A review of exploratory longline surveys and biological sampling of sharks from the Sandy Hook, NJ and Narragansett, RI labs: 1961-1991.

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INTRODUCTION

The United States National Marine Fisheries Service (NMFS), and its predecessor agencies; the Bureau of Commercial Fisheries (BCF) and the Bureau of Sport Fish and Wildlife (BSFW), have conducted periodic longline surveys for swordfish, tuna, and sharks off the east coast of the United States since the early 1950's. While the BCF surveys focused on the development of a tuna fishery, the initiation of shark surveys in 1961 at the Sandy Hook Marine lab (SHML) responded to concerns about shark attacks off the coast of New Jersey and resort owner demands for legislation that would require sport and commercial fishermen to fish further offshore. Reflecting the limited knowledge at the time about shark species composition, abundance, seasonal distributions, migrations, feeding, growth and reproductive life history characteristics; the SHML program was focused on obtaining a broad suite of biological observations.

While surveys predominantly relied on longline gear, early sampling also used chain bottom gear, gillnets, and sport fishing gear. In subsequent years, monitoring of sport fishing tournaments during summer months complimented dedicated surveys on research vessels and opportunistic trips aboard commercial and sport fishing vessels. Early experimentation with different tag types, ultimately lead to the establishment of the ongoing cooperative shark tagging program. After the initial coastal surveys were conducted between 1961 and 1965, there was a gradual transition from coastal work to offshore effort along the edge of the continental shelf and associated Gulf Stream waters. The shark research program moved from the Sandy Hook to the Narragansett lab (NARR) in the early 1970s

This report provides an update on the specific coastal and pelagic shark sampling initiatives that were based out of the Sandy Hook and Narragansett labs. It is a part of a larger project to electronically recover and archive historical longline survey and biological observations of large marine predators (swordfish, sharks, tuna and billfish) in the North Atlantic. Historical data is being entered into data structures similar to those currently used by the Southeast Fisheries Science Center (SEFSC) pelagic longline observer program. This will allow comparisons with more recent data in terms of species catches and when available; size information spanning more than 4 decades. Analyzing the temporal, spatial and operational characteristics of surveys and commercial operations; as well as the associated multi-species catch, provides an opportunity to better understand seasonal distribution patterns and relative vulnerability of various species to different fishing practices. Evaluating catch rates and operating practices from overlapping time-series provides an opportunity to investigate catch rate trends and may help inform analytical assessments of stock status.

MATERIALS and METHODS - Data Sources

Data from research cruises and opportunistic deployments were coded as consistently as possible with the data design for the more recent pelagic observer program. Not all of the gear and operational variables currently recorded by observers were recorded aboard early surveys or on opportunistic trips aboard commercial vessels. Some of these variables reflect new gear innovations. Set specific gear, deployment, retrieval, and species composition data were coded

from original cruise reports, field fishing logs maintained by scientific personnel, final grant reports, or published papers. Species counts were initially entered as catch per set totals. For the shark survey data, catch per set totals were subsequently matched against separate morphometric and tagging databases to verify total set counts. While catch per set discrepancies were rare, when they could not be resolved by referring to the original field notes the higher value was accepted for a specific species catch per set estimate.

SPECIES

Scientific observers attempt to identify all animals that are caught or entangled by the gear. Invariably there are animals that are coded as unidentified or unknown, and others that can only be identified to species family groups such as tunas, billfish, sharks, or species groups such as hammerhead, mako, or thresher sharks. This is particularly prevalent in recent observer data where between 80 and 90 unique codes are recorded for species, species families, species groups, and unclassified records. In the recent observer time series, 30 to 35 rare codes account for 10 or fewer individuals. To simplify analyses and presentation of species catch per set data, the original 80 to 90 codes are combined into @ 34 categories that include the dominant target and incidentally caught (bycatch) species and species groupings **(**Table 1**)**. The original species codes are maintained in associated animal files. The shark survey records are geographically and operationally less diverse than observer time series, so the number of unique species identified is reduced.

OPERATIONAL VARIABLES

Operating practices generally reflect targeting strategies that can influence catch rates for target and incidental species. Observers record gear characteristics and operating practices along with location and environmental variables. These include the date, location (latitude and longitude), time, and sea surface temperature at the start and end of setting and hauling operations for each set. For some of the earliest survey data, only one location was recoverable, although for most records the begin set and end haul locations were available. Survey gear information includes number of hooks set, gangion and dropper line lengths, mainline material, number of hooks between floats, hook sizes, types, and bait information. Additional information on the rare use of line throwers, lightsticks, weights, and sets where the gear is tended during the soak period is being recovered.

In comparison to recent observer records, the gear characteristics of the shark survey records; especially those north of Cape Hatteras, are less variable in terms of component dimensions and rigging patterns (hooks between floats, distances between hooks, etc.). The major change over time relates to the annual proportions of sets deployed in coastal shallow depths versus offshore effort along the edge of the continental shelf and in Gulf Stream waters. The vast majority of shark survey records described in this report deployed pelagic (free floating) gear similar to Japanese style “basket gear” used by the BCF in tuna surveys and “Yankee Style” swordfish gear. The primary characteristic of these gears is that the major components consist of a multi-filament nylon 3/8” mainline with ¼” nylon gangions that end with 3/32” stainless steel leaders. When deployed with between 5 and 10 hooks between floats and in depths less than 40 or 50 meters, field notes on bait loss, species composition of the catch and reported hangs, clearly indicate that the gear is fishing on or near-bottom.

Prior to 1966 almost all of the sets occurred in the northern Mid-Atlantic bight in the approaches to New York harbor. Most occurred east and southeast of Sandy Hook with a smaller number of sets off the southern coast of Long Island to Montauk in depths less than 40 meters. A small

number of sets occurred in Delaware Bay and three sets occurred in Baltimore and Hudson canyons. A multi-filament nylon mainline was generally suspended with 5 meter dropper lines, 8 hooks between floats and gangions that were 5 to 6 meters in total length. The major transitional changes that occurred in the shark surveys occurred after 1966. Most of these cruises occurred between Cape Hatteras and the northeast peak of Georges Bank, where they overlapped BCF and Woods Hole Oceanographic (WHOI) tuna cruises and Canadian DFO swordfish surveys. Effort was primarily concentrated along the edge of the continental shelf and in Gulf Stream waters. Occasional cruises, including cruises with other institutions, extend south of 34° N both along the US continental shelf and in deeper offshore waters north and north east of the Bahamas. While the mainline material remained constant, and hooks between floats rarely exceeded 10, gangion lengths increased slightly to 8 to 12 meters in length. Greater variability occurred in dropper lengths. While dropper lengths exceeding 30 meters were rare, these deep rigs were attempted in offshore waters with depths > 1,000 m especially south of 34 N. During the final three large scale pelagic surveys (Wieczno 86, Del II 89 and Del II 91), a small proportion of monofilament gangions were fished on 55 deep water sets. Recent NMFS shark surveys have switched to bottom anchored gear constructed of monofilament line (Natanson).

RESEARCH CRUISE DATA SUMMARY

A total of 1,916 longline set records were coded from the SHML and NARR cruise files. These included: 1) 340 sets by the BSFW-SHML between 1961 and 1970; 2) 1,488 sets on NMFS-NARR surveys between 1975 and 1996; 3) 44 sets from cruises sponsored by other institutions where NARR staff participated; and 4) 44 sets from opportunistic deployments of scientists aboard volunteer commercial vessels. Table 2 provides an inventory list of shark survey cruises by year and source (program). The months during which the cruises took place are indicated along with the number of sets, number of sets where hooks were recorded and the total number of hooks fished. Total catch numbers are provided separately for blue, sandbar, and dusky sharks. A coastal shark total is provided that accounts for hammerhead, blacktip, tiger, and silky sharks.

Table 3 provides annual set counts where records have been separated primarily relating to effort distribution by depth and/or unique locations or operational strategies that may be critical for the analysis and interpretation of coastal shark catch rate time series. In particular, early SHML sets that occurred within Delaware Bay and off the east coast of Florida are separated from the inshore effort in the Mid-Atlantic bight. A unique set of records from the Wieczno operating off the coast of Africa in 1982 is identified. Trips where NARR staff participated in BCF tuna or Canadian DFO swordfish surveys and opportunistic trips on swordfish vessels are separated from the more standardized NARR pelagic survey operations. NARR pelagic surveys are separated into PLL and Inshore categories with the later reflecting sets in depths <= 50 meters. The anchored bottom and mixed gangion sets (standard versus monofilament) identified in the previous paragraph are also identified.

The annual set counts for the NARR-PLL and PLL-Inshore shark survey records provide an indication of the number of relatively consistent fishing operations and their associated catch rates that may be linked with the more recent NMFS shark surveys, other survey time series and observer data in catch rate analyses. While the number of observations for specific inshore and pelagic sets is modest, they may be informative in terms of abundance trends for some of the more consistently recorded species, especially when combined with other time series. Figure 1 provides preliminary plots of nominal catch rates and proportion of positive sets for the more consistently recorded large coastal sharks by program or source code. Table 4 lists the survey catch totals for a more extensive list of species than provided in table2. The dominant target and incidental species and species groups clearly reflect the diverse group of cruises covered in this

report. The opportunistic trips on commercial vessels and the tuna and swordfish surveys, while small in number, account for a significant proportion of the recorded tunas, swordfish, and billfish.

Table 4 also provides a preliminary list of the numbers of length observations recorded in the NARR morphometric and tagging data files, including both measured and estimated lengths. While the vast majority of these records have been directly linked with the cruise file, this is a portion of the project that is still under review. For several species the total number measured exceeds the total set based catch, or is too high a proportion of that catch. This reflects the inclusion of animal records from other gears; including rod and reel, handline, and other sampling gears, that were fished during station soak times. Figure 2a provides histogram plots of all reported fork lengths for sandbar, dusky, tiger, silky and hammerhead sharks, while Figure 2b provides sandbar size histograms by decade.

Table 1. Species and species group list used to summarize species composition for survey longline catch per set.

Common Name	Scientific Name	Family
Yellowfin Tuna	Thunnus albacares	Scombridae
Bigeye Tuna	Thunnus obesus	Scombridae
Bluefin Tuna	Thunnus thynnus	Scombridae
Albacore Tuna	Thunnus alalunga	Scombridae
Other Tunas		Scombridae
Swordfish	Xiphias gladius	Xiphiidae
White Marlin	Tetrapturus albidus	
Blue Marlin	Makaira nigricans	
Sailfish	Istiophorus platypterus	
Spearfish	Tetrapturus sp.	
Unid Marlin		
Blue Shark	Prionace glauca	Carcharhinidae
Mako Sharks	Isurus sp.	Lamnidae
Thresher Sharks	Alopias sp.	Alopiidae
Porbeagle Shark	Lamna nasus	
Oceanic Whitetip	Carcharhinus longimanus	
Sandbar Shark	Carcharhinus plumbeus	Carcharhinidae
Dusky Shark	Carcharhinus obscurus	Carcharhinidae
Hammerhead Sharks	Sphyrna sp.	Sphyrinidae
Blacktip Shark	Carcharhinus Limbatus	
Tiger Shark	Galeocerdo Cuvieri	
Silky Shark	Carcharhinus falciformes	Carcharhinidae
Atlantic Sharpnose	Rhizoprionodon terraenovae	
Night Shark	Carcharhinus Signatus	
Sand Tiger	Odontaspis Taurus	
Other Sharks		
Unid Sharks		
Dogfish	Squalidae sp.	
Skates and Rays	Primarily Dasyatis sp.	
Lancetfish	Alepisaurus sp.	Alepisauridae
Oilfish and Escolar	Ruvettus pretiosus	Gempylidae
	Lepidocybium	
Dolphin Fish	Coryphaena sp.	Coryphaenidae
Other Fish		
Other Species and unidentified animals		

Table2. Inventory list of shark survey cruises (1961-1996). Fishing effort (sets and hooks) and total catch for blue, sandbar, dusky and a coastal shark group are provided by cruise.

Year	Source	Trip	Months	Sets		Total effort	# BSH	# SSB	# DUS	# CSTSHK
				Numbers	w hooks					
1961	BSFW-SHML	Cape May	Aug.-Oct.	36	36	4,645	0	108	71	29
1962	BSFW-SHML	Challenger	Aug.-Oct.	17	17	1,644	0	40	17	10
		Delaware Bay	July-Sept.	9	9	386	0	8	4	1
1963	BSFW-SHML	Challenger	May-Sept.	37	37	2,978	0	5	9	0
		Highlander	Aug.	6	6	490	0	2	0	1
		Lady Jean	Aug.	9	9	639	0	9	14	2
1964	BSFW-SHML	Challenger	May-Aug.	21	21	1,512	0	19	2	0
		Delaware Bay	June-Aug.	15	15	994	0	119	0	0
		Snapper II	July	5	5	381	7	0	5	0
1965	BSFW-SHML	Bluefish-Bluechip	March-Aug.	53	53	2,971	1	157	4	58
		Brigantine	May	2	2	66	0	0	0	0
		Challenger	Sept.	2	2	140	0	4	0	0
1966	BSFW-SHML	Dolphin 66-4	May	4	4	980	9	0	0	1
		Dolphin 66-6	June	8	8	2,414	11	0	6	6
		Dolphin 66-8	July	5	5	1,380	92	0	0	0
1967	BSFW-SHML	Dolphin 67-10	Aug.	14	14	2,939	290	8	0	1
		Dolphin 67-6	June	12	12	3,317	56	0	0	0
1968	BSFW-SHML	Dolphin 68-5	May-June	15	15	4,177	94	0	7	29
		Dolphin 68-6	July	13	13	1,782	339	1	1	0
1969	BSFW-SHML	Chain	Feb.-March	9	9	1,723	67	1	1	29
		Dolphin 69-11	May	10	10	2,182	124	7	1	37
		Dolphin 69-17	July	4	4	450	67	0	0	0
		Dolphin 69-7	March-April	5	5	945	0	0	0	0
		Gosnold 148 A & B	Oct.	10	10	2,825	72	0	4	0
1970	BSFW-SHML	Dolphin 70-22	Sept.	1	1	267	0	0	0	2
		Gosnold 171 A	Oct.	7	7	2,130	60	1	16	2
		Gosnold 171 B	Oct.	7	7	1,870	170	0	0	0
		Trident -80	March-April	4	4	1,036	3	0	42	2
1971	NARR-NE	Gosnold 175	April	13	13	3,461	273	0	0	71
		Trident - 92	Jan.	7	7	2,028	4	0	0	23
1972	NARR-NE	Cap'n Bill IV 72-2	Oct.	8	8	4,455	296	0	4	4
		Francis Geraldine 72-6	May-June	12	12	6,251	718	0	3	67
1973	NARR-NE	Eastward 73-1	April	4	4	350	0	0	0	40
1975	NARR	Geronimo 75	June	9	9	1,099	108	1	1	0
1976	NARR	Geronimo 76	June-Aug.	7	7	856	31	2	0	0
		Wieczno 76-05	Nov.	12	12	3,300	104	2	1	2
1977	NARR	Geronimo 77	June-Dec.	47	**42**	4,916	568	15	1	36
		Wieczno 77-03	March-April	19	19	2,438	141	0	0	9
	NARR-comm	Diane Marie	Nov.	10	10	4,420	188	0	0	5
1978	NARR	Geronimo 78	Feb.-Nov.	72	**67**	6,309	369	48	5	26
		Wieczno 78-02	March-April	13	13	3,286	253	10	0	76
		Wieczno 78-03	Sept.-Oct.	30	30	4,775	199	2	1	1
1979	NARR	Geronimo 79	Jan.-Nov.	84	84	7,699	892	53	2	74
		Wieczno 79-01	Oct.	28	28	7,640	271	6	0	24
1980	NARR	Geronimo 80	Feb.-Dec.	99	99	9,475	746	83	4	80
		Wieczno 80-03	March	17	17	2,566	67	30	1	61
1981	NARR	Geronimo 81	Feb.-Aug.	56	56	5,302	666	52	3	72
		Wieczno 81-03	Oct.-Nov.	19	19	4,550	111	0	0	1
	NARR-comm	Darana R	Aug.-Sept.	7	7	4,280	25	0	1	5
1982	NARR	Geronimo 82	Feb.-Nov.	64	64	4,991	405	21	10	45
1982		Wieczno 82	April-July	59	**58**	66,011	1,461	0	46	8
1983	NARR	Geronimo 83	Feb.-Nov.	49	49	4,765	433	41	0	61
		Wieczno 83-02	Feb.-March	17	17	3,310	76	2	0	99
1984	NARR	Geronimo 84	Feb.-May	19	19	1,422	0	51	0	21
		Wieczno 84-02	April-May	30	30	8,507	130	62	0	136
	NARR-comm	Sea Gull	July	11	11	4,956	56	0	0	0
1985	NARR	Delaware II 85-04	May	24	24	4,542	86	46	1	249
		Geronimo 85	March-Dec.	42	**41**	2,989	215	13	1	24
		Wieczno 85-01	Oct.	24	24	4,790	196	95	32	51
1986	NARR	Geronimo 86	Feb.-Nov.	42	42	3,637	66	1	8	9
		Wieczno 86-01	July-Sept.	120	120	14,000	32	325	37	82
1987	NARR	Geronimo 87	Feb.-Nov.	49	49	4,733	151	35	0	30
1988	NARR	Geronimo 88	Feb.-Sept.	31	**29**	2,772	124	10	0	15
1989	NARR	Delaware II 89-03	April-May	137	137	14,522	54	345	13	165
		Geronimo 89	Feb.-Nov.	34	34	2,782	32	38	0	24

Table 2 (continued).

Year	Source	Trip	Months	Sets		Total effort	# BSH	# SSB	# DUS	# CSTSHK
				Numbers	w hooks					
1990	NARR	Geronimo 90	March-Aug.	25	25	2,303	45	1	0	13
	NARR-comm	Seneca	Oct.-Nov.	16	16	9,035	249	0	0	0
1991	NARR	Delaware II 91-06	April-June	140	140	14,513	140	111	6	110
		Geronimo 91	March-Nov.	17	15	1,280	17	2	0	7
1992	NARR	Geronimo 92	March-Dec.	12	12	920	33	0	6	20
1993	NARR	Geronimo 93	May-Oct.	14	14	1,403	42	4	0	1
1994	NARR	Geronimo 94	March-Aug.	13	13	1,202	14	0	1	0
1995	NARR	Geronimo 95	May-Nov.	2	2	27	0	0	0	1
1996	NARR	Geronimo 96	July	2	2	180	0	0	0	0
		Oregon II 96-04	Aug.-Sept.	10	10	1,000	0	0	0	0
			Totals	**1,916**	**1,900**	**317,311**	**11,549**	**1,996**	**392**	**2,058**

Data sources:

(7 - BSFW-SHML) Bureau of Sport Fisheries and Wildlife, Sandy Hook Marine Laboratory
(8 - NARR) National Marine Fisheries Service, Narragansett Laboratory
(15 - NARR-NE) Cooperative cruises between NMFS Narragansett Laboratory and other institutions in the northeast US
(5 - NARR-comm) Opportunistic deployments of NMFS Narragansett scientists aboard volunteer commercial vessels

CSTSHK = 1,227 hammerheads + 84 blacktip + 472 tiger + 275 silky.
Note - Geronimo cruises 77 through 96 require review of other shark catch. Problems matching cruise and animal files.

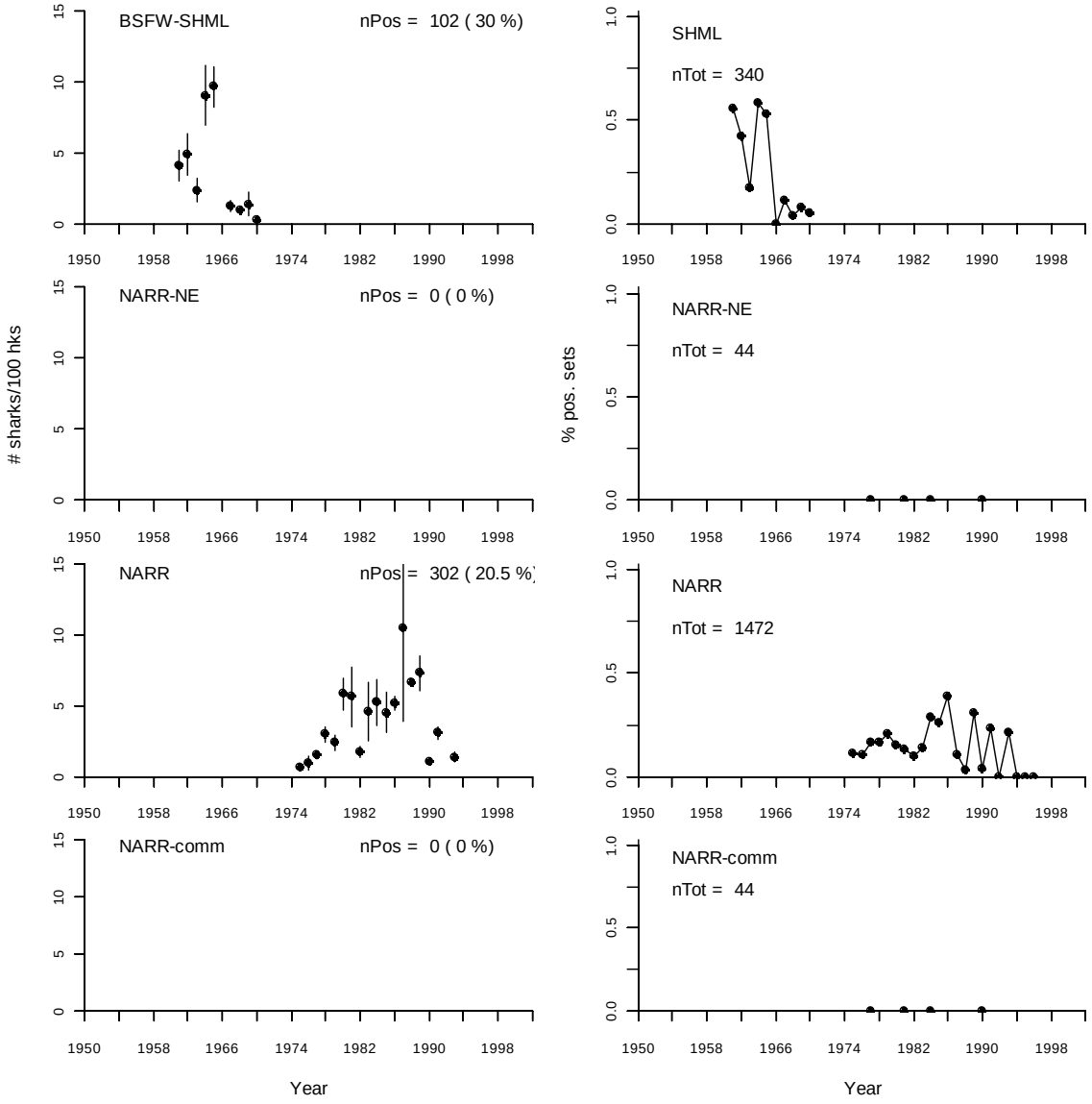
Table3. Annual number of shark survey sets separated primarily by depth distribution of effort and by cruise target strategies for specific species. A limited number of trips in unique geographic locations; including Delaware Bay, an early cruise off Florida and effort off Africa are segregated along with trips on surveys for tuna and swordfish.

YEAR	PLL-Inshr	DelBay	Inshr-FL	NARR-PLL	PLL-Mix	Bottom-LL	Swf - Tuna	Africa
1961	36							
1962	22	4						
1963	52							
1964	26	15						
1965	24	22	11					
1966	3			14				
1967	5			21				
1968	2			26				
1969	2			17			19	
1970				5			14	
1971				20				
1972							20	
1973				4				
1974								
1975				9				
1976				19				
1977	22			44			10	
1978	29			86				
1979	10			102				
1980	21			95				
1981	10			65			7	
1982	18			46				59
1983	11			55				
1984	6			43			11	
1985	12			78				
1986	83			63	16			
1987	6			43				
1988	7			24				
1989	104			43	19	5		
1990	3			22			16	
1991	74			63	20			
1992	2			10				
1993	4			10				
1994	3			10				
1995				2				
1996				12				
TOTAL	597	41	11	1051	55	5	97	59

Table 4. Total species counts for survey stations (total catch) and measured individuals for the SHML and NARR shark survey data set.

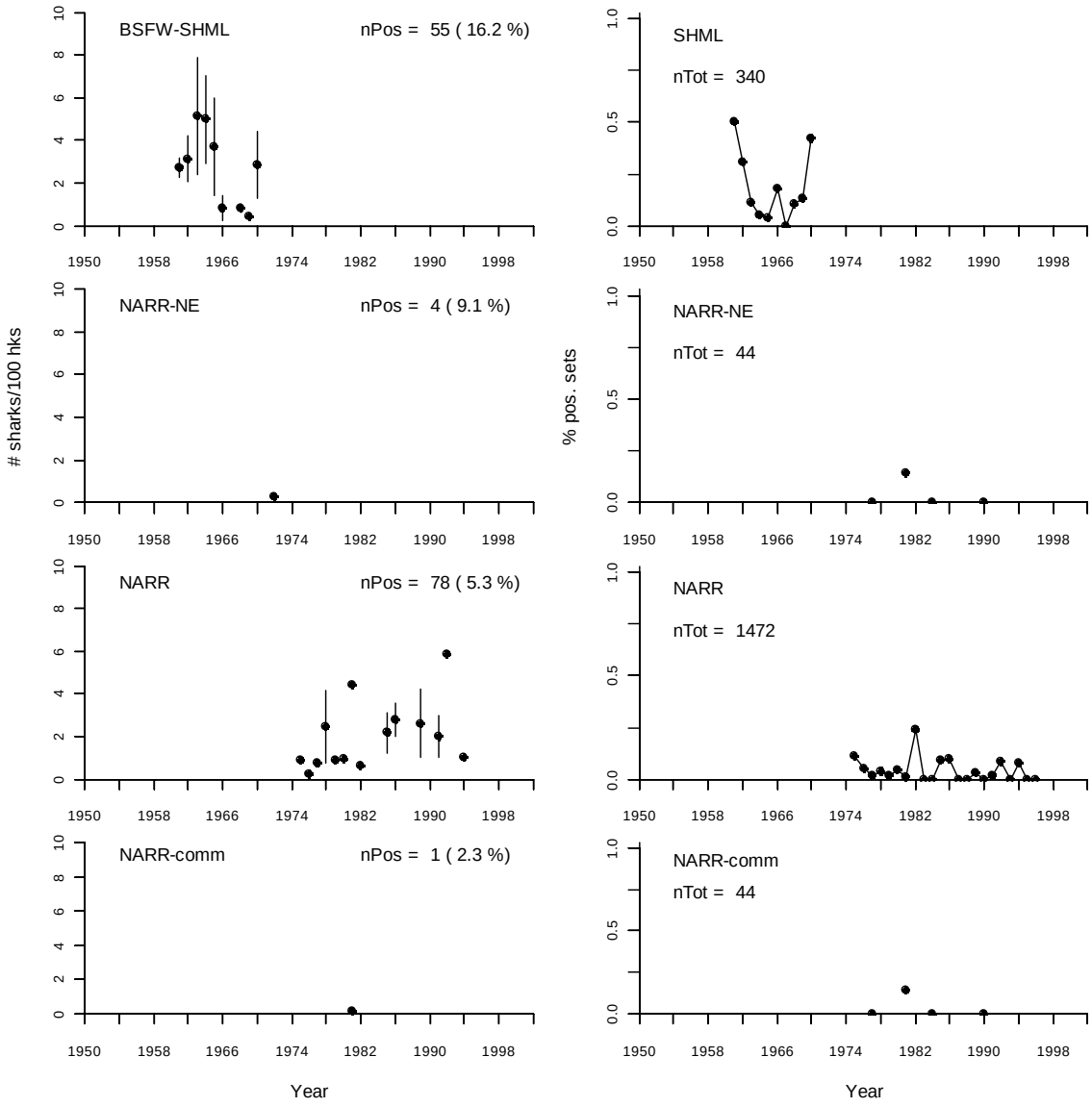
Common Name	**Scientific Name**	**Total Catch**	**Length Meas**
Yellowfin Tuna	Thunnus albacares	656	160
Bigeye Tuna	Thunnus obesus	39	9
Bluefin Tuna	Thunnus thynnus	116	10
Albacore Tuna	Thunnus alalunga	18	1
Other Tunas		14	
Swordfish	Xiphias gladius	1,027	438
White Marlin	Tetrapturus albidus	83	26
Blue Marlin	Makaira nigricans	4	1
Sailfish	Istiophorus platypterus	62	5
Spearfish	Tetrapturus sp.	4	
Unid Marlin		0	
Blue Shark	Prionace glauca	11,549	9,732
Mako Sharks	Isurus sp.	746	589
Thresher Sharks	Alopias sp.	216	157
Porbeagle Shark	Lamna nasus	45	39
Oceanic Whitetip	Carcharhinus longimanus	145	58
Sandbar Shark	Carcharhinus plumbeus	1,996	1,878
Dusky Shark	Carcharhinus obscurus	392	348
Hammerhead Sharks	Sphyrna sp.	1,227	***1,249***
Blacktip Shark	Carcharhinus Limbatus	84	40
Tiger Shark	Galeocerdo Cuvieri	472	444
Silky Shark	Carcharhinus falciformes	275	***330***
Atlantic Sharpnose	Rhizoprionodon terraenovae	108	103
Night Shark	Carcharhinus Signatus	230	***240***
Sand Tiger	Odontaspis Taurus	130	112
Other Sharks		1,115	
Unid Sharks		51	
Dogfish	Squalidae sp.	272	207
Skates and Rays	Primarily Dasyatis sp.	261	
Lancetfish	Alepisaurus sp.	688	
Oilfish and Escolar	Ruvettus pretiosus	26	
	Lepidocybium		
Dolphin Fish	Coryphaena sp.	58	
Other Fish		374	
Other Species and unidentified animals		30	

Figure1. Nominal CPUE plots and the proportion positive for selected large coastal shark species presented by survey source and year. Nominal CPUEs are catch per 100 hooks and have not been standardized for set duration.



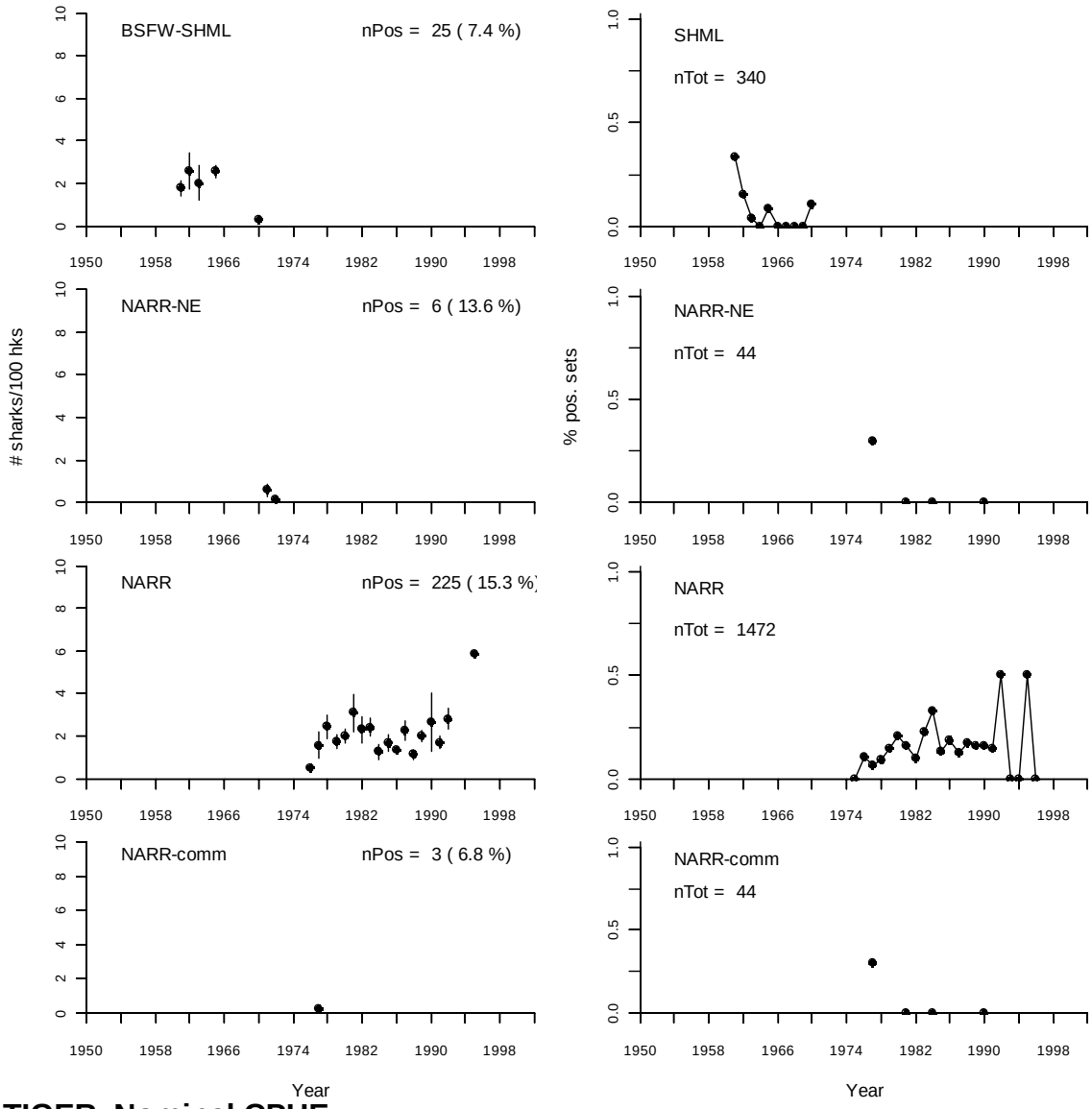
SANDBAR. Nominal CPUE

Figure1 (continued).



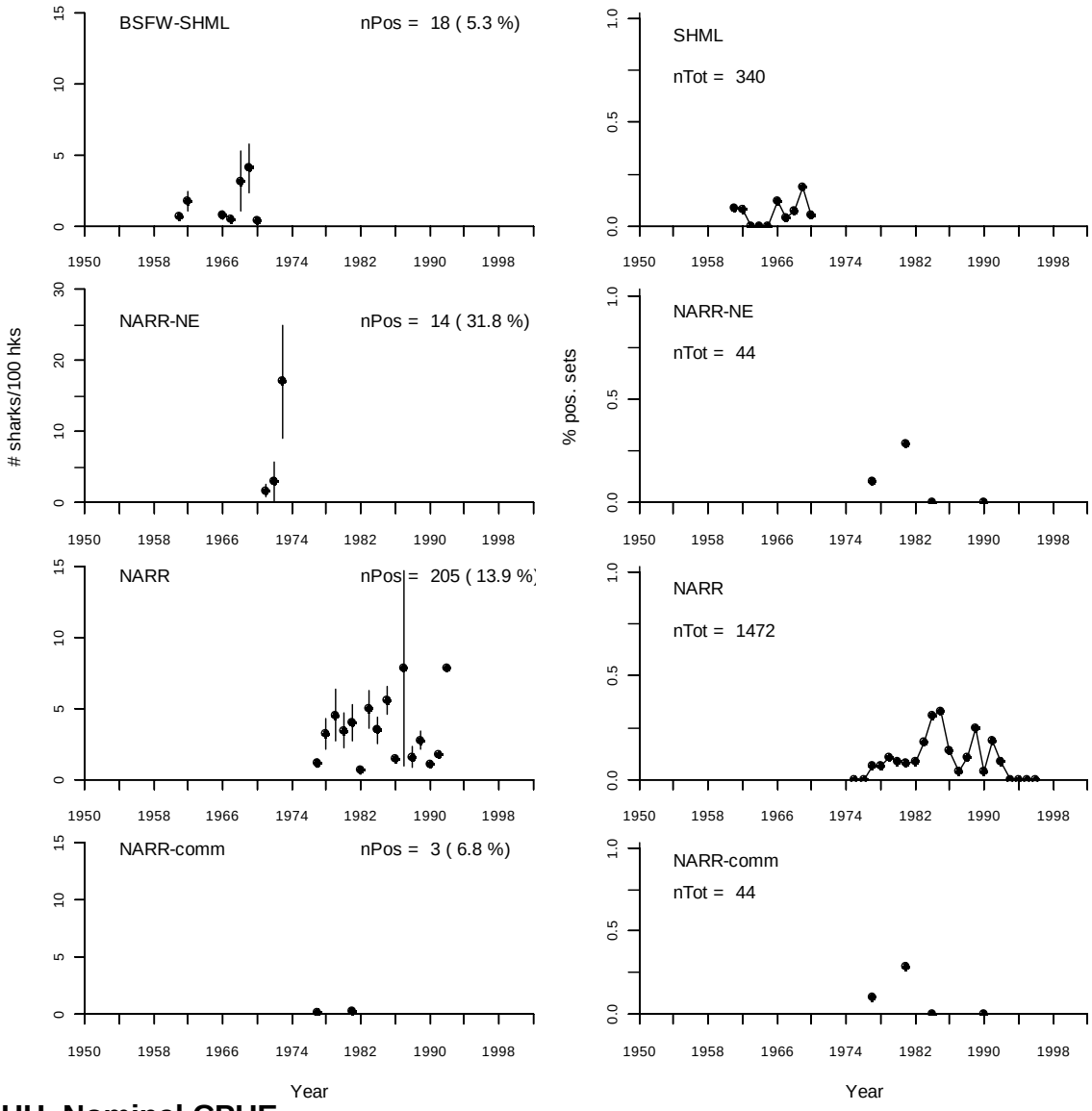
DUSKY. Nominal CPUE

Figure1 (continued).



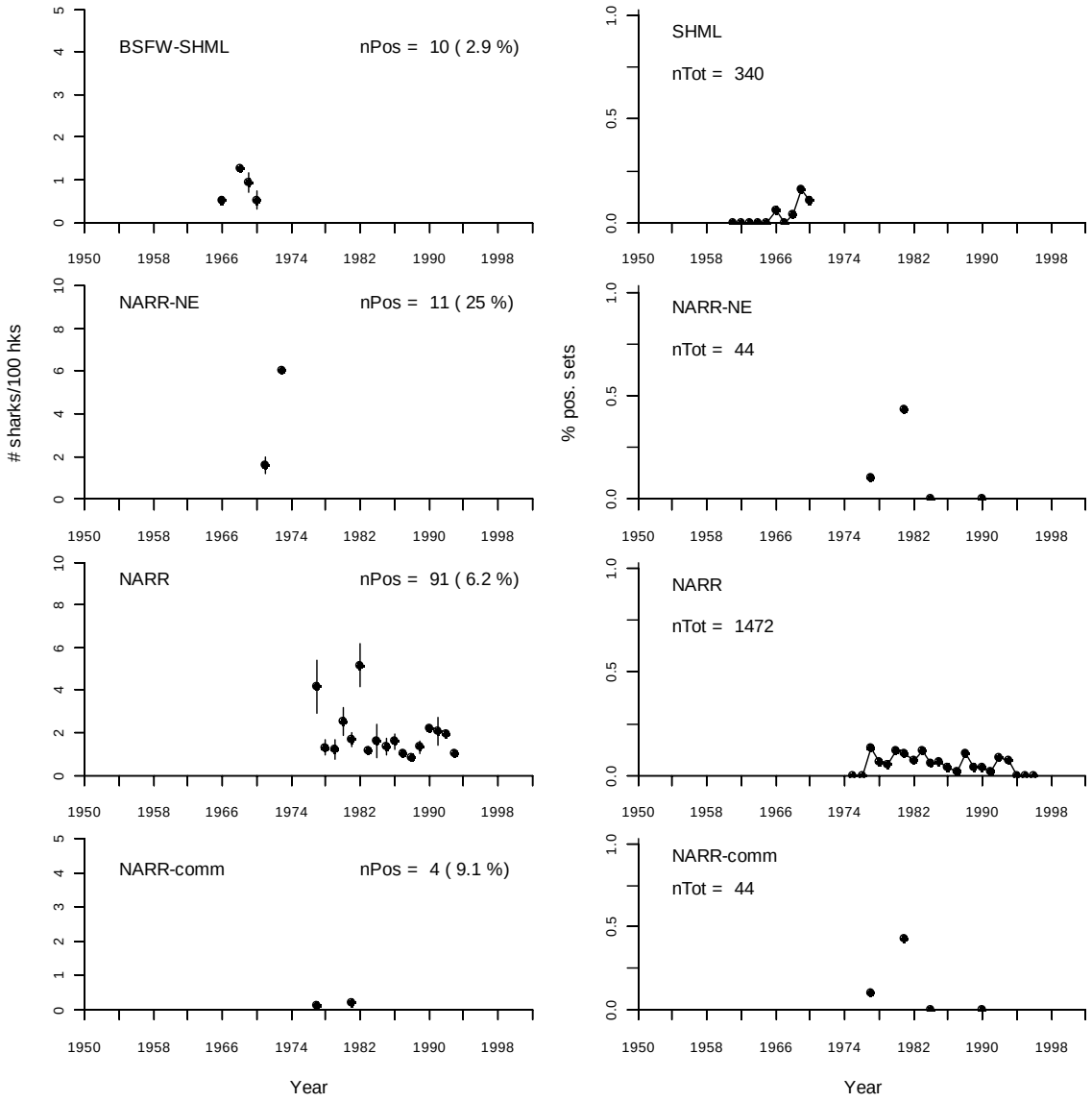
TIGER. Nominal CPUE

Figure1 (continued).



HH. Nominal CPUE

Figure1 (continued).



SILKY. Nominal CPUE

Figure 2a. Histogram plots of fork length frequency for selected large coastal sharks.

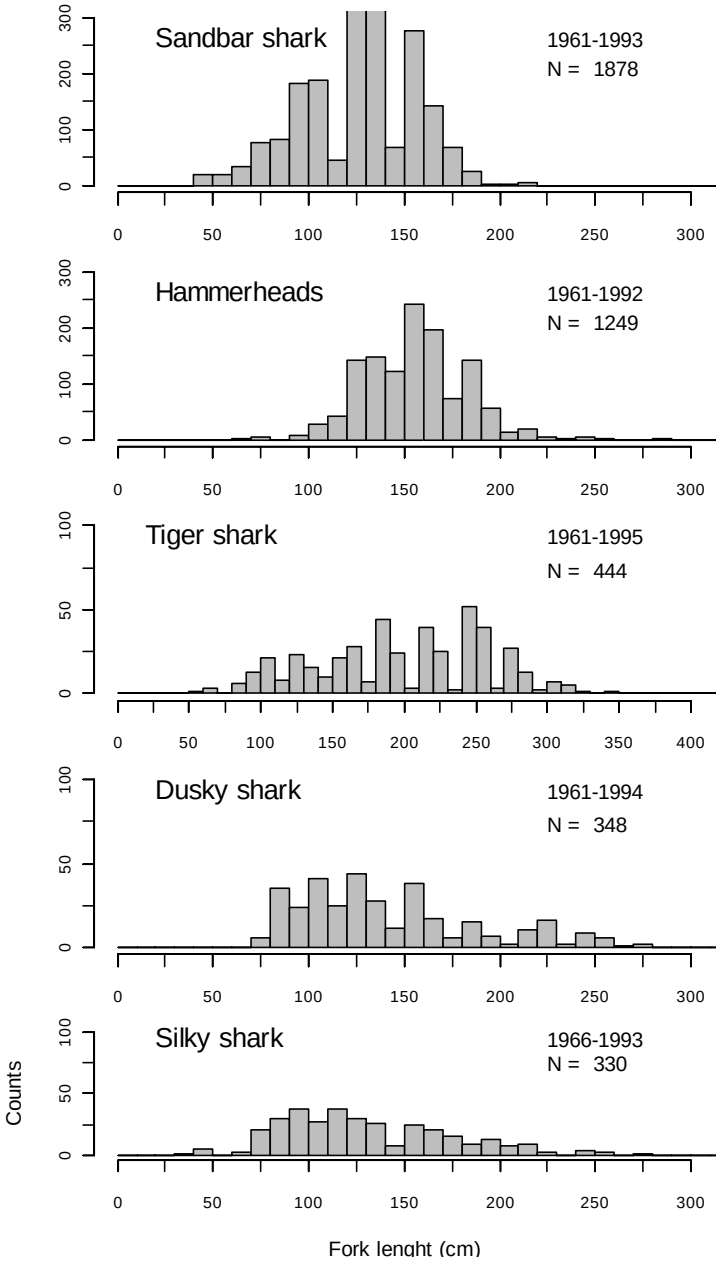


Figure 2a. Histogram plots of fork length frequency for sandbar sharks by decade.