Barb

INVOICE

TO: NOAA, Southeast Fisheries Center
75 Virginia Beach Drive
Miami, Florida 33149-1099
Attention: COTR Fred Berry

FROM: Government of the Virgin Islands
Division of Fish and Wildlife
101 Estate Nazareth
St. Thomas, Virgin Islands 00802
Principal Investigator: Ralf Boulon, Jr.

FOR: Purchase Order No. NA82-GA-A-00044

DESCRIPTION: Obtain new data through capture and tagging of Green and Hawksbill sea turtles in the U.S. Virgin Islands and to correlate this data with prior year data to prepare population estimates, movement patterns, and analysis regarding growth, mortality, and ecological considerations in accordance with the attached, "Population dynamics of Green and Hawksbill turtles in the U.S. Virgin Islands."

This financial assistance award is made utilizing small purchase procurement methods for the administrative convenience of the Government.

AMOUNT: $4,500.00

FINAL CONTRACT REPORT ATTACHED

I hereby certify that I have received the goods or services listed above in good condition and that same are in accordance with specifications.

Signature

Some Notes on the Population Biology of Green (*Chelonia mydas*) and Hawksbill (*Eretmochelys imbricata*) Turtles in the Northern U.S. Virgin Islands: 1981-83

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No. NA82-GA-A-00044

Some notes on the population biology of Green (*Chelonia mydas*) and Hawksbill (*Eretmochelys imbricata*) turtles in the northern U.S. Virgin Islands : 1981-83.

By: Ralf H. Boulon, Jr.

INTRODUCTION

The estimation of growth and population sizes in natural populations of marine turtles have been rarely attempted. One of the first attempts to do this was done by Schmidt (1916) in the Danish West Indies, now the U.S. Virgin Islands. Using silver flipper tags he found that young Green turtles (*C. mydas*) grew faster and were more resident than older turtles. He also notes the observation that turtle populations were drastically diminished due to "wanton destruction" of eggs and turtles.

Population estimates reported in the literature all deal with nesting females as caught on beaches (Richardson, *et al*., 1978; Carr and Caldwell, 1956; Carr, *et al*., 1978; LeBuff and Hagan, 1978). However, our knowledge of natural sex ratios and population age structures make the relation of number of reproductive females to the total number of turtles in the population impossible (Meylan, 1982). Growth data has been a logical consequence of these studies and yet has only related to sexually mature female turtles. Rates of growth under natural conditions are relatively unknown, although estimations have been published (Hirth, 1971).

Turtles grown in captivity have produced most of the known growth rate curves (Witzell, 1980; Caldwell, 1962; Witham and Futch, 1977; Kaufmann, 1975). These studies have indicated that turtles in warm, tropical waters grow faster and reach sexual maturity quicker than turtles grown in cooler, temperate waters.

Studies on immature sea turtles in the wild have been few. Recently, however, studies on the movement, growth and population sizes of immature sea turtles in their developmental habitats have begun in Florida (Mendonca and Ehrhart, 1982), Australia (Limpus, 1979; Limpus and Walter, 1980), and Hawaii (Balazs, 1979).

The objectives of this study were to determine various population parameters of local populations of Green (*C. mydas*) and Hawksbill (*E. imbricata*) turtles in the feeding pastures (*Thallassia testudinum* beds) and coral reefs around the northern U.S. Virgin Islands. Population parameters studied include size frequency, length-weight ratios, growth rates, movement patterns, and population estimates.

METHODS

Turtles were captured under a Federal Endangered and Threatened Species Permit No. PRT 2-6582. Captures were made using a 8.8 m diesel-powered fishing boat and a 394 m long, 9.8 m deep seine net. An area was selected on the basis of surface turtle sightings and depth, and the net was set out to encircle the area. Divers would swim along the net and as turtles swam into it, they would dive down and capture the turtles by hand. The mesh of the net was fine enough (5 cm) that turtles could not become entangled or caught by the net. The net was used as a barrier against which the turtles were herded and captured.

Once turtles were brought on board, various measurements were taken (see sample data sheet, Appendix I). The turtles were then tagged with two Hasco monel cattle ear tags. The large size tags (size 19) were used on turtles greater than 5 kg, and the small size (style 681) were used on turtles less than 5 kg. Tags were attached to the trailing edges of the front flippers. This was done to minimize the possibility of confusion through tag loss. Turtles were then released at the capture site.

Turtles were tagged at various locations around St. Thomas and St. John in the U.S. Virgin Islands (Figure I, Table 1). Subsequent trips were designed to include primarily those

Figure 1: Location of tagging sites for Green and Hawksbill turtles in the U.S. Virgin Islands.

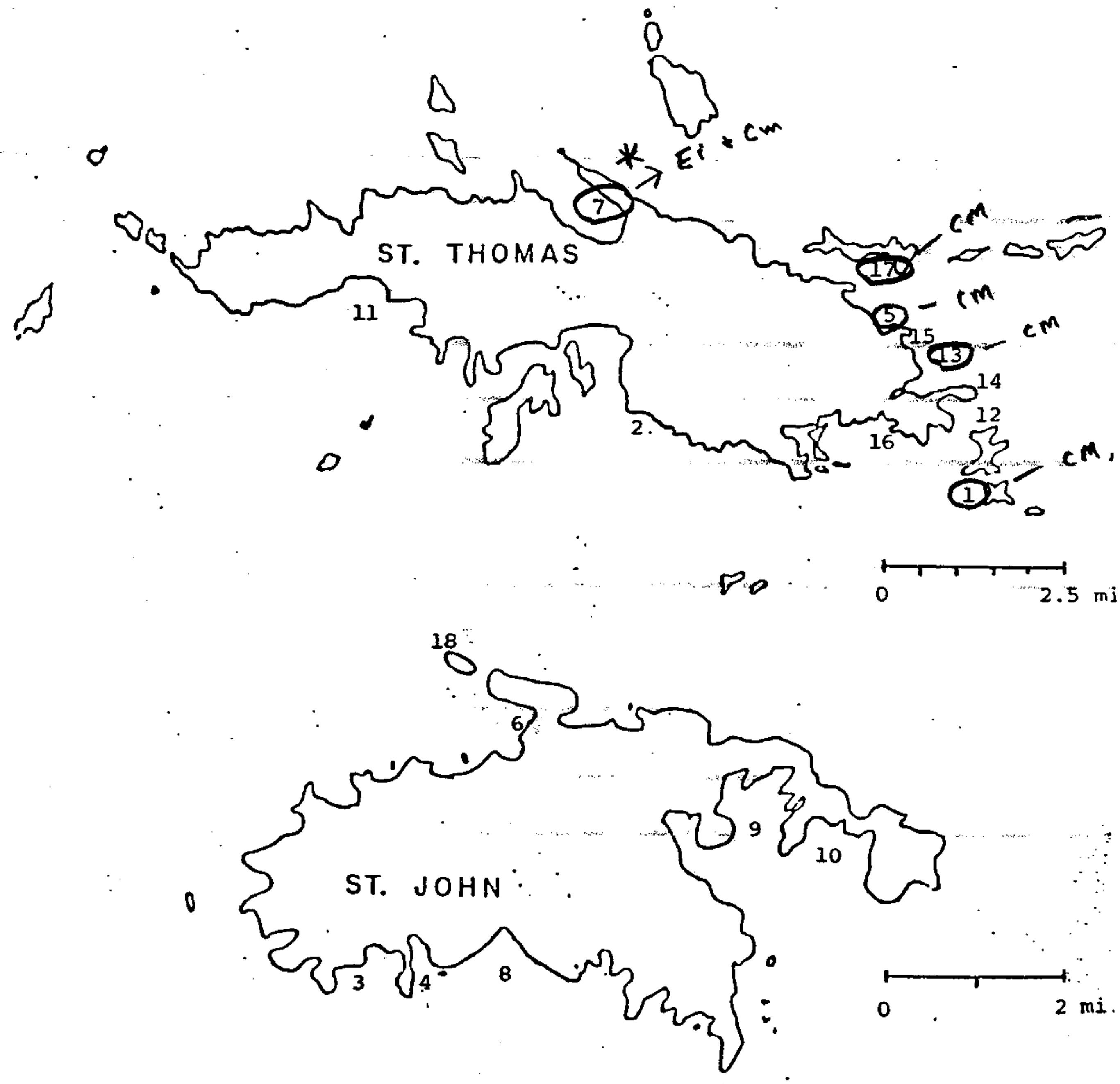


Table 1: Turtle tagging locations in the U.S. Virgin Islands.

# (See Fig. 1)	Location Description
1	Little St. James
2	Frenchman's Bay - St. Thomas
3	Rendezvous Bay & Ditliff Beach - St. John
4	Fish Bay - St. John
5	Smith Bay - St. Thomas
6	Francis Bay - St. John
7	Magens Bay - St. Thomas
8	Reef Bay - St. John
9	Hurricane Hole - St. John
10	Round Bay - St. John
11	Perseverance Bay - St. Thomas
12	Great St. James
13	Red Hook Point - St. Thomas
14	Cabrita Point - St. Thomas
15	Sapphire Bay - St. Thomas
16	Secret Harbour - St. Thomas
17	Thatch Cay
18	Whistling Cay - St. John

areas which were geographically discrete and appeared to have a relatively large population of turtles in order to obtain cost-efficient recapture data. Exploratory trips were occasionally made to new areas to look for other large populations. When an area did not appear to be promising, it was not revisited.

All capture and recapture data were entered and stored on an Apple Plus II computer for ease of data management. Most analyses of the data were carried out using this computer.

RESULTS

A. Capture and Recapture Rates

From the 18 tagging sites around St. Thomas and St. John a total of 178 turtles have been tagged as of July 1983 (Table 2). Of these, 128 were Green turtles and 50 were Hawksbill. Recapture rates range from 23 percent for Greens to 29 percent for Hawksbills. A number of localities in Table 2 were not revisited due to low initial captures giving the site a low potential for cost-effective recapture data to be obtained. Four areas were chosen as optimum sites for continuing to catch untagged turtles and also giving high recapture rates. These were: Magens Bay (34% recapture rates for Hawksbills), Thatch Cay (25% for Greens),

Table 2: Number and species of turtles caught at each site in Figure 1 as of July 1983.

Site #	GREEN # Tagged	GREEN # Recaptured	HAWKSBILL # Tagged	HAWKSBILL # Recaptured
1	33	19	2	0
2	1	0	0	0
3	1	0	1	0
4	1	1	0	0
5	16	9	0	0
6	1	0	0	0
7	31	3	38	20
8	1	0	0	0
9	1	0	0	0
10	1	0	1	0
11	0	0	1	0
12	3	0	0	0
13	11	0	2	0
14	0	0	1	0
15	6	0	1	0
16	0	0	2	0
17	21	7	0	0
18	0	0	1	0
TOTALS	128	39	50	20

Smith Bay (36% for Greens), and Little St. James (36% for Greens. Red Hook was also selected in spite of no recaptures because of the high number of large Green turtles caught there.

B. Size Frequency of Turtles Caught In-water

The size frequency distribution of 128 Green turtles caught during this study indicates that the majority of the local population consists of subadults and juveniles in the 35 to 44 cm carapace length range (mean = 40.4 cm) (Figure 2). The observable lack of large-sized individuals (> 75 cm) in the local populations most likely produces the ill-defined secondary peak near the 70 to 90 cm size class. This peak is characteristic of mature female breeding populations at Tortuguero, Costa Rica, and Ascension Island (Carr and Goodman, 1970). This lack of turtles caught in this size class correlates very well with the lack of any positive nesting evidence by Green turtles in the U.S. Virgin Islands. Sexually mature female Green turtles have been determined to be greater than 80 cm in carapace length (Hirth, 1971). Only one individual approached this size with a carapace length of 78.7 cm and a weight of 70.5 kg.

The small sample size of 49 Hawksbill turtles caught in this study produces a size frequency histogram with no well-defined peaks (Figure 3). The high points on the graph may

Figure 2: Size frequency histogram for Green turtles caught in the U.S. Virgin Islands (N=128).

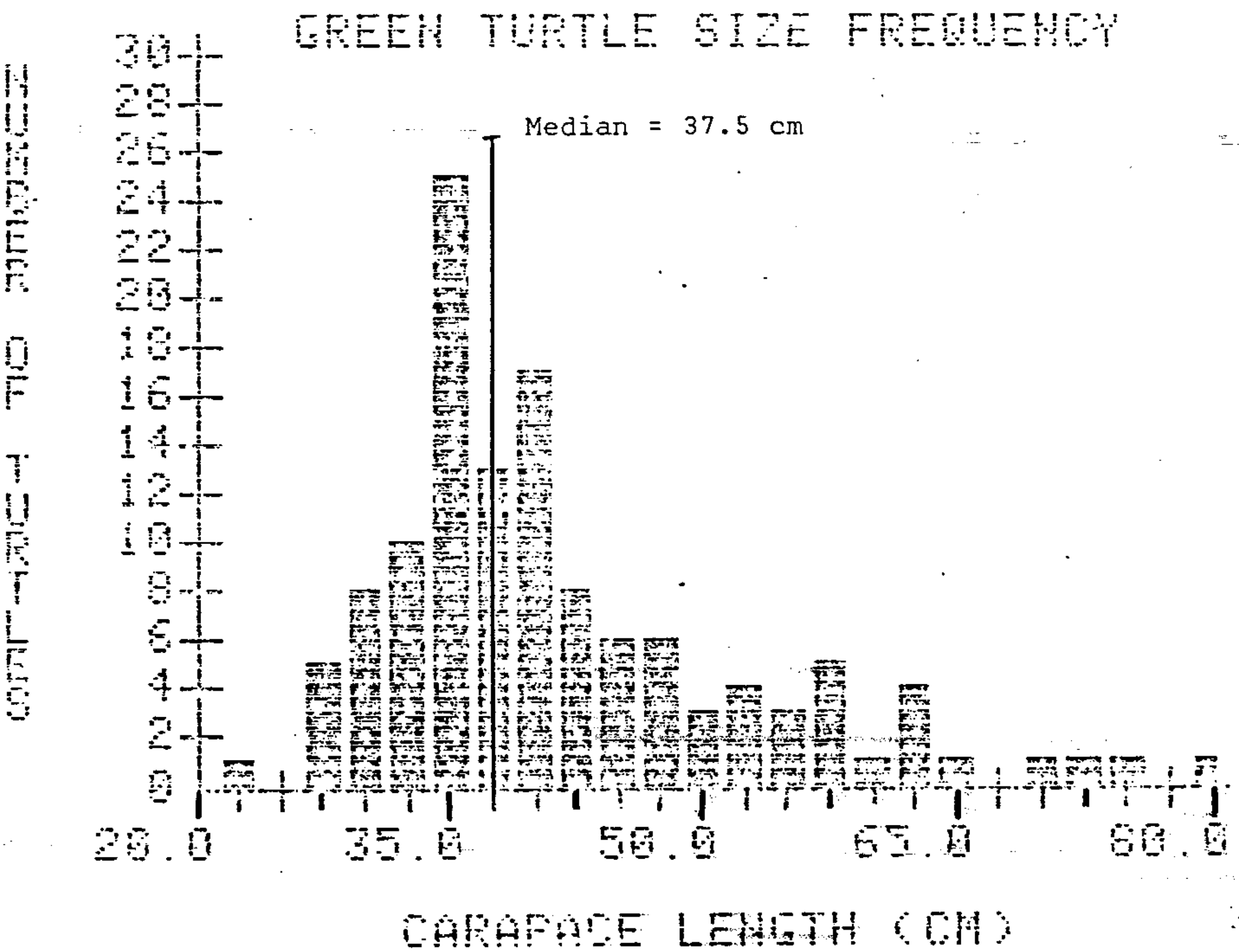
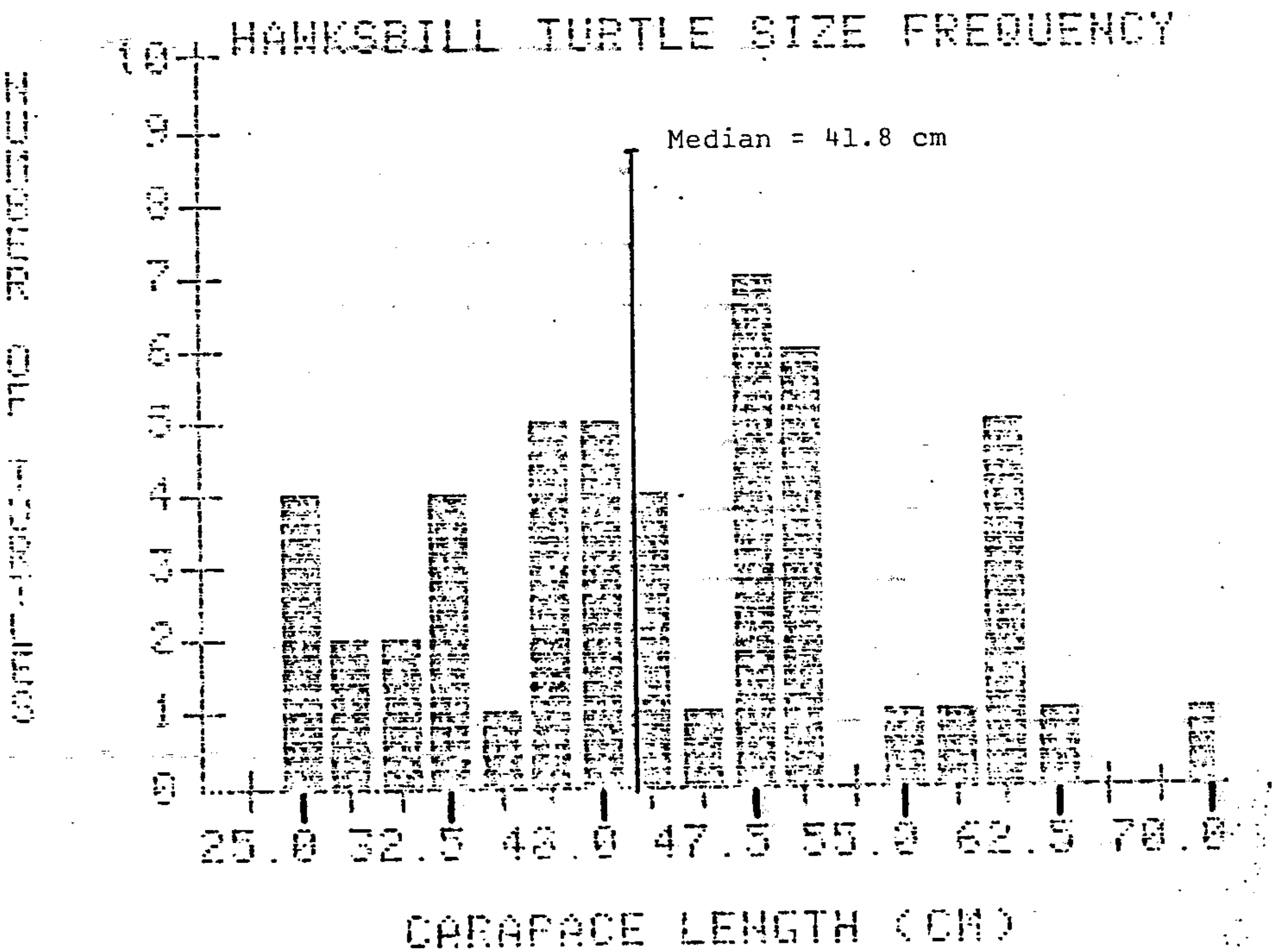


Figure 3: Size frequency histogram for Hawksbill turtles caught in the U.S. Virgin Islands (N=50).



represent different age classes, but no analysis was performed to determine this. Carr, et al. (1966) found mature female Hawksbills in Costa Rica to have a mean carapace length of 83 cm and males of 80 cm. Minimum nesting size for the Costa Rican female population was 75 cm, but some Indian Ocean populations have been found to nest when females are as small as 53 cm (Hirth and Latif, 1980). The only other Atlantic female population studied (Guyana) has a minimum nesting size of 80 cm (Pritchard, 1969). Two Hawksbills found nesting on St. Croix in May 1983 had straight-line carapace lengths of 76 cm (K. Eckert, pers. comm.). This would indicate that all the turtles caught in this study were subadults and not part of the fairly large, local Hawksbill breeding population (Boulon and Olsen, 1982; Small, 1982). The one exception may be a simple individual caught with a carapace length of 68 cm.

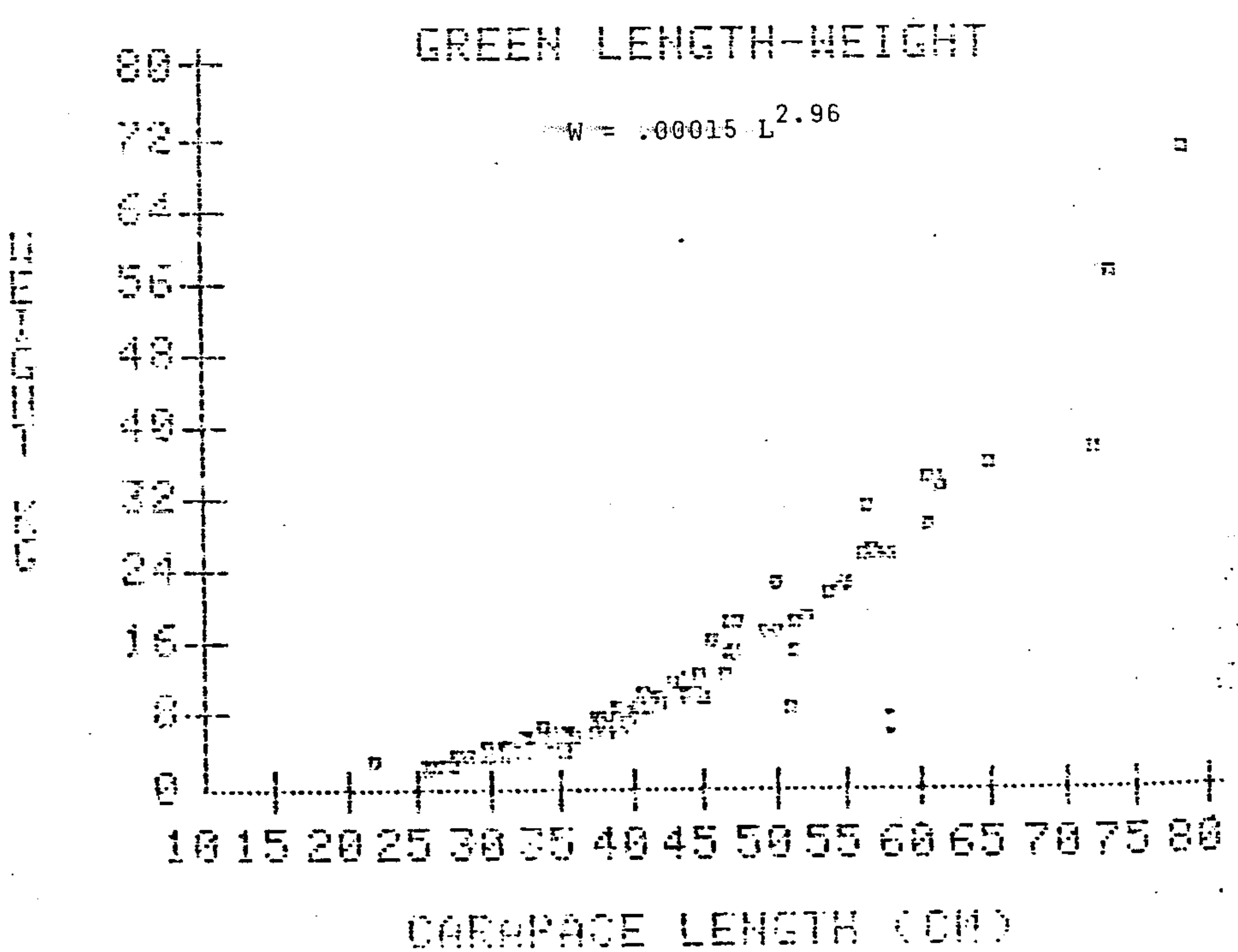
C. Length-Weight

The length-weight relationship for Green turtles is shown in Figure 4. The calculated formula for the log-transformed regression is

$$W = .00015 \, L^{2.96} \qquad 1.$$

where: W is body weight in kg and
L is carapace length in cm

Figure 4: Length-weight relationship for Green turtles caught in the U.S. Virgin Islands (N=128). Lengths are the straight-line carapace measurements at first capture.



This relationship agrees very well with the model proposed by Hirth and Carr (1970), which was based mainly upon turtles caught in the Gulf of Aden feeding pastures.

The length-weight relationship for Hawksbill turtles is shown in Figure 5. The calculated formula for the log-transformed regression is

$$W = .00011\ L^{3.02} \qquad 2.$$

where: W is body weight in kg and
L is carapace length in cm

The differences in equations 1 and 2 are probably related to the differences in carapace shape and body girth between the two species, as mentioned above. The Green turtle also reaches a much greater maximum body weight (230 kg vs. 80 kg) (Pritchard, et al., 1982) and, therefore, would have a less steep curve than the Hawksbill, as shown.

D. Growth Rates

Straight-line carapace growth rates for immature Hawksbill turtles were obtained from 15 recapture intervals ranging from 3.1 to 20.2 months (Table 3). The growth rates ranged from .03 to .66 cm per month with a mean of .28 cm per month.

Figure 5: Length-weight relationship for Hawksbill turtles caught in the U.S. Virgin Islands (N=50). Lengths are the straight-line carapace measurement at first carapace.

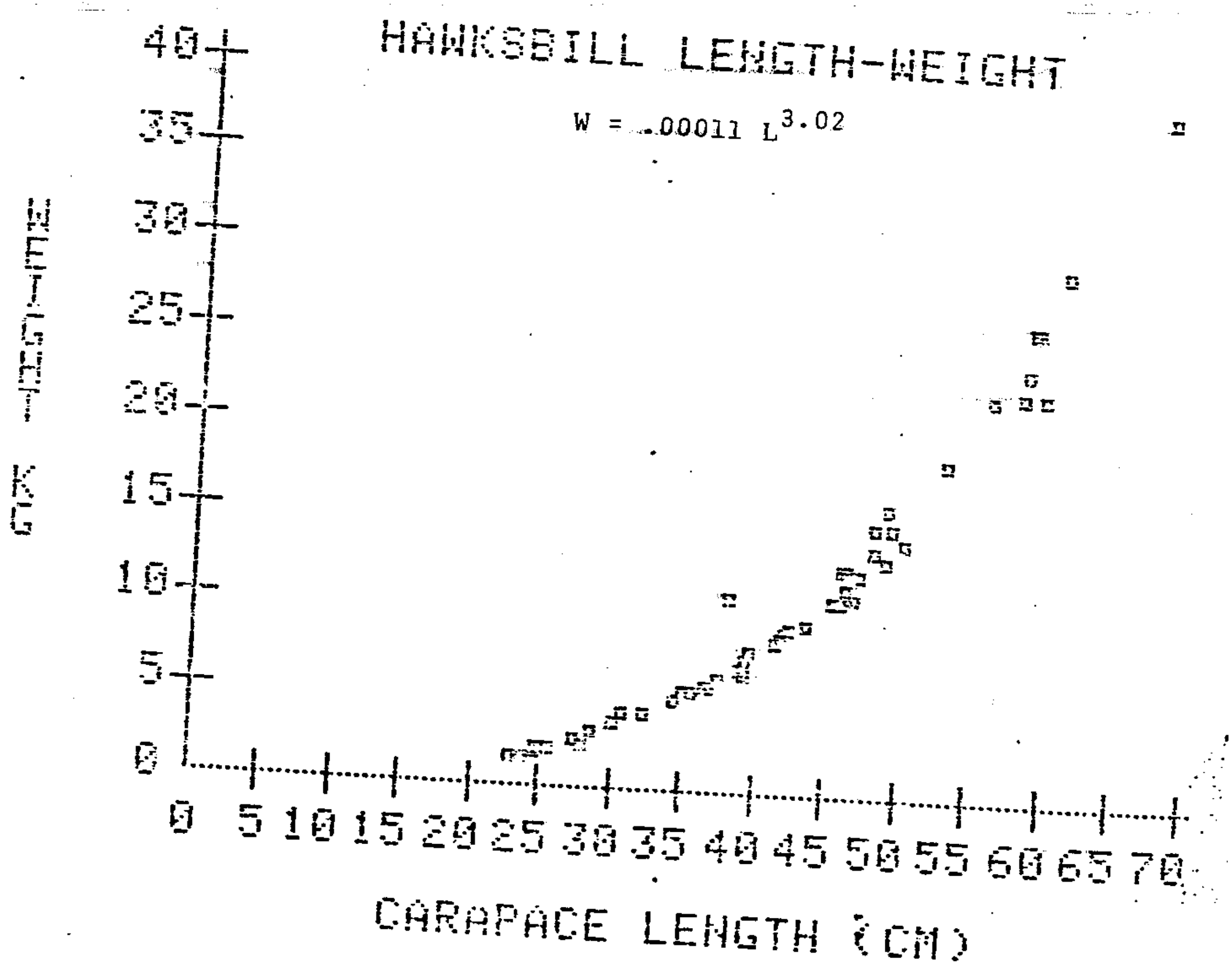


Table 3. Growth rates of immature Hawksbill turtles in the Virgin Islands.

Straight carapace length (cm)	Interval in months	Growth rate (cm per mo.)
46.9	3.1	.10
46.2	3.8	.18
60.7	15.1	.22
36.5	14.9	.40
39.6	20.2	.27
49.0	20.0	.24
58.4	18.6	.08
42.2	3.1	.16
47.1	8.6	.27
49.4	3.9	.03
48.8	13.9	.36
36.0	6.1	.66
40.0	13.9	.50
39.1	3.8	.24
27.4	14.9	.54

Mean growth rate (cm per month) = .28

(N = 15)

Straight-line carapace growth rates for immature Green turtles were obtained from 35 recapture intervals ranging from 1.3 to 16.9 months (Table 4). The growth rates ranged from .13 to .77 cm per month with a mean of .42 cm per month.

E. Population Estimates

Population estimates were computed for five tagging locations using the Schnabel estimating formula

$$N = \frac{\sum_{i=1}^{K} M_i N_i}{\sum_{i=1}^{K} X_i} \qquad 3.$$

where: N_i = number of turtles caught on the i^{th} occasion

X_i = number of turtles caught on the i^{th} occasion which were already tagged

M_i = total number of tagged turtles in the population on the i^{th} occasion

K = total number of sampling occasions

Population estimates for each species in Magens Bay are shown in Table 5. The other four locations have yielded only Green turtles so the estimates given are for the Green populations only. The Red Hook estimate is included because a large number of turtles have been caught there. However,

Table 4. Growth rates of immature Green turtles in the Virgin Islands.

Straight carapace length (cm)	Interval in months	Growth rate (cm per mo.)
29.7	1.6	.38
30.3	7.3	.63
30.7	1.3	.38
31.2	2.2	.45
32.7	7.7	.61
33.7	9.0	.60
39.1	8.7	.40
42.9	13.1	.40
31.2	2.2	.36
32.0	5.5	.31
31.7	2.3	.13
48.5	4.4	.36
35.0	5.2	.19
36.0	7.1	.68
34.0	1.7	.59
43.9	6.9	.16
37.5	5.7	.71
56.9	1.7	.18
35.6	12.6	.48
36.0	2.7	.70
35.7	5.7	.54
38.8	10.1	.39
39.8	3.7	.30
32.6	3.1	.77
51.0	3.9	.38
27.8	6.4	.86
30.0	4.5	.23
31.1	1.9	.21
31.0	16.9	.40
31.2	12.3	.28
32.7	5.3	.28
35.8	3.3	.36
32.0	14.4	.40
31.7	7.5	.40
25.6	3.7	.27

Mean growth rate (cm per month) = .42

(N = 35)

Table 5. Population estimates for selected sites in the U.S. Virgin Islands using the Schnabel estimating formula.

Location	Species	Total Caught	Total Recaptured	Total Tagged	Populatic Estimate
Magens Bay, St. Thomas	Hawksbill	58	20	38	56
Magens Bay, St. Thomas	Green	34	3	31	116
Smith Bay, St. Thomas	Green	25	9	16	20
Little St. James Island	Green	52	19	33	43
Thatch Cay	Green	28	7	21	34
Red Hook, St. Thomas	Green	9	0	9	52

with no recaptures the cumulative estimate is still on the upward part of the curve, whereas the other cumulative estimates have begun to level out and can be considered more accurate.

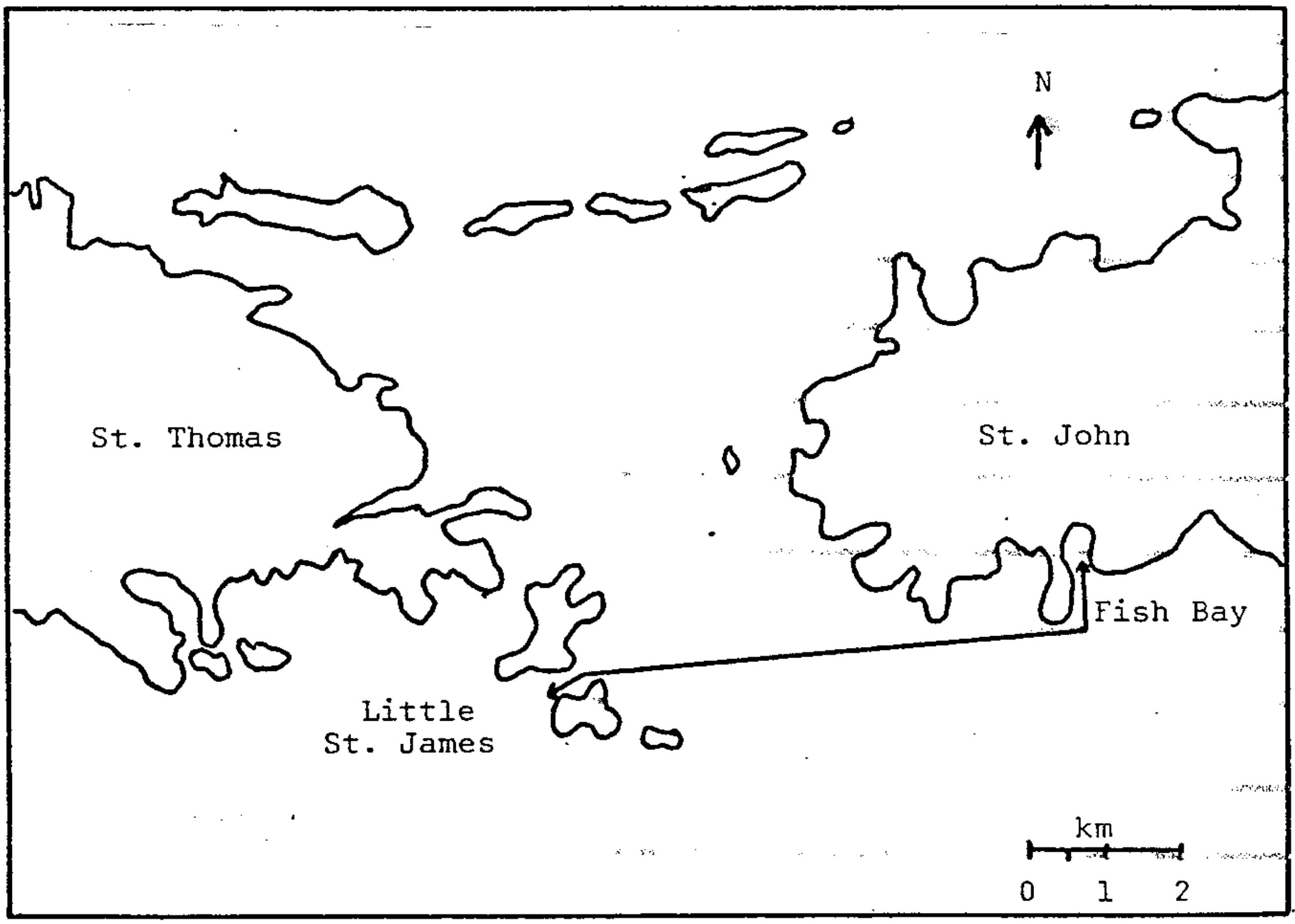
F. Movement Patterns

Recapture data has indicated that both species of turtles sampled remained in the bay where they were first captured with few exceptions. The longest recapture interval (at the site of first capture) is 20.2 months. This was a Hawksbill turtle. The only observed movement patterns have been between Fish Bay on St. John and Little St. James Island off St. Thomas, a distance of 6.5 km (Figure 6). A 5 kg Green turtle was first captured at Little St. James Island, was recaptured at Fish Bay, and then recaptured again back at Little St. James Island over a nine-month period. Another 4 kg Green turtle was captured first at Fish Bay and two months later was recaptured at Little St. James Island.

DISCUSSION

The results of this study indicate that populations of Green and Hawksbill turtles in the Virgin Islands are fairly large and appear to be quite resident with limited population

Figure 6: Map showing movement of tagged immature Green turtles between Fish Bay, St. John and Little St. James Island, St. Thomas.



movement. Nesting records for the northern Virgin Islands (Boulon and Olsen, 1982 and Small, 1982) indicate that nesting by Green turtles is undocumented; however, one recorded nest exists for St. Croix (Seaman and Randall, 1962). Reports of Green turtles nesting where the species identification is based on track width (Towle, *et al.*, 1978) must be treated with skepticism considering the rarity of documented nesting.

If the figures for size at sexual maturity from Caldwell (1962) or Carr (1967) are used, then our study results would indicate that the vast majority of Green turtles in the Virgin Islands are immatures and juveniles. This agrees with the size of turtles sighted on the surface and could explain the lack of nesting in these waters. This was observed earlier this century (Schmidt, 1916) and is explained by Hendrickson (1980) as an ecological strategy of habitat-type resource partitioning. He suggests that *Chelonia mydas* fit into the split-habitat, migratory group were herbivory is seen as integral to this strategy and also allows for resource partitioning by food type with the omnivore, *Eretmochelys imbricata*. By this theory Green turtles would be using the U.S. Virgin Islands as feeding pastures and then migrating elsewhere to breed. An alternate but parallel theory holds that the U.S. Virgin Islands may be a developmental habitat for Green turtles and, therefore, only immatures and subadults would be found here. Evidence from Hawaii (Balazs, 1982) agrees with Virgin Islands observations that residency of Green turtles continues for extended periods and may be permanent except for reproductive migrations undertaken as adults. It would be very enlightening if some of these tagged turtles were found nesting elsewhere in the Caribbean.

The Hawksbill's strategy appears to be that of a coral reef foraging omnivore tied closely to coral reef habitats which supply both nesting and feeding requirements within a small spatial range. This single-habitat, nonmigratory strategy could explain the presence of Hawksbills both in the water and nesting on the beaches of the Virgin Islands. Some turtles were caught during the study of a size that would fall into the sexually mature size range; however, the majority of sightings of large individuals occur in water too deep for capture using nets to be attempted.

Growth rates for immature Virgin Islands Green turtles compares nearly identically with growth rates reported by Schmidt for the Virgin Islands in 1916. His report was .43 cm/mo (N=8) using over-the-curve carapace length and the present study produced a value of .42 cm/mo (N=35) using straight-line carapace length. These values are most likely significantly the same. Balazs (1982) found growth rates for immature Green turtles in Hawaii to range from .08 to .44 cm/mo depending on location. These differences are believed attributable to sources and abundance of acceptable food. The U.S. Virgin Islands have a substantial amount of Thallassia testudinum meadows which is the primary foraging habitat for immature Green turtles in these waters. This abundance of food may account for the relatively high growth rates found here.

Little work appears to have been done on growth rates for wild populations of Hakwsbill turtles. Growth curves have been generated for captive individuals (Witzell, 1980), but must be treated with caution due to apparent inconsistencies with other data sources, primarily with regards to size at sexual maturity of wild turtles.

The growth rates generated by the present study for immature Hawksbills ($\bar{x}$=.28 cm/mo, N=15) are considerably lower than those for the Green turtles and may be related to a primarily carnivorous diet. It is well known that herbivores grow considerably faster than carnivores and generally attain greater body weight as do the Green turtles. Hawksbill turtles feed relatively indiscriminately on benthic invertebrates (Carr and Stancyk, 1975), mainly sponges. The Virgin Islands contain a large number of reef areas which support vast populations of benthic invertebrates. With this plentiful supply of food, immature Hawksbill turtles in the Virgin Islands should be growing at near maximum growth rates for wild populations.

Population estimates given in this study for particular bays and localities are not to be considered final. While our data suggests that little movement exists between capture localities, at least among the non-migratory subadult phase of Greens and Hawksbills, one of the basic assumptions of the Schnabel estimate has not been confirmed. It is not known to what degree immigration/emigration takes place and what effect this will have on the estimate. Continued tagging and monitoring will yield more information on this subject.

We also see in the one locality where the two species were compared that the estimated Green turtle population is higher than the Hawksbill population. If extrapolated out to the rest of the Virgin Islands, this agrees with surface sighting frequencies. However, this suggestion may be somewhat biased in that the majority of sampling was done in Thallassia meadows where the net would not get entangled in coral. Hawksbills were primarily caught when reef areas were sampled. Therefore, comparisons between population estimates for the two species should not be made until equal sampling has been made in each habitat type.

An aerial survey done in 1980-1981 (Boulon and Olsen, 1982) placed Magens Bay at the top of the list in terms of turtle abundance. This correlates very well to what was found through the in-water tag/recapture study and resulting population estimate, where Magens Bay is also at the top of the list. This could lead to an important comparative study which would produce a more cost-effective, less time-intensive method for obtaining turtle population data via aerial survey methods.

Discussions with local fishermen and boaters suggest that turtle population sizes in the U.S. Virgin Islands have been steadily on the rise since 1973 when the Endangered Species Act came into effect. This is based on an increase in surface observations over the years. One noticeable fact that was evident during the recent Western Atlantic Turtle Symposium (7/83) in Costa Rica was that the U.S. Virgin Islands was the only place in the wider Caribbean region to have observably increasing Green and Hawksbill turtle populations. This study, if continued on a long-term basis, may document this phenomenon and provide substantial evidence of the value of endangered species legislation.

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Appendix I: Sample turtle tagging data sheet. Used for both in-water and head-started turtles.

TURTLE DATA RECORD

1. Tag #				
2. Date				
3. Time				
4. Moon Phase				
5. Location				
6. Sea State	Beaufort scale used.			
7. Species				
8. Sex	Determination not attempted.			
9. Carapace Length	Straight line measurement.			
10. Carapace Width	Straight line measurement.			
11. Head Width				
12. Post Vertebral Scale Width	Last neural scute.			
13. Height	Taken at point between 1st & 2nd neural scut			
14. Plastron Length				
15. Weight				
16. Interocular Scale Count	Also called prefrontal scales.			
17. Dorsal Scute L	Also called costal scutes.			
C				
R				
18. Injuries/Scars				
19. Epifauna				
Comments:				

Initials: ____________