

Biological Observations of the Tope Shark, *Galeorhinus galeus*, in the Northern Patagonian Gulfs of Argentina

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Abstract

During 1994–96, an experimental longline fishery for tope shark (*Galeorhinus galeus*) was carried out in the Nuevo Gulf of northern Patagonia and, in the summers of 2000–2001 and 2002, three boats conducted an exploratory commercial fishery for this species, accompanied by a scientific monitoring program. This paper summarizes the results of these fishing trials, and provides information on the biology of tope shark. Catches were highest from February to April, when tope shark represented 36% of the total fish caught, and elephant fish (*Callorhynchus callorhynchus*) and argentine hake (*Merluccius hubbsi*) accounted for 33% and 23%, respectively. Tope shark arriving in northern Patagonian waters during the summer are primarily mature males, immature and maturing females in their first and second non-gravid year. No gravid females were caught. These fish are part of the South-western Atlantic stock, which shows signs of over-exploitation, so we suggest that any longline fishery in Patagonia should remain on a small scale. We also recommend that an effective management plan is needed for the whole tope stock, establishing agreements on effort control and co-ordinated research between Brazil, Uruguay and Argentina.

Key words: artisanal fleet, longlines, patagonia, tope shark

Introduction

There are few places where artisanal fishing is possible along the extensive and inhospitable coasts of Argentina. Artisanal fisheries operate in the Gulfs of San Matías, San José and Nuevo (42°–43°S; 64°–65°W), which are important and productive areas that support about 400 jobs (fishermen, factory workers, retailers etc.) in Puerto Madryn (Fig. 1). Shellfish and finfish resources currently support about 110 artisanal fishers and their families, many living along the coast. The main target species for the shellfish fishers is the scallop *Aequipecten tehuelchus*, harvested by hooka divers (Ciocco *et al.*, 1998). Fishing boats are <10 m long, equipped with outboard motors, typically operated by a crew of one deck assistant and two divers. The shellfishing is limited in time on biological and health bans, and the San José Gulf was designated as a Provincial Marine Park in 1974, being a sensitive ecological region due to its high concentration of marine mammals (southern right whale, *Eubalaena australis*; southern elephant seal, *Mirounga leonina*) and seabirds.

As part of a technological project designed to explore the feasibility of exploiting other natural resources in the gulfs and coastal zones of northern Patagonia, experimental fishing using longlines and gillnets was carried out between January 1994 and February 1996. Following a request by three artisanal boats to open an exploratory commercial longline fishery for tope shark (*Galeorhinus galeus*) in Nuevo Gulf, the Provincial Fishery Administration requested scientists to develop a monitoring programme, and fishing took place during the summers of 2000–2001 and 2002.

In the Southwestern Atlantic, tope is thought to comprise one population, ranging southern Brazil to north Patagonia (Menni, 1985, 1986; Peres Junior, 1998), which is exploited by coastal fisheries from Brazil to Argentina at different stages in its seasonal migrations (Siccardi, 1950; Gosztonyi and Menni, 1978).

The biology of tope has been studied from samples caught of Rio Grande do Sul (Brazil), (Ferreira and

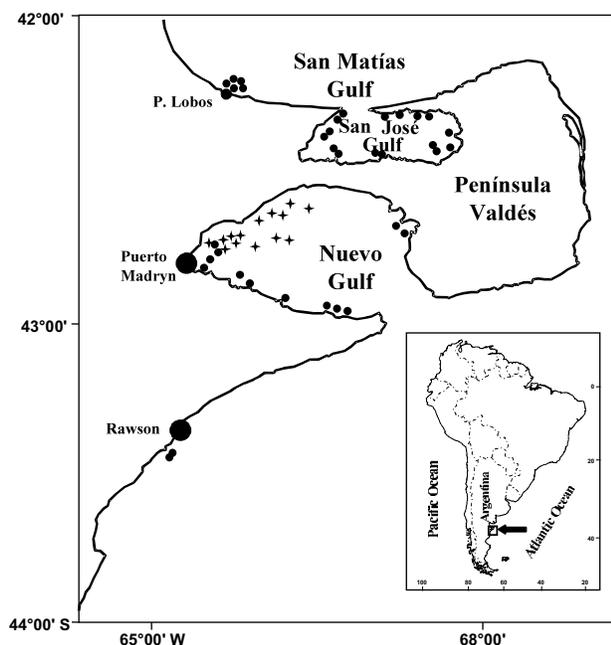


Fig. 1. The study area showing locations of (●) experimental fishing and (+) commercial fishing.

Vooren, 1991; Peres and Vooren, 1991) and in Uruguayan waters (De Buen, 1950; 1952; Arena *et al.*, 1974; Marín and Puig, 1987; Nion, 1999), and its fishery in Quequén Port (Argentina) has been described by Corcuera and Chiaramonte (1992), Corcuera *et al.* (1994) and Chiaramonte (1998). This paper summarizes the results of the experimental and commercial fisheries for tope in the gulfs of northern Patagonia, including catch composition and information on morphometrics and reproductive parameters.

Material and Methods

Experimental fishing

A total of 37 fishing trips were carried out from 1994 to 1996 in the San Matías, San José and Nuevo Gulfs, and in the open sea, at depths of 14–70 m. The fishing gear was a longline with a 1 000 m head rope and an average of 550 hooks. In order to detect the presence of juvenile tope in the area, monofilament gillnets (40, 60, 80, 100 and 120 mm mesh sizes) were set in shallow water.

Commercial fishing

Commercial fishing took place in Nuevo Gulf between October 2000 and April 2001 and in February and March 2002. Boats operated within 15 nautical miles of the coastline at depths of 40–120 m. Each boat used an average of 1 500 hooks, and catch per unit effort

(CPUE) was analyzed in terms of number of sharks per 100 hooks.

Biological sampling

Total length (L_T , cm, measured with the tail aligned with the long axis of the body), total weight (W_T , g) and eviscerated weight (W_E , g) were recorded for fresh specimens. Experimental catches were sampled in the laboratory and commercial catches were sampled on board the fishing boat and at the processing factory. Gonad weight was recorded when possible and, for females, the diameter of the largest oocyte, the width of the nidamental gland, and the maximum and minimum width of the non-gravid uterus were recorded. Sexual maturity, reproductive stage and gonadosomatic index (GSI) were determined using the criteria of Peres and Vooren (1991). The length-weight relationship was determined by linear regression on \ln -transformed data. Covariance tests (Sokal and Rohlf, 1994) were used to compare the regression lines. The condition factor ($C_f = W/L^3$) was subject to a Kruskal-Wallis test (Sokal and Rohlf, 1994) to determine significant differences in body condition between samples.

Results

Abundance and depth distribution

Throughout the study, mean catches of tope were highest between January and March, except in the first experimental fishing year, when the boats skippers were inexperienced regarding fishing grounds and the new type of gear (Fig. 2). Seasonal maximum CPUE declined from around 0.08 tope per hook in 1995 to 0.02 tope-per-hook in 2002, which may indicate that the stock's abundance was declining though this time. In commercial and experimental catches, tope accounted for 36% of the total fish caught, with elephant fish (*Callorhynchus callorhynchus*) and argentine hake (*Merluccius hubbsi*) accounting for 33% and 23%, respectively. Figure 3 shows that male tope tended to be caught in shallower water than females, for which catch rates were highest in water >110 m deep.

Longline selectivity

Catches of tope during experimental fishing were analyzed by hook size (5/0 and 10/0) and L_T (Fig. 4). The 5/0 hooks typically caught fish around 110 cm, whereas the 10/0 hooks obtained better yields and caught larger individuals.

Body size, total length – weight relationship and condition factor

A total of 987 tope were caught in experimental and commercial fishing, of which 408 (41.3%) were female

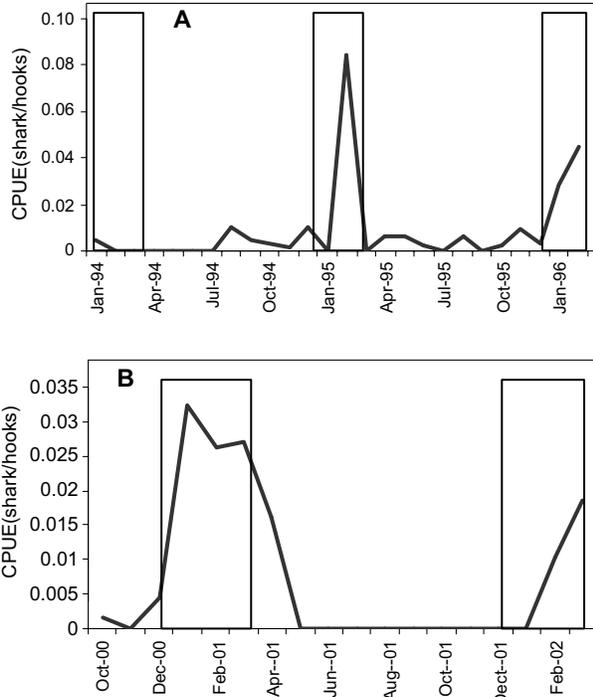


Fig. 2. Changes of CPUE (tope/100 hooks) in (A) experimental fishing and (B) commercial fishing. Boxes shows summer seasons.

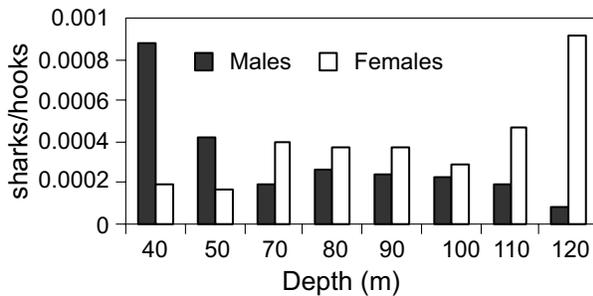


Fig. 3. Frequency of male and female tope caught by depth in both commercial and experimental fishing.

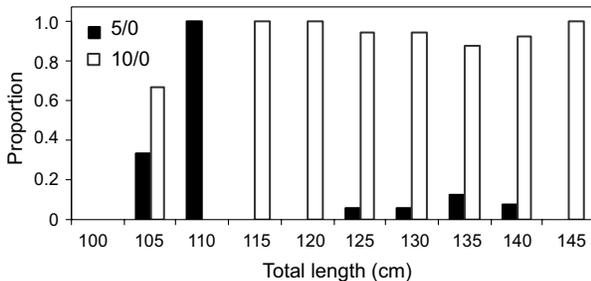


Fig. 4. Proportion of tope caught by hook size and length class.

and 579 (58.7%) were male. Though experimental fishing with gillnets caught only 32 specimens, the mean lengths of tope caught by gillnet and longline were not significantly different (Student's *t*-test $p > 0.05$). The mean $L_T \pm SE$ (range) of male and female tope were 132 ± 0.34 (105–150) cm and 121 ± 0.58 (92–148) cm respectively, with the majority of males being 120–145 cm, and the majority of females 110–135 cm (Fig. 5). The mean lengths of males and females changed during the fishing season, with maximum values in January and February respectively.

The total length-eviscerated weight relationships for females and males did not differ significantly (ANCOVA $p > 0.05$ $df = 460$) and the range in W_E was 3–10 kg for females and 3.5–10.5 kg for males (Fig. 6). Monthly condition factors are presented in Fig. 7, which shows that condition for both sexes peaked in March.

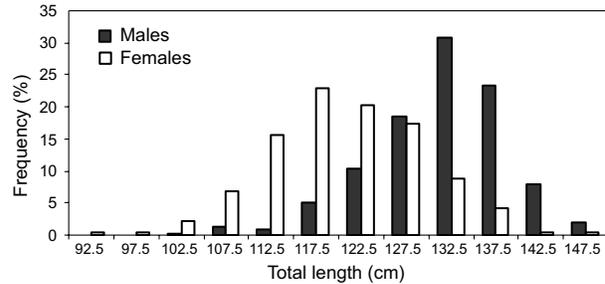


Fig. 5. Overall length frequency distribution of male ($N = 579$) and female ($N = 408$) tope caught in experimental (gillnets and longlines) and commercial fishing in Patagonian waters.

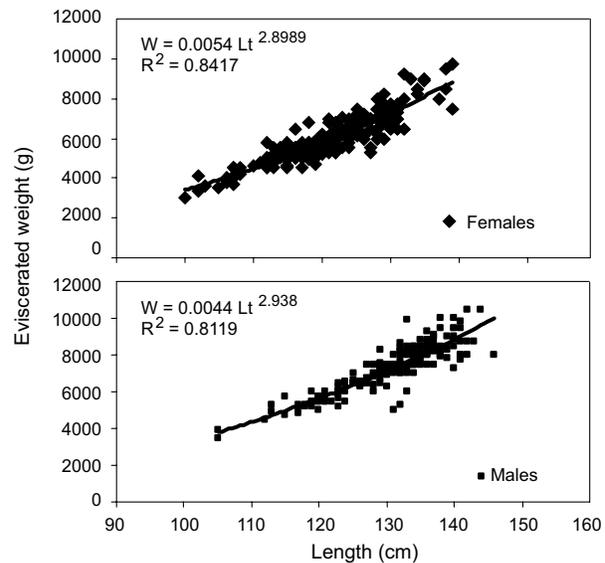


Fig. 6. Relationship between total body length and eviscerated weight for both sexes in tope.

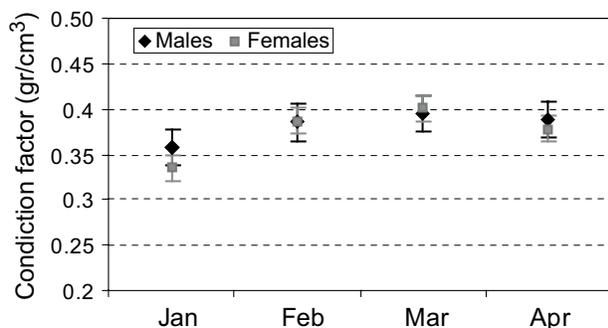


Fig. 7. Mean (+/-s.d) condition factor (Cf) index in both sexes plotted by month.

Sexual maturity

All females caught during the experimental fishing were immature ($N=11$), whereas GSI values of males ($N=100$) peaked during the summer, when they were sexually active, with sperm in the seminal vesicle and swollen testes. Males caught during autumn and winter ($N=26$) were sexually inactive, although there was no difference in mean L_T by season (Student's t -test, $P>0.05$).

Commercial catches (October–March) comprised 64% mature males and 36% females. Of the females, 30% were immature, 43% maturing, 24% mature and 3% unclassified. Mature females included first-year non-gravid females, which had light-yellow oocytes from 5–15 mm in diameter and a gonad weight of 6–60 g, and second-year non-gravid females with golden-yellow oocytes >30 mm and gonad weights >150 g. No gravid females were recorded. The proportion of maturing and mature female tope was highest in February and March.

Stomach contents

Stomachs fullness from 319 tope sharks from commercial catches through the season (February to April 2001) is shown in Table 1. Stomach contents included argentine hake, cuskeels (*Genypterus blacodes* and *Raneya brasiliensis*), silverside (*Odontesthes* sp.) and squid (*Illex argentinus*).

Discussion and Conclusions

Despite a small mesh size (120 mm between knots), the size range of tope sharks caught in experimental gillnets was the same as that taken by longlines, and no juveniles were caught in shallow water. Many tope sharks observed in samples in the province of Buenos Aires (Menni *et al.*, 1981; Menni, 1986; Chiaramonte, 2000) were smaller than the smallest (at 90 cm) caught in Patagonia. According Ferreira and Vooren (1991)

TABLE 1. Stomach fullness by sexes along the season.

Month	Empty	No empty
<i>Females</i>		
Feb	12	88
Mar	10	90
Apr	16	84
<i>Males</i>		
Feb	17	83
Mar	7	93
Apr	23	78

females caught in the gulfs were adolescent, further work is required to discover whether there are tope nursery grounds in Patagonian coastal waters.

Males caught in the North Patagonian Gulfs attained a greater length and weight than females, although there was no significant difference in the length-eviscerated weight relationship between the sexes. Whilst the total length-weight regressions did not differ between males captured in Patagonian waters and of Buenos Aires, there were differences for females, probably because catches in Buenos Aires included gravid females, while no gravid females were found in our study. Tope sharks caught in Nuevo Gulf during March appear to be in their best condition, which is possibly the result of increased feeding activity in the Gulf (90% of the stomachs contained food).

Rivas and Ripa (1989) noted strong summer stratification in the Nuevo Gulf, with bottom water temperatures of 11–12°C and surface waters at 16–17°C. Changes in sex ratio with depth indicated that females caught in the Gulf preferred deeper and cooler waters than males. Elías (1998) showed that males were caught in mid water and with bottom longlines and appeared to feed throughout the water column.

The schools of tope shark that arrive in northern Patagonian waters during the summer are formed primarily of mature males, with immature and maturing females in their first and second non-gravid year. Males caught in the gulfs during autumn in experimental fishing did not show signs of sexual activity, unlike those caught during the summer which had swollen testes and semen in their seminal vesicles. According to oocyte sizes and gonad weights, females in their second year of maturity could be ready to mate in the winter of Brazil.

Chiaramonte (2000) suggested that the South-western Atlantic tope stock may be over-exploited by a fishery based in the port of Quequén, and our CPUE data indicate a decline in stock availability in the Patagonian gulfs from 1995 to 2000. Consequently, we suggest that a precautionary approach should be taken to development of a tope shark fishery in Patagonia. Any longline fishery in the Nuevo Gulf should remain artisanal and on a small scale, controlling fishing effort and the number and size of hooks-per-boat by permits. We also recommend that an effective management plan is needed for the whole tope stock, establishing agreements between fisheries authorities of Brazil, Uruguay and Argentine, and that coordinated research into its biology and on fishing practices that reduce shark by-catch are needed.

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