The life History of the Carribean Spiny Lobster, *Panulirus Argus*

The Caribbean spiny lobster, *Panulirus argus* supports the most economically important fishery in Florida and is heavily fished from Bermuda to southern Brazil. The economics of the commercial spiny lobster fishery and the need for biological knowledge important for the effective management that fishery has driven a great deal of research on the life history of *Panulirus argus*. This lobster's incredibly complex life cycle consists of 6 distinct life-history stages spread across three distinct habitats: open ocean, shallow, vegetated coastal zone, and coral reefs. During its lifetime, *P. argus* grows from less than one gram as larvae to five kilograms as adults. This spiny lobster spends months traveling as larvae in the open ocean, lives asocially during its early benthic stages, forms social aggregations as older juveniles, and mass migrates by the thousands at the onset of winter. Here we present a synopsis of research done by our lab and others on the fascinating aspects of the life history of the Spiny Lobster.

The Phyllosome Larvae Stage of the Carribean Spiny lobster:

In Florida waters, most spiny lobsters reproduce during late spring and early summer. Spawning occurs in deeper waters near the fringes of the outer reefs and females at egg hatching are abundant in areas with strong water movement. During the night or early morning, eggs hatch as transparent, phyllosome (leaf-bodied) larvae and initially rise to the surface. As they are carried offshore, phyllosomas migrate between the surface at night and deeper waters during the day. Offshore dispersal can be rapid (5.25 km/day for some lobsters) in the wind-driven surface layer of water. The early life of spiny lobsters is spent in the open ocean, where *Panulirus argus* larvae moult 11 times over a period of 6 to 12 months. The phyllosomas are well adapted to life in the open ocean, bearing long, highly setose appendages extending from a dorsoventrally flattened, bilobed cephalothorax. Using their long appendages, phyllosomas move well vertically in the water column, within the upper 150 meters. Larvae are typically found in shallower waters at night and deeper waters during the day. Although little is still known about the ecology of phyllosomas, they likely use well formed, toothed mouthparts to feed on large, soft prey captured using their pereiopods. Although it is not certain what the source of returning larvae is for spiny lobsters, late stage phyllosomas are typically found near the edge of the

continental shelf, where they undergo a moult to the puerulus postlarval stage.

Postlarval Recruitment:

After the long-lived phyllosome larvae phase, lobsters metamorphose into the puerulus postlarval phase in the open ocean at the edge of the continental shelf. Although recruitment of *Panulirus argus* postlarvae occurs year-round, lobsters generally move from the open ocean to nearshore habitats in the Florida Keys at night on flood tides following the New Moon. The non-feeding, transparent postlarvae swim in the upper 1 meter of water and are aided in their movement by wind-driven surface currents. By moving inshore at night, under the darkness provided by a new moon, along the surface of the water and in a strong tidal current, lobsters appear to reduce predation as they recruit to nursery habitat from the open ocean. This is important since the pueruli must move across potentially dangerous offshore reefs, seagrass beds, and macroalgal-covered hardbottom habitat. (Acosta & Butler, 1999). During the day, the pueruli migrate down the water column and rest on the seafloor. In Florida Bay, FL postlarvae settle at a size of about 6mm carapace length in dense macroalgal clumps of red algae (Laurencia spp). The transparent postlarvae acquire dark pigmentation and molt into algal phase juveniles within a few days of settlement.

Algal-phase Juveniles:

Panulirus argus postlarvae in south Florida settle primarily in clumps of red macroalgae, especially *Lauencia* spp., which grow well in the shallow, protected portions of Florida Bay. Postlarvae may also settle in seagrass meadows, between the spines of sea urchins, or among the fouled prop roots of mangroves when macroalgal clumps are not readily available or are heavily sedimented. A broad tendency to settle into deep interstices allows *P. argus* to opportunistically recruit to a wide array of habitats. Young lobsters remain in macroalgal habitat from 6 mm carapace length (CL) to 15-20 mm CL over a few months. During this time, lobsters are asocial and maintain feeding territory through agonistic interactions with other young lobsters. Algal phase juveniles are cryptically colored and hide well from predators in these dense macroalgal clumps. Thus, food and shelter are essentially offered in the same package. This allows for foraging within the protective confines of an algal clump. In addition to increased protection, dense macroalgal clumps also provide greater surface area in which young lobsters can feed. As lobsters grow too

large to effectively move through the macroalgae, they begin to take up residence under the macroalgal clumps. Between 15-20 mm CL lobsters dissociate from the macroalgae and take up residence in nearby crevice shelters.

Post-algal Juvenilles:

Following settlement, juveniles leave the macroalgal habitat and seek out crevice shelters such as rock crevices, holes and ledges; undercut coral heads and sponges, which are more appropriately scaled to their body size. Small, crevice dwelling lobsters have fairly restricted, non-directional movement, emerging from shelters primarily to forage at night. As they grow larger, they travel further from shelter and their aggregate nightly movement over several months can equal several kilometers. Once lobsters move out of the macroalgae at around 15-20 mm CL, they become social and begin to aggregate in crevice shelters, attracted to the scent of conspecifics already dwelling in those shelters. Aggregations of spiny lobsters at this size range rarely occur more than one would expect by chance and sociality does not seem to increase their chances of survival. The primary benefit of chemically mediated attraction to conspecifics appears to be in locating dens. Attraction to conspecifics via chemoreception allows lobsters to locate appropriate dens more quickly, thus minimizing the time that they spend vulnerable to predation. Lobsters smaller than 15 mm CL do not appear to respond to attractive odors from conspecifics. Post-algal juveniles (20-50 mm CL) do not suffer the same high predation rates as do smaller lobsters (~95%), but they remain a prominent component of the diet of large fishes such as sharks and groupers. Therefore, the availability of appropriate shelter and finding that shelter expeditiously is particularly important for the survival of post-algal stage lobsters.

Sub-adults:

After about one year of benthic existence, lobsters 50-75 mm CL become nomadic sub-adults, occupying extensive shallow (3-10 m) banks where food is abundant. These nomadic juveniles forage nocturnally on benthic invertebrates and take up shelter during the day in aggregations around the bases of sea whips and large sponges or, if available, under ledges of rock, seagrass rhizome mats or an occasional coral head. Transient movements of juveniles are especially apparent in areas where there is intermittent shelter, such as in the shallow waters off of the Florida Keys or in the Bahamas. In mid-autumn, increasing numbers of lobsters begin to emigrate in nocturnal

queues (single-file lines) from the shallow banks to deeper (10-20 m) rock and coral shelters along the bank fringe. Upon the onset of the first major polar storm front, bringing several days of reduced temperature, high winds with large sea swells, constant overcast and rain squalls, lobsters living along the shallow bank fringes begin to migrate by the thousands to more sheltered habitats on the oceanic fringe. Queues with up to 65 lobsters travel day and night along the bank fringe for 30-50 km over the short migratory period. After migration, lobsters gradually disperse into more sheltered waters over the following few weeks. No analogous mass return migration of lobsters has ever been documented and dispersal back into the shallow banks occurs over the next several months.

Adult Lobsters:

Approximately two years after settlement, at about 75mm CL, lobsters mature and move seaward to reefs where mating and spawning occur. These emigrations are usually gradual and nomadic, but short-term mass movements do occur. These movements widely disperse the lobsters along the reefs that parallel the Florida Keys. Offshore lobster populations are composed predominantly of adults residing individually or communally in crevices of rock or coral. After foraging at night (up to several hundred meters) most adults return to the same or nearby dens. Homing to dens apparently involves orientation of the lobster to hydrodynamic (current and wave surge), chemical, topographic, and gravitational (slope) cues. Adult lobsters are highly selective of dens and reside most frequently in crevices that allow full withdrawal of the body, deny access by large predators and contain other lobsters. Concentrations of adult spiny lobsters around the Florida Keys tend to shift in the autumn and during the spring reproductive period. Females move to deeper reefs in the spring to mate and shed larvae and both sexes emigrate offshore when the first major fall storms arrive. Spiny lobsters can grow to very large sizes in unfished areas. Adult male *Panulirus argus* can attain a maximum size of ~200 mm CL at which size they are vulnerable to predation only by very large reef sharks, fish and humans.