Some Observations of the Breeding and Migration of the Bermuda Spiny Lobster, Panulirus argus *

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Introduction

THIS PAPER deals primarily with certain aspects of the investigations between March and September of 1951. Research on the spiny lobster (*Panulirus argus*) in Bermuda was started in 1949. Then and in 1950, except for short periods during the fall and winter, lobster research, conducted by Dr. E. P. Creaser, was confined mainly to summer work. In March, 1951, lobster investigations were put on a full time basis, aided by a grant from the Bermuda Government.

Methods

Much of the information was obtained from lobsters taken in traps or "pots" operated by the Biological Station. These were similar in design and construction to those used by the great majority of Bermuda fishermen. Since lobster fishing is not permitted in Bermuda from April 1 to August 31, little information has been obtained this year from commercial catches, although this source will be utilized in the appropriate season.

The trap is of 1½ inch galvanized iron wire mesh stretched over a framework of unsmoothed spicewood sticks bound together with short lengths of wire. The trap is rectangular in section and ordinarily 18 inches high (although "2-foot pots" are in use by some fishermen), 36 inches wide, and about 42 inches at its greatest length. The shape from above is somewhat on the order of a greatly thickened chevron, that is, one end pointed and the other end V-shaped or indented. A wire funnel is built into the concave end leading into the trap. The frame of spicewood, favored because of its durability and weight, usually varies slightly in pattern according to individual preference. The overall shape and design seldom varies.

The traps are baited with fish and, if set in shallow water down to about 30 feet, are unbuoyed. The set is usually made in a sandy hole on rocky bottom and left for several days. The trap is retrieved by casting a small grapnel with which the local fishermen are very skillful. If in deep water, the trap is buoyed with rope and corks.

Since March, 1951, from 15 to 30 traps have been maintained in various locations depending on weather and loss through theft. The traps were visited after two and not more than six nights of fishing if weather permitted.

Trapping efforts were concentrated in a two-mile section of the Bermuda Plateau which included North Rock, Ferry Reach, Castle Harbor, and the Nonsuch Area of the South Shore. All locality references to the North Reefs, North Shore, and the South Shore are within this section.

Breeding

The great majority of the population apparently did not begin to mate until mid-April, although a single sperm-bearing female was found late in March. Mating lasted for about one month for by the middle of May most of the mature females were found to be carrying the sperm masses. Sexual maturity in the females is attained sometime after the carapace length reaches about 90 mm, as may be seen from Figure 1, although Creaser (1950) has reported a female of 85 mm with eggs. This is to be compared with a length of around 45 mm (Smith 1951) for the Florida spiny lobster (see Figure 1) wherein

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breeding starts in March. This agrees with Bradstock (1950) in that *Jasus lalandii* was found to become sexually mature at a considerably smaller size in regions of warmer water. A similar situation was reported by Templeman (1936) for the northern lobster, *Homarus*. The dotted line in Figure 1 represents females carrying sperm masses only and showing no signs of carrying, or having carried, eggs. Since the sample was taken at the height of the egg-bearing season these were possibly females which had very recently become sexually mature. An alternate consideration is that these females had not yet become sexually mature but had the sperm masses deposited on them by males which had matured at a smaller size than those which ordinarily mate with the larger females.

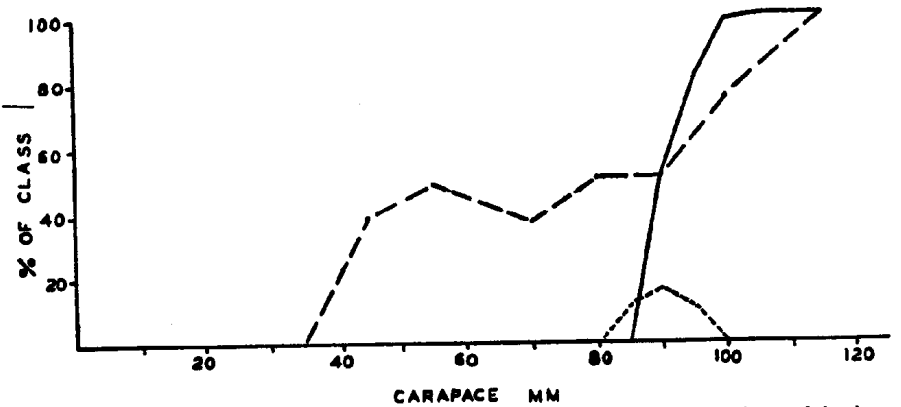

Figure 1. Size at maturity of spiny lobsters —— Females with eggs or signs of having carried eggs; - - - - - females with sperm only; — — — Florida females with eggs (from Smith 1951). For convenience the graph is terminated at 120 mm.

Mating has not yet been observed in the Bermuda lobster. It is to be inferred, however, that with this animal, as with the northern lobster (Templeman 1934), mating individuals are approximately the same size, for female lobsters always bore sperm masses in proportion to their size. It is not known with certainty whether moulting is a necessary prerequisite for the first mating, although it is a strong possibility, judging by other decapods, such as Homarus (see Templeman 1934). Moulting is not a necessary preliminary to subsequent matings during the same season, however, for females have been found with freshly deposited sperm masses, bearing eggs in all stages of development, with remnants of the old used sperm mass underneath the later deposit. By June most of the females were carrying eggs on the swimmerets.

Egg laying of the Bermuda lobster was observed in three instances in the laboratory. As has been previously reported (Crawford and de Smidt, 1922; Smith, 1948; Lewis, 1951), the female scratched the sperm mass repeatedly with the small chelae on the fifth legs. This activity has been observed in the laboratory on a number of occasions and seems to precede egg laying by a day or two. The scratching removes the hardened gray or blackish surface of the sperm mass and lays bare the somewhat softer creamy-white interior in which the spermatoza are inbedded, as shown by microscopic examination. Each fifth leg scratches the appropriate lobe of the sperm mass, for if one fifth leg is removed the scratching is unilateral. During the egg laying the female lies partly on its back, at an angle of about 50 or 60° from the bottom, propped up by

the reflexed antennae. Most of the weight, apparently, is borne by the flexed abdomen. The legs, including the fifth pair, wave about freely in the water. The fan-like telson and uropoda extend ventrally just beyond the openings of the oviducts while the leaf-like exopoda of the swimmerets seal in the sides of the curled abdomen, effectively forming an egg-laying chamber and prohibiting the escape of the eggs prior to attachment. Imperfections or absence of the uropoda or pleopoda may allow large numbers of eggs to be lost during egg laying. As the eggs are laid and carried down, apparently by gravity, a constant waving motion is kept up by the endopoda of the swimmerets. The eggs adhere to the hairs on these endopoda. Upon completion of the egg laying the female retains the posture for a few minutes longer while continuing to wave the egg-bearing endopoda. As the initiation of the actual laying behavior has not been observed, the time required for the completion of the act is not known. However, judging from the rapidity of egg deposition, it probably could not require more than a half hour and possibly much less. This procedure differs somewhat from the egg laying posture reported by Crawford and deSmidt (1922) for the Florida lobster, in which the eggs are layed in the usual resting position.

Fertilization must occur between the moments of laying and of attachment. It is possible that the enclosure formed in the process of egg laying serves also to insure fertilization. After egg laying is completed the surface of the sperm mass is eroded and pitted as if from solution or by chemical action. Smith (1951) suggested enzymic action as being responsible. This eroded appearance is distinct from that of the scratches and gouges left by the fifth legs before laying. It would thus appear that some substance is emitted with the eggs that releases the spermatozoa from the mass, and that the scratching by the fifth legs is not an act of fertilization but a preparation for the event. A concentrated solution of spermatozoa is produced within the laying chamber, through which the eggs must pass for attachment. It is of interest that the whitish surface of the used sperm mass soon assumes the hardened blackish or grayish aspect —characteristic of the original unused mass, although it retains its eroded sculpture. The female may spend the day or so following egg laying picking off most of the used sperm mass remnant.

The eggs hatch in about a month, as indicated by evidence obtained from females kept in the laboratory and by the appearance of many shed females in the first two weeks of July. These shed females can be distinguished by the discolored hairs on the endopoda, by the somewhat warped shape of the exopoda of the swimmerets, which look as though they still surrounded a mass of eggs, and by remnants of the first sperm mass which frequently remains beneath the second. In most cases females laid eggs for a second time within a week after shedding the first eggs. By mid-July a majority of the females were carrying eggs for the second time. The data on females are not yet complete enough to make an accurate timetable of all breeding events, although further investigation will probably provide this. The time of mating and egg laying will undoubtedly vary from year to year with environmental condtions.

Distribution and Migration

There seems to be a definite relation between depth and/or distance from shore and the size of the individuals encountered. Figure 2 shows length-frequencies of samples taken from three localities. The solid line represents a sample from the South Shore at depths ranging from 12 to 240 feet. The bottom is extremely rocky and the shore precipitous, with relatively little water shallower than 10 feet. The dashed line reperesents specimens from the Reach

and adjacent portions of Castle Harbor at depths of about 8 to 17 feet. The bottom is sandy or grassy and is dotted and ringed with small coral and low ledges. Collections were made here, as with the above sample, with standard lobster traps. These results are substantiated by two previous summers' records and by a small sample taken in January, 1951. The dotted line in Figure 2 represents a sample taken partly in small traps but mostly by hand collecting in the very shallow water (usually less than 4 ft.) close to shore. Thus it is seen that the smallest lobsters were found in the shallowest water near shore while lobsters of larger size were found in deeper water further from shore. The differences between the smallest and intermediate size ranges shown in Figure 2 can not be explained on the basis of collecting technique alone, for the 40 to 50 mm class is still large enough to be taken by standard traps and is nevertheless completely absent from the next sample containing intermediate size lobsters. The smallest lobsters were readily taken in shallow water using the same bait as the large traps. In addition to trap data, investigations with diving helmet have shown, as yet, no small lobsters in deeper water. Preliminary obervations in Harrington Sound bear out the above distribution pattern. None of the small and intermediate sizes have yet been taken at the North Reef stations although the data are rather scanty at present. Further research will show whether this situation is typical of Bermuda and of other seasons.

Migrations associated with breeding are well known in spiny lobsters and have been referred to by a number of workers. An outward migration of lobsters from Harrington Sound was intercepted in a later part of June. Of 64 specimens examined only four were males. All the females were in breeding condition, having eggs and/or sperm. This coincided with a considerable increase in the catch per unit of effort on the South Shore (Fig. 3) and a rise in the female to male ratio (Table 1). A similar change in sex ratio was found by Crawford and deSmidt (1922) in Florida.

The unit of effort for quantitative studies was established on the basis of the number of lobsters caught per trap-night of fishing. Although there are certain limitations to this unit, such that one trap fishing for six nights is

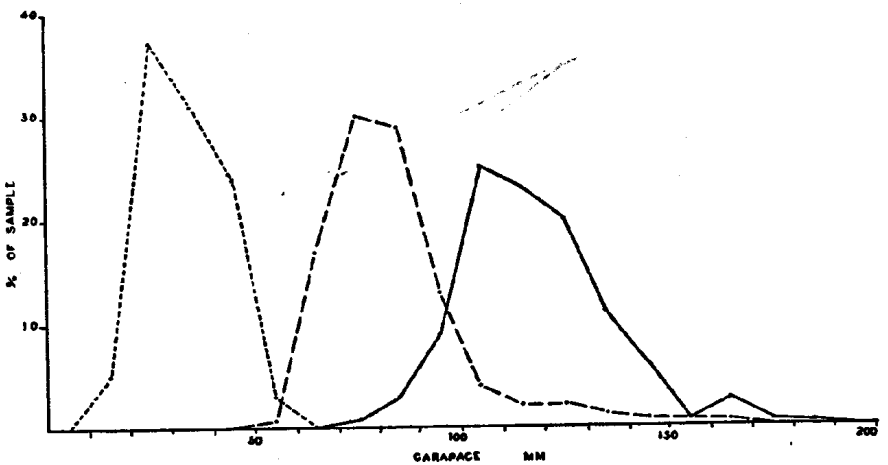

Figure 2. Length—frequencies of spiny lobsters taken in three localities. —— lobsters collected from the South Shore, 269 spec; — — — Ferry Reach, 179 spec ----- Ferry Reach and Whalebone Bay, 150 spec. All lobsters taken in summer, 1951.

not strictly comparable to six traps for one, it is felt that this standard is one that can be conveniently used for purposes within its limitations. Bradstock (1950) used a similar unit of effort.

The catch increase on the South Shore was more than could be accounted for by an influx of females only, so some males must have been coming into the South Shore area as well (see Table 1). There was in addition, a noticeable

TABLE 1. SOUTH SHORE. Percentage of females compared to catch in lobsters per trap night.

Date (1951)	Percent females	L/NT
June 1 —15	41	0.14
June 15—30	45	0.24
July 1 —15	56	0.49
Aug. 1 —15	53	0.31
Aug. 15—31	56	0.21

lack of breeding size (90 mm or more) females on the North Shore and in the Lagoon. There is thus a migration of breeding females in those portions of the South Shore investigated, if not to the entire periphery of the Bermuda Plateau. It should be pointed out that this is not necessarily a migration to deep water

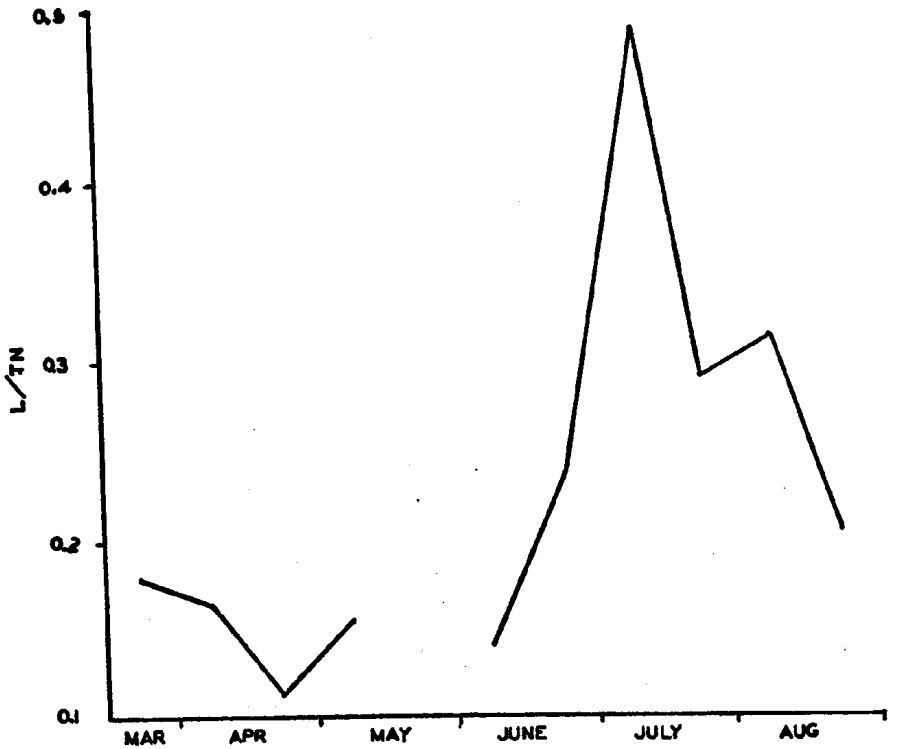

Figure 3. Bimonthly catch of spiny lobsters per trap night, on South Shore. Gap represents two weeks of bad weather. Total of 1404 trap nights with a minimum of 5 traps running concurrently.

for some of the South Shore trapping area is shallower (usually less than 30 feet) than many parts of the lagoon and sounds. There is tentative evidence pointing to an inward migration, or at least a lack of females, from deeper waters of the shelf and of the slopes since traps in these depths (on the South Shore) have caught only males. This breeding migration to the South Shore apparently follows the first mating and precedes the hatching of eggs.

A migration of considerable magnitude has been cited by a reputable local fisherman who witnessed the event in the fall "several years ago." He could give no information as to direction of movement. This might be comparable to a migration seen by C. M. Breder, Jr., at Bimini in October, 1950 (personal communication). In this case the lobsters were coming in from deeper water in great numbers. This lasted only a day.

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A Preliminary Report on the Biology and Economics of the Spiny Lobster in Puerto Rico

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THE SPINY LOBSTER, *Panulirus argus* (Latreille), is an important item in the local fish markets of Puerto Rico and is greatly in demand wherever taken. The most important method of taking these animals in Puerto Rico is by the use of wire traps supported by a framework of wood, ordinarily mangrove wood. These traps are of the same type used to take fish and are approximately 4 feet by 3 feet by 2 feet in size with an opening on one of the short sides. Some lobsters are taken with spears. but these are not included in the data of this report. During the past year the collection of data was begun to determine the extent of this fishery and to obtain notes on the biology of this species. This represents a preliminary report on this work now being carried on.

The Division of the Fish and Wildlife Service of the Department of Agriculture and Commerce of Puerto Rico, under the direction of Mr. Felix Inigo, conducted a contact survey of the local fishermen as to their catch of both fish and lobsters. There were 213 fishermen who reported a catch of lobsters. some only a few pounds which were incidental to their catch of fish. The results of this survey indicated a catch of 466,800 pounds of lobster annually. This represents a catch of approximately 200,000 lobsters. The value