890
Porter, J.	Tuna and Swordfish Biology and Assessment	MFD, SABS, DFO	506-529-8854
Rodman, K.	Shark Recreational Fishery Management	FMB, MC, DFO	902-426-6074
Showell, M.	Observer Program Data Analysis	MFD,BIO,DFO	902-426-3501
Simon, J.	Skate Biology and Assessment	MFD,BIO,DFO	902-426-4136
Stobo, W.	Finfish Distribution and Tagging	MFD,BIO,DFO	902-426-3316

Table 2. Reported Landings (t) of Shortfin Mako in the Canadian Zone

Year	Canada	Foreign	Total
1989	73	18	91
1990	78	13	91
1991	124	18	142
1992	119	34	153
1993	152	17	169
1994	157	23	180
1995	107	3	110

Notes: 1989 - 90 data for Canada from NAFO
1991 - 95 data for Canada from DFO Statistics Branch
1989 - 95 data for foreign countries from FOP

Figure 1. Von Bertalanffy Growth Model for Shortfin Mako Shark (from Pratt and Casey, 1983)



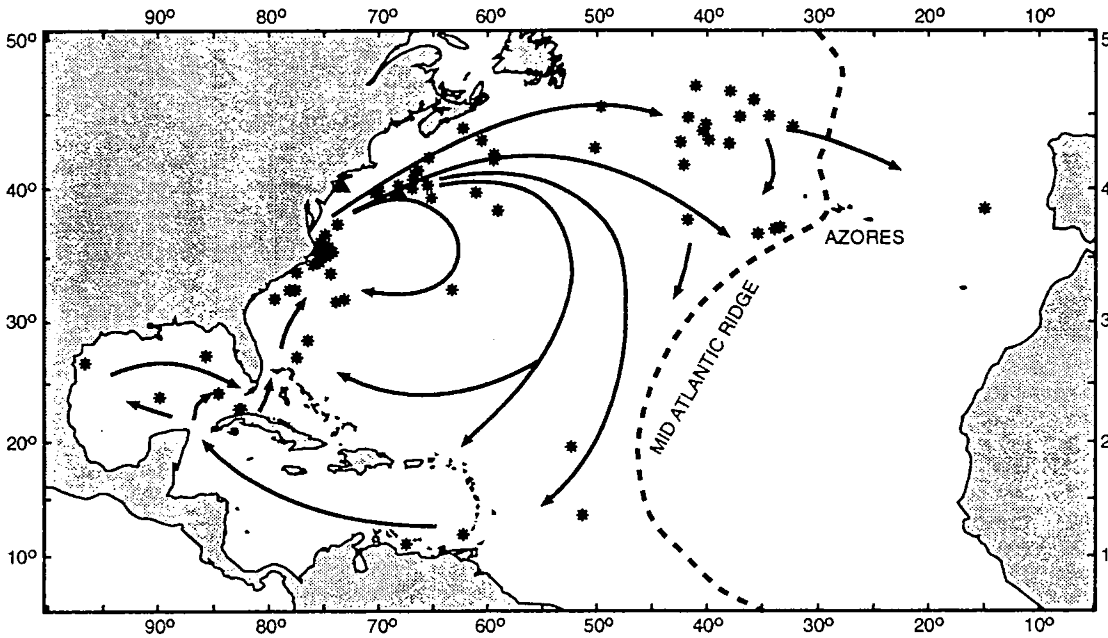


Figure 2. Movements of shortfin mako shark based on recoveries from tagging releases by the NMFS Cooperative Tagging Project (after Casey and Kohler, 1992).

Figure 3. Z_i and Z_m for Equilibrium in a Mako Shark Population