SPINY LOBSTER FISHERY OF BRAZIL

by

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Project Report
Submitted to
Marine Resource Management Program
School of Oceanography
Oregon State University
1981

in partial fulfillment of
the requirements for the
degree of
Master of Science
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ACKNOWLEDGMENTS

I would like to thank Dr. Richard A. Tubb for taking his time to carefully read the first draft of this report and present many suggestions and observations. I am also grateful to Dr. William Pearcy and Dr. Victor Neal for their advice and assistance. Special thanks to Ann P. Hochberg who kindly helped me to organize my thoughts and ideas in a foreign language. Thanks to all the good friends I made to whom I owe a great deal of gratitude for their encouragement and support during my stay in the United States.
GENERAL BACKGROUND

1 The Area

Northeast Brazil (Figure 1) is comprised of nine states: Maranhao, Piaui, Ceara, Rio Grande do Norte, Paraiba, Pernambuco, Alagoas, Sergipe and Bahia. It also includes the Island of Fernando de Noronha. The total area is 1,615,004 km² which accounts for 18.96% of entire Brazil (Table I). The estimated population in 1970 was 23,627,000 inhabitants with a population density of about 15/km² and some 25% of the population of the country.

The shoreline length is 3,671 km or 40.70% of the Brazilian coastline (Table II). The coastline is straight and does not include many embayments. The continental shelf is narrow, 37 km off Recife. From there it gradually broadens to some 200 km in both north and south directions (Figure 2).

The region encompasses three drainage basins: Northeast, Sao Francisco and East, with areas of
888,748 km², 632,666 km² and 569,845 km² respectively. In the Northeast basin, the rivers west of Paraiba River are perennial, while east the rivers are seasonal. Two major catchment basins are present: Maranhense Gulf where the estuaries are formed by drowned river mouths and the Paraiba River, a very swift river flowing from south to north, with a peak flow in the first months of the year. The rivers to the east of the Paraiba River are usually short, flowing only during the rainy season. The Sao Francisco Basin is formed by the S. Francisco River and its tributaries which are temporary streams. The adjacent estuarine areas are very productive and sustain the artisanal fishery as in the Mundau Lagoon, where large stocks of the Mussel *Mytela falcata* are found (Pereira-Barros, 1967).

2 Marine Fisheries

In the NE as well as in other areas of Brazil both industrial and artisanal fisheries are found. In some areas, the artisanal fishery may contribute as much as 50% of the landings. The number of fishermen engaged in this activity is estimated at 40,000, concentrated in several coastal villages. The vessels usually employed are canoes, dug-out boats or log rafts. They are either man powered or sail powered and consequently allow for little motility.
Fishing trip lasts no longer than a day. The boats leave at dawn and come back at dusk. Very often they do not carry ice and are ill-equipped for handling and storing the catch. The fish is sold immediately after the boats arrive.

The fishing grounds are located from 5 to 80 km offshore at depths from 10 to 45 m (Lima and Paiva, 1966).

The artisanal fishermen uses a variety of different fishing gear: fishing poles, long lines, gill nets, cast nets, dip nets, pots and traps. The present fishing methods are not very different from those passed down by the primitive Indians. The wooden fish weir is quite common in some states, supporting a subsistence fishery. However, its use is declining on account of its low productivity of about 100Kg/yr, and the low commercial value of the species caught (Almeida, 1974; Collyer and Aguiar, 1972).

Some species of commercial importance caught include rays, catfish, king mackerel (Scomberomorus cavala), Atlantic thread herring, red snapper (Lutjanus purpureus), and Spanish mekerel (Scomberomorus maculatus). The most economically important species is the king mekerel (Paiva, 1966).

Because of deficiencies in transport and in cold storage systems all the catch is consumed fresh or salted. In general, salting plants are totally inadequate
for handling and processing the fish. Not all of them operate year around (Paiva and Costa, 1966). Dry salting is the principal method employed. The salt utilized is coarsely ground and receives no treatment. Rain and attack by insects during drying account for large losses. Table III, shows the production of salted fish in Ceara State from 1961 through 1965. Substantial improvements can be made, through the use of acid brines which renders a final product more fit for human consumption (Caland et al, 1966), or by cleaning and eviscerating fish before salting (Freitas and Gurgel, 1969).

Coexisting with the unsophisticated artisanal fishery is an advanced industrial fishery with modern vessels and gear, as well as electronic devices for finding fish and navigation. The number of fishing companies currently licensed is about 50, which includes those paints for processing marine algae. Unlike the artisanal fishery, the industrial fishery concentrates on a small number of species of high commercial value. However, it only accounts for 11% and 35% of the total landings in weight and money value respectively (Paiva and Braga, 1968).

The industrial fishery is supported by the following species: lobster, tuna, Caribbean red snapper and whales. The tuna fishery based in Recife was developed through a joint venture in the mid 1950's with
the Japanese. The red snapper is caught in almost any coastal area off Brazil. The fishery for red snapper is complementary to the lobster fishery in the NE of Brazil. The red snapper fishery is recent in the area, started in the early 1960's, with low landings through 1963 (Paiva, 1971) (Table IV). The average snapper-lobster vessel has an overall length of 20 m and is crewed by 12 fishermen; the fishing trips last about 15 days. Vessels can hold from 20 to 50 metric tons and the gear used is a hand line bearing 10 to 15 hooks.

**THE LOBSTER FISHERY**

1. **Introduction**

   In 1955 the Brazilian spiny lobster fishery began concurrently with the dawn of the industrial fishery in the northeast (Paiva, 1967). The first fishing boats were sail powered rafts inherited from the artisanal fishery. This system predominated until 1962-63 (Costa, et al, 1974). Since the beginning two species of spiny lobsters predominated in the commercial landings, *Panulirus laevicauda* and *Panulirus argus*. *P. argus* accounts for 80% of the total landings, but there is an increasing participation of *P. laevicauda*. Both species are found in the Atlantic Ocean from southern US to southern
Brazil (Chace and Dumont, 1949). The five top-ranked fisheries for different species of spiny lobster are: Australia, South Africa, Brazil, Cuba and the United States. Cuba and Brazil account for about 75% of the landings of *P. argus* (Mas and Paiva, 1969). Due to a low internal consumption and high external demand most of the final product, frozen lobster tails, is exported from Brazil. Exportation originates at the ports of Fortaleza and Recife.

2 Fishing areas

Very little specific information is available about oceanographic conditions in the South Atlantic Ocean adjacent to the NE of Brazil. Okuda (1960), reported a thermocline between 75 and 300 m; the water masses present are Antarctic Intermediate Water, South Atlantic Central Water, North Atlantic Deep Water and Antarctic Bottom Water. The surface water temperature is fairly constant, oscillating between 25 an 27 C, dropping to about 19-25 C at 100 m. Surface salinity was found to increase sharply with latitude. The salinity maximum layer (36.41 ppm) is found at about 100 m, while the minimum salinity (34.44 ppm) was determined at about 800 m. The oxygen minimum layer is about 400-500 m and nutrients levels are low through the whole water column.
There are two distinct fishing areas for lobster off the NE of Brazil, roughly divided by Cape S. Roque. They have been classified in the literature as the Setentrional-NE and the Oriental-NE. The former extends from Cape S. Roque North to the Paraiba River, and the Oriental-NE extends from Cape S. Roque to the mouth of the S. Francisco (Figure 3). This distinction is not merely for geographic purposes, but also results from an array of environmental differences. Stocks of spiny lobsters of both *P. argus* and *P. laevicauda* are probably separate and distinct from other areas. The Setentrional-NE area was the first to be exploited and has led the landings since the fishery started. It is an area of low precipitation drained by temporary rivers, that tend to dry up during the long summer season. This results in less variability in the salinity of the adjacent Atlantic Ocean waters. The continental shelf is wider (Figure 2). On the other hand, the Oriental-NE has greater precipitation, rivers of permanent regime and a narrower continental shelf (Paiva, 1971).

Spiny lobsters are found in banks of calcareous algae ranging in depth from 20 to 50 m. as the stocks decreased the fleet moved gradually to deeper areas. Currently the fleet fishes to a depth of 50 meters. Species of the genus *P. argus* are usually found in deeper waters than *P. laevicauda*, but stocks are low at depths
greater than 50 meters and it is not economical to exploit this stock. The two species obviously differ in habitats, feeding or some other factor. Unfortunately little is known about their biology and I have lumped the two species in my discussions of exploitation.

3 Fishing methods

The fishing methods for lobster have not changed much since 1955. The gear currently used is the lobster trap (Figure 4). This trap is locally known as covo or manzua. It consists of an hexagonal wooden frame covered with chicken-wire mesh or synthetic fiber. Usually it has one funnel shapped opening for inserting bait and removing the catch. Costa and Albuquerque (1966), found that traps with two openings are more efficient. Power equipment is used to lower and raise the traps.

Although a few reed and wooden slat traps are also used (Paiva, 1967), wire traps are used almost exclusively. The "covos" are not only more effective, but also more economical since they have a longer useful life and require less repair. They are also easy to stack. Besides their adaptability to larger or small scale fishing operations they contribute to the local economy by requiring establishment of small wokshops to construct repair and supply.
The fishing grounds are located by running transects with a depth recorder, until a suitable gravel bottom is found. On the grounds, the traps are baited with waste products of slaughter houses or with red snapper carcasses. They are set in groups of 15 to 30 connected to a main line. The traps are hauled back aboard daily by means of a hydraulic block. As they come aboard the catch and any leftover bait are removed and fresh bait is added. The traps are then stacked ready for resetting in other grounds. Rafts and other small boats set traps isolated at random on the bottom. Costa and Bezerra (1970), compared this method with the one employed by the larger industrial fishing boats and found the catch per trap to be higher than with interconnected traps.

Lobsters are beheaded as they come aboard and the heads are discarded overboard. This practice has been criticized because it may attract predators and spoil the fishing grounds. Perhaps a worse practice is to leave behind any trap unsuitable for further use. Synthetic fiber traps can wastefully trap benthic animal and attract predators.

Bottom gill nets have been used to some extent in the commercial fishery since 1971. Gill nets are now regulated by the governmental fisheries development agency (SUDEPE) because they can induce physical alteration of the environment and catch lobster under
the minimum legal size. Paiva-Filho (1975), found bottom gill nets to be 69% more productive than the traps commonly used, but the loss of other valuable species cannot be condoned by the government.

Lobster boats are grouped into three categories: small, less than 10 m in overall length; medium, 10-15 m; and large, above 15 m (Figure 5). The relative participation in the fleet is 68% for small boats, 11% for medium and 21% for large size boats (Costa, 1966). Boats can stack up to 400 traps on the deck and upper deck. Small and medium size boats do not have built-in refrigeration equipment so they usually carry ice in blocks, which is hand crushed as the need arises. The crew varies from two to five men and the fishing trip may be as long as 8 days for medium size boats. Small boats usually return late in the afternoon of the same day. All the boats are powered by diesel engines ranging from 6 to 50 hp. Large boats are equipped with more accurate devices for fishfinding, navigation and have built-in refrigeration equipment and a hydraulic trap hauler. They are powered by diesel engines of 200 hp, and on the average carry a crew of five to nine men. The increase in fishing vessels since 1962 has led to a more uniform distribution of fishing effort (Sobreira-Rocha et al, 1974).
Unlike the true lobster (*Homarus americanus*), the spiny lobster is characterized by the absence of large claws and the presence of a flexible tail fan (Chace and Dumont, 1949). This muscular tail is the part of the animal that is normally consumed (Figure 6).

The lobster industry in Brazil is heavily oriented towards the export market. The high prices demanded in the international market make the consumption of lobster prohibitive by the ordinary seafood consumer in Brazil. Exporting records (Table V) show that the majority of the exported lobsters come from Ceará. The total Brazilian export increased from 40 metric tons in 1955 to a maximum of 3,069 tons in 1974. Paiva and Moura (1965), attribute the fluctuations in exports to climatic conditions and reduction in fishing effort.

The majority of the lobster export passes through the ports of Fortaleza and Recife, 65% and 36% respectively. The exit port for the Setentrional-NE is Fortaleza and the production in the Oriental-NE is funneled through Recife. Costa et al (1974), estimated that 40.2% of the tails exported in 1972-73 weighted less than 100 gr. This includes female lobster during their first spawning, whose tails weight 95 gr and 71 gr for *P. argus* and *P. laevicauda* respectively (Paiva and Costa, 1963).
5 Regulations

Regulations are needed to ensure the efficient and economic use of capital, labor and the spiny lobster resource. Several studies have been made concerning the rehabilitation and maintenance of the fishery to produce higher yields. Unfortunately, the regulatory agency has not used those studies. The management schemes proposed to regulate the fishery did not provide any significant results. Brazil was the only country that did not have a closed season. Early regulatory measures were concerned with mesh size restriction, catch of berried females, closed nursery areas, discard of heads and useless traps on the fishing grounds and the banning of trawl fishery (Paiva, 1967).

Substantial improvements of the management schemes started in 1972 when SUDEPE issued regulations banning the use of bottom gill nets. Later in 1974-75, concerned with high fishing effort and low cpue, SUDEPE limited entry to the fishery and closed the season for 30 days each year to a total of 120 days by 1978. In 1974 the minimum mesh size was increased to 50 mm. By 1978, the minimum legal size restrictions for fishing P. argus and P. laevicauda were issued as 14 and 11 cm tail size respectively. At the same time the closed area established in 1975 was extended and additional nursery areas were
included. Use of SCUBA gear was banned. In 1979 the minimum legal size was reduced to 12 and 10 cm tail size for P. argus and P. laevicauda respectively.

Finally, in 1980, after several changes in duration and time of the year, the closed season was set from December 1, through January 31. The closed area set in 1975 as the area between the Gurupi and Vaza Barris mouths was once more extended to include the area between the borders Amapa/Para and Espirito Santo/Rio de Janeiro. Table VI shows various regulatory restrictions for the P. argus fishery in different countries.

BIOLOGY AND FISHERIES DYNAMICS

The spiny lobster belongs to the Decapoda, which includes most of the larger shelled arthropods familiar to the fishermen: shrimps, lobster and crabs. (Chace and Dumont, 1949). Another characteristic of members of this order is the well developed carapace which covers the united head and thorax (Smith, 1965). The spiny lobsters found in the NE of Brazil belong to the family Palinuridae. The economically important species belongs to the genus Panulirus (White, 1874) and include Panulirus argus (Latreille, 1804) and Panulirus laevicauda (Latreille, 1817). Other species present in the area are P. echinatus and Palinurelus gundlachi (Fausto-Filho and Costa, 1969).
1 Habitat

Spiny lobsters are usually found in rocky bottom areas which provide them with protection from large predatory fishes such as snappers and sharks (Butler and Pease, 1965). In the NE of Brazil, both *P. argus* and *P. laevicauda* are found in calcareous algae bottoms on the continental shelf, *P. laevicauda* being found in shallower water (Fauto-Filho and Costa, 1969).

Juveniles of *P. argus*, typically live inshore, in shallow water of soft sediments with vegetation which provides the juveniles suitable cover (Berril, 1975). Little (1977), studying the recruitment of postlarval spiny lobsters (*P. argus*) in south Florida found that postlarvae were more abundant in the artificial habitats placed nearshore than those placed in deeper channels. This suggests the importance of the nearshore environment for juvenile nursery areas. He concluded that recruitment of juveniles to the bottom takes place mainly during the spring and fall along southeast Florida. The low summer recruitment was associated with reduced salinities from freshwater runoff. This may be explained by the fact the species is not a good osmoregulator, and it is stenohaline (Buesa, 1979). The stenohaline characteristics of *P. argus* probably act to segregate the Brazilian stocks from the Caribbean stocks. The large flows of freshwater from the
Amazon must act as a barrier to larval transport.

2 Reproduction

The sex of the spiny lobster is separated and can be determined by the form of the fifth or last walking leg. In the males this leg ends in a single claw, like those on its front, while in the females it terminates in a pair of pincers (Chace and Dumont, 1949).

Females may mate more than once before laying the eggs. Mota-Alves and Paiva (1976) reported that the presence of two or three intermediary layers of spermatophoric mass corresponds to the number of matings in *P. argus*. The number increased with female size. The authors give a description of the mating behaviour of the spiny lobster: the male deposits the spermatophoric mass on the females's sternum. The sperm sac is soft and white in color. It becomes dark and hardens after exposure to seawater. The female retains the spermatophoric mass until she is ready to fertilize her eggs. Fertilization takes place when the eggs are extruded and mix with the sperm released from the sperm mass by scratching it repeatedly with the small chelae of her fifth pair of legs.

Suttcliffe (1952) describes the egg laying behaviour of *P. argus*: during the egg laying the female lies partially on its back, at an angle of about 50 or 60 degrees from
the bottom, propped up by the reflexed antennae. This process does not require more than a half hour. Fertilization must occur between the moments of egg laying and attachment of them to the uropoda. Like most spiny lobsters, the incubation period is about a month (Berry, 1971).

The number of eggs carried by a female of *P. argus* depends on its size (Mota-Alves and Bezerra, 1968). Such is not the case for females of *P. laevicauda*. Females of this species range in total length from 16.1 to 20 cm and can carry a total of about 180,000 eggs (Paiva and Silva, 1962).

The size of mature females of *P. argus* in waters off the northeast of Brazil ranges from 16.8 to 33.9 cm total length (Paiva and Costa, 1963). Mota and Tome (1965), report that 20 cm total length is the minimum size for sexual maturing females of this species. Butler and Pease (1965), report that the smallest egg-carrying female of *P. argus* in the Caribbean waters off Panama measured 6.9 cm.

Females of *P. laevicauda* seem to attain sexual maturity at smaller sizes than *P. argus*. Paiva and Costa (1963) report that reproducing females of this species range from 15.9 to 28.1 cm in total length. A later study by Mesquita and Gesteira (1975) sets the minimum total length of sexual mature females even lower, ranging from 13.7 to 15.8 cm.
Males of both species may have to attain larger sizes before they are capable of making any reproductive contribution to the population. The figures reported in the literature are 20 and 17 cm total length for P. argus and P. laevicauda respectively (Mota-Alvas and Tome, 1965; 1966).

Mesquita (1973), identifies the period from March to June as the one in which reproduction is more intense in P. argus. He further states that the number of reproducing females declines from then throughout the year. Mature females of P. laevicauda are found year around with higher frequencies in October-February and May-July (Paiva and Costa, 1968).

3 Growth

The spiny lobster hatches to a form called Phyllosoma. This name was given because the larvae originally were thought to be a separate species of animal (Figure 7). The larvae goes through a series of peculiar stages before reaching the first stage postlarva or puerulus. A dominant feature of the biology of the spiny lobster is its long larval life, up to 11 months for some species (Phillips, 1979). This long larval life probably accounts for the widespread distribution of P. argus.

As the individual grows, its inelastic chitin
carapace becomes small and has to be shed. It is replaced with a larger one periodically. This causes a stepwise growth. Paiva and Costa (1968) reported that soft shelled lobsters of the species *P. laevicauda* can be found year around in the waters off Fortaleza-CE.

Correlation of total length (the distance from the anterior margin of the notch between the rostral spines to the end of the telson) with age for both species have been worked out by Santos et al (1964), Santos and Ivo (1973) \(r=0.996\), and Ivo (1975) \(r=0.989\). The individuals were aged by a length-frequency distribution. Figure 8 and 9 show the growth fitted to a von Bertalanffy curve for males and females of individuals of *P. argus*. For the species *P. laevicauda*, the authors conclude that there is no sexual differentiation in growth (Figure 10). The asymptotic length is 40.6 cm. Individuals as large as 30 cm can be found in commercial landings (Paiva and Costa, 1968).

Rolim and Rocha (1972) carried out several weight and length associations studies in young spiny lobsters. They concluded that for the species *P. argus* the relationships between total weight vs. abdomen weight, carapace weight vs. abdomen weight, and abdomen weight vs. total length proved sexual dimorphism. For *P. laevicauda*, the relationships in which sexual dimorphism was observed were total length vs. carapace length,
carapace length vs. abdomen length, and carapace weight vs. abdomen weight. Minimum and maximum carapace lengths for juveniles of *P. argus* and *P. laevicauda* in nursery areas off the northeast of Brazil were compared to the southeast United States (Table VII).

4 Migration

Seasonal migrations of thousands of individuals are characteristics of adult populations of many palinurids. However, *P. argus* appears to be unique in migrating gregariously in long queues, defined as head-to-tail single file formations (Berril, 1975).

Migration of spiny lobster in the northeast of Brazil is either for feeding or reproduction purposes. Paiva and Fonteles-Filho (1965) found that tagged *P. argus* moved an average of 32.56 km, predominantly in the onshore-offshore direction. Maximum movements were 367 km, much longer than what Warner et al (1977) found for the same species in south Florida. They identify two migration seasons, one at the beginning of the year and the other in July. Both are associated with feeding and reproduction seasons from March to May and August. The rock lobster *Jasus vereauxi* moves considerably larger distances at minimum rates of 0.03–2.0 km/d (Booth, 1979).
Migratory behavior probably depends in part upon environmentally induced neurohormonal changes (Herrnkind, 1969). Autumnal migration of *P. argus* at Bimini, Bahamas, were associated with autumnal storms over a period of 10 years (Kanciruk and Herrnkind, 1978).

A characteristic of mass migration of spiny lobster *P. argus* is the queuing behavior. Normal appearing lobsters with all appendages intact most often form queues by approaching the posterior of another moving individual until antennal contact is made (Figure 11). In juveniles of this species, queuing is believed to be of anti-predatory value, since they lack the size and excessive spines of the adults (Berril, 1975). For adults, queuing, besides providing orientational cues for migration also may reduce drag during locomotion, thus increasing speed and conserving energy during group migration (Figure 12) (Bill and Herrnkind, 1976).

5 Food

There is little information available about the feeding habits of the spiny lobster in the area, other than the types of baits used in commercial fisheries operations. It seems that these species are scavengers to a certain degree, although experiments have shown that *P. argus* prefer fresh food (Chace and Dumont, 1949).
A number of species of molluscs can be found on the lobster banks (Fauto-Filho et al, 1966), and one might expect that the lobster prey upon them in the same manner that the rock lobster *Jasus lalandii* on the west coast of Africa feed mainly upon ribbed mussels (Pollock, 1979).

Feeding and growth rate are likely to be affected by food supply. Chittleborough (1975), found that decreased food supply reduces the frequency of molting and depresses the growth increment per molt in juveniles of the western rock lobster *P. longipes*. Berry (1971) found that the composition of the diet changes with age for *P. homarus* off the east coast of southern Africa. Small specimens eat a higher proportion of barnacles than mussels. This might be due to the inability of the small animals to open mussel shells.

No studies concerning the concentration of chlorinated hydrocarbons pesticides such as DDT on lobsters have been made in the area. Cotton agriculture in the Brazilian northeast relies heavily on DDT, and about 70-75% of the DDT used in Brazil is used on cotton crops. Large amounts were also used in antimalaria programs, 10,000 tons were estimated for the period 1972-81 (Goldberg, 1976). For the American lobster (*Homarus americanus*), Dow (1975), states that DDT is toxic in concentrations of approximately 1 part in 10,000.
6 Mortality

Santos and Ivo (1973) estimated the mortality parameters for the population of the spiny lobster *P. argus* in coastal waters of Ceara State during the period 1965-72. Their conclusions were:

- Annual mortality rate \( A \) = 0.81
- Instantaneous mortality rate \( z \) = 1.78
- Instantaneous fishing mortality rate \( F \) = 0.84
- Instantaneous natural mortality rate \( M \) = 0.94

Table VIII shows the annual mortality rate, instantaneous mortality rate and fishing effort for *P. argus* from 1965 through 1972 in the same area.

7 Maximum Sustainable Yield

Maximum sustainable yield is defined as the largest average catch or yield that can continuously be taken from a stock under existing environmental conditions (Ricker, 1975).

Santos et al (1973), estimated the MSY for both species in the waters off Ceara State using the following expression:

\[ Y_e = afe - bfe^2 \]

which relates surplus production and the effective fishing effort, where:
Ye = yield when the stock is in equilibrium
a,b = parameters
fe = fishing effort in equilibrium conditions.

Figure 13 shows the parabolic relationship between yield in metric tons and f in trap-days. Assuming that P. argus accounts for 80% of the landings the authors conclude:

For P. argus
Ye = (0.85 - 0.036f)f
MSY = 5.0 x 10^3 metric tons
fe = 11.8 x 10^6 trap-days

For P. laevicauda
Ye = (0.20 - 0.0084f)f
MSY = 6.3 x 10^3 metric tons
fe = 11.9 x 10^6 trap-days

Paiva (1971), considering 390 gr of lobster/ trap-day as the minimum economic feasible level for the fishery in the NE, estimates the MSY for both species in the two major fishing areas.

For the Setentrional-NE area:
MSY = 8,685 metric tons
fe = 22.2 x 10^6 trap-days.

For the Oriental-NE area:
MSY = 1,248 metric tons
fe = 3.2 x 10^6 trap-days.
PROBLEMS AND ISSUES

1 Overfishing

In 1962, the industry started replacing the artisanal-type boats for modern vessels as a result of capital reinvestment (Paiva, 1967). Large sums of money were also made available to the industry after the Federal Law #221 of February, 1967 was passed. This law provides tax incentives for the development of fisheries in Brazil (Paiva, 1976).

An indicator of overfishing in the lobster fishery is an increase in effort from $3.15 \times 10^6$ trap-days in 1965 to a maximum of $36.99 \times 10^6$ trap-days in 1969, associated with a steady decrease in cpue during the same period (Figure 14). The sharp decrease in cpue from 1965 to 1967 is attributed to the low efficiency of the new fishing methods (interconnected traps) and to the geographic concentration of effort (Paiva, 1968). In 1968, though the fishing effort was greater than in previous years, it was applied more uniformly in the fishing area, resulting in a large increase in landings and a slight decrease in cpue (Paiva, 1969). In 1969-70 the small increase in cpue was due to an increase in landings and a lower effort level applied by the Ceara based fleet. From 1970 to 1974 the landings fluctuated
aroud 8,000 metric tons. Until 1973 there is a sharp increase in fishing effort and a decrease in cpue, reflecting overcapitalization of the industry (Paiva, 1971, 1972, 1973, 1974). After 1974 the landings dropped to a minimum of 6,679 metric tons and reached a maximum of 11,033 metric tons in 1980 only due to the increased effort applied after 1975. From 1975 through 1980 the cpue fluctuated around 0.3 lobster/trap-day, showing a decreasing trend after 1978.

Other indications of overfishing are the change in species composition in the landings and shifts in fishing areas. The relative participation of *P. laevicauda* increased from 6.2% in 1961 to a maximum of 75.7% in 1968 and averaged about 50% during the following years in waters off Ceara State.

Fishermen are now fishing new grounds along the coast of Bahia State. Once no lobster processing facilities are located in the state the lobster has to be trucked to Natal to process for export. As expected, the yield on these new grounds is much higher than in the old grounds. This unished stock contains relatively larger individuals. Catches will probably drop as the fishery develops, but it could be maintained at higher levels if the rate of fishing does not remove the surplus production of the stock at greater rates than it is produced.
Diversification

The lobster fishery has now achieved its maximum sustainable yield and diversification is needed both in marketing and in exploitation of underutilized species of potential market value. Lobsters are primarily exported as frozen tails to the United States and little advantage has been taken of the market for whole cooked lobsters which may offer better prices in countries like Japan. Certainly the industry would have to invest in new equipment and technology to handle and ship lobsters to these new markets but the ever increasing prices for lobsters would counter the cost of the investment.

Underutilized species are abundant in the northeast of Brazil. Some of these species could support a commercial fishery once the domestic market is expanded and new ones developed abroad. The exploitation of shark and octopus would have a positive impact on the lobster fishery, since these species prey upon spiny lobsters.

Octopuses are found in the same habitat as lobsters, which makes its fishery easier by the fishermen familiar with the area. They could be marketed as smoked or smoked-canned (Nobrega et al, 1975).

The Atlantic thread herring found in the area is
suitable for fish meal and oil used in animal formula feed (Beserra and Menezes, 1975).

Three species of sea trouts, Cynoscion acoupa, C. leiarchus and C. virescens, if exploited at industrial levels could render raw material for the production of hot smoked, fried fish paste and canned food items fit for human consumption (Zapata and Neto, 1975; Telles et al., 1975).

Bastos and Nunes (1973), report that the isinglass obtained from the air bladders of C. acoupa is of good quality and could be used by the gelatin industry and as a clarifier in the wine making process.

The crab Ucides cordatus, can be found in almost any mangrove area. Its exploitation on an industrial basis could be expanded to meet the high demand for crab meat. Crab harvesting is very labor intensive and could provide jobs for a number of fishermen's families. Crab meat could be successfully processed into frozen, frozen-pasteurized and canned meat with the technology presently available in the region (Ogawa et al., 1973).

Tarpon atlanticus is a species of fish caught seasonally in fish weirs. Tarpon roe demands high prices in the regional market. Alves et al. (1972), present methods for the industrial processing of tarpon roe into dry, dry-salted and smoked canned products, which render a final product of higher quality than that processed by the arti-
sanal methods.

Tuna and tuna-like fish can be fished seasonally with longlines off the northeast of Brazil with small motorized fishing boats similar to lobster boats (Paiva and Muniz, 1964; Paiva and Mota, 1961). This presents another option to the fishermen who can adapt their boats to haul longlines instead of lobster traps.

Pinheiro-Vieira and Ferreira (1968), show a list of 21 species of red algae (Rhodophyta) commonly found in the area, of value in the industrial production of agar-agar.

Two other ways the industry could minimize losses is to prevent lobster spoilage through darkening of the tissues after the lobster is beheaded on board and to extract the remaining meat of the head and process the hard parts into meal.

Costa (1969), estimated that between 1955 and 1968, about 30,000 t of lobster heads were discarded. He also estimated that each fresh cephalothorax can yield 26.5% in weight of meat, which represents a total waste of about 8,000 t of meat.

3. Regulations

It is too early for a complete impact assessment of the major regulations imposed on the fishery after 1975. It is clear though that the government does not have a
uniform policy concerning the exploitation of the lobster resource. Energy and export related activities are the two sectors which will not suffer any spending cuts under the present economic development policies. This means that more money will become available to the lobster industry. On the other hand, SUDEPE is limiting entry to the fishery and closing fishing seasons.

One of the major problems in regulating the fishery is the enforcement of regulations. Restrictions on the size and reproductive condition of lobsters will not have any positive impact on the fishery unless undersized or egg-carrying lobsters are actually released to the sea. One solution to this problem is the placement of observers on vessels instead of in the processing plants as is currently done.

Minimum size restrictions are likely to have a negative impact on the industry, because smaller tails sell for a higher price per pound than larger tails (Table IX). This measure alone would not guarantee that enough lobsters will survive to replace the stock. An alternative would be to enforce a maximum size limit to protect larger females that can carry more eggs.

Limitation of entry and gear restrictions has not proven to be a very successful measure. After such regulations were issued, the boats started to carry a greater number of traps and use bottom gill nets (Moura, 1979).
The regulatory agency could consider limiting the number of traps per boat or traps per line, whichever is the easier to enforce. This measure would also reduce the risk of losing large numbers of traps that attract predators to the fishing grounds.

The problem with fouling of the fishing grounds could be minimized if fishermen were forced to land whole lobsters instead of just the tails.

The alternative measures proposed above could not be implemented before a cost-benefit analysis of the effectiveness of such measures were carried out, taking into account the economic and social impacts.

4. Lobster Culture

This is an issue that is likely to come up in the near future if lobster prices continue to rise and if the programs for shrimp culture in the area prove successful.

Despite some successes which have been reported with the culture of juvenile and adult lobster, basic research is needed before routine larval rearing can be mastered and the technology developed can be transferred to commercial operations.

The major constraints in rearing spiny lobster are its long and complex larval period (Ingle and Witham, 1968),
the inadequate knowledge of its nutritional needs, and the maintenance of high water quality standards (Tamm, 1980). Before any decision is made about lobster culture, the agencies involved should consider the impact that farm-raised lobsters will have on the market. A successful program could have enormous social impacts, resulting in a number of fishermen losing their jobs. Any attempt to develop lobster culture in the area should be solely based on private funds. Public funds would be more wisely spent on programs for the production of less expensive food items.
BIBLIOGRAPHY


Bessa, R.J., 1979. Oxygen consumption of two tropical spiny lobsters, Panulirus argus (Latreille) and P. guttatus (Latreille) (Decapoda: Paliniridae). Crustaceana, 36(1);99-107.


### TABLE I
Geographic area of the northeast of Brazil and of its several states, including the area of Minas Gerais in the drought polygon.

<table>
<thead>
<tr>
<th>Unidades Região País</th>
<th>Áreas absolutas (km²)</th>
<th>Áreas absolutas (%) na região</th>
<th>Áreas absolutas (%) no país</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maranhão</td>
<td>334.809</td>
<td>20,73</td>
<td>3,93</td>
</tr>
<tr>
<td>Piauí</td>
<td>249.317</td>
<td>15,44</td>
<td>2,93</td>
</tr>
<tr>
<td>Ceará</td>
<td>153.245</td>
<td>9,49</td>
<td>1,80</td>
</tr>
<tr>
<td>R. G. do Norte</td>
<td>53.048</td>
<td>3,28</td>
<td>0,62</td>
</tr>
<tr>
<td>Paraíba</td>
<td>56.282</td>
<td>3,48</td>
<td>0,66</td>
</tr>
<tr>
<td>Pernambuco</td>
<td>98.079</td>
<td>6,07</td>
<td>1,15</td>
</tr>
<tr>
<td>Alagoas</td>
<td>28.331</td>
<td>1,77</td>
<td>0,34</td>
</tr>
<tr>
<td>Sergipe</td>
<td>21.057</td>
<td>1,30</td>
<td>0,25</td>
</tr>
<tr>
<td>Bahia</td>
<td>563.281</td>
<td>34,88</td>
<td>6,61</td>
</tr>
<tr>
<td>Minas Gerais *</td>
<td>57.328</td>
<td>3,55</td>
<td>0,67</td>
</tr>
<tr>
<td>Fernando de Noronha</td>
<td>27</td>
<td>0,01</td>
<td>0,00</td>
</tr>
<tr>
<td><strong>Nordeste</strong></td>
<td>1.615.004</td>
<td>100,00</td>
<td>18,96</td>
</tr>
<tr>
<td><strong>BRASIL</strong></td>
<td><strong>8.516.037</strong></td>
<td><strong>100,00</strong></td>
<td><strong>100,00</strong></td>
</tr>
</tbody>
</table>

* Sómente a área incluída no Polígono das Secas.
** Incluindo todas as ilhas oceânicas do Brasil.
Fonte: Fundação Instituto Brasileiro de Geografia e Estatística.

In Paiva et al, 1971

### TABLE II
Shoreline length of the northeast of Brazil and of its several states.

<table>
<thead>
<tr>
<th>Unidades Região País</th>
<th>Extensão absoluta (km)</th>
<th>Extensão relativa (%) na região</th>
<th>Extensão relativa (%) no país</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maranhão</td>
<td>640</td>
<td>17,43</td>
<td>7,10</td>
</tr>
<tr>
<td>Piauí</td>
<td>65</td>
<td>1,77</td>
<td>0,71</td>
</tr>
<tr>
<td>Ceará</td>
<td>573</td>
<td>15,62</td>
<td>6,56</td>
</tr>
<tr>
<td>R. G. do Norte</td>
<td>339</td>
<td>10,87</td>
<td>4,42</td>
</tr>
<tr>
<td>Paraíba</td>
<td>130</td>
<td>3,54</td>
<td>1,45</td>
</tr>
<tr>
<td>Pernambuco</td>
<td>178</td>
<td>4,85</td>
<td>1,97</td>
</tr>
<tr>
<td>Alagoas</td>
<td>335</td>
<td>9,12</td>
<td>3,77</td>
</tr>
<tr>
<td>Sergipe</td>
<td>183</td>
<td>4,44</td>
<td>1,60</td>
</tr>
<tr>
<td>Bahia</td>
<td>1.188</td>
<td>32,30</td>
<td>13,20</td>
</tr>
<tr>
<td><strong>Nordeste</strong></td>
<td>3.671</td>
<td><strong>100,00</strong></td>
<td><strong>40,78</strong></td>
</tr>
<tr>
<td><strong>BRASIL</strong></td>
<td><strong>7.920</strong></td>
<td><strong>100,00</strong></td>
<td><strong>100,00</strong></td>
</tr>
</tbody>
</table>

* Não incluindo as grandes reentrâncias do litoral brasileiro.
** Incluindo as grandes reentrâncias do litoral brasileiro.
Fonte: Fundação Instituto Brasileiro de Geografia e Estatística.

TABLE III
Production of salted marine fishes in Ceara State, from 1961 through 1965.

<table>
<thead>
<tr>
<th>Anos</th>
<th>Número de salgas controladas</th>
<th>Pescado fresco beneficiado (kg)</th>
<th>Produção do pescado salgado (kg)</th>
<th>Perda pelo beneficiamento kg</th>
<th>Rendimento do pescado salgado (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>sêco</td>
<td>salmoura</td>
<td>total</td>
</tr>
<tr>
<td>1961</td>
<td>54</td>
<td>744.500</td>
<td>435.595</td>
<td>48.200</td>
<td>483.795</td>
</tr>
<tr>
<td>1962</td>
<td>55</td>
<td>719.900</td>
<td>424.590</td>
<td>38.400</td>
<td>462.990</td>
</tr>
<tr>
<td>1963</td>
<td>62</td>
<td>707.000</td>
<td>404.110</td>
<td>36.700</td>
<td>440.810</td>
</tr>
<tr>
<td>1964</td>
<td>66</td>
<td>620.600</td>
<td>360.385</td>
<td>16.900</td>
<td>377.285</td>
</tr>
<tr>
<td>1965</td>
<td>68</td>
<td>431.700</td>
<td>256.910</td>
<td>8.500</td>
<td>265.410</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td>3.223.700</td>
<td>1.881.590</td>
<td>148.700</td>
<td>2.030.290</td>
</tr>
</tbody>
</table>

From Paiva and Costa, 1966.
TABLE IV
Dados relativos à pesca de pargo no nordeste brasileiro, durante os anos de 1963 a 1969.

<table>
<thead>
<tr>
<th>Anos</th>
<th>Produção (t)</th>
<th>Esfôrco * (x 10^3)</th>
<th>Índice de captura **</th>
</tr>
</thead>
<tbody>
<tr>
<td>1963</td>
<td>498</td>
<td>220,3</td>
<td>2,25</td>
</tr>
<tr>
<td>1964</td>
<td>1.031</td>
<td>348,1</td>
<td>3,02</td>
</tr>
<tr>
<td>1965</td>
<td>2.237</td>
<td>763,9</td>
<td>3,06</td>
</tr>
<tr>
<td>1966</td>
<td>3.241</td>
<td>2.843,3</td>
<td>1,14</td>
</tr>
<tr>
<td>1967</td>
<td>5.115</td>
<td>7.307,9</td>
<td>0,70</td>
</tr>
<tr>
<td>1968</td>
<td>3.404</td>
<td>3.781,8</td>
<td>0,90</td>
</tr>
<tr>
<td>1969</td>
<td>2.640</td>
<td>3.300,3</td>
<td>0,80</td>
</tr>
</tbody>
</table>

* Expresso em número de anzóis/hora utilizados nas pescarias.
** Expresso em quilogramas de peso vivo, nas capturas por unidade de esfôrco.

Fontes: Laboratório de Ciências do Mar — Universidade Federal do Ceará/Divisão de Recursos Pesqueiros — Superintendência do Desenvolvimento do Nordeste.

<table>
<thead>
<tr>
<th>Anos</th>
<th>Toneladas métricas</th>
<th>Participação do Ceará (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Ceará</td>
<td>BRASIL</td>
</tr>
<tr>
<td>1955</td>
<td>40</td>
<td>40</td>
</tr>
<tr>
<td>1956</td>
<td>90</td>
<td>155</td>
</tr>
<tr>
<td>1957</td>
<td>189</td>
<td>348</td>
</tr>
<tr>
<td>1958</td>
<td>237</td>
<td>432</td>
</tr>
<tr>
<td>1959</td>
<td>390</td>
<td>618</td>
</tr>
<tr>
<td>1960</td>
<td>711</td>
<td>1.197</td>
</tr>
<tr>
<td>1961</td>
<td>1.265</td>
<td>1.740</td>
</tr>
<tr>
<td>1962</td>
<td>1.382</td>
<td>2.070</td>
</tr>
<tr>
<td>1963</td>
<td>1.102</td>
<td>1.778</td>
</tr>
<tr>
<td>1964</td>
<td>938</td>
<td>1.578</td>
</tr>
<tr>
<td>1965</td>
<td>771</td>
<td>1.181</td>
</tr>
<tr>
<td>1966</td>
<td>764</td>
<td>1.066</td>
</tr>
<tr>
<td>1967</td>
<td>870</td>
<td>974</td>
</tr>
<tr>
<td>1968</td>
<td>1.416</td>
<td>1.683</td>
</tr>
<tr>
<td>1969</td>
<td>1.916</td>
<td>2.473</td>
</tr>
<tr>
<td>1970</td>
<td>2.036</td>
<td>2.793</td>
</tr>
<tr>
<td>1971</td>
<td>1.723</td>
<td>2.514</td>
</tr>
<tr>
<td>1972</td>
<td>1.954</td>
<td>2.630</td>
</tr>
<tr>
<td>1973</td>
<td>2.156</td>
<td>2.805</td>
</tr>
<tr>
<td>1974</td>
<td>2.223</td>
<td>3.069</td>
</tr>
<tr>
<td>1975</td>
<td>1.697</td>
<td>2.295</td>
</tr>
<tr>
<td></td>
<td>23.877</td>
<td>33.235</td>
</tr>
</tbody>
</table>

Exports of lobster tails in metric tons, through Fortaleza-CE, and the national total exported from 1955 through 1975.
(Source: LABOMAR-UFC).
<table>
<thead>
<tr>
<th>COUNTRY</th>
<th>MINIMUM SIZE</th>
<th>CLOSED SEASON</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>LENGTH (cm)</td>
<td>WEIGHT (gr)</td>
</tr>
<tr>
<td></td>
<td>TAIL</td>
<td>HEAD</td>
</tr>
<tr>
<td>BRAZIL</td>
<td>12.0</td>
<td>6.5</td>
</tr>
<tr>
<td>CUBA</td>
<td>13.4</td>
<td>7.6</td>
</tr>
<tr>
<td>NICARAGUA</td>
<td>12.8</td>
<td>7.2</td>
</tr>
<tr>
<td>DOMINICAN REP</td>
<td>15.0</td>
<td>9.0</td>
</tr>
<tr>
<td>VENEZUELA</td>
<td>17.0</td>
<td>10.0</td>
</tr>
<tr>
<td>BAHAMAS</td>
<td>14.6</td>
<td>8.4</td>
</tr>
<tr>
<td>USA</td>
<td>13.4</td>
<td>7.6</td>
</tr>
<tr>
<td>BELIZE</td>
<td>14.3</td>
<td>8.2</td>
</tr>
<tr>
<td>JAMAICA</td>
<td>12.5</td>
<td>8.4</td>
</tr>
<tr>
<td>MEXICO</td>
<td>13.5</td>
<td>7.7</td>
</tr>
</tbody>
</table>

Regulatory measures in different countries for spiny lobster (*P. argus*) fishery

Source: SUDEPE
<table>
<thead>
<tr>
<th>Locais</th>
<th>Panulirus argus</th>
<th>Panulirus laeviscauda</th>
<th>Métodos de captura</th>
<th>Fontes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Praia de Meireles (CE - Brasil)</td>
<td>0,9</td>
<td>5,0</td>
<td>0,8</td>
<td>6,4</td>
</tr>
<tr>
<td>Ponta de Pedras (PE - Brasil)</td>
<td>2,4</td>
<td>7,2</td>
<td>3,0</td>
<td>6,9</td>
</tr>
<tr>
<td>Biscayne Bay (Flórida - U.S.A.)</td>
<td>0,6</td>
<td>7,5</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Minimum and maximum cephalotorax lengths for juveniles of *Panulirus argus* and *Panulirus laeviscauda* in nursery areas off northeast of Brazil and southeast United States. *(In Rolin and Rocha, 1972).*
### TABLE VIII

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>$m^*$ ($dt$)</td>
<td>0.87</td>
<td>0.73</td>
<td>0.71</td>
<td>0.91</td>
<td>0.91</td>
<td>0.86</td>
<td>0.87</td>
</tr>
<tr>
<td>$M^*$ ($dt$)</td>
<td>1.11</td>
<td>1.31</td>
<td>1.23</td>
<td>2.41</td>
<td>2.41</td>
<td>1.95</td>
<td>2.04</td>
</tr>
<tr>
<td>$E$ (2)</td>
<td>2.7</td>
<td>3.3</td>
<td>5.5</td>
<td>9.2</td>
<td>12.2</td>
<td>10.3</td>
<td>15.2</td>
</tr>
</tbody>
</table>

(1) — julho de um ano a junho do ano seguinte; (2) — covos/dia (X 10⁶).

Mortality rates and fishing effort for Panulirus argus in the waters off Ceará State from 1965 through 1972. (In Santos and Ivo, 1973).
### TABLE IX

**SPINY LOBSTER PRICES**

<p>| | | | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>New York Market</td>
<td>June 19, 1980</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Australian Tails</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>5-6 oz.</td>
<td>$9.20/lb.</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>6-8 oz.</td>
<td>8.50/lb.</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>8-10 oz.</td>
<td>8.30/lb.</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>10-12 oz.</td>
<td>8.40/lb.</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>12-16 oz.</td>
<td>8.40/lb.</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*(NMFS Fishery Market News N-74)*

*(In Western Pacific Fishery Management Council, 1980 Management plan for spiny lobsters)*.
Figure 1 - From Riordan, R. 1972.
Figure 2 Continental shelf off the northeast of Brazil adapted from Paiva et al, 1971
Figure 3 Fishing areas for spiny lobsters.
From Costa et al., 1974 - UNDP/FAO.
Figure 4 The lobsters trap. A - Frame; B-one opening trap; C - two openings trap; D-mesh size; E- dimensions of the finished trap. (In Costa and Albuquerque, 1966).

- Principais características dos cõvos experimentados: A — armação de um covo hexagonal irregular; B — perspectiva da face anterior do covo com uma sanga; C — perspectiva da face anterior do covo com duas sangas; D — forma e dimensão da malha dos cãvos; E — vista geral de um covo hexagonal irregular.
Figure 5 A typical steel-hulled snapper/lobster vessel currently in use in the NE of Brazil.
(In Gomes, 1976).
Figure 6 - SPINY LOBSTER (Panulirus argus)
(From Chace and Dumont, 1949)
Figure 7  Phyllosomas of Panulirus argus. A, stage 1; B, stage 2; C, stage 3; D, stage 4. (ventral view throughout).
(From Lewis, 1951).
Figure 8 Growth curve for males of *Panulirus argus* (In Santos et al, 1964).
Figure 9 Growth curve for females of *Panulirus argus* (In Santos et al, 1964).
Curva de crescimento para a lagosta *Panulirus laevicauda* (Latreille), em águas costeiras do Estado do Ceará (Brasil).

Figure 10 Growth curve for individuals of the species *Panulirus laevicauda* in the waters off Ceará State (In Ivo, 1975).
Illustration of appendicular usage in queuing behavior of the spiny lobster *Panulirus argus*; appendages involved are blacked in. Lobster III joins the queue after touching lobster II with an extended antenna and turning until both antennular inner rami touch the sides of II. Lobster II maintains queue alignment either by frequent intermittent flicks of the antennules against lobster I, grasping or touching I with extended anterior pereiopods, or both. Antennae, antennular inner rami, and pereiopod tips are sensitive to tactile stimulation.

*Figure 11 (In Herrnkind, 1969).*
Results of experiments in a tow tank with individuals and queues of preserved spiny lobsters towed at 15 (●), 25 (□), and 35 (●) cm/sec. Proportional drag reduction for queues compared with the cumulated value for the same lobsters towed individually is apparent at all three speeds, but it was most prominent at 35 cm/sec, a speed that approximates the maximum sustained walking speed of queuing migrant lobsters. Abbreviations: I, individuals; Q, queues.

Figure 12.
(In Bill and Herrnkind, 1976)
Figure 13 Surplus production curves for Panulirus argus and Panulirus laevicauda in the waters off Ceara State from 1965 through 1972. (In Santos et al, 1973).
Figure 14  Catch, effort and cpue for Panulirus argus and P. laevicauda in the northeast of Brazil, from 1965 through 1980.

<table>
<thead>
<tr>
<th>LOWER BOUND</th>
<th>UPPER BOUND</th>
</tr>
</thead>
<tbody>
<tr>
<td>CPUE</td>
<td>0.27 - 1.12</td>
</tr>
<tr>
<td>CATCH</td>
<td>3,114 tons (m) - 11,033 tons (m)</td>
</tr>
<tr>
<td>EFFORT</td>
<td>$3.15 \times 10^6$ trap-days - $36.99 \times 10^6$ trap-days</td>
</tr>
</tbody>
</table>

![Graph showing catch, effort, and cpue](image-url)