Preliminary Compilation and Analyses of Shark Catch Data from the Hawaii-based Pelagic Longline Fishery[1]

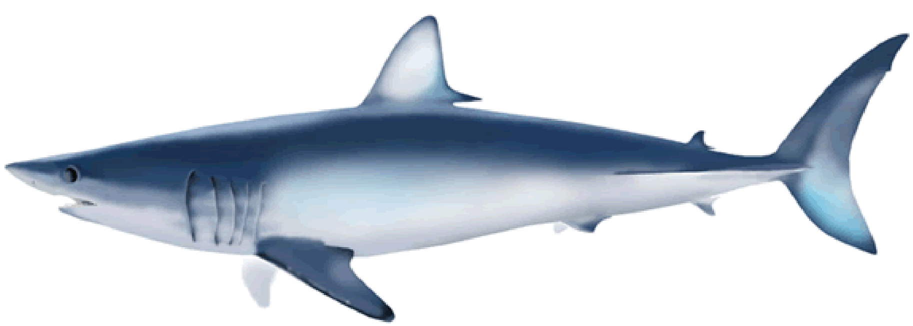
William Walsh

Joint Institute for Marine and Atmospheric Research
University of Hawaii
2570 Dole St., Honolulu, Hawaii 96822, USA

Dean Courtney

NOAA NMFS Pacific Islands Fisheries Science Center
2570 Dole St., Honolulu, Hawaii 96822, USA

Email: William.Walsh@noaa.gov



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Abstract

This working paper presents preliminary statistical information about four shark species (blue shark *Prionace glauca*; shortfin mako *Isurus oxyrinchus*; oceanic whitetip shark *Carcharhinus longimanus*; silky shark *C. falciformis*) taken by the Hawaii-based pelagic longline fishery. All are expected to be species of interest for international-scale stock assessments in the foreseeable future. Nominal catch, catch rate and length measurements were reported from January 1995 into early 2010 by personnel of the Pacific Islands Regional Observer Program (PIROP) and summarized herein as examples of the types of shark data available at the Pacific Islands Fisheries Science Center of the National Marine Fisheries Service. Results also include comparisons of fishery observer and commercial logbook data to elucidate typical patterns and biases associated with self-reporting of sharks taken incidentally or as bycatch.

Introduction

The Shark Working Group of the International Scientific Committee for Tuna and Tuna-like Species in the North Pacific Ocean (ISC) is preparing to conduct stock assessments of pelagic sharks in the Pacific Ocean in collaboration with other regional fishery management organizations. This working paper presents information (nominal data) about catches and catch rates for four shark species (blue shark *Prionace glauca*; shortfin mako *Isurus oxyrinchus*; oceanic whitetip shark *Carcharhinus longimanus*; and silky shark *C. falciformis*) taken by the Hawaii-based pelagic longline fishery. Length data (as available) are also presented for these sharks. All of these species are expected to be of interest for these international-scale stock assessments.

The nominal data used in these analyses were gathered by personnel of the Pacific Islands Regional Observer Program (PIROP) from 1995 into early 2010. Observer data were used for three reasons: a detailed quantitative description of the observed shark catch in this fishery is available as background material (Walsh et al. 2009); the commercial logbooks submitted by vessel operators or owners do not have species-specific fields for shortfin mako or silky shark; and the observer data are known to be more detailed and more accurate than the logbooks from unobserved trips (Walsh et al. 2002; 2005).

The objectives of this working paper are to present examples of the types of data that are available at the Pacific Islands Fisheries Science Center (PIFSC) of the US National Marine Fisheries Service (NMFS). We attained this objective by computing descriptive statistics for the aforementioned four shark species and length frequency distributions to exemplify the size data available for analysis.

A second reason to present an updated summary of shark data from the PIFSC is that conditions in this fishery now differ from those described previously (Walsh et al. 2009). In 1995–2000, observer coverage rates were relatively low (ca. 5–10% of all longline sets) and concentrated near the main Hawaiian Islands (Walsh et al. 2009). By 2004–2006, however, the coverage rates were ca. 20%, the geographic range of coverage had expanded and the shallow-set fishery targeting swordfish *Xiphias gladius* had undergone a closure and subsequent reopening with restrictions on effort (Walsh et al. 2009). Since 2007, however, an annual quota for bigeye tuna *Thunnus obesus* has been in force while conditions in the shallow-set fishery have been largely unaffected. Because the sharks are either bycatch or incidental catch, it was considered appropriate to investigate recent trends in catches and catch rates that may reflect changes in either operating conditions or relative abundance.

Methods

Descriptive statistics

Two sets of descriptive statistics were computed with data gathered by PIROP fishery observers in 2007 into 2010. The first updates published information about observed shark catches in this fishery (Walsh et al. 2009). The second summarizes patterns of observer reporting and self-reporting by vessel operators or owners to exemplify typical biases in shark catch data.

The observer data used to present an update were collected from 2007 through 2009 and tabulated on an annual basis, pooled and by fishery sectors. The fishery sectors are defined on the basis of hooks per float (shallow-set: <15 hooks/float; deep-set:≥15 hooks/float) as stated in the Federal Register (Department of Commerce 2004).

The summary of observer reporting and self-reporting was computed from observer data, commercial logbooks from observed trips and commercial logbooks from unobserved trips from 1995–2009. The purpose was to elucidate biases, especially under- and non-reporting and misidentifications in the logbooks.

Shark Lengths

Length frequency distributions were computed from shark size measurements (fork lengths; FL, cm) taken aboard commercial longline vessels during two periods (1994–2003, ‘legacy data’; 2003–2010, ‘recent data’). These FL measurements were plotted by longline set types (i.e., shallow sets: <15 hooks per float; deep sets: ≥15 hooks per float) and sexes.

Results

The nominal mean annual catches per set for four sharks are presented in Figure 1. The trajectory for blue shark revealed that it has consistently been the predominant species. The trace for shortfin mako revealed a pattern of increase for this species during the 15-year study period, whereas the opposite was observed with oceanic whitetip shark.

The blue shark catch and nominal CPUE data exhibited several noteworthy features (Table 1). This species was predominant in the shark catch in all circumstances, with a nominal CPUE of 4.31 for 2007–2009 combined. The pooled catches per set and nominal CPUE decreased from 2007 to 2008 and again in 2009. This pattern of decreases was observed in the shallow-set sector, although the percentage of shallow sets with positive catch remained nearly constant (94.3–95.3%). The latter result was probably associated with a 12% increase between 2007 and 2009 in the number of hooks deployed per shallow set. In contrast, the lowest catches per set and nominal CPUE in the deep-set sector occurred in 2008, rather than 2009, even though the percentage of sets with positive catch decreased each year. The annual mean hooks per deep set varied by 3% in 2007–2009 (2184–2285 hooks per deep set).

The pooled and sector-specific results for shortfin mako in 2007–2009 appeared stable (Table 1). The pooled CPUE was 0.27–0.28; the pooled catches per set were 0.30–0.35; and the percentages of sets with positive catch were 21.7–25.2%. The nominal CPUE in the shallow-set sector was 6.4–10.9 times greater than in the deep-set sector.

The catches per set and nominal CPUE for oceanic whitetip shark and silky shark were low in all years and both sectors. The most obvious difference between species was that the results for oceanic whitetip shark did not exhibit obvious sector effects, whereas 97% of the silky sharks were taken in the deep-set sector.

Reporting patterns for these sharks in this fishery are presented in Table 2. In all four species, the percentages of sets with positive catch and reported discards followed the pattern: observer>logbook (observed sets)>logbook (unobserved sets). The same was true with nominal CPUE and catches per set except for those of oceanic whitetip shark, where the results from observer reports and logbooks from observed sets were identical.

The size data (Fork length measurements) are summarized in Table 3 and depicted in Figure 2A-D. The largest sample size by far is that for blue shark. It was also apparent that most of the large blue sharks (i.e., >200 cm FL) measured were males (Figure 2A). For shortfin mako (Figure 2B), there were 43% more FL measurements from males than females in the shallow-set sector. Although the greatest number of measurements came from the 50–100 cm interval for both sexes, the decrease in measurements of females was more pronounced than for males at larger sizes. In contrast, the size distributions for males and females in the deep-set sector were similar. Sample sizes for the sex- and sector-specific presentations (oceanic whitetip shark: Figure 2C; silky shark: Figure 2D) of the other two species were much smaller, with totals of 164 and 10 FL measurements for oceanic whitetip sharks and silky sharks in the shallow-set sector, respectively.

Discussion

The results presented herein are consistent with those in Walsh et al. (2009) in several respects, including the predominance of blue shark, indications of increased shortfin mako catch rates in recent years and greater shortfin mako catch rates in the shallow-set than the deep-set sector, and low percentages of sets with positive catches of oceanic whitetip shark and silky shark. There are, however, other aspects of these shark data that will require very careful evaluation.

Self-reporting patterns in logbooks in 2007–2009 will require careful evaluation. In the present study, the percentage of observer records with blue shark discards reported, for example, exceeds that for logbooks on observed trips by 8.6% and those from unobserved trips by 20.2%. It is not yet clear whether lower nominal CPUE in the most recent years reflects reporting bias, lower relative abundance, or both. Nonetheless, self-reporting bias will probably be an important consideration for all shark species, and the crux of this aspect will probably be discards estimation.

It will also be important to consider the distribution of fishing activity in recent years with respect to shark catches. Walsh et al. (2009) concluded that low catches and catch rates for oceanic whitetip and silky sharks, particularly in 2004–2006, reflected the fact that much of the activity in this fishery occurred north of these species' usual distributions, which would have caused their nominal catch rates to be negatively biased.

An additional complexity regarding analyses of shark data from this fishery is related to the federal logsheet form itself. Blue shark has always had an individual line on the form, and an individual line for oceanic whitetip shark was added to a revised form in 2001, but there has never been an individual line for silky shark. Some silky sharks are entered by name under 'Other shark', and other logbook entries of 'Brown shark' come from locales where observers report high catches of silky sharks (Walsh, unpublished data). Nonetheless, silky shark analyses will confront the difficulties posed by small catches, small numbers of length measurements, and ambiguous logbook data.

Finally, another complexity may represent an analytical opportunity. The ratio of shortfin mako: longfin mako caught was 25:1 (Walsh et al. 2009), and it appears likely that the two species should be separable in the data. Most (55%) of the observed catch of shortfin makos has come from the shallow-set sector, compared to only 9% of the longfin makos. The mean latitude for the shortfin mako catches (27.2°N) was considerably north of that for longfin makos (15.2°N), and there was also some longitudinal separation (shortfin mako: 155.1°W; longfin mako: 159.1°W). If it is necessary to treat these congeners separately, it will probably be possible to do so.

Conclusions

This WP presents recent catch data for direct comparisons with published results (Walsh et al. 2009), size data that reveal the scope of available information and a characterization of self-reporting bias for four shark species. Hence, this document is expected to be useful to the ISC Shark Working Group in its planning of stock assessments because the data collected by the PIROP, the largest pelagic observer program in the Pacific Ocean, will be familiar to its membership. In addition, this WP also documents bias and other characteristics of the logbook data from this fishery that will demand consideration and may permit correction prior to employment in the stock assessments.

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Table 1. Summary of catch and catch rate data for four shark species taken by the Hawaii-based pelagic longline fishery as reported by PIROP observers in 2007–2009. Results are presented pooled and by the shallow-set and deep-set sectors.

Species	Year	Fishery Sector	Catch	Catch/set	Nominal CPUE	Percent Positive Catch	Nominal CPUE, Catch>0
Blue shark	2007	Pooled	32625	6.40	5.25	89.5%	5.87
		Shallow	16252	10.37	12.28	95.3%	12.89
		Deep	16373	4.64	2.13	86.9%	2.45
	2008	Pooled	21941	4.09	3.35	85.2%	3.94
		Shallow	12061	8.17	9.18	95.2%	9.65
		Deep	9880	2.54	1.14	81.4%	1.40
	2009	Pooled	19953	3.81	2.65	82.5%	3.21
		Shallow	7814	4.78	5.10	94.3%	5.41
		Deep	11779	3.36	1.50	77.0%	1.95
Shortfin mako	2007	Pooled	1547	0.30	0.28	21.7%	1.29
		Shallow	1013	0.65	0.76	42.2%	1.79
		Deep	534	0.15	0.07	12.6%	0.55
	2008	Pooled	1900	0.35	0.28	25.2%	1.11
		Shallow	982	0.67	0.74	40.9%	1.81
		Deep	918	0.24	0.10	19.3%	0.54
	2009	Pooled	1741	0.34	0.27	24.5%	1.10
		Shallow	989	0.60	0.64	38.5%	1.67
		Deep	752	0.21	0.10	17.9%	0.53

Table 1, continued.

Species	Year	Fishery Sector	Catch	Catch/set	Nominal CPUE	Percent Positive Catch	Nominal CPUE, Catch>0
Oceanic whitetip shark	2007	Pooled	358	0.07	0.05	5.6%	0.83
		Shallow	98	0.06	0.07	4.0%	1.84
		Deep	260	0.07	0.03	6.3%	0.54
	2008	Pooled	194	0.04	0.02	3.2%	0.69
		Shallow	47	0.03	0.03	3.0%	1.12
		Deep	147	0.04	0.02	3.3%	0.54
	2009	Pooled	301	0.06	0.03	4.6%	0.69
		Shallow	53	0.03	0.03	2.8%	1.17
		Deep	248	0.07	0.03	5.4%	0.57
Silky shark	2007	Pooled	279	0.05	0.03	3.4%	0.80
		Shallow	9	<0.01	<0.01	0.3%	1.89
		Deep	270	0.08	0.04	4.7%	0.77
	2008	Pooled	171	0.03	0.02	2.2%	0.68
		Shallow	7	<0.01	<0.01	0.5%	1.07
		Deep	164	0.04	0.02	2.9%	0.66
	2009	Pooled	328	0.06	0.03	2.7%	1.02
		Shallow	8	<0.01	<0.01	0.5%	1.00
		Deep	320	0.09	0.04	3.7%	1.02

Table 2. Summary of effort, catch and discarding for four shark species taken by the Hawaii-based pelagic longline fishery in 2007−2009. ‘Observer’ refers to data reported by PIROP observers; ‘Logbook (Observed)’ ‘Logbook (Unobserved)’ refer to data reported in logbooks from observed and unobserved trips, respectively.

Species	Source	Effort (Sets)	Catch	Catch/ set	Nominal CPUE	Percent positive catch	Discards/ set	Percent with discards
Blue shark	Observer	15607	74159	4.75	3.74	85.7%	4.75	85.7%
	Logbook (Observed)	15598	69407	4.45	3.50	77.6%	4.43	77.1%
	Logbook (Unobserved)	41820	97379	2.33	1.09	65.8%	2.32	65.5%
Shortfin mako	Observer	15607	5188	0.33	0.28	23.8%	0.26	18.1%
	Logbook (Observed)	15598	4679	0.30	0.24	21.1%	0.22	14.8%
	Logbook (Unobserved)	41820	5924	0.14	0.07	11.1%	0.06	4.7%
Oceanic whitetip shark	Observer	15607	853	0.05	0.03	4.5%	0.06	4.2%
	Logbook (Observed)	15598	813	0.05	0.03	3.7%	0.05	3.4%
	Logbook (Unobserved)	41820	2172	0.05	0.02	2.5%	0.05	2.2%
Silky shark	Observer	15607	778	0.05	0.02	2.8%	0.05	2.6%
	Logbook (Observed)	15598	286	0.02	0.008	0.6%	0.02	0.6%
	Logbook (Unobserved)	41820	105	0.003	0.001	0.1%	0.002	0.1%

Table 3. Summary of shark length measurements (Eye-Fork length) taken by PIROP fishery observers in 1994–2010. 'Caught%' refers to the percentage of sharks measured from the total catch of that species (i.e., observed+unobserved). Differences between the total numbers of measurements and sex-specific totals represent sharks of unknown sex.

Species	EFL Measurements		EFL Measurements Shallow-set		EFL Measurements Deep-set	
	Total	Caught%	Males	Females	Males	Females
Blue shark	8953	0.6%	3226	1963	2114	1625
Shortfin mako	2205	5.0%	504	353	642	684
Oceanic whitetip shark	1192	8.2%[2]	73	91	438	582
Silky shark	700	NA[3]	5	5	306	379

[2] Oceanic whitetip shark measurements are from 2000–2010.
[3] The silky shark catch percentage can not be estimated accurately because the logbook does not have a specific field for this species.

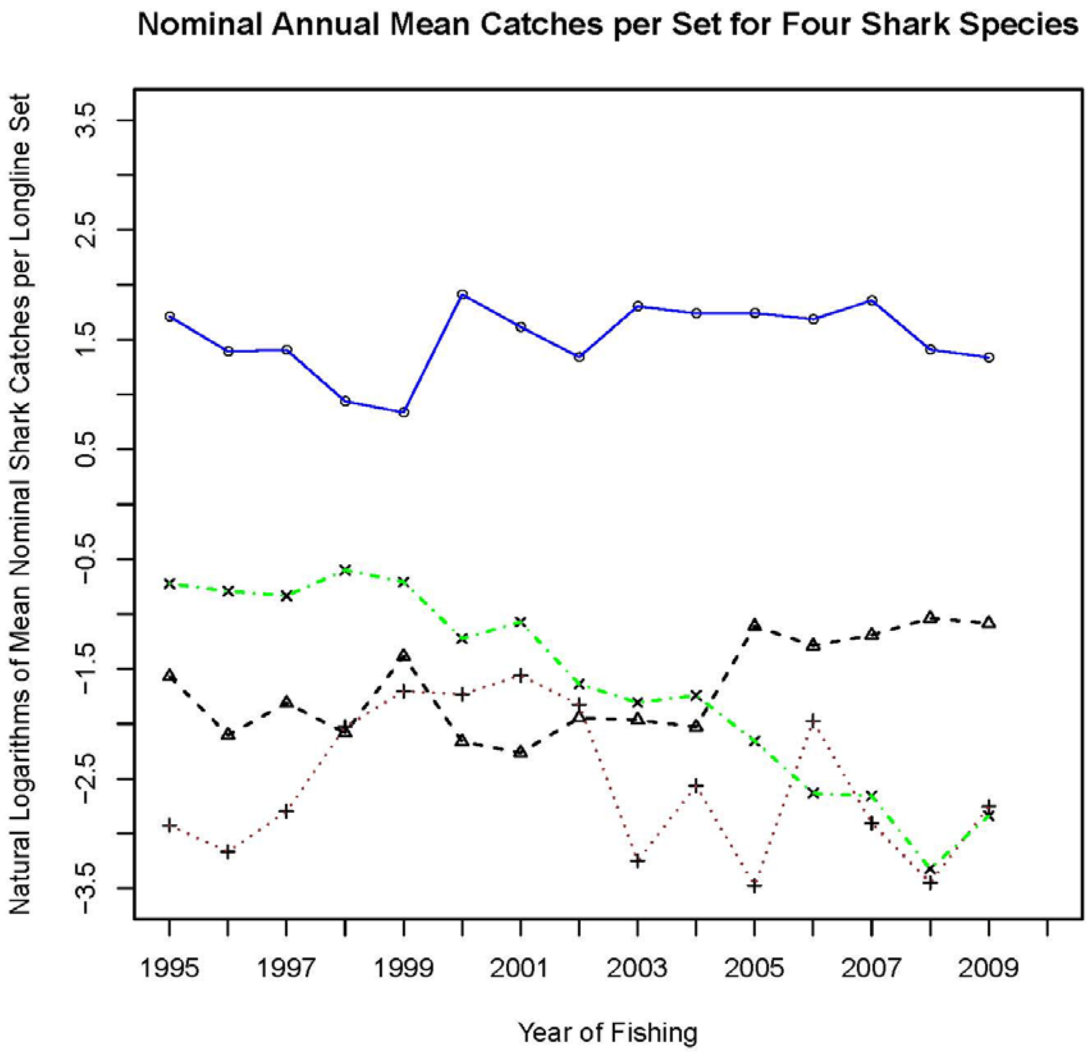

Figure 1. Nominal mean catches per set for blue shark (blue trace with circles), shortfin mako (black trace with triangles), oceanic whitetip shark (green trace with x) and silky shark (brown trace with +). The response axis is a logarithmic scale. Results are pooled observer data for both fishery sectors.

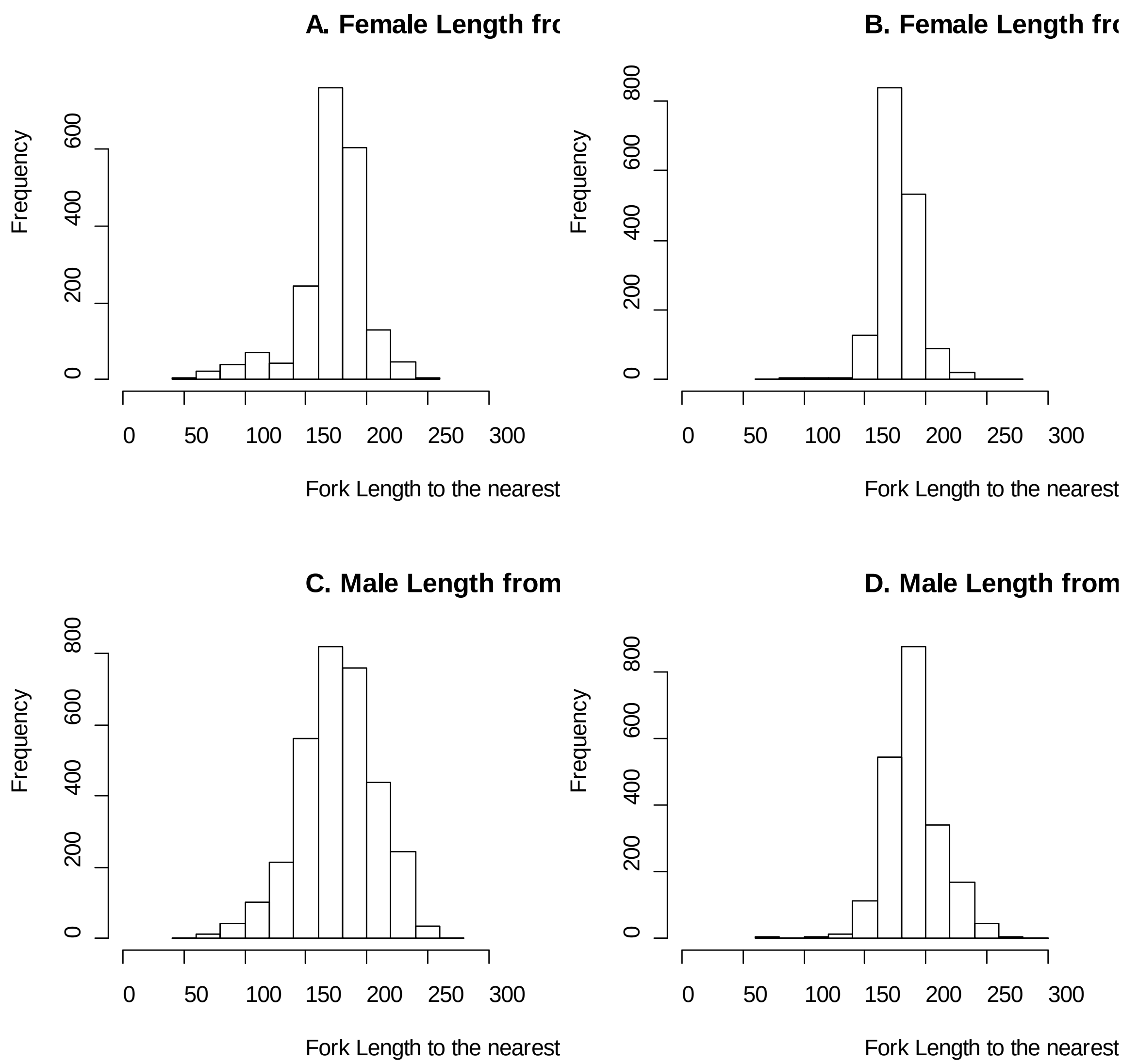

Figure 2A. Blue shark observed length frequency from the Hawaii-based pelagic longline fishery by sexes and fishery sectors in 1994–2010.

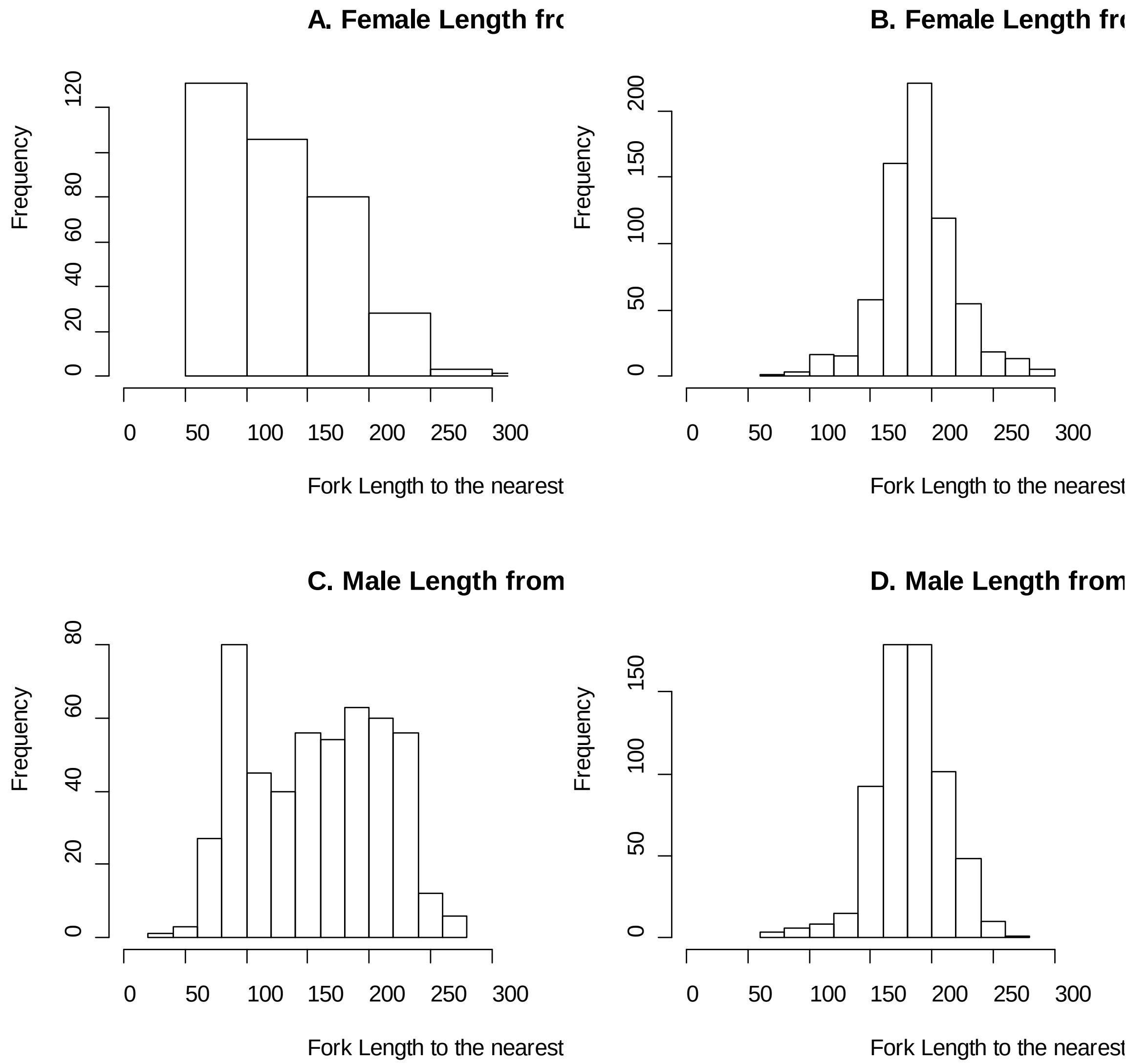

Figure 2B. Shortfin mako observed length frequency from the Hawaii-based pelagic longline fishery by sexes and fishery sectors for in 1994–2010.

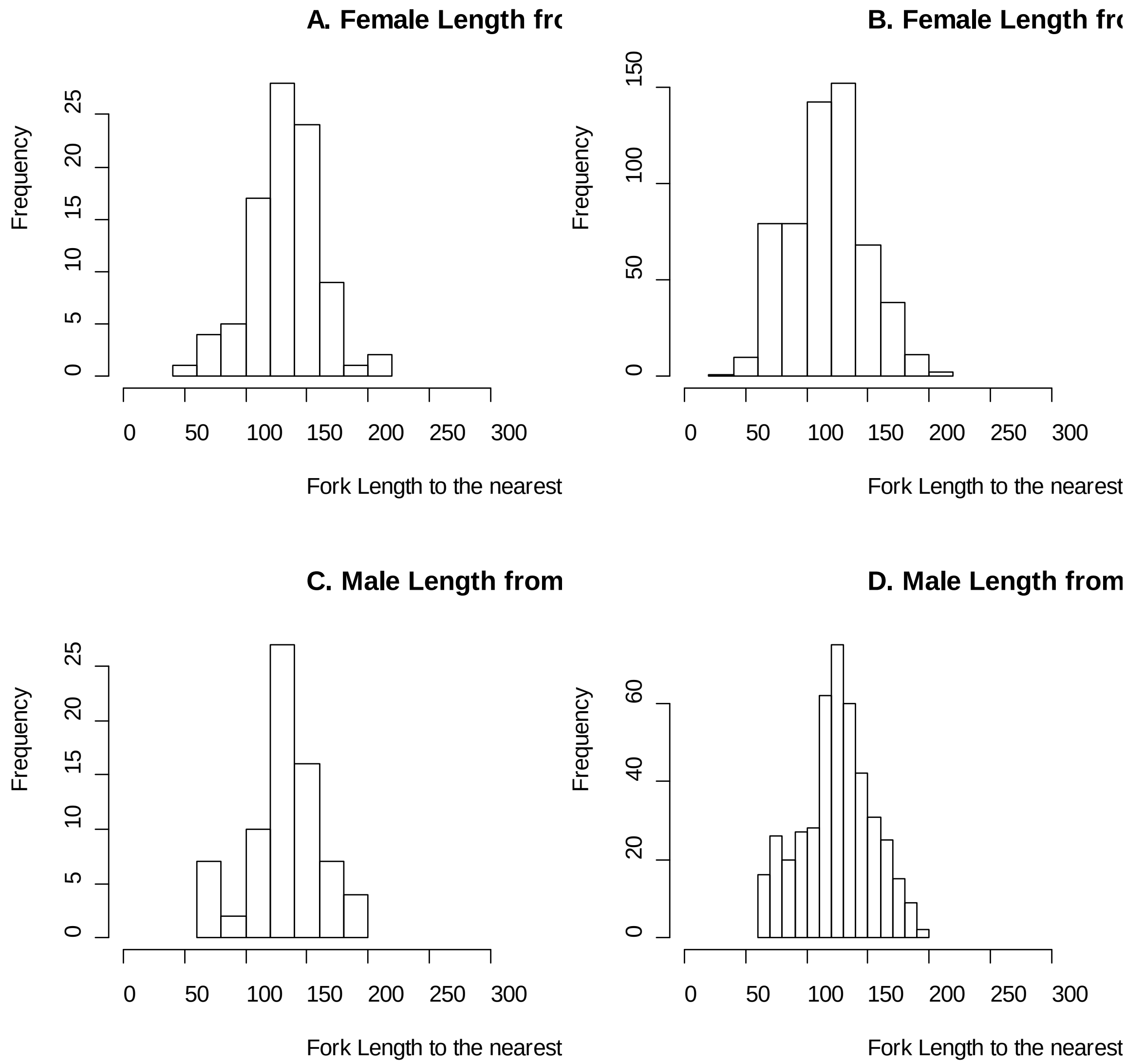

Figure 2C. Oceanic whitetip shark observed length frequency from the Hawaii-based pelagic longline fishery by sexes and fishery sectors for in 1994–2010.

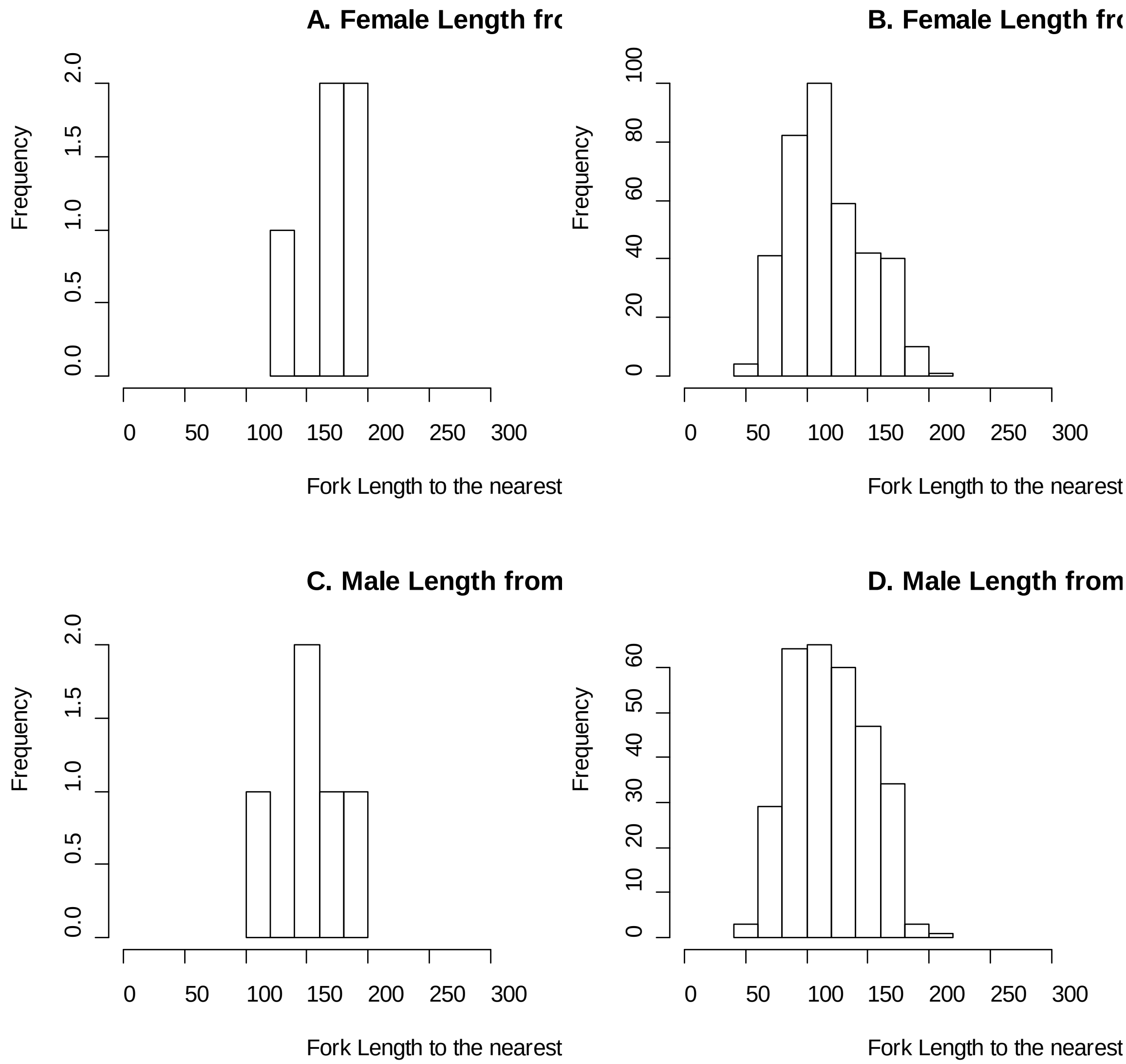

Figure 2D. Silky shark observed length frequency from the Hawaii-based pelagic longline fishery by sexes and fishery sectors in 1994–2010.