

## PRELIMINARY REPORT ON THE FLORIDA CRAWFISH INVESTIGATION

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### INTRODUCTION

During the winter of 1944 the South Florida crawfish or spiny lobster fishery was the subject of a considerable amount of discussion among commercial fishermen, anglers and others, with one faction contending that over fishing had seriously reduced the natural supply and that stricter regulations should be enacted. The opposing faction, consisting principally of commercial fishermen, contended that there was no evidence of over fishing and that no further regulations were necessary.

The question was finally discussed at an open meeting held at the Gulf Coast Fishermen's Union in Miami during the fall of 1944. The meeting was attended by fishermen and representatives of anglers' clubs and conservation associations, by Dr. Robert O. Smith, Area Fisheries Coordinator, by Mr. S. E. Rice, Supervisor of the Florida State Department of Conservation, and by Dr. F. G. Walton Smith, Director of the University of Miami Marine Laboratory. The consensus of opinion at this meeting was that a scientific investigation of the fishery should be made. Mr. Rice accordingly addressed a request to the Director, Fish and Wildlife Service, for the establishment of a survey.

As the result of Dr. Rice's request a meeting was arranged in November, 1944, by Dr. Gabrielson, Director, US Fish and Wildlife Service, for the purpose of discussing the possibility of organizing the survey. This meeting was attended by Dr. Elmer Higgins and Dr. Paul S. Galtsoff representing the Fish and Wildlife Service and by Dr. F. G. Walton Smith, who appeared on behalf of the Florida State Conservation Department and the University of Miami.

During the course of the meeting it was proposed and agreed upon, subject to Dr. Gabrielson's approval that a joint investigation should be carried out by the three agencies represented. The investigation would be under the direction of Dr. Walton Smith, who would in turn be responsible to a committee consisting of Mr. Higgins and Dr. Galtsoff for the Fish and Wildlife Service, the Supervisor of the Florida State Conservation Department or his appointed deputy, and a representative of the University of Miami. Under these arrangements the Fish and Wildlife Service would provide a full-time assistant and two part-time aides during the first twelve months of the survey. The necessary tags for marking crawfish and the cost of their recovery, together with disbursements to fishermen in payment for work in reporting statistical observations on their catches would also be the responsibility of the Fish and Wildlife Service. Traveling expenses of those under Federal employment would fall under the same head.

The Florida State Conservation Department agreed to provide the use of a motor vessel and the occasional services of local conservation agents, together with funds to cover the cost of gasoline, equipment and supplies and the local travel of those on the Federal payroll. This expenditure was limited to \$150.00 per month.

The University of Miami was to provide the services of Dr. Smith on a part-time basis, equivalent to approximately two days a week, and the use of laboratory facilities and equipment, office services and a motor vessel.

Since December 1944 changes were made in the personnel of the State Conservation Department but the arrangements were continued with the approval and cooperation of Mr. J. T. Hurst, the present superintendent of conservation. Failure to set up the machinery for Federal participation, however, resulted in failure to appoint the assistant and part-time aides and so far greatly reduced the extent of investigation.

While the State Conservation Department, in the persons of Mr. Hurst and his local agents, has been most cooperative and has provided funds to cover operating expenditures, the agents were unable to take any active part in the work. Members of the staff of the University of Miami's Marine Laboratory have devoted a limited amount of time to the investigation and some preliminary results have already been obtained. The present report is designed to summarize the progress of investigations to date and to outline plans for future work.

An excellent account of previous investigations into the South Florida crawfish industry by Crawford and De Smidt (1922), referred to in the text, was consulted in carrying out preliminary inquiries. The absence of detailed biological statistics or market analyses, however, has rendered this work of little value in comparing past and present conditions of the population. A brief account is also given by Schroeder (1923). Investigations into the South African and Californian species are described in papers listed in the bibliography.

The principal objective of the present investigation was to determine whether the South Florida crawfish are being over fished, and to make recommendations for the protection of the industry from unwise exploitation. In addition to breeding habits, growth rate, and migratory behavior were to be studied in order to indicate satisfactory restrictive measures which would follow maximum fishing combined with assurance of adequate conservation. It was further decided to investigate various fishing methods with regard to their efficiency, degree of destructiveness and effect on the fishery.

Before beginning field and laboratory investigations, preliminary inquiries were made on visits to Key West and places between Miami and Key West during February, 1945. Representative fishermen were interviewed. Their accounts of the relative scarcity of fish from year to year differed considerably although there was general agreement that lobsters over the while of the south Florida area are less plentiful than they were twenty years ago. The general impression also appeared to be that in localized areas the supply of lobsters may be reduced from time to time by over fishing and that while in the unproductive state they are avoided by fishermen. In the opinion of the fishermen recovery usually occurs after periods of two to five years.

During the month of February, 1945, arrangements were made for the biological sampling of representative samples from the catch of fishermen working between Miami and Key West. Measuring boards were constructed and data forms printed for the use of fishermen taking part in this work. Each fisherman was paid a small honorarium for his cooperation.

At the end of the fishing season, in March, it was intended to continue taking monthly biological samples using fishing equipment made fro the purpose and operated by persons employed on the survey. In spite of the lack of personnel, the traps were constructed and assembled, but unfortunately were not placed in operation until June.

In the absence of the original arrangements for supplying tags and the organization for their return, with relevant information, tests were begun in August to develop a suitable type of tag.

Similar investigations are being carried out in the Bahamas by personnel of the Agriculture and Marine Products Board, under the supervision of the Director of the Marine Laboratory. By permission of the Chairman of the Board, observations which are applicable to the Florida crawfish are referred to in this report.

Progress in the preliminary inquiries has been made possible by the cooperation of Mr. J. T. Hurst, Supervisor, Florida State Department of Conservation, and his predecessor, Mr. S. E. Rice, Mr. James W. St. Clair, General Agent, his predecessor Mr. Claude Lowe, and the local agents, who have also been of great service. Mr. Alonzo Cauthron and Mr. Berlin Falton, the principal fishing operators in Monroe County and Mr. A. V. Lang of Miami have assisted in recording the statistical samples.

### Brief Description of the Crawfish

The Florida Spiny Lobster (*Panulirus argus*) is here referred to as "crawfish", the name under which it is best known locally. It is also known under the names of "rock lobster" and "langouste". It differs from the northern lobster in having longer legs and in the absence of the large claws characteristics of the northern form. Other obvious characteristics are the long antennae or whips and the numerous spines which include two horn-like projections over the eyes (Figure 1).

The principal regions of the animal may be distinguished. The cephalothorax or body region is here referred to by the better known term "cape". The abdomen or tail region differs from the cape in having no long legs and in being divided into segments or rings. Small paddles take the place of legs.

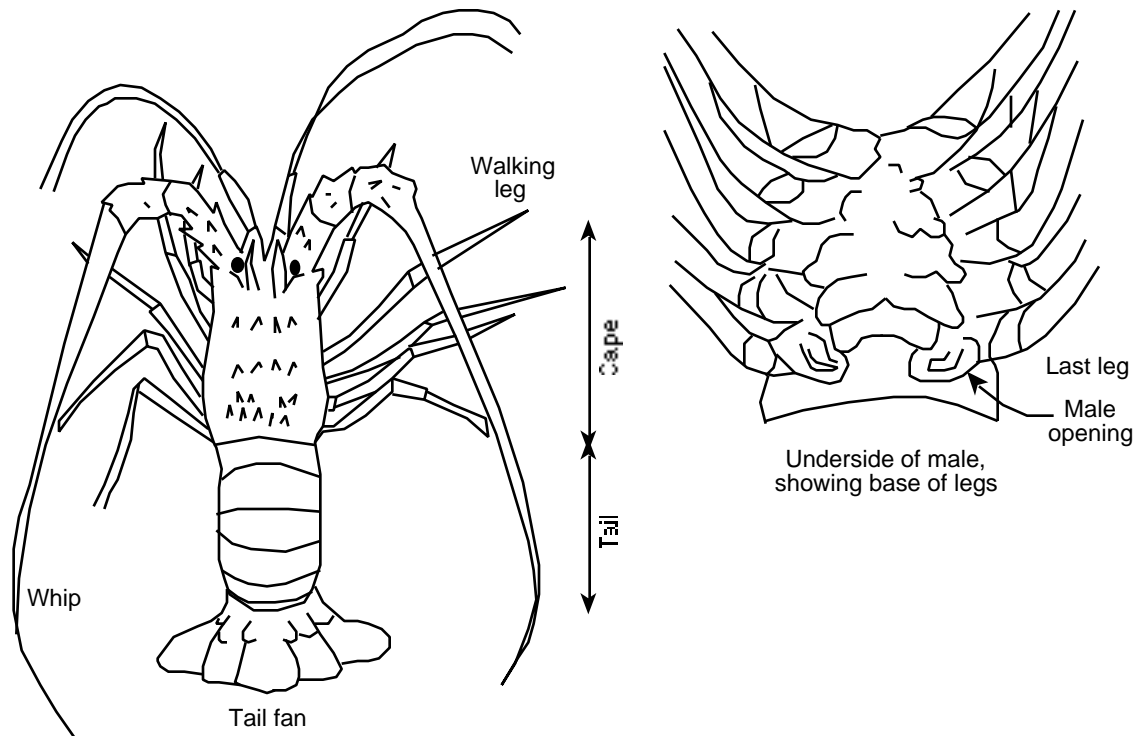


Figure 1. The spiny lobster.

The male crawfish is distinguished by the presence of swollen sexual openings at the base of the last pair of legs, not present in the female. In the female an extra spur is present on the tips of the last pair of legs. The male has a simple pointed tip only.

During the early part of the breeding season the female may have a dirty white or gray-black substance attached to the under surface between the last three pairs of legs. This is the sperm produced by the male and attached to the female during the mating act.

When the eggs are laid they are attached in the form of small orange-red berries to the paddles under the tail of the female.

Measurements of the crawfish used for various purposes are taken from the front of the cape, immediately between the whips. The cape length extends backwards to the hinder end of the cape, along the middle line of the back. The body length is measured from between the whips to the extreme end of the tail fan as it rests when held against a flat surface.

#### Importance of the Fishery

At the time of publication of Crawford and De Smidt (1922) the annual catch of the fishery was estimated at 300,000 pounds, valued at \$25,000, equivalent to \$0.09 per pound. This did not entirely represent were used by scale fishermen as bait.

During the past twenty years the fishery has increased both in quantity and value (Table I). The actual amount is difficult to estimate since the State Department of Conservation returns do not coincide very closely with the US Fish and Wildlife Service estimates. It appears, however, that the catch has recently approached an annual total 2,000,000 pounds with a market value of about \$350,000. While this is not a major industry, it is locally important, since it is mostly restricted to Dade and Monroe Counties.

The Bahamas output also approximates 2,000,000 pounds. No figures are so far available for Cuba.

The number of fishermen employed is also difficult to estimate, since many of them engage in catching crawfish as a casual employment, and others are apt to desert it when other fish are abundant or fetching good prices. The maximum number of men catching crawfish at any one time is probably less than 300, of whom 125 are active in Dade County. Many are mackerel fishermen who turn to crawfish trapping in the summer months.

#### Limits of the Fishery

The crawfish ranges from North Carolina to Brazil, but in the United States is only found in commercial quantities in South Florida. The Florida commercial fishery extends from Palm Beach south to Key West, and is most important south of Miami. The crawfish also supports commercial fisheries in the Bahaman Islands and in Cuba. Closely related species are found on the Pacific Coast of America, in the Hawaiian Islands, in Japan and off the coast of South Africa.

They are most numerous on rocky bottom, or bottom covered with turtle grass (*Thalassia testudinum*), in fairly shallow water, on the southern side of the Keys, but are also fished to a lesser extent on the bay side of the Keys.

Table I. Quantity and value of crawfish (spiny lobster) produced in the State of Florida and reported to the State Board of Conservation, Tallahassee, Florida.

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Year or years	Approximate market price per pound	Number of pounds per annum
1925 - 1926	\$ 0.08	87,561 Two-year average
1927 - 1928	0.08	817,396 Two-year average
1929 - 1930	0.09	872,946 Two-year average
1931 - 1932	0.08	1,341,713 Two-year average
1933 - 1934	0.05	266,250 Two-year average
1935 - 1936	0.06	832,359 Two-year average
1937 - 1938	0.07	643,094 Two-year average
1939	0.07	405,296
1940	0.07	399,837
1941	-	2,067,191
1942	-	1,673,065
1943	-	1,910,766
1944	0.16	1,176,044
1945		793,693
1946		1,585,510

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Legal Restrictions

The State holds title to all crawfish within its territorial limits and the right to fish commercially is conferred by license.

Taking crawfish less than one pound in live weight is prohibited, except for purposes of propagation by State agencies, and for biological research. Owing to the possibility of change in weight during transportation, it has been held that the weight limit cannot properly be applied except immediately after removal from the water.

Further difficulties in applying weight restrictions are caused by the practice some fishermen have of bringing in the edible tail after discarding the cape. A recent court ruling held that no conviction could be based on weights of mutilated or cooked lobsters. There is no serious reason why a body length or cape length limit should not be substituted for the weight limit so that these difficulties could be overcome. The practice of discarding the cape is reported to when the fish are injured during capture, or when they are likely to die since the meat is easier to preserve when separated from the viscera or entrails. The use of well boats and abolition of the method of capture by groins or spears would insure the marketing of live fish and would make it possible to insist upon the sale of whole crawfish only. In this way a length limit could be applied at any time between capture and sale to the dealer. The average body length of a one pound crawfish is slightly less than 9 inches in the male, slightly more in the female.

During the spring, according to Schroeder, the crawfish tend to congregate in shallow water and the females carry their eggs or berry. For this reason a closed season is in force, extending from March 21 to July 21.



Figure 2. Quantity and value of crawfish (spiny lobster) produced in the state of Florida and reported to the State Board of Conservation, Tallahassee, Florida.

Public carriers are not allowed to transport crawfish during the closed season, except in the case of imports in process of reshipment and accompanied by proper certified invoices. It is required that all sales be reported to the State Department of Conservation, upon request. These reports form the basis of market estimates made by the Department.

The method of fishing is not specified, but no nets or traps are allowed by law except for the wooden slat trap measuring 3' x 2' x 2' (Figure 2). This restriction has been enforced in Dade County during recent years but is not applied in Monroe County. Apart from trapping there is no restriction on methods of fishing.

The Bahamas crawfish industry is regulated by law with a size limit of 3.75 inches for the cape, measuring from the base of the rostral spines to the end of the jacket. This corresponds roughly to 10.5 inches body length, or a live weight of 1.5 pounds. A closed season extending from March 16 to September 16 is observed.

An additional control is the requirement that all crawfish shall be sold at government supervised collecting stations.

## Fishing Methods

The methods in general use are bully nets, slat traps, ice cans, grabs and grains. In occasional use are metal wire traps, rafts, pull or hoop nets, and spears. Seines and other nets, used during the early part of the century, are not now, used, since crawfish rarely congregate in large enough numbers.

Most of the fishing methods are adequately described by Crawford and De Smidt, and need only be briefly referred to here. They are arranged roughly in order of popularity.

Wooden Slat Trap. This is the only trap allowed by law, and is probably the most used in Dade County. Traps are baited with fish heads and backbones obtained from fish houses, and are operated from launches varying from twenty to thirty feet long with two or three men to the boat. Each boat works from 100 to 300 traps. They are laid in rows in the offshore part of the grounds and worked over at regular intervals, at the rate of about 100 traps per day. A good day's catch averages 400 - 500 crawfish, although at times more than 15 are taken in a single trap.

Bully Trap. This is operated by hand and rarely damages the crawfish. It is often used at night, when the fishermen work in pairs by boat, carrying a gasoline lantern, since the crawfish rarely feed in the open except during hours of darkness. During the daytime a stiff wire probe may be used to stir the crawfish from beneath the rocks. Average catches are 75 - 200 lbs. in one night, although as much as 500 lbs. is sometimes taken.

Ice Can Trap. This is not used in Dade County, where the trap restriction is enforced. The trap consists of a discarded ice mold of the type used in ice plants. It is made of light steel plate, rectangular in shape, about 4 feet deep and 8 inches by 30 inches in section. The fisherman prepares the trap by crushing in the middle of the open end, so as to leave two openings just large enough to admit the crawfish. Small holes are punched in the side so as to allow ready flow of water.

Prior to use the trap is immersed in the sea for several weeks, during which time a growth of algae and other accumulates. The crawfish are believed to avoid traps which have not been prepared in this way. No bait is needed, since crawfish enter the traps during daytime, apparently in the same manner as they enter rocky crevices in search of shelter.

In working the trap, it is hauled rapidly to the surface by means of a line attached to the mouth. The crawfish drop back to the bottom of the can during its ascent and are emptied on deck. Since operation in deeper water necessitates the use of a davit, the ice can is often used in shallow, water where it may be picked up by hand. It is probably the most efficient type of trap, and often catches an average of 10 crawfish or more in each trap.

Hoop Net. This is occasionally used from docks and bridges and more frequently from anchored boats. A three to six foot diameter net is used, baited and allowed to rest on the bottom. When hauled by a single rope and bridle the hoop is raised, trapping the crawfish in the bag of the net. Hoops are often used as an alternative method by bully fishermen.

Metal Wire Trap. The metal wire trap described by Crawford and De Smidt is still used, though illegally, by an occasional fisherman. Both slat traps and wire traps have been criticized by local fishermen on the ground that if they are unattended or lost, the fish that are caught are liable to die. The dead crawfish is then said to act as bait for other crawfish, so that, until the trap is found and removed, it is a continual source of destruction.

Grains. Grains consist of single or double-pronged spears attached to long wooden poles. The crawfish are impaled and therefore damaged. This method is not widely used except for catching bait.

Grabs. These are long wooden poles, fastened together so as to act like tongs. They are apt to damage the fish. This method is less used than those previously described, but may be used along heavy coral growth, where the bully net is difficult to use.

Rafts. Rafts are made of odd pieces of wood salvaged from flotsam. They are nailed over railroad ties so as to form a platform raised several inches from the ground, and covering an area varying from 50 to 300 square feet. When in use they are sunk in shallow water by means of rocks piled on the top, and are usually allowed to remain an indefinite period until the fisherman is again in the vicinity. Old pieces of net are then strung around the raft and the rocks removed. As the raft rises to the surface the crawfish rush out and become enmeshed in the net. Rafts are not widely used, although when allowed to remain for long periods they may catch large quantities of crawfish.

Seines. Seines and other nets do not appear to be used at the present day.

An estimate of the number of fishermen using the different types of gear is difficult to make, since many of the fishermen are engaged intermittently. The maximum employment in Dade County, however, is believed to be approximately 125, with 25 three-man crews using traps and 25 men using bullies and hoops. Grains are believed to be used by about 24 men working in pairs. In Monroe County it is estimated that the maximum employment is 175, with about 30 three-man crews using ice cans. The remainder use grabs, bully nets and wooden traps and occasionally rafts.

Marketing. Crawfish are usually brought in alive but in some cases this year the men have brought in tails only. In most cases the dealer removes the capes at the dock. The dealer buys by whole weight, paying 16¢ per lb. Small fish are preferred by restaurants since the caterer receives the same amount for small as large crawfish when served and prefer to buy low weights. Casual fishermen, who go out for crawfish during the first few weeks of the season, using bully net or grab, and turn to pelagic fish sometimes sell directly to restaurants and hotels.

There are about 20 fish dealers in Dade and Monroe Counties who handle crawfish, three of them large buyers, the remainder small, some only taking the crawfish to accommodate customers. There is one dealer in Palm Beach, one in Fort Lauderdale and most of the remainder in Miami. Trucks are sent to pick-up stations at Tavernier, Lower Matecumbe, Marathon and Key West. Two firms operate with their own fishermen and use ice cans at Islamorada and Key West.

#### Methods of collecting data

During the latter part of the 1944-45 fishing season, numerical data were obtained from the catches of commercial fishermen, working from the Florida Keys. It was arranged that the measurements and observations should be made of all crawfish taken until a total of 1000 had been reached each month.

The form provided for the recording of data is reproduced as an appendix to this report. Provision was made for observations as to breeding condition, signs of recent or approaching molting, and body length measurement.



Sexual condition was reported as presence or absence of sperm packets or eggs. Measurement was made by specially constructed board supplied to each fisherman, and graduated in quarter inches, numbered consecutively. Signs of recent molting are provided by the softness of the new shell, and the approaching molt is indicated by cracking of the old shell.

For the purpose of recording changes in the crawfish population during the closed season a number of traps were prepared from ice cans, since these are known to retain crawfish down to a very small size. Unfortunately lack of assistance in preparation and the time necessary for the seasoning of the traps delayed their use until the month of July.

#### Length Frequency Distribution and Growth Rate

Observations on commercial catches were based upon samples from bully net fishing, wooden trap fishing, and ice can fishing. Since smaller crawfish are retained by the ice can, catches from this source offer a more representative population samples, and were elected for analysis.

An error of one quarter inch interval was incurred in measurement. The curves were smoothed by using a running average of three intervals.

Figures 3 and 4 represent ice-can catches from the Florida Keys between Tavernier and Key West during the months of February and March. Similar catches from the Cape Florida Banks during July and August are represented in Figure 5 and 6.

It will be observed that some of the ice cans retained crawfish ranging in body length from one inch to 15 inches. Very few crawfish less than 5 inches long were taken in the Cape Florida traps however, and the smaller crawfish are not well represented in the traps from the middle Keys.

Fluctuations in the curves are generally similar for males and females. The number of females is somewhat greater than males in the March catch, but the reverse is true of the August catch.

Three major peaks are present in the curves of Figures 3 and 4. They occur at about the same place for both months, and for both sexes, and corresponds to body lengths of approximately 4 inches, 7 inches and 10 inches. Minor fluctuations are present at intervals of about 1 inch and appear at approximately the same places on each curve.

In Figures 5 and 6, the 4 inch and 10 inch peaks are absent. No clear correspondence between these curves is shown with respect to the minor fluctuations.

Crawford states that the growth at each molt is approximately 3%, and implies that molting does not occur more than once or twice a year. This would indicate that the

annual rate of growth of a 10 .inch crawfish is less than one inch. On this assumption only the smaller fluctuations in the length frequency curves could possibly be regarded as indicative of year classes. Since these are irregular and show poor correspondence from month to month it has not appeared possible to identify year classes and to obtain growth rate data from the records. It is possible that when sufficient consecutive monthly curves have been obtained from one locality the growth rate may be deduced from lateral displacement of the points of inflection. The irregular nature of these, however, does not encourage this belief. Studies now in progress on the ecdysis of captive crawfish may also provide evidence as to growth rate.

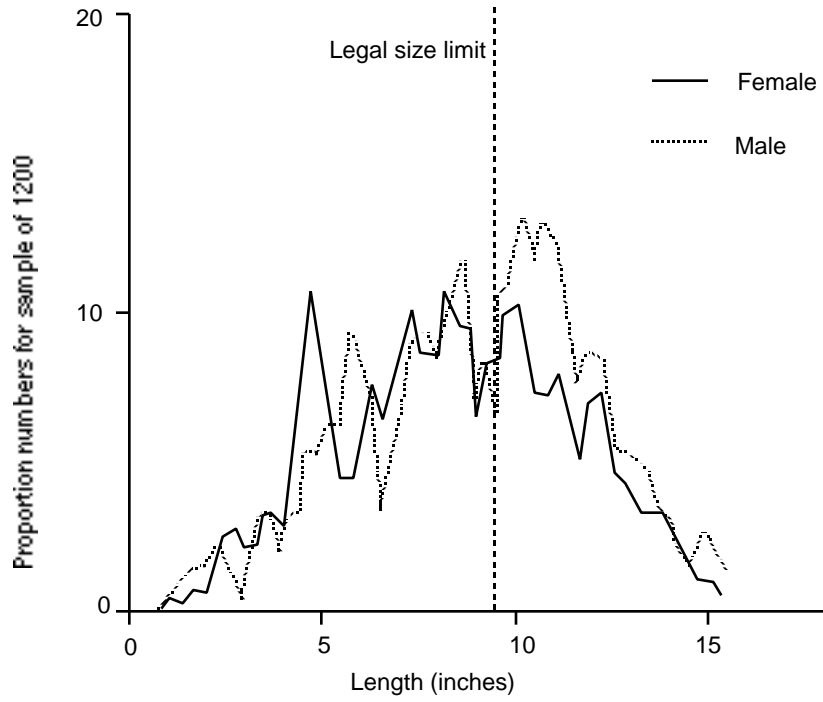


Figure 3. Length frequency distribution: Middle Keys; ice can traps; February, 1945; 600 in sample. (Smoothed by running an average of three.)

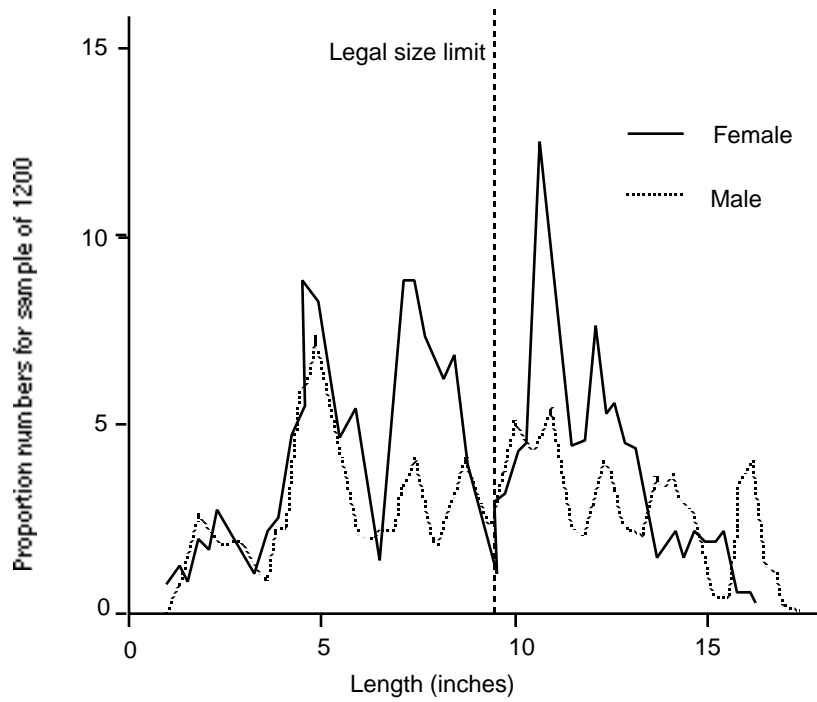


Figure 4. Length frequency distribution: Middle Keys; ice can traps; March, 1945; 400 in sample. (Smoothed by running an average of three.)

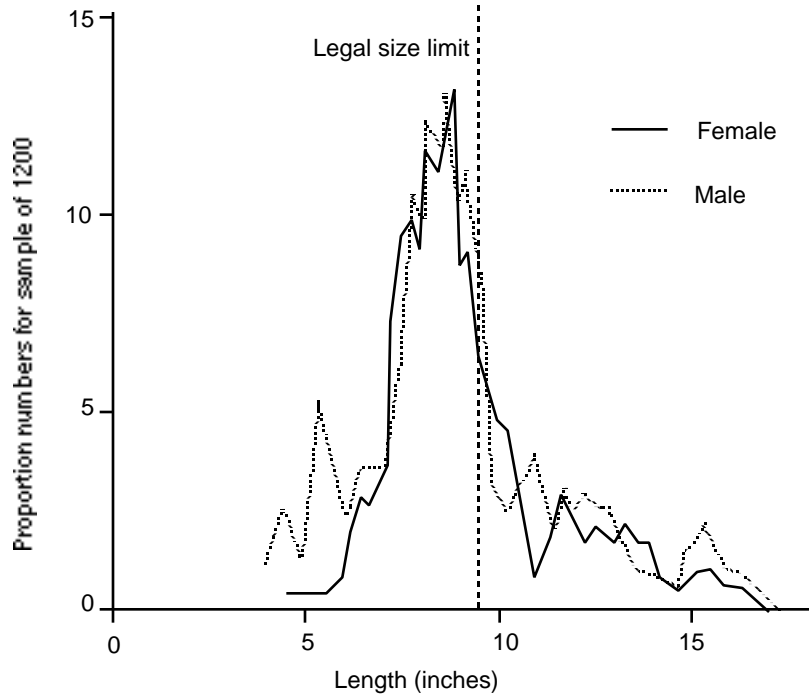


Figure 5. Length frequency distribution: Cape Florida Flats; ice can traps; July, 1945; 381 in sample. (Smoothed by running an average of three.)

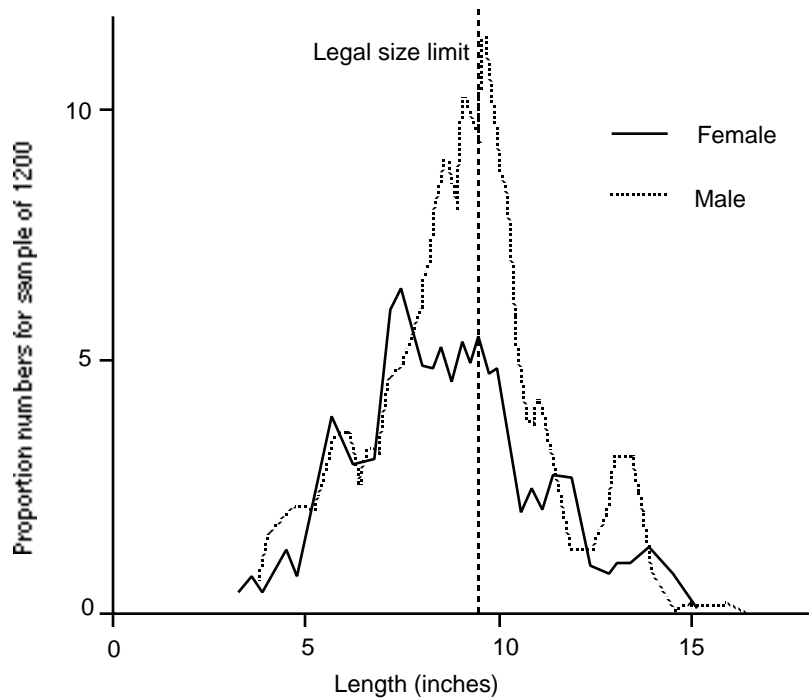


Figure 6. Length frequency distribution: Cape Florida Flats; ice can traps; August, 1945; 296 in sample. (Smoothed by running an average of three.)

### Relative Abundance

Comparison of the length frequency distributions at Cape Florida and in the Middle Keys discloses a relative scarcity of crawfish above 10 inches and below 5 inches in body length at Cape Florida. This might lead to a tentative conclusion that heavier fishing at Cape Florida recently may have reduced the number of crawfish above the size limit, and that heavy fishing over the past few years has reduced the production of younger fish. Should this conclusion be justified it would also support a belief that a further reduction would occur in the catch of future years. More extensive monthly samples are needed from the same stations over a greater period however before these conclusions may be drawn with certainty.

### Breeding in the Florida Keys Region

State regulations now provide a closed season between March 21 and July 21, prohibiting the taking of all crawfish, except for bait during what is considered the breeding season. Records taken in February prior to this closed season (Figures 7 and 8) show that large numbers of female crawfish have acquired a sperm sac from mating males by this time and to this extent are prepared to spawn their eggs, which apparently are fertilized as they pass from within the body to the under side of the abdomen. These pre-season records give no indication that the latter processes have taken place for there were no females with spawn (the term locally used for egg mass under the abdomen).

Records taken in July and August at the end of and following the closed season (Figures 9 and 10) show a large number of females retaining sperm sacs but the latter are in a ragged condition, apparently from being ruptured for fertilization at the time of spawning. None of these females were with spawn but, on some, the abdominal appendages were still roughened from having recently carried eggs.

First of all Figures 7 - 10 show that a relatively small proportion of the mating females are below the legal one pound size limit which averages around 9 inches total length. Records from the Bahamas show a similar situation there (Figures 11 - 15)\* .

The information in Figures 7 and 8 indicates that mating activity has commenced before the closed season. It is reasonable to assume that by the termination of mating almost all the large females would have a sperm sac as has been recorded at later dates in the Bahamas investigations. Just how soon spawning occurred remains questionable for although none of the females taken through March 20 were with spawn, it is possible that spawners commonly migrate to deeper water than is sampled by ice cans and bully nets.

The lack of females with spawn among the late and post season crawfish, so many of which had carried eggs (as judged by broken sperm sacs) would seem to indicate that breeding activities had terminated. Again, however, the fact that our records are restricted to fish taken by ice cans in shallow water is misleading for commercial fishermen report post-season catches of spawn bearing females from the deeper waters on and near the outer reefs to the extent that some feel the season opens too soon.

It is obvious that one of the most urgent needs is for expansion of sampling to cover catches from deeper water and for sustaining the work through the closed season. A tagging program would help answer many of the questions regarding relationships between breeding and both widespread and local migration.

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\* Parallel studies being carried out in the Bahamas by the University of Miami Marine Laboratory.

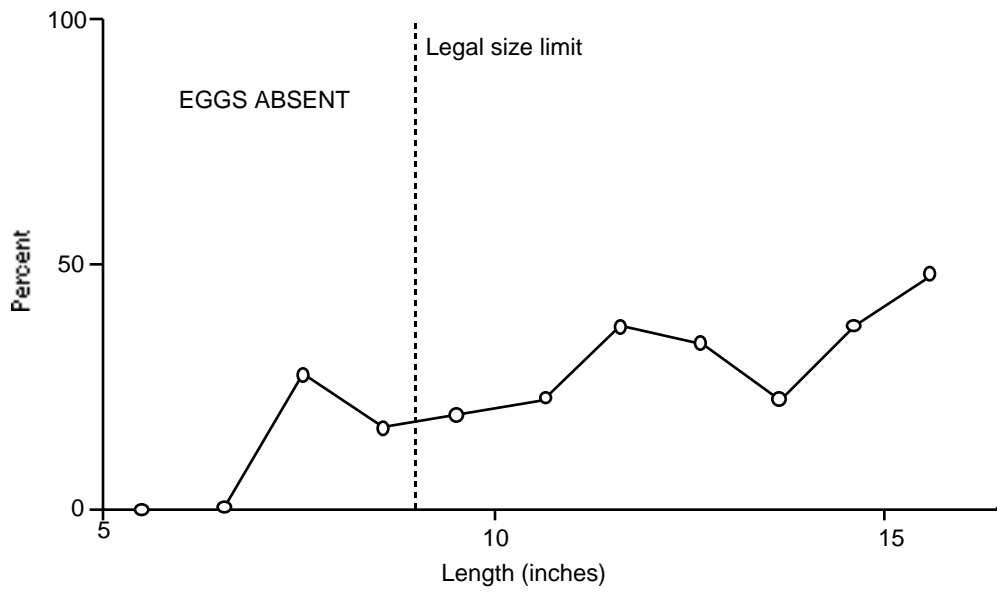


Figure 7. Percentage females with sperm packets: Key West; bully net; February, 1945; 208 in sample.

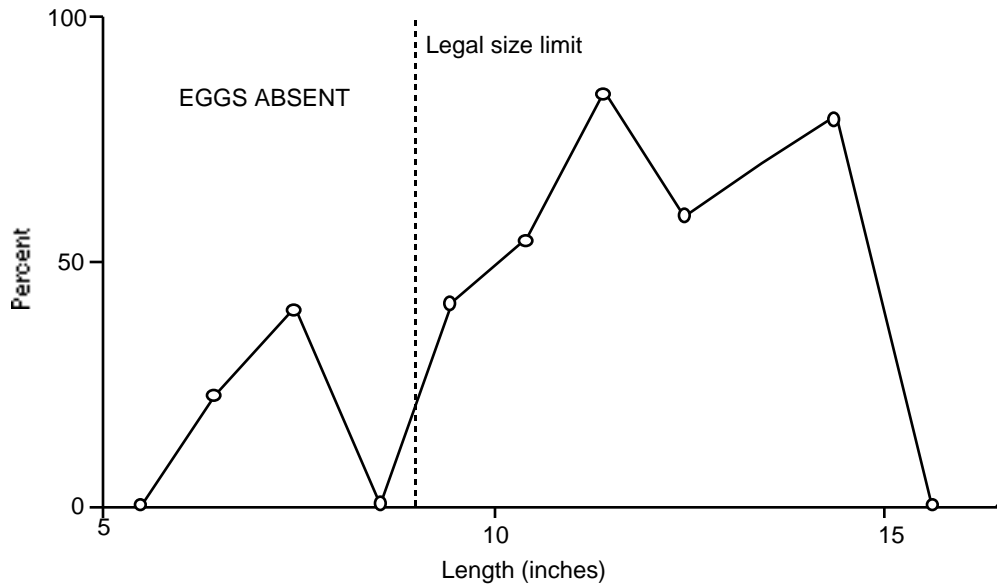


Figure 8. Percentage females with sperm packets: Summerland Key; ice cans; March, 1945.

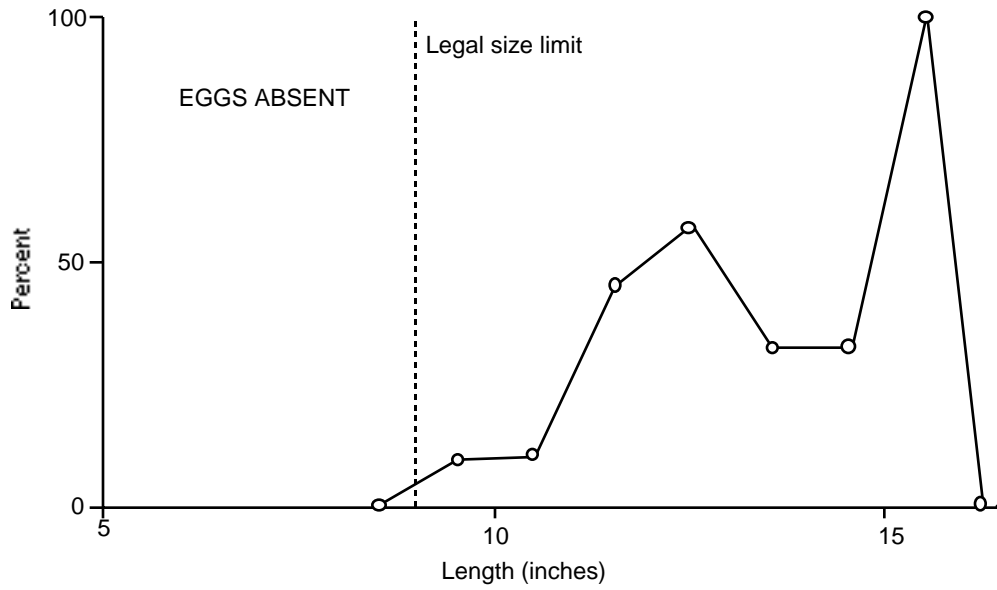


Figure 9. Percentage females with sperm packets: Cape Florida; ice cans; July, 1945; 381 in sample.

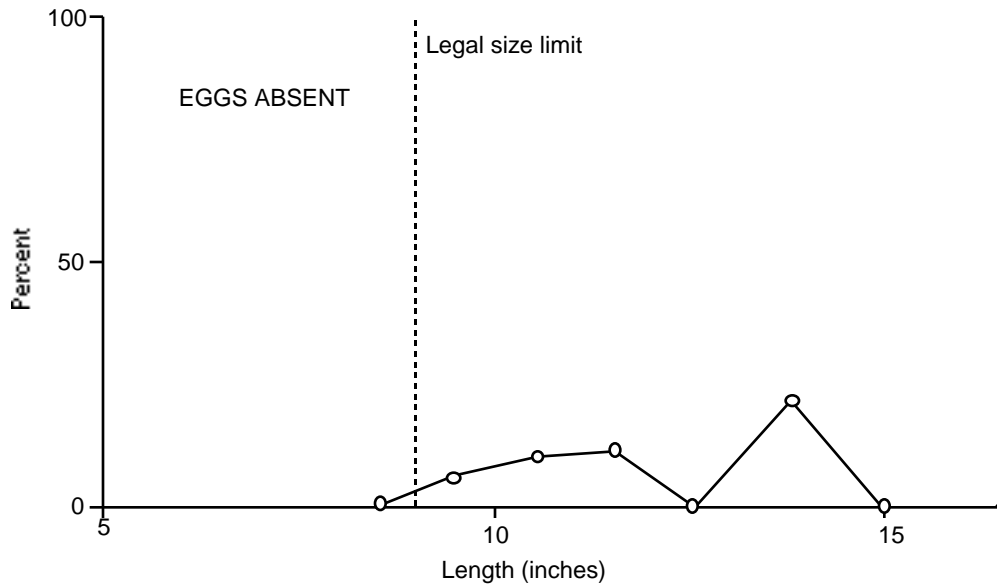


Figure 10. Percentage females with sperm packets: Cape Florida; ice cans; August, 1945; 298 in sample.

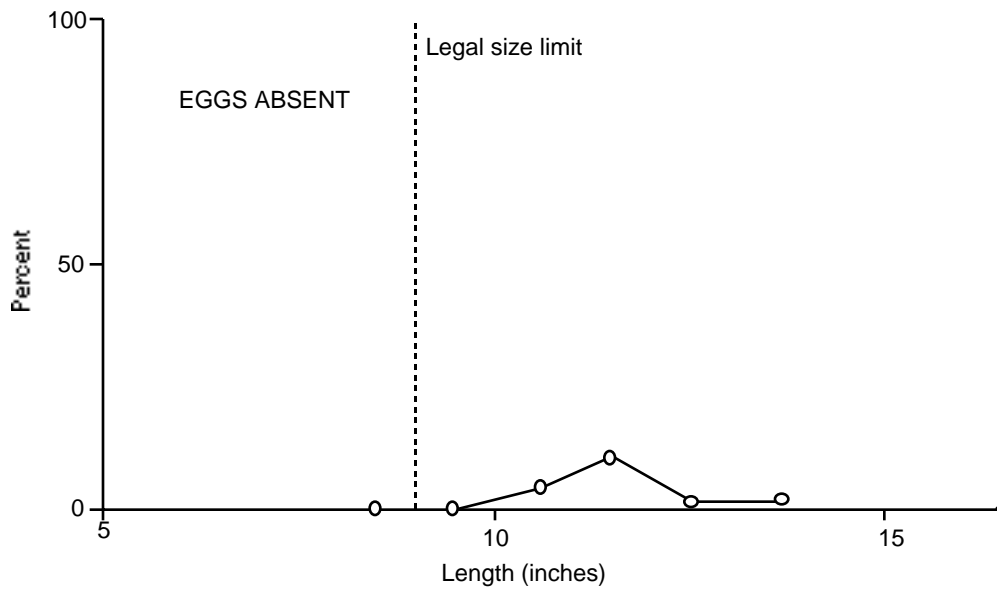


Figure 11. Percentage females with sperm packets: West End, Bahamas; bully net; March 5 - 6, 1945; 400 in sample.

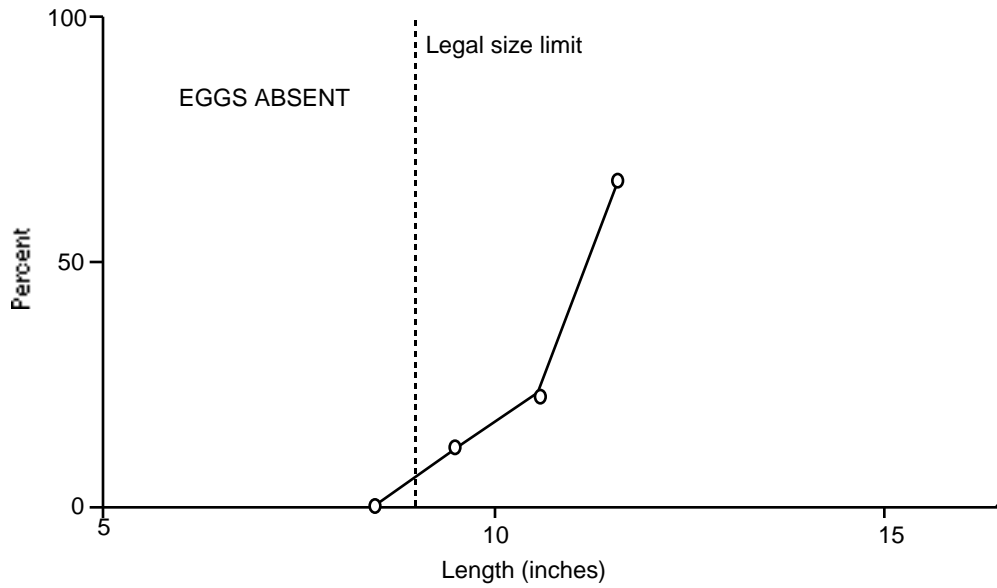


Figure 12. Percentage females with sperm packets: West End, Bahamas; bully net; March 13, 1945.

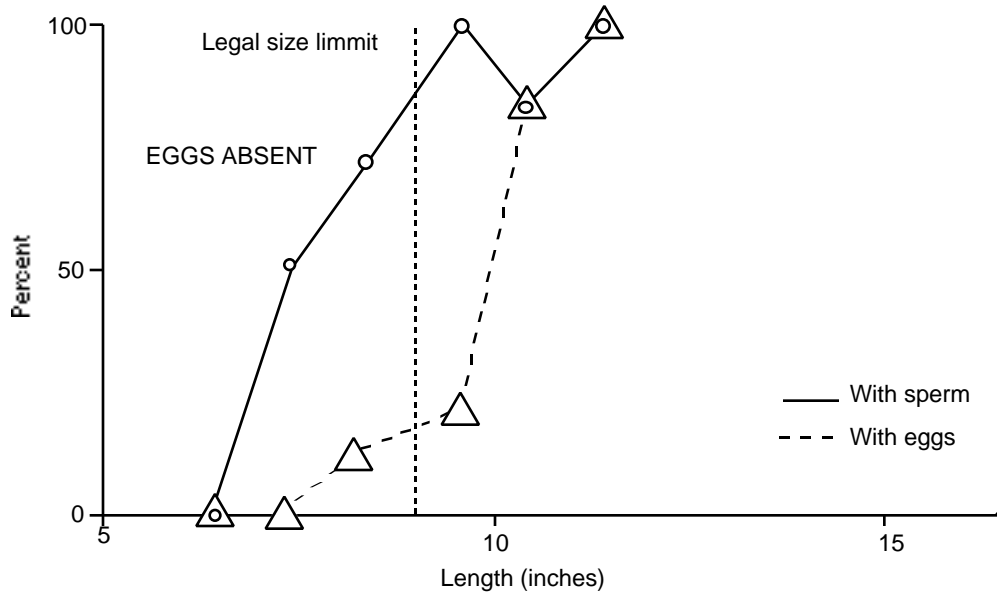


Figure 13. Percentage of breeding females: West End, Bahamas; bully net; April 25, 1945; 400 in sample.

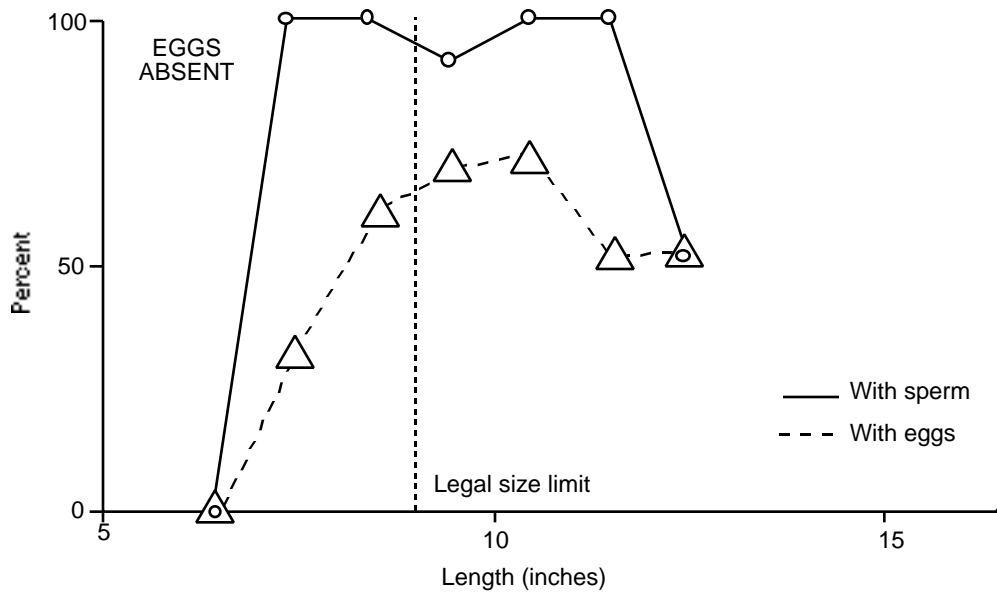


Figure 14. Percentage of breeding females: West End, Bahamas; bully net; May, 1945; 72 in sample.



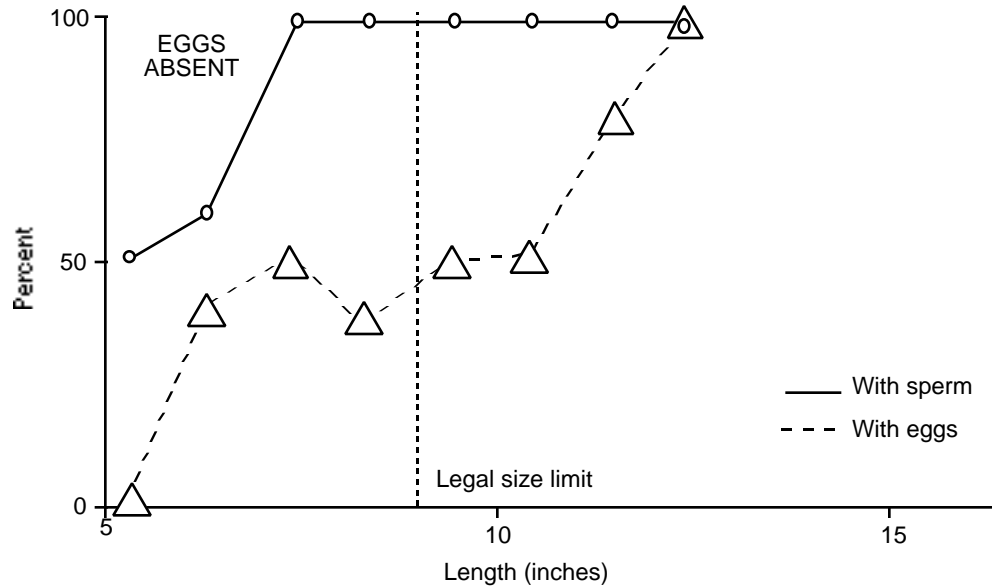


Figure 15. Percentage of breeding females: West End, Bahamas; bully net; June, 1945; 100 in sample.

#### Comparison of catches obtained by various methods of fishing

Samples taken by wooden trap, ice can and bully net are compared in Figure 16. The figure merely records the length frequency distribution for each method, and has no bearing on the efficiency of the method.

Bully net catches were taken in the ordinary manner, and all crawfish taken were measured before discarding under-sized animals. The fisherman naturally attempts to discriminate between under-sized and legal sized animals in the act of catching them and the curve indicates the efficiency with which this is carried out by an experienced fisherman. It is apparent that only a small percentage of fish below the legal limit are taken.

Wooden traps and ice cans give samples covering a somewhat similar size range. In a sample of 1200 crawfish the wooden trap takes 20 fish under 3", 120 fish under 4" and a little more than half of the catch is under the legal limit. The ice can takes in a sample of 1200, 10 fish under 1", 90 fish under 4", and more than half the catch under the legal limit.

Thus both methods of trapping catch considerable numbers of young crawfish. The objection to the ice can trap has been that it catches small fish and is therefore a source of danger to them. The analysis of catches shows that this is equally true of the legal trap.

#### Weight-Length Relationships

Figure 17 is a graphic representation of fifty-five weight-length records. The curve that has been sketched offers a means for quickly converting total length to weight and vice versa. It shows that the common practice of considering a 9 inch crawfish to be of legal size is probably justified but that variations can easily cause complications unless a definite length limit is

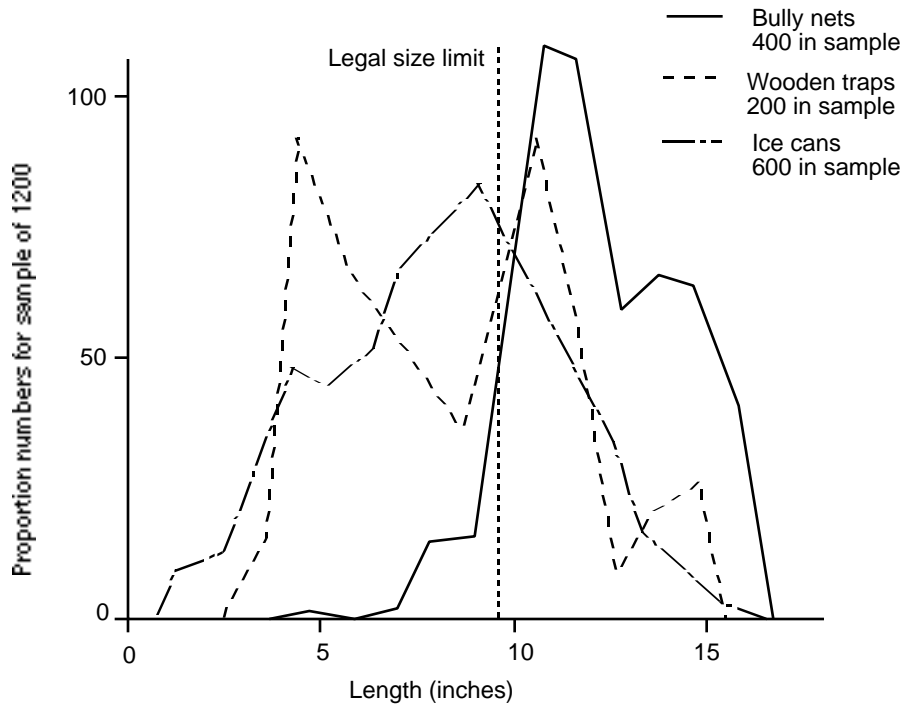


Figure 16. Comparison of catches from Florida keys by various methods during February, 1945.

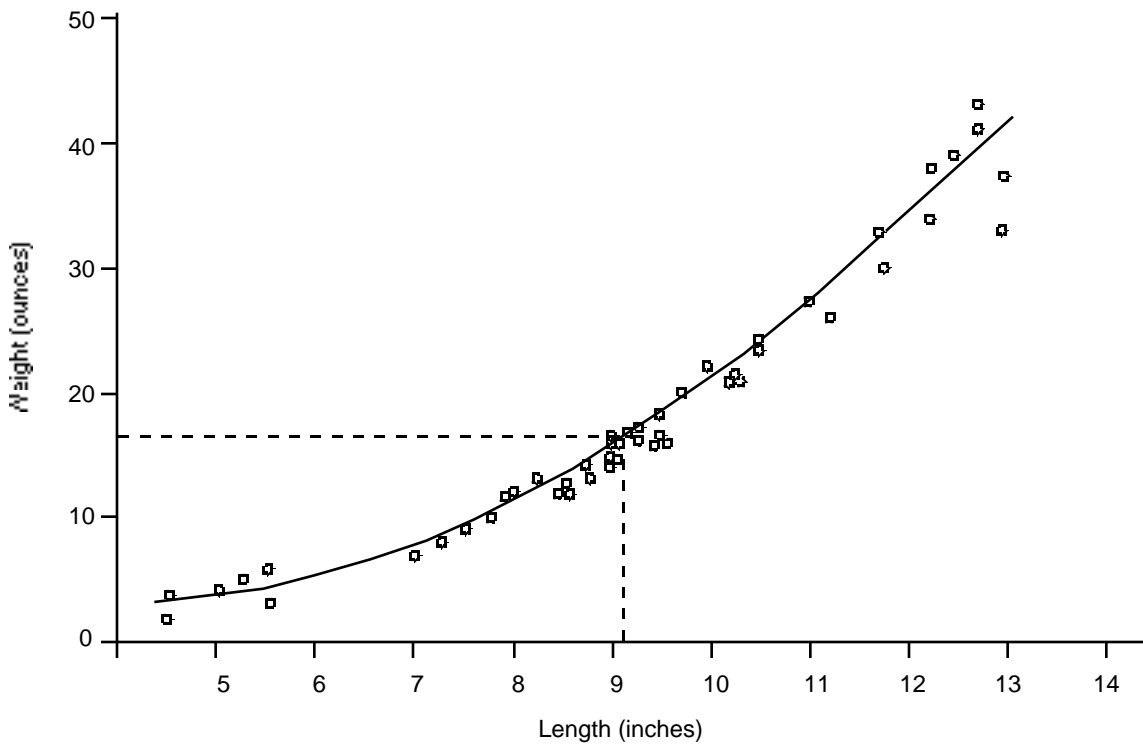


Figure 17. Weight-length relationship of the crawfish (from measurements of 65 specimens).

recognized by law. Such a limit should clearly specify how length is to be measured (see section on length-frequencies) and some allowance might be necessary for change in length due to contraction and relaxation of individual crawfish.

Speculation has been made to the effect that crawfish may lose weight by desiccation as they are being brought in to market. Preliminary trials gave no evidence of this with available measuring methods. It appears that the loss, if present, is slight; so the problem must be approached by taking precise measurements and leaving the crawfish in air for extended periods, perhaps up to twenty-four hours.

### CONCLUSIONS

1. During the past six months, in spite of difficulties mentioned in the Introduction to this report, some preliminary investigations have been carried out. While a considerable part of these are still incomplete, certain conclusions may be drawn, mostly of a tentative nature.

2. Over fishing. The evidence for over fishing is insufficient and not conclusive. The market curves shown in Figure 1 indicate that the fluctuation in quantity marketed is closely related to the price obtainable. There was however a decided downward trend from 1943 to 1945, which may however be due to the drain on manpower of wartime requirements. Some indication of over fishing in the Miami area is offered by the size-frequency data, but it is scarcely sufficient upon which to base any definite conclusions. Further investigation is required.

3. Breeding. The data show quite definitely that during 1945 eggs were no longer carried by females in shallow water during the month of July. Similarly, previous to March 20 no females were taken with spawn. There is therefore no evidence to warrant extending the closed season beyond its present limits, although more records should be sought from deeper water.

*The smallest size of crawfish with sperm packets is 6.5 inches, well below the present size limit. In the Bahamas the smallest of these is 5.5 inches. However, 100% of the crawfish at the Florida legal size limit at some time acquire sperm. No data is available for the minimum egg bearing size in Florida but in the Bahamas this is 6 inches. There appears to be sufficient evidence to indicate that the present size limit does protect a number of fish below the limit, but it is probable that this number is only a small part of the total population.*

Breeding data show that the greater number of crawfish acquire sperm packets after the month of February. Crawford's belief that mating takes place during September or the previous year is not, therefore, substantiated.

4. Migration. No evidence is offered to show the extent and nature, migrations, if any, nor their relations to such factors as seasons, breeding cycle, and physical conditions. Tagging experiments and an extension of the ice can sampling are required for this.

5. Methods of Fishing. Evidence is offered to show that ice cans entrap a similar size range of crawfish to show that of the legal traps. It is believed that ice cans are less likely to be destructive since the crawfish may enter or leave at will and are not in danger of death from starvation if the cans are left unattended.

The bully net is an efficient method, and the data show that an experienced fisherman is able to select legal sized fish with fair success.

The use of grains, which damage the crawfish, renders it necessary to bring the fish to market with reasonable speed or else to remove the viscera. The latter procedure makes it difficult to enforce weight or length or length restrictions at the market.

6. Size and Weight Limits. The body length corresponding to the one *pound* weight limit is nine inches. Insufficient data is available regarding the change in weight after capture and during transportation, but it appears to be slight.

#### RECOMMENDATIONS

1. It is not recommended that any changes be made in existing laws and regulations. The effects of fishing under the present regulations are not expected to result in any immediate and serious harm to the industry. If it were considered necessary *to bring into* force additional safeguards, however, the most efficient restriction would probably be to increase the size limit to 1.5 lbs. or to 10 inches. This would increase the number of sexually mature fish which could live in protection. A change in the duration of the closed season would be less effective.

There appears to be some grounds for putting wooden traps on the same basis as the ice can. However, further data should be obtained and possibly at a later *date* the ice can might continue to be proscribed and the legal trap specifications altered to allow wider spaces between the slats.

The substitution of length limits for weight limits might make enforcement simpler. It is not recommended, however, that these changes be brought about without further study.

2. It is recommended that the survey be continued for a sufficient time to obtain breeding and molting: data over a period of twelve consecutive months. This would be completely covered, including previous records before July, 1946. The estimated expenses during the last six months and the cost of continuing for a further year are shown in Tables II and III.

The principal reason for the incomplete nature of present records is the lack of personnel for field work. At least one full-time assistant and one part-time student assistant should be provided for this purpose. The full-time assistant need have no training in biology but he should be accustomed to handling boats, and should be sufficiently literate to record routine measurements and observations.

The estimated minimum expenditure for the completion of this survey would fall well within the provisions of the original arrangements. In the absence of participation by the U.S. Fish and Wildlife Service, approximately \$2,570 would be required to supplement the present rate of contribution by the Florida Conservation Department and the University of Miami. Should two assistants be provided the supplement would be in the neighborhood of \$4070, with total cost for the next twelve months of \$6970.

3. Measurements of captive crawfish, and studies of changes in them during ecdysis, should be carried out to provide data for determination of the rate of growth.

4. Tagging experiments should be carried out in order to determine the nature, season, and extent of migrations, and the effect of environment upon growth rate.

6. Monthly ice-can population samples should continue to be taken in shallow water and also in deep water to determine the duration of the breeding season under various conditions, and to provide more information regarding the size distribution of breeding animals. The continuation

Table II. estimate of expenditure for six month period - February 28 to August 30, 1945

	University of Miami	State Conservation Dept.
Salaries (Proportion of faculty salaries charged to survey)	\$ 500.00	-
Payment to fishermen	-	40.00
Maintenance and operation of research vessel	150.00	25.00
Equipment and supplies	-	400.00
Office expenses, etc.	50.00	-
	700.00	465.00
Total		\$ 1,165.00

of this sampling should also provide evidence of the frequency of molting, and indirectly of growth rate.

Further extension of this sampling to cover representative areas from Miami to Key West should offer definite information as to the danger of over fishing, specially when combined with knowledge of migration and growth rate gained from the tagging experiments. A portion of this work should be carried out economically as before by the cooperation of fishermen during the open season.

6. The relative efficiency and destructiveness of various methods of fishing, both in deep and in shallow water, should be determined by means of properly controlled test catches. Included in these tests should be ice cans and wooden slat (legal) traps with several sizes of opening larger than at present specified.

7. The rate of deterioration of fish speared by grains should be determined under various conditions by experiment. The rate of loss of weight following capture by trap' should also be determined under various conditions of transportation. The length/weight relationship should be determined for both shallow and deep water fish and its seasonal variation established,

8. The exploration of waters deeper than those usually fished should be carried out by means of traps in order to determine the possibility of extending the fishery.

9. An examination should be made of present machinery for collecting market statistics and investigations should be carried out with the object of advising the State Conservation Department so that these statistics may in future include some evidence of catch per unit effort.

Table III. Estimated requirements during the period September 30, 1945 to September 30, 1946.

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<u>Salaries</u>		
Faculty salaries charged to Survey	\$ 1,000.00	
Payment to fishermen	120.00	
Full time assistant	2,000.00	
Two part-time aides	1,500.00	
<u>Maintenance and operation of vessel</u>	750.00	
<u>Rewards for tags</u> (at \$ 0.25)	300.00	
<u>Equipment and supplies</u>	700.00	
<u>Office expenses</u>	100.00	
	<hr/>	
	\$ 6,970.00	
<u>University contribution</u> (Salary and office expenses)		1,100.00
<u>State Conservation Dept.</u> (at present rate)		1,800.00
		<hr/>
		\$ 2,900.00
	2,900.00	
	<hr/>	
Deficit	\$ 4,070.00	

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