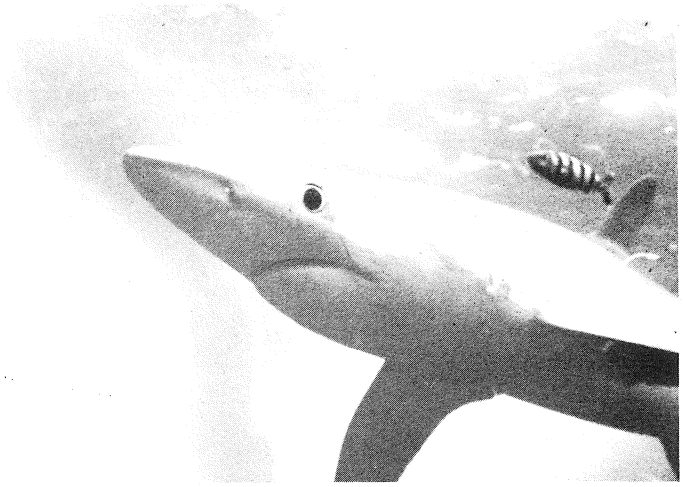
THE SHARK TAGGER 1990 SUMMARY



J. Casey, H. W. Pratt, N. Kohler and C. Stillwell

PHOTO BY H. W. PRATT

1990 OVERVIEW

- RECORD NUMBER OF SHARKS TAGGED (5000) AND RETURNED (385) IN 1990
- RECORD TIMES AT LIBERTY FOR SANDBAR (25 YRS.) AND TIGER SHARKS (8 YRS.)
- LONGEST DISTANCES RECORDED FOR SANDBAR (2039 MI.), SCALLOPED HAMMERHEAD (402 MI.), AND BULL SHARKS (231 MI.)
- TAGGED WHITE SHARK TRAVELS 384 MILES FROM VIRGINIA TO MASSACHUSETTS
- TAGGED SWORDFISH TRAVELS RECORD DISTANCE OF 2357 MILES BETWEEN THE FLEMISH CAP AND CUBA

OVERVIEW

A total of 5464 fish representing 34 species of sharks and 14 species of teleosts and rays were tagged in 1990. The majority were blue (47%), sandbar (14%) and tiger sharks (12%) (Table 1). This is more than the number tagged in 1989, despite the absence of an extensive NMFS survey cruise on which 588 sharks and teleosts were tagged in 1989. This difference is primarily due to an increase in tagging of blue sharks by anglers and tiger sharks by Florida commercial fishermen.

Overview continues on Page 2

Distribution of this newsletter is limited to active participants in the NMFS Cooperative Shark Tagging Program. This information is preliminary and subject to revision.

Newsletter of the
Cooperative Shark Tagging Program
U.S. Department of Commerce
National Oceanic and Atmospheric Administration
National Marine Fisheries Service
Northeast Fisheries Center
Narragansett, Rhode Island 02882

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Table 1. Summary of sharks and teleosts tagged, January-December 1990.

SPECIES	TAGGED BY COOPERATIVE TAGGERS	NARRAGANSETT BIOLOGISTS	TOTALS
Blue shark	2573	7	2580
Sandbar shark	767	9	776
Tiger shark	635	28	663
Dusky shark	318	15	333
Blacktip shark	194	1	195
Shortfin mako	117	0	117
Atlantic sharpnose shark	107	8	115
Galapagos shark	80	0	80
Lemon shark	75	0	75
Sand tiger	46	0	46
Bull shark	40	0	40
Nurse shark	39	0	39
Scalloped hammerhead	35	1	36
Reef shark	32	0	32
Bonnethead	21	0	21
Spinner shark	21	0	21
Smooth hammerhead	14	0	14
Atlantic angel shark	13	0	13
Blacknose shark	9	0	9
Silky shark	8	0	8
Tope	8	0	8
Great hammerhead	3	0	3
Finetooth shark	3	0	3
Bignose shark	3	0	3
Smooth dogfish	3	0	3
Longfin mako	2	0	2
Basking shark	2	0	2
Porbeagle	1	0	1
Brown smoothhound	1	0	1
Florida smoothhound	1	0	1
Bramble shark	1	0	1
Spiny dogfish	1	0	1
Common thresher shark	1	0	1
Hammerhead unspecified	36	0	36
Brown/Dusky unspecified	19	0	19
Sand unspecified	14	0	14
Carcharhinus unspecified	6	0	6
Thresher unspecified	4	0	4
Miscellaneous sharks and rays	74	0	74
Total sharks	5327	69	5396
Swordfish	20	0	20
White marlin	17	0	17
Bluefin tuna	7	0	7
Yellowfin tuna	3	0	3
sailfish	3	0	3
Blue marlin	1	0	1
Striped marlin	1	0	1
Miscellaneous teleosts	16	0	16
Total teleosts	68	0	68
Grand Total	5395	69	5464

(Overview continued)

Anglers accounted for 70% of the total releases followed by commercial fishermen (15%), the RV *Geronimo* biologists (10%), and NMFS and other biologists (5%). NMFS biologists tagged 69 fish while on board two commercial longline vessels (see Field Studies). Approximately 100 blue sharks were tagged by Italian sport fishermen in the Adriatic Sea, some of which were recaptured this year.

Cover Photo: Weighing a shortfin mako at a tournament in Montauk, NY. Nearly all U.S. shark tournaments encourage the release of small fish. *Photo by H. W. Pratt*

RECAPTURES

Three hundred and eighty-five fish including 19 species of shark and 4 species of teleosts were recaptured in 1990 (Table 2). Blue sharks (34%), sandbar sharks (23%) and tiger sharks (20%) were the most commonly returned. This is the largest number of fish recaptured in any year since the beginning of the Cooperative Tagging Program in 1962. The increase in the number of returns over 1989 is primarily due to the large number of tiger shark recaptures in 1990.

Anglers (59%), commercial fishermen (19%), NMFS and other biologists (14%) and Foreign Fisheries Observers (6%) tagged the sharks returned in 1990. The fishing gear used was rod and reel, longline, handline, trawl net, gill net and free swimming. Recaptured fish were originally tagged from vessels representing the U.S., Japan, Poland, Italy, Spain, and Mexico.

The sources of the recaptures were primarily commercial fishermen (69%) and recreational anglers (30%). Returns came from vessels from the following 15 countries and island territories: U.S. (326), Spain (19), Mexico (11), Canada (9), Cuba (9), Taiwan (2), and 1 each from Italy, Venezuela, Yugoslavia, Greece, Colombia, Japan, Malta, Barbados and England.

BLUE SHARKS (130 Returns)

Although no distance records were established for blue sharks in 1990, many returns provided useful and interesting information on long distance migrations. Twenty-three of the blue sharks were recaptured more than 1000 miles from their tagging sites; the longest distance travelled was 2843 miles. Areas of recapture included the waters off the Azores (8), Cuba (3), Trinidad (2), Portugal (2), Venezuela (2), the Canary Islands (2), Guyana and Barbados. One of the fish recaptured off Venezuela in December was pregnant with 30 pups. Although these and other blue shark recaptures show migratory routes over the entire North Atlantic, some returns do not follow a well-established seasonal pattern of movement. The blue sharks recaptured off Trinidad were both tagged during July 1989 off Montauk, NY, and caught within 19 days of each other. Alternatively, two sharks tagged on the same day near Hydrographer Canyon by a Foreign Fisheries Observer were recaptured thousands of miles apart after 1.2 and 1.4 years at liberty. One was returned 225 miles west of Portugal and the other off the coast of Barbados.

Five recaptured blue sharks were originally tagged east of Pesaro, Italy, in the Adriatic Sea by Italian sport fishermen. These fish were at liberty from 1 to 8.5 months and were recaptured off southern Italy, Malta, Yugoslavia, and Crete (distances travelled of 47 to 677 miles).

Tags from blue sharks were returned after the fish had been at liberty from 1 to 1934 days (5.3 years). This falls short of the current record of 8.5 years. Thirty-three percent of the blue sharks were out for less than 1 month, 66% for less than 1 year and 95% were at liberty for less than three years. Some of the fish with the longest times at liberty were recaptured near their original tagging sites. Two blue sharks tagged in July (in different years) off New York were recaptured less than 25 miles away, 4.0 and 5.1 years later. Another blue shark at liberty for 4.2 years was tagged and recaptured in the same area northeast of the Azores.

Multiple recaptures of the same fish indicate that blue sharks are able to withstand the rigors of capture, tagging and release. One blue shark tagged in 1989 was recaptured after one year and retagged. Thirteen days later it was caught again and retagged and released with a new tag. Two fish, reported in poor condition at tagging (gut-hooked and bleeding) were re-caught, one after 1 month and the other after 2 years at liberty. At recapture, both were reported in good condition and retagged and re-released. Forty-two recaptured blue

sharks are still at liberty, having been retagged, released with the same tag or released without a tag.

SANDBAR SHARKS (89 Returns)

A female sandbar shark tagged by a NMFS Narragansett biologist in Great Machipongo Sound, VA, on June 22, 1965, was recaptured 25 years later by a commercial longline fisherman east of St. Augustine, FL. This is the longest time at liberty for any shark in the Cooperative Tagging Program. The fish was measured at time of tagging and recapture and grew 2.5 cm (1") per year. This very slow growth agrees well with information from other sandbar shark recaptures. Two other sandbar sharks were recaptured after being at liberty for more than 20 years (20.7 and 22.6 years). Both were tagged off the Northeast coast and recaptured off the west coast of Florida. Overall, 82% of the sandbar sharks were out for more than one year, 39% for more than 5 years and 13% were at liberty for more than 10 years.

A record distance of 2039 miles between tag and recapture location was reported for two sandbar sharks. Both fish were tagged off Montauk, NY, and recaptured off the coast of Tamaulipas, Mexico. In all, 45 sandbar sharks showed movements from the Atlantic into the Gulf of Mexico. Five of these were returned off Mexico and three from the northern coast of Cuba. Sixty-two percent of the sandbar sharks were recovered more than 500 miles from the point of tagging, 44% more than 1000 miles, and 18% more than 1500 miles from their original tagging sites.

A rate of travel of 10.4 miles per day was reported for a sandbar shark that was tagged southeast of Ocean City, MD, and recaptured southeast of Pt. Judith, RI (240 miles in 23 days). This approaches a previous rate of 11.7 miles per day.

Recaptures from sandbar sharks came primarily from commercial fishermen who provided backbone samples from 16% of the returns to aid in our age and growth studies.

TIGER SHARKS (78 Returns)

Tiger shark recaptures were returned after record times at liberty of 7.0 and 8.0 years. Many of the recaptures showed local movements off the Florida coast with some tiger sharks moving very short distances in long periods of time (e.g., 16 miles in 1.1 years, 17 miles in 1.4 years). Overall, 19 travelled more than 100 miles from their tagging location and only 8 more than 300 miles. The furthest distance travelled was by a tiger shark tagged off New Jersey and recaptured northeast of San Juan, Puerto Rico, a distance of 1228 miles.

Commercial fishermen measured many of these fish at tagging and recapture to provide accurate growth information and collected thirteen backbone samples. Three fish were recaptured more than once; one of these was measured and released with the same tag in place. Overall, 24 of the recaptured tiger sharks were retagged and are still at liberty.

MAKO SHARKS (18 Returns)

Mako sharks were recaptured after a maximum of 850 days (2.3 years) at liberty. Twelve were out for less than one year and sixteen were at liberty for less than 2 years. Seven makos were recaptured within 100 miles of their tagging locations, up to 1.6 years later, and only one travelled more than 500 miles from its original tagging site. The furthest distance travelled was 891 miles by a mako tagged in March south of Miami, FL, and recaptured in Baltimore Canyon 5.8 months later. This is a valuable return as it provides south-to-north migration information. Another interesting return was a mako tagged and recaptured in an area southeast of the Flemish Cap after 1.1 years at liberty. Two makos tagged on consecutive days in November of 1988 by a Foreign Fisheries Observer near Hudson Canyon were recaptured in May and June of 1990 off Virginia and New York (1.5 and 1.6 years later). Backbone samples were collected from 2 recaptured makos for age and growth studies.

OTHER SPECIES (70 Returns)

Recaptures from other species provided valuable information including many long distance and maximum time at liberty records. A **WHITE SHARK** tagged by NMFS biologists off Virginia was recaptured 1.2 years later off Rockport, MA (384 miles NE). This white shark was harpooned near a dead finback whale and is only the second white shark ever recaptured in our Program. Three tagged fish that were recaptured off the northeast coast of Cuba set new maximum distance records for the following species: a **SCALLOPED HAMMERHEAD** tagged off Oregon Inlet, NC (402 miles); a **BULL SHARK** tagged off Bimini, Bahamas (231 miles); and a **SWORDFISH** tagged east of the Flemish Cap (2357 miles). A **BIGNOSE SHARK** tagged off Virginia was also recaptured off Cuba (899 miles) after six years at liberty. Other interesting recaptures included: three **BLACKTIP SHARKS** tagged off Texas and recaptured off Mexico (500+ miles); a **SPINNER SHARK** also tagged off Texas showed a similar movement to the Mexican coast; a **NURSE SHARK** that was tagged and recaptured off Yucatan, Mexico, travelled 154 miles (second longest distance recorded for a nurse shark); a **WHITE MARLIN** recaptured 12 miles from its tagging site in Veatch Canyon after 4.1 years at liberty; and the longest time at liberty of 7.3 years for an **ATLANTIC SHARPNOSE SHARK** that was tagged and recaptured off the east coast of Florida.

SHARK FISHERIES MANAGEMENT PLAN UPDATE

The revised *draft* of the Secretarial Shark FMP for the Atlantic Ocean has been extensively rewritten.

The most significant measures include: segregation of sharks into three separate biological/managerial species groupings consisting of (1) large coastal, (2) small coastal, and (3) pelagic sharks, with quotas and bag limits tailored to species grouping; a minimum size on mako sharks; no sale of recreational catch; a prohibition on landing fins unless carcasses are attached; a 50-percent reduction in commercial landings from (estimated) 1990 levels; recreational bag limits for large coastal, small coastal, and pelagic species; and a management program to rebuild stock abundance of overfished species by the year 2000.

Approximately eight public hearings will be held in May throughout the Northeast, Southeast, and Gulf to receive comment. The FMP is expected to be implemented by October 1991. (For additional details contact NMFS, Southeast Regional Office, St. Petersburg, FL 33702.)

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Table 2. Tag recoveries: January-December 1990.

	GENERAL LOCATIONS		MONTHS AT	DIST. (MI) AND DIR.		CAPTURE METHOD		TAGGED BY	
	TAGGED	RECAPTURED	LIBERTY			TAG REC.		TAGGER	RESIDENCE
Blue shark	E Montauk Pt, NY	E Banes, Cuba	4	1221	S	RR	LL	Frank Braddick	NY
" "	S Montauk Pt, NY	S Pt Judith, RI	NR	NR		RR	RR	Cliff Heaton	CT
" "	E Rimini, Italy	E Malta	8	495	S	RR	LL	Santoni Maurizio	Italy
" "	SW Hydrographer Canyon	NW Cumana, Venezuela	28	1653	S	LL	LL	Walter Quinn, NMFS Obs	MA
" "	E Rimini, Italy	Adriatic Sea	5	NR		RR	RR	Guidi Romeo	Italy
" "	SE Montauk Pt, NY	E Trinidad	7	1937	SE	RR	LL	Bob Weaver	NY
" "	SE Pt Judith, RI	E Trinidad	6	1931	SE	RR	LL	David Tyrrell	RI
" "	SE Nantucket, MA	W Horta, Azores	21	1380	E	HL	LL	Stephen Connett	RI
" "	SE Montauk Pt, NY	NW Horta, Azores	33	1640	E	RR	LL	Paul Lahullier	NJ
" "	SE Montauk Pt, NY	SW Las Palmas, Canary Is	43	2843	E	LL	LL	Stephen Connett	RI
" "	S Madeira Island	SE Saõ Miguel, Azores	28	261	NW	LL	LL	Stephen Connett	RI
" "	S Hydrographer Canyon	N Punta de Maisi, Cuba	28	1138	S	LL	LL	Steven Slota, NMFS Obs	MA
" "	N Veatch Canyon	Cadiz, Spain	18	NR		HL	LL	Stephen Connett	RI
" "	SE Fire Is Inlet, NY	SE Ocean City, MD	9	158	SW	RR	RR	Michael Townsend	NY
" "	SE Hydrographer Canyon	NW Barbados	14	1644	S	LL	RR	Georg Hinteregger, NMFS Obs	MA
" "	SE Atlantis Canyon	S Fire Is Inlet, NY	7	148	W	FS	RR	Frank Carey	MA
" "	E Cape May, NJ	E Beach Haven, NJ	1	45	NE	RR	RR	Ed Ottenthal	NJ
" "	SE Pt Judith, RI	NW Saõ Miguel, Azores	10	1730	E	RR	LL	Tony Tolentino	MA
" "	E Little Egg Inlet, NJ	E Manasquan Inlet, NJ	<1	35	NW	RR	RR	Ray Schmidt	NY
" "	SE Ocean City, MD	S Pt Judith, RI	<1	198	NE	RR	RR	Mark Sampson	MD
Blue shark	E Manasquan Inlet, NJ	E Shark River Inlet, NJ	<1	13	NW	RR	RR	Ron Read	NY
" "	SE Shinnecock Inlet, NY	S Pt Judith, RI	<1	21	NE	RR	RR	Don Ryan	NY
" "	S Munson Canyon	NE Horta, Azores	27	1829	E	LL	LL	Micah Kieffer, NMFS Obs	MA
" "	SE Pt Judith, RI	NW Horta, Azores	21	1429	E	RR	LL	David Tyrell	RI
" "	S Montauk Pt, NY	SE Pt Judith, RI	1	57	E	RR	RR	Bill Williams	NY
" "	S Montauk Pt, NY	SE Pt Judith, RI	<1	36	E	RR	RR	Frank Braddick	NY
" "	SE Pt Judith, RI	SE Shinnecock Inlet, NY	23	100	W	LL	RR	Stephen Connett	RI
" "	SE Montauk Pt, NY	SE Pt Judith, RI	1	43	E	RR	RR	Harry McAllister	NY
" "	SE Fire Is Inlet, NY	SE Pt Judith, RI	<1	93	NE	RR	RR	Tom Natoli	NY
" "	E Cape May, NJ	E Ocean City, MD	<1	33	SE	RR	RR	Newton Mount	NJ
" "	S Montauk Pt, NY	S Montauk Pt, NY	0	3	SW	RR	RR	Charles Witek	NY
" "	SE Fire Is Inlet, NY	S Montauk Pt, NY	<1	63	E	RR	RR	Ted Bingham	NY
" "	NW Atlantis Canyon	SE Manasquan Inlet, NJ	7	109	W	HL	RR	Frank Carey	MA
" "	S Shinnecock Inlet, NY	E Montauk Pt, NY	<1	72	NE	RR	RR	Ray Hendrickson	NY
" "	S Pt Judith, RI	SE Montauk Pt, NY	12	19	SW	RR	RR	Andy Dangelo	RI
" "	E Cape May, NJ	S Montauk Pt, NY	1	137	NE	RR	RR	Bill Kleimenhagen	PA
" "	E Montauk Pt, NY	S Fire Is Inlet, NY	9	93	SW	RR	RR	Joe McBride	NY
" "	SE Montauk Pt, NY	S Montauk Pt, NY	35	14	SW	RR	RR	Jim Humphrey	CT
" "	SW Montauk Pt, NY	S Martha's Vineyard, MA	<1	96	NE	RR	RR	Bob Hawie	CT
" "	E Little Egg Inlet, NJ	S Pt Judith, RI	<1	108	NE	RR	RR	Bill Freilsh	NJ
Blue shark	SE Pt Judith, RI	E Montauk Pt, NY	47	6	SW	LL	RR	Stephen Connett	RI
" "	S Montauk Pt, NY	SE Pt Judith, RI	<1	44	NE	RR	RR	James Murtha	NY
" "	S Montauk Pt, NY	E Montauk Pt, NY	13	40	E	RR	RR	Tom Federico	NY
" "	SE Montauk Pt, NY	E Shark River Inlet, NJ	<1	93	W	RR	RR	Howard Keldaisch	NY
" "	S Montauk Pt, NY	S Pt Judith, RI	<1	16	NE	RR	RR	Bob McReynolds	NY
" "	NE Saõ Miguel, Azores	NE Saõ Miguel, Azores	50	283	E	LL	LL	Butch Winter	FL
" "	E Saco, ME	S Las Palmas, Gran Canaria	12	2831	E	RR	LL	George Gardner	ME
" "	E Manasquan Inlet, NJ	W Cabo de Saõ Vicente, Portugal	13	2711	E	LL	LL	Biologist (NMFS)	RI
" "	SE Hydrographer Canyon	W Cabo de Saõ Vicente, Portugal	16	2545	E	LL	LL	Georg Hinteregger, NMFS Obs	MA
" "	SE Portland, ME	SE Montauk Pt, NY	11	211	S	RR	RR	Greg Walts	ME
" "	S Montauk Pt, NY	E Montauk Pt, NY	1	46	NE	RR	RR	Tom Birch	MA
" "	SE Cape Elizabeth, ME	SE Pt Judith, RI	23	172	S	RR	RR	Bob Nason	ME
" "	SE Cape Elizabeth, ME	SE Cape Elizabeth, ME	1	22	SE	RR	RR	Ben Garfield	ME
" "	E Cape May, NJ	Baltimore Canyon	<1	36	S	RR	LL	Gene Weldemoyer	PA
" "	E Folley Beach, SC	SE Montauk Pt, NY	63	571	NE	LL	RR	W. Lloyd, NMFS Obs	MA
" "	SE Pt Judith, RI	E Little Egg Inlet, NJ	12	109	SW	RR	RR	David Tyrrell	RI
" "	SE Montauk Pt, NY	NE Georgetown, Guyana	21	2085	SE	RR	LL	Stret Whitting	NY
" "	S Block Is, RI	SSE Montauk Pt, NY	10	NR		RR	RR	Charles Lee	RI
" "	S Montauk Pt, NY	S Montauk Pt, NY	14	3	N	RR	RR	Tom Federico	NY
" "	E Cape May, NJ	S Cape Sable, NS Canada	1	390	NE	RR	LL	Ralph Leyrer	NJ
Blue shark	E Montauk Pt, NY	S Montauk Pt, NY	12	53	SW	RR	RR	Bob Raimondi	MA
" "	SE Pt Judith, RI	S Pt Judith, RI	25	48	S	RR	LL	Tony Tolentino	MA
" "	SE Pt Judith, RI	NE Atlantis Canyon	4	66	SE	RR	LL	Denny Dillon	RI
" "	SE Block Is, RI	E Montauk Pt, NY	12	30	SE	RR	RR	Andy Dangelo	RI
" "	S Pt Judith, RI	SE Pt Judith, RI	<1	18	E	RR	RR	Charlie Donilon	RI
" "	SE Pt Judith, RI	SE Montauk Pt, NY	<1	30	SW	RR	RR	Dave Preble	RI
" "	S Montauk Pt, NY	SE Pt Judith, RI	<1	45	E	RR	RR	Larry Horn	NY
" "	SE Portland, ME	E Saco River, ME	1	8	SW	RR	RR	Mark Chase	ME
" "	SE Portland, ME	SE Cape Porpoise, ME	<1	16	SW	RR	RR	Mark Chase	ME
" "	SE Portland, ME	SE Cape Elizabeth, ME	<1	13	SW	RR	LL	Mark Chase	ME
" "	S Fire Is Inlet, NY	E Ocean City, MD	<1	101	S	RR	RR	John Frevola	NY
" "	S Shinnecock Inlet, NY	S Montauk Pt, NY	1	NR		RR	RR	Larry Luce	NY
" "	S Fire Is Inlet, NY	E Ocean City, MD	1	111	S	RR	LL	Pete Mikoleski	NY
" "	SE Manasquan Inlet, NJ	E Ocean City, MD	1	51	S	RR	LL	John Williams	NJ
" "	E Cape May, NJ	Veatch Canyon	3	194	E	RR	LL	Don Boterus	NJ
" "	SE Pt Judith, RI	Hydrographer Canyon	1	87	SE	RR	LL	Tony Tolentino	MA
" "	S Hydrographer Canyon	SW Montauk Pt, NY	31	135	NW	LL	RR	Walter Quinn, NMFS Obs	MA
" "	SW Montauk Pt, NY	Hudson Canyon	3	64	S	RR	LL	Robert Scattergood	NY
" "	SE Pt Judith, RI	E Barnegat Inlet, NJ	<1	64	SW	RR	LL	Rodman Sykes	RI
" "	SE Montauk Pt, NY	E Pt Judith, RI	11	110	E	RR	TN	Joe McBride	NY
Blue shark	S Montauk Pt, NY	SW Cape Sable, NS Canada	1	252	NE	RR	LL	Donald Notine	NY
" "	SE Montauk Pt, NY	SW Cape Sable, NS Canada	3	241	NE	RR	LL	Richard Russell	RI
" "	E Pesaro, Italy	E Civitanova Marche, Italy	1	47	SE	RR	LL	Paolo A. Cortiglioni	Italy
" "	SE Montauk Pt, NY	SE of Shinnecock Inlet, NY	<1	NR		RR	RR	Paul Lahullier	NJ
" "	S Pt Judith, RI	SE Pt Judith, RI	12	15	E	RR	RR	Frank Braddick	NY
" "	SE Pt Judith, RI	S Pt Judith, RI	<1	60	W	HL	RR	Stephen Connett	RI
" "	S Martha's Vineyard, MA	SE Pt Judith, RI	2	19	W	FS	RR	Stephen Connett	RI
" "	SE Martha's Vineyard, MA	E Pearl Is, NS Canada	12	349	NE	HL	RR	Stephen Connett	RI
" "	SE Martha's Vineyard, MA	NW Saõ Miguel, Azores	24	1684	E	HL	LL	Stephen Connett	RI
" "	S Martha's Vineyard, MA	S Martha's Vineyard, MA	<1	7	N	HL	RR	Stephen Connett	RI
" "	SE Martha's Vineyard, MA	S Martha's Vineyard, MA	<1	36	NW	HL	RR	Stephen Connett	RI
" "	SE Montauk Pt, NY	SE Pt Judith, RI	11	79	E	RR	HL	Michael Miller	NY
" "	SW Nantucket Is, MA	S Nantucket Is, MA	60	23	E	HL	RR	Stephen Connett	RI
" "	S Martha's Vineyard, MA	S Montauk Pt, NY	11	59	W	HL	RR	Stephen Connett	RI
" "	S Pt Judith, RI	SSE Shinnecock Inlet, NY	1	49	SW	RR	RR	Fred Gallagher	RI
" "	S Nantucket Is, MA	E Manasquan Inlet, NJ	2	72	SW	FS	LL	Stephen Connett	RI
" "	S Martha's Vineyard, MA	Veatch Canyon	3	61	SE	HL	LL	Stephen Connett	RI

Table 2 continued.

	GENERAL LOCATIONS TAGGED	RECAPTURED	MONTHS AT LIBERTY	DIST. (MI) AND DIR.		CAPTURE METHOD TAG	REC.	TAGGED BY TAGGER	RESIDENCE
Blue shark	SE Pt Judith, RI	Veatch Canyon	<1	82	SE	RR	LL	John Dodd	RI
" "	SE Pt Judith, RI	Veatch Canyon	<1	79	SE	RR	LL	Tony Tolentino	MA
" "	SE Cape May, NJ	Veatch Canyon	3	224	NE	RR	LL	James Musumeci	NJ
" "	S Montauk Pt, NY	S Oceanographer Canyon	3	172	E	RR	LL	Frank Braddick	NY
" "	S Lydonia Canyon	W Saõ Miguel, Azores	48	1631	E	LL	LL	Ralph Tegge, NMFS Obs	MA
" "	E Sebastian Inlet, FL	W Cabo de Saõ Vicente, Portugal	NR	NR		RR	LL	Cliff Schoonmaker	FL
" "	S Montauk Pt, NY	E Manasquan Inlet, NJ	2	51	S	RR	RR	Charles Timson	NY
" "	Veatch Canyon	SE Browns Bank, NS Canada	4	NR		RR	TN	Fred Iasiello	CT
" "	S Montauk Pt, NY	Lindenkohl Canyon	NR	NR		RR	LL	Otto Haselman	NY
" "	SW Montauk Pt, NY	E Montauk Pt, NY	1	86	NE	RR	RR	Paul Dispazio	CT
" "	S Montauk Pt, NY	E Montauk Pt, NY	NR	NR		RR	RR	Donald Childree	CT
" "	S Montauk Pt, NY	SE Montauk Pt, NY	NR	NR		RR	RR	Lionel Lavalle	MA
" "	S Shinnecock Inlet, NY	E Montauk Pt, NY	NR	NR		RR	RR	Michael Forman	NY
" "	SE Fire Is Inlet, NY	SE Fire Is Inlet, NY	<1	22	N	RR	RR	Elliot Glanz	NY
" "	S Pt Judith, RI	SE Pt Judith RI	<1	12	NE	RR	RR	Robert Guay	RI
" "	SE Fire Is Inlet, NY	SE Montauk Pt, NY	3	76	NE	RR	RR	Vincent Kingston	NY
" "	E Pesaro, Italy	Is of Brac, Yugoslavia	2	163	E	RR	RR	Giovanni Travaglini	Italy
" "	SE Pesaro, Italy	Crete, Greece	<1	677	SE	RR	LL	Francisco Dallago	Italy
" "	E Montauk Pt, NY	S Shinnecock Inlet, NY	10	77	SW	RR	RR	Frank Braddick	NY
" "	SE Shinnecock Inlet, NY	Wilmington Canyon	24	152	SW	FS	LL	Ed Parbst	NY
Blue shark	SE Fire Is Inlet, NY	Wilmington Canyon	12	127	S	RR	LL	William Ulrich	NY
" "	SE Montauk Pt, NY	NW LaGuaira, Venezuela	29	1594	S	RR	LL	Joe McBride	NY
" "	SE Pt Judith, RI	E Manasquan Inlet, NJ	11	129	W	RR	RR	Frank Braddick	NY
" "	E Manasquan Inlet, NJ	S Fire Is Inlet, NY	<1	16	NE	RR	RR	Allan Patsiner	NJ
" "	SE Nantucket Is, MA	E Nauset Beach, MA	25	72	N	HL	RR	Stephen Connett	RI
" "	S Montauk Pt, NY	SW Cape Race, NF Canada	3	662	E	RR	LL	Bob Weaver	NY
" "	SE of Powell Canyon	SE Rudee Inlet, VA	47	421	SW	LL	LL	Jerzy Cygler, NMFS Obs	MA
" "	SE Pt Judith, RI	N Cayo Moa, Cuba	17	1219	S	LL	LL	Stephen Connett	RI
" "	S Pt Judith, RI	SE Rudee Inlet, VA	6	316	SW	RR	LL	Fred Gallagher	RI
Sandbar shark	Great Machipongo, VA	W Tampa, FL	247	1248	SW	GN	LL	Biologist (NMFS)	RI
" "	Wassau Snd, Savannah, GA	W Tampa, FL	199	895	SW	RR	LL	Ralph Greenburg	FL
" "	SE Fire Is Inlet, NY	NE Sebastian Inlet, FL	125	827	SW	RR	LL	Hank Lunde	NY
" "	SE Cape May, NJ	NE Key West, FL	43	1183	SW	RR	LL	Bob Vichko	NJ
" "	E Ocean City, MD	Cape Canaveral, FL	39	667	SW	TN	LL	Roger Dow, NMFS Obs	MA
" "	SE Fire Is Inlet, NY	W Tampa, FL	41	1455	SW	RR	LL	Bob Baltrunas	NY
" "	Chincoteague, VA	SE Cape Canaveral, FL	7	644	SW	RR	LL	Gordon Campbell, Jr	NJ
" "	S Pt Judith, RI	W Madeira Bch, FL	18	1502	SW	RR	RR	Fred Gallagher	RI
" "	W Villas, NJ	W Naples, FL	271	1222	SW	RR	LL	Graham MacMillan	NJ
" "	SE Fire Is Inlet, NY	S Mobile, AL	81	1613	SW	RR	LL	Robert Lafferty	NY
" "	SE Oregon Inlet, NC	S Mobile, AL	52	1314	SW	LL	LL	Biologist (NMFS)	RI
" "	ESE Manasquan Inlet, NJ	S Mobile, AL	54	1595	SW	RR	LL	Carmine Vastola	NJ
" "	SE Rudee Inlet, VA	W Fort Myers, FL	33	1123	SW	RR	LL	Bill Moffett, Jr	VA
" "	S Montauk Pt, NY	NW Dry Torgugas, FL	7	1319	SW	RR	LL	Carl Safina	NY
" "	S Fire Is Inlet, NY	SE Moorehead City, NC	52	376	S	RR	RR	Bill Haga	NY
" "	E Manasquan Inlet, NJ	S Carabelle, FL	44	1491	SW	RR	LL	Dan DeMarco	NJ
" "	E Brielle, NJ	W St Petersburg, FL	166	1438	SW	RR	LL	Arthur Colabella	NJ
" "	SE Fire Is Inlet, NY	S Mississippi River, MS	57	1642	SW	RR	LL	Bob Lafferty	NY
" "	E Ft Pierce, FL	W Cape Sable, FL	95	480	SW	RR	LL	Joe Northrop	FL
" "	Great Bay, NJ	SW Fort Myers, FL	187	1278	SW	RR	LL	Bob Mangold	FL
Sandbar shark	E Wachapreague Inl, VA	W Dry Torgugas, FL	40	1097	SW	TN	LL	Roger Dow, NMFS Obs	MA
" "	SE Fire Is Inlet, NY	W Cape Sable, FL	20	1277	SW	RR	LL	Phil Bruckner	NY
" "	E Charleston, SC	SW Fort Myers, FL	43	850	SW	LL	LL	Biologist (NMFS)	RI
" "	E Rudee Inlet, VA	W Cabo San Antonio, Cuba	68	1161	SW	LL	LL	Biologist (NMFS)	RI
" "	SE Block Is, RI	W St Petersburg, FL	94	1522	SW	RR	LL	Charlie Donilon	RI
" "	NE Cape Hatteras, NC	W St Petersburg, FL	42	1122	SW	LL	LL	Biologist (NMFS)	RI
" "	E Cape Hatteras, NC	W Sarasota, FL	35	1079	SW	RR	LL	John Kerr	VA
" "	E Veatch Canyon	W Sarasota, FL	116	1447	SW	LL	LL	Biologist (NMFS)	RI
" "	S Fire Is Inlet, NY	N Ponce Inlet, FL	82	746	SW	RR	LL	Ralph Leyrer	NJ
" "	SE Shinnecock Inlet, NY	W Sarasota, FL	44	1428	SW	RR	LL	Ron Woodward	NY
" "	S Pt Judith, RI	W St Petersburg, FL	21	1518	SW	RR	LL	Fred Gallagher	RI
" "	S Fire Is Inlet, NY	W Apalachicola, FL	92	1561	SW	RR	LL	Wolf Hager	NY
" "	SE Cape May, NJ	SW Carrabelle, FL	43	1427	SW	LL	LL	Biologist (NMFS)	RI
" "	E Ocean City, MD	SE Oregon Inlet, NC	70	170	S	RR	LL	Roy Tarbutton	MD
" "	E Barnegat Inlet, NJ	SE Pensacola, FL	82	1590	SW	RR	LL	Joe Niemczyk	NJ
" "	SE Manasquan Inlet, NJ	NE Oregon Inlet, NC	83	225	SW	RR	LL	Frank Freer	NJ
" "	E Montauk Pt, NY	NE Tampico, Mexico	63	2038	SW	RR	LL	Gloria Hayn	NY
" "	S Fire Is Inlet, NY	E Cape Hatteras, NC	81	300	S	RR	LL	Phil Fraccalvieri	NY
" "	S Jones Inlet, NY	SE Cape Lookout, NC	69	378	S	RR	LL	John McShane	NY
" "	SSE Shinnecock Inlet, NY	W St Petersburg, FL	77	1458	SW	RR	LL	Douglas Wells	NY
Sandbar shark	E Manasquan Inl, NJ	W Dry Tortugas, FL	141	1232	SW	RR	LL	John Weigold	CT
" "	SE Pt Judith, RI	S Cape Lookout, NC	106	469	SW	RR	LL	Paul D'angelo	NY
" "	Charleston, SC	Bulls Bay, SC	8	34	W	RR	GN	Mark Thawley	SC
" "	SE Fire Is Inlet, NY	SE Panama City Bch, FL	35	1510	SW	RR	LL	Pete Scelfo	NY
" "	SE Cape Canaveral, FL	N Matanzas, Cuba	145	307	S	LL	LL	Biologist (NMFS)	RI
" "	Mayport, FL	E St Augustine, FL	35	57	SE	RR	LL	L.Nordin	FL
" "	Great Machipongo Snd, VA	E St Augustine, FL	300	520	SW	GN	LL	Biologist (NMFS)	RI
" "	SE Fire Is Inlet, NY	S Apalachicola, FL	70	1524	SW	RR	LL	Peter Jakits	NY
" "	SE Fire Is Inlet, NY	S Mobile, AL	34	1611	SW	RR	LL	Pete Scelfo	NY
" "	Jacksonville, FL	S Mobile, AL	93	945	SW	RR	LL	John Henry David	FL
" "	S Petite Boise, MS	S Mobile, AL	19	48	E	TN	LL	Ronny Greene	MS
" "	S Pt Judith, RI	S Fire Is Inlet, NY	11	96	W	RR	LL	Fred Gallagher	RI
" "	NE Ponce Inlet, FL	SE Oregon Inlet, NC	15	459	NE	LL	LL	Tris Colket	FL
" "	SE Pt Judith, RI	W Naples, FL	144	1416	SW	RR	LL	Charlie Donilon	RI
" "	SE Pt Judith, RI	SW Panama City Bch, FL	23	1632	SW	RR	LL	Jim Humphrey	CT
" "	SE Ocean City, MD	Isla de Lobos, Mexico	10	1823	SW	RR	LL	Mark Sampson	MD
" "	S Fire Is Inlet, NY	E Virginia Bch, VA	57	218	SW	RR	LL	Bill Venezia	NY
" "	E Cape May, NJ	E Barnegat Light, NJ	11	72	NE	RR	GN	Bill Bittmann	NJ
" "	S Shinnecock Inl, NY	S Montauk Pt, NY	37	38	NE	RR	TN	Jay Sayers	NY
" "	SE Ocean City, MD	E Wachapreague Inlet, VA	15	29	SW	RR	LL	Mark Sampson	MD
Sandbar shark	SE Absecon Inlet, NJ	Ventnor City, NJ	12	14	NW	RR	RR	Gil Gilmore	NJ
" "	SE Oregon Inlet, NC	N Pt Frontera, Mexico	74	1462	SW	LL	LL	Stephen Connett	RI
" "	S Jones Inlet, NY	NE Ponce Inlet, FL	154	727	SW	RR	LL	George Maisch	NY
" "	E Little Egg Inlet, NJ	E Barnegat Light Inlet, NJ	<1	29	N	RR	GN	Dave Newman	NJ
" "	SE Moriches Inlet, NY	Chesapeake Bay, DE	12	NR		RR	HL	Doug Wells	NY
" "	E Manasquan Inlet, NJ	S Pt Judith, RI	13	118	NE	RR	RR	Larry Brock	NJ
" "	SE Ocean City, MD	SE Pt Judith, RI	<1	240	NE	RR	TN	Mark Sampson	MD

Table 2 continued.

	GENERAL LOCATIONS TAGGED	GENERAL LOCATIONS RECAPTURED	MONTHS AT LIBERTY	DIST. (MI) AND DIR.		CAPTURE METHOD TAG	CAPTURE METHOD REC.	TAGGED BY TAGGER	TAGGED BY RESIDENCE
Sandbar shark	W Powell Canyon	E Ponce Inlet, FL	6	927	SW	GN	LL	Richard Dwyer, NMFS Obs	MA
" "	SW Mississippi River	SW Mississippi River	3	9	W	LL	LL	Judy Pitkin	FL
" "	E Stuart Inlet, FL	Marquesas, FL	17	282	SW	LL	LL	Jack Morton	FL
" "	SW Montauk Pt, NY	SE Tavernier, FL	15	1011	SW	RR	LL	Dave Hescheles	NY
" "	ESE Cape May, NJ	E St Augustine, FL	38	617	SW	RR	LL	Bob Vichko	NJ
" "	E Barnegat Inlet, NJ	E Stuart Inlet, FL	4	818	SW	RR	LL	Murray LaBarr	NJ
" "	SE Cape Hatteras, NC	SE Cape Henry, VA	16	80	N	LL	LL	Biologist (NMFS)	RI
" "	S Fire Is Inlet, NY	SE Cape Henry, VA	88	241	SW	RR	LL	Kenneth Schneider	NY
" "	SW Cape Lookout, NC	N Oregon Inlet, NC	17	163	NE	LL	LL	Biologist (NMFS)	RI
" "	E Townsends Inlet, NJ	E Ponce Inlet, FL	48	677	SW	LL	LL	Biologist (NMFS)	RI
" "	E Ocean City, MD	E Long Beach, NJ	2	88	NE	RR	RR	Wayne Daugherty	VA
" "	S Pt Judith, RI	E Oregon Inlet, NC	27	360	SW	RR	LL	Fred Gallagher	RI
" "	S Fire Is Inlet, NY	E Oregon Inlet, NC	NR	NR		RR	LL	Joseph McAleer	NY
" "	SE Ocean City, MD	E Oregon Inlet, NC	28	136	S	RR	LL	Mark Sampson	MD
" "	E Lewes, DE	E Cape Canaveral, FL	NR	667	SW	RR	LL	Marlin Longenecker	DE
" "	E Manasquan Inlet, NJ	S Miami, FL	NR	NR		RR	LL	Bruce Miller	NJ
" "	SSE Long Beach Is., NJ	N Progreso, Mexico	100	1506	SW	RR	LL	Bill Deal	NJ
" "	SE Ocean City, MD	NW Pt Maya, Matanzas, Cuba	89	963	SW	RR	LL	Gary Shores	MD
" "	SE Lewes, DE	E Oregon Inlet, NC	89	162	S	RR	LL	Pete Floyd	DE
" "	S Pt Judith, RI	SE Pt Jerez, Tamaulipas, Mexico	69	2039	SW	RR	HL	Francis Powers	MA
" "	Great Bay, NJ	NE St Augustine, FL	124	639	SW	RR	LL	Bob Mangold	FL
" "	Chesapeake Bay, VA	S Oregon Inlet, NC	<1	80	S	RR	GN	Mike Halperin	VA
Tiger shark	NE Ponce Inlet, FL	E Jacksonville Bch, FL	18	60	N	LL	LL	Tris Colket	FL
" "	NE Ponce Inlet, FL	E Jacksonville Bch, FL	6	53	N	LL	LL	Tris Colket	FL
" "	NE Ponce Inlet, FL	E Ponce Inlet, FL	1	29	S	LL	LL	Tris Colket	FL
" "	NE Ponce Inlet, FL	E Ponce Inlet, FL	1	33	S	LL	RR	Tris Colket	FL
" "	NE Ponce Inlet, FL	NE Ponce Inlet, FL	1	12	S	LL	LL	Tris Colket	FL
" "	NE Ponce Inlet, FL	NE Ponce Inlet, FL	2	12	NE	LL	LL	Tris Colket	FL
" "	E Ponce Inlet, FL	NE Ponce Inlet, FL	3	34	N	LL	LL	Tris Colket	FL
" "	E St Augustine, FL	NE St Augustine, FL	9	19	W	LL	LL	Tris Colket	FL
" "	NE Oregon Inlet, NC	NE Ponce Inlet, FL	10	486	SW	LL	LL	Stephen Connett	RI
" "	NE Ponce Inlet, FL	S Morehead City, NC	14	365	NE	LL	LL	Tris Colket	FL
" "	E Avalon, NJ	NE San Juan, Puerto Rico	29	1228	SE	RR	LL	Bill Deal	NJ
" "	NE Ponce Inlet, FL	E Savannah, GA	4	186	N	LL	RR	Eric Sander	FL
" "	NE Cape Hatteras, NC	NE Ponce Inlet, FL	69	457	SW	LL	LL	Stephen Connett	RI
" "	SE Ocean City, MD	E Oregon Inlet, NC	10	133	S	RR	LL	Mark Sampson	MD
" "	E Cape Hatteras, NC	SE Ocean City, MD	<1	164	N	LL	RR	Kenny Hester	MS
" "	E Cape Hatteras, NC	SE Oregon Inlet, NC	<1	19	N	LL	LL	Kenny Hester	MS
" "	NE Ponce Inlet, FL	NE Ponce Inlet, FL	2	9	S	LL	LL	Tris Colket	FL
" "	E St Augustine, FL	E St Augustine, FL	2	2	W	LL	LL	Tris Colket	FL
" "	NE Ponce Inlet, FL	NE Jacksonville Bch, FL	6	85	N	LL	LL	Tris Colket	FL
" "	NE Ponce Inlet, FL	E Oregon Inlet, NC	20	478	NE	LL	LL	Tris Colket	FL
Tiger shark	S Moriches Inlet, NY	Bimini, Bahamas	95	930	SW	RR	LL	Butch Arsenault	NY
" "	E Ocean City, MD	SE Cape May, NJ	2	10	S	RR	RR	John Morgan	NJ
" "	NE Ponce Inlet, FL	NNE Ponce Inlet, FL	<1	7	SW	LL	LL	Tris Colket	FL
" "	NE Ponce Inlet, FL	E Jacksonville, FL	8	64	N	LL	LL	Tris Colket	FL
" "	SE Gt Egg Hbr Inl, NJ	SE Pt Judith, RI	84	174	NE	RR	TN	Joseph Luff	PA
" "	NE Ponce Inlet, FL	NE Ponce Inlet, FL	<1	4	SE	LL	LL	Tris Colket	FL
" "	NE Cape Hatteras, NC	E Ocean City, MD	3	190	N	LL	RR	Kenny Hester	MS
" "	NE Ponce Inlet, FL	E St Augustine, FL	1	27	N	LL	LL	Tris Colket	FL
" "	E Jacksonville, FL	E St Augustine, FL	1	26	S	HL	LL	Tris Colket	FL
" "	NE Ponce Inlet, FL	E St Augustine, FL	1	28	W	LL	LL	Tris Colket	FL
" "	NE Ponce Inlet, FL	E St Augustine, FL	1	28	W	LL	LL	Tris Colket	FL
" "	E Jacksonville, FL	E St Augustine, FL	2	44	S	LL	LL	Tris Colket	FL
" "	E Jacksonville, FL	E St Augustine, FL	1	40	SW	LL	LL	Tris Colket	FL
" "	NE Ponce Inlet, FL	E St Augustine, FL	8	36	NW	LL	LL	Tris Colket	FL
" "	NE Ponce Inlet, FL	E St Augustine, FL	7	20	NW	LL	LL	Tris Colket	FL
" "	NE Ponce Inlet, FL	N Ponce Inlet, FL	4	32	SW	LL	LL	Tris Colket	FL
" "	E St Augustine, FL	N Ponce Inlet, FL	2	34	SW	LL	LL	Tris Colket	FL
" "	NE Ponce Inlet, FL	E Ponce Inlet, FL	3	24	S	LL	LL	Tris Colket	FL
" "	NE St Augustine, FL	E Ponce Inlet, FL	2	66	SE	LL	LL	Tris Colket	FL
" "	NE Ponce Inlet, FL	E Ponce Inlet, FL	1	24	S	LL	LL	Tris Colket	FL
Tiger shark	E Jacksonville, FL	E Jacksonville, FL	1	20	N	LL	LL	Tris Colket	FL
" "	NE Ponce Inlet, FL	E Jacksonville, FL	4	26	N	LL	LL	Tris Colket	FL
" "	E Daytona, FL	SE St Augustine, FL	2	33	N	LL	LL	Tris Colket	FL
" "	NE Ponce Inlet, FL	E Jacksonville, FL	24	80	N	LL	LL	John Fraser	FL
" "	E Jacksonville, FL	E Jacksonville, FL	1	20	W	LL	LL	Tris Colket	FL
" "	NE Ponce Inlet, FL	E St Augustine, FL	2	12	N	LL	LL	Tris Colket	FL
" "	E Ponce Inlet, FL	SE St Augustine, FL	<1	45	N	LL	LL	Tris Colket	FL
" "	SE St Augustine, FL	E Cape Canaveral, FL	4	125	SE	LL	LL	Tris Colket	FL
" "	NNE Ponce Inlet, FL	E St Augustine, FL	13	16	E	LL	LL	Tris Colket	FL
" "	NE Ponce Inlet, FL	SE St Augustine, FL	<1	26	NW	LL	LL	Eric Sander	FL
" "	NE Ponce Inlet, FL	SSE Ponce Inlet, FL	6	64	S	LL	LL	Tris Colket	FL
" "	NE Ponce Inlet, FL	SE St Augustine, FL	8	5	NE	LL	LL	Tris Colket	FL
" "	N Ponce Inlet, FL	E St Augustine, FL	<1	22	N	LL	LL	Eric Sander	FL
" "	N Ponce Inlet, FL	E Jacksonville, FL	<1	46	N	LL	LL	Eric Sander	FL
" "	Bimini, Bahamas	E Cape Hatteras, NC	13	636	NE	LL	LL	Sonny Gruber	FL
" "	E St Augustine, FL	E Cape Canaveral, FL	1	103	S	LL	LL	Tris Colket	FL
" "	E Ponce Inlet, FL	E St Augustine, FL	<1	36	NW	LL	LL	Tris Colket	FL
" "	NE Ponce Inlet, FL	E St Augustine, FL	17	17	N	LL	LL	Tris Colket	FL
" "	N Ponce Inlet, FL	N Ponce Inlet, FL	1	12	W	LL	LL	Eric Sander	FL
Tiger shark	SE Ponce Inlet, FL	E Ponce Inlet, FL	4	27	N	LL	LL	Tris Colket	FL
" "	E Gt Egg Hbr Inl, NJ	E Cape Henry, VA	2	185	SW	RR	LL	John Lapsley	NJ
" "	E Ocean City Inl, MD	E Rudee Inlet, VA	15	124	SW	RR	LL	Brion Babbitt	NJ
" "	E Rudee Inlet, VA	E Rudee Inlet, VA	2	7	W	RR	LL	John Thurston	VA
" "	E Rudee Inlet, VA	E Rudee Inlet, VA	<1	8	S	LL	LL	Tom Spencer	VA
" "	SE St Augustine, FL	E Ponce Inlet, FL	3	38	S	LL	LL	Tris Colket	FL
" "	NE St Augustine, FL	NE Ponce Inlet, FL	1	63	S	LL	LL	Tris Colket	FL
" "	NE Ponce Inlet, FL	NE Ponce Inlet, FL	6	37	S	LL	LL	Tris Colket	FL
" "	SE Oregon Inlet, NC	E Oregon Inlet, NC	5	37	N	LL	LL	Kenny Hester	MS
" "	E Barnegat Inlet, NJ	SE Oregon Inlet, NC	8	274	S	RR	LL	Thomas Conte	NJ
" "	SE Rudee Inlet, VA	E Oregon Inlet, NC	3	42	S	RR	LL	John Kerr	VA
" "	NE Ponce Inlet, NC	E St Augustine, FL	<1	35	NW	LL	LL	Tris Colket	FL
" "	SSE Ponce Inlet, FL	NE Ponce Inlet, FL	<1	52	N	LL	LL	Tris Colket	FL
" "	N Ponce Inlet, FL	NE Ponce Inlet, FL	2	33	SE	LL	LL	Tris Colket	FL
" "	NE Ponce Inlet, FL	E Jacksonville Bch, FL	9	55	N	LL	RR	Tris Colket	FL
" "	E Cape May, NJ	SE Ocracoke, NC	4	256	S	RR	LL	Robert Dworzak	NJ

Table 2 continued.

	GENERAL LOCATIONS		MONTHS AT LIBERTY	DIST. (MI) AND DIR.		CAPTURE METHOD		TAGGED BY	
	TAGGED	RECAPTURED				TAG	REC.	TAGGER	RESIDENCE
Tiger shark	NE Ponce Inlet, FL	E Ponce Inlet, FL	1	19	SE	LL	LL	Tris Colket	FL
" "	NE Ponce Inlet, FL	E Jacksonville, FL	1	28	NW	LL	LL	Tris Colket	FL
Mako shark	S Veatch Canyon	E Oregon Inlet, NC	27	304	SW	LL	LL	Georg Hinteregger, NMFS Obs	MA
" "	E Cape May, NJ	Poormans Canyon	11	70	S	RR	RR	Joe Lucas	PA
" "	SE Shinnecock Inlet, NY	SE Pt Judith, RI	12	62	E	RR	RR	Robert Scattergood	NY
" "	SE Flemish Cap	SE Flemish Cap	13	321	E	LL	LL	Charles Johnson	ME
" "	E Toms River, NJ	SE Shinnecock Inlet, NY	<1	67	NE	RR	RR	Mike Szegeski	NJ
" "	SE Cape May, NJ	SE Montauk Pt, NY	1	177	NE	RR	RR	George Jacob	NJ
" "	E Hudson Canyon	S Montauk Pt, NY	19	88	NW	LL	RR	Georg Hinteregger, NMFS Obs	MA
" "	SE Fire Is Inlet, NY	Hudson Canyon	26	45	SE	RR	RR	Rich Gibbons	NY
" "	E Barnegat Inlet, NJ	NE Munson Canyon	15	317	E	RR	GN	George Lewis	PA
" "	SE Fire Is Inlet, NY	E Barnegat Inlet, NJ	4	102	SE	RR	LL	Ed Cacioppo	NY
" "	SE Pt Judith, RI	E Barnegat Inlet, NJ	<1	109	SW	RR	LL	Robert Sangster	RI
" "	SE Manasquan Inlet, NJ	SE Montauk Pt, NY	1	101	NE	RR	RR	John Williams	NJ
" "	S Miami, FL	Baltimore Canyon	5	891	N	RR	LL	Mark Sampson	MD
" "	S Jones Inlet, NY	Veatch Canyon	NR	NR		RR	LL	John Steffgen	NY
" "	SE Montauk Pt, NY	E Manasquan Inlet, NJ	1	50	S	RR	RR	Howard Kiedaisch	NY
" "	S Pt Judith, RI	E Rudee Inlet, VA	18	221	SW	LL	LL	Georg Hinteregger, NMFS Obs	MA
" "	E Beach Haven, NJ	SE Cape Sable, NS, Canada	3	451	E	RR	LL	John Williams	NJ
" "	E Barnegat Inlet, NJ	Norfolk Canyon	4	176	S	RR	LL	Mike Verzaleno	NJ
Dusky shark	SE Manasquan Inlet, NJ	Cape Hatteras, NC	76	NR		RR	LL	Tom Knoble	NJ
" "	E Cape May, NJ	E Cape Hatteras, NC	9	NR		RR	LL	Jeff Caruso	NJ
" "	NW New Pass, FL	WSW Tampa, FL	12	37	W	LL	LL	Peter Hull	FL
" "	E Barnegat Inlet, FL	N Veracruz, Mexico	23	NR		RR	LL	Mike Golone	NJ
" "	SE Fire Is Inlet, NY	S Pt Judith, RI	23	77	NE	RR	HL	Peter C. Rao	NY
" "	S Fire Is Inlet, NY	SW Panama City Bch, FL	131	1557	SW	RR	LL	Ron Lepper	NY
" "	E Manasquan Inlet, NJ	E St Augustine, FL	34	726	SW	RR	LL	Ray Geary	NJ
" "	S Miami, FL	N Ft Lauderdale, FL	2	62	N	RR	RR	Joe Michalowski	FL
" "	SSE Montauk Pt, NY	SE Cape Henry, VA	2	302	SW	RR	LL	Robert Shane	NY
" "	E Beach Haven, NJ	SE Cape Henry, VA	75	205	SW	RR	LL	Jeff Merrill	NJ
" "	SE Ocean City, MD	Cape Hatteras, NC	2	180	S	RR	GN	Mark Sampson	MD
" "	S Morgan City, LA	E Key West, FL	10	674	SE	LL	LL	Judy Pitkin	FL
Nurse shark	Little Crawl Key, FL	Little Crawl Key, FL	22	0	-	RR	RR	William Botten	FL
" "	NE Yucatan, Mexico	N Yucatan, Mexico	32	154	W	LL	HL	Ramon Bonfil	Mexico
" "	SW Apalachicola, FL	W Pass, Apalachicola, FL	1	3	W	RR	RR	Bill Arrants	TN
" "	Boynton Bch, FL	Boynton Bch, FL	6	0		RR	RR	Mark Fischer	FL
" "	Boynton Bch, FL	Boynton Bch, FL	6	0		RR	RR	Mark Fischer	FL
Lemon shark	S Sarasota, FL	Grove City, FL	<1	11	SE	LL	HL	Basil Arend	FL
" "	Fat Deer Key, FL	Vaca Key Bight, FL	1	5	SW	RR	RR	William Botten	FL
" "	Long Pt Key, FL	Boot Key, FL	23	7	SW	RR	RR	William Botten	FL
" "	Big Pine Key, FL	Big Pine Key, FL	3	NR		RR	NT	William Botten	FL
" "	No Name Key, FL	No Name Key, FL	6	1	E	RR	RR	William Botten	FL
Blacktip shark	N Port Mansfield, TX	N Pta Frontera, Mexico	1	567	SE	RR	LL	Frank Eicholz	TX
" "	Padre Is, TX	Padre Is, TX	<1	0		RR	RR	Darrell Mostella	TX
" "	S Mississippi River, MS	SW Pascagoula, MS	8	41	N	RR	LL	Lloyd Marine	MS
" "	Mansfield, TX	NE Coatzacoalcas, Mexico	2	527	S	RR	GN	Frank Eicholz	TX
" "	Marathon, FL	Hawks Channel, Marathon, FL	11	4	SW	RR	RR	William Botten	FL
" "	S Ponte Vedra, FL	S Mayport Inlet, FL	1	20	N	RR	RR	Frank McAfee	FL
" "	N Ponce Inlet, FL	E Ponce Inlet, FL	18	20	E	LL	LL	Eric Sander	FL
" "	Pine Is Sound, FL	Pine Is Sound, FL	1	5	N	RR	HL	Leo Dunn	FL
" "	SW Port Aransas, TX	N Pta Frontera, Mexico	9	582	SE	RR	GN	Darrell Mostella	TX
" "	S Charleston, SC	Cape Hatteras, NC	111	271	NE	RR	TO	Rick Stringer	SC
Sc hammerhead	E Ocracoke, NC	SE Rudee Inlet, VA	19	83	NE	LL	LL	Biologist (NMFS)	RI
" "	NE Oregon Inlet, NC	SE Rudee Inlet, VA	61	16	NE	TN	LL	Jerzy Cygler, NMFS Obs	MA
" "	SE Cape Hatteras, NC	N Myrtle Bch, SC	10	196	SW	LL	NT	Biologist (NMFS)	RI
" "	S Pt Mansfield, TX	E Padre Is, TX	36	NR		RR	RR	David Schoenfeld	TX
" "	E Ft Pierce, FL	NE St John's R, Mayport, FL	NR	210	NW	LL	LL	Jack Morton	FL
" "	NE Oregon Inlet, NC	N Puerto Sama, Cuba	56	902	S	TN	LL	Ray Sutherland, NMFS Obs	MA
" "	SE Hatteras Inl, NC	E Pt Judith, RI	40	518	NE	LL	GN	Stephen Connett	RI
Silky shark	SW Cape Verde Is	SW Cape Verde Is	<1	114	N	LL	LL	Arturo Vidal	Spain
" "	E Jacksonville, FL	E Oregon Inlet, NC	17	446	NE	LL	RR	Biologist (NMFS)	RI
" "	E Progreso Yucatan, Mex	SW Panama City Bch, FL				LL	LL	Ramon Bonfil	Mexico
" "	Little San Salvador, Bahamas	Little San Salvador, Bahamas	2	4	E	LL	RR	Stephen Connett	RI
Sand tiger	E Ocean City, MD	E Rehobeth Bch, DE	11	26	N	RR	RR	Mark Sampson	MD
" "	S Fire Is Inlet, NY	Cape Henry Pt, VA	3	252	SW	LL	TN	Tom Spencer	VA
Hammerhead	E Jupiter Inlet, FL	S Tavernier, FL	147	125	S	RR	LL	Charlie Donilon	RI
"	SE Manasquan Inlet, NJ	Cape Lookout, NC	112	NR		RR	LL	Henry Diehl	NJ
White shark	NE Wachapreague Inl, VA	E Rockport, MA	14	384	NE	LL	RR	Biologist (NMFS)	RI
Bignose shark	SE Wachapreague Inl, VA	N Cayo Frances, Cuba	72	899	S	LL	LL	Biologist (NMFS)	RI
Atl. sharpnose	E Jacksonville, FL	E Ponce Inlet, FL	87	70	SE	RR	LL	Jim La Force	FL
Spinner shark	SE Corpus Christi, TX	Tecolutla, Veracruz, Mexico	2	425	S	RR	GN	Darrell Mostella	TX
Porbeagle	NE Munson Canyon	S Cape Sable, NS, Canada	30	125	N	LL	GN	Georg Hinteregger, NMFS Obs	MA
Bonnethead shark	Jacksonville Bch, FL	S St Augustine Bch, FL	107	25	S	RR	TO	Jim La Force	FL
Bull shark	Bimini, Bahamas	Cayo Verde, Cuba	6	231	SE	LL	LL	Michael Joseph	FL
Reef	Highborne Cay Exuma, Bah	Highborne Cay, Exuma, Bahamas	44	0		LL	RR	Stephen Connett	RI
Swordfish	E Ocean City, MD	E Charleston, SC	23	397	SW	LL	LL	Charles Bergmann	NJ
"	E Flemish Cap	SE Punta Maisi, Cuba	43	2357	SW	LL	LL	Charles Johnson	ME
"	Powell Canyon	NE Munson Canyon	19	45	NE	LL	GN	Walter Quinn, NMFS Obs	MA
"	SE Munson Canyon	SE Lydonia Canyon	42	60	W	LL	GN	Georg Hinteregger, NMFS Obs	MA
"	E Powell Canyon	E Cape Sable, NS, Canada	21	242	NE	LL	LL	Walter Quinn, NMFS Obs	MA
"	SE Flemish Cap	E Cape Sable, NS, Canada	14	954	W	LL	LL	Charles Johnson	ME
"	E Oregon Inlet, NC	E Oregon Inlet, NC	72	9	E	LL	LL	Mary Kirby, NMFS Obs	MA
White marlin	SE Veatch Canyon	Veatch Canyon	49	12	N	LL	LL	Jerzy Cygler, NMFS Obs	MA
Tuna	E Manasquan Inlet, NJ	E Manasquan Inlet, NJ	NR	NR		RR	RR	Jack Newitts	NJ
Striped Bass	Montauk Pt, NY	Warren Pt, RI	33	40	NE	RR	RR	Tom Hage	NY
Red Drum	N Jacksonville, FL	NE Jacksonville, FL	5	16	SE	RR	RR	Clark Krazit	FL
Unknown	S Montauk Pt, NY	W Cartagena, Colombia	NR	NR		RR	LL	Howard Glickberg	NY
"	E Manasquan Inlet, NJ	E Drum Inlet, NC	NR	NR		RR	TN	George Sincox	NJ

NOTE: FS=Free Swimming; GN=Gillnet; TO=Tag Only Found; HL=Handline; LL=Longline; NT=Net; RR=Rod & Reel; TN=Trawl Net; Obs=Foreign Fisheries Observer; NR=Not Reported

NEW BOOK ON SHARKS AVAILABLE

The following articles on reproduction, food habits, and migrations are summaries of longer articles that appear in a new book, ***DISCOVERING SHARKS****, published by the American Littoral Society (S. Gruber, ed.; April, 1991). This volume, honoring the eminent shark biologist Stewart Springer, includes chapters by 27 researchers and covers a wide variety of subjects including shark evolution, anatomy, behavior and physiology. The book is available for $10.00 (incl. mailing) from* ***THE AMERICAN LITTORAL SOCIETY, HIGHLANDS, NJ 07732****.*

SHARK REPRODUCTION: PARENTAL INVESTMENT AND LIMITED FISHERIES AN OVERVIEW

Harold L. Pratt, Jr. and Jose I. Castro

Sharks and their relatives, the skates, and rays, are successful as a group because of many factors. Probably the most important, is the development of remarkably efficient reproductive strategies. These include internal fertilization, maternal nourishment of embryos, and the birth of large young that are well-developed miniatures of the adults, sometimes up to three feet long and weighing 30 to 40 pounds.

The tactic of most bony fishes, of releasing large quantities of eggs and sperm into the water, has been replaced in sharks by copulation and the production of small quantities of large young. Internal fertilization permits the development of several interesting and diverse modes of reproduction.

The most primitive shark species usually lay eggs (OVIPARITY). Developing embryos are dependent solely on the yolk reserves within their eggs. The eggs are large for fish eggs (1 to 2 inches), well supplied with yolk and protected by a tough shell. The eggs must survive unguarded for weeks or months until they hatch. Parental care is unknown in elasmobranchs. The hatchlings are small (compared to live born) as they are limited by the amount of yolk in the egg. A newborn whale shark may emerge from the egg at 14 inches. The adult is the largest fish in the ocean, reaching at least 40 feet.

In more advanced sharks the reproductive strategy is to maintain relatively large embryos in the uterus until development is complete. When the embryos are not attached to the mother with a placenta, this developmental process is called OVOVIVIPARITY, also termed APLACENTAL VIVIPARITY. This is the most common mode of reproduction in sharks and affords shelter from predation and environmental hazards. The result is a reduction in numbers of young in favor of larger newborn with a greater chance of survival. The embryos are nourished by yolk stored in a yolk sac attached directly to their digestive system. The dogfish sharks, cow sharks, frill sharks, angel sharks, tiger sharks, and some nurse sharks are a few of the many ovoviviparous species.

Another method of embryonic development in sharks involves a type of cannibalism called OOPHAGY (egg eaters). In this mode, the young hatch within the uterus in the first three months of gestation and consume eggs which the female continues to ovulate throughout gestation. The lamnoid sharks: makos, white sharks, threshers, crocodile sharks, sand tigers and false catsharks, are known to be oophagous. The sand tiger shark is in fact EMBRYOPHAGOUS (embryo eaters !) in that the first embryo to hatch within the uterus attacks and consumes its siblings before settling down to a diet of maternal eggs.

A one inch long blue shark embryo attached to its yolk sac in the uterus before formation of the placenta. *Photo by H. W. Pratt.*

The most complex form of shark reproduction, PLACENTAL VIVIPARITY is employed by the requiem and hammerhead sharks. These advanced families have developed a maternal nutrient system very similar to the one found in mammals. After a short period of embryonic dependence on the yolk sac (see figure), the empty, flaccid yolk sac attaches to the maternal uterine wall to form a yolk sac placenta. The embryo is supported at the end of an umbilical cord which enters its body between the pectoral fins. The placenta transports resources from the mother's bloodstream, including nutrients and oxygen supply, and provides elimination of waste products.

In some viviparous sharks, such as the sharpnose sharks and some of the hammerheads, additional structures are present. The umbilical cord may have leaf-like structures that increase the cord's surface area for exchange of nutrients, gases, and waste products with the uterine fluid (see figure). "Uterine milk", secreted by special cells in the walls of the uterus of these sharks, may be absorbed through gill filaments, and the skin and mouths of the embryos.

Sharks have developed many unique organs and anatomical features. A single ovary, usually the right, contains dozens to sometimes thousands of large, yolky eggs. Ovaries can be of two forms, with the eggs developed and dispatched from the surface of the gland, or as a tissue mass with a central cavity from which eggs escape through pores. Eggs enter the oviduct through a funnel-shaped tube and pass down into paired oviducts to the shell gland where sperm is stored in some species and fertilization sometimes occurs. The shell gland also secretes a protective covering, either tough, flexible and thick as in the whale shark, or thin and transparent as in the blue shark. The oviducts end in paired uteri where the embryos develop in viviparous species.

The number of embryos born to a single mother varies from 2 (bigeye thresher, sand tiger) to 135 (blue shark). Gestation lasts from 3 or 4 months in small sharks to two years in the spiny dogfish and perhaps longer for the frilled shark. A period of 9 to 12 months is typical of most large sharks. The young usually emerge tail first; although some species, like the sand tiger, are born

head first. "Tee-shaped" heads of young hammerheads are soft and pliable at birth to permit easy passage through the birth canal. Sharks give birth in a variety of habitats from the deep ocean floor to coral reef environments, but many seek out shallow, near-shore waters, or estuaries, because of their abundant food supply and absence of most large predators. Any environmental degradation of coastal areas, however, threatens the nursery area of even these nomadic ocean wanderers.

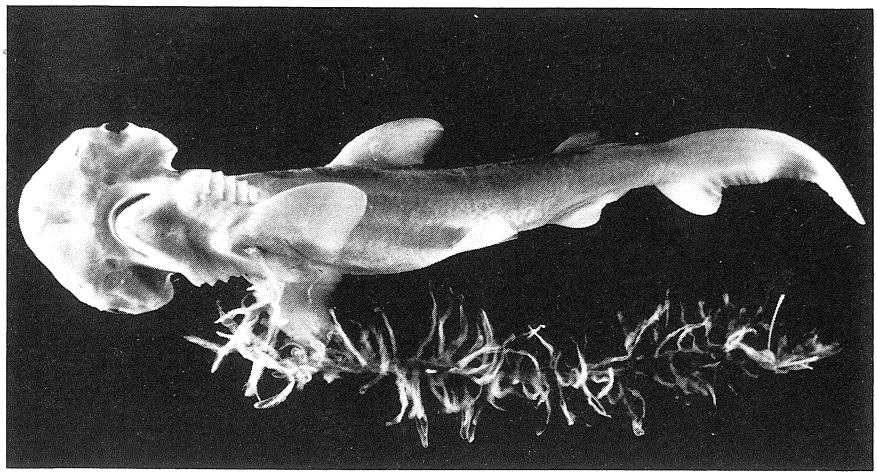
The age at sexual maturity of sharks is difficult to determine, and consequently it is poorly known. Unlike the bony fishes that often grow quite rapidly and mature in just a few years, most species of sharks grow slowly and take many years to reach maturity. The larger requiem sharks usually mature in 6 to 18 years, or longer, depending on the species. The maximum ages attained by these sharks and their years of reproductive life can only be guessed. Current age research indicates that the largest individuals landed have reached ages of 30 to 40 years. Evidence suggests that certain dogfish species can live 70 years.

Many of the large species of sharks reproduce every other year. A female sandbar shark giving birth this spring will not mate again until the following spring; and give birth in the next spring. Many females are thin and emaciated when they reach full term. Alternate year pupping may be required to allow the female to store sufficient nutrients to pass to the offspring. Some species such as the blue, hammerhead, sand tiger, and sharpnose sharks reproduce every year as do most of the egg-laying species.

Male sharks are as reproductively complex as the females. Internal fertilization is accomplished using one or both claspers, which are rod-like appendages of the male's pelvic fins. Claspers are rotated and inserted into the female's vagina after a sometimes elaborate but poorly known courtship process in which the male bites the female's fins and flanks until she is receptive. The maneuvering to permit copulation must be complex, especially with females weighing thousands of pounds. The clasper is anchored in the female by terminal spurs or sharpened expandable ridges and sperm is transferred in a stream of water driven by paired siphon sacs. These sacs are a muscle-driven hydraulic system in the abdominal wall of the males. All of this rough interplay with teeth and spurs has been softened over the eons by the development of thicker skin in some female sharks. The skin of the adult female blue shark, for example is three times thicker than the male's and thicker than the length of his teeth!

Sperm is produced in small, round sacs or ampullae in two large testes located far forward, deep in the male body cavity. It is stored as thousands of sperm packets, dense pellets of aligned spermatozoa, formed and held in large vesicles at the posterior end of the reproductive tract. Thus, male sharks are prepared to deliver large quantities of sperm to the female when chances of reproductive success are highest. In some sharks, the females can store sperm for years; another tactic for ensuring fertilization in the uncertain life of a migratory animal.

The interplay of all of these factors enhances the success of fertilization and survival of the young. However, these strategies work against sharks when they are harvested by man. The high maternal investment in each embryo means a very low rate of reproduction. Sharks propagate by two's and four's, dozens at most. These small numbers are enough to keep up with natural mortality, but not large enough to keep pace with predation by humans.

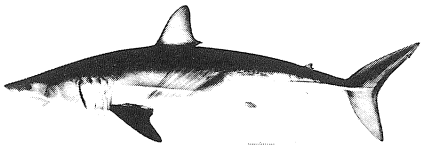


A bonnethead shark embryo showing absorptive structures of the umbilical cord. *Photo by J. I. Castro.*

Little is known about the resilience of sharks under these circumstances. In some populations of animals, fecundity of individuals increases when stock size decreases. The evidence of collapsed fisheries for threshers, porbeagles, school sharks, dogfish, and other species indicates that sharks lack the resilience to adapt to intensive fishing. Because of these reproductive strategies and the limitations and unknowns that surround them, we must be conservative in harvesting these fragile shark populations.

THE RAVENOUS MAKO

C. E. Stillwell



Knowledge of the rate of food consumption and the impact of most shark species on their prey groups is incomplete or unknown. Evidence does show, however, that food consumption is related to the rate at which food is digested and the activity level of a particular species. Sedentary and slow-moving species such as the nurse shark may eat 0.2 to 0.3% of its body weight per day and take at least six days to digest an average sized meal. Results of our studies on more active species shows that sandbar and blue sharks consume 0.2 to 0.6% of their body weight per day and digest an average meal in three or four days, while the most active species, the shortfin mako shark, eats 3.0% of its body weight per day and digests an average sized meal in 1.5 to 2 days. This means that a 140 pound mako eats about 4 pounds of food per day, or an equivalent of just over 10 times its body weight per year. To compensate for energy expended during periods of higher activity (pursuing prey, feeding, migration) the resulting daily

Mako continues on Page 11

LONG DISTANCE MOVEMENTS OF ATLANTIC SHARKS FROM THE NMFS COOPERATIVE SHARK TAGGING PROGRAM

J. G. Casey and N. E. Kohler

Fish tagging can have several objectives, including studies of migrations, age and rates of growth, identification of different stocks, and population dynamics (e.g., assessing the size of the population, the size and age of individuals making up the populations, whether the population is increasing, decreasing, or remaining stable). Tagging data also provides information for monitoring shark populations to help detect changes in species composition, geographical distributions, and size compositions. These variables can then be compared to shifts in prey abundance or environmental changes such as annual rainfall, water temperature, or the effects of fishing, pollution and other man-made influences.

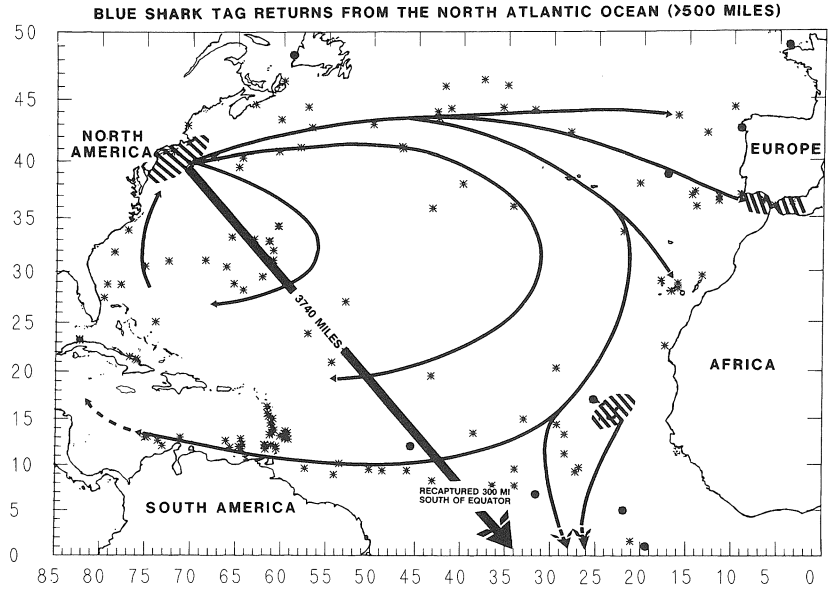
Of the 32 species of sharks from which tags have been recovered under the NMFS program, 10 species have demonstrated movements that have exceeded 1,000 miles between tag and recapture locations (see figures). With the exception of the oceanic whitetip shark, the maximum distance for each species is supported by additional, if somewhat shorter, long-range tag returns. For example, the averages of the five furthest distances traveled for the shark species shown in the figures are as follows: blue (3,383 mi.), sandbar (1,994 mi.), mako (1,909 mi.), dusky (1,888 mi.), tiger (1,351 mi.), bignose (1,202 mi.), night (908 mi.), blacktip (771 mi.), and bigeye thresher sharks (745 mi.).

These maximum distances between tag and recapture locations are measured as straight lines and do not reflect random movements, the effects of current systems, temperature zones, and other environmental features that influence migratory pathways and would certainly increase these distances significantly. For example the maximum straight line distance recorded for a tagged blue shark is 3,740 miles. Yet multiple recaptures suggest blue sharks may make round-trip movements between North America and Europe that exceed 10,000 miles. Sandbar sharks travelling on the continental shelf between Southern New England and Yucatan, Mexico, could easily cover 3,500 miles. On the other hand, a single long-distance recapture must be interpreted with caution since it may only reflect the stray movement of an individual shark outside the normal range of that species. For example, the oceanic whitetip shark (see figure) is a highly pelagic species that is so rare in Hudson Canyon off New York that the fisherman provided a photograph of the shark being tagged to confirm the identification. When interpreting tag-recapture data, consideration is also given to the possibility that the returns are more indicative of areas of intensive fishing. On the other hand, the absence of recaptures in an area does not automatically rule out the possibility that a species does not occur there. The blue shark was considered rare in the Caribbean because it was known to be a temperate species that preferred cooler waters. However, expanding longline fisheries for tunas and swordfish in warmer regions of the Atlantic showed blue sharks to be common in the deeper offshore zones and around islands where upwelling brings cooler, deeper waters closer to the surface. Another consideration is that tagged sharks are sometimes recaptured after several years in the same area where they were released. Where a particular shark travelled during those years can only be deduced from other information. Moreover, sharks generally segregate by size and sex and the different segments of the population can have different migration patterns.

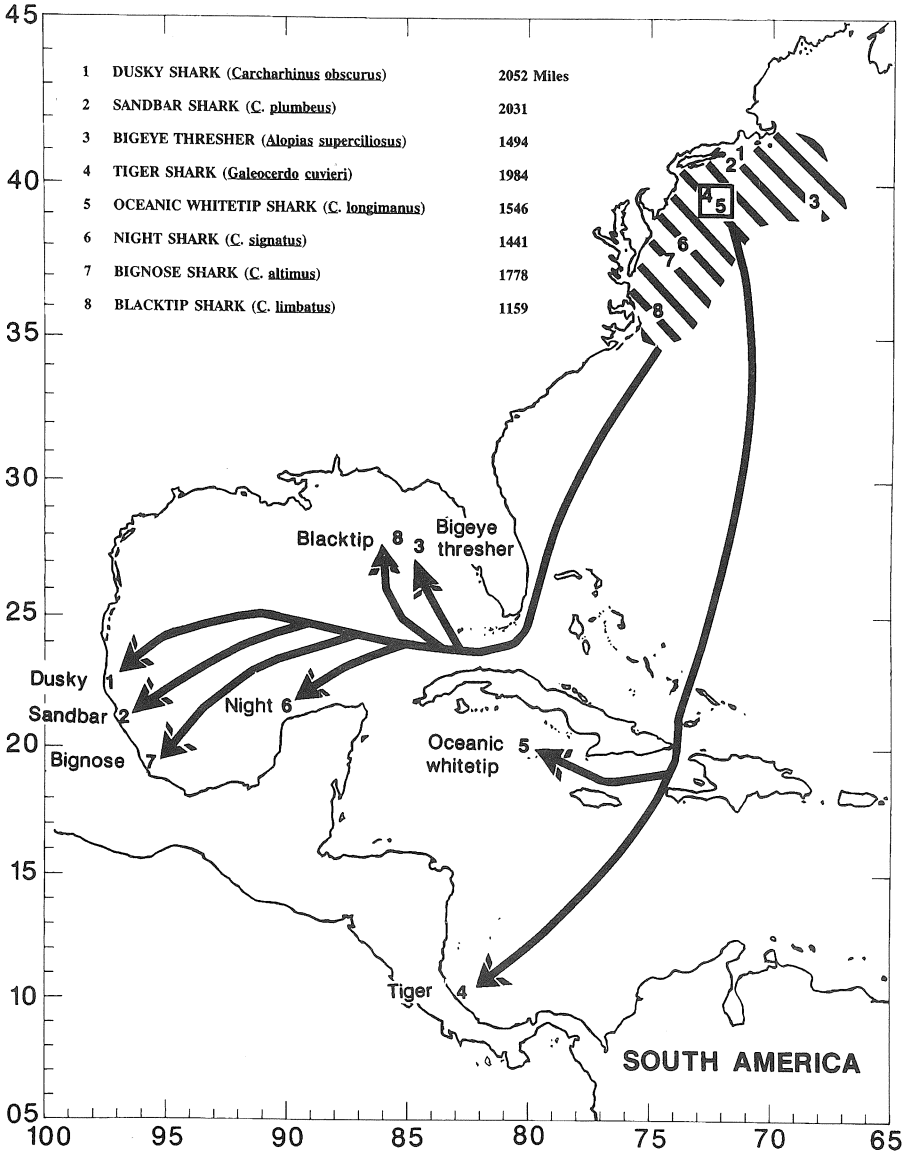
For these and other reasons, the NMFS long term tagging program can be likened to thousands of people working on an extremely complicated puzzle. The work is fascinating, challenging, and rewarding but at times frustrating because it requires a great deal of patience and the picture remains far from complete. The discovery of new pieces of scientific information from tagging, particularly when they involve new records such as the longest distances traveled, represent focal points in the advancement of knowledge that are a credit to everyone past and present who has participated in the research. In addition to contributing to basic biological knowledge of sharks, the significance of this information in demonstrating movements across international boundaries is an important consideration to those initiatives directed to the management of sharks. The fact that fishermen from many countries have returned NMFS tags from sharks released in U.S. waters can be used to argue for international management of highly pelagic species. Other Atlantic shark species might best be managed through cooperative action between Northern and Central American countries. Finally, the responsibility for some local shark populations may rest with a few, or even single states.

Whatever management directions are taken in the future, the success of those actions will depend on a better understanding of the biology of each shark species, including additional knowledge of their reproductive biology, food requirements, life spans, rates of growth, and migratory patterns. The Cooperative Shark Tagging Program is an attempt to bring this knowledge into a clearer perspective to ensure the wise use of sharks as living marine resources.

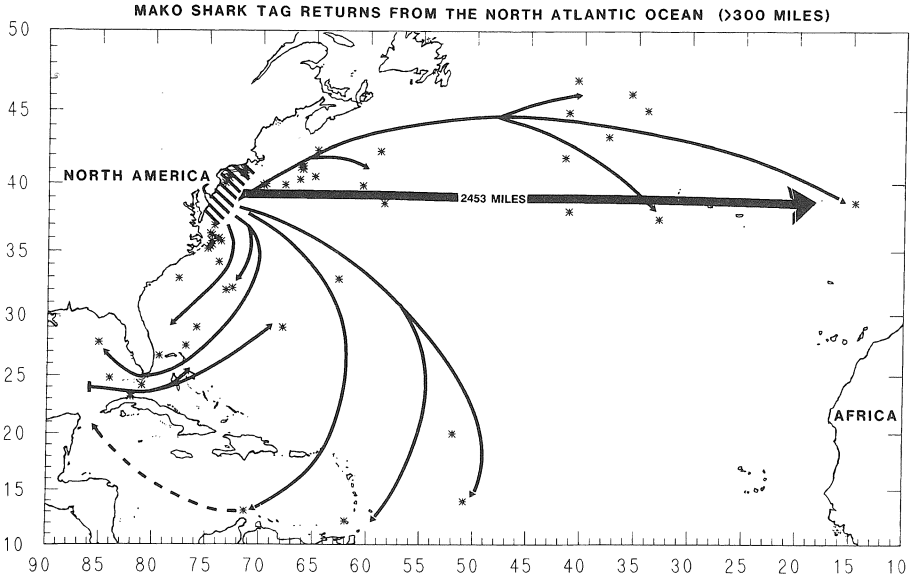
BLUE SHARK TAG RETURNS FROM THE NORTH ATLANTIC OCEAN (>500 MILES)



MAXIMUM DISTANCE TRAVELLED BY COASTAL PELAGIC SHARKS



MAKO SHARK TAG RETURNS FROM THE NORTH ATLANTIC OCEAN (>300 MILES)



Mako continued from Page 9

ration can approach 5.5 pounds per day, an annual consumption rate of 12-15 times the average body weight. The large amount of food required by the mako is not only needed for physiological maintenance and movement, but also to accommodate rapid growth compared to many other sharks. A study on the growth of the mako shows that following a birth weight of 5-6 pounds, males grow to around 300 pounds in 4.5 to 5 years, while females reach approximately 500 pounds by age seven. In the first three years of life, the weight may increase an average of 60 pounds per year.

To provide the energy required by the mako to live its fast paced life, the food consumed must be digested and processed at an accelerated rate. This is accomplished by the maintenance of an elevated body temperature (12-18°F above ambient) and a controllable blood network that can direct warmed blood to the stomach and intestines, thereby increasing the rate at which food is digested. The white and porbeagle sharks, relatives of the mako, have similar heat retaining systems.

Bluefish are the most important food in the mako's diet off the northeast coast of the United States. Hundreds of stomachs, examined by NMFS biologists in this area shows that bluefish comprise 77% of the mako's food by volume and that large makos can seize and swallow 12-15 pound bluefish whole or in two to three pieces. The biomass of bluefish consumed by makos in the area between Cape Hatteras, N.C. and Georges Bank is estimated to be 8,500 tons or 7.3% of the bluefish population in this region.

Other prey of the mako consists of various fish species ranging from bottom dwelling eelpouts and searobins to pelagic tunas and swordfish. A shift to large prey such as swordfish appears to occur when makos attain weights greater than 300 pounds. Accounts of makos attacking and eating large swordfish of 400 pounds or more are not uncommon. Although bony fish comprise almost 70% of the mako's diet, squid contributes about 15% overall, and are eaten most frequently offshore where water depths are greater than 600 feet.

Based on recreational catch data for the past 10-12 years, the mako population along the U.S. Atlantic coast has been relatively stable and may in part be explained by the high abundance of bluefish during this period.

FIELD STUDIES

Field studies by our staff this year included cruises aboard two commercial longlining vessels, the *Revenge V* and the *Penobscot Gulf*, and attendance at twelve shark fishing tournaments from Massachusetts to New Jersey. Volunteers and tournament directors in Florida (4), New Jersey (1), and Massachusetts (1) provided additional catch information.

REVENGE V CRUISE — During the first week of June, staff biologists were invited to examine the catches of the commercial shark longline vessel, *Revenge V*. Fishing operations were conducted in an area 25 miles NE of Cape Lookout, NC, to 25 miles NNE of Oregon Inlet, NC. In six days of fishing, sixteen longline sets were made. A catch of 684 sharks was sampled, representing 9 species. Sandbar sharks were the most common (49%), followed by dusky (26%), blacktip (8%), tiger (7%), scalloped hammerhead (5%), and four miscellaneous species (5%). Sandbar and dusky sharks were caught on every set with tigers taken on all but two. All sharks were taken onboard. Those less than three feet in length were measured, tagged, and released. All sharks were sexed and many were measured, weighed, and sampled for reproduction and age and growth information. Fifty-four sharks representing six species were tagged and 43 injected with oxytetracycline (OTC) prior to release. This antibiotic leaves a visible ring on the vertebrae when exposed to ultraviolet light. Tiger (28) and dusky sharks (16) were the primary species tagged.

Vertebrae and morphometric information (body dimensions) from 16 sharks (5 species) were collected for ongoing studies. Morphometric measurements were used to calculate factors for converting dressed carcass weights and lengths to whole-fish measurements for sandbar, dusky, blacktip, scalloped hammerhead, and tiger sharks.

The reproductive systems were examined from several shark species including adult female tiger, Atlantic sharpnose, sandbar, and dusky sharks. Thirty-four sandbar sharks contained pups close to full-term. All active pups were immediately released. A few of the largest were tagged and injected with OTC for growth studies. Several sandbar females showed signs of having pupped a few days to perhaps a few weeks before reaching the fishing area. Mature dusky sharks were examined but none held any pups. The reproductive systems in all cases appeared to be in a resting stage or recovering to that stage, suggesting that dusky sharks pup earlier in the season and further south than the sandbar shark.

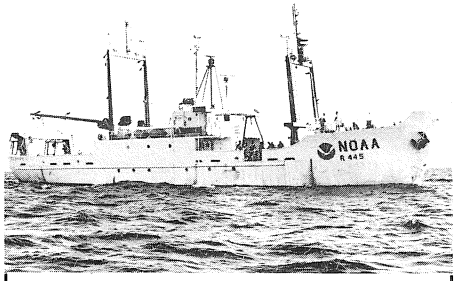
PENOBSCOT GULF CRUISE — The purpose of the six-day trip on the *Penobscot Gulf* in the Gulf of Maine (2-8 October) was to catch porbeagle sharks. Due to heavy weather, only three longline sets were made. The total catch was seven blue sharks that were tagged and released, and three spiny dogfish that were examined for reproductive studies.

TOURNAMENTS—At the twelve shark tournaments attended by staff biologists, 264 sharks were measured, examined, and/or dissected for sampling purposes. Blue sharks were most common (158), followed by makos (70), sandbars (14), and common threshers (11). The remainder of the catch was comprised of tigers (4), scalloped hammerheads (4), duskies (2), and one smooth hammerhead. Morphometric measurements and fin weights were obtained from each species. Tournament data from the volunteers in Florida, and two northern tournaments included length and weight measurements from 144 sharks representing 13 species. The northern tournaments (NJ and MA) landed blue and mako sharks almost exclusively. The Florida catches were dominated by sandbars, Atlantic sharpnose, bull, nurse, and blacktip sharks with a few great hammerhead, lemon, and blacknose sharks.

Our thanks are extended to the vessel captains, their crews, and tournament officials for allowing us to examine their catches and to collect data critical to our research program.

Those of you who catch a tagged shark are encouraged to call us collect (401-782-3200). We need vertebral samples from recaptured sharks for age studies and request that you contact us so that we can arrange shipment.

Capt. M. Bartlett tagging blue sharks on F/V Penobscot Gulf. *Photo by H. W. Pratt*



SHARK SURVEY CRUISE PLANNED FOR 1991

The NMFS research vessel, *Delaware II*, will conduct a 47-day survey cruise of sharks between Miami, FL and Georges Bank. The vessel will leave Woods Hole, MA on April 22 and return on June 7, 1991. The primary objectives of the cruise are to: (1) survey the species composition, abundance, and distribution of sharks using standardized longline gear; (2) examine stomachs of sharks for predator-prey studies; (3) collect biological samples of sharks for age and reproductive studies; and (4) tag sharks for migration studies. Visiting scientists from universities and other agencies will participate in the cruise to study shark parasites, genetics, and taxonomy.