Biological Studies of the Spiny Lobster, *Panulirus argus* (Decapoda; Palinuridae), in South Florida

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ABSTRACT

In recent years, the commercial fishery for spiny lobster (*Panulirus argus*) in Florida has ranked second only to the shrimp fishery in economic importance. With increased fishing pressure, the catch per unit of effort has declined, causing significant profit losses to lobster fishermen.

The present study was designed to examine the seasonal movements, reproductive biology, growth rates, population structure, distribution, and relative abundance of local adult and sub-adult populations of spiny lobster, especially as these parameters relate to the commercial lobster industry.

Overt reproductive activity, as evidenced by spermatophore or eggs, was observed in 14.9% of 1,591 females captured on or outside the deep offshore reef-line in the Atlantic. Reproductive activity, however, was negligible among 697 females trapped and tagged in the shallow Gulf.

Analysis of arbitrarily selected sub-samples of recaptured tagged lobsters indicated that non-reproductively active animals in the shallow Gulf moved generally west-southwest toward the Atlantic reef-line and deeper waters. These movement patterns, and observations on reproductive condition in these and previously studied Gulf females, preliminarily suggested that the large numbers of Gulf-captured lobsters do not exercise their reproductive potential. In the Atlantic, long-distance movements of lobsters (greater than 8 km) are eastward (predominant) and westward along the reef-line. Shorter distance (less than 8 km) and inshore-offshore movements have not yet been analyzed. Maximum movements by lobsters were 107 km (58 n. mi) in the Gulf (40 km average), and 37 km (20 n. mi) in the Atlantic (17 km average).

Mean carapace length of 2,666 lobsters, captured in commercial wooden slat traps during the 1975-76 season (August 1, 1975 - March 31, 1976), was 72.9 mm, or 3.3 mm below the minimum legal size (76.2 mm or 3 in); the mode was 68.5 mm, or 7.7 mm below the minimum legal size. Only 37% of all animals sampled were of legal size or larger.

The south Florida commercial fishery is stressed heavily in both the Gulf and Atlantic. A re-evaluation of the current management program for the lobster resource in south Florida is necessary to insure the perpetuation of the fishery.

INTRODUCTION

The spiny lobster commercial fishery has in recent years ranked second only to the shrimp fishery in economic importance in Florida (Florida Department of Natural Resources 1952-75; U.S. National Marine Fisheries Service 1952-70, 1970-75 a and b; see also Fig. 1). Local catches in 1975-76 were lower than the 6.7 million pounds landed in 1974, and significantly reduced catches are anticipated for the 1976-77 season.

[1] In the absence of the senior author, who was on extended overseas assignment, the manuscript was prepared by the junior authors.

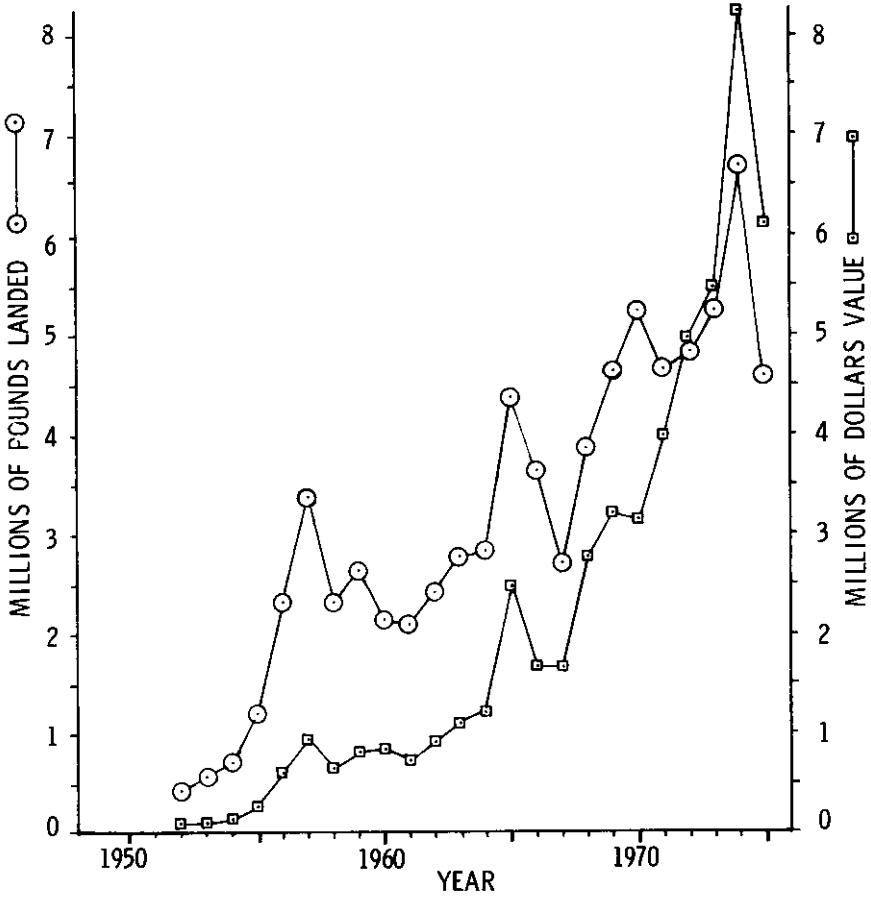

Fig. 1. Lobster landings and value in Monroe County, 1952-1975.

In early 1974, concerned members of the Organized Fishermen of Florida (OFF) requested assistance through the Monroe County Marine Advisory Program in addressing the problem of annual reductions in individual catches per unit of effort (CPUE). Questions of concern to fishermen included alternative management schemes, such as a reduction in minimum legal size; limited entry; and equitable allocation of the resource among commercial and recreational users.

Sea Grant-sponsored conferences, to address these problems, were held in Miami in March and October, 1974 (Seaman and Aska 1974; Seaman and Jones 1975).

The present program began in the Key West area in early 1975. The objectives of the study are to evaluate seasonal movements, reproductive biology, growth rates, population structure, distribution, and relative abundance of local adult and sub-adult lobster populations, especially as these parameters relate to the

commercial industry. This paper contains preliminary analyses and interpretations of selected findings, and is presented here specifically for the purpose of updating our current knowledge of the lobster fishery in south Florida.

STUDY AREAS AND METHODS

Four sampling sites within the commercial fishing grounds near Key West were selected in June and July, 1975; two in the Atlantic and two in the Gulf of Mexico (Table 1; Figs. 2 and 3). A fifth site was established in April, 1976, in the Atlantic, south of the offshore reef in deep waters. Each site, representative of a different habitat, was sampled by placement of 25 specially marked (Univ. Fla. Research), buoyed, and numbered commercial wooden slat traps in a 1 km^2 grid pattern of five rows of five traps each equidistantly spaced at 250 m. All traps were sampled weekly using a chartered commercial lobster boat, and all captured lobsters were tagged, measured, and released. Traps were baited each week with cut-cowhide squares (approximately 10 x 10 cm) placed in a standard perforated plastic bait-cup hung inside the trap adjacent the topside entrance. The trap-pulling procedure routinely caused a 250 m displacement of each trap to the next station weekly, eventually resulting in slight displacement of the grids. Grid location was checked and adjusted periodically by sighting of standard landmarks from the four corners of each grid using Hepplewhite compass-bearing binoculars.

Table 1. Lobster-trap grid sample sites

Sample Site	Location *	Depth Range	Bottom Type
No. 1 Gulf Mid-Depth	Gulf of Mexico – 6.4 km north of Mud Keys – 24°44′N. x 81° 43′W.	7-9 m (23-30 ft)	Flat, hard substrate with overlying layer of coral sand, scattered sponges, soft corals, small stony corals, some grass, few isolated rocks
No. 2 Gulf Shallows	Gulf of Mexico – 1.6 km north of West Harbor Key – 24°41′N. x 81° 45′ W.	4-6 m (13-20 ft)	Sand and grass flats in deeper parts; sponges, some stony corals, many soft corals, ledges shoreward
No. 3 Atlantic Shallows	Atlantic Ocean – 0.8 km south of Pelican Key – 24° 34′N. x 81° 38′W.	5-6 m (16-20 ft)	Sand and grass flats, mud, scattered soft and stony corals
No. 4 Atlantic Patch Reef	Atlantic Ocean – 1.6 km north of "I" marker – 24°31′N. x 81° 36′ W.	7-12 m (23-39 ft)	Typical patch reef, with large heads of stony corals, grass and sand patches
No. 5 Atlantic Deep Reef	Atlantic Ocean – 0.8 km south of "I" marker – 24° 29′N. x 81°36′W.	12-27 m (39-89 ft)	Seaward edge of offshore reef, rock out-crops, mud and stony coral patches, some spur and groove formations

* Latitude and longitude are given at approximate center of each grid.

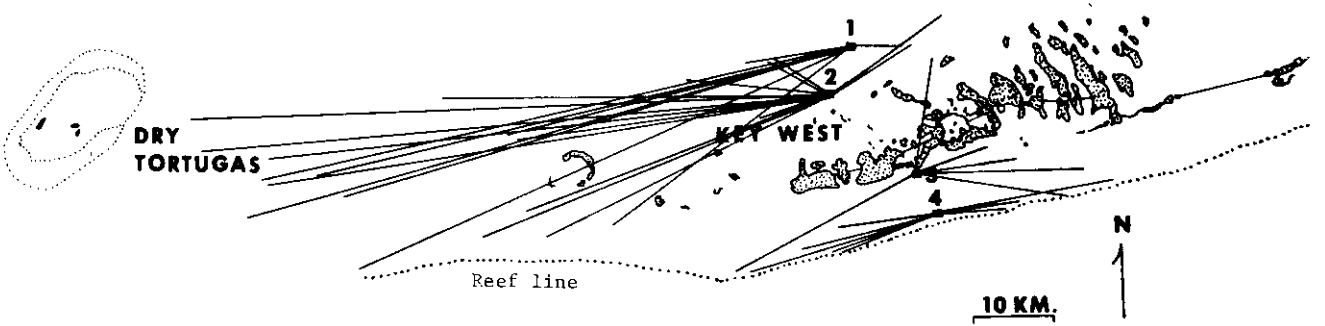

Fig. 2. Long distance movements of tagged lobsters, June-December 1975.

Successful *in situ* studies on lobsters have been conducted elsewhere in the Caribbean where little fishing pressure had existed on the lobster stocks (Herrnkind and Cummings 1964; Herrnkind et al. 1973; Peacock 1974; Herrnkind et al. 1975; Olsen et al. 1975; Kanciruk and Herrnkind 1976; Davis, in press). In our lobster study, which examined heavily fished stocks, we employed standard SCUBA equipment to survey habitat, distribution, and relative abundance within each grid. Comparison of SCUBA-collected data with trap-data was intended to calibrate the commercial slat-trap as a quantitative sampling device (see Peacock 1974; Davis, in press). Methods used to locate lobsters included tow-board surveys by two divers; 100 m (328 ft) x 20 m (66 ft) band-transect line surveys; random searches for lairs (dens); and non-random searches of probable lair sites. Lobsters were captured with a tail-snare (Kanciruk and Herrnkind 1976), returned in a net bag to the boat, tagged, measured, and returned to the point of capture on the bottom.

All lobsters captured in traps, or by diving, were tagged with a continuous-feed tagging gun[2] using sequentially numbered, plastic international-orange spaghetti tags with nylon T-bar anchors[2] (labelled, "UF, Box 2545 Key West, Return"). The tags were inserted dorsally into that portion of the abdominal muscle exposed between the posterior margin of the carapace and the first tail segment. Tags were inserted immediately lateral to the mid-dorsal line to avoid piercing either the large dorsal blood vessel, or the intestine.

Data were recorded in the field on a cassette tape recorder and on a standardized data form adapted from forms used by the National Park Service and the National Marine Fisheries Service in other lobster studies. Data recorded from each lobster included carapace length (CL) measured to the nearest 0.1 mm (from the rostral groove between the horns to the posterior margin of the carapace), sex, overt sex condition of females (eggs and/or spermatophore condition), color, molt condition, principal fouling organisms, and injuries. Short lobsters, those below the minimum legal size of 76.2 mm (3 in) CL, were tagged and placed back into traps in order to test their reported effectiveness as bait. Legal lobsters were returned to the water after tagging. Selected lobsters, e.g., premolts or certain injured animals, were returned alive to the laboratory for aquarium studies, primarily to determine instantaneous growth rates.

Tagged lobsters captured by commercial fishermen or recreational divers were voluntarily retained for our examination, after which they were returned to the catch. Tagged shorts were released if still alive or, if dead, were frozen for certified transfer to officers of the Florida Marine Patrol.

Public awareness of this study was effected primarily by extensive dockside contact with fishermen, seminars before commercial fishermen's and other organizations, and by placing English and Spanish explanatory posters in fish houses, dive shops, restaurants, and other public places in the lower and middle Keys.

[2] Tag type FD-68B; tag gun type FDM-68. Floy Tag and Manufacturing, Inc., P.O. Box 5357, Seattle, WA 98105.

RESULTS AND DISCUSSION

A total of 6,362 spiny lobsters was tagged and released between June, 1975, and August, 1976. Of these, 791 (12.4%) tagged lobsters have been returned by numerous commercial lobster fishermen and sport divers. A very high return rate of 25% (mostly legals) early in the season reflected the intensity of fishing pressure on local stocks, the excellent public response to our publicity campaign, and the effectiveness of the data retrieving system.

Movement Patterns

Movements are classified for analysis purposes in this study as either long distance (equal to or greater than 8 km, or 4.3 n. mi), or short distance (less than 8 km) movements. Single file migrations such as those described by Herrnkind and Cummings (1964) have been anecdotally reported for this area, and diffuse, large scale, westerly and southwesterly movements in the fall have been observed or detected during trapping operations by commercial lobstermen and others. However, these anecdotal data are not included in this report.

Analysis of short range movements is incomplete, but one animal was recaptured nearly one year after initial tagging only 3 km from the original point of tagging and release on the reef.

In the Gulf, long distance movements of tagged lobsters from our study areas were more uni-directional and of greater average distance than those in the Atlantic (Figs. 2 and 3). Between June and December, 1975 (Fig. 2), 87% of the long distance sample moved generally west-southwesterly from Gulf grid sites No. 1 and No. 2, towards the Atlantic reefs and deeper waters near Dry Tortugas. West-southwesterly movements averaged more than 40 km (22 n. mi) (maximum 107 km or 58 n. mi) during the year from the Gulf grids.

In the Atlantic, tagged lobsters moved both easterly and westerly up to 37 km (20 n. mi) (average 17 km or 9 n. mi), primarily along the offshore reef-line. About 21% of tagged lobsters recovered in both the Gulf and Atlantic between June and December, 1975, had moved distances greater than 8 km.

One animal was recovered after 318 days of freedom, but the average number of days between tagging and recapture is presently about 50. In the Gulf, long distance movements averaged 0.9 km/day, and in the Atlantic, about half that distance per day.

Seasonal changes in commercial fishing pressure in different areas may bias these data, but this aspect has not yet been studied.

Previous tag-recapture studies in the Atlantic off south Florida have suggested generally short distance movements for adult (legal size or larger) spiny lobsters. Dawson and Idyll (1951) reported 78% of 251 recovered tagged lobsters had moved less than 11 km (6 mi). Little (1972) found that 53% of 118 recovered tagged lobsters had moved less than 9 km (5 mi), and Davis (in press) found no movement in excess of 8 km (4.3 mi) of adult lobsters in the Dry Tortugas in periodic samples collected over several years. In each case the method of release subsequent to tagging was different; the results are therefore not readily comparable.

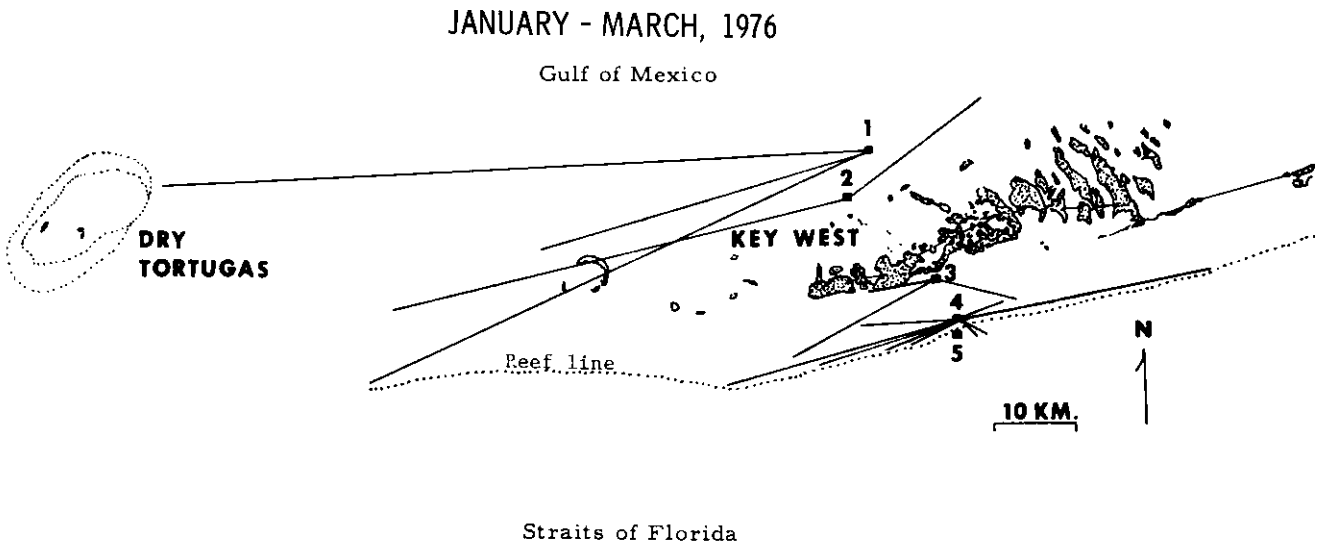

Fig. 3. Long distance movements of tagged lobsters, January-March 1976.

A comparative analysis of size-class movements according to sex, area, and season is incomplete, but preliminary review suggests the possibility of local residency of adult lobsters in the reef environment, as suggested by Davis (in press).

Probably the most interesting observation concerning long distance movement patterns quantified in the present study is the generally westward movement of legal-sized Gulf lobsters. The apparent speed with which they move suggests purposive movement, possibly towards wintering and/or breeding grounds. Further evidence of this is given below. This movement pattern raises the question of similar movements from northeast Florida Bay toward the Key West area. Such movements are believed by commercial fishermen using the area to occur each fall. The question should be investigated.

We found it difficult to obtain recovered tagged shorts from fishermen, who understandably preferred to return them to the water when captured. Unfortunately, a large body of valuable data on growth and long-distance migratory habits of sub-adult (between approximately 30 mm and 76.2 mm CL) lobsters was therefore lost.

The shorter distances moved in the Atlantic along the reef-line may relate to observed reproductive activities in that zone and may suggest more localized movements following the onset of active reproduction. Apparent relative movement might, however, relate to local monthly fishing pressure.

Reproductive Biology

Overt reproductive activity (presence of eggs and/or spermatophore) was observed in only one (or 0.08%) of 1,259 adult or sub-adult female lobsters tagged in the Gulf during a 13-month period (July, 1975 - August, 1976). Overt reproductive activity was otherwise restricted to females sampled in the Atlantic grids. For this preliminary report, numbers of reproductively active females were tallied (Table 2). Of the total 6,362 lobsters tagged during the year, 2,850 were females, 1,591 from the Atlantic and 1,259 from the Gulf. In a total of 238 reproductively active females observed, 237 were from the Atlantic. Of these, 54 Atlantic females had spawned (3.4% of total Atlantic females captured), mostly in the Deep Reef grid (No. 5). The single reproductively active female observed in the Gulf was a short with a normal spermatophore, captured in the Gulf Shallows grid in August, 1975. No evidence of spawning was observed in the Gulf.

The 238 reproductively active females observed comprised 8.4% of the total 2,850 female lobsters captured in the Gulf and Atlantic (the total sample, representing the fished population), and the 54 egg-bearers represented 1.9% of the total sample. Considering the Atlantic grids only, the 237 reproductively active females comprised 14.9% of the 1,591 females observed, and the 54 egg-bearers represented 3.4% of the sample (Table 2). One-third of the spawners in the Deep Reef grid were shorts. Since this grid was apparently representative of an area of maximum reproductive activity, this large proportion of short egg-bearers suggests that larger females, which carry more eggs (Creaser 1950), were harvested in large numbers thereby significantly reducing egg-production.

Table 2. Overt reproductive activity in sampling grids (July 1975 through August 1976)

Grid	Carapace length (mm)	Mated females–spermatophore (Tarred)		Spawned females–spermatophore and eggs (Berried)		Total reproductively active		Total reproductively inactive		Total sampled this grid	
		No.	%	No.	%	No.	%	No.	%	No.	%
Grid 3 Atlantic Shallows	≤76.1 Shorts	2	0.1	0	0	2	0.1	259	16.3	261	16.4
	≥76.2 Legals	5	0.3	0	0	5	0.3	148	9.3	153	9.6
	Total	7	0.4	0	0	7	0.4	407	25.6	414	26.0
Grid 4 Atlantic Patch Reef	≤76.1 Shorts	14	0.9	0	0	14	0.9	472	29.7	486	30.5
	≥76.2 Legals	49	3.1	19	1.2	68	4.3	334	21.0	402	25.3
	Total	63	4.0	19	1.2	82	5.2	806	50.7	888	55.8
Grid 5* Atlantic Deep Reef	≤76.1 Shorts	41	2.6	10	0.6	51	3.2	74	4.7	125	7.9
	≥76.2 Legals	72	4.5	25	1.6	97	6.1	67	4.2	164	10.3
	Total	113	7.1	35	2.2	148	9.3	141	8.9	289	18.2
Atlantic Grids 3,4,5	≤76.1 Shorts	57	3.6	10	0.6	67	4.2	805	50.6	872	54.8
	≥76.2 Legals	126	7.9	44	2.8	170	10.7	549	34.5	719	45.2
	Total	183	11.5	54	3.4	**237**	**14.9**	1354	85.1	**1591**	**100.0**
Gulf Grids 1,2	≤76.1 Shorts	1	0.08	0	0	1	0.08	770	61.2	771	61.2
	≥76.2 Legals	0	0	0	0	0	0	488	38.8	488	38.8
	Total	1	0.08	0	0	**1**	**0.08**	1258	99.9	**1259**	**100.0**

* Grid No. 5 sampled April through August, 1976, only.

Alternately, this could be the first evidence of genetic selection toward smaller size animals because of continued heavy harvesting of large animals. The smallest egg-bearing (berried) female (71.4 mm CL) captured during this study was found in this grid, as was the largest (102.9 mm CL). Also captured here were the smallest (66.6 mm CL) and largest (107.4 mm CL) females with spermatophore only (tarred).

Overt reproductive activity was first apparent in Atlantic females in April, 1976. In the Atlantic Deep Reef grid there was a steady increase in reproductive activity as follows: April = 16/66 = 24.2%; May = 11/29 = 37.9%; June = 69/101 = 68.3%; July = 37/54 = 68.5%; August = 55/79 = 69.6%. Unfortunately, because of discontinued sampling beyond August, 1976, no additional data are available from this obviously important reproductive zone.

Sex ratios at the beginning (August - October, 1975) of the commercial lobster season, as determined from grids No. 1-4, are given in Table 3. The largest females are found in deeper waters in both the Gulf and Atlantic (grids No. 1 and No. 4). Sex ratios show that females significantly (p=0.05) outnumber males on the reef.

Crawford and DeSmidt (1922) observed an autumnal breeding season, and a minimum size of berried females of 76.2 mm (3 in) CL. Dawson and Idyll (1951) observed mating activity March through November with a peak in April. In their 5-year sample of 9,956 females, 11.1% showed evidence of mating and 2.7% had spawned. A small proportion of mating females was observed to be smaller than 0.45 kg (1 lb) in weight (approximately equivalent to 80-85 mm CL). Smith (1951) reported significant size differences between heavily fished and unfished Bahamas lobster populations. He recorded berried females with a 38 mm CL (1 in) in a heavily fished area. Davis (1975) found no berried shorts in an unfished population in the Dry Tortugas, and the largest berried females did not exceed 135 mm CL. He concluded that in this protected population sexual maturity was reached by females in the 86-95 mm (3.4-3.7 in) CL size

Table 3. Sex ratio and mean size of lobsters, by area (beginning of season – August, September, October, 1975)

	Grid No. 1 Gulf Mid-Depth 7-9 m (23-30 ft)		Grid No. 2 Gulf Shallows 4-6 m (13-20 ft)		Grid No. 3 Atlantic Shallows 5-6 m (16-20 ft)		Grid No. 4 Atlantic Patch Reef 7-12 m (23-39 ft)	
	Males	Females	Males	Females	Males	Females	Males	Females
No. in sample	144	165	187	133	137	144	129	172
Sex ratio (% of sample)	46.6%	53.4%	58.4%	41.6%	48.8%	51.2%	42.9%	57.1%
Significance level (chi-square used)	NS		p=0.01		NS		p=0.05	
Carapace length (mode)	73.5mm (2.9 in)	85.5mm (3.4 in)	73.5mm (2.9 in)	69.5mm (2.7 in)	81.5mm (3.2 in)	81.5mm (3.2 in)	81.5mm (3.2 in)	81.5mm (3.2 in)

class, as 60% of these were berried. He also concluded that the present minimum size of 76.2 mm CL permits harvest of females which have not attained even limited reproductive potential. Kanciruk and Herrnkind (1976) in deeper waters of the Bahamas found larger females and sex ratios very similar to ours. They also found sexually mature females only in offshore reef areas.

Preliminary findings from our 1975-76 data, and findings reported by other investigators, indicate that average size at first sexual maturity in *P. argus* may be reduced as fishing pressure is increased. A nearly exponential relationship between animal size and egg-production has been reported in *P. argus* (Creaser, 1950). Peacock (1974) and Davis (1975) described apparent reproductive senility in females larger than 130 mm (5.1 in) CL, but females just slightly smaller (116-125 mm, or 4.5-5 in CL) were reported by both investigators to be most reproductively active. Creaser (1950) reported that a single 127 mm CL female *P. argus* from Bermuda produced in one season more eggs than four 85 mm CL females. Assuming the Florida *P. argus* to be reproductively comparable to Bermuda *P. argus*, our preliminary data suggest that local egg-production is low. Of the 54 egg-bearers captured during this study, 41 (or 76%) were smaller than 86 mm CL, and 13 (or 24%) were larger than 86 mm CL. Maximum size observed was 102.9 mm CL. Since the fate of lobster larvae hatched in local waters remains unknown, the quantity of egg-production may be important, if not to local stocks, then to stocks elsewhere in the Caribbean.

Our preliminary findings support those of previous studies summarized here, indicating that a minimum legal CL of 76.2 mm (3 in) does not protect the largest portion of the reproductively mature females. The minimum size of sexual maturity in males is not yet known, and also needs to be determined. It is clear that if the minimum legal size of lobsters is to be modified, it should not be reduced, as has been suggested by many fishermen.

Growth Rates

Instantaneous growth rates were observed in laboratory aquaria on 45 premolt lobsters ranging in size from 66-107 mm CL. Growth was determined by measuring the carapace before molting, and again 1 week after molting. For the 45 animals observed, growth in CL averaged 5.4 mm per molt. Estimates of growth by sex, size, and season are expected to be determined from multiple recaptures (up to 5 times) of lobsters within our sampling grids. These data will be reported in a later publication.

Previous studies (Crawford and DeSmidt 1922; Dawson 1949; Smith 1951; Dawson and Idyll 1951; Sweat 1968; Little 1972; Eldred, Futch, and Ingle 1972; Munro 1974; Olsen and Koblic 1975) draw differing conclusions concerning growth rates in *P. argus*. Some indicate differential growth rates by sex, males growing up to twice as rapidly as females. Reported time required for reaching legal size from time of larval settlement varies by several years in previous studies.

Growth rate in lobsters must be understood clearly for proper resource management. The large number of growth increment data from the present study, when fully analyzed, are expected to significantly clarify this problem.

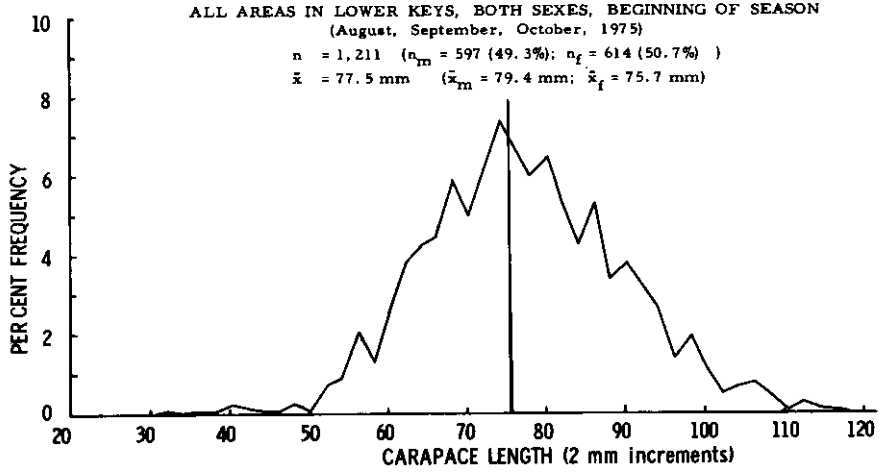

Fig. 4. Length-frequency, all lobsters, all areas, beginning of 1975-76 season (Vertical rule indicates minimum legal size at 76.2 mm).

Population Structure, Distribution, Abundance

Male-female length frequencies were combined (Fig. 4) for 1,211 lobsters sampled in grids No. 1-4 during the most heavily fished portion of the commercial lobster season. A 1:1 sex ratio was indicated. The 77.5 mm mean CL was slightly above the minimum legal size limit of 76.2 mm, while the mode was below the limit at 74.5 mm CL. Table 3 lists total numbers of animals, sex ratios, mean CL, and modal CL by sex for each grid at the beginning of the season. Monthly determinations of sex ratios and mean CL for each area are not yet complete, but a combined length frequency curve for all lobsters sampled (n=2,666) using slat traps during the 8-month 1975-76 commercial season (Fig. 5A) shows an overall decrease to 72.9 mm in mean CL by the end of the season. The CL mode was 68.5 mm. This result is compared in Fig. 5B with F.G.W. Smith's (Dawson and Idyll 1951) determination of lobster population structure in the Keys between 1944-49, and in Fig. 5C with Davis' (1974) 1-month determination of lobster population structure in the protected waters of Ft. Jefferson National Monument, Dry Tortugas.[3]

In our grids, the difference between observed mode and mean CL during the first 3 months of sampling (Fig. 4, $\bar{x}$=77.5 mm, mode=74.5 mm) and after 8 months of fishing (Fig. 5A, $\bar{x}$=72.9 mm, mode=68.5 mm) is indicative of heavy

[3] Histograms are plotted in 10 mm increments because: 1) Davis (1974) reported his findings in 10 mm increments; 2) Smith's (Dawson and Idyll, 1951) data were originally reported as total length (TL) in inches – we converted these to CL by combining Peacock's (1974) formulas (TL_m=2.61 x CL_m; TL_f=2.91 x CL_f) to get TL=2.76 x CL, and CL=TL/2.76 – the results were plotted in 10 mm increments to reduce variability induced by conversion, and for convenience in comparing with Davis' results; 3) our data could be compared with Davis' and Smith's. Smith's data were also plotted using formulas recently derived by D. Simmons (pers. comm.), and the results were similar.

fishing pressure. Only 37% of lobsters sampled in our intensely fished study areas were of legal size or larger. In Smith's sample, from a moderate fishery, 75% of the animals were larger than the present minimum size, and 83% exceeded the present minimum size in Davis' unfished sample.

DISCUSSION OF RELATED QUESTIONS

Annual catch statistics provided by the U.S. National Marine Fisheries Service were graphed (Fig. 6) to show the effects of heavy fishing pressure on the Key West and Marathon lobster populations during the last four seasons. These data provide temporal and spatial approximations of local lobster distribution and

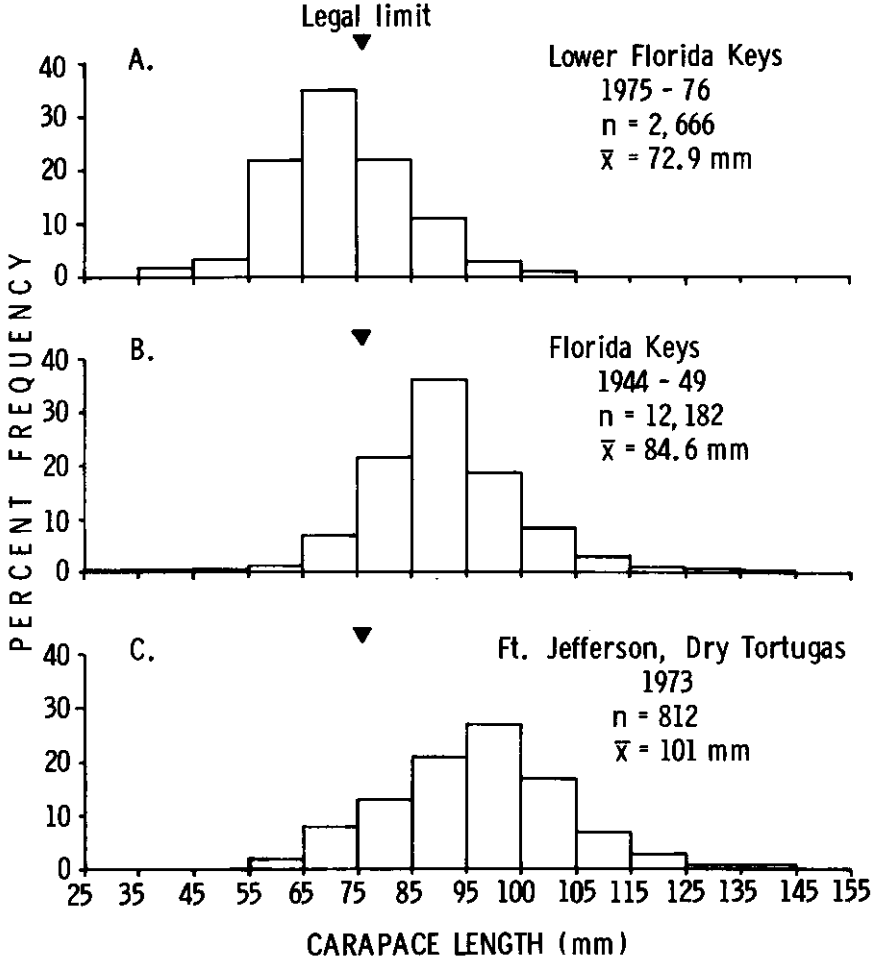

Fig. 5. Length-frequency, three studies compared: A=heavily fished; B=moderately fished; C=unfished.

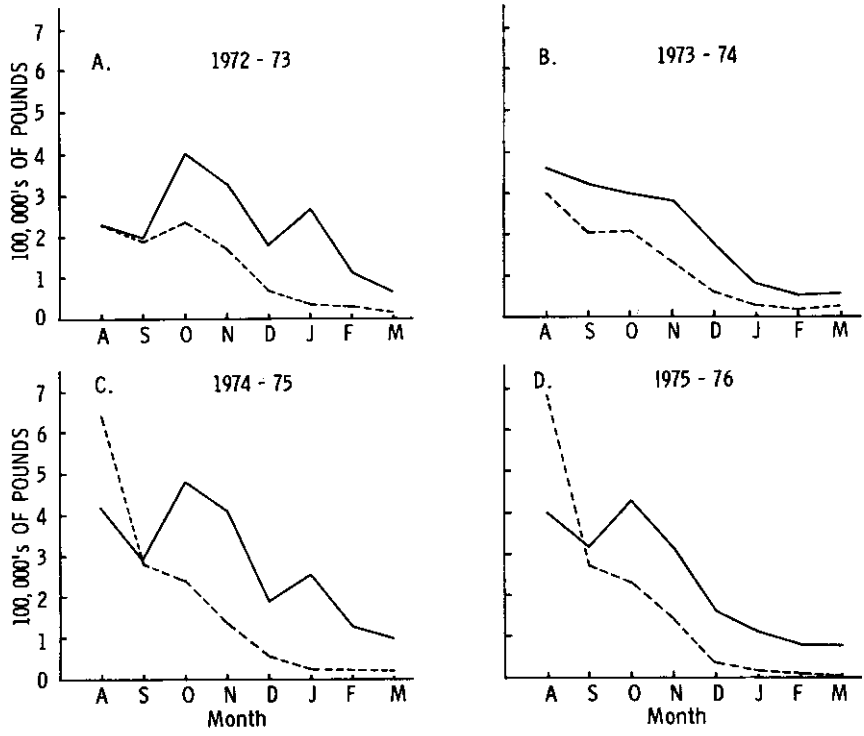

Fig. 6. Monthly lobster landings, 1972-1975, Key West (solid line) and Marathon (dotted line).

abundance, but would be of more value for management purposes if catch per unit of effort (CPUE) were known. No recent records are available on numbers of commercial traps in Keys fishing grounds. Data from our experimental traps will provide CPUE for only those areas sampled, but may reflect a fisherman's typical CPUE in that our traps, like his, were occasionally robbed, lost, broken, or stolen.

This externally induced loss of lobsters, and likewise our data, might bias results because apparent abundance and true abundance of lobsters could possibly differ greatly. When fishermen (or we) are robbed, true abundance of lobsters matters little. Actual CPUE may therefore be reduced regardless of lobster availability, individual fisherman's skill, size of boat, or numbers of traps set. Because no official records have been kept since 1970 on numbers of traps, and no limits are set on numbers of traps permitted to individuals, fishermen in general are placed in the position of having to increase capital outlay continually to compete with other relatively unregulated fishermen who are investing more capital in order to compete.

Some fishermen have sought counsel through our offices and those of the Department of Natural Resources concerning a possible moratorium on further issuance of commercial lobster licenses, or other forms of limited entry. These are questions worthy of serious consideration by the proper authorities, and precedents have been set in the states of Washington, Alaska, and elsewhere.

Local fishermen report that CPUE continues to drop, and trap-robbing becomes more serious each year, causing already difficult law enforcement to become ever more difficult, causing trap-robbing to become even more tempting, continuing to drop individual CPUE. No statistics are available, of course, on the extent of problems such as trap-robbing, but during a study such as ours which requires considerable personal interaction between investigators and fishermen, the magnitude of such problems eventually becomes apparent.

Possibly the single most important element in the problem of reduced average size of local lobsters, and reduced individual annual CPUE in the Keys, is the large and constantly growing illegal market in short lobsters. Existing laws, and the existing load on enforcement officers and courts, permit fishermen so inclined to illegally catch and sell, at high prices, with little risk of arrest and successful prosecution, large numbers of shorts (see also Beardsley et al. 1975). As a result there now exists a short market in the Keys variously estimated at 20-50% by weight of the legal catch. This implies that large numbers of shorts are harvested. From the standpoint of sound management practices the implications of such significant reductions in recruitment potential into the legal fishery are staggering. Again, statistics are unavailable, so the true magnitude of the problem is unknown, yet it is real and must be recognized. These problems are now in part being addressed through sophisticated statistical analyses of our catch data at the University of Florida, and will be reported separately.

The long-term importance and value of the Florida lobster fishery demands continued extensive research in the present spirit of multi-agency cooperation until effective management practices are established. The array and extent of problems remaining to be resolved, as outlined in this report, emphasize the necessity of this approach.

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