Status Report of Florida's Research on Spiny Lobster Biology[1]

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In recent months groups ranging in composition from commercial fishermen to representatives of national governments have been intensely discussing existing and proposed regulation of fisheries for *Panulirus argus,* the most valuable of the western Atlantic spiny lobsters. These dialogues illustrate that an understanding of the biology of an exploited fish stock is indispensable in evaluating management concepts. Thus it is timely to summarize existing knowledge of lobster biology, how this insight was obtained, and what remains to be learned.

Diverse and international sources have contributed to our present knowledge, but I will focus chiefly on highlights of research accomplished in Florida. Organizations such as the Florida Board of Conservation (now the Florida Department of Natural Resources), the University of Miami, the National Marine Fisheries Service (formerly the Bureau of Commercial Fisheries), the University of Florida Sea Grant Program, Florida State University, and the National Park Service have all contributed to the biology of larval, postlarval, juvenile, and adult segments of Florida lobster populations.

Important to assessment of the population dynamics of any species is the manner in which young or larvae are produced and ultimately recruited into the adult stock. This information was initially determined for Florida lobsters through research conducted from 1917 through 1920 by Crawford and De Smidt at the old Bureau of Fisheries Biological Station at Key West. Lobster copulation and fertilization were observed and fecundity of lobsters 76-mm to 100-mm carapace length was estimated to be from 500,000 to 700,000 eggs, respectively. Only females greater than 76-mm carapace length bore eggs. Although the flat, spider-like larvae were hatched, rearing was unsuccessful, the researchers finding that "the short embryonic development may predict a long larval life which may render artificial propagation a very difficult problem." This is still the primary obstacle that has confounded all attempts to rear Florida spiny lobster larvae to the juvenile stage.

Research at Key West provided the impetus for the first legislation protecting Florida lobster stocks. Beginning in 1920, commercial harvesting of lobsters was prohibited from the first day of March to the first day of June each year in an

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effort to conserve brood stock. Despite this demonstration of promising potential of Key West lobster investigations, the facility was all but abandoned after 1920.

In 1944, Smith, Dawson, and Idyll of the University of Miami began comprehensive lobster studies for the Florida Board of Conservation. This research was supplemented by major contributions to larval and postlarval biology by Lewis in the early 1950s. As is true for other palinurids, larvae were shown to drift in the plankton for periods of 6 months or longer before developing into postlarvae. Thus, larvae hatched from Florida stocks were probably carried elsewhere by currents, leaving recruitment to Florida principally from Caribbean sources.

During the early 1960s, there was another great upsurge in research on larval lobsters and their method of recruitment. The Florida Board of Conservation, through the work of Ingle, Sims, and Witham, further demonstrated year-round transport of larvae to Florida via the Yucatan and Florida Currents. Significant retention of larvae spawned from Florida lobsters was again shown to be unlikely, as extensive plankton sampling from the Florida Keys to Stuart produced few larvae in intermediate stages of development. Most larvae taken were either newly hatched, or were late stage specimens. Principal influxes were at night on flood tides. Cultivation of larvae again proved futile, indicating that development might proceed only in oceanic offshore waters.

Although not readily justified from a replenishment basis, protection of egg-bearing female Florida lobsters (requested by the fishing industry) does give the resource a respite from harvesting and is undoubtedly beneficial. One of the principal benefits is as a regulatory example for responsible Caribbean lobster management programs. Also, a small percentage of Florida-spawned larvae may survive to replenish either Caribbean stocks or our own stocks through entrainment in fortuitously cycling currents.

Prospects for further successful exploration of spiny lobster larval biology are not encouraging. Deductions regarding length of the developmental period, factors that trigger metamorphosis, relationships to brood stock density, mortality, places of origin, transport routes, fate of Florida spawned larvae, and larval behavior, all must be based on examinations of larvae of known species identity. Methods for identification are currently unreliable. A bewildering variety of larval developmental stages of at least three similar species of *Panulirus* can be present in plankton samples, mitigating against positive identification of specimens. Cultivation of larvae of known parentage to determine characteristic species morphology has yet to be achieved. Some hope for new understanding of larval biology does however exist in the form of studies on larval transport presently being completed by the National Marine Fisheries Service Southeast Fisheries Center.

Although progress on larval studies may have reached an impasse, the outlook is bright for increased understanding of biology of the postlarval stage. In the early 1950s, recruitment of postlarvae and morphology of early juveniles were first described. Unfortunately, another decade passed before these investigations, Growth slows, probably not exceeding an increase of 15-mm in carapace length per year. Approximately 3 years would thus be required for a postlarval lobster to reach the minimum legal exploitable carapace length of 76 mm.

The effects of fishing pressure on the structure of juvenile and adult stocks have been an important component of lobster research in Florida since the late 1940s. However, inadequate funding generally prevented the sampling of all fishery areas to acquire an accurate determination of age groups within the exploited population. Nevertheless, valuable observations have been made. The most notable of these are that in recent years, although total annual landings have remained constant, fishing pressure has caused a decline in the average individual size of lobsters landed. These observations indicate that the traditional inshore fishery in Florida is producing the maximum sustainable yield. Lobster measurements made in the late 1940s by Dawson and Idyll and in the early 1960s by Robinson and Dimitriou both showed modes at about 82-mm carapace length and only rather gradual decreases in abundance of larger lobsters. Measurements recently made by Warner and by Davis show that the mode has decreased to between 65 to 75-mm carapace length and that abundance of lobsters larger than 76 mm now declines much more sharply. In addition, most of the female lobster population now being harvested is thought to be comprised of size groups that have not yet had the first chance to reproduce. These studies also indicate that lobsters generally don't become vulnerable to the trap fishery until they have reached carapace lengths greater than 60 mm. Therefore, additional lobster sampling techniques must be used to gain a realistic picture of the entire population structure.

One very important aspect of lobster biology that has been almost completely ignored to date is assessment of lobster stocks in deeper waters or in other areas peripheral to the traditional inshore fishery. Lobsters have been found beneath the Florida Straits, on the continental shelf as far north as the Carolinas, and on the West Florida shelf. However, the distribution and commercial potential of stocks in such areas have yet to be determined. These stocks are of interest not only for establishment of alternative fisheries, but also for the information they might provide concerning lobster growth, migration, recruitment, and interaction with inshore populations. Florida Department of Natural Resources Executive Director, Harmon Shields, recently initiated an exploratory lobster fishing project to provide answers to some of these questions.

An area exceeding 2,000 square miles north of Dry Tortugas has just been surveyed. Bottom topography along the 50-fathom curve showing features which could harbor unfished lobster populations comprise over half of this vast area. Side scan sonar surveillance of the sediments conducted by the University of South Florida marine geologist Dr. Thomas Pyle constitutes the initial phase of this work. The next cruise of DNR's RV *Hernan Cortez* will utilize traps and an underwater TV camera provided by the National Marine Fisheries Service Miami Laboratory to intensify the search over similar promising bottoms for fishable stocks of lobsters.

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which had been begun by Lewis at Miami, were resumed. Witham, working for the Florida Board of Conservation, devised a floating artificial substrate which approximated the matted vegetation in which postlarvae were known to hide. This innovation greatly facilitated collection of postlarvae. By 1970, Witham, Sweat, and others had found that free swimming transparent postlarvae are recruited throughout the year into inshore nursery grounds, such as the Indian River and Florida Bay, chiefly at night during the interval between the new moon and first quarter moon.

The relationship of recruitment to subsequent lobster abundance, specific environmental factors determining success of postlarval recruitment, and the relationships between egg or larval production and postlarval abundance still need clarification. Research is being initiated now by the Florida Department of Natural Resources, with financial assistance from the National Marine Fisheries Service Federal Aid Office, to address some of these points. If true insight into recruitment can be realized, this information could be applied to forecasting changes in abundance of adult stock as well as to enhancing nursery ground survival of postlarvae and juvenile spiny lobster.

Although some of the principal elements of lobster behavior, growth, and migration were known by 1950, subsequent research has been directed at resolving these subjects in greater detail. Underwater study of lobster behavior by scuba diving has developed into a powerful new tool for this effort. These *in situ* observations have produced new insight into lobster migratory patterns and have shown that trap sampling of the structure of lobster populations may often be misleading. Previous tagging studies indicated that lobsters could travel up to 100 miles from the point of release. However, more recent taggings, coupled with underwater observations such as those of Davis and Herrnkind, revealed that most lobsters roam over rather small home ranges and seldom undertake more than local seasonal migrations.

Also essential to understanding lobster population dynamics is a thorough knowledge of growth and the relation between age and lobster size. Success in obtaining this information has been hindered. Growth cannot yet be accurately deduced from the progression of modal size frequencies because separation of the population into groups of known age is difficult. Possible year round recruitment, differential growth of juvenile groups recruited at different seasons, and variation in growth of individual lobsters may permit several age groups to comprise specific size classes. Past tagging studies have also been ineffectual in providing growth information because too few recaptures were available for remeasurement. Growth of captive lobsters should not be considered representative of growth of wild populations, so our present estimates of lobster growth must be extrapolated.

Monthly carapace length increases of juvenile lobsters average 3.0 to 5.0 mm for the first year of life after postlarval recruitment. Then, at carapace lengths of 40 to 50 mm, these juveniles leave the nursery grounds for deeper waters.

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