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A PRELIMINARY EVALUATION OF THE COMERCIAL SPONGE RESOURCES OF BELIZE WITH REFERENCE TO THE LOCATION OF THE TURNEFFE ISLANDS SPONGE FARM

BY

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SUMMARY OF FINDINGS

Our discovery of concrete disks used for planting sponge cuttings confirms the location of the Turneffe Island sponge farm activities as described by Smith (1941). It is hoped that this information will be useful to the Government of Belize in identifying potentially historic or unique marine resources.

We here also report the occurrence of the velvet sponge, Hippospongia gossypina, at Turneffe Islands. The occurrence of the velvet sponge is particularity worthy of note since a devastating commercial sponge mortality in 1938-39 drastically reduced velvet sponge abundance throughout a portion of its geographic distribution. We observed that the attachment substrate of the Turneffe Islands velvet sponge, mangrove peat, was different than that reported for sheepswool sponge, Hippospongia lachne, and different than the attachment substrate previously reported for velvet sponge.

The quality of the Turneffe Islands velvet sponge is such that it is commercially marketable, but would be less valuable than the sheepswool sponge. The velvet sponge is sufficiently abundant at one location to support commercial fishing activity. However, our survey work was not adequate to establish whether the abundance of velvet sponges was sufficiently extensive to support a sustainable sponge fishery. The lack of more extensive data on abundance and the historical accounts indicating the effects of past sponge disease and fishing pressure on velvet sponge distribution warrant a conservative approach to managing velvet sponges as a commercial fishery resource. Additional survey work will be required to more fully understand the commercial sponge resources of Belize.

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INTRODUCTION

The usefulness of commercial sponges is based on their soft, compressible nature and their ability to absorb and hold water. Sponges from the genera Spongia and Hippospongia have been used for personal bathing and household cleaning for thousands of years. The taking of sponges for commercial purposes was first practiced in the Mediterranean Sea and the sponge fishery was often noted in early Greek literature (Moore, 1951). More recently, commercial sponges have been used in manufacturing pottery and ceramics, and in a variety of applications in surgery, painting, polishing, printing, horse grooming, and professional cleaning services. Synthetic sponges have replaced natural sponges for many of these uses because they are cheaper and more readily available. Today, natural sponges are principally used for bathing (Josupeit, 1991) and the application of cosmetics by people in westernized communities because these people prefer a natural product (Wilkinson, unpub. mans.). Although synthetic sponges are less expensive, they cannot equal the softness and absorbency of natural sponges, and, importantly, natural sponges can be more easily and thoroughly cleaned due to the truly porous nature of the sponge skeleton.

Until the 1840's the world's sponge supply was derived solely from the waters of the Mediterranean. However, the discovery of quality commercial sponges in the Bahamas and Florida Keys led to the rapid development of sponge fisheries in Caribbean and Gulf of Mexico waters. During the early part of the 20th century (1900 - 1940's) the commercial sponge fishery was the most economically important fishery in Florida, U.S.A. (Stevely, et al., 1978). Cuba produced 440,000 lb (198,000 kg) of sponges, the Bahamas 670,000 (302,000 kg), while U.S. production totaled 610,000 lb (275,000 kg) (Moore, 1951). The large-scale attempts to culture sponges in the Bahamas (Storr, 1964), Belize (Smith, 1939) and Florida (Moore, 1910a; Shubow, 1969) further attest to the importance of sponges as a fishery resource during this period.

A sponge disease swept through the Caribbean and Gulf of Mexico in 1938-39 and dramatically reduced commercial sponge abundance. The decline in supply caused by the disease and the outbreak of World War II, which curtailed production in the Mediterranean, resulted in dramatically higher prices. Although production in Florida declined precipitously in the 1940's, rapidly escalating prices were sufficient to increase fishing effort and actually increase the total value of the fishery. The result was increased fishing effort at a time when fishing effort probably should have been curtailed to allow the commercial sponge populations to recover (Storr, 1964). The Florida commercial sponge grounds were depleted to the point of causing the virtual economic extinction of the fishery and many years were required for commercial sponges to increase to abundances that approached those found before the sponge disease epidemic. The effects of the sponge blight were similar throughout the Caribbean. The cause of the disease has been confused somewhat by the presence of bacteria including symbionts, that live in close association with sponge tissue (Lauckner, 1980).

Although the Caribbean sponge disease and introduction of synthetic sponges in the post World War II era has resulted in reducing the world sponge trade to a fraction of its former importance, a significant sponge trade still exists. Prior to WW II (1927-1936), world sponge production annually averaged 1,346.1 MT, and in more

recent times (1977-1986) it has annually averaged 222.1 MT (Josupeit, 1991). The world's supply of bath sponges comes from the lesser-developed countries of the Mediterranean and Caribbean: Tunisia (48%), Greece (17%) and Cuba (26%) are the principal suppliers. Countries importing the largest volume of natural sponges are France (37%), USA (26%), Japan (10%), and Italy (9%) (Josupeit, 1991). In terms of the quantity landed by weight, most fishery managers would consider the world sponge fishery to be insignificant. However, it must be noted that the highest grade of commercial sponge can command a price of over U.S. $50.00/lb ($110.00/kg) in the export market.

Currently, market demand for natural sponges is such that the opportunity exists for expanded production from the Caribbean and Gulf of Mexico. A decline in commercial sponge abundance caused by disease (Gaino and Pronzato), 1989), and pollution and overfishing (Verdenal and Verdenal, 1986) has significantly reduced the supply of Mediterranean sponges. Reduced supply has resulted in higher commercial sponge prices and focused attention on increasing sponge production on other areas of the world. For example, Josupeit (1991) reported that, in France, the reduced sponge supply, as well as a general trend for increased use of natural products, resulted in retail sponge prices doubling and even trebling. During 1988, Florida sponge prices more than doubled and fishing effort and production significantly increased (Stevely, pers. obs.). Although Florida sponge prices have stabilized below the peak prices of 1988, they are still substantially higher than pre-1988 prices.

Increased market demand and the consequent higher prices for Caribbean sponges has resulted in a need to carefully assess sponge fishery potential and fishery management needs throughout the region. The objectives of this project were to (1) evaluate the fishery potential for harvesting commercial sponges in the marine waters of Belize, (2) provide the Belizean Fisheries Unit with information pertinent to management of a commercial sponge fishery, and, (3) establish the location of the historic Turneffe Islands commercial sponge farm before its location was lost to posterity in general, and to the fisheries heritage of Belize in particular. Project funding was provided by the Smithsonian Institution's Caribbean Coral Reef Ecosystem Program (CCRE Contribution No. 402).

METHODS AND MATERIALS

Field surveys to determine the distributions and abundance of commerical sponges were conducted from 14 May to 30 May, 1989. These surveys were performed using dive mask, snorkel and fins. To cover large areas, a diver was towed by boat for 30 to 90 minutes. Three locations were surveyed (Figure 1): Carrie Bow Cay, Ambergris Cay, and Turneffe Islands. The maximum and minimum diameters of commercial sponges were measured with a pair of large calipers. Field notes on duration of tow and habitat type were recorded. Plans to collect commercial sponge abundance within quantifiable transect lines had to be aborted due to inclement weather and contractual problems with a local fishing guide.

Surveys at Carrie Bow Cay, capitalizing on the Smithsonian Institute facilities there, were conducted to field-test survey procedures, and collect information on the distribution of commercial sponges in the vicinity of the barrier reef and associated

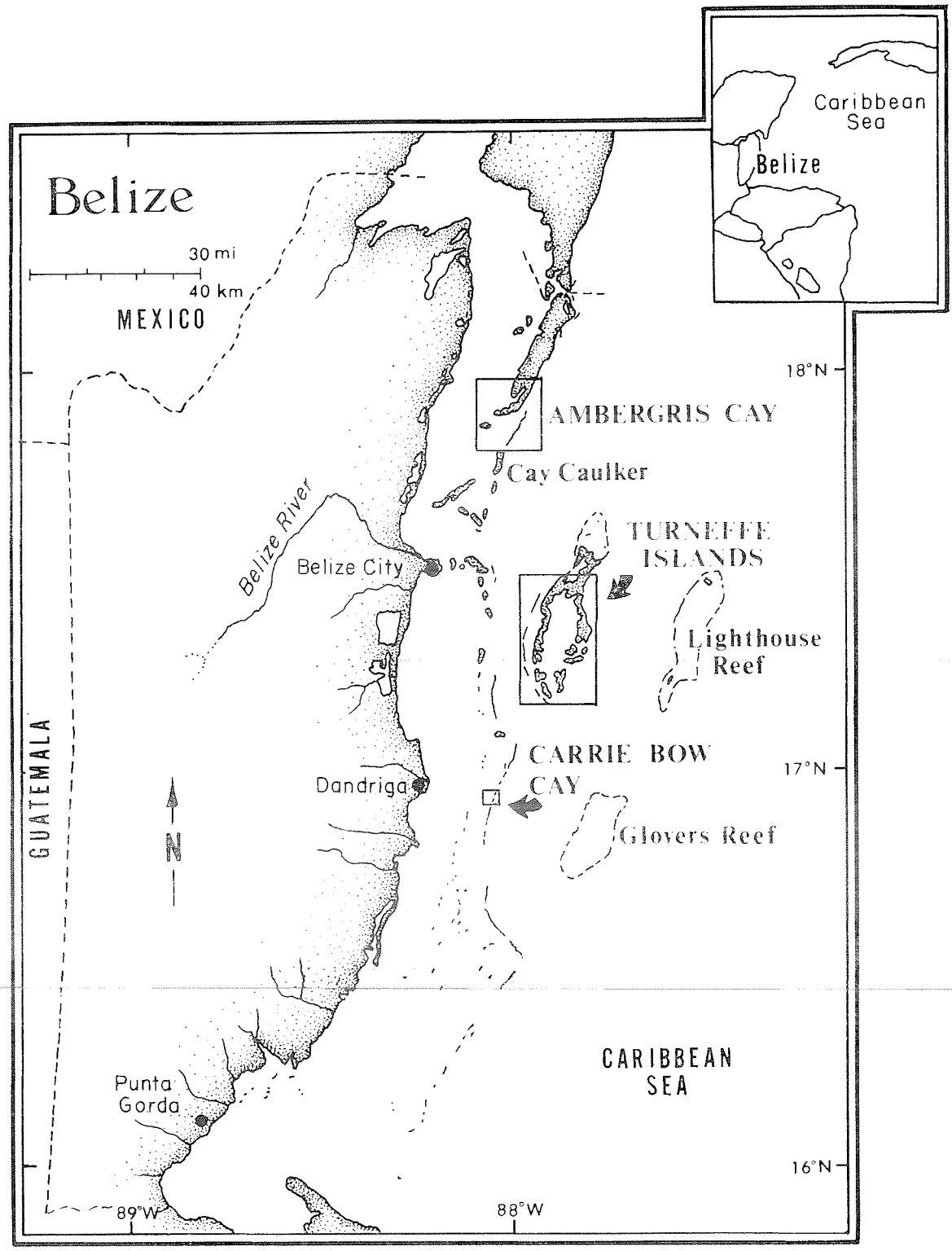

Figure 1. Location of commercial sponge survey sites (Carrie Bow Cay, Ambergris Cay, and Turneffe Islands).

habitats. Ambergris Cay was chosen as a survey site because anecdotal observations suggested that commercial sponges could be found there and because a fishery cooperative was located at San Pedro. Turneffe Island was selected as a survey area because it was the reputed site of a large scale sponge farm in the 1930's and interviews with fishermen indicated that Turneffe Islands was the most likely area where commercial sponges could be found. To assist with the Turneffe Islands field work, the services of two fishermen were contracted, one of which was old enough to have personal knowledge of the sponge farm location. Fisheries Unit personnel, commercial fishermen and fishing guides were interviewed to obtain information prior to conducting the field work in each area.

RESULTS

A total of 19 locations were surveyed by either towing a diver or by having the boat follow 2 divers. These surveys represent a total of 24 hours of underwater observations.

Distribution and Abundance of Commercial Sponges

Carrie Bow Cay

No commercial sponges of the genera Spongia and Hippospongia were found. Habitats surveyed included: seagrass beds surrounding Twin Cayes (occasional loggerhead sponges, Spheciospongia vesparium, were seen), seagrass beds west of South Water Cay, Barrier Reef sand/rubble zone, and Barrier Reef habitat accessible by snorkeling from South Water Cay through South Water Cut (Figure 2). Strong winds precluded surveying exposed areas, and, by necessity, surveys had to be conducted in nearby protected locations. The inability to travel appreciable distances limited the thoroughness of the survey. In general, the Carrie Bow Cay vicinity did not appear to be a productive area for commercial sponges. However, one of the authors (Stevely) has observed the presence of the reef sponge (Spongia obliqua) in patch reef areas located between the mainland and barrier reef during field work on a different project. The reef sponge is generally not considered to be of sufficient quality to support commercial harvest.

Ambergris Cay

No commercial sponges were found. Based on conversations with local fishing guides, five potential sponge habitat areas in the vicinity of Ambergris Cay were surveyed. These included: north of San Pedro, south of San Pedro, offshore of Laguna de Boca Ciega, seagrass beds near Congrejo Cay, and Cayo Romero (Figure 3). Survey sites north of San Pedro, south of San Pedro, and offshore of Laguna de Boca Ciega were "hard bottom" habitats with numerous "loggerhead" sponges (Spheciospongia vesparium), and represented habitat in which commercial sponges are sometimes found in Florida.

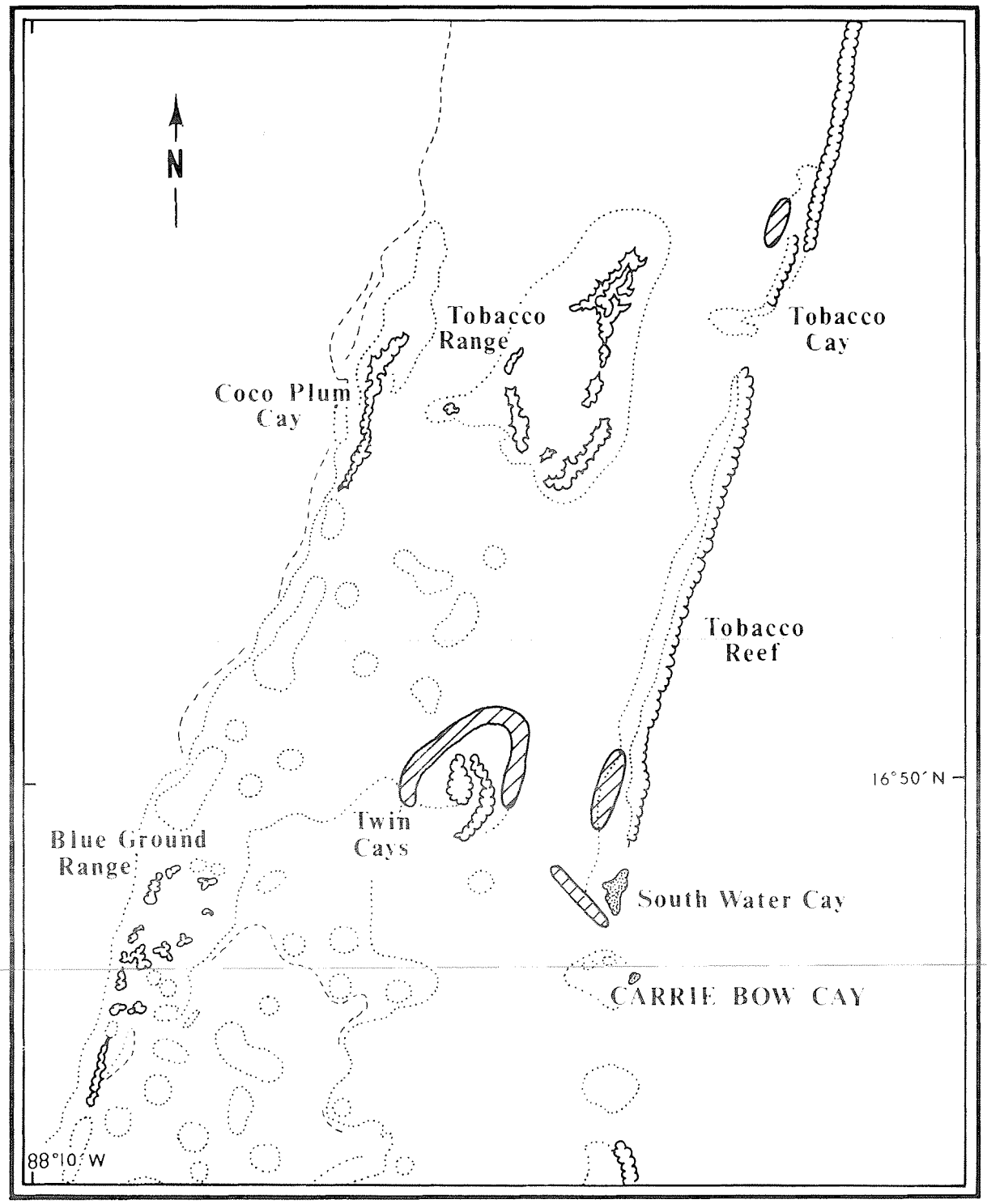

Figure 2. Carrie Bow Cay commercial sponge survey sites.

Key: = survey site

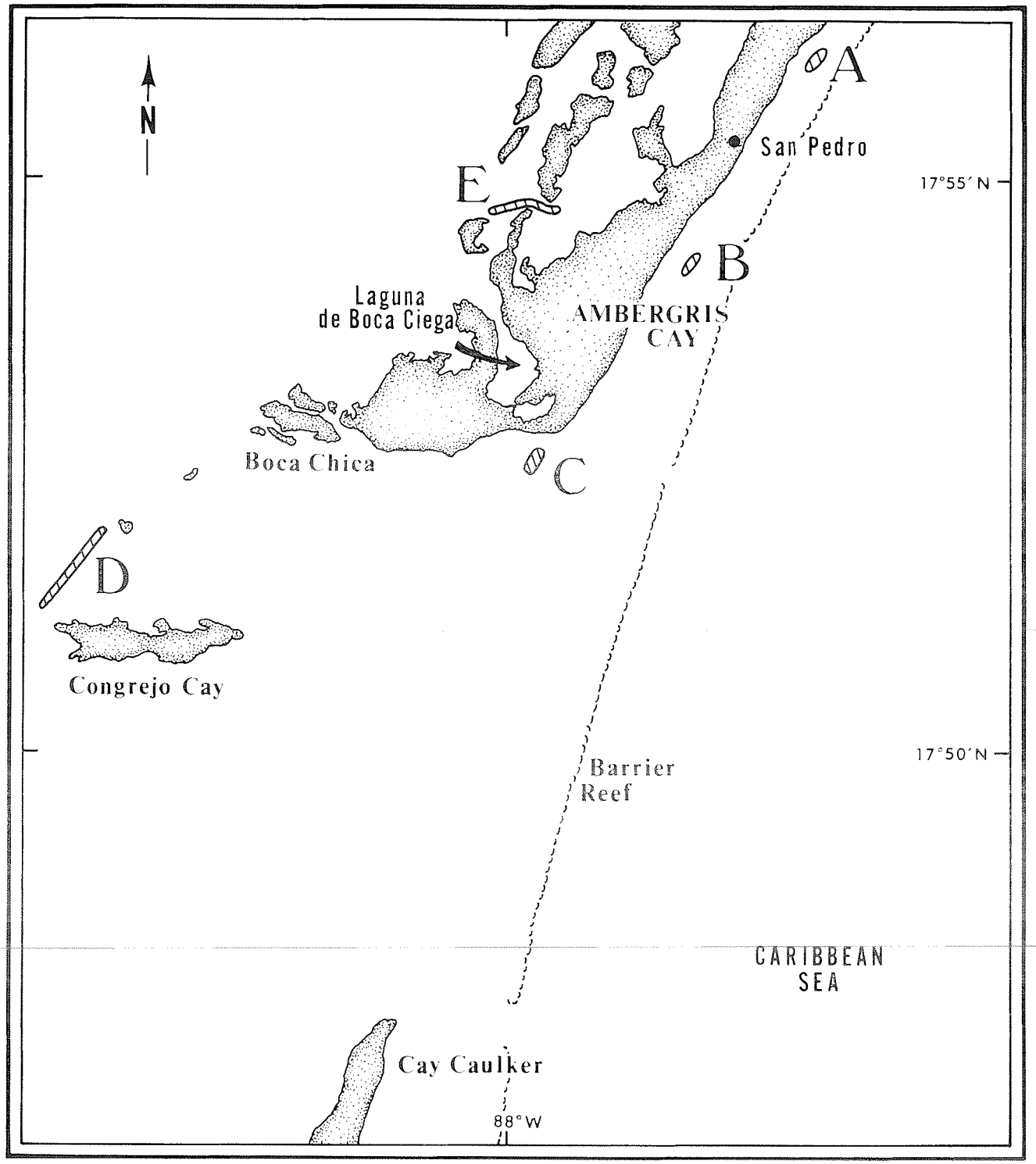

Figure 3. Ambergris Cay survey sites. A - north of San Pedro, B - south of San Pedro, C - offshore of Laguna de Boca Ciega, D - seagrass beds near Congrejo Cay, E - Cayo Romero.

Key: = survey site

Turneffe Island

A total of 9 areas within the Turneffe Islands lagoon were surveyed, but velvet sponges, Hippospongia gossypina, were found only in one location, the "Crooked Creek" area (Figure 4). Velvet sponges were abundant in water 3-6 ft (1-2 m) deep, 400-500 ft (400-500 m) north of the Crooked Creek entrance into the Turneffe Islands lagoon (a tidal cut between mangrove islands). Ircinia sp. and Spheciospongia vesparium, were also present at this location. Additional field observations made on October 19, 1991, as part of a different survey project, documented the presence of velvet sponges in other areas within the Turneffe Island lagoon. These areas included: the eastern shoreline of Soldier Bight and shallow waters near mangrove islands and mangrove shoreline in the vicinity of the western opening of Grand Bogue Creek into the main lagoonal area. The October 19th, 1991 observations did not include measuring the sponges or recording quantifiable data on whether the sponges were attached to the substrate.

Data on maximum and minimum sponge diameter and type of attachment to the substrate was recorded for a total of 15 velvet sponges (Table 1). The velvet sponges were growing on a mangrove/seagrass peat substrate. A considerable percentage of these sponges had broken free from their attachment to the substrate, with only 53% found growing attached to the substrate.

A species of Spongia, probably a variety of sponge that would commonly be referred to as "yellow sponge" in the commercial trade (Spongia barbara, sensu de Laubenfels and Storr, 1958), was found in patch reef habitat to the west of Douglas Cay (outside the lagoon environment). This sponge did not appear to have significant value for commercial trade. Unfortunately, the collected specimens were lost in the process of having the specimens shipped.

Evaluation of Commercial Sponge Fishery Potential

A commercially valuable grade of velvet sponge (Hippospongia gossypina) was found at Turneffe Islands (Figure 5). After evaluating a sample of 13 Turneffe Island sponges, tarpon Springs, Florida sponge buyers indicated that they would pay US $2.00-3.00 per sponge. The velvet sponge quality was such that it would be considered to be somewhat inferior to the sheepswool sponge (Hippospongia lachne), but would have a market value greater than that of other commercial sponge varieties. Velvet sponges tear more easily than sheepswool sponges, partially because of the characteristic presence of large pseudoscula or vents on the upper surface (Moore, 1910b).

Based on our experience with sponge fisheries in Florida and the Bahamas, we estimate that the value and quantity of sponges at Turneffe Islands were sufficient to support sponge fishing activities. Field observations indicated that it would not be unreasonable for a 2-man fishing team to produce in excess of 100 sponges per day. For example, we collected 15 sponges in 1 hour, and this included time taken to measure each sponge and record data. However, there are several important factors and limitations which must be considered before the fishery potential can be properly evaluated. These are considered in detail in the following discussion section.

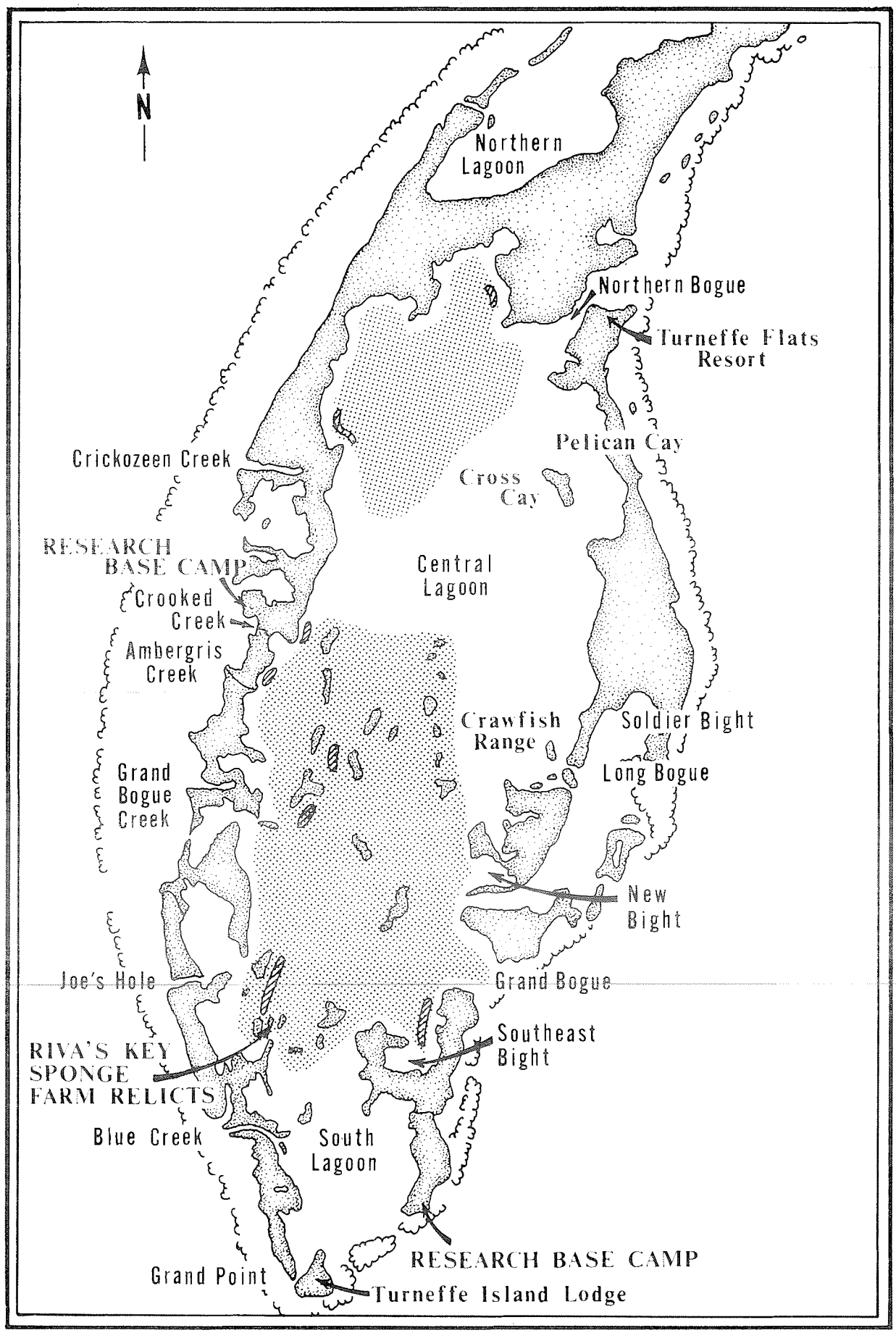

Figure 4. Turneffe Islands survey sites and approximate location of the sponge farming area (stipled area).

Table 1. Maximum and minimum sponge diameters and category of attachment to the substrate for 15 velvet sponges (Hippospongia gossypina) collected at Turneffe Islands, Belize, May 24, 1989.

Maximum Diameter in (cm)	Minimum Diameter in (cm)	Attachment to Substrate
10.8 (27)	9.6 (24)	Attached
11.2 (28)	10.8 (27)	Unattached
10.8 (27)	8.8 (22)	Attached
11.2 (28)	11.2 (28)	Unattached
7.2 (18)	6.8 (17)	Attached
12.8 (32)	12.4 (31)	Attached
13.2 (33)	12.4 (31)	Unattached
13.6 (34)	13.2 (33)	Unattached
12.8 (32)	12.0 (30)	Unattached
12.0 (30)	11.6 (29)	Attached
15.6 (39)	10.0 (25)	Unattached
10.0 (25)	8.8 (22)	Unattached
8.0 (20)	6.4 (16)	Attached
6.8 (17)	6.8 (17)	Attached
3.6 (9)	3.6 (9)	Attached
Mean Diameter	Maximum 10.6 (27)	Minimum 9.6 (24)	Percent Attached 53%

Location of the commercial sponge farm

Information provided by local fishermen (Mr. Joseph Garbutt, Mr. Carl Carbal) indicated the approximate location of sponge planting areas in the Turneffe Islands lagoon (Figure 4). The approximate location of the sponge planting area in the southern portion of the lagoon was verified by finding the concrete disks used to "plant" sponges (Figure 6) on the western side of Riva's Cay, approximately 200 m south of the northern tip of the island (Figure 4). The disks found along the mangrove shorline and in the water immediately adjacent to the shoreline. This site marked the location where sponge farm workers docked a live-aboard boat. No navigation charts that located Rivas Cay could be found. However, the approximate location, as determined by triangulation on the open water is shown in Figure 4. Smith (1941) did not describe the precise location of the sponge farm but his figure showing the

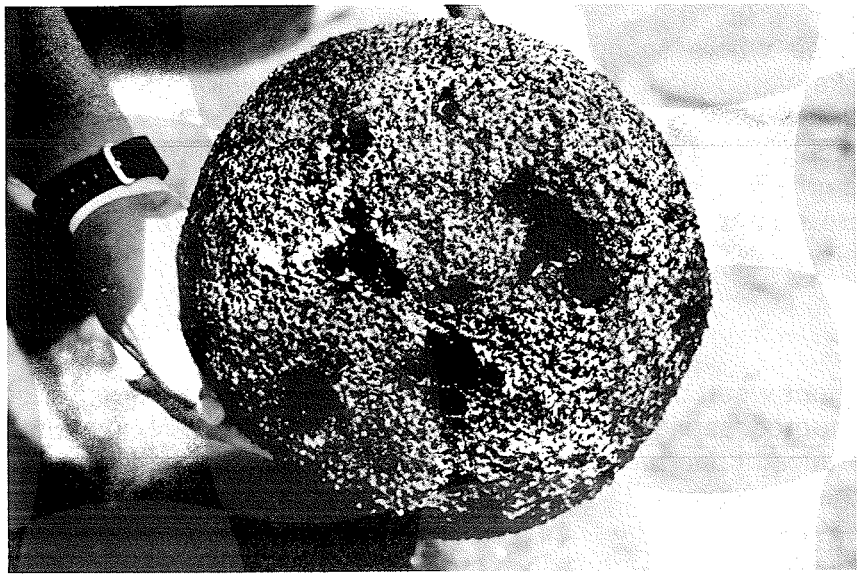

Figure 5. Live velvet sponge (Hippospongia gossypina) removed from water. Note pseudoscula described by Moore, 1910b.

Figure 6. Concrete disks used to "plant" sponge cuttings at the Turneffe Islands sponge farm.

progression of sponge disease throughout the large planting areas is consistent with our location of the sponge planting areas.

The area where sponges were planted was extensively surveyed, but no concrete disks were found. Wood stakes were found which the local guide (Joseph Garbutt) claimed were marking the sponge planting area. These wood stakes were obviously much older than stakes used to mark lobster traps (they were covered with an extensive growth of fire coral). Although all of Mr. Garbutt's comments during the expedition proved to be accurate, the verification of these stakes as artifacts from the sponge farm was impossible.

DISCUSSION

Inclement weather (sustained 25-30 mph winds) and failure of a local guide to provide contracted services (a new Turneffe Islands expedition team had to be organized) reduced opportunities to conduct more extensive surveys. These factors prevented the collection of quantitative data on sponge density and population structure. However, two significant goals were realized: useful ecological and fishery information was collected on the velvet sponge, Hippospongia gossypina, in the marine waters of Belize and the location of the Turneffe Islands sponge farm was documented. These observations increase the information available for understanding and managing the marine biological and fishery resources of Belize.

Distribution and Abundance of Commercial Sponges

Within the Turneffe Island lagoon (the only location where commercially valuable sponges were found), velvet sponge were found growing on a mangrove peat substrate. Although the mangrove peat provides a substrate for sponge attachment (Figure 7), it crumbles easily and is sufficiently soft to allow the establishment of the seagrass Thallassia testudinum. Our observations indicate that, although this substrate is adequate for the attachment of sponges, many of the sponges eventually break loose (Table 1). Sponges that break loose from the substrate but continue to survive and grow are commonly called "rollers" in the commercial trade (Figure 8). The percentage of rollers was much higher than the percentage observed in the Florida commercial sponge harvest (Stevely, pers. obs). The occurrence of commercial sponge growing on a non-rock substrate was a new observation for us. In our extensive field observations in both the Gulf of Mexico and the Bahamas, we have found commercial sponge species (Hippospongia and Spongia growing either attached to rock outcroppings or to any suitable hard surface (coral/rock fragments, gorgonians, etc). De Laubenfels (1948) reported that sheepswool and velvet sponge were common on these substrates, often in precisely the same localities.

Although the previously noted additional field observations taken on October 19, 1991 were extremely cursory, they did confirm the observation that the velvet sponge was found growing on mangrove peat/seagrass substrate. Also, there was a general impression that the percentage of "roller" sponges varied considerably from site to site. In some areas it seemed that most sponges were found growing attached to the substrate. In the Soldier Bight area it appeared as if almost all the velvet sponges were rollers and that they had accumulated along the eastern shoreline as a result of

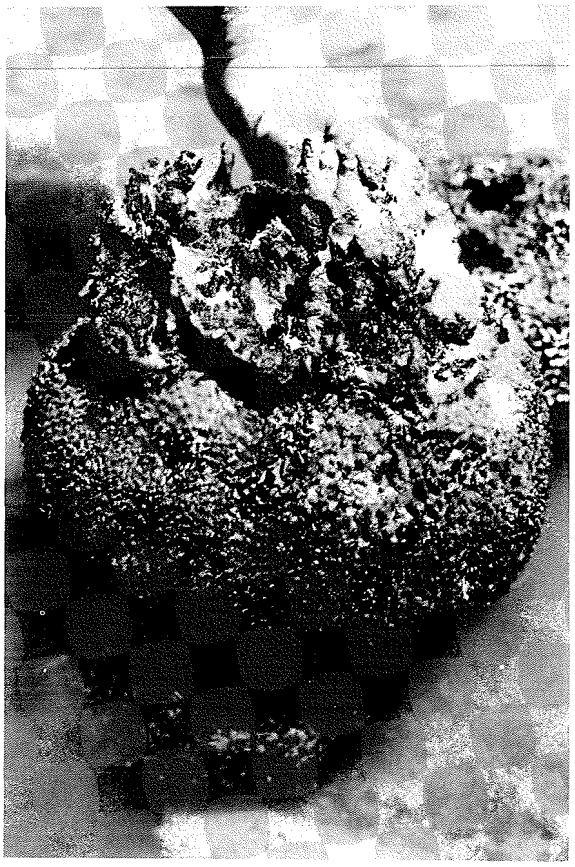

Figure 7. Live velvet sponge (Hippospongia gossypina) removed from water to show growth habit of attachment to mangrove peat substrate.

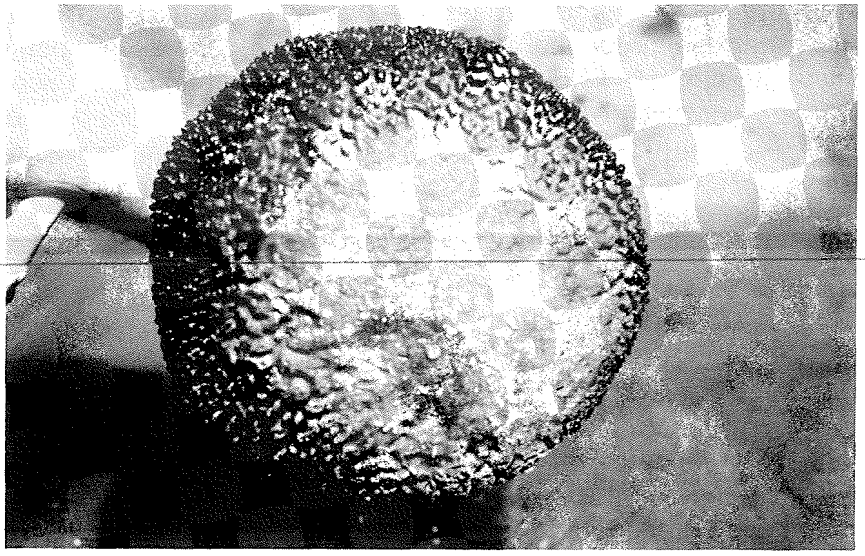

Figure 8. Live velvet sponge (Hippospongia gossypina) removed from water to show growth habit of "roller sponge". Former point of attachment to substrate is now covered by ectosome.

tidal and/or wind driven currents. However, these observations need to be verified by more detailed field work.

Smith (1941), in describing the Turneffe Islands lagoon sediments, stated that "the floor of the lagoon consists of calcarious mud, with admixed shell and coral sand predominate near the eastern entrances, and with organic matter formed from the detritus of eel-grass and mangrove roots present in varying degree throughout the lagoon". Mangrove/seagrass peat substrate was observed in several areas in the Crooked Creek and Chickozeen vicinity. The depth of the mangrove peat appeared to be considerable. On one occasion crevices were seen in the mangrove peat which extended 6-8 ft (2-2.5 m) in depth. Observations made while snorkeling Crooked Creek (a channel between mangrove islands carved boy tidal currents) indicate the depth of the mangrove peat deposits extended to at least 30 ft (10 m). These observations suggest that the Turneffe Islands represent an atoll formation consisting of mangrove peat and suggest that mangrove peat formation has kept pace with seamount subsidence/and or sea level rise.

Prior to the 1938-39 sponge mortality, the velvet sponge was known for its commercial value and was considered to be the most valuable commercial sponge after the sheepswool sponge (Moore, 1910b). Although it was considered to be less compressible, absorbent, and durable compared to the sheepswool sponge, velvet sponges from some area (e.g., the Bahamas) were regarded as almost equivalent in quality to the sheepswool sponge.

Moore (1910b) reported the velvet sponges were found in the straits of Florida, the Caribbean Sea, and the Bahamas. De Laubenfels and Storr (1958) stated that velvet sponges had been common around Florida and the west Indies. In Florida, velvet sponge was harvested from the fishing grounds between Key West and Cape Florida (Moore, 1910b) in living coral areas at depths of 3-25 ft (1-8 m) (Storr, 1964). Florida sponge fishermen produced 8,000 lb (3,600 m) of velvet sponge in 1899 (Moore, 1910b). Although velvet sponges were sufficiently abundant to sometimes be reported in Florida commercial sponge landings, they were the least abundant of the commercial sponges (Smith, 1898). The best quality of velvet sponge was regarded to be from the Bahamas (Moore, 1910b), and at one time it was the principal commercial sponge of the Bahamas (de Laubenfels and Storr, 1958). Moore (1910b) noted some commercial sponge production from the British Honduras, including velvet sponge. Moore also reported that sheepswool, velvet and grass sponges (Spongia sp.) were found along the entire coast of British Honduras, in the shallow waters about the numerous islands, rocks, and banks, and that many commercial sponge varieties grow "attached to staghorn corals and gorogonians". No mention was made of either sponges at Turneffe Islands or velvet sponges found growing attached to mangrove peat substrate. Cresswell (1935) mentioned an effort by commercial sponge fishermen in 1895 to explore the waters of British Honduras and reported that velvet sponge was the most common sponge harvested.

After the devastating sponge mortality, the velvet sponge was thought to be essentially extinct in areas that had been known to produce commercial quantities, although many years later a few were reported from Cuba (de Laubenfels and Storr, 1958; Storr 1964). An extensive survey of the Florida sponge grounds in 1947 and 1948

was conducted to evaluate the condition of the sponge grounds following the effects of the sponge disease and overfishing during the early 1940's. The resulting fishery report did not report the occurrence of any velvet sponge (Dawson and Smith, 1953). However, later taxonomic study of the sponges collected during the survey reported a velvet sponge specimen collected from a station in the northern Gulf of Mexico (de Laubenfels, 1953). Storr (1964) stated that the velvet sponge had not been reported in the Bahamas since the disease. In 1975 a report on the Bahamian sponge fishery indicated that the fishery was based on the harvest of sheepswool and grass sponge and contained no reference to velvet sponge (Thompson, unpubls. mans.). Wiedenmayer (1977) surveyed the shallow-water sponges of the western Bahamas and reported eighty-two sponge species, including 3 commercial species of the genus Spongia but no velvet sponge (his study was not intended as a survey of commercial varieties). Repeated communication with Florida sponge fishermen and sponge buyers has failed to indicate even the rare occurrence of the velvet sponge. The effects of disease and overfishing were apparently sufficiently severe to drastically reduce velvet sponge abundance throughout a major portion of its geographic range. In view of the long-term change in distribution and abundance of the velvet sponge and a lack of knowledge of its current distribution, the apparently healthy population at Turneffe Islands is worthy of note to fishery managers and scientists.

The Turneffe Island's velvet sponge population may represent a relatively small genetically isolated population. Storr (1964) indicated that the sheepswool sponge (Hippospongia lachne) larval state is short-lived (1-2 days) and does not have strong swimming capabilities. The Turneffe Islands atoll is separated from other shallow water habitats by waters at least 250 fathoms in depth. Prevailing surface current patterns (Hartshorn et al., 1984: Figure 9, this report) support the idea that larval recruitment (i.e., genetic exchange) may be limited between Turneffe Islands and other shallow water Caribbean sponge populations. If the prevailing surface currents depicted in Figure 9 accurately indicate a likely transport mechanism for velvet sponge larvae, then the larvae would have to traverse open Caribbean Sea waters in a relatively short time.

The ability of the velvet sponge to grow attached to a mangrove peat substrate, and possibly the ability to utilize a food source enriched with detrital particles may help to explain to future investigators subtle differences and commonalities in the ecological niches occupied by commercial sponge species. Although speculative, field observations may suggest that seagrass/mangrove derived detrital particles may contribute to velvet sponge nutrition. On windy days, waves and currents agitated the shallow water where the velvet sponges were found, and, in effect, produced a suspension of detrital material consisting of decaying seagrass leaves and eroding mangrove peat. The detrital suspension was sufficient to noticeably reduce water clarity in mangrove peat areas exposed to windy conditions. Sponges are efficient filter feeders, evidently capable of filtering bacteria size food particles. It is possible that fine detrital particles in the water column could either directly or indirectly, by promoting bacterial growth or elevating the level of dissolved organic, contribute to nutritional intake. Lauckner (1980) reviewed data that suggest the presence of symbiotic bacteria associated with several sponge genera, including Spongia and Hippospongia, which possibly could assist the sponge in utilizing dissolved organic substances.

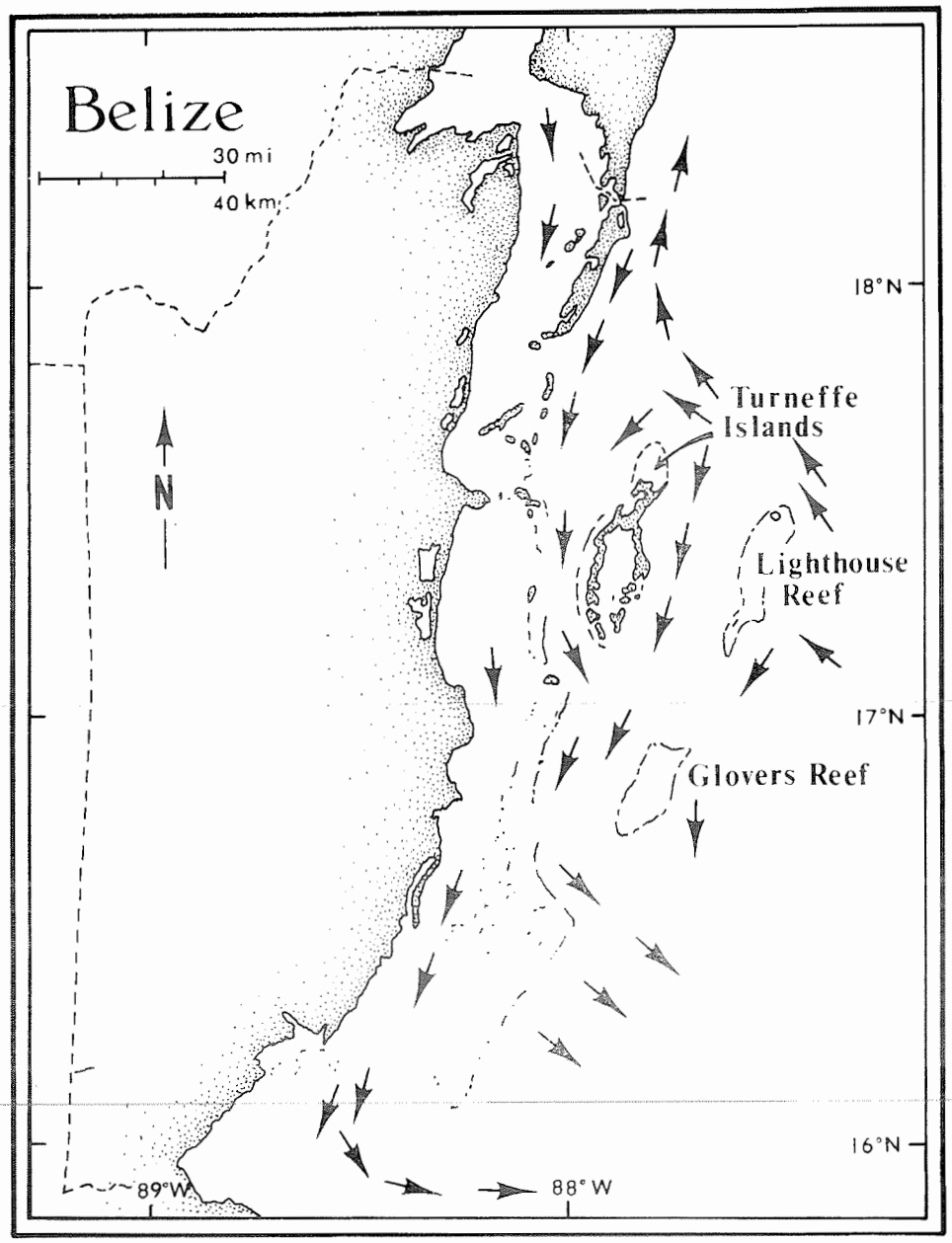

Figure 9. Prevailing surface currents for waters of Belize (adapted from Hartshorn et al., 1984).

Evaluation of Commercial Sponge Fishery Potential

Although a commercially valuable grade of velvet sponge was found to occur at a density capable of supporting fishery activities, several important factors must be considered before the fishery potential can be properly evaluated. Most importantly, the extent of sponge producing areas within the Turneffe Islands lagoon must be assessed more thoroughly. Although the additional field work conducted on October 19, 1991 found more areas that supported velvet sponge growth, the areas were limited in size and might be easily depleted by continuous intensive fishing effort. The comments by Moore (1910b) indicating the presence of several varieties of commercial sponges from the coast of British Honduras suggest that additional surveys are required to more fully define the commercial sponge resources of Belize.

The unique substrate to which the Turneffe Islands sponges are attached may not be conductive to allowing long-term harvest. Sponge fisheries in Florida and the Bahamas are supported by harvesting sponges that grow attached principally to carbonate rock outcroppings. Field observations in the Bahamas (Stevely, pers. obs.) and experimental work in the Florida Keys (Stevely and Sweat, 1985) indicate that when sponges are either cut or torn from such substrate, a significant quantity of sponge tissue sometimes remains attached to the substrate. This tissue is capable of regenerating to produce another viable sponge. In Florida, survival of harvested sponges ranged from 30% for sponges torn free using a sponge hook to 70% for sponges cut free with a knife. In Turneffe Islands, where sponges are anchored only to mangrove peat, it is likely that all the sponge tissue would be taken when the sponges were harvested by either hooking or cutting and that no attached sponge tissue would remain for regeneration. The same would be true for harvested roller sponges.

The large size of the Turneffe Islands velvet sponges (Table 1) may suggest that the legal size for sheepswool sponge required by either Florida (5 in, 12.5 cm, minimum diameter) or Bahamian law (7 in, 17.5 cm, minimum diameter) would provide little protection for the resource if sponge harvesting was economically feasible. Only one of the 15 sponges measured (Table 1) would have been protected by a law requiring a minimum harvest size of 5 in (12.5 cm). However, may more sponges from several areas should be measured before fishery management regulations are suggested. Also, consideration must be given to managing a regularly harvested resource compared to harvesting a virgin stock. A conservative approach that insures adequate protection of the resource should be taken in managing Turneffe Islands sponge fishery development until more complete information is available. Establishing an enforceable minimum legal size of 8-9 in (20-22.5 cm) exemplifies such a conservative approach.

Conservative management of the Turneffe Islands sponge fishery requires protection of reproductive stocks. Historically, research on reproduction in commercial sponges has focused on the more valuable sheepswool sponge, and essentially no information on velvet sponge biology is available. The sheepswool sponge attains reproductive maturity at a size of from 3 in (7.5 cm) in the Florida Keys to 5.5 in (14 cm) in the northernmost Florida west coast sponge grounds; reproductive maturity is attained at a smaller size in the warmer portions of its geographic range (Storr, 1964). Assuming a similar trend in the size of maturation in the velvet sponge it is reasonable

to assume that a minimum size of 8 or 9 inches (20-22.5 cm) in Belizean waters would protect sponges capable of a significant contribution to larval production.

The physical remoteness of Turneffe Islands presents transportation problems for sponge fishermen. Most likely, it would be necessary to store sponges accumulated for several weeks before transport to the mainland. Fortunately, cured and dried sponges do not require refrigeration and could be collected over weeks or months while intermittently pursuing other fishing activities. Storage of cleaned sponges would require some shelter to prevent rotting and long-term exposure to the sun. Cleaned sponges are also lightweight and can be easily transported by small boats.

Proper cleaning of sponges is hard work, but it is critical for receiving top price; improperly or incompletely cleaned sponge are either worthless or are worth only a fraction of their true value. In addition to time allotted for sponge harvesting, the sponge fishermen must commit an equal proportion of effort to cleaning, storing, and transporting the catch.

Conversations with fishery cooperative manager indicated some lack of interest in exporting sponges for two reasons: they were unfamiliar with the current value of commercial sponge in the export market and they did not know whether sponges were sufficiently abundant to support fishery development. The fishery cooperatives are the obvious focal points for collecting and exporting sponges. Belizean fishery cooperatives routinely ship seafood to Florida. Sponges are a highly valuable commodity (e.g., US $20.00-50.00/lb; $44.00-110.00/kg), and reasonable shipping costs (e.g. US $1.00-2.00/lb; $2.00-4.00/kg) would not be prohibitively expensive. Thus, sponge exports may significantly increase the cash flow and profitability of fishery cooperatives. For example, a 5,000 lb (2250 kg) annual shipment could easily result in an annual cash flow of $100,000 based on an estimated minimum price of US $20.00/lb ($44.00/kg) for velvet sponge. If a reliable supply of quality velvet sponges was established, it is reasonable to expect that the price paid for sponge to further increase.

Location of the Commercial Sponge Farm

A significant amount of historical information exists for sponge culture work in the Florida Keys, Bahamas, and Pacific Ocean (Stevely et. al., 1978). However, only sparse notes in the literature, referring principally to the occurrence of sponge disease and briefly describing sponge farm operations and location are available for the Turneffe Islands sponge farm (Smith, 1941). Smith (1941) stated, "Cultivation consists of cutting the sponge into small pieces, attaching these to stone or cement disks and allowing them to grow to market size on areas of the lagoon bottom most favorable to fast and healthy development". In the Bahamas, a length of palmetto string made from splitting a palmetto palm leaf was used to tie the cut sponge pieces to the concrete disk (Storr, 1964). One of the sponge disks found during our investigation still had a piece of aluminum wire attached through the small hole in the disk, suggesting that aluminum wire was at least sometimes used to attach sponge cuttings at Turneffe Islands. Aluminum wire also was used in sponge farming attempts in the Florida Keys (Stevely, et. al., 1978). The Turneffe Islands concrete sponge planting disks (Figure 6)

were similar in appearance to those used in both the Bahamas (Storr, 1964; Figure 9) and Florida Keys (Stevely et al., 1978, Figure 15).

Smith (1941) stated that the farm was run by concessionaires (Messers. R.E. Foote and H.T. Grant) licensed by the British Honduras Government. At the time of the sponge disease mortality, approximately 700,000 sponges were under cultivation (225,000 sheepswool sponges, and 475,000 velvet sponges). Mortality of the densely planted sponge cuttings (in some places one per square meter) was estimated to be 95%.

Some of the geographical advantages of attempting sponge farming in the Turneffe Islands lagoon are readily apparent. The lagoon contains extensive shallow areas 3-12 ft (1-4 m) deep that are reasonably protected by mangrove islands. Sheltered and relatively clear waters would permit sponge farm operations to proceed in all but the most severe weather conditions. The remoteness of the Turneffe Islands would probably assist in enforcing security of the farm. Difficulty with protecting sponge plantings from theft has been a major problem for sponge farming attempts in many areas (Stevely et al, 1978). However, Turneffe Islands sponge farm workers living in the immediate vicinity of the farm could serve as security guards in the area. Potential thieves interested in stealing sponges from the farm would have to establish a camp for harvesting, cleaning, and storing a sufficient number of sponges to justify transport back to mainland. In general, it would be difficult for a potential sponge poacher to escape notice in these remote surroundings populated principally with sponge farm workers.

Finally, the abundance of "wild" sponge stock in the lagoon may have played a key role in the decision to attempt sponge farming. The natural sponge populations may have been insufficient to support a fishery harvesting hundreds-of-thousands of sponges, but capable of producing tens-of-thousands of "seed" sponges for propagation.

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