2.—NOTES ON BISCAYNE BAY, FLORIDA, WITH REFERENCE TO ITS ADAPTABILITY AS THE SITE OF A MARINE HATCHING AND EXPERIMENT STATION.

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The United States Commissioner of Fish and Fisheries having under consideration the establishment of a hatching and experiment station on the coast of Florida, the writer was directed to visit Biscayne Bay to ascertain the adaptability of the region for the purpose named. A period of about two weeks in February, 1895, was devoted to the examination, and the accompanying memoranda embody the observations then made.

In constructing a station on the east coast of Florida for the purpose of preserving and increasing the supply of economic marine products of the region, of studying scientific problems having an important bearing on the directly practical work of such a station, and of pointing out the lines along which the fishery resources of the State may be developed, the essential point to be determined is the most advantageous location.

The desire of the Commissioner of Fish and Fisheries to have such a station deal with as many classes of water animals as can properly be considered, including sponges, oysters, turtles, terrapins, and, possibly, several crustaceans, as well as fish, makes it necessary to seek a more southern position than would be required if the operations were to be more restricted. The interest of late being manifested in the preservation and extension of the sponge fishery, both by the public men of the State and by those engaged in the industry, renders it especially desirable that sponges should be one of the subjects to receive attention. As the natural distribution of the marketable sponges embraces only the southern fourth of the east coast of the State, a marine station would have to be located at least as far south as Lake Worth. The latter body of water has many advantages as the site of a station, being readily accessible by rail, bountifully supplied with desirable food-fishes, and possessing excellent land features; but the absence of a natural growth of sponges in the lake itself, and the excessive salinity of the water, owing to the circumstance that no fresh-water streams drain into the lake, thus precluding the possibility of successful oyster

culture, are thought to be sufficient reasons for debarring it from present consideration.

South of Lake Worth, the physical and other conditions are not favorable for the purpose in question until Biscayne Bay is reached, while the region south of that bay is too remote from present and prospective lines of communication to entitle it to notice. It was, therefore, the Biscayne Bay region that the Commissioner of Fish and Fisheries conceived to be the most inviting section of the east coast of Florida for the special object named, and it was there that the writer was instructed to make a preliminary investigation covering the physical conditions, natural resources, eligible sites for a station, commercial fisheries, and prospects for the future development of the fishing industry.

The inquiries of the Commission were greatly facilitated by Mr. J. E. Ingraham, general agent of the Jacksonville, St. Augustine and Indian River Railroad, and by Hon. Frederick S. Morse, of Miami, to whom acknowledgments are due.

GEOGRAPHICAL FEATURES OF THE BISCAYNE BAY REGION.

Key Biscayne Bay, or Biscayne Bay as it is more commonly designated, is one of the finest bodies of water on the coast of Florida. It is the most northern member of a series of shallow bays or sounds intervening between the Florida keys and the mainland. It occupies almost the extreme southern part of the east side of Florida and extends from 25° 57′ to 25° 22′ north latitude, its length being about 35 miles. Its northern third is comparatively narrow, having an average width of only 2 miles. The remaining part has a maximum width of about 8½ miles and an average width of 7 miles. Its area is 210 miles. On the south, at Arseniker Keys, it merges into Cards Sound. In the upper 10 miles of its length it is separated from the Strait of Florida by a very narrow strip of mainland ending at Norris or Narrow Cut, which is the most northern opening into the bay. South of this inlet the following keys form the eastern boundary of the bay: Virginia Key, Key Biscayne, Soldier Key, Ragged Keys, Sands Key, Elliott Key, and Old Rhodes Key. The largest and widest of these is Key Biscayne, at whose southern end is Cape Florida, which marks the principal passageway into the bay.

The shores of the bay are for the most part low and densely overgrown with mangrove trees; in places, however, on he mainland, the shores are comparatively high, consisting of an abrupt bank of coral limestone overgrown with deciduous trees, constituting a topographical feature said to exist nowhere else in Florida.

The bay is shoal throughout. In that part north of the Miami River a greater depth than 7 feet is not found, and the average is not more than 4 feet. In the southern part the depth varies from 7 to 13 feet in the center of the bay and gradually decreases toward the shores. The

deepest water occurs in a small depression west of Cape Florida, where from 13 to 17 feet are found.

The water of Biscayne Bay is exceedingly clear. In no part can one fail to clearly distinguish objects on the bottom when the surface is not especially rough. It seldom becomes roily, and the amount of muddy water brought down from the Everglades is too small to have any noticeable effect on the clearness of the bay.

Four small streams flow into the northern third of the bay from the mainland, and exert an appreciable influence on the salinity of the water and the character of the fauna. At the extreme northern end of the bay, Snake Creek enters; one branch rises in the Everglades, another in Dumfounding Bay, a small, shallow lagoon located in a long, wide marshy belt intervening between the ocean and the pine lands. Arch Creek is a short Everglade stream discharging near the head of the bay. About 8 miles south of Snake Creek, Little River enters the bay, flowing from the Everglades, which at this point are within 2 or 3 miles of the bay. The largest stream emptying into the bay is the Miami River, whose mouth is nearly opposite Norris Cut, the most northern passage between the bay and the ocean. A few creeks flow into the lower part of the bay, but their volume is too small to have any effect on the water of the bay. The water brought down by all the streams named is mostly clear, but has a dark-brown color, owing to the presence of decomposed vegetable matter. On the eastern side of the bay, opposite the entrance to Little River, a long, narrow body of water, known as Indian Creek, communicates with the bay by three broad mouths. It extends parallel with and near to the coast for a distance of 5 miles. The water is in general much deeper than that in the adjacent part of the bay and is salt throughout.

Besides the water discharged by the rivers mentioned, it is said that considerable fresh water enters the bay from the Everglades by seepage. The surface of the Everglades is reported to be 10 or 12 feet above the level of the bay, and the underlying coral formation between the Everglades and the coast prevents much absorption by the soil and serves as an underground drain. At a depth of a few feet fresh water may be found at almost any point on the shore of the mainland.

The shores of the bay are very thinly populated, and only at a few points are there settlements. The latter, which are very small, are all on the mainland, and are located on the northern half of the bay. The most northern community is Lemon City, situated a short distance south of the mouth of Little River. Six miles farther south is Miami, at the mouth of Miami River. The principal settlement is Cocoanut Grove, opposite Cape Florida. Buenavista is a small place between Miami and Lemon City. The mainland below Cocoanut Grove is an almost unbroken wilderness, known as the "Hunting Grounds," and resorted to by the Seminole Indians. Some of the keys are under partial cultivation and have a sparse population.

ANIMAL RESOURCES OF BISCAYNE BAY.

The animal resources of the southern part of the eastern coast of Florida are very abundant and varied. The rich West Indian fauna, which extends to this region, is supplemented by numerous species belonging to a more northern faunal area. Biscayne Bay and the water lying about the adjacent keys and reefs are probably as well supplied with economic water products and interesting forms having special scientific value as any part of the Florida coast. Mammals, fishes, reptiles, crustaceans, oysters, sponges, and other invertebrates of commercial importance occur. The following notes on some of the more valuable products are intended rather to illustrate the possibilities for developing the fisheries of the region than to serve as even an incomplete list of the animals of different classes there found:

MAMMALS.

The mammalian resources of the region are limited, and will scarcely ever support commercial fishing of much importance. The most interesting mammal is the sea cow or manatee (*Manatus americanus*). It is by no means common, but is not especially rare. It is found throughout the bay, in Indian Creek, and in the lagoons on the bay side of the keys, and is sometimes observed in droves in the ocean near the bay. Up to a few years ago it was assiduously persecuted by all classes of people and killed in pure wantonness; it was yearly becoming scarcer, and its extermination in a short time seemed inevitable. Mr. F. S. Morse, of Miami, brought up the question of preserving the sea cow in a recent session of the Florida legislature and secured the passage of a law prohibiting under heavy penalties the killing of that animal except for scientific purposes.

Porpoises of various kinds frequently enter Biscayne Bay, where large schools are at times seen, while outside the bay they are also common. The shoal waters of the bay appear to be favorite feeding-grounds, and they may often be observed in water hardly deep enough to cover them where they have followed the schools of mullet. A few are killed for their oil, but there is no regular effort made to take them. Small schools and straggling individuals were observed on several occasions during my visit.

FISHES.

These are the most interesting and important of the water animals of this region. The number of species of economic importance which inhabit the bay and the adjoining ocean is very large and includes some of the best food-fishes of the United States. The comparatively shallow water of the bay affords excellent feeding-grounds for some of the pelagic fishes, besides being the resort of many other fishes which regularly frequent the littoral waters. It is not known that any systematic collecting has been done in Biscayne Bay, and a full list of the

fishes can not be given, but the following list, based on personal observations and inquiries in February, 1895, is thought to embrace most of the principal economic fishes of the bay at that season. The unusual cold which prevailed in Florida during the month of February had driven nearly all the important fishes into the ocean, and many of them had not returned in any noteworthy numbers when the examination of the bay was made.

Bonefish (*Albula vulpes*).—Common. Taken by the professional line fishermen.

Tarpon (*Megalops atlanticus*).—Large numbers enter the bay, the northern part of which seems to be the ground most frequented. During the cold weather which prevailed throughout Florida in February many tarpon were killed in the upper bay by the sudden change in temperature before they could reach the ocean. February 8 and 9 were very cold days on Biscayne Bay, the thermometer on the morning of the 9th registering 26° F. On that day a few numb fish were observed near Lemon City. On February 11 Mr. J. H. Peden picked up 24 dead or dying tarpon, weighing from 30 to 160 pounds each, and placed them on his land for fertilizing purposes, and during the few days following the cold snap over 200 tarpon were secured and utilized in a similar way by people living in the vicinity of Lemon City. Many of the fish were not dead when found, but were floating belly up in a stupefied or benumbed condition, and it would appear that the immediate cause of death was drowning or asphyxiation. On February 16 and 17 about 25 dead tarpon, with an average weight of 75 or 80 pounds, were observed by the writer in different parts of the bay. These had begun to decompose. By that time the water of the bay was getting warmer, and a school of several hundred very active tarpon was seen at the mouth of the Miami River.

Striped Mullet (*Mugil cephalus*).—Abundant at all times. Ascends the fresh-water rivers as far as the Everglades. But little utilized in this region, although the most valuable Florida fish.

Barracuda (*Sphyræna picuda*).—Reported to be found in the bay at all seasons, but takes the hook most freely in April and May, when it is caught by trolling along the shores. Single fish or scattered bodies were often seen in the grassy flats in the upper part of the bay.

Spanish Mackerel (*Scomberomorus maculatus*).—At one time this fish was common in the bay, which was a favorite resort, but it is now scarce, and is said to have become so since the extensive seine fishing by Gloucester vessels began along the keys about five years ago.

Kingfish (*Scomberomorus cavalla*).—Sometimes enters the bay in schools, but is not common. About the inlets is found in large bodies, and is taken by trolling. Examples weighing from 6 to 30 pounds observed.

Pompano (*Trachinotus carolinus*).—This, the best and most popular of the Florida food-fishes, is probably less abundant in Biscayne Bay than in Indian River and Lake Worth; in the absence of net fishing, however, no accurate idea of the abundance of the fish can be gained.

Permit or Pompano (*Trachinotus rhodopus*).—This large pompano, which attains a weight of over 25 pounds, is not uncommon along the keys.

Runner or Crevalle (*Caranx crysos*).—Very common in the inlets.

Jack or Crevalle (*Caranx hippos*).—Very common.

Bluefish (*Pomatomus saltatrix*).—Not common, and as a rule found only in the vicinity of Cæsar Creek, in the lower part of the bay. The presence of large schools of kingfish at the inlets is thought by some to keep the bluefish out of the bay.

Squirrel-fish or Sand Perch (*Diplectrum formosum*).—Very common in the bay adjacent to the inlets. A small but good food-fish. At Norris Cut, on February 21, the fish was found in great abundance, biting readily at a hook baited with conch meat; all caught were 7 or 8 inches long.

Groupers (*Epinephelus and Mycteroperca*).—At least six species of groupers are found in greater or less numbers in the lower part of the bay and about the adjacent reefs, keys, and inlets. All are valuable food-fishes, some being very small and others very large. Small jewfish (*Epinephelus nigritus*) occur in the bay, but the larger ones are rare; some individuals weighing 250 pounds have, however, been taken in the bay.

Sheepshead (*Archosargus probatocephalus*).—Common, and averages about 4 pounds in weight, the largest being about 7 pounds. Feeds largely on raccoon oysters.

Yellow-tail (*Ocyurus chrysurus*).—Common about the reefs and inlets.

Mangrove Snapper (*Lutjanus griseus*).—Extremely abundant around the shores of the bay and not uncommon in the fresh-water streams almost as far as the Everglades. At times in February the fish was found in incredible numbers under the mangrove trees, the shores for miles being lined with immense bodies of snappers, in company with smaller quantities of redfish, pigfish, mullet, and other fishes. The average weight of the fish was probably less than a pound, but some weighed 4 or 5 pounds. This fish is quite shy, and in the clear waters of the region takes the hook with great hesitation. Several other snappers, *e. g.*, the schoolmaster (*L. caxis*) and the lane snapper (*L. synagris*), are also common in the bay.

Grunts, etc. (*Hæmulon*).—Numerous species of sparoid fishes belonging to this genus are found in and adjacent to the bay. They occur in abundance and are all valuable as food. A number of fish belonging to closely related genera also frequent the Biscayne region.

Redfish or Channel bass (*Sciæna ocellata*).—Abundant at all seasons. It is generally regarded as an excellent food and game fish.

Spot (*Leiostomus xanthurus*).—Common in bay.

Drum (*Pogonias cromis*).—Found near the oyster beds in the bay. Common. By most persons it is looked on as a food-fish of little value, owing to the fact that it is reported to always have "worms" in its back.

Trout (*Cynoscion nebulosus*).—Common.

Anchovies (*Stolephorus*).—Several species of anchovy occur in great abundance in the bay and constitute an important food for the larger fishes. Doubtless the business of salting and canning these fish would be profitable and will in time be undertaken.

In the small fresh-water streams entering the bay the supply of food and game fishes is large, although the variety is limited. Besides the mangrove snappers, mullet, and several other salt-water species which are almost constantly found in these rivers, there are large-mouth black bass (*Micropterus salmoides*) and a number of sunfishes belonging to the genera *Lepomis*, *Acantharchus*, and *Chænobryttus*.

Mr. W. F. McCormick, of Cocoanut Grove, has devoted some attention to the fish fauna of Biscayne Bay, and, in response to a request, furnished the following list of species he had taken or observed in that body of water. Mr. McCormick states that the list is not complete, as it does not contain a number of species, principally of small size, which he was unable to identify. The common and scientific names are those given by Mr. McCormick, with a few exceptions indicated by means of brackets.

List of marine fishes observed in Key Biscayne Bay, Florida, by W. F. McCormick.

1. Yellow shark (*Carcharhinus platyodon*).
2. Cub shark (*Carcharhinus lamia*).
3. [Sharp-nosed shark] (*Carcharias terræ-novæ*).
4. Bonnet-cub (*Sphyrna tiburo*).
5. Hammerhead (*Sphyrna zygæna*).
6. Stingaree (*Trygon sayi*).
7. Whip ray (*Stoasodon narinari*).
8. Sawfish (*Pristis pectinatus*).
9. Catfish (*Ailurichthys marinus*).
10. Catfish (*Arius felis*).
11. Anchovy (*Stolephorus mitchilli*). There are numerous species of *Stolephoridæ* and *Clupeidæ* here, but I can not give their correct names.
12. Tarpum (*Megalops thrissoides*).
13. Bonefish (*Albula vulpes*).
14. Houndfish (*Tylosurus notatus*).
15. Houndfish (*Tylosurus crassus*).
16. Needle-fish (*Hemirhamphus roberti*).
17. Needle-fish (*Hemirhamphus unifasciatus*).
18. Skipjack (*Scombresox saurus*).
19. Mullet (*Mugil cephalus*).
20. Silver mullet (*Mugil curema*).
21. Sardine (*Atherina stipes*) [=*laticeps*].
22. Barracuda (*Sphyræna picuda*).
23. Spanish mackerel (*Scomberomorus maculatus*).
24. Kingfish (*Scomberomorus cavalla*).
25. Cero (*Scomberomorus regalis*).
26. Bonito (*Sarda sarda*).
27. Crevallé or Jack (*Caranx hippos*).
28. Yellow jack (*Caranx pisquetus*) [=*bartholomæi*].
29. Running jack (*Caranx chrysus*).
30. Pompano (*Trachinotus carolinus*).
31. Permit (*Trachinotus goreensis*) [=*goodei*].
32. Permit (*Trachinotus rhodopus*) [=*falcatus*].
33. Leather jack [*Oligoplites saurus*].
34. Moonfish (*Selene vomer*).
35. Amber jack (*Seriola lalandi*).
36. [Scad or Round robin] (*Decapterus punctatus*). Very rare.
37. Bluefish (*Pomatomus saltatrix*).
38. [Squirrel-fish] (*Serranus fasciularis*) [=*Diplectrum formosum*].
39. [Scamp] (*Mycteroperca falcata phenax*).
40. [Gag] (*Mycteroperca microlepis*).
41. Black grouper (*Mycteroperca bonaci*).
42. Jewfish (*Epinephelus nigritus*).
43. Red grouper (*Epinephelus morio*).
44. Nassau grouper (*Epinephelus striatus*).
45. Red hind (*Epinephelus apua*).
46. Rock hind (*Epinephelus adscencionis*).
47. Rockfish (*Enneacentrus punctatus*).
48. Lane snapper (*Lutjanus synagris*).
49. Mutton-fish (*Lutjanus analis*).
50. Red snapper (*Lutjanus blackfordi*). Very rare.

List of marine fishes observed in Key Biscayne Bay, Florida, by W. F. McCormick—Cont'd.

51. Gray snapper (*Lutjanus griseus*).
52. Schoolmaster (*Lutjanus caxis*).
53. Grunt (*Hæmulon plumieri*).
54. Yellow grunt (*Hæmulon elegans*).
55. Black grunt (*Hæmulon parra*).
56. Chub (*Hæmulon rimator*).
57. Black margate fish [*Hæmulon ?*].
58. Bream (*Lagodon rhomboides*).
59. Yellow-tail (*Ocyurus chrysurus*).
60. Sailor's choice (*Orthopristis chrysopterus*).
61. Porkfish (*Anisotremus virginicus*).
62. Porgy (*Calamus calamus*).
63. Grassfish (*Calamus arctifrons*).
64. Porgy (*Calamus bajonado*).
65. Sheepshead (*Archosargus probatocephalus*).
66. Redfish (*Sciæna ocellata*).
67. Drum (*Pogonias chromis*).
68. White perch (*Bairdiella chrysura*).
69. Weakfish; Trout (*Cynoscion maculatum*).
70. Spot (*Leiostomus xanthurus*).
71. Whiting (*Menticirrus alburnus.*)
72. Whiting (*Menticirrus nebulosus*).
73. Croaker (*Micropogon undulatus*).
74. Shad (*Gerres olisthostoma*).
75. Shad (*Gerres cinereus*).
76. Shad (*Gerres harengulus*).
77. Angel-fish (*Chætodipterus faber.*) There are also other fishes known as "angel-fish" which I am unable to name. [These belong to the genera *Holacanthus* and *Pomacanthus.*]
78. Snooks (*Centropomus undecimalis*).
79. Hogfish (*Lachnolaimus falcatus*).
80. Pug (*Sparisoma flavescens*).
81. [Parrot-fish] (*Sparisoma cyanolene*).
82. Flounder (*Platophrys ocellatus*).
83. Plaice (*Paralichthys squamilentus*).
84. Flounder (*Achirus lineatus*).
85. Sole (*Symphurus plagiusa*).
86. Turbot (*Balistes carolinensis*).
87. Leather-fish (*Monacanthus hispidus*).
88. Shellfish (*Ostracion trigonum*).
89. Cowfish (*Ostracion quadricorne*).
90. Burfish (*Chilomycterus schœpfi*).
91. Porcupine-fish (*Diodon hystrix*).
92. Rabbit-fish (*Lagocephalus lævigatus*).
93. Swellfish (*Spheroides spengleri*).
94. Green moray (*Sidera funebris*).
95. Moray (*Gymnothorax moringa*).

REPTILES.

Among the aquatic reptiles inhabiting the Biscayne Bay region are crocodiles, alligators, green turtles, loggerhead turtles, and diamond-back terrapins.

The crocodile (*Crocodilus acutus*) is of no economic value and is chiefly interesting as a freak of geographical distribution. While it is by no means common, it can not be regarded as rare, and it is known to exist, in communities, in a number of localities around the shores of the bay, as, for instance, in Crocodile Hole near the head of Indian Creek, in a landlocked pond on Virginia Key, and in Arch Creek. From the last-named place specimens of large size have been obtained for museum purposes. It is very wary and difficult to approach, and for this reason appears to be less common than it really is. Almost every season the nests and eggs are found by boatmen under bushes on the sandy shores of the holes to which the animal resorts.

The issue of the Tropical Sun, of West Palm Beach, for March 16, 1895, gave an account of a trip of Mr. Charles B. Cory to Card Sound for crocodiles. A "large family" of crocodiles was found; one 16 feet long was observed, and a specimen 13½ feet long was obtained for Mr. Cory's collection. The paper recalls the killing of a crocodile in Snake Creek about five years ago by Mr. Charles Peacock and Mr. Ralph M. Munroe. This example was 14 feet 7 inches long, and is said to be now in the American Museum of Natural History, New York.

On February 16 the writer came upon a sleeping crocodile in Crocodile Hole, and had an excellent opportunity to identify it. The animal was between 9 and 10 feet long. At the eastern side of the "hole," where there is a small sandy beach, there were numerous crocodile tracks of various sizes. Under a bush at the edge of the beach the native boatman pointed out a depression in which he had on several occasions found crocodile eggs.

The existence of a species of crocodile in the United States was first made known in 1869 by Wyman, who based a paper* on a skull sent from the Miami River.

Alligators (*Alligator mississippiensis*) are found in all the fresh-water streams discharging into the bay. Of late they have been so assiduously hunted by the Indians that their number has been greatly reduced, and the species is approaching extinction here as elsewhere in Florida.

The green turtle (*Chelonia mydas*) is one of the most valuable water animals of this region. It has undergone a noteworthy diminution in abundance within a comparatively few years, and it would appear that some protective measures are urgently demanded in order to preserve it from practical extermination. The poaching of turtle fishermen from Bahama Islands is a source of great annoyance and injury to the people of Biscayne Bay, who have seriously felt the effects of the wholesale capture of turtles on the grounds lying off the bay. As many as 10 or 12 sail of Nassau vessels are sometimes seen taking turtles within jurisdictional waters. They withdraw on the approach of a revenue cutter and are seldom apprehended by the customs officers. As a result of the indiscriminate fishing done by these fishermen the turtle fishery along the reefs and keys is reported to have been almost ruined, and the turtles are yearly becoming scarcer in the bay itself. The turtles found in the bay range from 75 to 10 pounds in weight, the average being about 25 pounds. The average weight of those taken outside is probably 60 or 75 pounds. It is reported by the fishermen that only a few green turtles now visit the beaches of southern Florida and that no eggs are there deposited. This species is supposed to chiefly frequent the shores of Yucatan for the purpose of breeding.

The loggerhead turtle (*Thalassochelys caretta*) resorts to the outer beaches in large numbers for the purpose of depositing its eggs. The supply is much less than formerly owing to the wholesale destruction of the eggs by fishermen and by various predaceous animals, such as bears and raccoons, which walk the beach incessantly at night and devour a large part of the eggs not taken by man. The loggerhead turtle is much less valuable as a commercial product than the green turtle, and is chiefly taken for local consumption, although at times considerable numbers are secured by the turtle smacks from Key West. Their average weight is about 300 pounds.

* Amer. Journ. Sci. and Arts, XLIX, 1870, p. 105.

The diamond-back terrapin (*Malaclemmys palustris*) is found in suitable situations throughout the bay. It is said to be most abundant in the southern part. It is said to be somewhat inferior in food value to the same terrapin taken farther north. No efforts are made to take it for shipment or local sale.

CRUSTACEANS.

This section is well supplied with crustaceans suitable for food, but, owing to the absence of any fisheries for them, their abundance and local distribution are only imperfectly known.

The common blue crab (*Callinectes*) is found throughout the bay in considerable numbers, and it or an allied species also exists in the fresh-water streams flowing from the everglades. The stone crab (*Menippe*) frequents the inlets and channels of the section, and is well known to the people of the bay, but is eaten in only limited quantities. The lady crab (*Platyonichus*) is observed along the sandy beaches of the keys, and is reported to be abundant.

The horseshoe crab or king crab (*Limulus*) is found throughout Biscayne Bay and in other suitable localities along this coast. It is not utilized.

Perhaps the most valuable crustacean of this region is the salt-water crawfish or spiny lobster (*Panulirus*), which is reported to occur in immense bodies around the keys forming the eastern boundary of the lower part of the bay. It is marketable as food and bait and is similar to the "lobster" of the Pacific coast, which is eaten in large numbers, but no use is at present made of the animal in the Biscayne Bay region, except its casual employment in very small quantities for bait and family supply.

Shrimp (*Penæus*) are probably present in sufficient numbers to warrant the prosecution of a fishery, if the facilities for marketing the catch were better.

OYSTERS.

There is a luxuriant growth of oysters in parts of Biscayne Bay. They are all raccoon oysters, growing in dense reefs or beds in the open bay, and on the roots and submerged limbs of mangrove and other trees along the shores. In places they hang in large compact bunches to the mangroves, forming long continuous lines of oysters 10 or 12 inches deep. They also attach themselves to the piling of docks, the bottoms of boats, and submerged logs and branches.

The oysters are uniformly small. The average length of the shells is under 2½ inches and the maximum size of the oysters growing on the reefs is but little over 4 inches. When the clusters are separated, however, the oysters attain a much larger average size. The oysters grow very rapidly. Mr. Ralph Munroe, of Cocoanut Grove, has seen oysters on the bottom of a boat at his wharf attain a length of over 2 inches from the spat in nine months. A large proportion of the oysters on

the reefs have remarkably well-shaped shells, considering the condition under which they exist. The shells are rather thick, owing to the presence of lime salts in abundance brought down by the rivers and by surface drainage from the limestone formation which is such a conspicuous feature of the topography of this region. Many of the shells are marked by high radiating ridges which project beyond the proper margin of the shell and give it a fluted appearance.

According to Mr. Munroe, who has had extended practical experience in oyster planting in New York, the oysters in Biscayne Bay have an excellent flavor, and, when scattered, become quite fat in a short time. Some oysters taken from a large reef near the mouth of Little River on February 21 were in very fine condition, although the flavor was somewhat less agreeable than that of the oysters of more northern States. The oysters are eaten to a limited extent by the people living around the bay, but there is no regular fishery.

It appears that only the upper part of the bay—that is, the part north of Cape Florida—is now suitable for oyster-culture. The absence of fresh-water streams in the southern section leaves the water of too high a density to permit the production of the best oysters. Even in the upper section an inlet seems to be needed which, while providing for a freer movement of the water, will at the same time prevent excessive freshening of the upper bay, which occasionally results from a heavy rainfall in the Everglades and jeopardizes the oyster life. At a point known as "Baker's Haulover," only a narrow piece of sandy land intervenes between the ocean and bay, and communication between them could easily be established at little cost. The existence of such an inlet would doubtless greatly improve the general fishery resources of the entire bay, and is much desired by the people of the section.

The character of the bottom of the upper bay varies greatly. There are large areas covered with a growth of long grass; soft sand or muck predominates in places; hard shelly bottom is found in some parts, and a mixture of sand and firm mud exists in others. While a considerable part of the bay would not be suitable for oyster-planting purposes, there is beyond question ample bottom of a suitable nature to permit extensive operations. Probably the best grounds will be found to occur in the lagoons or coves in the northern part and on the eastern side of the bay.

The drum (*Pogonias cromis*) is reported to be destructive to the oyster beds in the bay, but Mr. Munroe and others doubt if much harm is done by that fish. While starfish in great variety occur in the bay, their numbers are not especially large, and they are not, as a general thing, found on the oyster beds.

At the head of Indian Creek, a large indentation on the eastern side of the bay running parallel with the coast, some beds of very fine oysters formerly existed. The shells that remain and the testimony of the inhabitants of the region indicate that the oysters were of large size

and excellent quality, such as do not now exist in the bay. The ground was resorted to by people from all over the bay, and many boat loads were taken annually for local use. The quality of these oysters is thought to have been due to the breaking up of the dense clusters and the scattering of the oysters by the people who visited the ground, so that in time the oysters partook of the character of planted stock. None of these oysters have been found in the creek since the famous hurricane of 1878, when the sea washed into the creek and the beds were destroyed by being covered with sand.

SPONGES.

South of a line drawn west from Cape Florida sponges are found in great abundance. Besides loggerhead sponges, sulphur sponges, and other nonmerchantable species, which exist in remarkable profusion, there are the valuable sheepswool, yellow, and grass sponges. The commercial species are well distributed throughout the southern part of the bay, growing on muddy and rocky bottom. The relative freshness of the water in that part of the bay north of Cape Florida precludes the existence of the desirable sponges. The specific gravity of the water in the bay opposite the cape on February 18 was 1.023. As about the normal amount of fresh water was at that time being brought down by the Miami, Little, and other rivers, the figure given may be taken as approximating the mean density of that part of the bay and as marking the minimum density in which the economic sponges are found. While loggerhead and other useless species were observed some miles north of that position, in water having a specific gravity as low as 1.019, few sheepswool or other similar sponges exist in water having a lower density than 1.023.

Of the marketable sponges growing in Biscayne Bay, the most abundant and valuable are the sheepswool. These grow very rapidly, and some specimens of large size are obtained, notwithstanding the comparative facility with which the grounds are worked and the assiduity with which the business has been carried on. The yellow sponge ranks next to the sheepswool sponge in abundance and value, and then comes the grass sponge. On the authority of experienced sponge fishermen and dealers, it may be stated that the sponges in the bay are of a finer quality and grow faster than those found on the ocean reefs, although the latter, extending from Key West to Cape Florida, of course constitute a much more productive ground.

Off Elliott Key and Cæsar Creek, in Biscayne Bay, sponges are found within a short distance of the shore and are said to grow faster than elsewhere in the bay. Some of the finest sponges ever obtained in the waters of Florida have been taken near Elliott Key. On Featherbed Bank, which is a narrow shoal extending across the bay opposite Ragged Keys and has from 1 to 6 feet of water, sponges also grow rapidly, and some good specimens have at times been taken on that very shallow ground.

Biscayne Bay has been resorted to by sponge fishermen from Key West for fully forty years, and it is still regarded as a very good sponging ground. At times within a few years as many as 30 or 40 sponge vessels have been observed in the bay during one day, and within four months of the date when the visit to the bay was made some very satisfactory fares of sponges had been taken.

While the sponges exist in less abundance than when the fishery was first begun, they seem to be holding their own remarkably well, and no areas have been entirely exhausted, so far as known. The failure to deplete grounds having such a limited extent has been due to the extremely rapid growth of the sponges. In a single year a ground from which practically every marketable sponge was taken has been known to produce a good crop of fair-sized sponges. On the reefs adjoining the bay the sponge grounds also continue to be productive, and nowhere on the east coast of the State has that permanent depletion of the beds ensued which has occurred on some parts of the Gulf coast.

The artificial culture of sponges is one of the subjects to be considered in the event of a construction of a station in this region. The feasibility of raising sponges from cuttings is well known; fully fifteen years ago it was demonstrated at Key West, while in Europe successful experiments were made in the Adriatic Sea as early as 1863.* Attention may here be appropriately drawn to the very extensive and painstaking experiments in this line conducted in Biscayne Bay by Mr. Ralph Munroe, of Cocoanut Grove, by whom the adaptability of the bay to practical sponge cultivation has been clearly proved. The general shoalness of the bay, its protected position, and other favorable conditions have permitted the prosecution of an elaborate series of successful studies and experiments, an account of which has been courteously furnished by Mr. Munroe and is appended hereto.

Mr. Munroe's experiments were restricted to the rearing of sponges from cuttings, although he is convinced of the feasibility of artificially raising sponges from the egg stage. The three species of commercial sponges before named were experimented with, with the same general results. Briefly stated, Mr. Munroe's methods consisted in preparing cuttings of fresh sponges, fixing them to suitable supports, and placing them in the water where their growth could be watched. He had at one time several thousand sponge cuttings in different stages of growth, and his work covered a sufficiently long period and such diverse methods of fixation, etc., as to afford a safe basis for calculating the possibilities of practical efforts in this direction. For several months after the cuttings are placed in the water they remain inert, but when growth once begins it is very rapid, and in 8 to 10 months after planting cuttings the size of the end of one's thumb, marketable sponges 5 inches

*The Sponge Fishery and Trade, by Richard Rathbun. The Fisheries and Fishery Industries of the United States, sec. v, vol. 2, pp. 832-836.

in diameter have resulted. The absence of any protection to his growing sponges from the depredations of ignorant or malicious persons and the completion of his experiments up to a point where scientific research was needed to give full success to his practical studies, caused Mr. Munroe to discontinue this work.

COMMERCIAL FISHING IN BISCAYNE BAY REGION.

Owing to the remoteness of this region from the markets and the poor facilities for shipping perishable products, the general fisheries have never attained any prominence. It may be safely predicted, however, that the completion of the canal route between Lake Worth and Biscayne Bay will give a decided impetus to the fishing industry, and that the valuable water resources of the region, of which mention has been made, will be utilized to supply distant markets and the local demand resulting from the increase in permanent and transient population.

The most important fishing done in the Biscayne Bay region is for sponges. This is carried on wholly by Key West fishermen, and is not participated in by the people living on the bay. "Crawls," or pens for the cleaning and bleaching of sponges, have been located at Cocoánut Grove, Lemon City, Soldier Key, and elsewhere. There seems no reason why sponge fishing in this section might not be very profitably prosecuted by local fishermen.

The taking of green turtles is the most important fishing in which the people of the bay are engaged, and, besides the line fishing, is the only branch of commercial importance. In 1894 the business was of much less extent than formerly, the season being very poor. Three boats, belonging at Lemon City, Miami, and Cocoanut Grove, devoted a short time to turtle fishing in Biscayne Bay and the adjacent ocean reefs. Nets and pegs were used in the capture of the turtles. The aggregate catch was about 205 turtles, weighing 6,175 pounds, with a value to the fishermen of about $708; of these, about 175 turtles were taken in the bay. The turtles are shipped by sailing vessels to Key West. The fishermen find that it is much more difficult than formerly to make a remunerative business of this fishery, owing to the increasing scarcity of the turtles.

The quantity of loggerhead turtles taken exceeds that of green turtles. There is no regular fishery for the former, however, and they are simply taken on the beaches for family supply. Several hundred, with an average weight of 300 pounds, are obtained annually in spring by people residing around the bay. In 1894 the turtles were much scarcer than usual and only about 100 were secured, but in previous years from 300 to 400 were taken. Large numbers of eggs of this turtle are also utilized.

A small line fishery is carried on from the several settlements on Biscayne Bay, the catch being sold to meet the local demand. Fishing is done with hand lines at the inlets or on the adjacent ocean reefs.

Grunts (*Hæmulon*) and groupers (*Epinephelus*) constitute about three-fourths of the yield. The principal other fishes taken are the porgy, yellow-tail, turbot, bonefish, Spanish mackerel, kingfish, and redfish. Only about 4 men followed this business in 1894, and the aggregate catch was only about 11,000 pounds of fish, having a value of $410.

BISCAYNE BAY AS THE SITE FOR A STATION.

The special points considered in the examination of Biscayne Bay with reference to its adaptability as the site for a hatching and experiment station were accessibility, presence of fish and other water animals, proximity to fishing-grounds, existence of natural beds of oysters and sponges, harbor facilities, possibility of constructing salt-water ponds, and the acquisition of land.

Perhaps the principal objections which may be urged against the Biscayne Bay region as the location for a station are its distance from railroads and the poor transportation facilities for reaching it by water and stage. The nearest railroad point in 1895 was West Palm Beach, on Lake Worth, which is about 77 miles by stage from Lemon City, the most northern settlement on the bay.* Two days and nights are required to go from West Palm Beach to Lemon City by stage, the road being very heavy and traveling extremely tedious. Another means of reaching the bay is by water. Sailing vessels leave Lake Worth for Lemon City and Cocoanut Grove at somewhat regular intervals, and, if the wind be propitious, make the trip in one day, although the uncertainty of this means of travel (vessels often being three or four days on the way) leads one to prefer the slow but certain stage route.

Within a short time, however, Biscayne Bay will become easily accessible through the construction of a canal from the southern end of Lake Worth to the northern extremity of the bay. Much of the excavating has already been done, and it is thought that early in 1896 steamboats will be running on the canal. The existence of the canal will doubtless lead to the development of facilities for communication between the bay and Key West, and will certainly prove a great boon to a region having valuable land and water resources. The climate is excellent, even in summer, and the section is free from miasmatic diseases. While mosquitoes are very troublesome in summer, they are reported to be much less annoying than on the west coast or farther north on the east side of the State.

The localities on Biscayne Bay which may be considered as possible sites for a station are the end of the peninsula forming the eastern boundary of the upper third of the bay, the southern extremity of Virginia Key, the northern and southern ends of Key Biscayne, Soldier Key, and the several settlements on the mainland. The keys south

*In 1896 the East Coast Railroad was extended from West Palm Beach to Miami, thus making the Biscayne Bay region easily accessible. The canal alluded to was completed some months before the railroad. The bay now has triweekly steamer connections with Key West. Miami has (1896) become an important town with over 2,000 inhabitants.

of Soldier Key may be dismissed from consideration, owing to their remoteness.

The point of the peninsula mentioned is low and sandy. Back from the water line there are mangroves, palmettoes, and other characteristic vegetation of the region. On the side of the inlet and bay there are several natural salt ponds, some isolated and others connected with the bay by narrow channels. These ponds are practically persistent, but nearly all are subject to obliteration during the prevalence of hurricanes, which occur at rare intervals. They are simple depressions in the sand and are kept replenished and fresh by water which soaks through the soil at the rise and fall of the tide. Their length varies from 25 to 150 feet, their width from 15 to 50 feet, and their depth from 1 to 5 feet. All of them contain small fish, and some of them have various invertebrate animals, such as echini, starfishes, conchs, crabs, many kinds of small mollusks and crustaceans, etc. There is a natural growth of algæ and grass in all the ponds. Through the inlet known as Norris Cut the water runs with great swiftness during the tidal changes, and a channel 8 or 9 feet deep has been formed in the bay; the entrance to the cut, however, is occluded by a sand bar on which there is only 4 feet of water. A large sandy island bar lies in the bay to the west of the point and protects the shore from the waves during the prevalence of strong westerly winds.

This locality has some advantageous features, chief of which is the existence of natural ponds, which are capable of being enlarged and deepened to almost any required extent. The excavation of additional ponds could also be easily accomplished. The point is, however, 7 miles north of the sponge grounds, and the water on the bay side is usually too fresh to permit the prosecution of successful experiments with sponges. On February 19 the density of the bay near the shore, about 1 mile north of the point, was 1.010. As the tide was rising and there was a southerly wind at the time the observation was made, it is probable that this figure represents about the normal maximum density of the bay side of the end of the peninsula.

The southern shore of Virginia Key is a long, wide, regular, sandy beach extending along Bear Cut for a distance of 1½ miles. Bear Cut is one of the most used passageways into Biscayne Bay; it is three-eighths of a mile wide, and, with the exception of a small shoal area lying southeast of the key, on which there are only 5 to 7 feet of water, there is a good though somewhat tortuous channel through which a vessel drawing as much as 9 or 10 feet of water might go. The general land features of the key are similar to those previously mentioned. A large salt-water pond occupies a part of the southern shore. It is a permanent body of water not connected with the bay or ocean. The pond contains mullet and some other fishes of comparatively large size, as well as multitudes of small species; it is also the resort of a colony of crocodiles. The whole of Virginia Key is private land, and is now for sale. The agent expressed the belief that a station site would be donated by the present owner. The conditions are favorable for the

construction of a large series of ponds, which, however, would be open to the same objection that was made to the site first referred to, namely, that the position is not very near the sponge grounds, and the water becomes so fresh that sponge-cultural experiments could not be satisfactorily carried on.

Bear Cut separates Virginia Key from Key Biscayne. At the northern extremity of the latter there is a rocky bluff about 6 feet high, which would be an admirable site for buildings, considered from a purely architectural standpoint. The bay side of the point is thickly overgrown with mangrove trees, while the part nearest the ocean is covered with saw palmettoes. A long, shallow cove (bare at low tide), in which there are a number of islands, extends into the northern end of the point from the west; but the shores of the cove and its shoalness probably render it unfit as a site for ponds. The south end of Virginia Key, however, is sufficiently near to be utilized for the purpose named in the event of the northern part of Key Biscayne being found a suitable place for a station.

One of the localities most strongly recommended, and one which was thought to combine many necessary features, is Cape Florida, which forms the southern point of Key Biscayne and lies immediately opposite Cocoanut Grove, the principal settlement on the bay. An abandoned light-house occupies a reservation at the extremity of the cape, and it has been suggested that the Government ownership of the property would permit its acquisition by the Fish Commission without expense. On inquiry, it was learned that since the abandonment of the light-house the reservation has reverted to the heirs of the original owners, under the terms of the agreement by which the property was ceded to the Government.

Cape Florida is a rounded, sandy projection. For a key, the land is comparatively high, but in hurricanes, as in September, 1894, the sea breaks over the entire point. The cape is occupied by a private residence, buildings, etc., and a large part of the land is planted with pineapples and other subtropical fruits. It lies in close proximity to the channel constituting the deepest and best passage into Biscayne Bay. A recent preliminary examination of the channel has been made by the engineer office of the War Department with a view to deepen the entrance into the bay and the approaches to the cape. At present it is the principal thoroughfare between bay and ocean, and may be traversed by vessels drawing 9 feet of water. Along the bay side of the cape there is a sandy beach a third or half a mile long, beyond which an unbroken mangrove swamp occupies the water line. Adjoining the sandy beach is low land overgrown with scrub palmetto. No natural indentations or depressions exist suitable for the construction of ponds. About a mile above the end of the cape a large shallow lagoon enters the key from the bay; its sides are thickly overgrown with mangrove trees.

Cape Florida possesses many advantages for the purpose under consideration, in addition to its accessibility by water and its nearness

to the settlements on the bay as compared with the keys lying farther south. It is the most conveniently located point in the region from which to visit the sponge grounds within the bay and around the adjacent reefs. As a headquarters for biological investigations of the littoral and pelagic fauna of the section it is well situated. It appears, however, that the construction of salt-water ponds for hatching and experimental purposes would be attended with considerable labor and expense, the only available place for excavation being the saw-palmetto land mentioned. The light-house reservation, which originally had an area of 3 acres, is now much smaller, owing to the encroachment of the sea, and, being located on the ocean side of the cape, is not well adapted to fish-cultural work. While a limited tract of land on the bay side of the cape would probably be donated by the present owner, it is not likely that the full amount of land required for buildings, ponds, etc., could be obtained without a monetary consideration.

Soldier Key, located 4½ miles south of Cape Florida, is the property of the Government and was some years ago turned over to the United States Commission of Fish and Fisheries to be used, if suitable, as the headquarters for scientific studies of the fauna of the region. The island has an area of about 2 acres, and is densely wooded with mangrove and other subtropical trees. Good sponge grounds exist around the key, and the Key West sponge fishermen have crawls and an anchorage at the island. Vessels drawing under 7 feet of water can approach near to the northwestern side by means of a narrow circuitous channel.

The exposed condition of this key, its small size, the impossibility of constructing ponds, and its isolated situation render it unsuitable as a station site, although it would doubtless serve as a valuable collecting ground and temporary rendezvous for a station located in the vicinity.

Some years ago Mr. Ralph Munroe, of Cocoanut Grove, was, with other gentlemen of this section, instrumental in having a bill presented to the Florida legislature providing for a protected area of several square miles around Soldier Key for sponge-cultural purposes. Some very objectionable features were added to the bill, however, and its defeat was secured by those who first brought the matter to the legislature's attention. Enough was developed at that time to lead to the belief on the part of Mr. Munroe and his coworkers that the legislature would willingly sanction the segregation of ample territory for such purposes. The vicinity of Soldier Key would undoubtedly prove an admirable ground for practical experiments in the artificial production of sponges, and the proximity to the deeper reefs would permit a wider range of experimentation than would be possible in Biscayne Bay.

With reference to the availability of the western side of the bay as the site for a station, it may be stated that the construction of salt-water ponds on the mainland is entirely impracticable, owing to the fact that the seepage from the Everglades renders all ponds fresh except when there are high tides. All excavations along the shore quickly become filled with fresh water. The extreme shoalness of the western side of the lower bay is another feature to be considered.

ACCOUNT OF SPONGE-CULTURAL EXPERIMENTS IN BISCAYNE BAY.

By Ralph M. Munroe.

Agreeably to request made by you for a brief report on my experiments in sponge culture, I am pleased to submit the following:

Having had my attention called to the possibilities of sponge culture by Mr. J. Fogarty, of Key West, a gentleman of much experience as a buyer and packer of the article, who had a few years previously successfully grown a few samples from cuttings, I began work in the same line in November, 1889, at Biscayne Bay, a place admirably adapted to such experimenting, far more so than any other place on the coast, having a greater range of bottom, from the oozy marls of the inner lagoons to the hard outer coral reef, waters of all degrees of density from the Gulf Stream to fresh, and currents to suit.

Being already well provided with a vessel, boats, sponge hooks, and water glasses, the question of suitable material for attaching to and sinking the cuttings to the bottom gave some trouble, although apparently a simple problem. Saplings of white wood, which were plentiful, fairly proof against worms, and heavy enough to retain their place in strong tide ways, were finally chosen. They were about 12 feet in length, with a cross piece at one end to prevent rolling over. The cuttings were fastened to them by various contrivances, wedged into holes with pegs, wires around the pole, etc., but the quickest, if possibly not the best, as it afterwards turned out, were short pieces of brass wire doubled and driven into the pole with a peculiar grooved punch, which could be done rapidly. At other stages of the experiment I used bamboo stakes, long double lines of twisted wire connected by cross pieces of white wood with the cuttings inserted between the strands, also flat pieces of coral rock with drilled holes and wooden wedges. Galvanized iron in any form did not answer, especially wire, as it quickly corroded. Most of the first plantings were lost by its use, and I am also inclined to condemn brass wire on account of the possible poisonous effects of the salts formed on it, although some of the best results were obtained when it was used.

Having prepared the sinkers and hooked up sufficient sponge for several days' work, placing them in nets hung from the side of the schooner, the process was as follows: Take the poles or other sinker material in a small boat, two kedge anchors, a small long line, and the sponge in buckets, in which the water was changed every few minutes, a cutting board and knife, the latter very thin and resharpened often, owing to the calcareous matter embedded in the sponge. In this connection it has been generally understood that exposure to air and sun for even a few minutes was fatal to a sponge, and at first I was very careful in this respect. Subsequently I found that several hours of such exposure did not hurt them to any extent. Stagnant water, however, will kill them in a very short time.

Having reached the locality which was at first selected by the natural sponge growth already on it, the two kedges were let go at either end of the long line, and by hauling along this line the plantings could be kept quite regular, and when finished were marked by range stakes set up on the adjacent dry banks. The depth of water ranged from 8 feet to less than a foot at low tide, at which latter depth many fine sponges are found. By the use of a water glass the plantings could be easily observed at any time without disturbing them.

In cutting the sponge it was done as nearly as possible in a line with the radial circulating canals, and so that each piece should have on it a part of the outer cuticle. As many were not cut this way and lived, it may not be at all necessary. Each piece was about 1 inch square on top and somewhat more in length, coming to a point, averaging 25 to a sponge. In cutting care was taken not to express the natural juices or milk, and quickly attaching to the sinkers were immediately put into the water. The poles held on an average 12 pieces placed 12 inches apart, and with one assistant I was able to plant about 200 cuttings per day. With a more suitable boat, having a well to keep the sponge in, and another assistant, I could easily plant from 600 to 800.

This work was continued with intervals from November, 1889, until June 11, 1891, with various results, under all the conditions of bottom, depth, current, etc. With but few exceptions the sponge survived the cutting process and began a good, healthy growth, to be afterwards lost or destroyed in various ways. In many cases, notably one lot planted back of Elliot Key in 4 feet of water on hard bottom, 75 per cent lived and in six months had doubled in size. These were mostly taken up before reaching maturity, as a gale would have swept them away, and did so with those that were left. Mature specimens were gotten from many of the other plantings, but the average loss from defective fastenings and other causes was greater.

The results can be summed up as follows:

Material for anchoring cuttings: While very many things other than those used suggested themselves in the progress of the work, I kept strictly within the limits of what was economic and practical; therefore poles and stone seemed best suited, preferably the former, arranged so as to be elevated a short distance above the bottom to avoid smothering with silt and to avoid the coral, etc., which is apt to grow in with the sponge. Fastenings of just the right character have yet to be invented.

Location: Anywhere within the bays and lagoons free from heavy sea, too strong current, and too much fresh water, and in moderate depths for easy handling and observation.

Growth: This is faster in strong currents, but shape is apt to be poor and quality harsh. This point, however, is not fully determined. Under favorable conditions the cuttings double their size in six months; consequently eighteen months to two years will produce marketable sponge. The sheepswool was the only one of the useful kinds experimented on, although a few cuttings of velvet, grass, and others seemed to thrive and do equally well. It is quite possible that, with State protection to the planters and better methods to be determined upon by further experiment, sponge culture might be profitable. My belief is, gained in oyster culture from spawn, that a similar method with sponge will eventually prove the correct one, but until more is known of sponge biology it would be useless to suggest methods, notwithstanding the fact that several points in connection with it have been to my mind quite clearly demonstrated. Unfortunately, having had to turn my attention to matters of more immediate pecuniary return, the subject has remained in abeyance.

REPORT* ON A PRELIMINARY EXAMINATION OF BISCAYNE BAY

By Thomas H. Handbury,
Major, Corps of Engineers, U. S. Army.

I have the honor to submit the following report upon a preliminary examination made by me of the entrance to Biscayne Bay, Florida, authorized by the river and harbor act of August 17, 1894, and directed by your letter, August 20, 1894:

Biscayne Bay is located upon the east coast of Florida and near its southern extremity. It is about 36 miles in length, with an average width of 6 miles, and has an approximate area of 216 square miles. Over fully one-half of this area there is a low-water depth of 6 feet and less; over the remaining half the average is not above 10 feet. There are occasional holes where the water is 13 feet, and in the cuts which connect it with the ocean depths as high as 16 and 18 feet are to be found. The mean rise and fall of the tide is 1 foot.

The west shore of the bay is coral rock, which rises in places to a height of from 6 to 10 feet above the water level. This rock extends back under the Everglades, the eastern edge of which is about 6 miles from this shore of the bay. Several small streams that take their rise in the Everglades empty into the bay. The most considerable of these is the Miami River, at the mouth of which old Fort Dallas was located. About 4 miles from the mouth of this river there is a rapid a quarter of a mile in length, on which the fall is about 4 feet.

This seems to be the edge of the rim which holds the water of the Everglades at its present level. By excavating through this the level of water would undoubtedly be lowered and much valuable land reclaimed. The east side of the bay is limited throughout its entire length by coral reefs that have risen from the ocean bed. The greater portion of these are above high water, have some soil upon them, and are covered with a thick growth of mangrove, saw palmetto, and other semitropical vegetation. These are commonly designated "keys." The balance that is not to this height is covered with sand, bare at low water. Through this reef there are several openings or "cuts," by means of which communication is had between the bay and the ocean. Outside of this line of keys, at a distance of about 3 miles, and running nearly parallel to it, there is a second line of detached coral rocks that are only just awash at high water. There are also numerous rocks of the same character lying between the two reefs. In these waters lie what is known as Hawk Channel, an inside passage permitting a draft of about 12 feet from Cape Florida around to Key West. This is taken advantage of by light-draft vessels coasting along these shores.

Communication is had with Biscayne Bay by these boats through the passages just under Cape Florida—Bear Cut and Norris Cut. These may be considered as the "entrances to Biscayne Bay" contemplated by the act of Congress, and have been the subject of this preliminary examination.

Norris Cut is the most northerly of these entrances, and is the first to separate the keys from the mainland. It is about one-fourth of a mile in width, and has upon its bar at low water about 4 feet. I was told by reliable persons well acquainted with these waters that there is a reef under this bar with about 2 feet of sand upon it. This

* Dated February 18, 1895, and addressed to Chief of Engineers, U. S. Army.

would make 6 feet the maximum depth that could be obtained without recourse to blasting. I had no means of ascertaining how wide this reef is. Within the cut and in the shoal inside there is a narrow channel about a mile in length, having a depth of from 6 to 8 feet. The water then shoals up, and for the next 2 miles, going toward the interior of the bay, there is an average depth of about 3 feet. The mouth of the Miami River is directly opposite this cut. Near it there is a narrow channel in the bay, having a depth of 7 feet. The best water to be found within the bay and a range of 3 miles from the mouth of the cut does not exceed 8 feet.

Bear Cut is 1½ miles to the southward of Norris Cut and separated from it by a low island, called Virginia Key. It is about one-half mile in width, and has upon its bar a low-water depth of 4 feet. I was told that there is a rock reef 8 feet below the low water on this bar, covered with about 4 feet of sand. Eight feet, then, is the limit of the depth that can be expected over this bar without recourse to blasting. The width of the reef was not ascertained.

From the bar there is a narrow channel about 3 feet in depth, leading into the bay. Through this 10 feet could be carried with very little improvement of its present condition into the bay, where the same depth is found. If the difficulty at the bar were removed this would be a very accessible and desirable route for vessels passing between the bay and Hawk Channel.

About 4 miles to the southwest of Bear Cut and at the lower end of Key Biscayne we find Cape Florida. Immediately below this point there are three narrow channels making in across the low sand flats that here cover the coral reef. Through these depths of 10 and 12 feet can be carried into the bay to where there is the same depth; but in order to get into either one from the Hawk Channel a tortuous course over a shoal flat, having about 8 feet limit upon it, must be gone over. By this course the distance is about 9 miles. The most direct course would be about 4 miles, but over this there is a less depth of water. A small amount of dredging might give 11 feet over this course, but owing to the exposed location of the shoal and the attendant circumstances of light sands and prevailing storms it could not be expected that the dredged cut would maintain itself. Permanent works, such as training dikes or jetties, would be impracticable, as their cost would be out of proportion to the benefits to be derived from them.*

My observation and study of the country bordering Biscayne Bay lead me to suppose that the bottom of the bay throughout its whole extent is a coral rock formation, similar to that between its western shore and the Everglades, not always level, but containing depressions which are filled with sand. This being the case, the prospects for improving much beyond their present depths any portion of the bay or either of the cuts leading into it are not very encouraging. A series of borings will be necessary to ascertain at what depth rock is to be found.

Of the three different entrances here considered, that at Bear Cut seems to offer the most encouraging prospects for improvement at a reasonable expense and to the advantage of commerce. It is doubtful if this can be so improved that vessels of the class now plying between Key West and other Gulf ports and New York can be induced to make Biscayne Bay a stopping point. There might, however, be established here a very considerable trade with the southern keys of Florida, the Bahamas and other West India Islands, through the medium of light-draft vessels. This will require some improvement at this entrance and extension of the East Coast Railroad down to some point on the borders of the bay. By this means early vegetables and tropical and subtropical products of this region could be brought several days earlier to the markets of the North.

The winter climate of Biscayne Bay is mild and salubrious and can not be excelled by any to which our people resort for health-giving air and exercise during the

* In 1896, a channel was opened between Cape Florida and the railroad terminus at Miami; in the vicinity of the latter place a large amount of excavating was done at private expense.—H. M. S.

winter months. The scenery is delightful, and the winds and waters fulfill all requisites for pleasure sailing and light-draft vessels. As soon as better facilities are provided for reaching the locality, there is no doubt but it will become the most popular of our winter resorts and the headquarters for pleasure cruisers from this country among the adjacent islands.

The country in the vicinity is as yet sparsely populated. A few thriving settlements are growing up on the bay. The rich hummock land in the vicinity is being cleared of its dense natural growth and devoted to raising vegetables, which come to maturity and are shipped to northern markets in midwinter. Bananas, cocoanuts, pineapples, oranges, limes, lemons, and the ordinary tropical fruits flourish here.

The export products from this region and the keys lying to the south are now sent in light-draft sailboats to Key West, and from there shipped by steamer as Key West products to the North. This is the usual route of communication with the bay. There is a triweekly mail between Lemon City, on Biscayne Bay, and Lantana, at the lower end of Lake Worth; distance, 60 miles. This mail is carried in a hack, drawn by two mules, and two days are consumed in the journey each way. The Florida East Coast Canal Company is opening a canal 5 feet in depth, with 50 feet width, through the swamp lands which lie between Lake Worth and the head of Biscayne Bay. In a few weeks this will be open from Lake Worth as far as New River, a distance of 40 miles. The company expects to open the balance of the line during the coming year. When this is finished a large amount of excellent land will be drained, more convenient access will be had with the Biscayne Bay country, and a great impetus will be given to its development.

I am indebted to the Hon. F. S. Morse, of Miami, Fla., for the following statistical information relative to the commerce of Biscayne Bay and the adjoining keys:

"Merchant vessels' tonnage coming in during 1894 aggregate 5,164 tons. This does not include the vessels chartered to take away the pineapple crop or vessels coming into the bay on account of weather or for wood and water; also a large fleet of yachts coming here during the winter months.

"Actual tonnage of general merchandise brought in during 1894, with statistics at hand, amounts to 3,985 tons. There were shipped out from Biscayne Bay and the keys during 1894, 250,000 dozen pineapples, 5,000 crates pineapples, 50,000 peck crates tomatoes, 10,000 carrier crates tomatoes, 1,000 crates limes, 50,000 alligator hides, besides tropical fruits, cocoanuts, jellies, sponges, fish, etc., of which I have not had time to obtain statistics.

"I have only included the commerce of those keys that would naturally use this harbor for their shipments of freight. The resources of this section are just beginning to be developed."

From the above facts I conclude that the present and prospective commerce of this locality is worthy of the fostering care of the General Government, and that the entrance at Bear Cut is worthy of improvement, provided that on further investigation by surveys and borings, to be taken on its bar, it does not appear that the cost will be excessive and out of proportion to the commerce to be benefited.

For the purpose of making additional investigations, surveys, plans, and estimates of the cost of the work proper to be done, I estimate that the sum of $1,500 will be required