

**NURSE SHARKS (*GINGLYMOSTOMA CIRRATUM*)
 OF BIG PINE KEY, FLORIDA (U.S.A.) :
 AN INVESTIGATION OF GROWTH AND MOVEMENT,
 AND A COMPARISON OF THE SUCCESS
 OF SEVERAL TYPES OF EXTERNAL TAGS**

**LES REQUINS DORMEURS (*GINGLYMOSTOMA CIRRATUM*)
 DE BIG PINE KEY, FLORIDE (U.S.A.) :
 RECHERCHE SUR LA CROISSANCE ET LE DEPLACEMENT,
 AINSI QUE SUR LES ESSAIS COMPARATIFS
 DE PLUSIEURS TYPES DE MARQUES EXTERNES**

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ABSTRACT

During the last 5 years, over 100 nurse sharks (*Ginglymostoma cirratum*) have been tagged in the Coupon Bight Aquatic Preserve, Big Pine Key, Florida (USA), a shallow, inshore bay measuring approximately 6 square kilometers in area. Combinations of 3 types of external tags have been used, and 10 animals have been tagged and tracked with the use of ultrasonic telemetry. The average size (total length) of the animals upon initial capture was 123.4 ± 19.6 cm (range: 48-172.5) and 9.9 ± 4.1 kg (range: 0.7-24.8). 22% of the animals have been recaptured at intervals ranging from 7-884 days, with an average at large time of 315 days. Recapture data predict an average length increase of 10.6 ± 4.6 cm/yr and average weight gain of 3.4 ± 1.2 kg/yr. Preliminary results of ultrasonic telemetric tracking indicate no correlation with tidal water movement. Success of three types of external tags was compared. Rate of recovery of animals tagged with stainless steel barbed dart tags was higher than for animals tagged with either plastic barbed dart tags or modified Carlin disc tags. Injuries caused to animals tagged with Carlin disc tags suggest that these tags should be used only for nurse sharks who have attained adult size.

RESUME

Au cours des cinq dernières années, plus de 100 requins dormeurs (*Ginglymostoma cirratum*) ont été marqués dans la réserve marine de Coupon Bight à Big Pine Key en Floride (USA), une baie côtière peu profonde qui s'étend sur environ 6 km². Des combinaisons de 3 sortes de marques externes ont été utilisées et 10 animaux ont été marqués et suivis par télémétrie ultrasonique.

La taille moyenne des animaux (longueur totale) au moment de la première capture était de $123,4 \pm 19,6$ cm (de 48 + 172.5) et le poids de $9,9 \pm 4,1$ kg (de 0.7 + 24.8). 22% des animaux ont été recapturés dans un intervalle compris entre 7 et 884 jours, la moyenne étant de 315 jours. Les données obtenues montrent des accroissements de $10,6 \pm 4,6$ cm par an pour les tailles et de $3,4 \pm 1,2$ kg par an pour les poids.

Les résultats préliminaires de dépistage par télémétrie ultrasonique ne révèlent aucune corrélation entre les déplacements des requins et les marées.

Les évaluations des essais comparés de 3 types de marques indiquent que le pourcentage de recouvrement des marques barbelées en acier inoxydable est supérieur à celui des marques barbelées en plastique ou des disques de Carlin modifiés. Les blessures infligées aux animaux marqués avec les disques de Carlin suggèrent que ce type de marquage devrait être réservé aux animaux ayant atteint leur taille adulte.

INTRODUCTION

A variety of investigations have been undertaken in recent years attempting to detail the long-term (e.g. migratory) and short-term (e.g. diel) movements of elasmobranchs. The most elaborate of these investigations is perhaps that of Casey (Casey et al., 1978). These investigators have been involved for many years in the cooperative shark tagging program for the United States National Marine Fisheries Service, and have tagged large numbers of sharks of many species from many locations, primarily Atlantic. In Casey's studies a stainless steel barbed, heavy gauge, monofilament, dart tag has been used with a plastic message capsule on the exposed end.

Other investigators have concentrated on fewer species and have used different tags or a multiple tagging protocol. The most popular tag has been the dart tag. Beckett (1970) tagged several species of sharks and employed both plastic barbed and metal barbed dart tags, but reported no returns from multi-tagged sharks.

Holden (1965) used a variety of external tags on Squalus acanthias. He favored Petersen disc tags because they produced a higher rate of recapture. Templeman (1976) reported on transatlantic migrations of S. acanthias tagged with Petersen disc tags. A variation of the disc tag was used by Stevens (1976). More recently, Beamish et al., (1981) reported some success using Petersen tags and a modified design of the Carlin disc tag (double pinned) through the dorsal fin of S. acanthias.

Gruber (1982) has undertaken a study of lemon sharks in the Florida Keys and Bahamas using a variety of tags on every animal: dart tags, disc tags, and freeze-branding externally, and a plastic tag internally.

A study by McLaughlin and O'Gower (1971) employed rubber or metal collars placed around the caudal peduncle of Port Jackson sharks (Heterodontus portusjacksoni) to facilitate identification of the sharks by divers. Another tracking study (Medved and Marshall, 1983) utilized tethered styrofoam floats to follow animals moving in shallow, inshore estuarine areas.

The most popular procedure currently involves the use of ultrasonic telemetry. Since continuous, frequent contact is required, these studies are generally limited to short-term tracking. The technique has permitted evaluation of daily movement for several shark species including blue sharks (Prionace glauca; Sciarrotta and Nelson, 1977), Pacific angel sharks (Squatina californica; Standora and Nelson, 1977), lemon sharks (Negaprion brevirostris; Gruber, 1982), dusky sharks (Carcharhinus obscurus; Huish and Benedict, 1977), and sandbar sharks (Carcharhinus plumbeus; Medved and Marshall, 1983). Most of these studies, however, seem to have been constrained by the fact that a large percentage of the shark species studied appear not to be restricted to small ranges. Therefore, the time between initial tagging and recapture may be quite long and thus periods permitting continuous telemetric monitoring may be quite short. Most studies to date have involved species which primarily inhabit deeper, offshore waters where the problem is further complicated. Until recently, few clues have been provided

regarding intermediate movements.

The nurse shark (Ginglymostoma cirratum) is a coastal species found in the western Atlantic from the northeastern coast of the United States to Brazil (Bohlke and Chaplin, 1968; Castro, 1983). While some osmoregulatory studies (Carrier and Evans, 1972) and behavioral studies relating to capture, confinement, and stress (Kramer, unpublished) have been conducted on this species, little has been published on its life history. Preliminary investigations in the Big Pine Key region of the Florida Keys suggested that this species may be restricted in its movements and indeed may not have the migratory habits known for many other species. Furthermore, nurse sharks are found in great abundance in local areas, including a recently designated National Marine Sanctuary (Looe Key). Therefore, a tagging program was initiated to permit a thorough investigation of growth and daily and seasonal movements for G. cirratum. This report presents a preliminary evaluation of some results of this study.

METHODS

Sharks were taken mainly by rod and reel from various locations around the Coupon Bight region of Big Pine Key in the Florida Keys. Animals were removed from the water by means of a canvas sling. Hooks were removed where possible, and total length, weight, and sex were recorded.

Water was continuously applied to the sling to minimize evaporative water loss during the tagging procedure. Animals were normally released within five minutes after capture.

Various combinations of tags were used through the course of the study. Stainless steel barbed dart tags (Floy FH-69A, Floy Tag and Manufacturing Co., Seattle, Washington, USA) and nylon barbed dart tags (Floy FT-1) were used in various combinations with modified Carlin disc tags from Floy (after Beamish et al., 1981). For dart tags, a small (0.5 cm) incision was made lateral to the first dorsal fin, into which the barb of the tag was inserted. This procedure was preferable to forceful insertion of the tags with a tagging pole. It minimized tagging trauma to the animal, and also reduced damage to tags, particularly the nylon-barbed tags. Injections of tetracycline (tetracycline hydrochloride; 25 mg/kg body weight) were given intramuscularly at the posterior base of the first dorsal fin for eventual age determination studies (Gruber, 1982).

Ultrasonic transmitters (75 KHz; SONOTRONICS, Tucson, Arizona, USA) were implanted through a surgical incision in the lateral peritoneum and the incision was closed with sutures. Animals were monitored in closed circulating tanks prior to release to evaluate transmitter activity and healing of the incision. A USR-5 Digital Receiver and Directional Hydrophone (both SONOTRONICS) were used for tracking.

RESULTS

Over 100 nurse sharks were captured and tagged during the study interval. Fifteen were sacrificed for gut content studies and five others were used as control animals for tetracycline-aging studies.

Nineteen different animals were recaptured once (11 females and eight males; 22.1% recaptures based upon different animals), and four animals have been recaptured twice. The average interval between capture and recapture was 315 days.

The average total length for animals taken in the study was 123.4 ± 19.6 cm and the average weight was 9.9 ± 4.1 kg. No significant difference between the mean of length or weight was found between males and females or the total population (T-test).

Eighty-six animals were released after tagging, including 40 females and 46 males. Reliable length/weight data are available from 72 different animals representing 82 measurements. Some animals captured early in the study were tagged and released by local fishermen and only estimates of lengths and weights were available.

Table 1 summarizes the recovery data and shows the relative success of the three types of tag employed in the study. Table 2 presents a more detailed evaluation of the individual tag performance. Table 3 summarizes the changes in length and weight for recaptured animals. Table 4 presents the annual percent changes in length and weight from the recapture data.

DISCUSSION

The 22.1% recapture rate in this study is considerably higher than recapture rates reported in other studies. The time between release and recapture averaged 315 days with a range of seven to 884 days. Thirteen of the 19 different animals recaptured were free for more than 328 days. None of the recaptures came from outside Coupon Bight, whose total area is approximately six km². This seems to suggest that this population has very restricted movement. Animals have in fact been recaptured near the original capture site on the same day, indicating little movement and little reluctance to feed. This is encouraging because it suggests that no immediate ill effects result from the trauma of capture and tagging. The high percentage of recaptures suggests that either the animals are reasonably restricted in their total movement, or they are faithful in their return. Recaptures in the winter months were sparse, possibly because water temperatures in this shallow region often drop to 20–22°C which may affect feeding. Observations of animals in the shallow *Thalassia* flats tend to confirm the reduced numbers of animals present in winter. However quantitative sampling efforts of the same intensity as are undertaken in the summer months have not been pursued.

Ultrasonic telemetry has recently been employed to attempt to detail daily movements and to assist in locating the animals if they leave the study area. The studies have met with marginal success to date. The maximum continuous tracking time for any one of the ten animals tagged to date was 96 hours, after which the animal could no longer be detected. Control tests of the transmitters suggest that battery life may exceed six months. But problems with the effective range of the transmitters has prevented extensive work offshore. Additionally, many areas of the study site are too shallow to permit access by boat, yet do not appear to

restrict shark movement. In spite of these difficulties, preliminary work suggests that movement of *G. cirratum* shows no correlation with tidal water movement, unlike the studies of Medved and Marshall (1983) and others. Animal movement seems to be random. Most of the telemetry work was begun in the first week of July of 1983. One animal who was tracked during the initial period was later detected in the second week of March, 1984, and was found within 100m of the initial tagging site inside the shallow Bight area.

Table 2 shows that seven animals were recaptured from a group of 23 that were tagged with only stainless steel barbed tags (30%). Thirty-eight animals were tagged with both nylon barbed dart tags and Carlin disc tags, and 10 animals from this group were recaptured (26%). Of those 10, three retained both tags (30%), nine of the 10 retained Carlin tags (90%), and four of the 10 retained the nylon barbed tag (40%). Thirty-four animals were tagged with all three tag types, and six recaptures have been reported to date. All animals recaptured from this tagging protocol retained the stainless steel barbed tag. Four of the six retained the Carlin tags, and two of the six retained the plastic-barbed tag. Only two animals have retained all three tag types, but one of those animals was recaptured after only seven days at large.

Some difficulties have been encountered with all these types of tags. Generally the dart tags have enjoyed a fair success, with the stainless steel barbed tag apparently retained somewhat better than the nylon barbed tag. Disc tags have also experienced a high rate of success. However when they are used on juvenile sharks, there can be enough lateral growth of the dorsal fin that it eventually splits and grows around the tag. An abscess can then form which could potentially harm the animal. Similar difficulties were reported by Beamish et al. (1981) with *Squalus acanthias*. A detailed discussion of these and other tag-related problems appears elsewhere (Carrier, 1984, 1985).

The total length of the animals captured in the study ranges from 48 to 172.5 cm. Smaller spotted juvenile *G. cirratum* have been captured by trawl or by hand in nearby *Thalassia* beds or sponge flats, but larger animals (200 cm and larger) are not commonly observed in this area, although they have been taken in nearby shark tournaments. Bohlke and Chaplin (1968) and Castro (1983) suggested that the maximum size of this species may exceed 400 cm. The largest specimen taken in this study measured 172.5 cm. Apparently large individuals do not inhabit the area, or else the sampling method favors a limited size range.

Of the 23 total recaptures, usable data are available for change in weight of 12 animals and change in length of 17 (Table 3). For all these animals with at large intervals greater than 75 days, the average change in weight was 3.4 ± 1.2 kg/yr (N=11), and the average change in length was 10.6 ± 4.6 cm (N=15). These rates are comparable to those reported for *Negaprion brevirostris* (Gruber, 1982, and personal communication). These changes represent a mean increase in length of 8.6 ± 3.7 for males and 10.9 ± 2.0 for females. Similarly, the changes in weight for males were 38.3 ± 10.3 and for females were 36.8 ± 9.4 . These changes are

TABLE 1. Tags in place at release and recovery, and at large times for G. cirratum*.

Tag No.	Tags at time of release	Tags at time of recapture	Time between captures (da)
16262	SS	SS	369
33	SS	SS	347
49	SS	SS	364
51	SS	SS	378
16264	SS	SS	792
78041	SS	SS	657
77011	SS	SS	31
15	Y,C	Y,C	10
20	Y,C	C	373
24	Y,C	Y,C	49
48	Y,C	Y,C	11
48	Y,C	C	29
54	Y,C	Y	365
11	Y,C	C	30
63	Y,C	C	884
65	Y,C	C	88
73	Y,C	C	876
137	Y,C,SS	SS,C	328
206	Y,C,SS	Y,C,SS	7
212	Y,C,SS	SS	161
114	Y,C,SS	SS	536
208	Y,C,SS	Y,C,SS	178
25	Y,C,SS	SS,C	387

* 'Y' = plastic barbed dart tag; 'C' = modified Carlin disc tag; 'SS' = stainless steel barbed dart tag.

TABLE 2. Recovery data by tag type* of G. cirratum. The number shown under 'Number in tag group released' includes 9 animals for whom the tagging arrangement was changed upon recapture.

Tag Group: Tags in animal at time of release	Number in tag group released	Number in tag group recovered	Recapture percentage for tag group
SS only	23	7	30
Y & C	38	10	26
Y, C, & SS	34	6	18

*'Y'=plastic barbed dart tag; 'C'=modified Carlin disc tag; 'SS'=stainless steel barbed dart tag.

TABLE 3. Recapture data for G. cirratum. Lengths and weights are provided only for animals for whom actual measurements were taken. L_1 = initial length; L_2 = recapture length; W_1 = original weight; W_2 = recapture weight.

TAG NO.	TIME OUT (da)	SEX	L_1 (cm)	L_2 (cm)	CHANGE (cm/yr)	W_1 (kg)	W_2 (kg)	CHANGE (kg/yr)
16262	369	M	128	137.5	9.4	9.1	12.5	3.4
33	347	F	130	144.7	15.5	-	13.6	-
49	364	F	120	136	16	-	11.7	-
51	378	M	141	146.5	5.3	-	16.4	-
16264	792	M	115	131	7.4	-	-	-
78041	657	M	-	122	-	-	8.6	-
77011	31	F	-	126	-	-	-	-
15	10	F	119.5	-	-	7.7	-	-
20	373	M	137	147	9.8	11.1	14.2	3.0
24	49	F	150	153	22.3	17.1	-	-
48	11	F	-	-	-	-	-	-
48	29	"	95.2	97	22.7	4.2	4.3	1.3
54	365	M	106	120.3	14.3	5.5	8.6	3.1
11	30	F	130	132	-	11.9	11.7	-
63	884	F	132	169.4	15.4	11.7	24.8	5.4
65	88	M	105	106	4.2	6.2	6.8	1.7
73	876	F	109	133.7	10.3	6.8	12.9	2.5
137	7	M	-	-	-	-	-	-
206	328	M	108.6	121.7	14.6	6.8	8.9	2.3
212	161	F	122.8	127.3	10.2	9.1	10.2	2.5
114	536	M	124.7	149	16.6	9.9	16.5	4.5
208	178	M	128	132.7	9.6	9.7	11.9	4.5
25	387	M	137.5	151	12.7	12.5	16.8	4.1

NOTE: Includes all recaptures, including 3 that were re-tagged with different numbers: 16262 -> 25, 11 -> 63, and 137 -> 206.

TABLE 4: Percentage change in length and weight for G. cirratum (adjusted to a yearly basis)

TAG NO.	SEX	% CHANGE LENGTH (/year)	% CHANGE WEIGHT (/year)
16262	M	7.3	37.4
51	M	3.8	-
16264	M	6.4	-
20	M	7.2	27.0
54	M	13.4	56.4
65	M	4.0	27.4
206	M	13.4	33.8
114	M	13.3	45.4
208	M	7.5	46.4
25	M	9.2	32.3
33	F	11.9	-
49	F	13.3	-
63	F	11.7	46.2
73	F	9.4	36.8
212	F	8.3	27.5

based upon too few recaptures to permit accurate comparisons to other studies. Future returns of sharks injected with tetracycline will permit more complete comparisons to the results of Gruber and others, as well as provide sufficient data for the use of conventional growth curves for this species.

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