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An Investigation of the Feeding Habits of the Bull Shark, Carcharhinus leucas, in the Lake Nicaragua-Rio San Juan System

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An Investigation of the Feeding Habits of the Bull Shark, *Carcharhinus leucas*, in the Lake Nicaragua-Rio San Juan System

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INTRODUCTION

The bull shark or cub shark, *Carcharhinus leucas* (Müller and Henle, 1841), occurs in tropical and subtropical waters of the Atlantic, Pacific and Indian oceans. In the western Atlantic it occurs from New York to southern Brazil. It also frequents fresh water, especially certain large lakes and rivers, and is commonly found in estuaries and coastal lagoons. Although no comprehensive study has been made of the biology of *C. leucas* in general, limited information is available on its morphology, distribution, life history and general biology (Bigelow and Schroeder, 1948; Baughman and Springer, 1950; Springer, 1963).

Until recently the bull sharks of Lake Nicaragua were considered a landlocked species, distinct from *C. leucas*, and were named *C. nicaraguensis* (Gill and Bransford, 1877). However, in 1961 they were recognized by Bigelow and Schroeder as a population of *C. leucas*. This was later confirmed in a morphometric study by Thorson, Watson and Cowan (1966) and free intermingling of the lake population and the coastal population of the Caribbean Sea has been conclusively demonstrated by Thorson (1971).

Concerning the general biology of the Lake Nicaragua-Río San Juan population, very little reliable information has been reported. For several years a comprehensive study of these sharks has been conducted by Thorson and co-workers. This paper reports on the portion of that study concerned with the foods and feeding habits of this population.

METHODS AND MATERIALS

Most of the sharks used were taken from the Río Colorado where it empties into the Caribbean Sea, in the vicinity of Barra del Colorado and Laguna Samay, Costa Rica. A smaller number were taken at the source of the Río San Juan where it leaves Lake Nicaragua, at San Carlos, Nicaragua.

Sharks were usually captured on hand lines, each consisting of about 50 feet of quarter-inch rope with a chain leader and swivel and a steel hook measuring approximately two and one-half inches from shank to point. Fishing was done from dugout canoes by local residents who were paid for their catches. A few small sharks were caught from the river bank on monofilament lines with small hooks. Baits usually consisted of portions of fresh, cut fish which were selected entirely at the discretion of the fishermen, depending upon what was available.

Upon capture, the sharks were opened and stomach contents were removed, placed in plastic jars and preserved in formalin. If the bulk of samples prevented storage, preliminary notations were made and selected portions of each sample were saved and the remainder discarded. Content analyses were made later in the laboratory.

The samples were sorted according to types of food items present. Most of the contents were in such a state of digestion as to render them unidentifiable. When recognizable structures, such as scales, were present attempts were made to identify the species from which they came, with the use of various keys, distribution records and outside expert help when necessary.

PREVIOUS WORK AND PRESENT RESULTS

Stomach Contents

A wide variety of food items have been recovered from stomachs of bull sharks. Phyla include Echinodermata (Echinoidea); Mollusca (Cephalopoda); Arthropoda (Crustacea); and Chordata (Chondrichthyes, Osteichthyes, and Mammalia).

The phylum Echinodermata appears in the literature only once as a source of food for these sharks. Linton (1904) recovered several plates of an unidentified sea urchin from the stomach of a shark, probably *C. leucas*, near Beaufort, North Carolina.

Among the Mollusca, squids were found in stomachs of bull sharks off the east coast of South Africa by D'Aubrey (1964) and fragments of mollusks have been taken from stomachs along the central Gulf Coast of Florida by Clark and von Schmidt (1965).

Arthropods have appeared in several stomach analyses. Crab remains were reported by Bell and Nichols (1921) off Morehead City, North Carolina, and by Dahl (1964) in Colombian rivers. Crustaceans remnants were found by Clark and von Schmidt (1965) off Florida and a single white shrimp, *Penaeus setiferus*, and a small crab, probably *Callinectes sapidus*, were taken from a shark from Lake Pontchartrain, Louisiana, by Darnell (1958).

The most common phylum encountered in the stomachs of *C. leucas* reported from the literature is the phylum Chordata. Other Elasmobranchii are taken as food, including small black-tipped sharks, *C. limbatus* (Bell and Nichols, 1921; Gudger, 1932); black-nosed sharks, *C. acronotus*; sharp-nosed sharks, *Scoliodon terra-novae*; fine toothed sharks, *Aprionodon isodon*; sandbar sharks, *C. milberti*; and small tail sharks, *C. porosus* (Springer, 1960). The bull shark also consumes adult bonnethead sharks, *Sphyrna tiburo* (Springer, 1967). Various rays have been reported in its diet, including unspecified sting rays, whose spines have

been recovered from stomachs by Nichols (1917), and devil fish, *Mobula* sp., recovered by Bell and Nichols (1921). Unnamed sharks and rays were mentioned by D'Aubrey (1964) as dietary items near the South African coast and Clark and von Schmidt (1965) agreed that the same is true for *C. leucas* in Florida waters. In Colombian rivers the shark was reported to prey on large rays and sawfish, *Pristis pectinatus* (Dahl, 1964). Schwartz (1959) reported that a hooked bull shark bit several cow-nosed rays, *Rhinoptera bonasus*, while the shark was being landed in Chesapeake Bay.

According to Springer (1960), *C. leucas* is the only shark occurring along the Atlantic and Gulf coasts of the United States, Central America, and South America which has a preference for shark meat as food. Although sharks have a reputation as man-killers, they are reported by Nichols (1921) as probably more dangerous to one another than to humans. Only one reference indicates that intraspecific cannibalism occurs. In "shark-eat-shark" episodes created by Vorenberg (1962) lemon sharks and bull sharks were induced to perform a series of "feeding frenzies" in which one or more sharks were consumed after being injured in fights for food by an agitated shark pack. Bull shark predation on young sandbar sharks, *C. milberti*, in their nursery areas is cited by Springer (1960) as a major reason for nonextension of the range of the latter.

Examination of the stomachs of three bull sharks from Lake Pontchartrain by Darnell (1958) showed over 90% of the contents encountered to be bony fishes. Included were striped mullet *(Mugil cephalus)*, black drum *(Pogonias cromis)*, menhaden *(Brevoortia patronus)*, and croaker *(Micropogon undulatus)*. A male *C. leucas* captured in Chesapeake Bay and reported by Schwartz (1960) yielded 74 eels *(Anguilla rostrata)*, four white perch *(Morone americanus)*, and two croakers (unidentified). Another catch reported by Schwartz from the same area contained striped bass *(Morone saxatilis)*, gray sea trout *(Cynoscion regalis)*, flounder *(Paralichthys dentatus)*, and menhaden *(Brevoortia patronus)*. Other teleosts taken from *C. leucas* by Clark and von Schmidt (1965) included *Archosargus probatocephalus, Caranx* sp., *Centropomus undecimalis, Euthynnus alletteratus, Galeichthys felis, Lactophrys tricornis, Megalops atlanticus, Mugil* sp., and *Prionotus* sp. Shad and mackerel, not identified, were found by Bell and Nichols (1921).

Among mammal remains, porpoise fins were collected from bull sharks by Bell and Nichols (1921) off North Carolina. D'Aubrey (1964) stated that these sharks often feed on discarded whale carcasses washed from shore-based processing areas in South Africa.

Little information is available specifically concerning the *C. leucas* population in the Lake Nicaragua - Río San Juan System. Carr (1953) and McCormick *et al.* (1963) allude to the taking of dogs by sharks in the Lake Nicaragua region. The lake shark is reported by Severin (1953) to consume vegetation such as coconuts and bananas as well as meat of any type "from a dead colleague to live cattle." One shark taken at San Carlos by Severin contained the remains of a crustacean. Smith (1893) reported that the sharks in the Río San Juan were attracted by a monkey's skull which was thrown into the water.

In this study 101 sharks were sampled for stomach contents. Of the total, 59 had empty stomachs. The quantity of food in the stomachs was remarkably small in most instances. Most contained only a few scales or bits of debris. Only two contained more than 0.1 kg of food. The maximum was 3.74 kg of assorted fish remains found in a 206 cm female taken at San Carlos.

Identified specimens included ten families of fishes —Pristidae, Lepisosteidae, Elopidae, Characidae, Cichlidae, Mugilidae, Centropomidae, Pomadasyidae, Lutjanidae, and Eleotridae; one family of birds—Tyrannidae; one family of mammals—Bradypodidae; one family of reptiles —Cheloniidae; and one family of land crabs—Gecarcinidae. Table 1 provides a listing of identified food specimens.

Of the 42 sharks containing food items, including those from all locations, eighty-six percent contained remnants of bony fishes, 10% yielded crustaceans, 5% yielded reptilian parts, while in a single instance each, sawfish, bird and mammal remains were found. Forty-eight percent contained materials such as vegetation, pebbles, paper and a glass bottle—apparently swallowed with other food materials or accidentally consumed in place of animal matter.

Except for differences in local prey species, no real difference can be noted between the food items of sharks from the head and the mouth of the Río San Juan. In both cases food items consisted largely of local species of fish. The sawfish remains recovered from a San Carlos shark were probably from a dead animal. Sawfish are numerous at San Carlos and sharks were occasionally taken with the marks of the rostral teeth of sawfish on their bodies, suggesting that there may be encounters between them. However, there is no evidence concerning which species ordinarily wins such confrontations. It appears doubtful that sharks prey on live adult sawfish in this area. Fishermen at Granada, Nicaragua reported (pers. comm.) that they found a rostrum in a net, the only remains of a small sawfish which had apparently been devoured by a shark while entangled in the net. The sloth and tyrannid bird found in Río Colorado shark stomachs were probably from dead remains floating in the river.

There appears to be no difference between adult and juvenile stomach contents. Juvenile stomachs contained almost exclusively small fish, although two held crustaceans and several contained plant materials. Adult recoveries were similar except for the occurrence of turtle remains, which most likely are too large for juveniles to cope with, and the sloth and bird referred to above. No evidence was found to suggest differences in the feeding habits of males and females.

Baits

Limited information has been published concerning baits used, for capturing *C. leucas*. References to items as fresh fish, beef, other shark flesh, whale meat, tuna, sardine, mullet, and a variety of other baits are scattered throughout the literature. Bull sharks and lemon sharks *(Negaprion brevirostris)* were taken from Lake Worth estuary, Florida, on hooks baited with bony fishes (Vorenberg, 1962). Vorenberg reported that certain species of whole, live fish, especially ladyfish, *Elops saurus*, were more effective baits than certain other species as snook *(Centropomus undecimalis)*, snapper *(Lutjanus griseus* and *L. synagris)*, sheepshead *(Archosargus probatocephalus)*, and lookdown *(Selene vomer)* which were also used with limited success.

In contradiction to Vorenberg's statement concerning live bait, Springer (1960) stated that cut baits were in general much better than entire fish of any species. This contention is probably based on the greater diffusion of body juices from cut bait than from whole fish. Springer also

TABLE 1. Frequency of occurrence of items found in stomach contents.

I. San Carlos Sharks (6)

Class	Number of sharks	Percentage of total
Osteichthyes	6	100%
Family Lepisosteidae	1	17%
Lepisosteus tropicus	1	17%
Family Cichlidae	5	83%
Cichlasoma sp.	4	67%
Unidentified cichlid	1	17%
Family Megalopidae	2	33%
Megalops atlanticus	2	33%
Family Mugilidae	1	17%
Agonostomus monticola	1	17%
Family Pomadasyidae	1	17%
Unidentified	2	33%
Crustacea	1	17%
Unidentified	1	17%
Chondrichthyes	1	17%
Family Pristidae	1	17%
Pristis sp.	1	17%
Miscellaneous		
Vegetation	1	17%

II. Barra del Colorado and Río San Juan Sharks (36)

Class	Number of sharks	Percentage of total
Osteichthyes	30	83%
Family Centropomidae	1	3%
Centropomus sp.	1	3%
Family Characidae	2	7%
Brycon guatemalensis	2	7%
Family Cichlidae	4	13%
Cichlasoma sp.	4	13%
Family Eleotridae	1	3%
Guavina guavina	1	3%
Family Megalopidae	1	3%
Megalops atlanticus	1	3%
Family Lutjanidae	1	3%
Lutjanus sp.	1	3%
Family Mugilidae	2	7%
Agonostomus monticola	1	3%
Mugil sp.	1	3%
Family Pomadasyidae	6	20%
Unidentified	10	33%
Crustacea	3	10%
Family Gecarcinidae	3	10%
Reptilia	2	7%
Family Cheloniidae	2	7%
Chelonia mydas	2	7%
Aves	1	3%
Family Tyrannidae	1	3%
Myiarchus tyrannulus	1	3%
Mammalia	1	3%
Family Bradypodidae (*Choloepus* sp. or *Bradypus* sp.)	1	3%
Miscellaneous		
Vegetation	16	53%
Pebbles	1	3%
Paper	1	3%
Glass	1	3%

noted that *C. leucas* occasionally preferred pieces of fresh shark as bait. A fishing crew working off the northeast coast of South America had good success taking bull sharks using fresh shark baits, alternated with baits cut from frozen little tuna (Springer, 1963). These sharks appeared to be attracted by the tuna, but bit on the hooks baited with shark meat. Lines baited only with pieces of shark flesh were unsuccessful. Springer (1943) reported that, for catching sharks in general, it seemed that oily, bloody fish such as bonito, jack, or tarpon worked best, but sharks could also be taken using cut porpoise and sea turtle. Less successful baits included beef, pork, goat, chicken, and rotten or frozen meats. Davies (1964) listed whale meat, tuna flesh, sardine, and live mullet as baits used off the South African coast. Francis (1961) reported fish heads (unidentified) as successful baits for *C. leucas* in Florida canals during high water periods.

In the Lake Nicaragua-Río San Juan System (Table 2). Approximately 93% of these catches were taken on seven species of bait fish. These species are common and easily taken locally. Several less common species also attracted sharks when they were employed. Other baits known to be used in the study area, but not recorded, included sting rays, turtle meat, caiman, gar, and chicken entrails. One shark was also taken on earthworms.

Only one shark was taken using shark flesh as bait. This seems remarkable in view of observations that captive sharks are often fed shark meat; hooked sharks are often eaten alive by other sharks; and other investigators have had success catching bull sharks using shark meat as bait.

TABLE 2. Summary of baits used.

Spanish name	English common name	Scientific name	Number of sharks taken
Roncador	Drummer	Family Pomadasyidae *Pomadasys* spp.	403
Mojarra	Mojarra	Family Cichlidae *Cichlasoma* spp.	282
Machaca	none	Family Characidae *Brycon guatemalensis*	165
Róbalo	Snook	Family Centropomidae *Centropomus* spp.	125
Sábalo	Tarpon	Family Megalopidae *Megalops atlanticus*	65
Lisa	Mullet	Family Mugilidae *Mugil* spp.	64
Guapote	none	Family Cichlidae *Cichlasoma dovii* or *Cichlasoma managuense*	63
Jurel	Jack	Family Carangidae	22
Bagre	Sea catfish	Family Ariidae	18
Barbudo	Catfish	Family Pimelodidae *Rhamdia* spp.	12
Calva	*	*	7
Sardina	none	Family Characidae	7
Pez Sierra	Sawfish	Family Pristidae *Pristis* sp.	5
Sabalete	Shad	Family Clupeidae *Dorosoma chavesi*	4
Guavina	Guavina	Family Eleotridae *Gobiomorus dormitor*	3
Tiburón	Bull Shark	Family Carcharhinidae *Carcharhinus leucas*	1
Guapotito	*	Family Cichlidae *Cichlasoma friedrichsthalii*	1
Moga	*	Family Cichlidae *Neetroplus nematopus*	1
Palmito	*	Family Gerridae	1
Chocolla	*	*	1
Juarena	*	*	1
Libreacha	*	*	1
Lombriz	Earthworm	Oligochaeta	1
			1252

*Not determined.

However, local fishermen believed almost unanimously that sharks would not feed upon one another, and thus refused to use shark flesh as bait, even though it is the most plentiful bait available. The question of whether or not these bull sharks would take baits of shark flesh freely if it were offered remains unanswered.

It appears that sharks will take practically any type of animal flesh. Although my data do not demonstrate bait preference, it may very well exist, as claimed by some investigators and by most local fishermen.

Feeding in Captivity

In aquaria, shark feeding is under artifical control. However, these situations give some insight into types of food bull sharks will consume. Aquarium living is not well suited to this species as they generally survive at most only one or two years according to Clark (1963), compared to other species surviving as much as 25 years under similar conditions.

Once in the artificial environment, bull sharks often refuse to eat for as much as two months, become emaciated, and may die of starvation (Davies, 1964). Davies reported the case of a six-foot female bull shark taken from the Umgeni River in eastern Africa. She was placed in a large tank in the Durban Aquarium where she fasted for 39 days before consuming a sting ray. Close observation thereafter showed that she fed at irregular intervals. While in the tank she consumed large chunks of ray and shark flesh offered as food, but also destroyed valuable live specimens, including a spotted eagle ray *(Aetobatus narinari)*, various sting rays, some duckbilled rays *(Aetobatus* sp.), several skates *(Raja* sp.), three dusky sharks *(C. obscurus)*, and several hound sharks *(Mustelus canis)*.

Davies (1964) reported that small fish are introduced into the tanks to stimulate feeding by specimens newly placed in the aquarium. Top quality frozen tuna flesh, shark or ray flesh, live sardines *(Sardinops ocellata)*, mullet *(Mugil* sp.), and hake *(Merluccis* sp.) are the most acceptable. A three-day interval between feedings has been most successful. The sharks eat until satiated and will not readily take food for approximately 48 hours.

At the Miami Seaquarium and Marineland, Florida, observations of various sharks, including bull sharks, from 1949 to 1955 by Essapian (1962) concur with Davies' statement about starvation. Here the majority of mature sharks refused foods of various types despite several feeding techniques employed. As a result, hundreds of sharks, including *C. leucas*, died of starvation amidst plenty of potential food. Foods used for sharks in these tanks included fish and squid, whole and cut, live fishes inhabiting the tanks, and blue crabs *(Portunus pelagicus)*.

Observations of sharks taken from the Río San Juan verify that the bull shark is indeed difficult to keep alive in captivity. Many attempts were made at Barra del Colorado to keep live sharks of various sizes in holding tanks for observation. All attempts were unsuccessful and the sharks expired within a few days. A variety of species of small fishes were offered to these captive sharks, but none were ever accepted.

Attacks on Humans

A comprehensive treatment of shark attacks in which the shark responsible was indentified as *C. leucas* is beyond the scope of this paper. The bull shark is a proven man-killer in various parts of the world. It possesses all of the vital equipment—size, sharp, triangular, serrated teeth, and powerful jaws—to deal effectively with large prey, including humans. It will attack in both salt and fresh waters and most freshwater attacks may be attributed to this or closely-related species. Davies (1963) reported that, for the Natal coast of Africa, "the period of increasing and maximum abundance of *C. zambezensis (=C. leucas)* coincides closely with the seasonal increase of shark attack." Authoritative identification of bull shark attacks, listed in the shark attack files at the Mote Marine Laboratory, Sarasota, Florida, have been reported from Lake Nicaragua, Florida, Lesser Curacao, South Africa, Zululand, Lourence, and India (Garrick and Schultz, 1963). Several attacks have resulted in fatalities and the shark is feared and respected in localities where it is present.

Since human flesh is not a common dietary item for this species, various theories have been proposed as to if and why the shark seeks out swimmers as food. One suggestion is that the bull shark has more than the normal amount of contact with man as a result of its presence in shallow and fresh waters (Randall, 1963). Another idea is that *C. leucas* attacks humans after it has developed a taste for human flesh, as for example, in regions where cadavers are disposed of in rivers. Such is the case in the Ganges River where *C. gangeticus* has attacked numerous swimmers and bathers (Day, 1878). D'Aubrey (1964) stated that the sharks probably attack humans when nothing better is available.

In the Lake Nicaragua-Río Juan System the bull shark is feared as a deadly man eater, although it seems that its reputation is somewhat exaggerated. The species has been documented as responsible for attacks in the area by Garrick and Schultz (1963). Although the Lake Nicaragua population is credited by Springer (1963) with being exceptionally voracious and bold, no evidence is available to indicate that it is more so than bull sharks in the sea.

Only one minor case of provoked shark-bite was observed during my investigation. A small boy carelessly placed his hand into the mouth of a small shark to remove a hook and received a series of shallow lacerations on the fingers. The cuts required first aid treatment, but were not extensive enough to be a major problem.

Discussion

The bull shark occupies varied habitats over the world and is presented with different food items in each situation, especially when freshwater and marine situations are considered. My data substantiate contentions by Baughman and Springer (1950) and by Casey (1964) that *C. leucas* is an indiscriminate feeder and will consume almost any kind of animal matter available. It will also swallow many objects which have little or no food value, as shown by the presence of sticks, leaves, stones, orange peelings, and a glass bottle in the stomachs examined.

Although no information is available on the velocities at which these sharks swim when feeding, the presence in their stomachs of such remains as mullet, snook, tarpon, and cichlids from fresh water and porkfish, parrotfish, bluefish (Springer, pers. comm.), menhaden, and mackerel from the sea would discount the claim of McCormick *et al.* (1963) that the species is a slow swimmer. The shark probably attacks live fish when no other food is readily available, but it does so with marked effectiveness.

A feeding problem facing the species in the San Juan river system is the turbidity of the water. The secchi disk depth is ordinarily less than a meter and may be as little as

0.25 m during high water. In such a situation the shark must rely a great deal upon sensory systems other than vision in locating its food. In tests reported by Gilbert (1961), especially with lemon sharks, *Negaprion brevirostris*, it was shown that, at distances greater than 100 feet, olfaction is more important than vision in guiding sharks to prey, while at distances of 100 feet or less, depending upon the turbidity of the water, vision increases in importance. At distances of less than ten feet vision is probably the most important factor in directing the shark to its target. Gilbert (1961) has shown that lemon sharks die in three to five days if both vision and olfactory senses are simultaneously obliterated. Tester (1961) has reported that sharks can detect both live prey and sliced meat in the water through olfactory stimulation. It appears that the more bloody, oily, or rotten the food sample, the easier it is for a shark to detect its presence.

My data show that the bull shark is indeed a scavenger, consuming items that fall into the water, such as birds and mammals. The apparent predilection for fish may be more a matter of availability than preference.

It is significant that such a large proportion of the sharks sampled had no food in their stomachs. This observation was also cited by Springer (pers. comm.). Two possible considerations may account for the lack of food items in so many of the stomachs: First, logically, the shark took bait and it would appear that it was actively seeking food because it was hungry. However, it has been questioned by Springer (pers. comm.) that hunger, as defined from a human standpoint, is an important drive for sharks. Secondly, the stomach may have been empty because, during the sruggle of capture, the shark, in its violent efforts to escape, may have regurgitated any food held in the stomach. It was frequently observed that the entire stomach was everted and protruded from a captured shark's mouth. Evidence by Coppleson (1958) indicated that regurgitation is common in sharks, especially in the selective elimination of undigested remains such as bones and scales.

The proposal by Springer (1960) that gravid *C. leucas* are inhibited from feeding upon entering shallow waters to give birth to their young does not seem to be borne out by this study. Springer hypothesized that suspension of feeding during such intervals served to isolate young *C. leucas* from heavy predation pressure by larger members of the same species. However, three of five pregnant females used in my study, containing fetuses up to 60 cm in length, had recently eaten, and all obviously had taken bait. Jensen (1976) studied 66 pregnant female *C. leucas*, all of which were caught on baited hooks. Thirty-three of these contained fetuses 50 to 75 cm long, considered by Jensen to be the range of size at birth. Of these, twenty-seven had pups over 60 cm in length and five included pups exceeding 70 cm.

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Summary

Examination was made of the stomach contents of 101 bull sharks *(Carcharhinus leucas)* taken from the fresh waters of the Lake Nicaragua-Río San Juan System. Fifty-nine were empty; of the 42 that contained food, most held only small quantities. Food items included representatives of one family of arthropods (in four stomachs), one family of elasmobranchs (1), nine families of bony fishes (36), one of reptiles (2), one of birds (1), and one of mammals (1). Nonfood items included leaves, sticks, orange peelings, pebbles, paper, kernels of corn and a glass bottle.

Except for the difference in locally available food species, no difference could be shown between the foods of sharks taken at San Carlos on Lake Nicaragua and at Barra del Colorado at the mouth of the river, nor between juveniles and adults, or males and females.

Records of 1252 baits taken by sharks indicated that 93% of the catches were made on seven of the most common local species of fish. Fifteen other species of teleost fishes, the bull shark, and an earthworm accounted for the other 7%. Other baits not recorded included sting ray, gar, turtle, caiman, and chicken entrails.

The bull shark is an opportunist and an indiscriminate feeder, taking virtually any kind of animal flesh available. It is a scavenger, but pursues living prey, probably when dead items are not readily available. Its predilection for fish may be more a matter of availability than preference.

Bull sharks kept in small pools up to several days refused to eat while in captivity, although they have been known to do so in large aquaria.

Although there are verified instances of attack on humans in Lake Nicaragua and the Río San Juan, the reputation of the bull shark in fresh water has been exaggerated.

Contrary to some reports, females in late stages of pregnancy were still feeding. At least 33 containing fetuses within the range of length at birth (50 to 75 cm) are known to have taken hooks baited with fish, and the stomachs of three of five examined contained food.

Resumen

Se examinó el contenido estomacal de 101 tiburones *(Carcharhinus leucas)* colectados en las aguas dulces del sistema Lago de Nicaragua-Río San Juan. Cincuenta y nueve se encontraron vacíos, y de los 42 restantes la mayoria contenían poco alimento. Los alimentos encontrados incluían representantes de una familia de artrópodos (en 4 estómagos), una familia de elasmobranquios (1), nueve familias de peces óseos (36), una de reptiles (2), una de aves (1) y una de mamíferos (1). Objetos no alimenticios incluyeron hojas, palos, cáscaras de naranja, piedrecillas, papel, granos de maíz y una botella de vidrio.

No se encontraron diferencias entre el alimento tomado por los tiburones en San Carlos, Lago de Nicaragua, y en la Barra del Colorado en la desembocadura del río, si se exceptúan las diferencias entre el alimento disponible localmente; tampoco se encontraron diferencias entre el elimento encontrado en adultos y juveniles, o en machos y hembras.

El 93% de 1252 carnadas tomadas por tiburones consistió de peces de las siete especies más comunes localmente. El 7% restante consistió de 15 especies adicionales de peces teleósteos, de tiburón y de una lombriz. Otras carnadas, no registradas, consistieron de rayas, gaspar, tortuga, caimán y entrañas de pollo.

El tiburón come oportunística e indiscriminadamente, tomando practicamente cualquier clase de carne animal a su disposición; es carroñero, pero persigue también presas vivas, probablemente cuando no encuentra animales muertos. Su aparente predilección por los peces probablemente se deba más a la disponibilidad de estos que a una verdadera preferencia.

Tiburones confinados a pequeñas piletas, hasta por varios días, rehusaron comer, aunque se sabe que comen en grandes acuarios.

Aunque hay casos verificados de ataques a humanos en el Lago de Nicaragua y el Río San Juan, la reputación de este tiburón en agua dulce ha sido exagerada.

En contradicción a algunos reportes, se encontró que hembras en estado avanzado de gravidez aún estaban alimentádose. Al menos 33 que contenían fetos de un largo apropiado para el nacimiento (50–75 cm) se pescaron con carnada, y tres estómagos, de cinco que se examinaron, contenían comida.

Literature Cited

Baughman, J. L. and S. Springer. 1950. Biological and economic notes on the sharks of the Gulf of Mexico, with especial reference to those of Texas, and with a key for their identification. Amer. Midl. Nat., 44:96–152.

Bell, J. C. and J. T. Nichols. 1921. Notes on the food of Carolina sharks. Copeia 1921(92):17–20.

Bigelow, H. B. and W. C. Schroeder. 1948. Sharks. *In*: Fishes of the Western North Atlantic. Mem. Sears Found. Mar. Res., Yale Univ., New Haven, Conn. 1(1):59–576.

Carr, A. 1953. High Jungles and Low. Univ. Florida Press, Gainesville.

Casey, J. G. 1964. Anglers' guide to sharks of the northeastern United States, Maine to Chesapeake Bay. Bur. Sport Fish. Wildlife Circ. 179:1–32.

Clark, E. 1963. Maintenance of sharks in captivity with a report on their instrumental conditioning. *In*: Sharks and Survival. P. W. Gilbert, ed. D. C. Heath Co., Boston.

Clark, E. and K. von Schmidt. 1965. Sharks of the Central Gulf Coast of Florida. Bull. Mar. Sci. 15:13–83.

Coppleson, V. M. 1958. Shark Attack. Angus and Robertson Ltd. Sydney, Australia.

Dahl, G. 1964. Los peces y la pesca del Rio Sinu. Departamento de Investigaciones Ictiologicas y Faunisticas. Bogotá, Colombia.

Darnell, R. M. 1958. Food habits of fishes and larger invertebrates of Lake Pontchartrain, Louisiana, an estuarine community. Pub. Inst. Mar. Sci. Univ. Texas 5:353:416.

D'Aubrey, J. D. 1964. Preliminary guide to the sharks found off the east coast of South Africa. South African Assn. Mar. Biol. Res. Investigational Report No. 8.

Davies, D. H. 1963. Shark attack and its relation to temperature, beach patronage and the seasonal abundance of dangerous sharks. *Ibid.* No. 6.

Davies, D. H. 1964. About Sharks and Shark Attack. Brown, Davis, and Platt Ltd. Durban, South Africa.

Day, F. 1878. The Fishes of India, being a natural history of the fishes known to inhabit the seas and freshwaters of India, Burma, and Ceylon. Facsimile edit., 1958. Dausen and Sons Ltd., London.

Essapian, F. S. 1962. Notes on the behavior of sharks in captivity. Copeia 1962:457–459.

Francis, P. 1961. Florida ditch fishing. Florida Wildlife. 1961(4):12–15.

Garrick, J. A. F. and L. P. Schultz. 1963. A guide to the kinds of potentially dangerous sharks. In: Sharks and Survival. P. W. Gilbert, ed. D. C. Heath and Co., Boston.

Gilbert, P. W. 1961. The visual apparatus of sharks and its probable role in predation. Abstracts of symposium papers, Tenth Pacific Science Congress, Honolulu.

Gill, T. and J. F. Bransford. 1877. Synopsis of the fishes of Lake Nicaragua. Proc. Acad. Nat. Sci. Phila. 1877:175–191.

Gudger, E. W. 1932. Cannibalism among the sharks and rays. Sci. Monthly 1932(34):417.

Jensen, N. H. 1976. Reproduction in the bull shark, *Carcharhinus leucas*, in the Lake Nicaragua-Río San Juan System. *In:* Investigations of the Ichthyofauna of Nicaraguan Lakes. T. B. Thorson, ed. School of Life Sciences, Univ. Nebr.–Lincoln.

Linton, E. 1904. Parasites of fish of Beaufort. Bull. U. S. Bur. Fish. 42:321–428.

Marden, L. 1944. A land of lakes and volcanoes. Nat. Geog. 86:161–192.

McCormick, H. W., T. Allen and W. E. Young. 1963. Shadows in the Sea. Chilton, Inc., New York.

Nichols, J. T. 1917. Ichthyological notes from a cruise off southwest Florida with description of *Gobiesox yuma*. Bull. Amer. Mus. Nat. Hist. 37:873–877.

Nichols, J. T. 1921. What sharks really eat. Nat. Hist. 21(3):272–278.

Randall, J. E. 1963. Dangerous sharks of the western Atlantic. *In*: Sharks and Survival. P. W. Gilbert, ed. D. C. Heath and Co., Boston.

Schwartz, F. J. 1959. Two eight-foot cub sharks, *Carcharhinus leucas* (Müller and Henle), captured in Chesapeake Bay, Maryland. Copeia 1959:251–252.

Schwartz, F. J. 1960. Additional comments on adult bull sharks *Carcharhinus leucas* (Müller and Henle), from Chesapeake Bay, Maryland. Chesapeake Sci. 1(1):68–71.

Severin, K. 1953. The landlocked man-eaters. Ture (magazine), July 1937: 37–39, 95–96.

Smith, H. M. 1893. Sharks in Lake Nicaragua. Science 22:166–167.

Springer, S. 1943. Sharks and their behavior, with particular reference to eight genera implicated in reports of attacks on man. Mimeographed report for the coordinator of Research and Development, U. S. Navy. Cited by Clark, E. 1963. *In*: Sharks and Survival. P. W. Gilbert, ed. D. C. Heath and Co., Boston.

Springer, S. 1960. Natural history of the sandbar shark *Eulamia milberti*. U. S. Fish. Wildl. Serv., Fish. Bull. 178, 61:1–38.

Springer, S. 1963. Field observations on large sharks of the Florida-Caribbean region. *In*: Sharks and Survival. P. W. Gilbert, ed. D. C. Heath and Co., Boston.

Springer, S. 1967. Social organization of shark populations. *In*: Sharks, Skates, and Rays. P. W. Gilbert, R. F. Mathewson, and D. P. Rall, eds. Johns Hopkins Press, Baltimore.

Thorson, T. B. 1971. Movement of bull sharks, *Carcharhinus leucas*, between Caribbean Sea and Lake Nicaragua demonstrated by tagging. Copeia 1971:336–338.

Thorson, T. B., D. E. Watson and C. M. Cowan. 1966. The status of the freshwater shark of Lake Nicaragua. *Ibid.* 1966:385–402.

Tester A. L. 1961. The role of olfaction in shark predation. Abstracts of symposium papers, Tenth Pacific Science Congress, Honolulu.

Vorenberg, M. M. 1962. Cannibalistic tendencies of lemon and bull sharks. Copeia 1962:455–456.