phosis, then most *P. vetulus* had completed transformation by about 120 d old or 4 mo. The influence of substrate and water depth on rate of transformation in this species could be clarified only with laboratory experiments. A detailed description of body morphology versus age, as opposed to length would yield useful information on the variability in the timing of transformation. Unfortunately, we do not have such data.

Acknowledgments

The authors gratefully acknowledge the assistance of the following persons: Dorinda Ostermann, Betsy Washington, H. K. Phinney, Sally Richardson, and Wayne A. Laroche.

Literature Cited

BROTHERS, E. B., AND W. N. MACFARLAND.
In press. Correlations between otolith microstructure growth and life history transitions in newly recruited French grunt, *Haemulon flavolineatum*. Rapp. P.-V. Réun. Cons. Int. Explor. Mer.

BROTHERS, E. B., C. P. MATHEWS, AND R. LASKER.
1976. Daily growth increments in otoliths from larval and adult fishes. Fish. Bull., U.S. 74:1-8.

HOAR, W. S.
1976. Smolt transformation: evolution, behavior, and physiology. J. Fish. Res. Board Can. 33:1233-1252.

JAKÓBCZYK, J.
1965. Investigations on the metamorphosis of *Rhombus maximus* L. (*Pleuronectiformes*). Zool. Pol. 15:191-211.

LAROCHE, J. L., S. L. RICHARDSON, AND A. A. ROSENBERG.
1982. Age and growth of a pleuronectid, *Parophrys vetulus*, during the pelagic larval period in Oregon coastal waters. Fish. Bull., U.S. 80:000-000.

MARLIAVE, J. B.
1977. Substratum preferences of settling larvae of marine fishes reared in the laboratory. J. Exp. Mar. Biol. Ecol. 27:47-60.

METHOT, R. D., JR., AND D. KRAMER.
1979. The growth of northern anchovy, *Engraulis mordax*, larvae in the sea. Fish. Bull., U.S. 77:413-423.

RICKER, W. E.
1979. Growth rates and models. *In* W. S. Hoar, D. J. Randall, and J. R. Brett (editors), Fish physiology, Vol. VIII, p. 677-743. Acad. Press, N.Y.

SALE, P. F.
1969. A suggested mechanism for habitat selection by the juvenile manini *Acanthurus triostegus sandvicensis* Streets. Behaviour 35:27-44.

STRUHSAKER, P., AND J. H. UCHIYAMA.
1976. Age and growth of the nehu, *Stolephorus purpureus* (Pisces: Engraulidae), from the Hawaiian Islands as indicated by daily growth increments of sagittae. Fish. Bull., U.S. 74:9-17.

ANDREW A. ROSENBERG

School of Oceanography
Oregon State University, Corvallis, Oreg.
Present address: *Department of Oceanography*
Dalhousie University, Halifax, N.S. B3H 3J5 Canada

JOANNE LYCZKOWSKI LAROCHE

Gulf Coast Research Laboratory
P.O. Drawer AG, Ocean Springs, MI 39564

OBSERVATIONS ON LARGE WHITE SHARKS, *CARCHARODON CARCHARIAS*, OFF LONG ISLAND, NEW YORK

Fishermen report sightings of large white sharks, *Carcharodon carcharias*, off Long Island and southern New England every year. A popular book on shark fishing (Mundus and Wisner 1971), reported encounters with 23 large white sharks between 1958 and 1966 off Montauk Point, N.Y. Five of these were landed and weighed or estimated to range from 660 to 2,025 kg. Bigelow and Schroeder (1948) noted the occurrence of a few white sharks in southern New England waters. Otherwise most documented captures of white sharks off eastern North America are from coastal locations north of Cape Cod, Mass. (Schroeder 1938, 1939; Bigelow and Schroeder 1948, 1953, 1958; Scattergood et al. 1951; Scattergood and Coffin 1957; Scattergood and Goggins 1958; Scattergood 1959, 1962; Skud 1962; Templeman 1963; Arnold 1972). Information in these reports is limited to location sightings and morphometric observations.

We report here our detailed examinations of two white sharks landed off Long Island, N.Y., in 1964 and 1979. We also describe the feeding behavior of white sharks that were near a dead fin whale, *Balaenoptera physalus*.

Material Examined

One of us (J. G. Casey) caught a 406 cm TL (total length) immature female white shark on rod and reel 7.2 km south of Amagansett, N.Y., (lat. 40°53′ N, long. 72°06′ W) on 5 October 1964. When landed, its stomach was everted. Weight was estimated at 1,500 lb (680 kg) and morphometric measurements were taken to the nearest millimeter.

On 29 June 1979 Captain Thomas Cashman from the charter boat *Rogue* harpooned a male white shark (457 cm TL) while it fed on a 14-15 m dead and floating fin whale 24 km southwest of Moriches Inlet, N.Y., (lat. 40°32′ N, long. 72°50′ W) in 35-40 m of water. The white shark landed at Center Moriches, N.Y., weighed 2,075 lb (943 kg). The following morning we photographed, measured, and dissected the specimen. Morphometric measurements for both specimens (Table 1) follow the conventions of Bigelow and Schroeder (1948).

Biological Observations

Maturity.—The male white shark was sexually mature judging from the condition of the 40 cm claspers (Clark and von Schmidt 1965). The well-developed testes and spermatophores in the lower ductus deferens (Pratt 1979) provided additional evidence of fecund male maturity. The female was immature judging from the small size of the oviducts (approximately 1 cm in diameter).

TABLE 1.—Morphometric measurements of body parts with proportional dimensions as percent of total length.

Body part	1964 female		1979 male	
	cm[1]	% of TL	cm	% of TL
Total length	[1]406.4	100	457	100
Fork length	[2]375.9	92.5	425	93
Distance from snout to:				
eyes	27.9	6.9	27	5.9
nostrils	16.5	4.1	18	3.9
mouth	25.4	6.3	—	—
first gill (base)	99.1	24.4	100	21.9
pectoral	106.7	26.3	126	27.6
first dorsal	154.3	38.0	179	39.2
second dorsal	—	—	334	73.1
pelvic	—	—	277	60.6
anal	—	—	347.5	76.0
upper caudal pit	335.9	82.7	389	85.1
Interspace between:				
1st and 2d dorsal	99.1	24.4	110.5	24.2
2d dorsal and caudal	38.1	9.4	57	12.5
pelvic and anal	43.8	10.8	58.3	12.8
anal and caudal	30.5	7.5	43	9.4
nostrils (proximal)	19.1	4.7	20.3	4.4
Height of:				
1st dorsal	45.1	11.1	43.5	9.5
free tip	11.4	2.8	10.3	2.3
2d dorsal	7.0	1.7	6.5	1.4
free tip	8.9	2.2	7.8	1.7
Diameter of eye:				
horizontal	3.8	.9	3.5	.8
vertical	—	—	4.5	1.0
Right clasper	—	—	40.4	8.8
Left clasper	—	—	40.5	8.9
Width of mouth	43.2	10.6	37.5	8.2
Height of mouth	24.1	5.9	—	—
Max length pectoral fin	78.7	19.4	76	16.6
Girth	218	53.8	260	47.7
Weight, kg	[3]680	—	943	—

[1]Female measured in inches and converted.
[2]Calculated from total length using 92.5% (mean derived from author's unpubl. data).
[3]Estimate.

Stomach Contents and Liver.—The male's stomach and its contents weighed 52 kg when separated at the esophagus. Fifteen "bite-sized" pieces of whale blubber and muscle, 18-60 cm in diameter, in the stomach weighed 28 kg. The largest piece measured 60 × 30 × 10 cm. The stomach, distended and taut, appeared filled nearly to capacity. The liver was large, light-colored, and robust. Both lobes together weighed 178.9 kg.

Parasites.—Circumstances did not permit an exhaustive search for parasites; however, one copepod species, *Dinemoura latifolia*, was collected from the lateral surface of the caudal fin of the male.

Behavior.—One of us (R. B. Conklin) observed at least four and possibly as many as nine white sharks intermittently for 30 h (28-29 June 1979) in the vicinity of the dead fin whale. No more than two ever occurred together, and these appeared agonistic. On one occasion a 3-4 m white shark with a tooth slash over the gills approached the fin whale, then quickly changed direction and disappeared without feeding. This may have been an evasive action because seconds later a much larger male (5-6 m) appeared in the same place and began feeding on the fin whale. Some of the white sharks observed around the fin whale, including the harpooned male, had either fresh or healed tooth slashes on their sides, between the gills and caudal peduncle. These are probably not the mating cuts reported for other shark species (Stevens 1974; Pratt 1979), since they occurred on males and immature females. The tooth slashes and cuts observed on these white sharks are most likely inflicted on co-specifics while competing for prey.

Feeding behavior was observed on four occasions and probably involved different sharks. In three of the four contacts the white shark rolled and attacked with its ventral surface up (Figure 1). After the teeth were in the fin whale carcass, the white shark rolled upright thrashing its tail and cleanly cut away a mouthful of blubber. This behavior was characteristic of attacks on intact parts of the fin whale near the waterline. On the fourth occasion the white shark fed in an upright swimming position, biting on a broad piece of floating flesh.

Fishermen and film makers visited the fin whale each day from 1 to 6 July to observe and photograph the white sharks. Each morning a

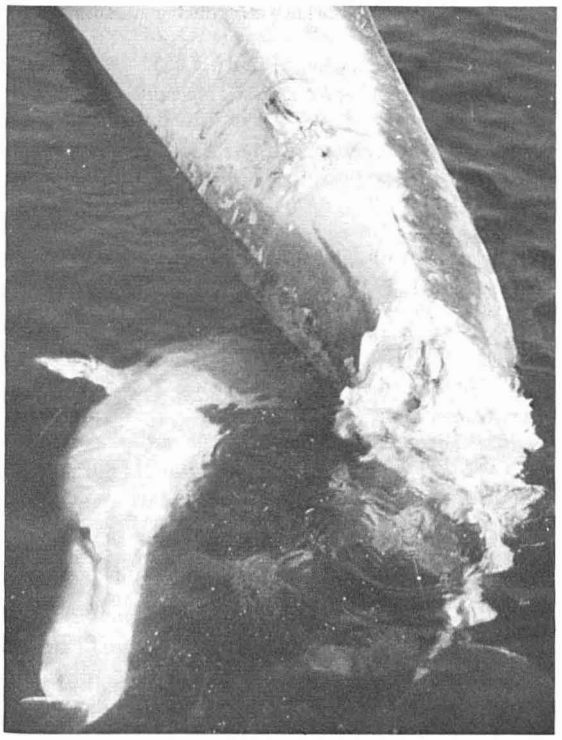

FIGURE 1.—A 4 m male white shark rolling ventral side up to feed on the tail section of a dead 14-15 m fin whale. The white shark's head is under the fin whale toward the right.

white shark of 4-5 m appeared within minutes of the boat's arrival and patrolled or fed for 10-15 min. The observers believed that three to six different white sharks fed on the fin whale during this week; however, only one white shark was observed patroling and feeding at any one time after the initial discovery.

On 6 July 1979, two of us (H. L. Pratt and J. G. Casey) visited the whale carcass, which was in an advanced state of decay. A 4.5 m white shark soon appeared after the boat arrived at the fin whale. The white shark slowly circled the boat and the fin whale, then disappeared. It returned and repeated this behavior at 2-4 h intervals occasionally feeding on the fin whale.

Although the blue shark, *Prionace glauca*; shortfin mako, *Isurus oxyrinchus*; and other pelagic sharks are abundant in this area in July, they were conspicuously absent from the vicinity of the fin whale carcass. Blue sharks were being caught 5-10 km away from the fin whale. Ken Grimshaw, an experienced fish spotter pilot, made several flights over the area, and saw no blue sharks or fish schools within a 3.2 km radius of the whale. It is not unusual for fishermen to report poor catches just prior to a white shark sighting. We suggest that in these cases, the white sharks territorially exclude other species from the area.

Strength.—Based on the amount of time and size of tackle needed to land a large white shark, its strength assumes heroic proportions. The harpoon dart entered the body cavity of the 457 cm white shark forward and below the right pectoral fin, pierced the stomach and lodged in a 5 kg piece of whale blubber. The white shark then towed a 29 l keg and 26-30 m of 9.5 mm nylon line for 14½ h. Nine of these hours were spent with added resistance from the boat through 80-lb test fishing gear attached to the keg. In its final dive, it pulled a heavy nylon line out of the hands of four men. In a similar situation in June 1978, a white shark reported to be 10 m long towed Captain John Sweetman's 42-ft (12.8 m) charterboat backwards a distance of 22 km in 13 h before breaking free (Simons 1978).

Discussion

The occurrence of large white sharks in the shelf waters of the New York Bight is a well established, though often overlooked, fact. Difficulty in observing, field-identifying, and catching white sharks has resulted in a poor understanding of their presence and numbers. Their occurrence in these shelf waters may be related solely to feeding habits; however, it may also be related to reproductive activity. Judging from newspaper and other photographs, most of the large white sharks in this area are females that are approaching maturity (3-4 m FL) or are mature (4-5 m FL). At least three mature males were attracted to the dead fin whale. The presence of mature individuals of both sexes suggests that these offshore waters may be a seasonal mating ground for the white shark.

The presence of young (118-150 cm FL) white sharks in coastal waters of the New York Bight (Casey and Pratt unpubl. manuscr.) and the presence of very large females suggests that pupping may occur here or enroute during the spring migration.

Documentation in popular literature (Baldridge 1974; Ellis 1975) and commercial motion picture films indicate that white sharks attack in

an upright position. The rolling behavior reported here may be a specific pattern for feeding on large flat or slightly convex surfaces (i.e., flanks of whales).

White sharks are known to prey on seals and porpoises (Fitch 1949; Arnold 1972). Records of predation on whales are sparse and usually cited in personal communications (Randall 1973). Calculations of the energy requirements of white sharks (Carey et al. 1979), suggested that dead whales may be a primary food source for white shark populations in the western North Atlantic.

Acknowledgments

The authors wish to thank: John Walton and the crew of the sportfishing boat, *Chief Joseph Brant*, for assistance in obtaining the Amagansett specimen; Tom Cashman and the crew of the *Rogue* for providing the male for examination; Alan Lintala for photographic and histological support; George Benz for identification of parasites; Gary Carter of the University of Rhode Island CETAP program for identification of the whale; Scott Emery, Chet Wilcox, and the people of Center Moriches for logistical support; and Rick Walsh of Nesconset, N.Y., for Figure 1.

Literature Cited

ARNOLD, P. W.
1972. Predation on harbor porpoise, *Phocoena phocoena*, by a white shark, *Carcharodon carcharias*. J. Fish. Res. Board Can. 29:1213-1214.

BALDRIDGE, H. D.
1974. Shark attack. Drake House/Hallux, Inc.

BIGELOW, H. B., AND W. C. SCHROEDER.
1948. Sharks. *In* A. E. Parr and Y. H. Olsen (editors), Fishes of the western North Atlantic, Part one, p. 59-546. Mem. Sears. Found. Mar. Res., Yale Univ. 1.
1953. Fishes of the Gulf of Maine. U.S. Fish and Wildl. Serv., Fish. Bull. 53, 577 p.
1958. A large white shark, *Carcharodon carcharias*, taken in Massachusetts Bay. Copeia 1958:54-55.

CAREY, F. G., G. GABRIELSON, J. W. KANWISHER, O. BRAZIER, J. G. CASEY, AND H. L. PRATT, JR.
1979. The white shark, *Carcharodon carcharias*, is warm bodied. ICES (Int. Counc. Explor. Sea) C.M. 1979/H-50, 8 p.

CLARK, E., AND K. VON SCHMIDT.
1965. Sharks of the central Gulf coast of Florida. Bull. Mar. Sci. 15:13-83.

ELLIS, R.
1975. The book of sharks. Grosset and Dunlap, N.Y., 320 p.

FITCH, J. E.
1949. The great white shark *Carcharodon carcharias* (Linneaus) in California waters during 1948. Calif. Fish Game 35:135-138.

MUNDUS, F., AND B. WISNER.
1971. Sportfishing for sharks. Macmillan Co., N.Y.

PRATT, H. L., JR.
1979. Reproduction in the blue shark, *Prionace glauca*. Fish. Bull., U.S. 77:445-470.

RANDALL, J. E.
1973. Size of the great white shark (*Carcharodon*). Science (Wash., D.C.) 181:169-170.

SCATTERGOOD, L. W.
1959. New records of Gulf of Main fishes. Main Field Nat. 15:107-109.
1962. White sharks, *Carcharodon carcharias*, in Maine, 1959-1960. Copeia 1962:446-447.

SCATTERGOOD, L. W., AND G. W. COFFIN.
1957. Records of some Gulf of Maine fishes. Copeia 1957:155-156.

SCATTERGOOD, L. W., AND P. O. GOGGINS.
1958. Unusual records of Gulf of Maine fishes. Maine Field Nat. 14:40-43.

SCATTERGOOD, L. W., P. S. TREFETHEN, AND G. W. COFFIN.
1951. Notes on Gulf of Maine fishes in 1949. Copeia 1951:297-298.

SCHROEDER, W. C.
1938. Records of *Carcharodon carcharias* (Linnaeus) and *Pseudopriacanthus altus* (Gill) from the Gulf of Maine, summer of 1937. Copeia 1938:46.
1939. Additional Gulf of Maine records of the white shark *Carcharodon carcharias* (Linnaeus) from the Gulf of Maine in 1937. Copeia 1939:48.

SIMONS, S.
1978. The real great white shark story! The Long Island Fisherman 13:18-37.

SKUD, B. E.
1962. Measurements of a white shark, *Carcharodon carcharias*, taken in Maine waters. Copeia 1962:659-661.

STEVENS, J. D.
1974. The occurrence and significance of tooth cuts on the blue shark (*Prionace glauca* L.) from British waters. J. Mar. Biol. Assoc. U.K. 54:373-378.

TEMPLEMAN, W.
1963. Distribution of sharks in the Canadian Atlantic (with special reference to Newfoundland waters). Fish. Res. Board Can., Bull. 140, 77 p.

HAROLD L. PRATT, JR.
JOHN G. CASEY

Northeast Fisheries Center Narragansett Laboratory
National Marine Fisheries Service, NOAA
Narragansett, RI 02992

ROBERT B. CONKLIN

70 Pleasure Drive
Riverhead, NY 11901