FLSGP-T-78-008 c. 2

THE BIOLOGY AND UTILIZATION OF FLORIDA'S COMMERCIAL SPONGES

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TECHNICAL PAPER NO. 8
October 1978

Marine Research · Education · Advisory Services
A Sea Grant Program for Florida

Florida Sea Grant

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The information contained in this paper was developed under the auspices of the Monroe County Marine Resource Inventory, and funded by the Comprehensive Employment Training Act. This document is a Technical Paper of the State University System of Florida Sea Grant College Program, 2001 McCarty Hall, University of Florida, Gainesville, FL 32611. Technical Papers are duplicated in limited quantities for specialized audiences requiring rapid access to information, which may be unedited.

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ACKNOWLEDGEMENTS

Many people have made invaluable contributions towards the completion of the present paper. Collection of important information would not have been possible without the assistance of: Mr. Elmer Allen, Mr. Julio Arellano, Mr. Peter Bartholi, Ms. Julia Josiek, Ms. Robbin Kuhlik, Ms. Shirley Pomponi, Ms. Deborah Shaw, Dr. F. G. Walton Smith, Simon and Mimi Stafford, and Mr. Tom Weyant.

Of equal importance was the assistance of our scientific colleagues in the critical review of the manuscript and in providing valuable consultation in its preparation. A heartfelt note of thanks is extended to: Ms. Terrie Bert, Dr. James Cato, Mr. Chris Combs, Mr. Douglas Gregory, Mr. Thomas Murray, Ms. Leigh Taylor, Dr. Harold Humm, Dr. F. G. Walton Smith, and Mr. Jim Tilmant for their constructive criticism of the manuscript.

Ms. Nancy Brewer, Ms. Charlotte Howard, and Mrs. Mary Sasnett, were responsible for preparing the manuscript, for which sincere thanks are tendered. Many thanks are due to Mr. H. Samuel Gamble III, who assisted in the preparation of the figures.

Financial support for this undertaking was provided by the Monroe County Board of Commissioners, which made available Comprehensive Employment Training Act Funds for the Marine Resource Inventory. Their continuing sympathetic and interested support, and that of the Monroe County Manpower Planning Subcouncil, is gratefully acknowledged. A heartfelt thanks is extended to the Florida Cooperative Extension Service Marine Advisory Program for direction and guidance in completion of this project.

1. INTRODUCTION

Since the time of the Ancient Greeks man has recognized the usefulness of the natural sponge. Because of their ability to absorb large amounts of water, compressable nature, and durability, sponges have been used for a wide variety of tasks ranging from washing dishes to packing instrument panels in rockets. Up until the 1940's the sponge fishery was one of the most valuable fisheries in Florida. However, a combination of disease, heavy harvesting pressure, and the introduction of synthetic sponges has resulted in reduction of the industry to a small fraction of its former importance. Production in the Tarpon Springs area, the traditional center for sponging in Florida, has declined to extremely low levels of harvesting activity. Dade County has emerged as the center of the existing sponge industry. Persistance of low level sponging activities in Florida for the last 30 years indicates that the sponge industry, as it is currently structured, will probably not return to former production levels without specific kinds of help.

This paper reviews the sponge fishery from several points of view, utilizing data from scientific literature, state and federal fishery statistics, commercial fishermen, and sponge processors. It is written for several audiences, including the commercial fishing industry, marine researchers, management agencies, conservation interests, interested students, and laymen.

The purpose has been to: 1) describe the extent of available biological information; 2) define the present status of the resource; and 3) identify future potentials. It is hoped that this information can be used in providing for optimun utilization of this resource.

2. SYSTEMATICS

Sponges (phylum Porifera) are members of an ancient group of animals whose origin dates back hundreds of millions of years ago to the first appearance of multicellular animals in the fossil record. Sponges are considered to be primitive in relation to other animal groups because of their simple structure and the fact that apparently no other group of animals has evolved from them. The low level of cellular specialization (sponges lack distinct organs and tissues) and interdependence (sponges closely resemble colonies of independent single cell organisms) are primitive characteristics. A body structure based upon a water canal system and lacking distinct anterior and posterior ends is found in no group of animals other than sponges. All these features would suggest that sponges are remotely related to other animals. Due to these characteristics, ancient naturalists thought they were plants, and it was not until 1765, when internal water currents were observed, that the animal nature of sponges became clearly established.

The phylum Porifera is divided into three classes based primarily on the composition and structure of the animals' skeletal framework. The skeleton may be composed of calcareous spicules, siliceous spicules, protein spongin fiber, or a combination of the last two. These spicules are minute bodies of calcium carbonate (shell-like) or silicon dioxide (glass-like). The commercial sponges all come from one group, those having their skeleton made of spongin fibers only. This substance (spongin) is related by general chemical and physical properties to silk, horn, and chitin, the foundation of the shells of insects and crabs. The arrangement of spongin into a fibrous network is responsible for the commercial sponges properties of compressibility, resiliency and ability to absorb large quantities of water. However, the usable sponge form is attained only after the living material embedded in the skeleton has been removed. Other sponge groups are commercially unsuitable because of the inclusion of lime or silica spicules. The following is a brief synopsis of the taxonomic relationships of commercial sponges to other sponges in general.

2.1 Classification of Sponges (Storr, 1964).

Phylum - Porifera (Pore-bearing)

Class - Calcispongiae or Calcarea (chalk sponges): Members of this class have spicules composed of calcium carbonate. They are of no economic importance and are generally restricted to relatively shallow coastal waters.

Class - Hyalospongiae or Hexactinellida (glass sponges): Members of this class are distinguished by siliceous, six-pointed spicules. They are generally found only at great depths (greater than 500 m; 1640 ft), and are of little economic importance.

Class - Demospongiae (horny sponges): This class contains all of the commercially important species and in general contains the greatest number of sponge species. These sponges exhibit a wide variety of skeleton types, ranging from no skeleton to siliceous spicules, spongin fibers, or a combination of the latter two.

Order - Keratose or Keratosida: This classification grouping contains the commercially important species of Florida, and is distinctive in that the skeleton is composed of spongin fibers only.

Genus - *Hippiospongia*

Species - *Hippiospongia lachne* (sheepswool sponge)

Genus - *Spongia*

Species - *Spongia barbara* (yellow sponge)
Spongia graminea (key grass sponge)
Spongia graminea tampa (gulf grass sponge)

At one time, there were as many as 8 or 9 species of sponges taken commercially in Florida. Currently the sponges listed above are the only ones of commercial importance. The finger sponge (*Axinella polycapella*), glove sponge (*Spongia cheiris*), and wire sponge (*Spongia sterea*) were once of minor importance but are no longer collected, although sometimes glove sponges are sold for ornamental purposes. The reef sponge (*Spongia obliqua*) and the velvet sponge (*Hippiospongia gossypina*) were once of considerable importance, but none have been found since a sponge disease in 1939 apparently destroyed them.

2.2. Sheepswool or Wool Sponge

The sheepswool sponge (Figure 1) is considered to be the highest quality commercial sponge found in the western Atlantic. It is the most valuable species, representing 75% of the dollar value of sponges collected in Florida and 87.9% in Monroe County during 1976. When alive, the sponge is black, the color changing to a light grey at the base. Usually this sponge displays a rounded, cake-shaped form with a diameter to height ratio of 2:1 to 1:1. However, there is considerable variation in quality and shape depending on environmental influences. The surface of this sponge is usually covered with blunt points, and the sides of the sponges have a number of small inhalent openings. There are larger exhalent openings (oscules) on the top of the sponge varying from 1.25 cm - 3.0 cm (0.5 - 1.25 in) in diameter. Commonly the oscules are surmounted by thin-walled chimneys up to 5 cm (2 in) in height, with the oscules normally larger in shallow water sponges.

2.3 Yellow Sponge

The yellow sponge (Figure 2) is extremely elastic and resilient but is harder than the sheepswool, harsher to the touch, less absorbent, less retentive of water, and less durable. Yellow sponges accounted for 14.7% of the dollar value of sponges collected in Florida and 6.3% in Monroe County in 1976. The price per pound paid to the fishermen is usually less than half that of the sheepswool. When alive, the sponge is black, dark brown, or creamy tan in color depending on the area and depth from which it is taken. The smooth rounded shape is much like that of the wool sponge. However, the oscules are never surmounted by chimneys as is common in the sheepswool sponges. When cleaned, the color is yellow or yellowish brown, the surface is devoid of the long fibrous filaments characteristic of the sheepswool, and is covered with a nap of short bristles of uniform length.

2.4. Keys Grass Sponge and The Gulf Grass Sponge

Grass sponges collected off the west coast of Florida differ considerably from those taken in the Keys. The best are the Anclote grass sponges from the west coast of Florida which grow in vase-shape, except under optimal conditions when the inside of the base is almost completely filled in. Sponges of this latter form have a fine texture and good market value. However, during 1976, only 18 lbs. were reported to have been harvested.

The grass sponges of the Florida Keys (Figure 3), Bahamas Islands, and Cuba vary in form and general appearance, and are entirely different from those just described. They grow in a rounded, more compact form with a flat or concave top that is perforated by a number of oscules up to 0.65 cm (1/4 in) in diameter. When cleaned, the edges of the oscules are quite thin and feathery and, in most cases, form chimneys 2.5 cm (1 in) or so in height. These sponges are soft and absorbent but have

Figure 1. Sheepswool Sponge (*Hippiospongia lachne*).

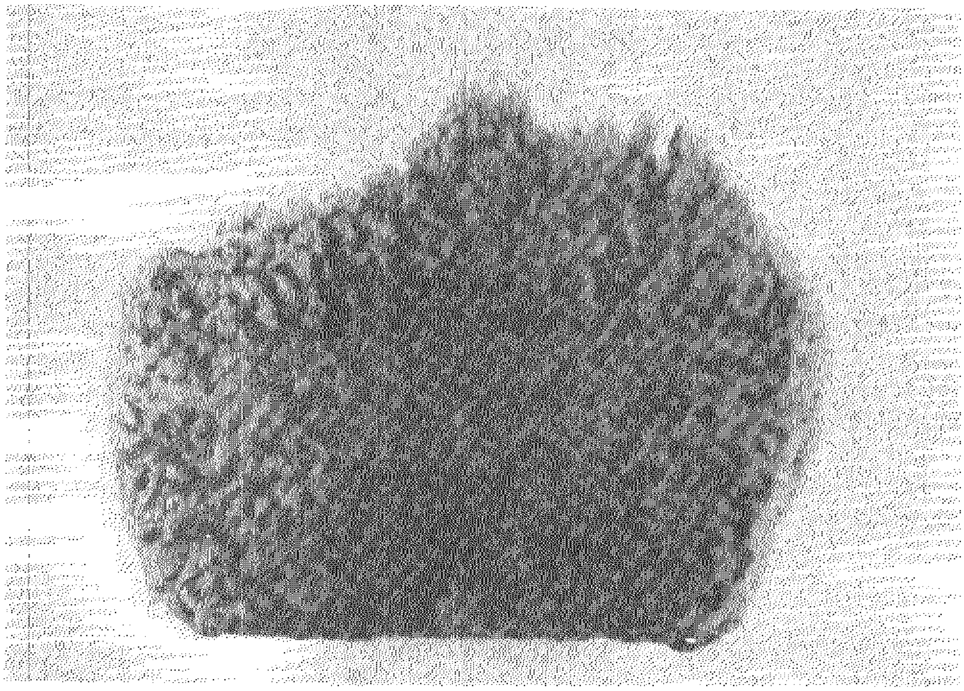
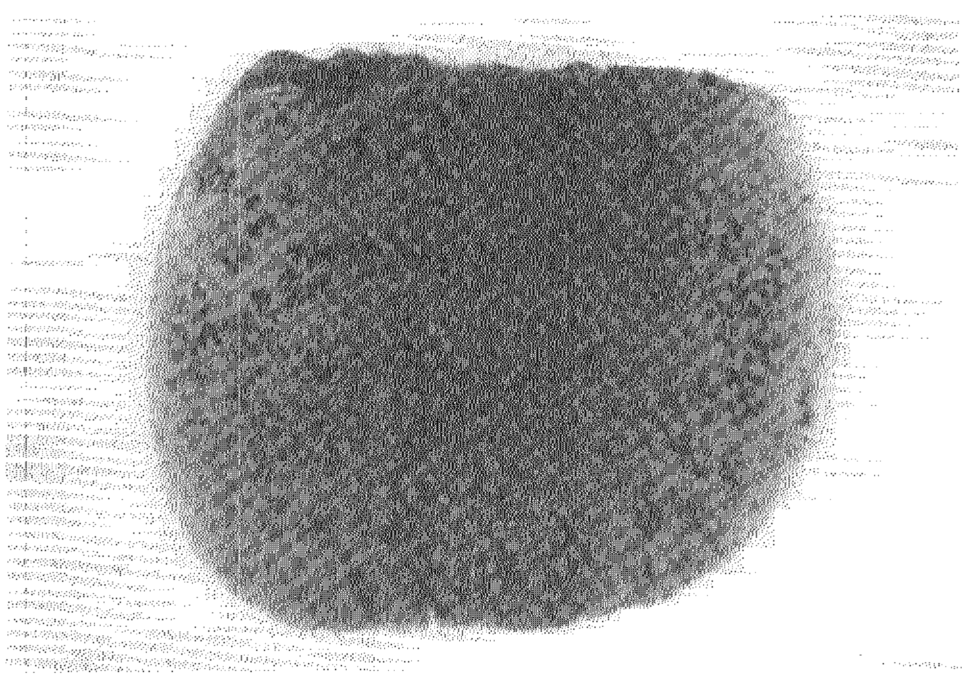
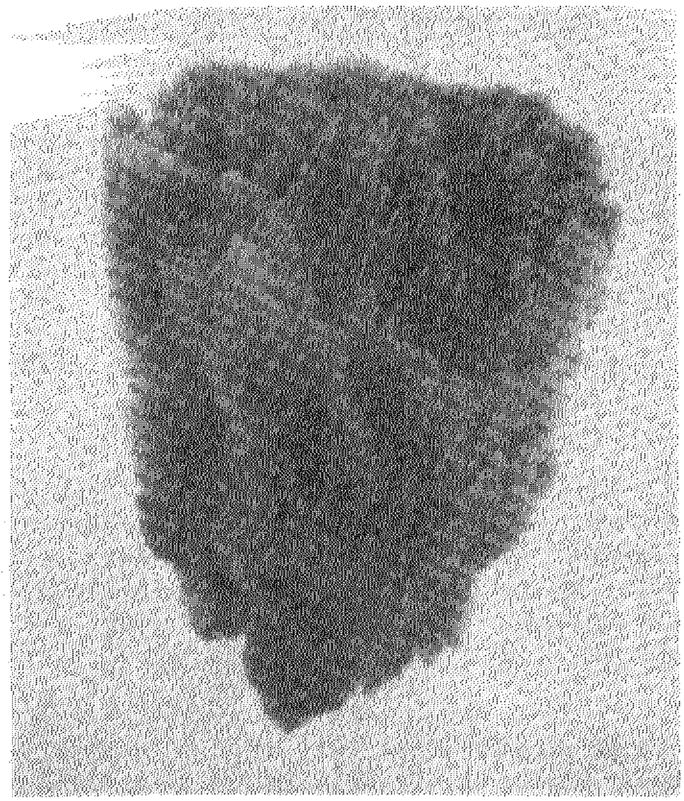


Figure 2. Yellow Sponge (*Spongia barbara*).



little durability. Large numbers of these sponges are presently collected in Biscayne Bay, but the market value of these sponges is the lowest of all the commercial sponges representing 9.5% in Monroe County.

Figure 3. Key Grass Sponge (*Spongia graminea*)



3. BIOGEOGRAPHY

Sponges are exclusively marine except for a single family of fresh water species. They are found in all seas, wherever there is suitable substrate. A few species live on soft sand or mud bottom. Some sponges are able to bore into calcareous structures, such as coral and mollusc shells. Worldwide, more than 3,000 species of sponges have been described, and in Florida's waters, over 100 species have been collected.

Commercial sponges are found in warm ocean waters only, principally in the Mediterranean Sea, off the coast of Florida and Central America, in the Gulf of Mexico, and throughout parts of the West Indies and the Bahamas. To a lesser extent, similar types of commercial sponges are found in the western parts of the Pacific. The commercial sponge species found in Monroe County occur throughout the West Indies (which includes the Bermudas), the eastern Gulf of Mexico including the coasts of Cuba, the Antilles, the Bahamas, and as far north as Cape Hatteras (de Laubenfels, 1953).

Sponge grounds in Florida's coastal waters are divided into two separated areas: 1) the "Bay Grounds" includes approximately 8,704 sq km (3,400 sq mi) in the open waters of the Gulf of Mexico, adjacent to Florida's west coast from about Johns' Pass to St. Marks, and 2) " Keys grounds" includes approximately 2,432 sq km (950 sq mi) stretching along and among the reefs and Keys from Cape Florida to Boca Grande Key (west of Key West, FL.).

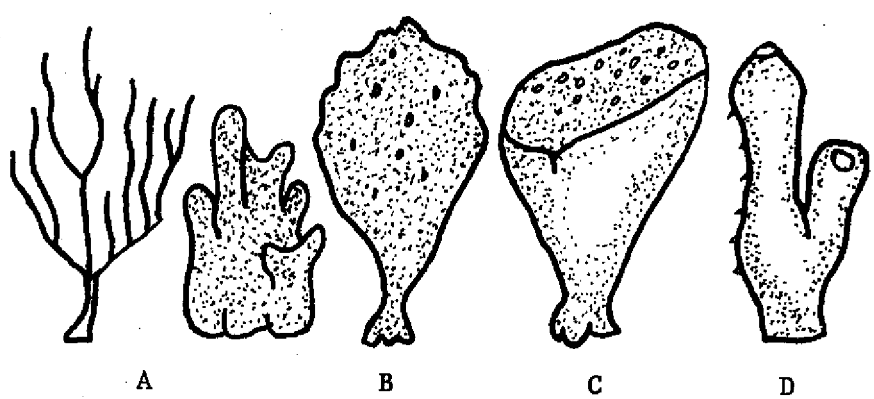
4. NATURAL HISTORY

The living sponge in nature is quite different in appearance to the sponge of commercial use. Alive, it is a solid, rather slimy-feeling, fleshy mass, varying in color from light greyish-yellow through a wide range of browns to black. Through numerous inhalent canals water is drawn into the sponge to provide sustaining food and oxygen and to flush waste products out larger exhalent canals. The following discussion will attempt to summarize the available information obtained by researchers on the physical make-up and mode of existance of sponges.

4.1. Structure

Sponges vary greatly in size. They may range from the size of a bean to more than a meter (several feet) in diameter. Some are radially symmetrical (similar parts of the animal symmetrically arranged around a central axis), but the vast majority are irregular and exhibit massive, erect, encrusting, or branching patterns (Figure 4). The type of growth pattern displayed is influenced by bottom type, current velocity and wave action.

Figure 4. Some Common Non-Commercial Sponge Shapes. A: Two samples of ramose shape. B: Flabellate. C: Vasiform. D: Tubular. Others exist and can have extremely bizarre and symmetrically grotesqe shapes (de Laubenfels, 1953).



The body wall is relatively simple in structure. The outer surface is covered by an epidermis (skin) of flattened polygonal cells, called the pinococytes. The surface of the wall is perforated by many small openings, called ostia, or incurrent pores, which allow water to flow into an interior cavity. This internal cavity may be a single large chamber (spongocoel) which opens to the outside through the osculum, a large opening at the top. However, nearly all sponges are more complex. In order to increase water flow through the sponge, there has been an evolutionary trend toward reducing volume of the spongocoel, and increasing the surface area of the body wall. This has been accomplished by the folding of the body wall to form hundreds, thousands, or up to millions of very small chambers. The folding of the body wall has resulted in the formation of branching incurrent channels, which open into flagellated chambers. The spongocoel, in many species, has disappeared except for water channels leading to the osculum (Figure 5). This structure, characteristic of the commercial sponges, is responsible for the sponge's porous nature.

Beneath the epidermis lies a layer of mesenchyme (unspecialized connective tissue), which consists of a gelatinous protein matrix containing skeletal material and wandering amoebocytes (cells capable of independent motion). The skeleton is relatively complex and provides a supporting framework for the living cells of the animal. The skeleton may be composed of calcareous or siliceous spicules (Figure 5-D), protein spongin fibers (Figure 5-C), or a combination of the last two. The spicules exist in a variety of forms and are used in the identification and classification of sponges. The amoebocytic cells in the gelatinous matrix are responsible for skeletal formation.

On the inner side of the mesenchyme, and lining the wall of each chamber, is a layer of cells, the choanocytes. The choanocytes are more commonly referred to as collar cells, due to the presence of a distinctive collar (Figure 5-E). Collar cells bear a flagellum (whip-like hair) surrounded by a basal contractile collar. The beating of the choanocytes' flagella is responsible for the movement of water through the sponge.

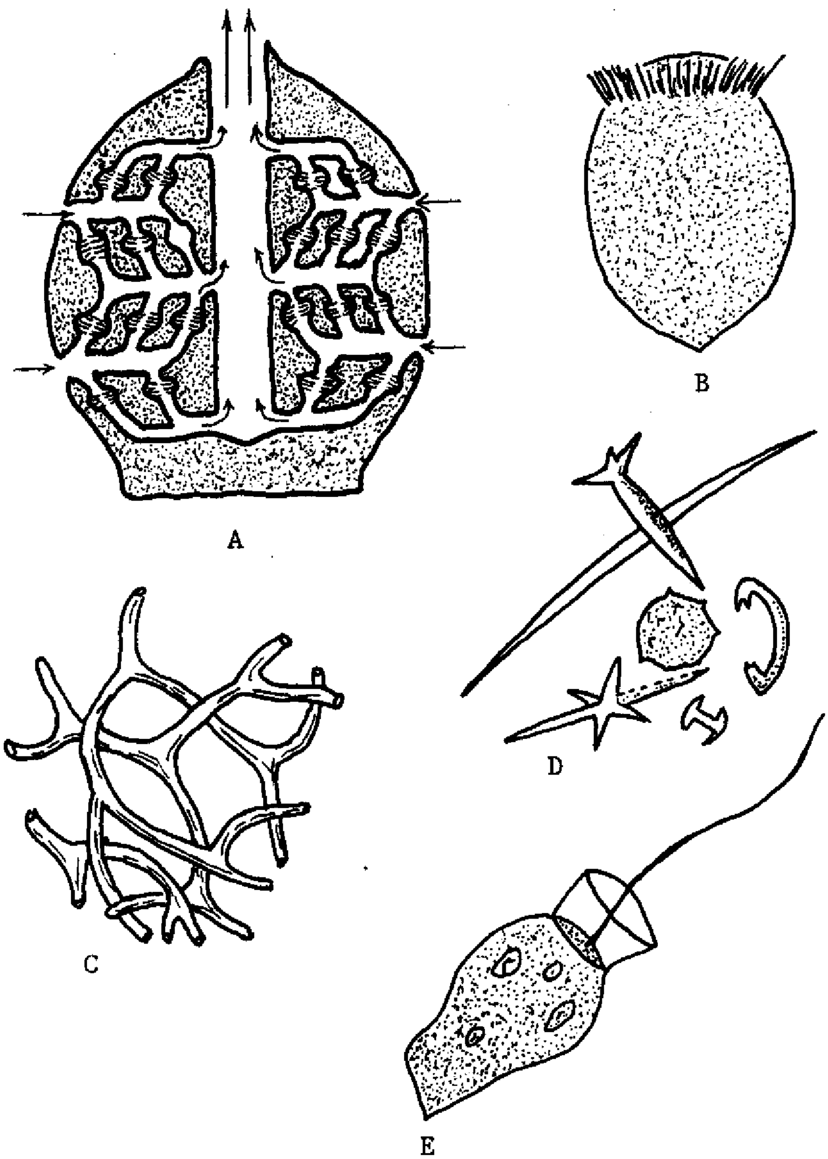
4.2 Physiology

The physiology of the sponge is largely dependent on the current of water flowing through the body. The beating of the whip-like hairs is capable of generating an exhalent current of 8 cm/sec (about 2 mph) and transporting large quantities of water. A commercial sponge 6 inches in diameter may pump over 100 gallons of water in an hour (Galstoff, 1969).

The exact nature of the food particles utilized in the sponge's nutrition has still not been properly defined. Laboratory and ecological information gathered to date indicate that sponges probably feed on fine detritus particles (decaying organic matter) and small planktonic organisms, such as protozoans, diatoms, and bacteria brought in by water currents.

Pearse and Williams (1951) suggested that sponges of the reefs of the Carolinas may strain plankton from the water. Smith (1954) mentioned that commercial sponges are usually found attached on rocks only in areas where there are muddy sediments nearby. These calcareous mud sediments were found to contain 160 million bacteria per cm^3 (Crawshay,

Figure 5. Structure Of A Sponge. A: Diagram of the canal system of a sponge. B: Larva of the Sheepswool Sponge (magnified about 1,500 times). C: Fiber-skeleton of the Sheepswool Sponge (magnified about 2,500 times). D: Types of spicules found in the non-commercial sponges (magnified about 2,500 times). E: Collar cell found in the pumping chamber of the Wool Sponge (magnified about 2,500 times). (from Storr, 1957)



1939). Crawshay and Smith both suggest that certain bacteria form the main food source of the sponges. It is also possible that sponges filter out minute particles of detritus or directly absorb dissolved oxygen nutrients (Smith, 1954). Reiswig (1973) demonstrated that Haliclona permollis (a non-commercial sponge) removes 83% of the bacteria circulating through the sponge over a wide range of bacterial concentrations. Bacterial uptake was judged sufficient to meet the nutritional requirements of the sponge.

Food particles are apparently selected largely on the basis of size and are screened in the course of their passage into the flagellated chambers. Jorgensen (1966) suggested that food particles adhere to the surface of the collars of the choanocytes and are engulfed by the cell body. Digestion occurs within the collar cell or after transfer to an ameobocyte.

Waste products leave the body in water being expelled through the oscules. Gaseous exchange occurs by simple diffusion between the flowing water and the cells in the sponge along the course of water flow (Barnes, 1968).

Adult sponges are incapable of any locomotion, although some species can contact or alter the body shape to some degree. There is probably no nervous system in the sponge, and reactions are local and independent (Barnes, 1968).

4.3. Reproduction

Sponges may reproduce by either sexual or asexual means. Asexual reproduction is accomplished by budding or by a variety of processes that involve formation and release of an aggregate of essential cells, particularly amoebocytes. Sponges display remarkable powers of regeneration. Pieces cut from a sponge will grow to produce a viable individual. This phenomenon will be discussed in greater detail in the section dealing with sponge culture.

Sponges are known to produce eggs and sperm, hence to exhibit sexual reproduction. Commercial sponges are known to be monoecious (same individual produces both eggs and sperm). The sperm and eggs develop from either collar cells or from amoebocytes. Sperm leave the sponge by means of water currents and enter other sponges in the same manner. After a sperm has reached a flagellated chamber, it enters a collar cell or an amoebocyte. These cells act as carriers and transport the sperm to eggs. After the carrier cell with its sperm has reached the egg, the carrier fuses with the egg and transfers the sperm to it. Fertilization thus occurs within the sponge. After fertilization, the sponge egg remains within the body of the sponge for its first stages of development. The final stage of development of the larval form is the growth of a crown of cilia at one end (Figure 5-B). At this point, it is released into the nearest excurrent canal where it is carried out of the sponge by the outgoing water currents. The crown of cilia allows for some motion (primarily in a vertical direction), but the larva is essentially at the mercy of water currents. If the larva lives through its 1-2 day planktonic stage and is able to find clean hard bottom, it will attach and rapidly change into the typical sponge form.

4.3.1. Factors Influencing Reproduction in the Sheepswool Sponge

Reproduction in the commercial sponge has been most closely examined in the sheepswool sponge. In field studies of living sponges, Storr (1964) found evidence to suggest that several factors effect reproduction in the sheepswool sponge.

1) Influence of sponge concentration on larval production. Reproduced below are the data collected by Storr (Table I) on concentration and larval content of sponges examined in his study. He was able to draw several tentative conclusions from these data:

a) There may be a critical density of sponges required for optimum production of larvae. Areas with high concentration of large sponges, those greater than 14 cm (5½ in) in diameter, exhibited a higher percentage of sponges containing larvae than did areas of low sponge concentration. In addition, the density of larvae in reproductive sponges was much higher in the areas of high concentration (500 larvae per cubic inch compared to 50 larvae per cubic inch). Storr attributed this to a direct relationship between numbers of embryos produced and concentration of sperm in the water surrounding the egg-producing sponges.

b) Sheepswool sponges may not be capable of self-fertilization. Sponges in areas of low concentration would be expected to have as many larvae as those in areas of high concentration if the sheepswool sponge was capable of self-fertilization. Storr found that sponges from areas of extremely low concentration did not contain developing larvae.

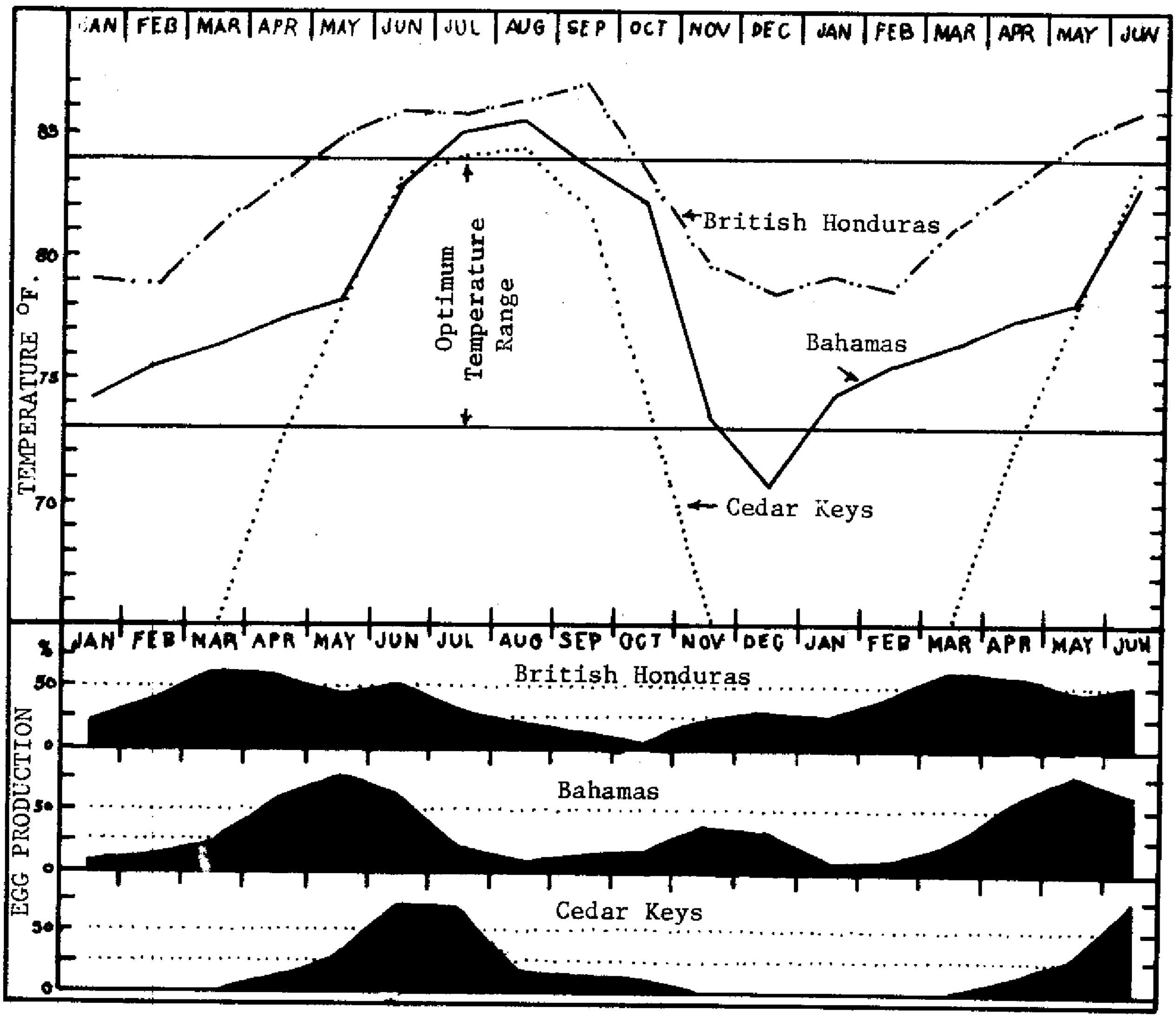
c) In the study area, sponges less than 14 cm (5½ in) in diameter may not be sperm producing sponges. Further, sponges in high concentrations but less than 14 cm (5½ in) in diameter had no relationship to the percentage of mature sponges that were producing larvae.

d) In evaluating all the information gathered, Storr indicated that perhaps only one out of every two hundred thousand larvae survives to settle on the bottom and grow to maturity.

2) Influence of sponge size on potential larval production. Storr (1964) presented information on the relationship of larval production to volumetric increases in sponges of increasing diameter (Table II). These calculations show that as the diameter of the sponge increases, there is an extremely rapid increase in the reproductive capacity of the sponge. This data indicates that it is the volume of reproducing sponge in an area, and not the number alone, which must be considered in evaluating the reproductive potential in that area.

3) Influence of temperature on sponge reproduction. Data collected on the reproduction of the sheepswool sponge from different areas of its geographic range (Figure 6) was used by Storr to determine the effects of

Figure 6. Optimum Temperature For Sponge Egg Production In Various Areas. In the upper portion the temperature graphs for year and a half periods for three areas are drawn, with the probable optimum temperature range indicated as being between 73° and 84° F. In the lower portion the approximate monthly percentage of Wool Sponges carrying developing eggs (larvae) for the same season is shown (from Storr, 1964).



temperature on the reproductive cycle. Based on this data, the optimal temperature for larval production lies between 22.5° C and 28.6° C (73° F and 84° F). Apparently above and below this temperature range, reproductive activity ceases.

Table I. Concentration of Sheepswool Sponges Collected in July, 1956 for Determination of Larval Content (from Storr, 1964).

Station No.	Total Sponges Taken per Acre	Under 5½" Diameter	5½" Diameter and Over	Total Sponges with Larvae
	Number	Number	Number	Number
XVII	11	0	11	9
XVIII	1	0	1	0
XXIII	2	2	0	0
XXIV A	14	11	3	3
B	15	8	7	6
C	5	0	5	4
D	4	0	4	4
XXV	4	1	3	2
XXVI A	25	24	1	1*
B	5	0	5	4
XXVII	2	0	2	2
XXVIII	20	18	2	2*
XXIX	9	6	3	0
XXX	7	6	2	0
XXXII	5	0	5	4
XXXIII A	4	1	3	1*
B	3	2	1	0
XXXIV	1	0	1	0

* Very few larvae in any one sponge.

Table II. Potential Larval Production Related to Volume (From Storr, 1964).

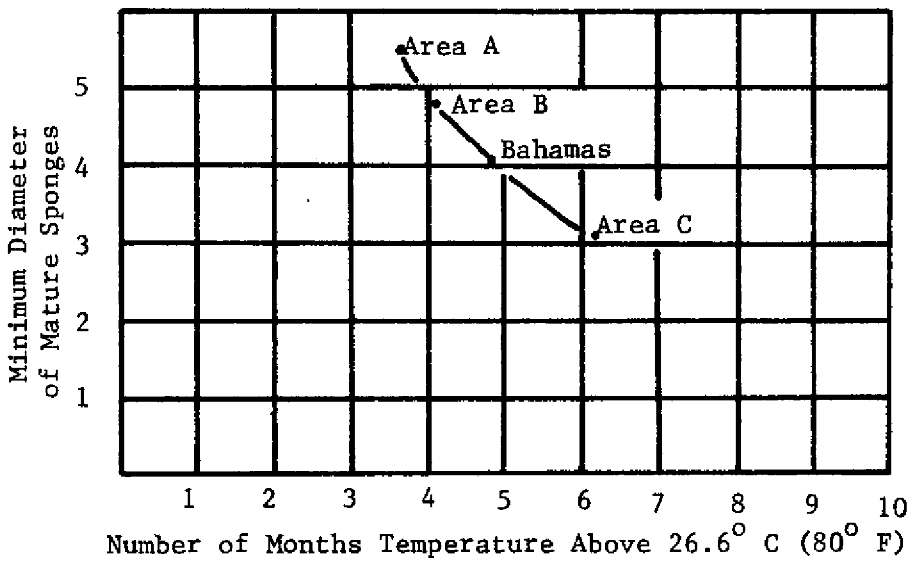
Diameter	Ratio of Larvae Produced from 6" Sponge	Potential Larvae Being Developed[1]	Yearly Production of Larvae[2]
Inches		Number	Number
6	1 : 1	60,000	200,000
7	1.6 : 1	96,000	320,000
8	2.4 : 1	144,000	480,000
9	3.5 : 1	210,000	700,000
10	4.7 : 1	282,000	940,000
11	6.2 : 1	372,000	1,240,000

[1]With the observed number of larvae in a 6 inch sponge being taken as unity.

[2]Based on length of larval production season and length of time for maturation of one larva (4 weeks).

Storr also presented data indicating the wool sponge reaches sexual maturity at a smaller size in the warmer portions of its geographic range (Figure 7). Because sexual maturity is reached at a smaller size and the reproductive season is longer, Storr concluded that sheepswool sponge egg production is greatest in the warmer parts of its geographic distribution.

Figure 7. Effects of Temperature on Size and Maturation in Wool Sponges in Various Areas (From Storr, 1964).



Area A: Northernmost portion of sponging grounds off west coast of Florida.

Area B: Southern portion of sponging grounds off west coast of Florida.

Area C: Florida Keys sponging grounds.

Storr also made another ecological observation. He postulated that size at maturation affected by variation of temperature with geographical location might also be affected by variation of temperature with depth of water. If this is true, it seems reasonable to suggest that dispersion of sheepswool sponges, especially in northern regions, to deep water areas in the Gulf may be retarded by the effects of temperature on the reproductive period and the sexual maturation of the sponges.

4.4. Growth of Commercial Sponges

Several researchers have made observations on the growth rate of commercial sponges in different areas of their geographic ranges. Growth may be expressed in terms of increase in diameter, or, as has been most commonly expressed in past studies, in terms of a growth factor (the number of times a sponge increases in volume during a 1-year period). Table III presents data obtained on the average growth factor, for comparable growth periods, by a number of investigators working in different locations. The information gathered shows wide variation.

Table III. Growth Rates of Commercial Sponges in Different Geographic Areas

Species	Location	Growth Factor
sheepswool	Sugarloaf Key, FL. (Moore, 1910a)	1.86
sheepswool	Anclote Key, FL. (Moore, 1910a)	1.91
sheepswool	Piney Point, FL. (Storr, 1964)	2.27
sheepswool	Bahamas (Crawshay, 1939)	2.34
sheepswool	British Honduras (Crawshay, 1939)	2.94
grass	Card Sound, FL. (Smith, 1973)	0.77

Crawshay (1939), working with sponge cuttings in the British Honduras, suggested that a growth factor of 2.0 was adequate and 2.5 was good. He also considered a growth factor of 3 or more as high, and that a high accumulation of waste matter accompanying the high intake of food necessary for such growth might prove detrimental and result in disease.

Based on a growth factor of 2.3, Storr (1964) calculated that a sponge in the northern Gulf of Mexico would require 3 years to reach a size of 12.7 cm (5 in) and 4 years to reach 15.2 cm (6 in) in diameter. Information gathered on growth rates of wool sponges in the Keys by Moore would indicate an even longer peroid of time until sponges attain market size. The slower growth rate in the warmer waters of Sugarloaf Sound (compared to Anclote Key and Piney Point, Florida) is surprising. Sponges in the warm waters of the Bahamas and British Honduras exhibit the most rapid growth. Smith (1973) found that when temperatures fell below 27° C (80.6° F) water temperatures were positively correlated with sponge growth. Moore felt that the slow growth rates that he observed might have been attributable to an absence of strong currents or by the character of the seed sponges. Apparently, the seed sponges used in that area were all small specimens despite the fact that the area had, in the past, produced many large sponges. Moore indicated that in these shallow waters the spongers might be able to rigidly select out all the marketable sponges, a process which would logically tend to eliminate those which grew rapidly and had an inherited tendency to reach larger dimensions. Also, it is worthy of note that growth rates from within an area can be extremely variable. Smith (1973) obtained growth factors for the grass sponge (Spongia graminea) in Card Sound, Florida that ranged from 0.24 to 1.31. Storr, (1964) made the observation that there was considerable variation in growth rates of sponges even when they were located on the same rock outcropping.

Many investigators have noted that sponge growth is affected by water currents in the surrounding area. Cotte (1908) noted that a moderate current seemed most suitable for sponge growth. Crawshay,

(1939) states that the most favorable conditions for sponges are usually found in or near areas subject to regular tidal interchange. Storr (1964) observed unusually rapid growth of sponges in a current of two knots or more. However, these sponges had heavy overgrowths of tunicates and algae which distorted their shape. Smith (1973) attributed a dramatic increase in the growth rate of sponges in his study area to an increase in water currents.

4.5 Environmental Factors Affecting Sponges

4.5.1. Physical Factors

The commercial sponges apparently cannot tolerate salinities much below oceanic levels. Moore (1910a) considered salinities of 27.5 parts per thousand (ppt) as detrimental and salinities below 26 ppt as lethal. In the Bahamas, W. Smith (Storr, 1964) reported that salinities of less than 32 ppt are harmful to sponges. Sponge kills, caused by an increase in fresh water run-off reducing salinities have been reported by many investigators (Rathbun, 1887; Moore, 1910; Crawshay, 1939; Storr, 1964).

Temperature has been shown to be an important factor affecting sponges. Commercial sponges appear to have a tolerance range from 10° C to 35° C (50° F to 90° F, Smith, cited in Storr, 1964). The effects of temperature on reproduction and growth have been discussed in the preceding sections dealing with these topics.

Sponges due to their sessile nature, are dependent upon water currents to bring food, dissolved oxygen, disperse larvae, and to carry away wastes. Bidder (1923) demonstrated that despite the relatively impressive water currents generated by the sponge's flagellated cells, sponges can remove wastes no further than a few meters, and the excurrent water is soon recirculated unless there is a current to carry it away. Japanese researchers working in the South Pacific found that sluggish turbid waters were unsuitable for sponges (Cahn, 1948). The effect of water currents on growth was discussed in the section dealing with sponge growth (see section 4.4).

The availability of clean, hard substrate for the sponge larvae to settle upon is extremely important. Larvae are easily smothered by sediments (Moore, 1910a). Only a small percentage of the large areas defined as the Florida sponge grounds actually support sponge populations due to the scarcity of rock outcroppings. Many times the structure on which a sponge is growing breaks off and the sponge continues to live as it is rolled along the bottom by water currents. Such sponges are termed "rollers" and are distinguished by new growth over the area of former attachment.

4.5.2. Biological Factors Affecting Sponges

During 1938-1939, populations of commercial sponges throughout the western Atlantic were decimated by disease. Mortality was similar to Brice's (1898) description of heavy losses of sponges in the Knight

Key to Cape Sable region of Florida, when the sponges "rotted internally". The disease first appeared in the Bahama Islands and rapidly spread throughout the West Indies and the Gulf of Mexico (Galstoff, 1940). The progress of the mortality was recorded in a detailed manner and transmission of the disease attributed to water currents (Smith, 1941). Galstoff (1940) estimated that from 60% to 90% of the adult population of the commercial sponges of the Bahama Islands were killed by the disease. He also indicated that the disease was somewhat milder in Florida waters and suggested that sponges in this area might have been more resi-tant.

Examination of diseased sponges led Galstoff (1940) to conclude that a fungus was the probable cause of the disease. His conclusion was primarily based on a number of observations: 1) filaments of a fungus were always present in the affected parts of diseased sponges; 2) only a few filaments were found attached to skeleton fibers of the dead portion of the body; and 3) no filaments were found outside of the diseased layer in healthy tissues. Further evidence supporting the contention that a fungus was the causitive agent was obtained by Galstoff in a number of experiments dealing with transmission of the disease. He found that when a diseased sponge was placed in contact with a healthy sponge, the destruction of sponge tissue spreads from the affected sponge to the healthy sponge and that the progress of the disease was accompanied by the spread of fungal infection.

Carter (1878; cited in Galstoff, 1940) had observed the presence of a fungus-like organism in the tissues of sponges which he named Spongiophaga communis. Carter describes the fungus as destroying the entire body of the sponge, leaving only an outside crust (this was similar to Galstoff's description of the sponge disease of the Bahamas and Florida). Galstoff tentatively placed the fungus he observed in Carter's genus Spongiophaga.

Investigation of the disease was hampered by the researchers' inability to culture the fungus in the laboratory. In British Honduras, Spongiophaga was observed growing on the surface of turtle grass, Thalassia, with no apparent ill effect (Storr, 1964).

If the observations of Carter, Brice and Galstoff deal with the same pathogen, it would appear that outbreaks of the disease are quite infrequent. A sponger in the Key West area reports that he continually finds a small number of sponges affected by the blight. Exactly why the blight has not triggered mass mortalities, as it has been reported to do in the past, is not understood.

During 1947-1948, a disease affecting the commercial sponges along the west coast of Florida was reported. Investigation of this phenomenon by members of the Marine Laboratory, University of Miami, did not reveal the cause of this sponge mortality. No evidence of fungal disease was found (Storr, 1964).

Mortality of sponges due to the outbreak of red tide (tremendous accumulations of planktonic organisms that sometimes have a deleterious affect on marine organisms) has been noted. Rathbun (1887), and Smith

(1976) have reported sponge mortality associated with outbreaks of red tide.

Sponge fishermen have reported that sponges in shallow water are occasionally killed off by a phenomenon they call "mallee". This "mallee" is a heavy growth of fine algae that usually breaks loose, smothering sponges.

There is a wide assortment of organisms living in association with sponges (Pearse, 1934; Storr, 1964). Numerous animals and plants live within the mass of the sponge, in the internal canals, or on the surface. However, no animal or plant, with the exception of the fungus disease, can be said to be parasitic exclusively on commercial sponges (Storr, 1964).

The commercial value of a sponge can be greatly reduced by deformities caused by algae or other fouling organisms growing on the sponge surface or by the sponge crab, *Pilumnus sayi*. This crab often occupies a hole at the base of the sponge. The hole may not affect the sponge as a living animal but destroys the commercial value of the sponge.

5. THE SPONGE FISHERY OF FLORIDA

5.1. Methodology Involved in Sponge Industry

5.1.1. Harvesting

The methods used for harvesting commercial sponges have essentially remained the same since they were first introduced to sponging activities in Florida. There are two methods by which sponges are harvested in Florida: hooking and diving.

1) Hooking. In the hooking method, a heavy, four-pronged iron rake attached to the end of a 5.5 to 7.3 m (18 to 24 ft) pole is utilized to bring the sponges to the surface. The hooker works from a small skiff, checking the bottom for sponges by looking through a glass-bottomed bucket. When a sponge is seen, the hook is lowered quickly to the bottom and the size of the sponge is estimated by the width of the hook. If the sponge is legal size, 12.8 cm (5 in) minimum diameter, the hooker sets the hook into the base of the sponge and tears it loose. If a small fraction of the sponge is left attached to the base, a new sponge will regenerate. By lashing rakes together, sponges may be collected in this manner from water up to 12.2 m (45 ft) deep. However, the majority of sponges collected by this method are taken from water less than 3 m (10 ft) in depth.

In Tarpon Springs, sponge fishermen work in pairs, one man rowing and the other hooking. In the past, hooking methods in the Florida Keys differed from those used in Tarpon Springs. In the Keys, the dinghy is usually operated by one man. Instead of using oars for propulsion, the hooker uses a pole. Sometimes a small quantity of oil is poured over the water to smooth surface chop for better vision. The pole is used mainly to keep the hooker in the center of the oil slick which moves with the tide. Recently, the use of small outboard motor boats has become extremely popular with sponge hookers (Figure 8).

2) Diving. Historically, the diving suit has been employed in the sponge fisheries of the Mediterranean since about 1866, but it was not until 1905 that it was successfully introduced in Florida. Diving boats from Tarpon Springs are basically of the same design as boats used by the Greeks 2,500 years ago. The only modifications are the addition of diesel-power and the air pump, which is powered by the main engine.

Sponge divers wear the standard diving gear consisting of a thick rubberized suit with bronze shoulder piece and metal helmet. The diver uses a hook attached to a pole about two feet in length, which is similar to the one used by the hooker. The shortness of the pole enables the diver to handle it adeptly. Also, he can uproot the sponge with a sideways motion which insures against rips and tears.

The suit diver can descend to depths of over 100 ft. However, at this depth, he can remain no more than several minutes due to physiological limitations. In water thirty feet deep or shallower, he may, however, remain for two hours or longer. In good weather, two divers work a twelve-hour day, with each diver making an average of five decents a day. When a bag is filled, the diver signals by tugging on his lifeline. The tender then hauls up the bag and sends down another. A good day's catch for one boat is estimated at one hundred and seventy sponges (Shubow, 1969).

The advantages of diving are: 1) it permits the exploitation of deeper waters, and 2) operations may be conducted under weather conditions which would prohibit the use of hooking. Sponges collected in deep water by diving are of a larger size, higher quality, and command a higher price than those collected by surface hookers. There are several reasons for this difference:

a) the highest quality of wool sponge naturally occurs in the deep water sponging grounds off the west coast of Florida;

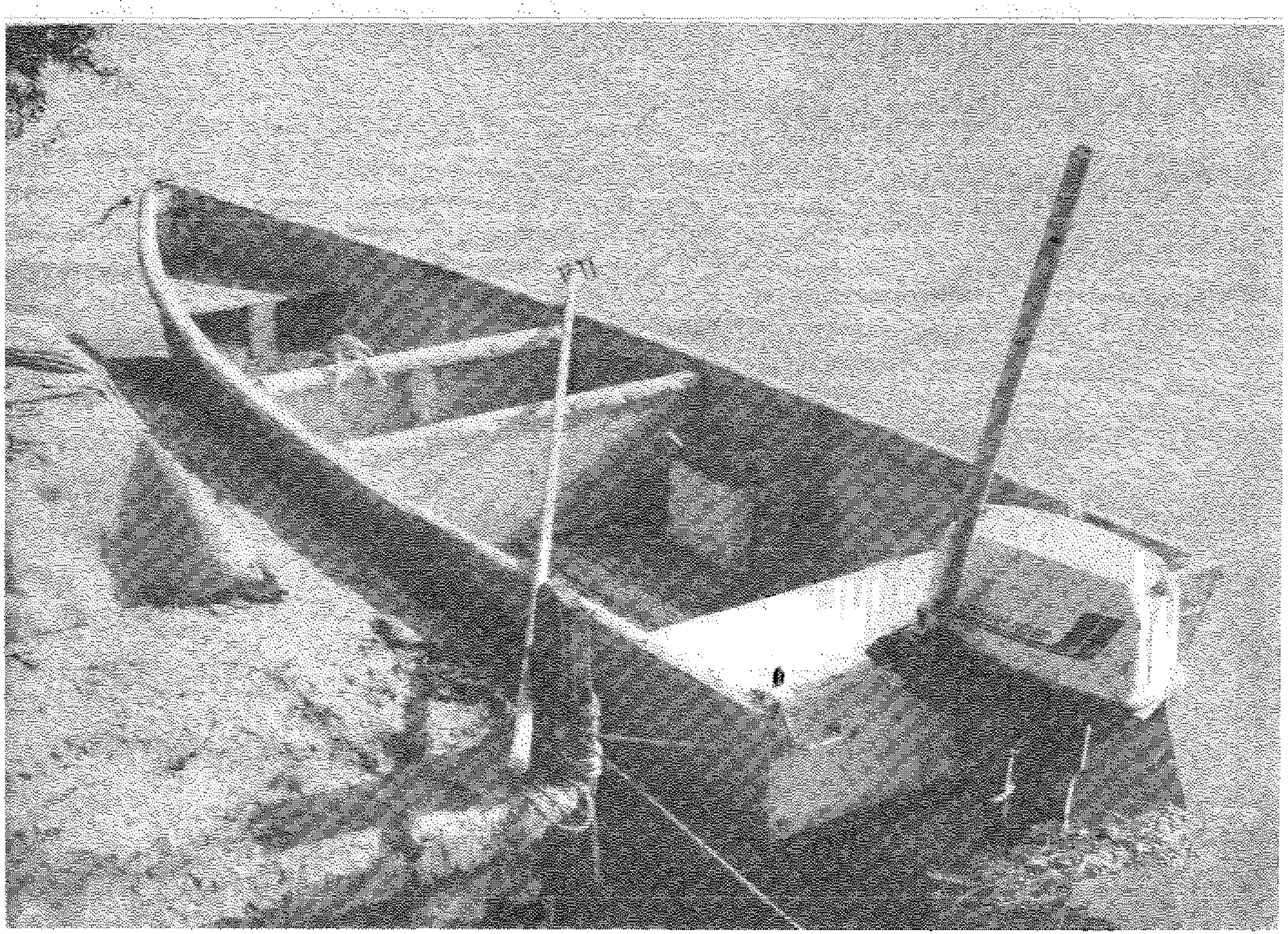
b) hookers are restricted to shallow, consistantly harvested areas where sponges do not have a chance to grow to a large size;

c) sponges collected by hooking usually suffer more damage than those collected by diving.

The invention of self-contained underwater breathing apparatus (SCUBA) in the 1940's has provided a newer and possibly more efficient method of gathering sponges. Shubow (1969) reported that in 1964, James S. Cullison, Florida Development Commission, experimented with using SCUBA diving for sponge harvesting. Cullison found that SCUBA divers brought up more sponges in less time and with faster boats were able to put into shore each night. Recently, one sponger in the Tarpon Springs area has reported the use of small, fast, trailable boats and snorkling gear.

Diving can be a particularly effective harvesting method. Since sponges can be cut from the bottom rather than torn, a higher quality

Figure 8. Small Boat Used By Sponge Hooker In The Key West Area.



sponge can be obtained. Also, cutting the sponge free usually enhances the chance that the remaining sponge material will be able to grow back (pers. obs.).

A Florida state statute (Florida Statutes, 370.17;2) prohibits in Florida's territorial waters, "apparatus used by deep sea divers, in taking commercial sponges". The law was passed to prevent damage to young sponges by divers walking on them with heavy lead boots. However, the applicability of this law to SCUBA or hooka gear seems subject to question. An informal legal opinion requested by the writers from the University of Florida, under the auspice of, Dr. Maloney, Dean Emeritus of the School of Law, indicates that this law does not apply to these methods because: 1) SCUBA or hooka gear did not become a viable method of extended underwater diving until many years after enactment of the law; 2) the purpose of the law was not to prohibit reasonable methods of harvesting sponges, but to prohibit the use of harvesting equipment which would damage young sponges.

Summer, including May, is the time of year when most sponges are collected. Two reasons explain this: 1) the weather at this time of year is best for sponging activities; and 2) the season on spiny lobster and stone crab are closed and people involved in these fisheries turn to sponging.

5.1.2. Cleaning and Marketing

The sponge of commerce is the skeleton of the living animal. The process of removing the "skin" covering the sponge, and the living matter within the skeleton once sponges are collected is a simple process. When the sponges are brought aboard, any foreign matter is squeezed out, and the sponges are placed with the base down to allow the "gurry", or decaying matter, to drain from the sponge. Next, the sponges are suspended in seawater or covered with wet burlap. During these procedures, the skin and internal matter decompose. After a couple of days (additional time is required in cool weather) they are ready for the final cleaning. This is done by rinsing the sponges in clean seawater and beating with a stick to remove all debris. The skin of the sponge is scraped off with a dull knife. Finally, the sponges are dried, sorted, and strung on a piece of yarn 6 ft long. The ends of this yarn are tied together to form a wreath that is called a "bunch".

Traditionally, sponges were sold in lots to dealers at auction. More recently, due to low sponging activity, organized auctions are becomming increasingly infrequent (Tarpon Springs Sponge Exchange, pers. comm.). In Monroe County, many spongers sell their product to middlemen in the Keys and Miami rather than transport them to Tarpon Springs. Prices are extremely variable depending on size, type, and even geographic location of collection.

In the hands of the dealers, the sponges are trimmed with sheep shears to remove the irregularities, torn parts, and foreign bodies such as shells and pieces of coral. If the whole sponge is trimmed into a regular shape it is called a "form". In the case of irregularly shaped sponges, those with crab holes, or very large sponges, the sponge is trimmed and cut into regularly shaped pieces. These are called "cuts". They are then baled and shipped to the customer. Some sponges are bleached for marketing. However, chemical bleaching injures the fiber of the sponge and results in an inferior sponge.

5.2. History and Pattern of Exploitation

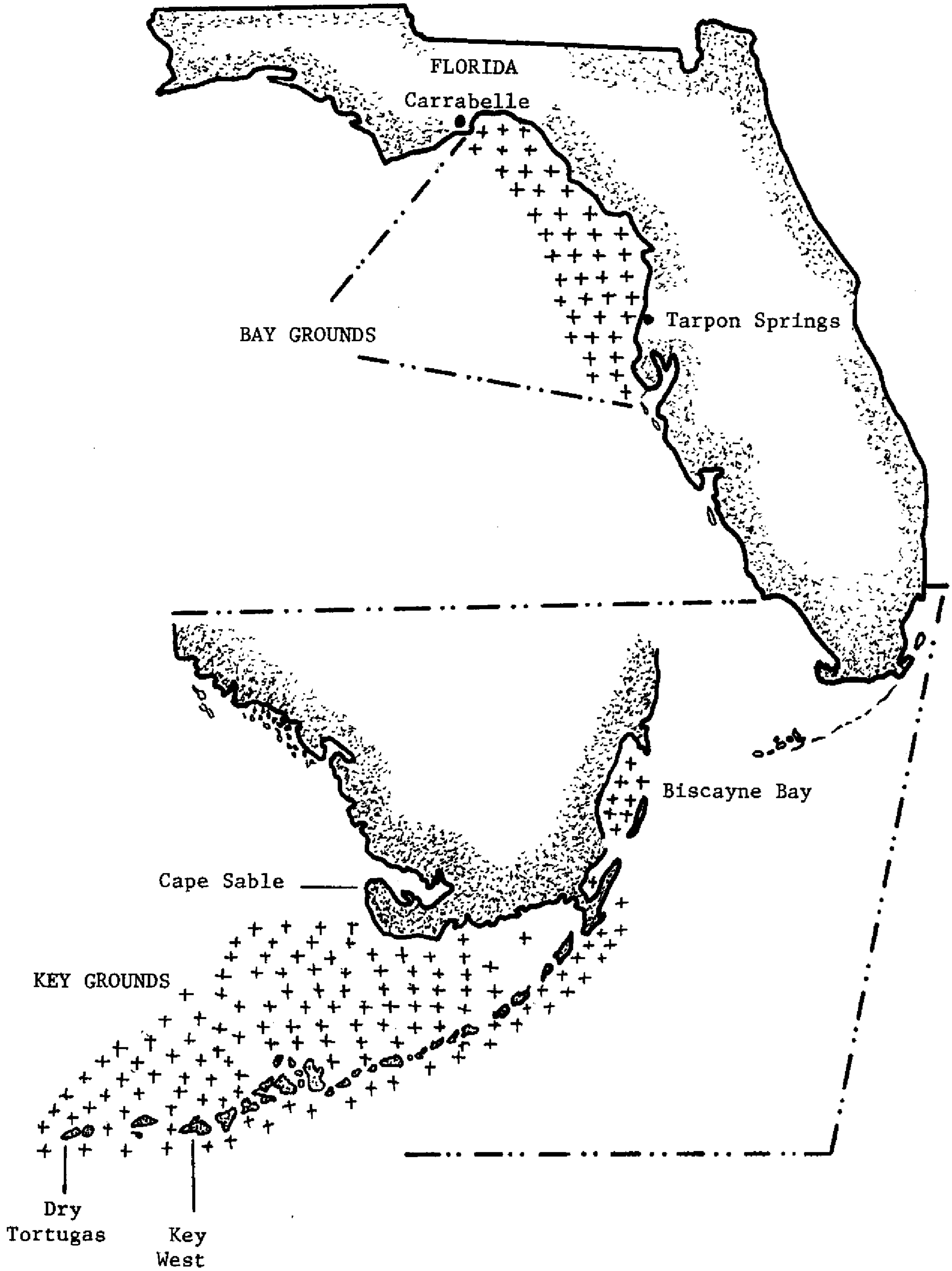
The history of sponging is an ancient one. The occurrence, properties, and uses of the sponge were familiar to the Ancient Greeks. There was an extensive, lucrative, and well recognized sponge trade several centuries before the Christian Era, not infrequently mentioned in early Greek literature.

Commercial sponging originated in the Aegean Islands of the eastern Mediterranean Sea. The Greeks in this area gradually, over the centuries, extended their field of operations to the north coast of Africa and the central Meditteranean. Until 1841, the world sponge supply was derived solely from the waters of the Mediterranean. In that year, a French sponge merchant, impressed with the native sponges, shipped a sample lot of sponges from the Bahamas to Paris. Eight years later, exports of sponges from the Bahamas were valued at $10,000. In 1849, the first Florida sponges were shipped from Key West to New York. The sponges' quality and good price established a growing market and a large group of men began to rely on gathering sponges for their livelihood. By 1890, sponging was a business that annually netted Monroe County nearly one million dollars (Shubow, 1969). In 1897, sponges were the most important fishery product of Florida, representing one-third of the annual value of the fishery industry (Smith, 1898). At first the fishery was confined to the waters adjacent to the Florida Keys, and until about 1900 Key West was the center of sponging activity in Florida. However, from 1868 to 1879 extensive beds of superior sheepswool sponges were found in the Gulf of Mexico northward from Anclote Key to Cedar Key (Figure 9). Because of Tarpon Springs proximity to the valuable Gulf of Mexico sponge grounds it soon became an important sponging center (Table IV). Introduction of diving in 1905, and establishment of Tarpon Springs as the headquarters for Greek divers, resulted in Tarpon Springs surpassing Key West as the principal market in the early 1900's (Moore, 1951).

Table IV. Sponge Landings in Key West, Tarpon Springs, and Other Areas, 1883 - 1918 (Schroeder, 1924).

	1883		1887		1902		1918	
Locality	Number of pounds landed	Per cent of total catch	Number of pounds landed	Per cent of total catch	Number of pounds landed	Per cent of total catch	Number of pounds landed	Per cent of total catch
Key West	238,038	94	270,906	82	266,841	77	107,743	24
Tarpon Springs	....	..	56,000	16	67,218	19	344,445	76
Others	15,652	6	4,640	2	12,830	4	....	...

Figure 9. Sponge Producing Areas Of Florida.



Sponge production in Florida reached its maximum in 1936 - 1937 when 324,000 kg (600,000 lb) of sponges valued at more than $1.2 million were collected (Figure 10). In 1939, a blight, attributed to a fungus disease, struck all western Atlantic commercial sponge populations and severely reduced production (Figure 10). Also, removal of Greek sponges from the U.S. market during World War II caused an even greater shortage of supply. In spite of the reduced landings, sponging remained one of the major industries in the state during World War II because increases in prices more than offset the reduction in production. The value of sponges landed reached a peak of almost $3,000,000 in the years 1945 to 1946. At one point, high quality sheepswool sponges were commanding a price as high as $30/lb. As a result, the number of boats actively engaged in sponging increased by more than 50% (Storr, 1957). This increased pressure further depleted the grounds. Despite increased fishing effort, the total number of sponges taken per year from 1941 to 1946 remained about the same. According to the reports of the Sponge and Chamois Institute, undersized sponges were being taken indiscriminately in large numbers during this time (Shubow, 1969).

A wide spread mortality struck the sponges again in 1947. Production of commercial sponges declined rapidly thereafter, and many spongers withdrew from the fishery. By 1951, a low point was reached in production and dollar value. Total return for 1951 was estimated at 5,940 kg (11,000 lb) with a value of $80,000. This was less than 3% of previous maximum landings and dollar value. Storr (1957) stated:

> "it seems fairly certain now that had the sponge beds been in as good condition to start with as they were before the first disease in 1938 the remaining sponges would have repopulated the sponge beds at a rapid rate. With the beds already depleted by overfishing there were such few sponges left after the additional losses by disease, that even today (in 1956) large areas have never become repopulated with commercial sponges. It is significant that the non-commercial sponge population shows every sign of healthy growth."

5.3. Present Status of the Sponge Fishery in Florida

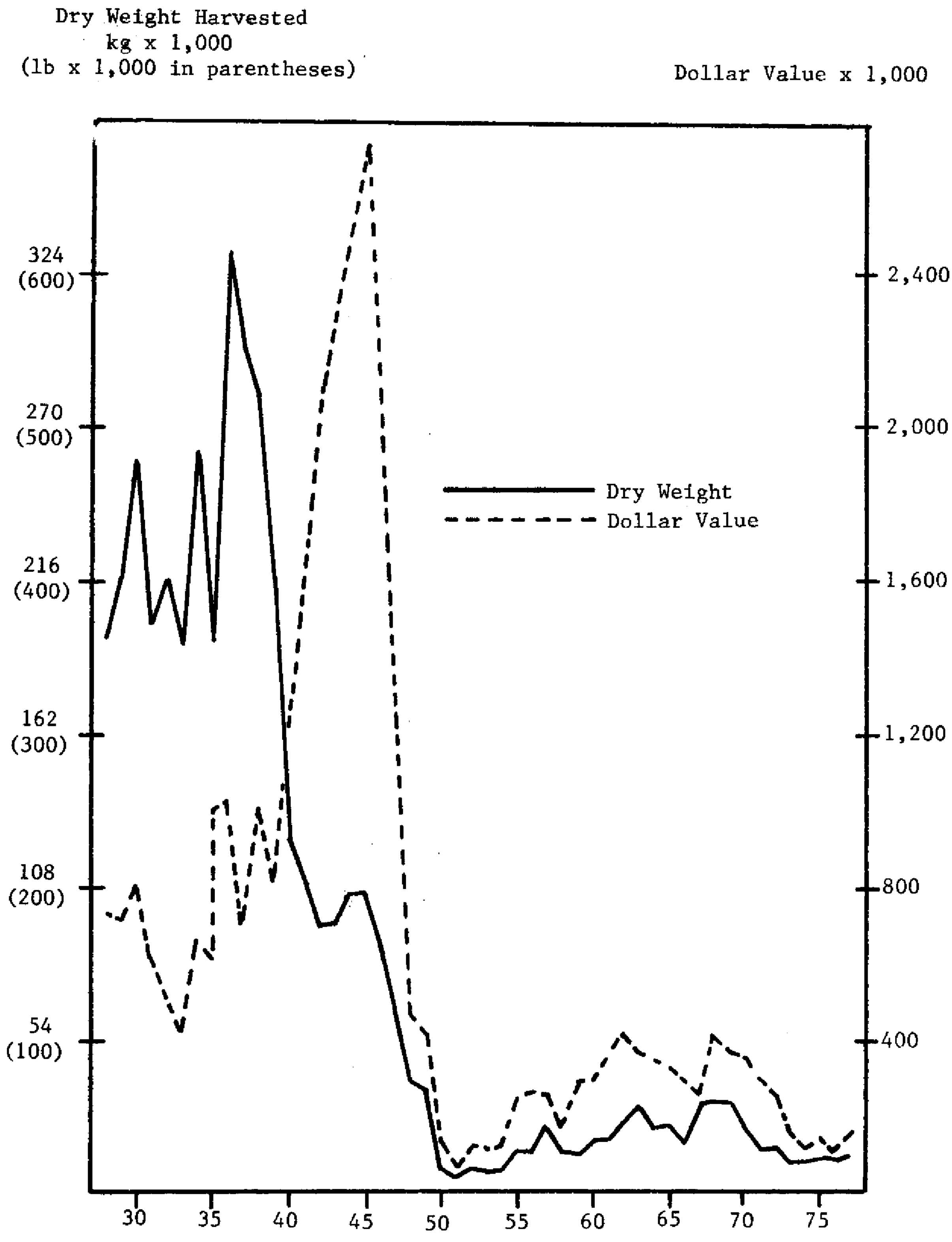
Production of sponges has remained extremely low since the 1947 sponge mortality. By 1962, landings were down to 21,600 kg (40,000 lb). In 1976, landings were 11,022 kg (21,000 lb) or 2.6% of the 1938 total. Several interrelated factors were responsible for this decline:

1) The blights of 1939 and 1947 severely reduced sponge populations.

2) The increase in price after the blight of 1939 attracted a large number of people to sponging. As a result, fishing pressure was maximized just as the sponge grounds were recovering. This reduced the population to such an extent that repopulation was an extremely slow process.

3) After the blight of 1947 and failure to return to normal production levels, people involved in sponging took to other jobs.

Figure 10. Dry Weight And Dollar Value Of Sponges Harvested In Florida From 1926 Until 1977.



Source: Storr (1964) and Florida Department of Natural Resources Landing Statistics.

Sponge buyers in the Tarpon Springs area claim that the sponges have been slowly returning to the area, but that as the old Greek spongers retire, they are not being replaced by younger men. Due to hard work, separation from families during long stays at sea, and low monetary return, no new people are being attracted to the industry in this area.

4) Introduction of the synthetic sponge at a significantly lower price reduced the overall demand for natural sponges.

In 1945, after the first blight, Monroe County produced 44,200 lbs of sheepswool sponges valued at $256,000. In the years after the second blight, recorded production was non-existant (Figures 11 and 12). However by 1975, for the first time since the 1900's, Tarpon Springs (Pinellas County) lost its position as number one producer of sponges in Florida, with both Monroe and Dade Counties sponge production exceeding that of Tarpon Springs. Production of sponges in Monroe County began increasing in the 1960's reaching a value of $90,000 in 1964 and averaged $34,000 per year from 1973 - 1976. Sponges collected in Monroe County are sold to buyers in Miami and Tarpon Springs or local sponge dealers.

From information gathered in interviews with people connected with the sponge industry, it appears that there are approximately 50 people in the Keys earning part of their income from collecting and selling sponges. Most of these spongers derive the greater part of their income from other enterprises such as trapping the spiny lobster or other fishery related occupations.

In 1962, Dade County began making a significant contribution to sponge production in Florida. At this time, Cuban refugees began arriving in Miami. A number of them were sponge hookers and they began harvesting sponges for a livelihood. The Arellano Brothers, former sponge merchants in Cuba, established their own sponge market in Miami during the early 1960's. They began buying sponges in the Keys and helped outfit fellow Cubans with boats to collect sponges in Biscayne Bay and along the Keys, at least as far south as Marathon. These sponge beds had lain unexploited since most spongers left the fishery in 1946 (Shubow, 1969).

Statistics for sponge production in Monroe County compiled by the National Marine Fisheries Service are supplied by the Arellano Brothers. Since some sponges are sold through other outlets, it is possible that sponge production in Monroe County is underestimated.

There is a considerable difference in prices paid to fishermen for sponges collected from different geographic areas of Florida (Figure 13). Sheepswool sponges collected from Tarpon Springs have always commanded a higher price than those collected in Dade and Monroe Counties, and the difference has become even more pronounced in the past five years (Figure 13). Members of the sponging industry have indicated that this is the result of three factors:

1) The highest quality sheepswool sponge occurs in the deep water sponging grounds off the west coast of Florida. Sheepswool sponges collected in the Keys exhibit a red-brown discoloration

Figure 11. Sponge Production From Sponge Producing Counties Of Florida 1953 - 1977 (Florida Department of Natural Resources Landing Statistics).

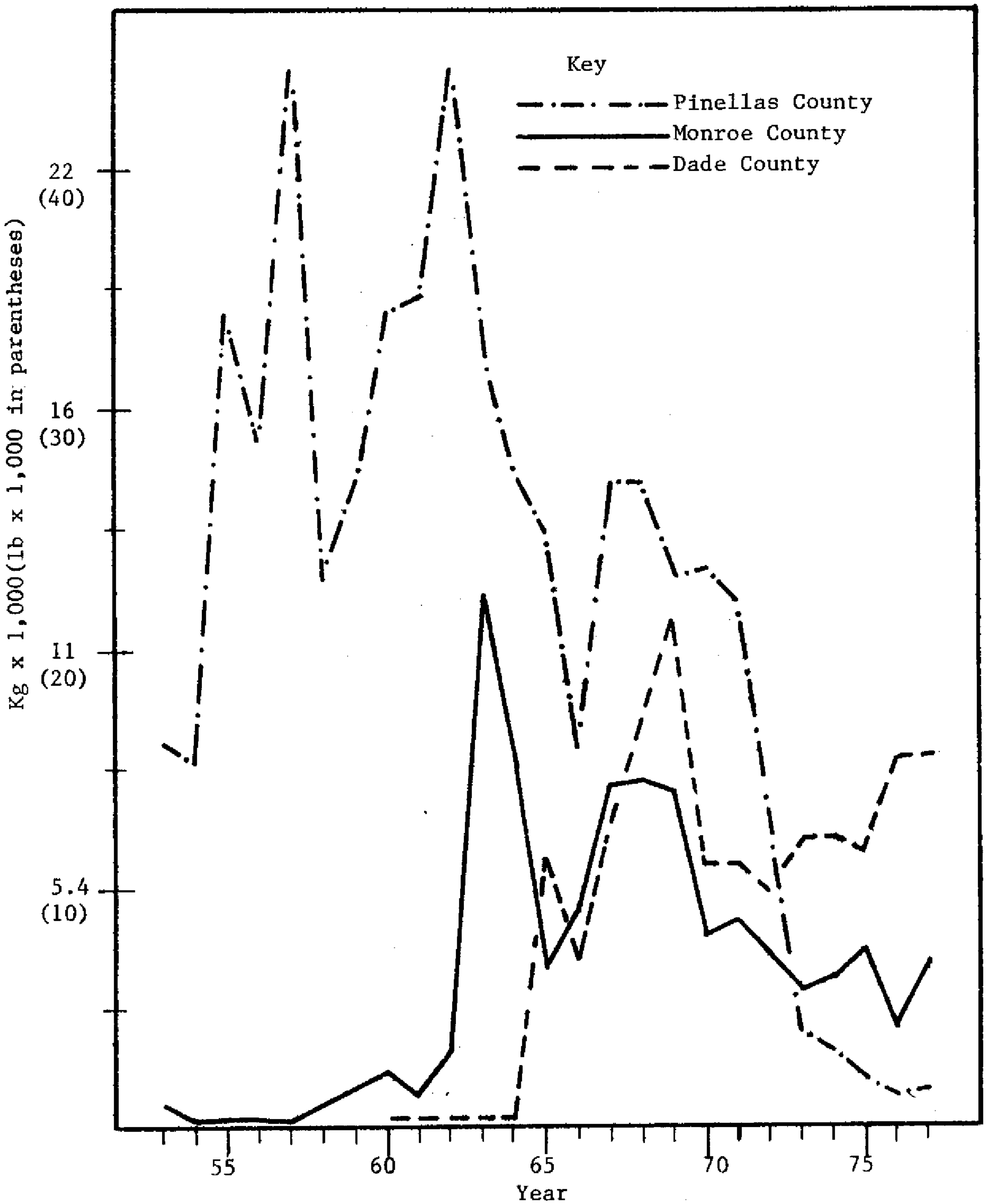


Figure 12. Total Dollar Value Of Sponges Harvested From Sponge Producing Counties Of Florida.

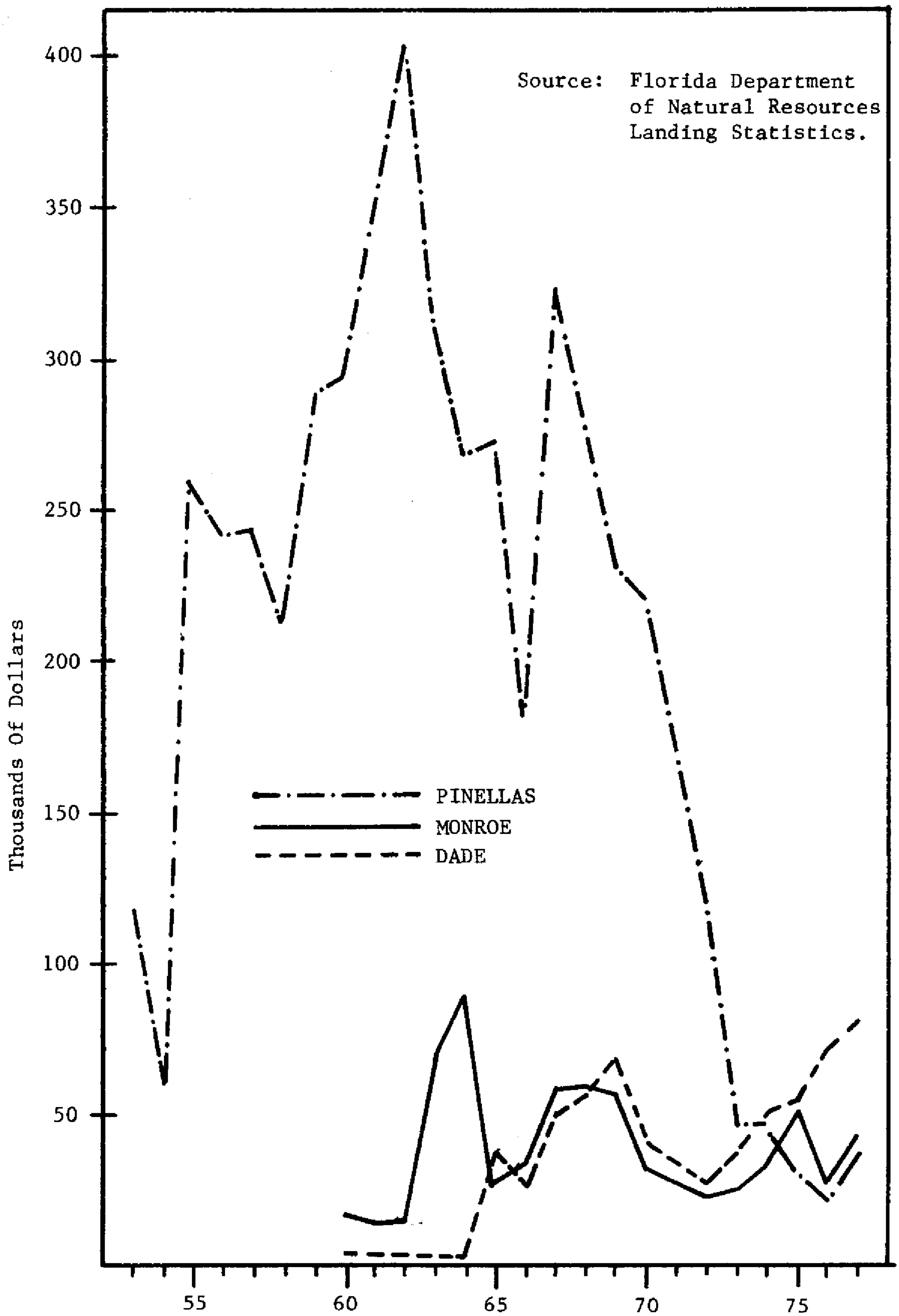
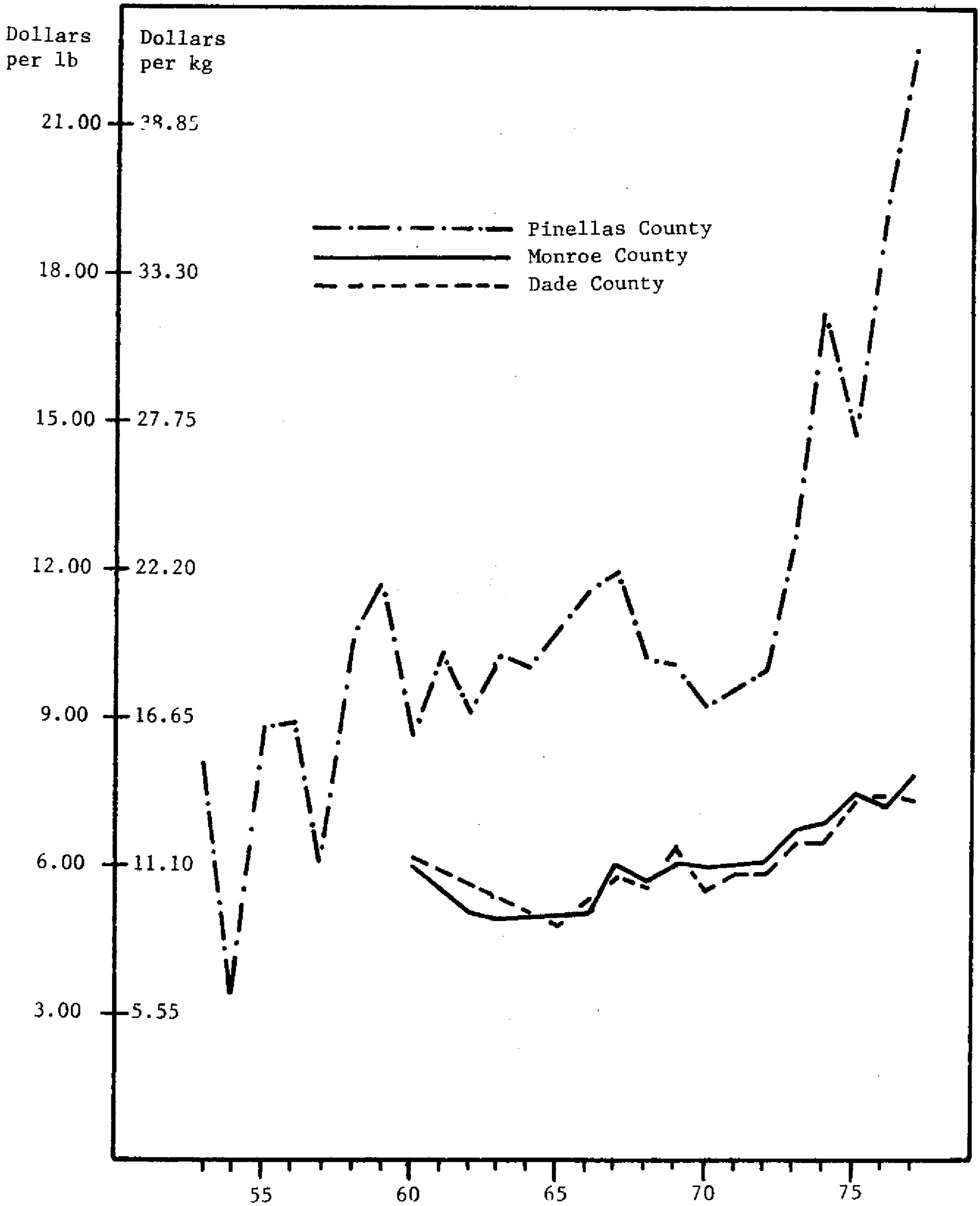


Figure 13. Dry Weight Value (Per Kilogram And Per Pound) Of Sheepswool Sponges Harvested In Different Counties of Florida, 1953-1977.



Source: Florida Department of Natural Resources Landing Statistics.

of the inner fibers and are usually smaller and have a weaker fiber.

2) In Monroe and Dade Counties, all sponges are collected by hooking. Sponges collected by hooking are usually of inferior quality as previously discussed.

3) Sponges collected in Monroe County are often sold through middlemen.

One Tarpon Springs buyer indicated to the present authors that although he paid a higher price for Tarpon Springs sponges, the difference was not nearly as much as reported by the National Marine Fisheries Service(Figure 13). Over the phone a price of $2.40 was quoted for a Tarpon Springs sponge 7 - 7½ in. in diameter while a Keys sponge of the same size was worth $1.80. This would indicate that, to a substantial degree, the difference in price is the result of middlemen buying. To verify this, price quotations for the same sponges were obtained from the Arellano Brothers in Miami and a sponge buyer in Tarpon Springs. However, the results were confusing. One sponge approximately 8 in. in diameter was quoted as being worth $1.30 in Miami, while the price in Tarpon Springs was quoted at $2.00. Other sponges approximately 6 in. in diameter were quoted at the identical price by both sources. While the extent of these results are inconclusive in determining the extent of middlemen mark up, it appears that in some cases it can be considerable. It is significant to note that some spongers feel it worth their time to drive to Tarpon Springs from the Keys in order to obtain a higher price for their sponges.

5.4. Present Market Outlook

Although natural sponges have generally been eliminated from widespread household use, there are some markets for natural sponge in which an acceptable substitute has never been found. Shubow (1969) pointed out that:

> "Synthetic sponges have never posed a threat to the future of natural sponges, since the demand for natural sponges has always been greater than supply. There is a tremendous market for natural sponges regardless of the success of the synthetic sponge."

Natural sponges are in demand in hospitals, since they can withstand the high temperatures needed for sterilization. Other users of natural sponges are painters, lithographers, janitors, artists, ceramic and leather workers, window cleaners, and tile setters. Sponges are also used in the cosmetics, medical, and automotive fields, and by other miscellaneous manufacturers (Shubow, 1969).

Industry continues to demand natural sponges. The sponge industry of Florida has not been able to produce enough sponges to meet this demand, and large quantities of them have to be imported from other sponge producing countries. In 1975, sponges valued at $682,000 were imported into this country (Table V).

Table V. U.S. Sponge Imports in 1975

Country	kg	lb	Dollar Value
Bahamas	7,032	13,022	19,000
Egypt	2,503	4,636	64,000
Greece	15,435	28,583	417,000
Japan	4,855	8,991	75,000
Tunisia	3,821	7,076	66,000
Other	3,238	5,997	41,000
Total	36,884	68,305	682,000

The high prices during the 1940's and shortage of supply during the 1950's resulted in the synthetic sponge capturing the market for house-hold use. Consequently, it has been widely held that natural sponges are no longer competitive. However, if efficient collection methods were introduced, that would provide a greater supply at a reasonable price, there is evidence to indicate that natural sponges would be competitive. Natural sponges exhibit superior qualities of durability and absorbtion. They are also more hygenic due to their porous nature which allows water to be drawn through the sponge in a cleansing action.

James S. Cullison, manager of the Department of Marine Science and Technology, Florida Development Commission has expressed the opinion that there will always be a demand for natural sponges, even at a higher price, due to their superior qualities. He felt that the key to the revival of the sponge industry was in the modernization of both the production and marketing methods, particularly the old fashioned diving techniques (Shubow, 1969).

To prove that the retail market in sponges still exists, Cullison directed a survey for the Florida Development Commission. One thousand sheepswool sponges averaging 12.8 cm (5 in) in diameter were distributed from door to door. The results of this survey indicated that a large market would exist if sheepswool sponges were made available through retail outlets for household use at a competitive price (there was no indication of what a competative price would be). The survey indicated that 95% of those who tried the sponges would purchase them at retail stores if they were available (Shubow, 1969).

Communication with sponge buyers has indicated a desire on their part to obtain more sponges. The Arellano Brothers, sponge buyers in Miami, have indicated that they could sell more sponges than they presently are able to buy (pers. comm.). Mrs. Myrtle Perry, a sponge buyer in Tarpon Springs, Florida (pers. comm.) provided the following observations on the sponge market:

1) there may be a market for as much as 54,000 kg (100,000 lb) of sponges a year, five times the current landings;

2) presently customers have to wait to have their orders filled, and many customers are being lost due to the industry's inability to fill orders;

3) no new people are entering the business.

Comparison of prices paid for sponges gathered in Florida to the Consumer Price Index (the C.P.I. is a relative measure of price changes compared to the base year, 1967) indicates that the price of sponges has not kept pace with the inflation rate experienced by the U. S. economy (Figure 14). Dade County is excluded from the graph but displays essentially the same pattern as Monroe County. The result has been a decrease in the "real" return to the sponge harvester for his efforts. The dramatic decline in production in the Tarpon Springs area beginning in 1972, is probably the cause of the more recent upward surge in the price for sponges from all areas of Florida (Figure 13, page 40).

The inflation rate (ie; the CPI increase) of chemicals and allied products (Figure 14) in recent years has been even more dramatic than that for all commodities. Perhaps this will enable the natural sponge to compete more effectively with the synthetic varities and result in higher prices and returns to the sponge harvester.

In summary, although natural sponges have been eliminated from widespread use, current production is insufficient to meet existing demand, and large quantities have to be imported. Despite this need for sponges, there has been continual decline in sponge production, and an inability of prices paid for sponges to keep pace with inflation. Modernization of production and marketing methods might result in: 1) increased utilization of Florida sponges to meet current demand, and; 2) expansion of the presently existing market.

6. SPONGE CULTURE POTENTIAL

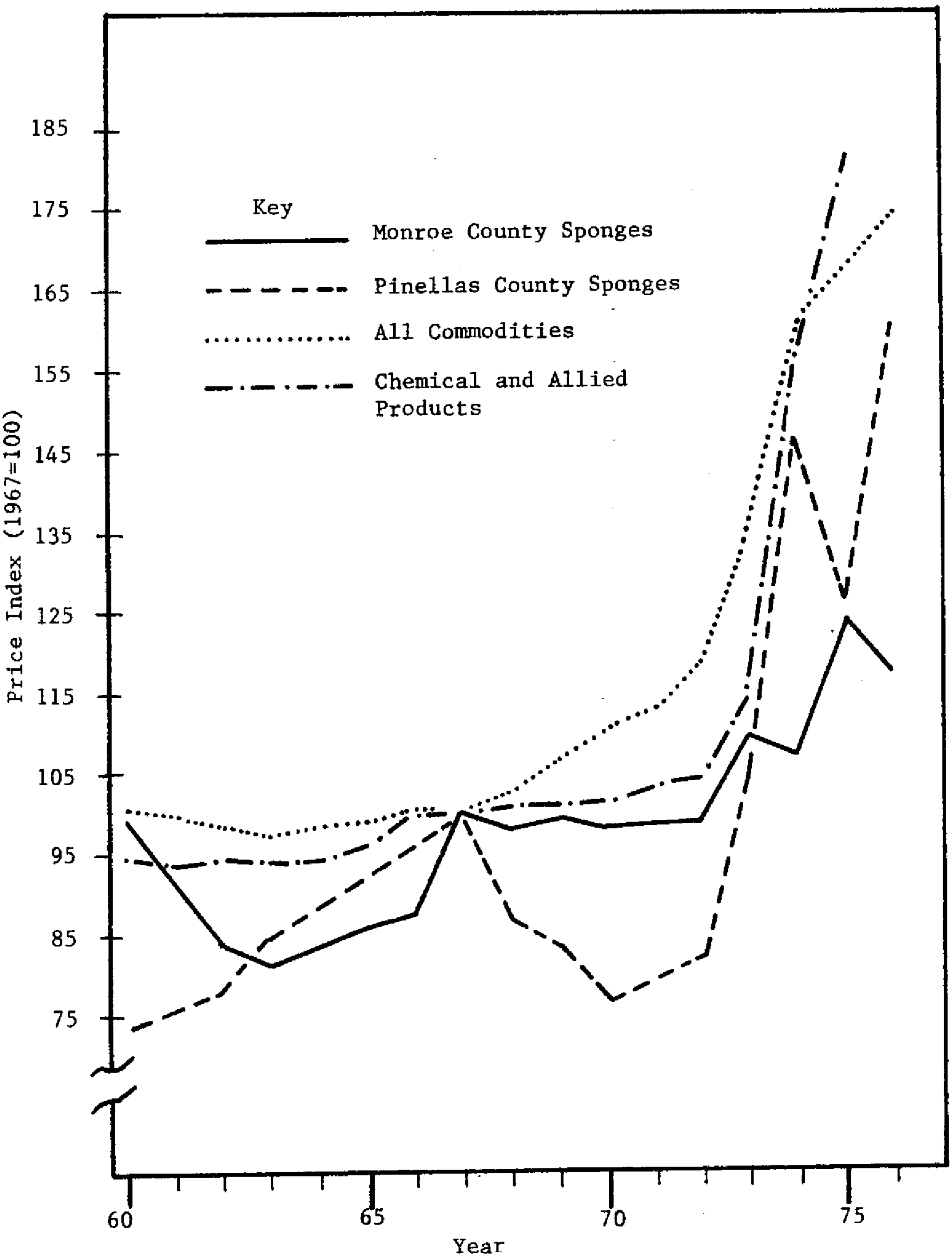
6.1. History of Sponge Culture

In order to insure a more consistant and cheaper supply of sponges men in the past experimented with sponge culture. The basis for these sponge culture attempts was the fact that sponges cut into pieces would attach to foreign bodies and grow.

The first practical suggestion that sponges' regenerative capabilities might be utilized in the development of a sponge culture system was made by Oscar Schmidt in 1862(Moore, 1910b). This led to the establishment of a research station on the island of Lesina by the Austrian Government and certain merchants of Trieste in 1863 (Moore, 1910b). It was found that, indeed, pieces cut from commercial sponges could survive and grow to commercial size.

No specific information was reported on growth and mortality, although it was noted that seven years would be required to grow a

Figure 14. Dockside Price of Sheepswool Sponges (adjusted to Consumer Price Index) And Important Price Indices, 1960-1976.



commercial product (Moore, 1910b). Experimentation was ended after nine years because of the hostile attitude of local inhabitants, the inability to develop materials suited for commercial production, and the long per of time required for growth to an adequate size (Moore, 1910b).

The failure of this work ended experiments in Europe, however, a number of men began experimenting with sponge culture in the Florida Keys in the 1880's and 1890's. These efforts failed because of the unsuitable nature of the bottom and materials used, and vandalism by local inhabitants (Shubow, 1969).

Although these early attempts were unsuccessful, in 1910, Dr. H.F. Moore, the director of the U.S. Bureau of Fisheries, established a research facility on Sugarloaf Key, FL, to experiment with sponge culture (Moore, 1910b). Supplied with ample resources, equipment, and manpower (this had not been the case in many of the previous privately conducted experiments), he was able to develop a successful method of sponge culture. The planting process consisted of cutting live adult sponges into pieces and attaching them to cement slabs with alunimum or lead wire (Figure 15). Dr. Moore concluded that sponge culture was feasible if the following conditions were met:

1) selecting an area that could be guarded against vandals;

2) absence of fresh water run-off;

3) firm bottom to prevent concrete discs from sinking;

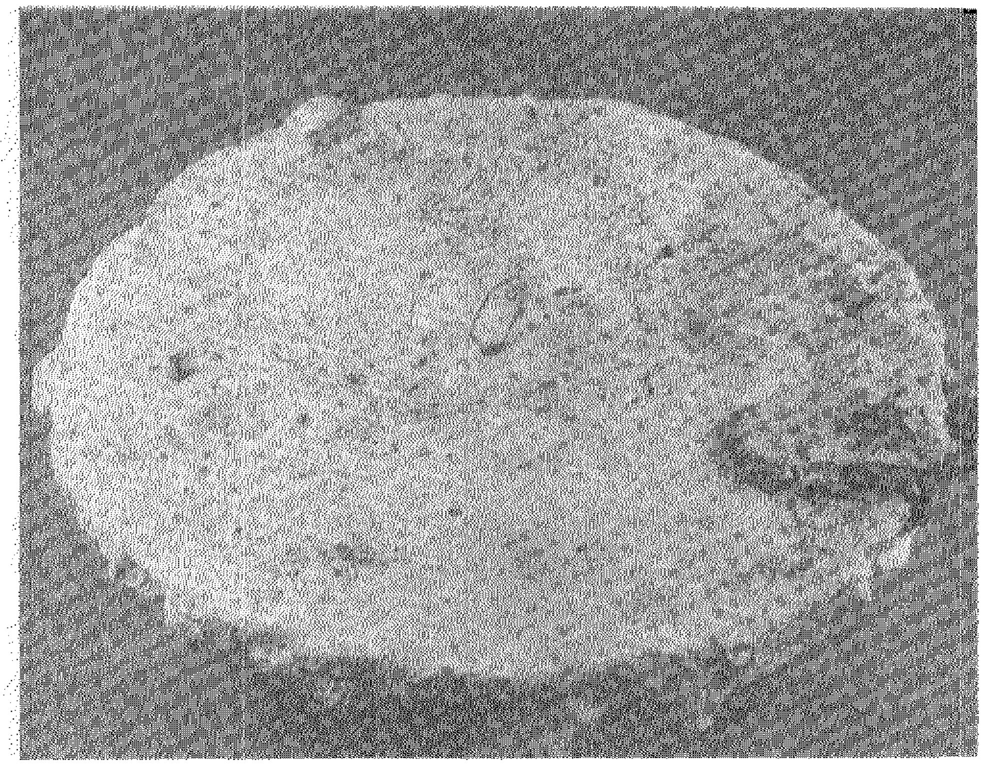
4) use of concrete discs 25.4 cm (10 in) in diameter and 5.0 cm (2 in) thick tied with alunimum wire (Figure 15);

5) water shallow enough for quick and easy planting and harvesting.

Impressed by these findings several Englishmen established the Florida Sponge and Fruit Company and began a sponge farm on Sugarloaf Key, Florida. By 1912, over 100 persons were employed in the enterprise and the site was on its way to becomming the largest community in the Keys east of Key West (Shubow, 1969). The firm expected to enter the commercial sponge business with an anticipated annual output of 2,000,000 sponges, however, financial disaster was precipitated by the outbreak of World War I. The majority of stockholders were British citizens with their assets in British banks. At the start of the war Great Britian froze the firms assets and the company was left with insufficient financial resources to continue operation. Attempts to raise capital from American investors were unsuccessful and several hundred thousand sponges were left to poachers who fished the waters in this area for many years afterwards (Shubow, 1969).

Failure of the sponge culture venture on Sugarloaf Key marked the end of attempts to raise sponges in America. However, from 1927 until 1943, the Japanese carried on extensive experimentation on sponge culture in the South Pacific. Although early experimentation was unsuccessful due to selection of unsuitable sponge habitat, sponges were successfully raised at Ailinglapalap Atoll in the Marshall Islands (Cahn, 1948). The most successful method developed by the Japanese was the floating bottle method. This entailed stringing sponges on a piece of alumimum wire which was anchored on one end and supported at the other end by a float (usually a sealed beer bottle). All of the Japanese sponge research in the South Pacific ended with the occupation of Japan at the end of World War II (Cahn, 1948).

Figure 15. Cement Disc Used for Growing Sponges in the Sugarloaf Key Area. Such discs were typically 25.4 cm (10 in) in idameter. Note wire in center of disc for attaching sponge cutting This disc was found intact after remaining under water for nearly 60 years.



The practicality of sponge farming was further demonstrated by the British Government in the Bahamas and British Honduras. The planting method was similar to that developed by Dr. Moore. Sponge cuttings were tied to concrete discs with a length of palmetto string (made from splitting a palmetto string) and placed on firm mud bottom in about 6 feet of water where there was good but not excessive tidal flow. The raw surface of the cut was found to heal over within 2 weeks, with the new sponge being rounded out with new growth within 6 months. Approximately three years was required to grow a commercially valuable sponge (Walton Smith, pers. comm.).

Although large numbers of sponges were raised around Andros Island, Bahamas and at Turneffe Lagoon, British Honduras, from 1935 until 1939, the sponge blight of 1939 completedy wiped out the planted sponges (Storr, 1964). Apparently there have been some sponges grown at a plantation at Pot Cay, Andros Island, in the years since the blight, but not on an active commercial basis (Storr, 1964).

To the best of our knowledge there are no commercial sponge culture ventures in existance today.

6.2. Present Day Practicality of Sponge Culture

Past experimentation with the culture of sponges has shown that, due to their regenerative power, sponges may be artifically cultivated from cuttings. Unfortunately, the occurence of disease and/or war have prevented sponge culture programs from realizing their potential. Since harvesting of natural sponges in Florida has proven insufficient to meet current demands (see section 5.4), sponge culture ventures might be able to supply the sponges currently imported from other countries. However, a number of disadvantages as well as advantages of sponge culture can be identified.

6.2.1. Advantages Of Sponge Culture

1) The planting operation has been successfully demonstrated and is a relatively simple operation.

2) Sponges can be concentrated in a small area and therefore loss of time in harvesting is minimized. Also, sponges can be collected as needed while the remaining sponges continue to grow.

3) When sponges are cut from a rock or cement disc, the remaining base produces a new sponge. Therefore, the operation of harvesting and planting would be accomplished at the same time.

4) Cultivation of sponges allows for some control over quality, size, and shape through the proper selection of the seed sponges, the growth area, and the growth period.

5) Cultivation of sponges would provide a reliable and increasing supply of sponges. This might enable natural sponges to expand their market into areas dominated by the synthetic varities.

6) Cultivation of sponges would provide an opportunity to increase quality and value by selective breeding. It would not be unreasonable to expect reduction of time from planting to harvesting by selection of sponges exhibiting rapid growth rates.

7) Heavy concentration of sponges in the cultivation area would result in a large number of naturally growing sponges occurring in the surrounding area.

8) Sponges planted using the cement disc method would in no way interfere with boating activities and reduce legal conflicts.

9) Sponge culture is a clean and non-polluting enterprise that would not conflict with new laws concerning alteration of the natural water supply.

6.2.2. Disadvantages Of Sponge Culture

1) The selection of a growing area that would assure the fastest growth of good quality sponges might require considerable experimentation.

2) A long term lease providing for the cultivation of sponges would have to be obtained. However, this has been provided for by the Mariculture Bill of 1969.

3) Arrangements would have to be made for patrolling the area to prevent theft. This has been a serious problem in sponge culture ventures in the past.

4) Due to the slow growth rate of sponges, harvesting could not begin until the third or fourth year of operation. Full production might not be reached until several years after the first harvest.

5) Sponge disease, although it appears infrequently, would be a constant threat. Disease would probably spread very quickly among densely planted sponges.

6) If large numbers of people turn once again to collection of "wild" sponges, the market might become flooded.

7) Large scale production would require an increased market size to ensure obtaining a reasonable price.

6.3 A Sponge Farm Model

In order to evaluate the potential monetary return of a sponge farm the costs and returns of a hypothetical sponge farm were calculated (Table VI). The planting schedule and labor requirements are based on Storr's (1964) description of the planting operation used by the British Government in the Bahamas and British Honduras. During the first three years five men would be required to collect sponges and plant 50,000 cuttings per year. Assuming an 80% survival rate and that three years would be required to grow a commercial size sponge, 40,000 sponges would be harvested in the fourth year of operation. From the sponges harvested 10,000 to 15,000 would be used to increase plantings to 100,000 sponges per year (this would probably require 10 men). This same schedule would be continued during the 4th, 5th, 6th, and 7th year. After the seventh year no additional cuttings would be necessary since sponges could be cut from the concrete disc so that a new sponge would grow from the sponge material left behind.

The calculations presented in Table VI show that a profit would not be obtained until after seven years. Full production would not be reached until the tenth year of operation. Considering the potential problems that could be encountered (section 6.2.2.) sponge culture would appear to be a risky undertaking. It should be noted that the major expense is labor. Therefore a sponge culture venture in a lesser

Table VI. Summary of Pertinent Information For A Hypothetical Sponge Farm Employing The Concrete Disc Method.

Year	Year Class Harvested	kg. (lbs.) Harvested	Cost	Gross Return	Net Return
1	----	----	66,500	0	-66,500
2	----	----	54,500	0	-54,500
3	-----	----	54,500	0	-54,500
4	1	945 (2,083)	117,000	27,287	-89,713
5	2	945 (2,083)	109,000	27,287	-81,713
6	3	945 (2,083)	109,000	27,287	-81,713
7	4, & 1	4,536 (10,000)	109,000	131,000	+22,000
8	5, & 2	4,536	47,000	131,000	+84,000
9	6, & 3	4,536 (10,000)	47,000	131,000	+84,000
10	7,4, & 1	7,560 (16,667)	47,000	218,000	+171,000

ASSUMPTIONS:

1) One sponge planted per 0.836 m^2 (1.0 yd^2) ; 2) end of 7th year 45.98 hectares (113.3 acres) under cultivation; 3) 26.4 sponges 1 kg (12 sponges/lb.); 4) \$28.82 kg (\$13.10 lb), average of ex-vessel prices paid for Tarpon Springs sponges and Monroe County sponges. 5) 80% survival rate over the three year time span required to grow a commercial size sponge; 6) labor, 5 men needed for years 1-3 to plant 50,000 cuttings per year, 10 men needed for years 4-7 to plant 100,000 cuttings per year, after 7th year 5 men needed for farm operation; salary-\$8,000 per year; 7) concrete discs- \$0.15/disk - 50,000 needed years 1-3; 100,000 needed years 4 - 7; none needed after 7 years; 8) boats and boat maintenance -2 boats used years 1 - 3; 4 boats used years 4 - 7; 2 boats used thereafter; maintenance - \$1,000 per boat per year; gas and oil - \$2,500 per boat per year.

* Assumptions pertaining to labor, number of sponges planted, and return in lbs of sponges from Storr, 1964.

developed country with substantially lower labor costs would appear considerably more attractive.

7. CONCLUSIONS AND RECOMMENDATIONS

Conclusion 1

The sponge fishery of Florida has been reduced to a small fraction of its former importance. This condition has existed for the past 30 years and has been the result of a combination of several factors:

1) decimation of natural populations due to disease in 1939 and 1947;

2) heavy fishing pressure acting in conjunction with the sponge disease resulting in an almost total elimination of the natural sponge supply and precluding quick recovery to former production levels.

3) people leaving the industry when production fell and then did not immediately return to levels adequate to support them;

4) introduction of the synthetic sponge at a significently lower price reduced demand for natural sponges.

Conclusion 2.

Sponge production from Monroe and Dade Counties now surpasses production from the Gulf of Mexico sponge grounds off Tarpon Springs, the traditional sponging center in Florida for the past 70 years. This has been the result of decreasing fishing effort in Tarpon Springs while fishing effort has increased in Monroe and Dade Counties due to the establishment of a Cuban sponging community beginning in the mid 1960's.

Conclusion 3.

Although the market for natural sponges is only a fraction of its former size, current sponge production levels are insufficient to meet demand. Considerable quantities of sponges are imported into the U.S. from other sponge producing countries, and Florida sponge buyers have indicated the ability to sell more sponges than they currently are capable of buying. The magnitude of currently existing demand as indicated by sponge imports (68,000 lbs in 1975) only represents a fraction of sponge production prior to the sponge blight of 1939. If sponge stocks have fully recovered in the last 30 years, this demand could easily be met while providing a yearly return to fishermen of approximately $500,000 - $600,000 (the 1975 value of sponge imports).

Recommendation A. Field research should be undertaken to objectively determine if sponge stocks have recovered from past mortalities and intensive fishing pressure.

Recommendation B. In light of the inability of current sponge production to meet demand, and the possibility that sponge stocks have recovered due to decreased fishing pressure (this will have to be objectively verified), commercial sponges should be considered an underutilized fishing resource. Since the Gulf of Mexico Fishery Management Council will probably be considering a management plan for commercial sponges in the future (Mr. Terrance Leary, Gulf of Mexico Fishery Management Council, pers. comm.), the potential for increased utilization of this resource should be carefully considered in the preparation of that management plan.

Conclusion 4

SCUBA and surface supplied air diving gear may be a more efficient harvesting method than the methods used in the past.

Recommendation A. Field research aimed at evaluating the efficiency of SCUBA and/or surface supplied air diving gear for harvesting sponges should be undertaken.

Conclusion 5.

A considerable difference in prices paid to fishermen for Tarpon Springs sponges vs. Florida Keys sponges exists. Part of this difference is due to the inherently superior qualities of Tarpon Springs sponges. However, to an undetermined degree (see section 5.3), different prices may be obtained for sponges of equal quality, depending on whether the sponges are sold to wholesalers in Tarpon Springs or Miami.

Recommendation A. In preparing a commercial sponge management plan, the Gulf of Mexico Fishing Management Council should carefully examine sponge marketing, and determine if there is potential for increased monetary returns to the fishermen for Florida Keys sponges.

Conclusion 6.

Past experimentation has proven that sponge culture is possible. However, high labor costs, and length of time required to attain a profitable operation, and threat of sponge disease are major drawbacks. Sponge culture would be far more practical in a lesser developed country with low labor costs.

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