SHARK RESEARCH INSTITUTE NEWSLETTER

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THE GIANT PLANKTON-EATERS

WHALE SHARK - *Rhincodon typus*

The shark is aptly named; it is the largest living fish and is reported to reach a length of 59' and weigh more than four tons. Despite its massive size the shark feeds only on plankton and small fish which it strains from the water. The huge mouth, situated at the front of its broad flattened head, holds rows of tiny rasping teeth. If this behemoth had the dentition and disposition of a great white shark it would indeed be a candidate for the title role in *Jaws* but the whale shark has a docile nature. A checkerboard of pale bands and spots cover its back and it is propelled by a nearly symmetrical mackerel-like tail which is strengthened by a lateral keel.

In addition to remoras, the giants are often accompanied by a host of gamefish: cobia, queenfish and jacks. Little is known about their method of reproduction. In 1953 a large egg case containing a 14-inch live embryo was found in the Gulf of Mexico. The embryo resembled the adult, but still had part of its yolk sac, indicating that it was not ready to be born, and the egg case, 30 centimeters (12") long, 14 centimeters (5.6") wide and nine centimeters (3.6") thick, was extremely thin and lacked tendrils as are commonly found on the egg cases of oviparous sharks. Up to 16 egg cases have been found in the uterus of a female whale shark, and it may be that the egg case found in 1953 was aborted, not laid. Due to the rarity of whale-shark eggs and the presence of umbilical scars on free swimming specimens 55 centimeters (22") in length, it is thought development may be aplacental viviparous.

Whale sharks are found in tropical and warm-temperate seas worldwide and frequently travel in groups. In some years up to 55 have been sighted in a single aerial survey; in other years they are scarce. One morning SRI Director, Marie Levine, counted 29 whale sharks on a 200-mile flight. All were swimming just behind the backline of breakers, most were moving northward. Whale sharks often venture close inshore - to the consternation of swimmers - and occasionally strand in the rocks along shore or on the beach.

Divers who have encountered whale sharks have hitched rides. They have clung to its mouth, hung onto the huge first dorsal fin or pectoral fins and have been taken on an unforgettable ride through the sea until the shark tires of the game and sounds.

There are, however, several confirmed reports of whale sharks displaying aggression towards divers and boats when gamefish have been speared or hooked in their vicinity. The late Margaret M. Smith cited three incidents reported by Maurice Jauffet in 1965 and 1966 in which generally inoffensive whale sharks displayed aggression towards fishing boats off Mauritius. In each case fish had been hooked from a shoal and were being played. In one instance a 50' shark was near a shoal of tunny while a 44-lb fish was brought to the surface. The shark raised its head out of the water and charged the boat with such force that the crew were thrown off their feet. The engine was put in full throttle and the shark did not follow.

BASKING SHARK - *Cetorhinus maximus*

This shark is a giant; most specimens are 9,8 meters (32') or less, but there have been reports of 12 and 15-meter (40-50') individuals. The shark is often seen basking on the surface - open mouthed - feeding on plankton which it strains from the water with its gill rakers. The gill slits are huge and nearly encircle the head and its mouth is filled with a hundred or more rows of minute hooked teeth. The snout is pointed and a young juvenile possesses a horn-like protruberance at the end of its snout. The shark is dark grey above, paler below, and its

caudal peduncle has the strong lateral keels of a surface feeder.

The basking shark is a coastal-pelagic migratory shark found in boreal to warm temperate waters throughout the world. It usually remains well offshore, but sometimes comes very close to land and, off South Africa, it has been recorded from the Agulhas Banks to Table Bay. The sharks are usually seen at or near the surface, singly, in pairs, and traveling in groups of a hundred or more. They have also been sighted swimming in tandem, which suggests that a row of these giants could have been mistaken for a sea-serpent, and there have also been instances in which their decayed bodies have been misidentified as marine "monsters".

The sharks periodically shed their gill-rakers and thus are no longer able to feed, which leads to speculation that they may descend to great depths and/or become inactive when food is scarce. It is also thought that the shark may reduce its rate of activity and rely on the oil stored in its liver as an energy source. Their livers are huge and hold extraordinary quantities of oil; it has been estimated that a 30' basking shark might yield 500 gallons of oil. Sharks lack swim bladders and they are supposed to sink when they die, but from time to time dead basking sharks wash ashore, possibly their bodies kept afloat by their enormous livers.

Reproduction is thought to be aplacental viviparous; there is an unconfirmed report of a 1,7-meter (5'7") fetus. It is thought that females reach sexual maturity at a length of five to six meters (16'-20'), males mature when they are 12 to 16 years old (or later) and have attained lengths of four to five meters (13'-16'). The shark is usually inoffensive and sometimes circles divers, but it is armored with hooked dermal denticles that can inflict abrasions and lacerations. When harpooned the shark may react aggressively and, because of its immense power and size, it may be dangerous; however, the potential danger has not prevented small-boat harpoon fisheries from periodically decimating local stocks.

MEGAMOUTH - *Megachasma pelagios*

When the first specimen of megamouth was caught in 1976 it startled the shark world. Almost as surprising, the shark - which represented a new family, genus and species - went without a scientific name for the next seven years. Thus far only two mature males have been reported: the first, caught at a depth of 545' south of the Hawaiian Islands, was almost 4.5 metres (+14') in length, and the second (only a few centimeters longer) was caught in 1984 in comparatively shallow water (125') off Santa Catalina Island, California. The shark's teeth indicate, like the whale and basking shark, it is a filter-feeder and eats euphausiid shrimp, copepods, and (possibly) jellyfishes. The shark's most striking feature is its mouth: its upper jaw and palate are silvery, iridescent and luminescent, its lower jaw and tongue resemble black velvet. It may be that megamouth swims open-mouthed, like the basking shark; its black lower jaw invisible in the darkness of the depths, its upper jaw and palate luring plankton like moths to a light. Like other deep-dwelling sharks it has a loose skin and poorly calcified skeleton. However, most deep-sea sharks are uniformly dark, but megamouth is countershaded like other sharks found near the surface; it is gray-blue above, white below. Perhaps when feeding the shark migrates vertically from deep water. The first specimen caught had wounds caused by a cookie-cutter shark, making it the only known species of shark preyed upon by the tiny shark.

SHARK TAGGING

Much of what is known about sharks comes from dead or captive sharks. By dissecting dead sharks we can learn what they fed upon, their mode of reproduction, and the size at which they reach sexual maturity. From captive sharks we can gain insights into the rate of growth of those species.

No single method exists to calculate age and growth for all species of sharks. One method commonly used is to count the growth rings (annuli) on vertebral centra. However distinct annual rings appear more apt to form in sharks that live in seas with wide changes in temperatures. One way of determining if growth rings are formed annually is to inject the shark with tetracycline; the antibiotic is deposited in the vertebrae and fluoresces under ultraviolet light. After recapture the shark's vertebrae are examined to see how many rings have formed outside the tetracycline marker. If the shark was free for five years after tetracycline marking and three rings formed, it could be safely concluded that a ring had been formed each year. In real-life this works well with captive sharks and spe-

cies with a limited territory, but the odds of recapturing a tetracycline-marked pelagic shark aren't very good.

Although some species of sharks thrive in aquariums, most do not. Another way we can learn more about those species is through tagging. Tagging of fish began in 1873 and today thousands are tagged annually. The fish is caught and measured, tagged and released. When the same fish is subsequently recaptured and remeasured it is possible to determine its rate of growth in its natural environment. It was once thought that lemon sharks matured in one or two years, but we have learned that they take at least 12 years, and possibly 15 to 20 years, to reach sexual maturity, and they may attain an age of 50 years or more. Tagging provides clues as to a species life-span. A school shark, thought to be 20 years old when it was initially tagged, was recaptured 33 years later. Tagging also reveals the range of different species. For example, a blue shark tagged off New York was recaptured after 14 months 3,740 miles away off the coast of Brazil, and another (also tagged off New York) was recaptured six years later off Liberia.

TAGGING SHARKS: A Brief Look at the History, Hardware, and Methods

SURFACE - The conventional method of tagging a shark consists of hooking and fighting the shark until it is subdued and brought to the side of the boat where a tag is inserted by a harpoon. This method of tagging has yielded much valuable information regarding long-term movements of sharks, their rates of growth and life-spans. However, the procedure places considerable physiological stress on the shark; when the object of the procedure is to study the movements of the shark immediately after capture, as in telemetric tracking, the validity of results obtained after the ordeal is questionable.

UNDERWATER - In 1970 Jacques-Yves Cousteau and Philippe Cousteau developed a method of tagging sharks in the Red Sea; their technique utilized a hand spear and had a range slightly in excess of a meter. In 1978 Marc Hastings Griffiths developed a technique using an Arbalete speargun and modified spearhead which permitted accurate placement of a Floy FH-69 spaghetti tag in a shark up to four meters (+13') from the tip of the spear. The spearhead consists of a stainless steel needle which holds the tag, and a stop ring to limit its penetration in the shark. Although tags have been placed by divers using SCUBA, it is considered a less hazardous (to the diver) and more efficient procedure when performed by free divers.

In January 1984 marine biologist Geremy Cliff of the Natal Sharks Board used Griffiths spearheads to tag raggedtooth sharks *Carcharias taurus* in Zululand and Natal, and he has tagged more than a hundred sharks without incident.

In 1987 the spearhead was also used (using SCUBA and inside a shark cage) to tag a great white shark *Carcharodon carcharias* on the Agulhas Banks in the Indian Ocean. The tagging procedure didn't appear to disturb the shark; two different type of tags were placed in the shark (a spaghetti tag and a Casey capsule tag) and it did not flee after either procedure, but continued its investigation of the boat, cage, buoys and bait shark. Since then a number of other species of sharks have been tagged underwater with these spearheads. The technique holds promise; telemetric (acoustic or radio) tags inserted without causing stress to the shark could yield valid results regarding the shark's movements and range.

SRI's Tom Dore has fabricated a number of Griffiths spearheads; any member who needs training in their use and who will be participating in underwater tagging operations should contact SRI Headquarters.

TYPES OF TRACKING DEVICES

PASSIVE TRACKING - There are many types of passive tags available. Although some sharks still bearing row or disc tags may be recaptured, such tags have not been inserted for some years. Dart tags are commonly used today. The tag is anchored below the skin of the shark by means of a small metal dart. The tag itself consists either of a long spaghetti-like plastic string bearing instructions to be followed if the shark is recaptured, or a plastic string to which a sealed lucite capsule (with instructions inside) is attached. Row tags have been recovered 15 years after initial tagging, but many have become illegible. Spaghetti tags may become ob-

scured with marine growth and the printed instructions eroded by the shark's rough skin. The capsule tag was developed by Jack Casey of the National Marine Fisheries Cooperative Shark Tagging Program specifically for use on sharks. Casey tags have been most successful; more than 5,000 tags are used annually by sport and commercial fishermen and marine biologists. Passive tags have provided considerable data on long-term migratory movements, extent of range, rate of growth and life-span of sharks.

If you wish to join the NMFS Program write to: Cooperative Shark Tagging Program, U.S. Department of Commerce, NOAA, National Marine Fisheries Service, Northeast Fisheries Center, Narragansett, Rhode Island 02882.

ACOUSTIC TRACKING - Sharks have been tracked using acoustic transmitters attached to individual animals. Acoustic transmitters have a maximum range of about 1.2 miles and thus it is necessary that a ship equipped with sonar receiving gear remain continuously within a small radius of the animal.

RADIO TRACKING - VHF radio transmitters have also been used successfully to track the movements of individual fish and marine mammals. Transmissions are restricted to "line of sight"; the support boat needs to remain within six miles of the animal, although an aircraft can extend the range of detection. However, high-frequency radio signals cannot be transmitted through sea water, so fixes can only be obtained when the animal surfaces.

SATELLITE TRACKING - Tracking movements of marine animals for extended periods at sea is very expensive and labor-intensive. At present, the only method that holds promise for world-wide tracking in long-term studies is satellite tracking. Although satellite tracking has been used successfully with terrestrial and marine mammals it has been attempted only once with a shark. The species selected, a basking shark, feeds on plankton near the surface and the objective of the study was to investigate its foraging and migratory movements in relation to sea surface temperature and plankton distribution patterns.

The basking shark was equipped with a special UHF radio transmitter and was tracked for 17 days (June 27-July 14, 1982) off the West Coast of Scotland using the ARGOS satellite data collection and location system. The shark surfaced during warm sunny weather and its movements were somewhat localized. Between zero and 12 fixes per day were transmitted. Swimming speed was estimated as 0.106 body lengths per second between locations on successive satellite orbits. Simultaneous infrared imagery using the NOAA 7 AVHRR indicated the shark's movements relative to sea surface temperature variations. Satellite tags are expensive ($5,000 apiece), but the experiment clearly demonstrated the feasibility of satellite-based monitoring of marine animals using currently available satellite systems. A satellite tracking study of whale sharks has been scheduled by SRI scientists.

FROM THE CAGE...

We are proud to announce that one of our Board members has been selected as Explorer of the Year by the Philadelphia chapter of the Explorer's Club. Congratulations to Vincent Capone, FN '89! Vince is the President of Marine Search and Survey, a company specializing in side scan sonar, and he is the co-owner of Princeton Aqua Sports.

Vince is also currently working as a consultant to the Environmental Protection Agency, tracking and locating drums of arsenic off the New Jersey coast. His knowledge and skill in side scan sonar has been of use in other studies; he mapped and photographed the USS Monitor, and located the oldest shipwreck in the United States.

All this leaves Vince little time for his passion - sailing; he relaxes by sailing the open seas on board *Jedi* -

HAWAII CONSIDERS "SHARK CONTROL" LEGISLATION

A fatal shark attack off Olowalu, Maui, has led Hawaii to consider implementing a shark control program. In late January 1992 a bill (H.B. No.2878, State of Hawaii H.D.1.) was proposed to the Hawaii State Legislature to initiate a "selective" shark hunting program. The program targets tiger, Galapagos, and grey reef sharks, presumably because of their previous involve-

ment in attacks on humans. Unfortunately, there is little data regarding the population density, movement patterns and behavior of these species. Some members of the scientific community have presented testimony attesting to the lack of information about the target species and proposed that some of the program funding be given to research, but a strong public outcry is fueling the bill along with the fear that tourist dollars may be lost unless visible measures to control sharks are implemented.

Swimmers, surfers and divers have become a part of the coastal environment. We use the sea for recreation, and we recognize that sharks play a vital role in the ecological balance of the sea. Unfortunately a shark attack elicits a collective hysteria out of proportion to the event; an attack disrupts the security of our role in our environment, as we perceive it (i.e. we are the top predator, not the prey.) To the tourist industry it is considered economically prudent to implement a shark control program whether, in fact, it is effective or not; to the tourist industry a perceived threat can be just as devastating as a real one.

Shark control is not new in Hawaii; shark abatement programs in 1959 and 1967-69 resulted in the killing of 3,125 sharks. Six month programs in 1971 and 1976 killed 336 sharks. Throughout the four programs 669 tiger sharks were killed, however shark attacks remained constant (approximately 1 attack per year). Afterwards (1978 to the present) the attacks rose to 2.7 per year. However, prior to 1979 Hawaii kept no official records regarding shark attacks; the higher figure may simply reflect greater interest in documenting attacks. Further, many of the attacks listed after 1979 were questionable (i.e. the person may have drowned and their body was later scavenged by sharks). If such non-confirmed attacks are removed from the statistics the number of shark attacks per year drops to less than 1 for the post-abatement period.

The proposed bill, scheduled to take effect on July 1, 1992, was brought before the Hawaii State House Finance Committee on February 23, 1992. It is hoped that more testimony will be heard from other scientists attesting to the lack of effectiveness of such programs and their great expense. If members wish more information they can call or write to Chris Lowe or Brad Wetherbee at the University of Hawaii at Manoa, Hawaii Institute of Marine Biology, P.O. Box 1346, Kaneohe, HI 96744. Lab phone: (808) 236-7430. FAX: (808) 236-7443.

*** PRESS RELEASE FROM NOAA ***

The National Oceanic and Atmospheric Administration (NOAA) today proposed the first federal plan for curtailing shark fishing.

The plan would regulate commercial and recreational shark fishing in the 200-mile U.S. exclusive economic zone of the Atlantic Ocean, Gulf of Mexico and Caribbean Sea. It is designed to prevent overfishing of shark stocks and encourage effective management of oceanic shark species throughout their ranges.

NOAA's National Marine Fisheries Service developed the plan in response to the rapid expansion of commercial shark fisheries in the 1980s which developed, in part, to meet heavy Asian demand for shark-fin soup, a delicacy in the Orient.

Although sharks have survived atop the food chain for over 400 million years, over-fishing has threatened the survival of some species in less than a decade," said William W. Fox, Jr., NMFS assistant administrator. "Sharks are extremely vulnerable to unregulated fishing pressure because they have low reproductive rates and are slow to mature."

The plan will require federal permits for commercial fishing and sales of shark meat; establish commercial quotas and recreational bag limits; eliminate finning (removing the fins from sharks and discarding the remainder of the carcass at sea); and initiate a data collection program. The plan covers 39 species of sharks caught in commercial or recreational fisheries.

Thirty-four additional species are also included in the plan for monitoring purposes but will not be federally regulated. These species include small, deep-water sharks and dogfishes which are not considered overfished at this time.

Sharks are an important part of the ocean's ecosystem because they eat many weak and diseased marine species. Shark biology continues to be studied because of the shark's unparalleled resistance to all forms of cancer.

The shark plan will be available for public comment for a 60-day period ending March 9, 1992. Following this public review, NMFS will consider comments received and implement a final plan in April 1992. To obtain copies of the shark plan contact the NMFS Southeast Region at (813) 893-3161.

An Invitation to Join the Shark Research Institute

*Learn more about the biology, distribution and global movements of sharks.
*Support the Institute's projects to study sharks and assist ir the development of marine sanctuaries for sharks.
*Take part in shark tagging and research studies with the Institute.

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