Marine Parks and Sanctuaries for Spiny Lobster Fisheries Management

GARY E. DAVIS and JON W. DODRILL
South Florida Research Center
Everglades National Park
Homestead, Florida 33030

RESUMEN

Los parques marítimos podrían proveer servicios valiosos para los científicos y administradores pesqueros si estuvieran libres de los impactos de la captura. Los estudios de la langosta espinosa en cuatro parques nacionales de los Estados Unidos se utilizan para describir beneficios potenciales por repoblación, conservación de la variabilidad genética; proveen oportunidades educacionales, deportivas y estéticas; actúan como base para el estudio y evaluación de programas de administración; y proveen poblaciones vírgenes para los estimados de la producción sostenida. En la Florida, tres parques nacionales contienen amplios recursos de langosta espinosa, principalmente *Panulirus argus*. El Monumento Nacional Fort Jefferson en las Dry Tortugas cubre 190km^2 de arrecifes de corales y placeres de grama marina que mantienen langostas espinosas adultas y juveniles. El Monumento Nacional Biscayne, al sur de Miami en la parte norte de los cayos de la Florida, incluye 190km^2 de laguna tropical en el sur de la Bahía Biscayne y 200km^2 de arrecifes de corales y placeres al este de los cayos. Juveniles de langosta espinosa ocupan cerca de 1,000km^2 de grama marina y del fondo dominado por octocorales en la Bahía de la Florida dentro del Parque Nacional de los Everglades. En el Parque Nacional de las Islas Vírgenes, cerca de 230km^2 de arrecifes de coral costeros y de bahías costeras alrededor de la isla St. John, mantienen langostas espinosas adultas y juveniles.

Las observaciones de mas de 15,000 ejemplares de *P. argus* marcados en las poblaciones de estos parques, están resumidos para proveer información del desarrollo, mortalidad, reproducción y movimiento. Los factores que se encontraron afectaban más el desarrollo, fueron las estaciones y daños a los juveniles, y el sexo de los adultos. Las poblaciones vírgenes proporcionaron estimados directos de mortalidad natural. El tamaño de la madurez primaria en las problaciones vírgenes fué mayor que en las poblaciones más explotadas. Juveniles de *P. argus* demostraron movimientos direccionales extensivo hasta de 200km, mientras los adultos demostraron movimientos restringidos por aproximadamente dos años. Las devoluciones de las placas de identificación durante la temporada de 1977-1978 en la Florida se dividieron igualmente entre pescadores deportivos (49%) y comerciales (51%). Sin embargo, las devoluciones de las placas de identificación que fueron situadas directamente en las nasas (o trampas) comerciales demostraron que solamente 11% de las placas de identificación en las nasas fueron reportadas. Estas devoluciones demuestran que la captura deportiva fué 9% del total en la parte norte de los cayos de la Florida, si todas la placas fueron reportadas. El escape promedio de la langosta de nasas no recobradas fué de 1.2% diario durante los 14 días de caladas.

INTRODUCTION

National parks and sanctuaries with significant marine resources can play important roles in effective fisheries management. However, if fishery resources are exploited and not protected to the same extent terrestrial resources are protected in parks and sanctuaries, they may not be available to provide the dynamic standards for comparison, reproductive/genetic reserves, unique educational opportunities, recreational escape from daily

routine or aesthetic/emotional resources for remote users that virgin resources can. Aquatic resources in parks historically have suffered from an "out-of-sight, out-of-mind" complex, and rarely have they been considered as integral parts of fishery management programs (Wallis, 1971). Observations of spiny lobster populations in national parks and monuments of south Florida and the U.S. Virgin Islands provide examples of how such areas can be useful in fishery management.

METHODS

Studies of spiny lobsters, *Panulirus argus,* were recently conducted in two national parks and two national monuments. Investigations of recreational harvest and food habits of *P. argus* were conducted in Fort Jefferson National Monument at Dry Tortugas, Florida between 1971 and 1979 (Davis, 1975; 1977; Davis, Dodrill and Lyons in prep.), and studies of juvenile *P. argus* distribution, abundance, growth and migration were conducted in Biscayne National Monument and Everglades National Park during 1975-79 (Davis, 1978a, 1978b, 1978c). A number of ecological, behavioral and fisheries studies of *P. argus* were conducted in conjunction with the 1969-70 TEKTITE Man-in-the-Sea projects in Virgin Islands National Park, St. John, U.S. Virgin Islands (Davis, 1971; Herrnkind et al., 1975; Olsen and Koblic, 1975).

These areas represent a variety of lobster habitats and levels of exploitation. Fort Jefferson National Monument encompasses 190km^2 of coral reef and seagrass meadows that support both juvenile and adult spiny lobsters which are completely protected from all fishing activity. Just south of Miami, Florida, Biscayne National Monument includes 190km^2 of tropical lagoon in southern Biscayne Bay in which primarily juvenile lobsters are presently protected from harvest. During our study, however, harvest was permitted in the bay. This monument also includes 200km^2 of coral reefs and associated seagrass beds, east of the northernmost Florida Keys, in which virtually unlimited recreational and commercial lobster harvest occurs. Juvenile lobsters occupy about 1,000km^2 of seagrass and octocoral dominated bottom in northeastern Florida Bay in Everglades National Park, where only recreational harvest is permitted. A limited recreational lobster harvest is allowed in the 230km^2 of bay bottom and fringing coral reefs in Virgin Islands National Park, but harvest was prohibited around the TEKTITE habitat during the projects.

Juvenile and adult *P. argus* were captured by hand, bully net, snare, roller frame trawl or top-entry wooden slat traps, and most were individually marked with spaghetti tags (Davis, 1978b). Data on the size (carapace length-CL), reproductive condition, molt state, injuries, capture method, date and location were recorded. Samples were taken during every month of the year, with a concentrated effort each spring at Dry Tortugas. Periodic efforts were made to recapture tagged lobsters. In the Florida studies, assistance in recapturing tagged lobsters was requested directly from recreational divers and commercial fishermen and indirectly through posters displayed at local dive shops and fish processing centers. News releases were issued to local and regional media, and handbills describing the tags in Spanish and English were widely distributed. Tagged lobsters were surreptitiously placed in active

commercial traps to measure the actual return rate of recaptured tags. Tagged lobsters were also placed in unbouyed, diver-tended, traps to measure escape rates so that the tag return rate from commercial fishermen could be based on the number of tags actually available to them.

RESULTS

During these studies, 14,119 *P. argus* were tagged and another 5,961 were measured and examined (Table 1). They ranged in size from 8 mm to 190 mm CL. Growth rates were calculated from 2,628 recapture observations, and precise determinations of movement were possible from a total of 2,476 recaptures. The time at large of the recaptured lobsters ranged from less than 1 week to 2 years, but less than 15% were free more than 20 weeks, with a mean of 10.6 weeks (Table 2). Tag returns from the 1977-78 season in Florida were divided equally between recreational (49%) and commerical (51%) fishermen. However, returns of the tags placed directly into commercial traps, adjusted for escapement, showed that only 11% of the trap caught tags were reported. These tag returns suggest that recreational harvest was 9% of the total landings in the upper Florida Keys, if all of the recreationally caught tags were reported. The mean lobster escape rate from unfished slat traps was consistently 1.2% per day for soak times up to 14 days.

Growth Rates

Growth of spiny lobsters takes place as the result of a series of molts, during which measurable changes in size occur discontinuously. The rate of growth is dependent on both the magnitude of change in size with each molt (molt increment) and the frequency of molts (intermolt period). Growth rates were determined as change in carapace length per week, since most observations of tagged lobsters were made at weekly intervals. To reduce the variability inherent in measuring the discontinuous changes in size that resulted from random observations of growth during the molting cycle, all changes in carapace length were summed for each class of observations (that is, adult, juvenile, injured or uninjured), and divided by the sum of the time intervals for the appropriate class of observations, so that:

$$\text{Growth Rate} = \Sigma Y \div \Sigma X$$

where Y = change in CL (mm),
and X = weeks between CL measurements.

Growth rates of adult *P. argus* at Dry Tortugas (85-144 mm CL) averaged only 16.6 mm CL per year, but there was a marked difference between sexes (Table 3). The mature sized males averaged 22.9 mm CL per year, whereas females showed a mean growth of only 7.3 mm CL per year. It appeared that males were molting and growing three or four times each year. From the conditions of their exoskeletons, it looked as if females were molting at the same rate, but not growing during the molt following egg bearing in the fall. Their molt increment was reduced to only a millimeter or two immediately prior to mating in the spring.

Table 1. A summary of spiny lobster, *Panulirus argus*, tagged, measured, examined and recaptured during studies in south Florida national parks (1971-79)

Area*	Number Tagged	Measured & Examined w/o Tag	Recapture Observations	
			Growth	Movement
FOJE	4,257	1,248	138	167
BISC	6,080	3,058	1,688	1,719
EVER	3,782	1,655	644	590
Totals	14,119	5,961	2,628	2,476

*FOJE = Fort Jefferson National Monument, BISC = Biscayne National Monument, EVER = Everglades National Park.

Juvenile *P. argus* in Biscayne Bay and Florida Bay showed no sexual differentiation in growth rates, but exhibited marked seasonal variation associated with mean monthly water temperatures that varied 8°C (from 21.1 to 29.1°C) between winter and summer. Another major factor influencing growth rates of juvenile lobsters in Biscayne Bay was injuries that were apparently associated with fishing activity in the shallow bay. We found 71% of the lobsters harvested by sport divers were injured, including illegal "shorts" that comprised 8.3% of their harvest. The incidence of injured lobsters in the bay increased from 30% to 50% during the lobster season, and fell back to 30% during the closed season. In lightly fished Florida Bay, the incidence of injured lobsters averaged 13%, but ranged as high as 35%. Fewer than 25% of the same sized lobsters at unfished Dry Tortugas showed injuries. The incidence of injuries at Dry Tortugas may be a reflection of the high density of lobster predators there, as compared to Florida Bay. The mean growth rate of juvenile *P. argus* (40-85 mm CL) in Biscayne Bay was 21.3 mm CL per year, but uninjured lobsters showed a mean growth rate of 26.5 mm CL per year whereas injured lobsters had a mean growth rate of only 16.1 mm CL per year. Both molt increment and intermolt period were apparently influenced by injuries. Mean molt increment was 0.5 mm CL less ($t = 2.25$, $p = 0.05$), and the mean intermolt period 50% longer (15 versus 10 weeks) for injured lobsters. The extent of injury did not appear to be related to the degree of growth rate suppression since lobsters missing fewer than three appendages had growth rates virtually the same as lobsters missing five or more appendages and/or additional injuries to the abdomen or cephalothorax.

The mean growth rate of juvenile lobsters in Florida Bay was 40.0 mm CL per year. This was much higher than the rate observed in nearby Biscayne Bay and suggested that better growing conditions existed in Florida Bay. Other factors contributing to the higher mean growth rate in Florida Bay were the much lower incidence of injuries there and the fact that injured lobsters in Florida Bay showed only slightly lower growth rates than uninjured ones, 38.5 mm CL versus 41.1 mm CL per year. It appeared that optimum growing

Table 2. Distribution of time intervals between observations of tagged spiny lobsters, *Panulirus argus*, used for growth or movement determinations

Interval (weeks)	Observations (% frequency)
0-4	32.0
5-9	23.3
10-14	14.8
15-19	9.0
20-24	5.7
25-29	3.9
30-34	1.6
35-39	1.0
40-44	0.4
45-49	0.6
50-54	1.1
55-59	0.1
60-64	0.1
65-69	0.1
70-74	0.1
75-79	0
80-84	0
85-89	0
90-94	0.1
95-99	0
100-104	0.1
Total	2,518

conditions and minimal disturbance reduced the negative effects of injuries on growth.

Reproductive Biology

A recent study in the Florida Keys demonstrated one of the problems of investigating the reproductive biology of spiny lobsters in areas of intense fishing, when over 63% of the lobsters available for study were found to be sub-adults (Warner et al., 1977). In contrast, the unfished population of *P. argus* at Dry Tortugas provided ample adult specimens for study (Davis, 1975). An interesting contrast in the reproductive biology between the Dry Tortugas and lower Florida Keys *P. argus* populations was a smaller size at first sexual maturity in the Keys. Warner et al. (1977) speculated that the smaller size of first maturity in heavily fished populations may be the result of genetic selection.

Reduced competition from larger lobsters is another possible explanation, but in light of the information presented above regarding the effects of injuries on lobster growth rates, yet another explanation seems likely. Since maturity is apparently more a function of age than size in spiny lobsters (Chittleborough, 1974), a heavily fished, and therefore injury prone,

Table 3. Summary of growth rates for tagged *Panulirus argus* in south Florida

Area*	Size†	Sex	Injured‡	Water Temp (C)	Growth Rate (mm CL/yr)
FOJE	adult	both	13%	26.8	16.6
FOJE	adult	male	13%	26.8	22.9
FOJE	adult	female	13%	26.8	7.3
BISC	juvenile	both	44%	25.7	21.3
BISC	juvenile	both	44%	21.1	16.1
BISC	juvenile	both	44%	29.1	39.0
BISC	juvenile	both	100%	25.7	16.1
BISC	juvenile	both	0	25.7	26.5
EVER	juvenile	both	13%	25.8	40.0
EVER	juvenile	both	100%	25.8	38.5
EVER	juvenile	both	0	25.8	41.1

*FOJE = Fort Jefferson National Monument, BISC = Biscayne National Monument, EVER = Everglades National Park.

†Adult = 85-144 mm CL, Juvenile = 37-85 mm CL.

‡Injured indicates the percentage of the lobsters with an injury, usually missing appendages.

population with reduced growth rates would be expected to produce smaller mature lobsters. The significance to fishery management is clear. While age is the key to maturity, size is a major limit to fecundity (Creaser, 1950), and an injury-stunted population will produce fewer larvae.

Movement Patterns

A number of investigations into the movement patterns of Florida *P. argus* populations have been conducted over the past third of a century (Smith, 1948; Dawson and Idyll, 1951; Sweat, 1968; Little, 1972; Warner et al., 1977; Davis, 1977, 1978a, 1978c; Florida DNR in prep.). Those conducted in the national parks were designed to answer specific questions and introduced new approaches. For the first time, SCUBA equipped observers released tagged lobsters underwater on the bottom to reduce the potential of disorientation attendant in the daytime trapping and surface releases over deep water utilized in previous studies. In the park studies, capture and release sites were virtually identical, and the number of sites used was geographically restricted to aid in definition of movement patterns by specific populations. Previous workers used various degrees of geographical displacement and/or multiple capture and release sites giving a "shotgun" pattern to the initial distribution of tagged lobsters.

The results of the Dry Tortugas tagging revealed a resident adult lobster population that exhibited limited seasonal movements (less than 10 km) between shallow waters in the summer and early fall and deeper reefs in the winter and early spring (Davis, 1977).

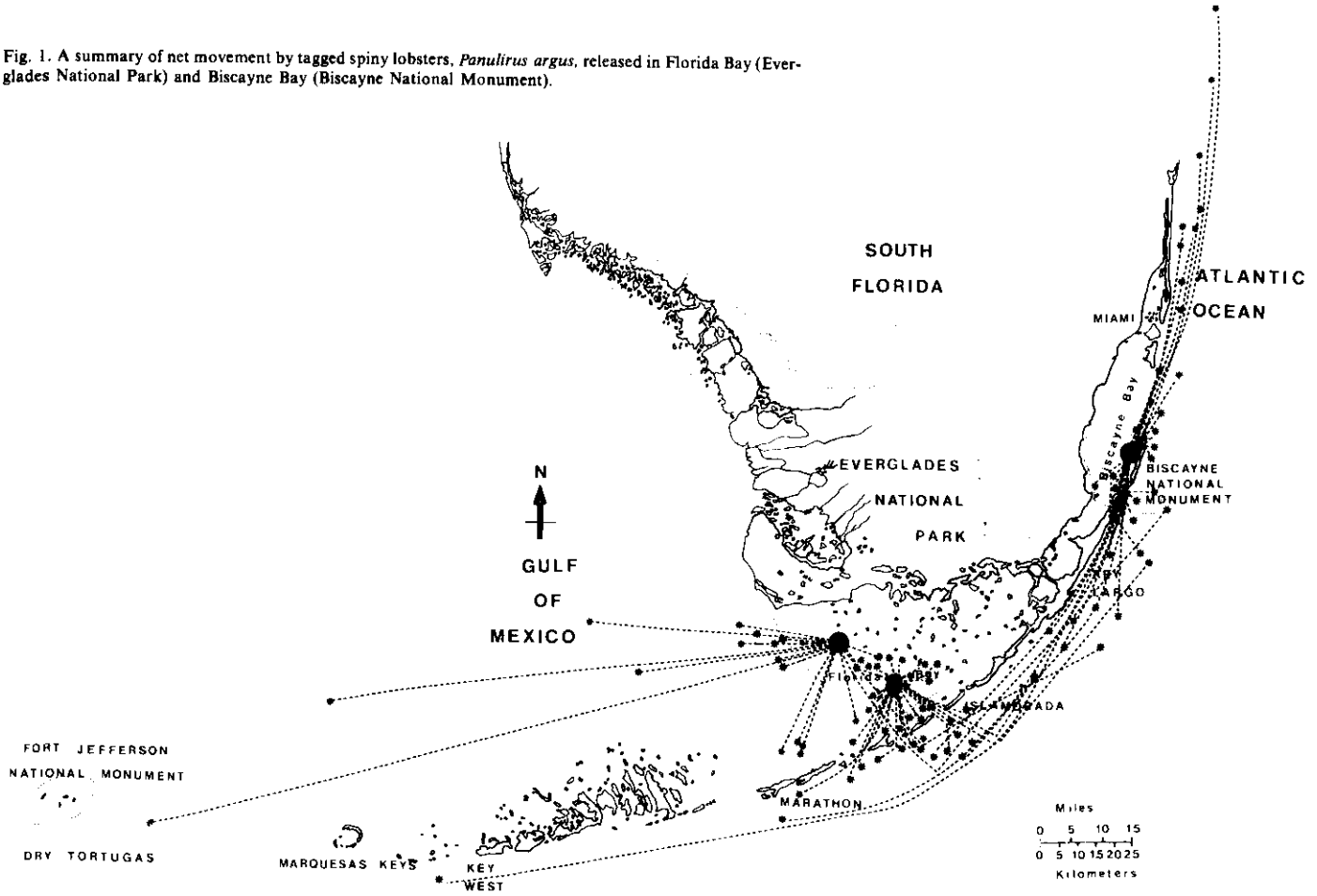
In sharp contrast to the lack of movement observed in the relatively undisturbed adult population at Dry Tortugas, juvenile *P. argus* in Biscayne Bay and Florida Bay showed a distinctive long-range radiating pattern of movement stretching 135 km to the north and 190 km to the southwest (Fig. 1). At sizes of 30 to 40 mm CL, lobsters in the bays abandoned their relatively scattered distribution in seagrass and sponge beds and concentrated gregariously in rocky dens. As they approached maturity, they left the bays and moved east or south through the tidal creeks on the north and south ends of the Keys at 7- to 9-week intervals. Tag returns from recreational divers and commercial trap fishermen also tended to be concentrated at approximately 8-week intervals. Short queues of four to six lobsters were frequently observed moving across open areas in the Elliott Key Marina, and a single queue of 13 *P. argus* was seen at night in October 1976, moving south from the marina in the open bay. Once the juvenile lobsters reached the coral reef zone 5 to 7 km east of Elliott Key, they turned north or south and continued moving along the reef tract at depths of 20 to 40 m.

In 1976, all reported movement was to the south. Recaptures ranged from Pacific Reef and Carysfort Reef in the upper Florida Keys, to Alligator Reef and Woman Key in the middle and lower Keys, respectively. Distances of up to 190 km were traversed in less than 6 months during these southerly movements. In the fall of 1977, there was a notable change in the offshore movements, with northerly movements of up to 135 km. Several marked lobsters released in Biscayne Bay during the previous summer were recaptured to the north off Miami Beach, Fort Lauderdale, Boca Raton and Lake Worth, Florida. During the winter and spring of 1978, recaptures were evenly distributed between the Florida Keys to the south and the Gold Coast area to the north.

An examination of sex ratios by size classes of *P. argus* in Florida Bay revealed a potential explanation of when in their life cycle they leave the bay. Up to a size of about 80 mm CL, the sex ratio was unity, but it shifted steadily from 60% male in the 81-85 mm CL size class to 85% in the >95 mm CL sizes. None of the lobsters examined in the bays was reproductively active. If lobsters leave the bays when they reach maturity and males mature at larger sizes than females, as suggested by Crawford and DeSmidt (1922), then this is the pattern of size and sex ratios we would expect. Furthermore, these observations suggest that the "decision" to leave the bay is not size dependent, but rather the hormonally mediated process of maturity.

It now seems clear, from these observations and those of the other investigators, that Biscayne Bay and Florida Bay serve as nursery areas for the entire Florida lobster fishery. Post-larval *P. argus* grow up in the bays, and as juveniles and adolescents they leave the bays, often traveling hundreds of kilometers, and would establish themselves as residents of particular regions of reef if they were not harvested before they got there. The strong southwestern trend of juveniles out of Florida Bay toward the "upstream"

Fig. 1. A summary of net movement by tagged spiny lobsters, *Panulirus argus*, released in Florida Bay (Everglades National Park) and Biscayne Bay (Biscayne National Monument).



Dry Tortugas resident adult population offers some interesting speculation about potential parallels between pink shrimp, *Penaeus duorarum*, and spiny lobster life history strategies. Is it possible lobster larvae produced at Dry Tortugas settle into Florida Bay, and the observed southwestern juvenile migration represents completion of a life cycle?

DISCUSSION

Having made these observations and subsequently raised more questions about spiny lobsters, of what value are parks and sanctuaries in understanding and managing this resource?

Standards

Perhaps the most important value of an undisturbed natural ecosystem is as a dynamic standard for comparison with exploited systems. Determinations of growth and mortality rates are important for estimating potential fishery yields, and establishing an optimum minimum size of harvest to achieve an acceptable fishery yield. The observations of growth rates in unfished and lightly fished areas demonstrated that growth estimates made in injury-stunted populations may significantly underestimate potential growth rates. They also provided data on large adult lobsters generally unavailable in heavily fished populations. By necessity, estimates of natural mortality are usually derived by subtraction of fishing mortality from total mortality. Natural mortality may be estimated directly in parks and sanctuaries, as shown by Olsen and Koblic (1975) in the Virgin Islands. Unexploited resources can provide standards for growth and mortality measurements that would otherwise be unavailable.

They can also provide the basis for estimates of habitat carrying capacity and evaluation of general resource conditions. Spiny lobster populations, as do most biological systems, have a great deal of natural year-to-year variability. The ability to establish cause and effect relationships and separate the effects of fishery harvest or other direct human impacts from natural fluctuations is essential for effective management. Estimates of standing crops in the Virgin Islands and at Dry Tortugas have been used as one approach for estimating maximum sustainable yield for regional fisheries. The relatively unexploited population at Dry Tortugas also yielded a different size of first sexual maturity than that observed in an exploited population, again acting as a standard against which conditions in the exploited stocks could be compared. Only after such comparisons are made can management decisions be made regarding the potential costs and benefits of specific actions.

Reproductive/Genetic Reserves

The small undisturbed population of large adult spiny lobsters at Dry Tortugas probably produces far more larvae than the great population in the lower Florida Keys. The reproductive potential of the Keys population is severely limited by a low number of reproductively active losters and the generally small average size (82 mm CL) of gravid females (Warner et al.,

1977). The Dry Tortugas lobster population is composed of a high proportion of large reproductively active females with a mean size of 98 mm CL. Nearly 90% of the females were gravid during much of the reproductive season (Davis, 1975).

The production of large numbers of larvae also serves to maintain or increase the genetic variability of the stocks. Severe fishing pressure, which may be economically desirable, tends to reduce the number of breeding individuals and thereby reduce genetic variability. That pressure may even eliminate particular genotypes such as fast growing individuals that consequently mature at larger sizes as suggested by Warner et al. (1977). Indeed this genotype, if one does exist, may be the very one preferred for mariculture efforts. Maintenance of a few unexploited populations would provide a reserve of natural genetic variability, and protect some reproductive potential for the region.

Concern for ensuring high reproductive potential is only warranted if there were some reason to believe that post-larval recruitment was limited by egg production. Although no stock recruitment relationship has been established for the Florida lobster fishery, it may be significant to note the recent drastic decline in small lobsters in Biscayne Bay. From March 1976 to March 1978, 706 *P. argus* were caught and measured in 392 tows by shrimp trawlers in Biscayne Bay. The mean size of *P. argus* caught nightly by bait shrimp trawlers over the turtlegrass beds and hard open bottom of Biscayne Bay was 32.0 mm CL, ranging from 8.5 to 85.1 mm CL (Table 4). The abundance of *P. argus* in the shrimp trawl catch showed considerable seasonal variation, part of which was undoubtedly a result of seasonal variation in the geographical distribution of the shrimpers as they followed the shrimp through the bay. There was a major peak in the lobster catch rate in the late summer and early fall, and a minor peak in the spring. This seasonal variation was similar to that reported by Eldred et al. (1972) for 1968 and 1969, however, the number of lobsters caught per tow in 1976-78 was dramatically lower (67%) than in 1968 and 1969 (Table 5). It seems reasonable to assume that the seasonal movements of the shrimping operations were about the same in each of the two year sampling periods, so the differences observed in catch rates probably reflected a real reduction in lobster abundance.

In addition to the decrease in abundance, the mean and maximum sizes of lobsters caught in shrimp trawls in the bay were apparently much larger in 1976-78 than in 1968-69. Of 1,464 lobsters caught during the 1968-69 sampling, only 0.4% were larger than 60 mm CL, and one had attained legal size (76 mm CL) (Eldred et al., 1972). In the 1976-78 samples the mean size was 32 mm CL, 4 mm larger than 1968-69, and 5% were larger than 60 mm, with a maximum of 85.1 mm CL (Table 4).

Unique Educational Opportunities

Juvenile *P. argus* are remarkably gregarious (Berrill, 1975). One of the effects of recreational diver harvest on lobsters is scattering, a behavioral response (Davis, 1977). Undisturbed populations are needed to study the effects of this type disruption and determine the potential value of specific

Table 4. Sizes of spiny lobsters, *Panulirus argus,* caught at night by bait shrimp trawls in Biscayne Bay, Florida

		Carapace Length (mm)				Mean	
Date	N	Mean	Min	Max	Mode(s)	Water Temp (°C)	Salinity (ppt)
1976							
March	14	30.6	12.5	53.7	27		
April	16	24.3	11.1	43.9	17,32,42		
May	15	22.7	11.1	58.3	12,27,37	29.4	35.9
June	20	22.1	14.8	32.5	15,27		
July	40	28.1	12.4	55.2	22,42		
August	129	32.8	15.2	85.1	27	30.7	19.0
September	58	36.0	8.5	70.1	38	30.2	22.5
October	150	30.1	11.6	56.2	38	27.6	34.0
November	9				15	24.5	27.6
December	1	40.5	40.5	40.5		20.3	27.6
1977							
January	19	43.9	16.4	56.0	15,40,55		
February	27	37.7	14.6	68.1	17,40,65		
March	10	41.0	33.0	56.2	45		
April	4	36.4	28.2	46.2	30		
May	17	37.6	18.1	72.0	15,35,45	25.5	28.2
June	16	37.3	15.5	61.6	20,52,61	30.7	33.9
July	66	24.7	11.3	76.2	18,48	31.0	33.9
August	0					28.1	26.4
September	8	25.6	21.5	30.2	25	31.9	3.5
December	8	39.1	31.1	49.6	38		
1978							
January	31	35.7	19.2	52.2	35		
February	6	38.8	26.0	47.7	38	18.2	31.2
March	42	38.4	15.7	64.0	38	22.8	26.0
Total/Mean	706	32.0				27.0	26.1

management actions. The Florida State Legislature established a lobster nursery sanctuary in Biscayne Bay in 1979. The effects of disturbance and injuries on juvenile lobsters can now be evaluated. It is hypothesized that reduced disturbance and injuries in the nursery will promote increased growth rates and subsequently reduce mortality rates, leading to increased fishery yield per post-larval recruit in areas supported by the nursery.

A great deal of concern has recently been expressed about the "health" of Florida's reefs (Voss, 1973; Dustan, 1977), and there are perennial questions about declines in historical fisheries. What roles did the species removed by

Table 5. Comparison of mean number of juvenile spiny lobsters caught per tow by live bait shrimpers in Biscayne Bay, Florida, 1968-69 and 1976-78

	Years			
	1968-69*		1976-78	
Month	No. Lobsters per tow	N†	No. Lobsters per tow	N†
January	1.37	62	0.75	67
February	0.58	65	0.57	58
March	0.86	51	0.77	86
April	1.64	79	0.23	86
May	1.53	75	0.36	87
June	0.74	38	0.57	63
July	2.69	55	0.87	132
August	2.33	36	1.57	82
September	10.97	35	0.66	98
October	1.39	36	2.39	59
November	4.68	25	0.19	48
December	3.73	44	0.19	47
Grand Mean/Total	2.31	284	0.77	392

*From Eldred et al., 1972.
†N = Number of tows; 1968-69 tows seldom exceeded 20 minutes and 1976-78 tows averaged 21 minutes.

fisheries play in maintenance of these ecosystems? Fishing apparently removes nearly every available adult lobster from Florida reefs every year. An investigation of the ecological role of *P. argus* on Florida reefs to examine this often overlooked impact of fisheries should be conducted. Spiny lobsters are middle to high level predators. Their removal could precipitate a reduction in species diversity in reef and seagrass systems. Preliminary results of our *P. argus* diet study suggest important differences between the northern Florida Keys and Dry Tortugas and/or between large and small lobsters. Study of both exploited and unexploited populations may provide the ecological information necessary to evaluate impacts of lobster removal on coral reefs.

Recreation

Allocation of fishery resources among various user groups is becoming more and more of a problem as the number and diversity of user groups increases and limits of resources are approached. One common method of allocation is zoning use to reduce conflict between competing groups. Parks and sanctuaries are readily identifiable management units that people already associate with restricted, specialized activities. These units offer "ready made" areas where new management actions can be tested and special harvest constraints easily implemented. Our lobster tag returns from recreational and commercial fishermen ranging from Lake Worth to Rebecca Shoal (68 km west of Key West) suggested that recreational fishermen accounted for only 9% of the total landings in Florida during the 1977-78 season. However,

decisions regarding allocation of this resource should reflect not only total landings, but also recreational and other values many people derive from diving for lobsters, thereby escaping from their daily routines.

Spiny lobster resources in parks and sanctuaries can provide dynamic standards for comparisons with exploited systems, regional reproductive and genetic reserves, unique educational opportunities, and recreational values if they are adequately protected. They can also provide the intrinsic emotional value of undisturbed natural ecosystems that we sometimes call wilderness. In a period when natural resources are rapidly vanishing before our eyes, preserved wilderness that we can touch, see, and experience, is particularly important. If a pragmatic fisheries value can also be added to this less tangible one, perhaps more and better protection of these resources will result, and we will all be the better for it.

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