Spiny Lobster (*Panulirus argus*) Recruitment to Artificial Habitats in Waters Off St. Thomas, Virgin Islands

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ABSTRACT

Settlement of the pueruli of the western Atlantic spiny lobster, *Panulirus argus* (Latreille, 1804), was monitored on a fortnightly basis at three locations from July to October 1992 in waters off St. Thomas, U.S. Virgin Islands. Sampling is continuing. The catch ranged from 0 to 29 lobster per collector. There were significant differences between sites. The Great St. James site, off shore of the mangrove lagoon and near a major current channel, had the greatest catch per unit effort. The lowest settlement occurred on the collector farthest in the mangrove system. Settlement occurred primarily during the new moon phases. Overall settlement rates were lower than those in Antigua, Bermuda and Florida.

INTRODUCTION

The western Atlantic spiny lobster, *Panulirus argus* (Latreille, 1804), supports a commercial – recreational fishery in the U.S. Virgin Islands which is minor compared to other regions in the Caribbean such as Bahamas, southern Florida, and Mexico. The general feeling is that catches in the 1990s are down from 1967 when landings totaled 47,518 kg. (104,540 lbs) (Swingle *et al.*, 1969). In 1967 this was approximately one fourth of the lobster consumed in the territory (Island Resource Foundation, 1977). In 1975 the average annual catch per boat of lobster by St. Thomas - St. John fishermen using fish traps and fishing 5.8 days per month was reported at 91 kg (200 lbs) (Olsen, 1975).

Thorough knowledge of population dynamics is essential to effective management of fishery stocks. Changes in the levels of recruitment to fishery stocks often result from changes in survival of young (Cushing, 1973). Consequently, the dynamics of the Virgin Islands lobster fishery might be understood by studying the origin and recruitment of post larvae and survival of juveniles. However, studies of recruitment have drawbacks. Exact sources of the phyllosoma larvae and pueruli to Virgin Islands stocks, each source's contribution, the length of time spent as plankton, their growth rates and the conditions relating to their movement to inshore waters are still unknown.

Spiny Lobster Life History

The oceanic phyllosoma larvae of *Panulirus argus* metamorphose after an estimated 6–9 months (Ingle *et al.*, 1963) into transparent nocturnally active pueruli which swim to inshore nursery areas aided, perhaps, by physical transport mechanisms (Lyons, 1980; Calinski and Lyons, 1983). Most of the larvae are transported from areas hundreds of kilometers away (Phillips and McWilliam, 1986). In Florida Bay, once near shore, pueruli are carried on flooding night tides through inter-island channels with the influx peaking each month around the new and first quarter moon (Little, 1977). The pueruli settle selectively among structurally complex benthic vegetation, particularly the common benthic *Laurencia* spp. (Marx and Herrnkind, 1985; Herrnkind and Butler, 1986; Butler and Herrnkind, 1991). Settled pueruli metamorphose into first benthic instars (Sweat, 1968) 5–7 mm in carapace length (CL). The pueruli remain associated with algae, which provide abundant epibiont food resources and shelter from predators, for up to three months (Marx and Herrnkind, 1985; Herrnkind and Butler, 1986; Herrnkind *et al.*, 1988). At 15–20 mm CL, habitat preference changes and the postalgal juveniles seek daytime shelter among sponges, octocorals, or rock crevices (Andree, 1981). When they attain 30–35 mm CL, the postalgal lobsters lose the last vestiges of algal phase coloration and take up the nomadic life-style characteristic of late-stage juveniles and adults (Kanciruk, 1980) and move into deeper offshore regions. Some studies (Davis, 1985) have suggested that low levels of post-larval recruitment were a more important limit to larger adult populations than shelter.

Before one can begin to use changes in abundance of postlarval and juvenile lobsters to understand adult population dynamics the annual and lunar recruitment patterns and areas with the highest recruitment must be identified. Phillips and McWilliam (1986) state that the perpetuation of palinurid populations, especially on isolated, oceanic islands, seem to depend on the behavior and mobility of the puerulus stage.

This study, presently in a preliminary stage, seeks to test the hypotheses:

1) H_0: there is no significant difference in puerulus recruitment between sites in St. Thomas, U.S. Virgin Islands, and other Caribbean and western Atlantic locations.

2) H_0: there is no significant difference in puerulus recruitment between sites in St. Thomas.

3) H_0: there is no lunar periodicity in recruitment of *Panulirus argus* at sampling sites.

4) H_0: there is no seasonal variation in puerulus recruitment at sampling sites.

5) H_0: there is no annual variation in puerulus recruitment at sampling sites.

MATERIALS AND METHODS

In June 1992, three modified Witham collectors (Little and Milano, 1980) were placed in Mangrove Lagoon (18°19'N, 64°53'W), on the east end of St. Thomas (Figures 1a and 1b). The collectors were deployed at a depth of 1 m in water 2 m deep over a substrate of fine sand and mud. The mangrove community is dominated by *Rhizophora mangle* (Nichols & Towle, 1977).

In July an additional four collectors were deployed in waters off two islands 3 km from St. Thomas, Saba (18°18'N, 65°00'W) on the southwest end and Great St. James (18°19'N, 64°50'W) on the southeast end (Figures 1a and 1b). The two collectors at Saba are moored 2 m from the surface in water 8 m deep. They are positioned on a sandy patch between a *Syringodium filiforme – Thalassia testudinum* sea grass meadow and a *Montastrea annularis / Millepora alcicornis* dominated reef.

The two collectors at Great St. James are in water 11 m deep and positioned 5 m from the surface. They too are located on a sandy patch between a *Syringodium filiforme – Thalassia testudinum* sea grass meadow and a *Montastrea annularis* dominated reef.

The collector frames are made from 1.91 cm diameter PVC pipe and measure 65 cm x 43 cm. For each collector, six hogs hair (Precisionaire Inc., St. Petersburg, Florida) air conditioning filters were cut into 40.5 cm x 61 cm pieces (total surface area 14,823 cm^2), folded lengthwise with the webbing backing material to the inside, slipped over each crossbar in the PVC frame and attached with electrical cable ties. Moorings are two 8 kg cinder building blocks fastened with rubber hose reinforcement around 8 mm polypropylene anchor rope. A float is used to suspend each collector.

Prior to recovery a 2 mm mesh bag is placed around each collector. This necessitates using SCUBA equipment at the Saba and Great St. James sites. Sampling is conducted fortnightly in the morning at alternating weeks, one week Saba is sampled and the following week Great St. James / Mangrove Lagoon. All pueruli are removed from collectors, counted, staged and carapace length measured in the laboratory. Each sample represents recruitment to the collector over a two week period. When considering lunar effects, the phase prior to or on the sampling date is used.

We use the term "larvae" to include the various phyllosoma stages, and use the term "post larvae" and "pueruli" interchangeably to include postmetamorphic lobsters regardless of degree of pigmentation.

The measure of catch per unit effort was determined by dividing the catch by the number of collectors at the site.

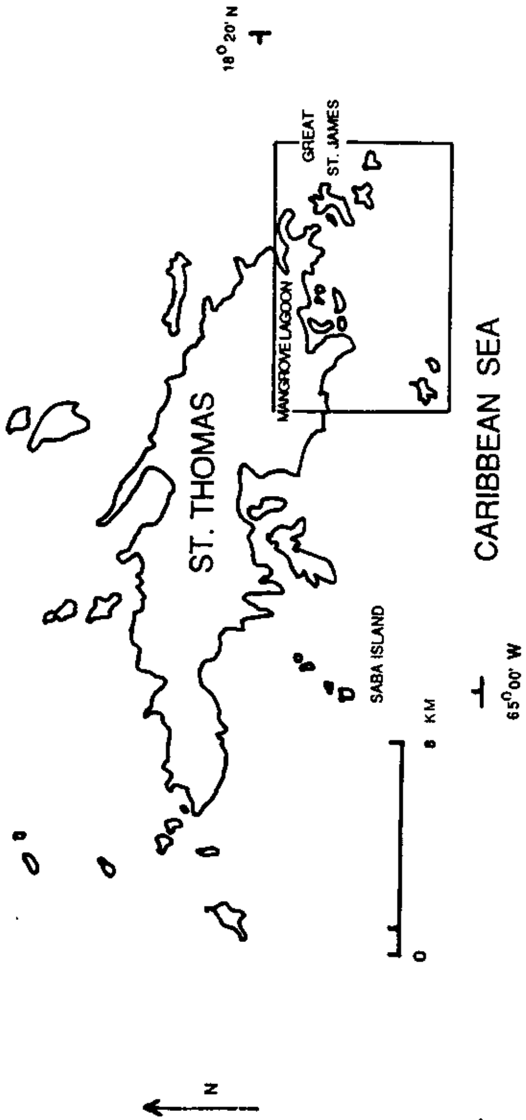

Figure 1a. St. Thomas, U.S. Virgin Islands.

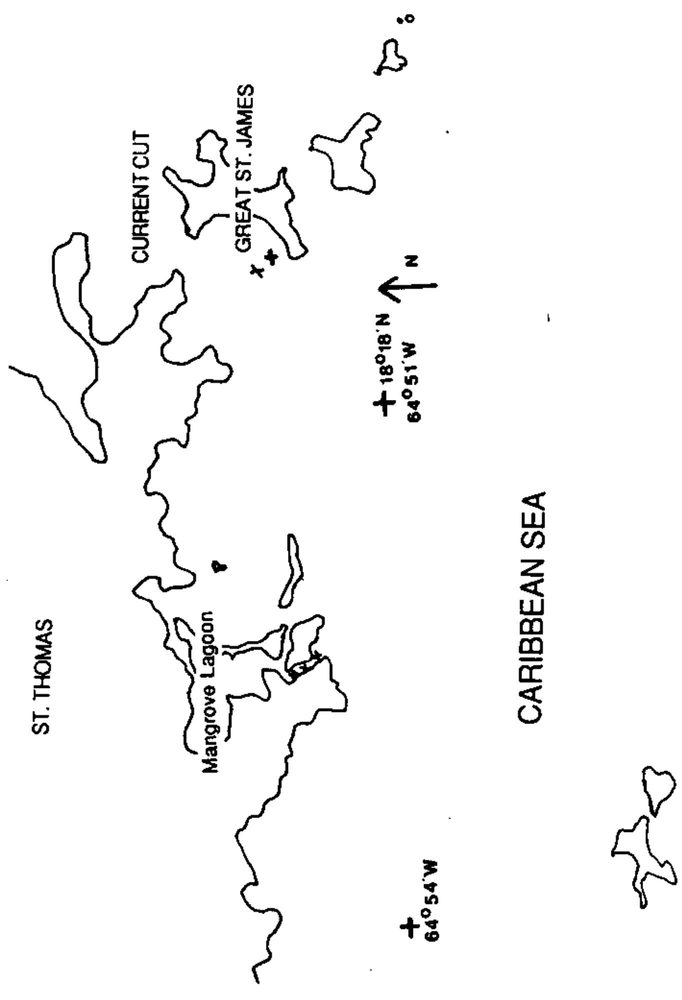

Figure 1b. Eastern end of St. Thomas, puerulus collector sites indicated by x.

Sea water temperature was recorded daily at 9 am to the nearest 0.05°C and at 17m at Greater Lameshur Bay, St. John from 16 June 1992 to 25 March 1992 and at 9 am off Saba from 28 March 1992 to 21 August 1992 using a Hugrun underwater temperature recorder. The sites are separated by 19 km of water. The underwater temperature recorder is still deployed.

RESULTS

As of 25 October, 1992, 18 transparent, 13 semi-transparent and 124 pigmented puerili totaling 155 lobsters have been collected in a total of 56 samples (one sample refers to one Witham collector sampled at a single sampling time) (Figure 2). Settlement of at least one individual was observed in 58% of the samples. Settlement ranged from 1 to 29 lobsters per sample (Figure 3).

The length of immersion did not influence the settlement effectiveness of the collectors. The settlement on replacement collectors was comparable with the settlement on collectors that had been deployed for much longer. This is similar to the observations of MacDonald (1986) in Hawaii.

Spatial Variation

Large differences in the number of post larvae settling exist between stations (Figure 4). Settlement was highest on collectors at Great St. James with a CPUE (catch per unit effort) of 6.2 pueruli (Table 1). Pueruli were present in 86% of the samples at that site. The next highest settlement rate was on collectors located closest to the mouth of the Mangrove Lagoon with a CPUE of 2.2 pueruli. Pueruli were found in 65% of the samples. The site located farthest in the Mangrove Lagoon had the lowest settlement rate with pueruli settling on only 22% of samples. The CPUE was only 0.3. The off shore island, Saba, had a CPUE of 1.6 and pueruli in 33% of the samples.

Regional Spatial Variations

Settlement of pueruli was sampled simultaneously from August 1987 through July 1988 in Antigua, Florida Keys, and Bermuda (Hunt, *et al.* 1990). The mean catch per collector (CPUE) ranged from 9.3 puerulus in Antigua, 6.1 in Florida Keys and 1.4 in Bermuda. The mean CPUE from the Great St. James site compares with the results in the Florida Keys. The CPUE for Mangrove Lagoon, 2.2 puerulus, and the Saba site only just had more settlement than Bermuda. The site farthest in the Mangrove Lagoon with a CPUE of 0.3 was the least productive site.

Another Antigua study (Anon. ms) with 35 collectors lasted 4 1/2 months (Figure 5a) with only two months, September and October, overlapping with this study (Figure 5b). The settlement in Antigua was 26% greater than this study in September (Antigua: 3.465 lobsters per collector (lpc), V.I. 2.75 lpc)

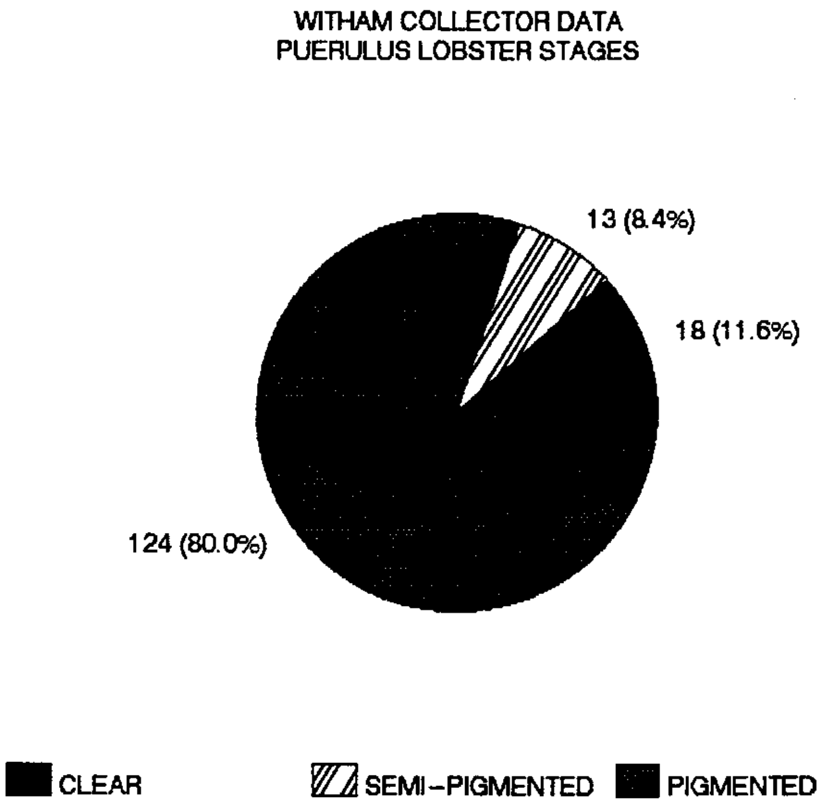

Figure 2. Percentage of each puerulus stage for all sites.

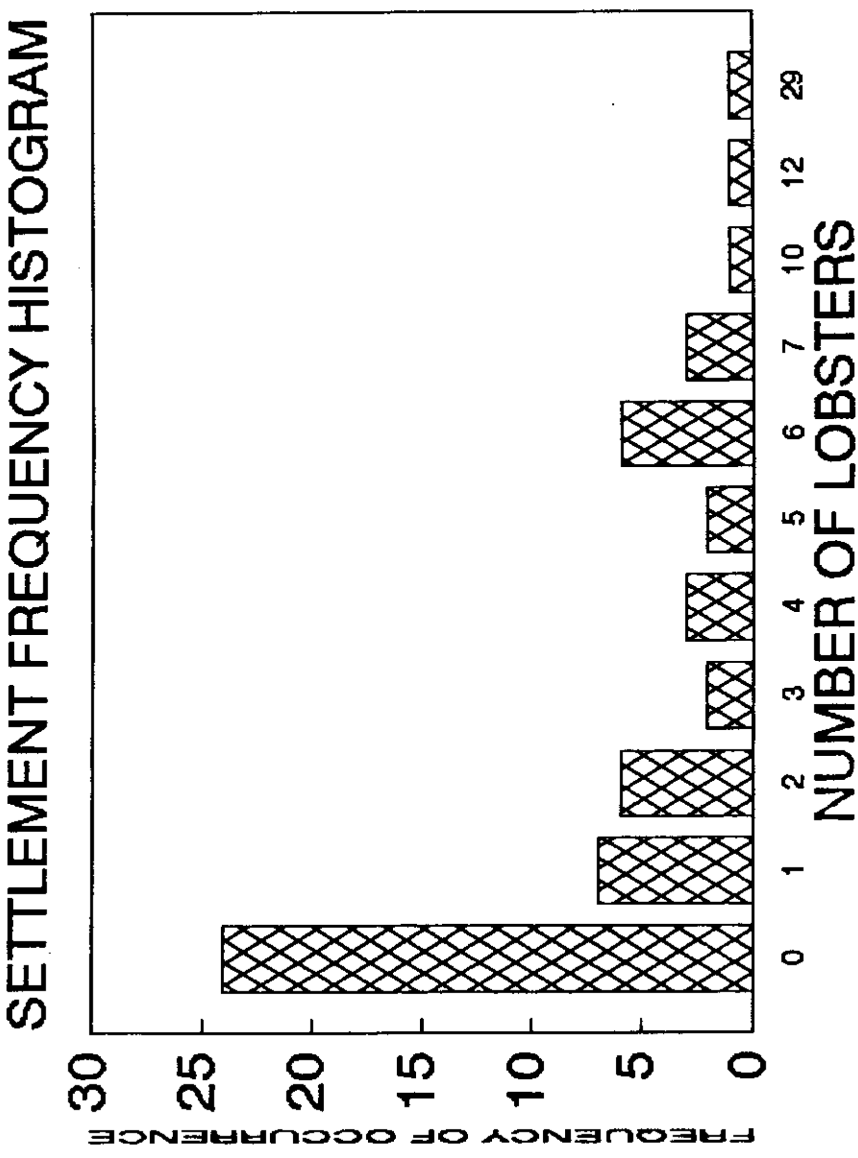

Figure 3. Settlement frequency histogram of puerulus for all sites.

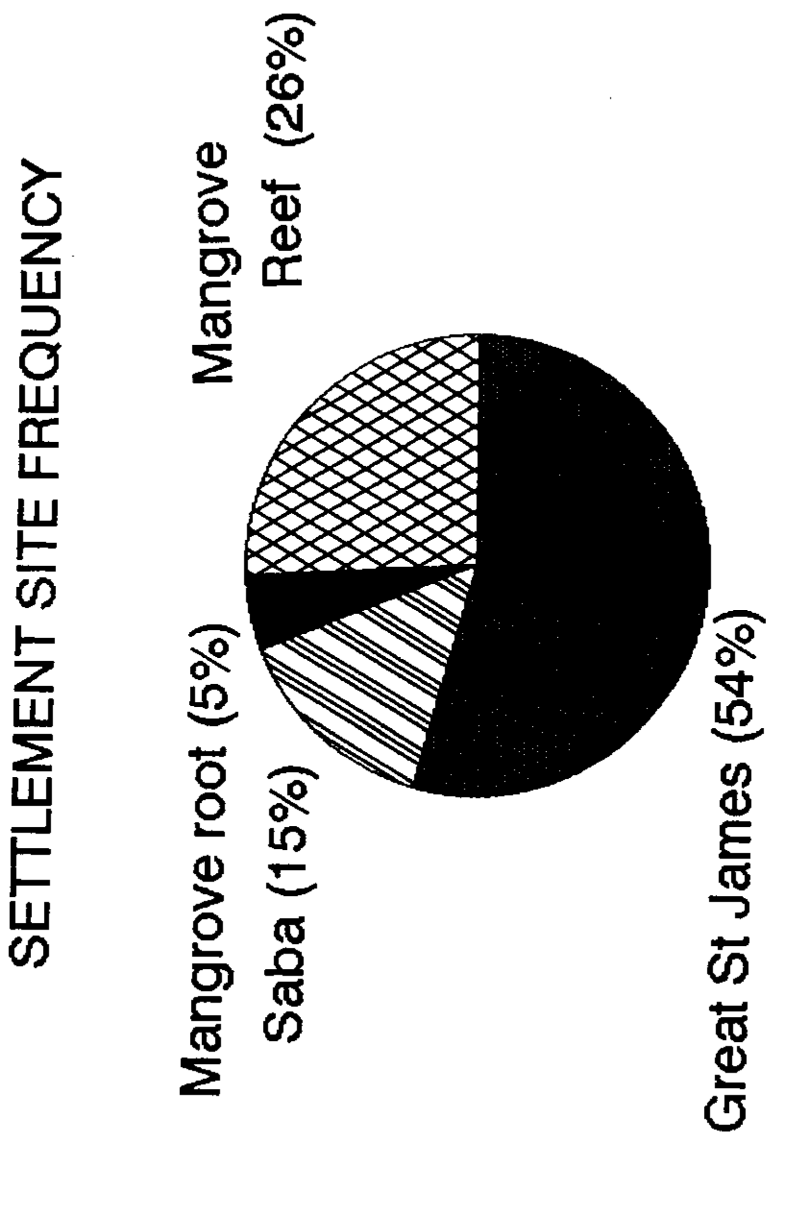

Figure 4. Percentage of puerulus settlement by site.

Table 1. Catch per unit effort at collector locations.

LOCATION	LATITUDE	NUMBER OF COLLECTORS	MAX. CATCH	MONTH	MEAN CATCH # PUERULI
Antigua	17°N	28	355	February	9.3
U.S.V.I	18°N	7	29	August	6.2
St. James					2.2
Mang. Reef					1.6
Saba					0.3
Florida Keys	25°N	3	61	August	6.1
Bermuda	32°N	10	44	March	1.4

and nearly five times greater in October (Antigua: 6.325 lpc, V.I. 1.28 lpc). Another study in Antigua (Peacock, 1974) found settlement much high in May and October.

In south Florida, settlement of pueruli occurs year-round, but seasonal trends are not consistent. Recruitment is commonly greatest in spring, but sometimes occurs in other seasons.

Seasonal Variations

With only four months of sampling completed it is too early to draw firm conclusions. There has been a decline in CPUE in the Great St. James and Mangrove sites (Figure 6). The Saba location does not show any trends.

Lunar Variations

Recruitment at Saba Island was related to the lunar cycle. During the new moon phase, catches ranged from three to thirteen lobsters per collector (Table 2). No lobsters were caught during the full moon phase. Lunar patterns were less evident at the other sites. However, the yields at Great St. James and the Mangrove Lagoon were both 65% larger during the new moon period.

Sea water temperature

The sea water temperature range was 4.1°C. The warmest temperature recorded was 29.5°C in September 1991 and coolest 25.4°C in January 1992 (Figure 7). This contrasts with the 10°C temperature range experienced by Bermuda (18-28°C) (Farmer *et al.*, 1989).

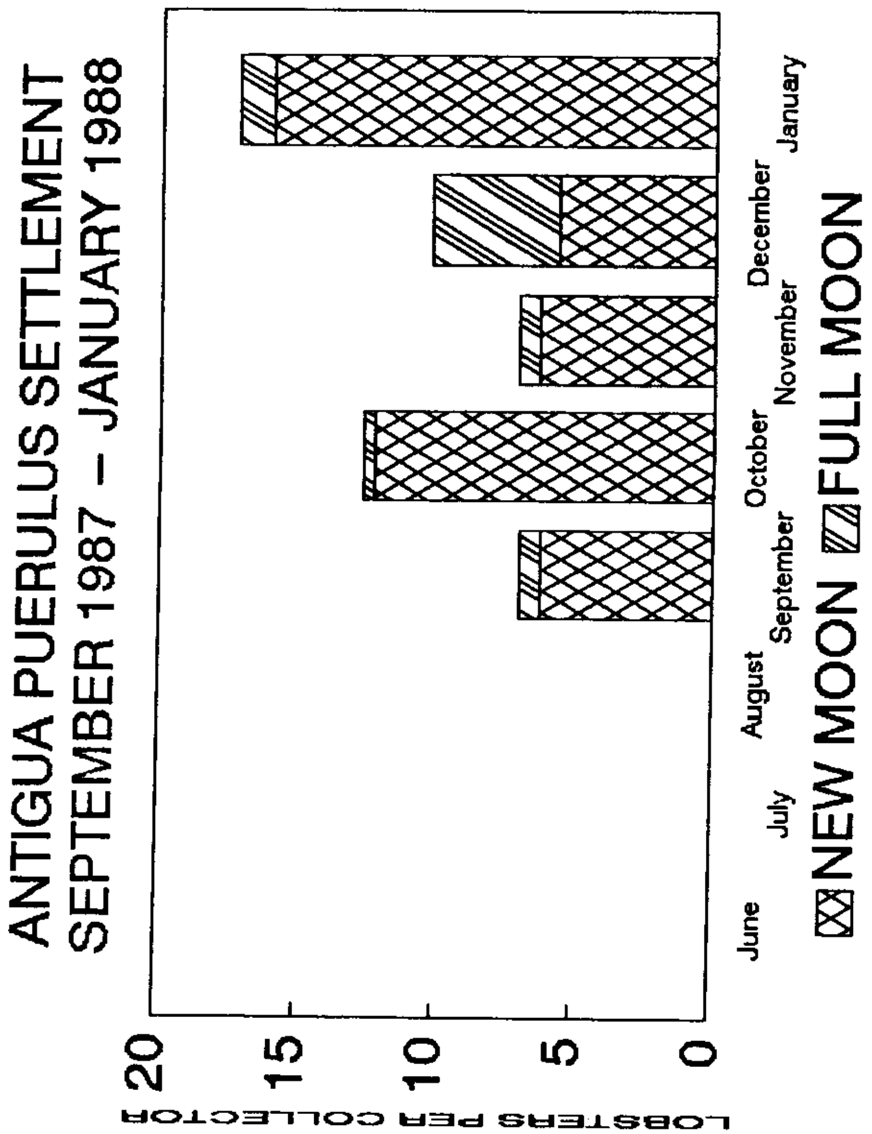

Figure 5a. Catch per unit effort of puerulus settlement in Antigua by month from September 1987 to January 1988.

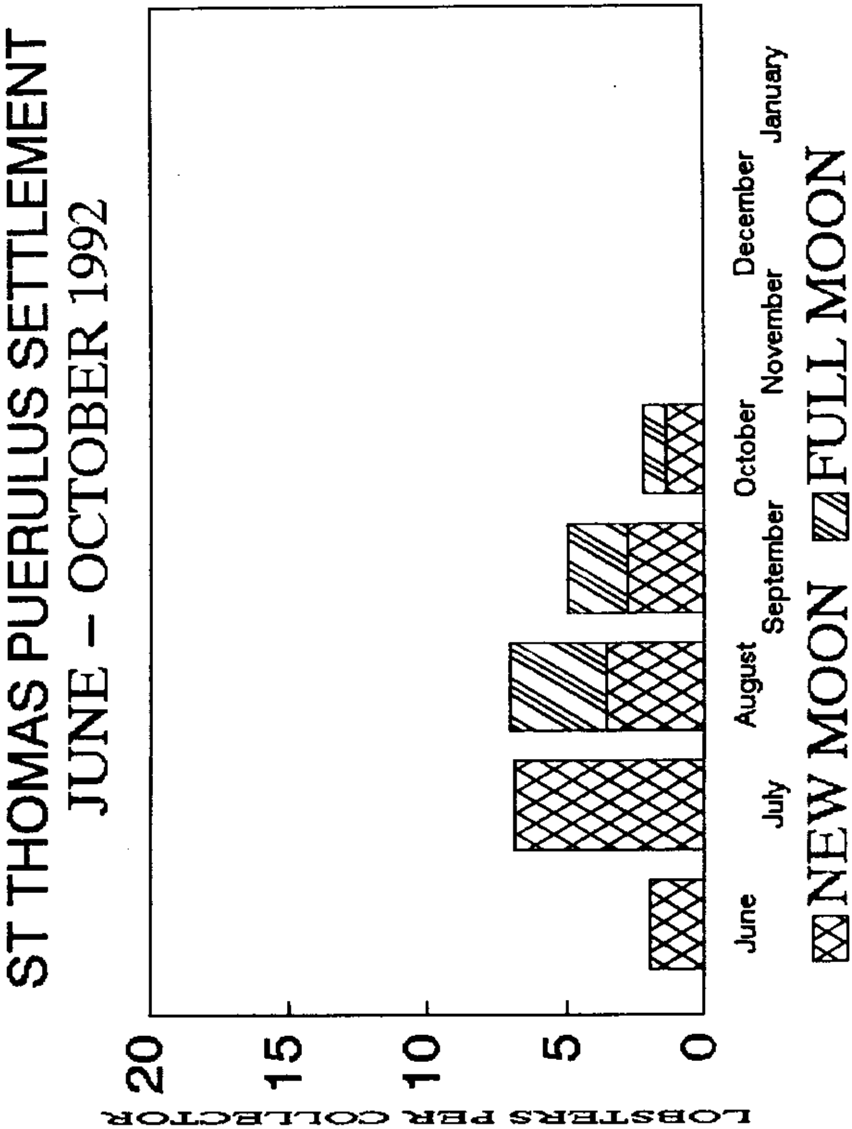

Figure 5b. Catch per unit effort of puerulus settlement in St. Thomas by month from June to October 1992.

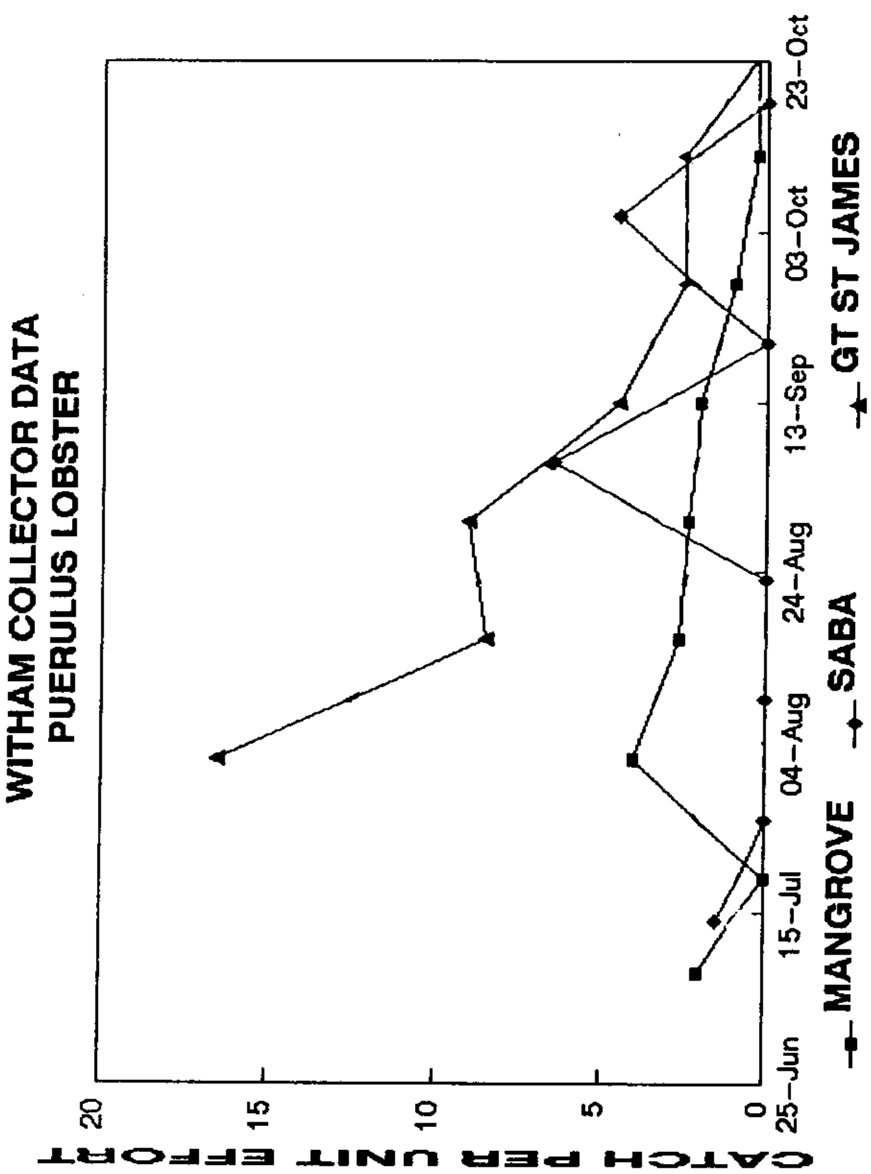

Figure 6. Temporal variation from June to October 1992 in puerulus settlement at three locations in St. Thomas.

Table 2. Lunar cycle variation on catch per unit effort.

LOCATION	TOTAL # PUERULI FULL MOON	TOTAL # PUERULI NEW MOON	1 TRIP MAX. FULL MOON	1 TRIP MAX. NEW MOON
GT ST JAMES	31	56	17	33
SABA	0	25	0	13
MANGROVE	15	28	8	12

DISCUSSION

The Great St. James site, the site with the most lobster recruitment, is adjacent to Current Cut which experiences water movement up to 0.5 m/sec compared with 0.1-0.2 m/sec at other sites. Currents along with wind-induced surface water movement probably affects settlement. Pueruli were collected during all sampling periods at Great St. James from July through September. No pueruli were found when wind speed dropped to less than five knots for over two weeks. Settlement for all the collectors was the lowest during this period of calm weather.

In Antigua (Anon. ms) the highest settlement rate was on the five collectors in locations which receive direct exposure to the southeast trade winds and eastwardly flowing equatorial current. However, not all sites on that side were highly productive. It is unclear what effect currents, eddies or other types of micro-environment have in concentrating pueruli.

In southern Florida, collectors deployed in channels had less settlement than collectors in slower moving water juxtaposed to channels (Little, 1977; Little and Milano, 1980). In Bermuda, the greatest settlement occurred on collectors adjacent to major channels which pass a large volume of water. We agree with Ward's (1989) observation that some water movement will increase settlement, but there may be a flow rate, which when exceeded, results in reduced settlement.

The extremely low CPUE in the mangrove site contrasts with the observation by Little (1977) in Florida that post larvae were more abundant in collectors placed in mangroves than in collectors placed in deeper channels. Little (1977) interpreted this to suggest the importance of the near shore environment as juvenile nursery areas. The Mangrove Lagoon on St. Thomas is not a pristine habitat. Over one half million gallons per day of minimally treated effluent from four sewage treatment plants is discharged directly into the mangrove lagoon or into Turpentine Run which empties into the lagoon. The effluent is discharged down current from the collectors throughout most of the year. However, when the trade winds die and the wave induced flushing ceases, especially for extended periods as occurs commonly in September and October,

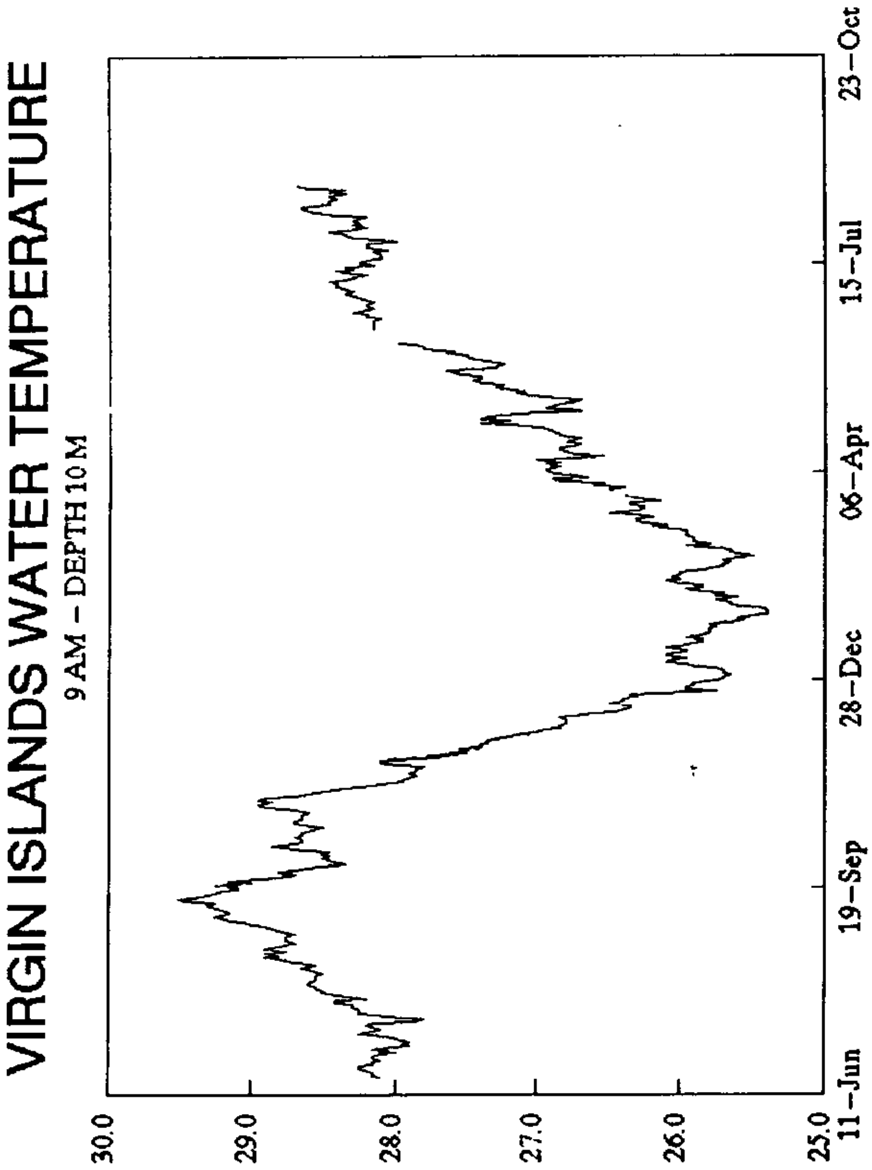

Figure 7. Sea water temperature at 9:00 am in the Virgin Islands from June 1991 to August 1992.

the lagoon water becomes green and visibility drops to less than 0.3 m. Perhaps the low puerulus settlement in the mangroves is a function of less than optimal conditions caused by residual effects of the incursions of polluted water.

In Bermuda (Ward, 1989), most settlement of pueruli occurred in late summer and there was virtually no mid-winter recruitment. Ward (1989) suggested that the cooler oceanic waters around Bermuda (32°N) in winter may act to inhibit the metamorphosis of the phyllosoma to the puerulus stage. St. Thomas experiences a smaller temperature range than Bermuda. In St. Thomas, water temperatures that never fall below 24°C and winter water temperatures are over 7°C warmer than Bermuda. Since most of the Bermudian recruitment occurs when water temperature exceeds 24°C, we anticipate year round settlement in St. Thomas.

Studies of year-to-year fluctuation in the magnitude of *Panulirus* puerulus recruitment has been done in Florida (Little, 1977), Bermuda (Ward, 1989) and with another species of *Panulirus* in Hawaii (MacDonald, 1986). The settlement variability implicates puerulus recruitment levels as a possible factor regulating harvestable stock abundance.

Year round spawning of *Panulirus argus* was recorded for the neighboring island of Puerto Rico (Mattox, 1953), Jamaica (Munro, 1974) and in Bahamas (Kanciruk and Herrnkind, 1976). Anticipated year round puerulus recruitment in the Virgin Islands, characterized by geographic variability, has potential implications for establishing a relationship between puerulus abundance and subsequent fishery yield. Accurate puerulus abundance estimates will require year-round sampling by collectors at several locations. After quantification of puerulus recruitment, relative contributions of many settlement classes to later harvest will have to be estimated.

Estimates will be complicated greatly because settlement classes within a given year will enter the harvestable stock during more than one fishing year. Available growth data is not sufficiently precise to identify cohort growth accurately. Estimates of postsettlement periods required to attain harvestable size (88 mm carapace length (CL) in Florida range from 20 to 40 months and depend on several factors (Lyons *et al;* 1981; Marx and Herrnkind, 1986). Growth rates vary among lobsters within a single recruitment cohort (Witham *et al.*, 1968). A change in water temperature from 27°C to 30°C increases growth by 19% (Lellis and Russell, 1990). There is also significant variation in growth rates between different bays in the same geographical region (Davis and Dodrill, 1980), between different seasons (Marx, 1986), and between areas affected by physical disturbance to benthic substrates (Little and Milano, 1980). Efforts to relate puerulus abundance estimates to later fishery harvests require that postsettlement dynamics of seasonal settlement classes be determined.

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LITERATURE CITED

Andree, S.W. 1981. Locomotory activity patterns and food items of benthic pueruli spiny lobster, *Panulirus argus*. M.S. thesis, Florida State University, Tallahassee, Florida. pp.1-50.

Anon., ms. Report to Antigua / Barbuda Government on spiny lobster. pp.1-40.

Butler, M.J. IV and W.F. Herrnkind. 1991. Effect of benthic microhabitat cues on the metamorphosis of pueruli of the spiny lobster *Panulirus argus*. *Journal of Crustacean Biology*. **11(1)**:23-28.

Calinski, M.D. and Lyons, W.G. 1983. Swimming behavior of the puerulus of the spiny lobster *Panulirus argus* (Latreille, 1804) (Crustacea: Palinuridae) *Journal of Crustacean Biology*. **3(3)**:239-335.

Cushing, D.H. 1973. Recruitment and parent stock in fishes. Univ. Washington *Sea Grant Publ.* WSG **73-1**. pp.1-197.

Davis, G.E. and J.W. Dodrill. 1980. Marine parks and sanctuaries for spiny lobster fishery management. *Proc. Gulf Carib. Fish. Inst.* **32**:194-207.

Davis, G.E. 1985. Artificial structures to mitigate construction on spiny lobster, *Panulirus argus*. *Bull. Mar. Sci.* **37**:151-156.

Farmer, M.W., J.A. Ward and B.E. Luckhurst. 1989. Development of spiny lobster (*Panulirus argus*) phyllosoma larvae in the plankton near Bermuda. *Proc. Gulf Carib. Fish. Inst.* **39**:289-301.

Herrnkind, W.F. and M.J. Butler, IV. 1986. Factors regulating pueruli settlement and juvenile microhabitat pueruli settlement and juvenile microhabitat use by spiny lobsters, *Panulirus argus*. *Mar. Ecol. Prog. Ser.* **34**:23-30.

Herrnkind, W.F., M.J. Butler, and R.A. Tankersley. 1988. The effects of siltation on recruitment of spiny lobsters, *Panulirus argus*. *Fisheries Bulletin*, United States. **86**:331-338.

Hunt, J., S.P. Bannerot, J. Ward and T.R. Matthews. 1990. Comparison of *Panulirus argus* puerulus influx between three western Atlantic locations: Antigua, Bermuda and Florida, USA. Programme/Abstracts International Workshop on Lobster Ecology and Fisheries, p.25.

Ingle, R.M., B. Eldred, H.W. Sims and E.A. Eldred. 1963. On the possible Caribbean origin of Florida's spiny lobster populations. *Tech. Ser. Fla. Board Conserv.* **40**:1-12.

Island Resource Foundation. 1977. Marine Environment of the Virgin Islands. *Island Resource Foundation Tech. Supplement*, **1**:1-122.

Kanciruk, P. and W.F. Herrnkind. 1976. Autumnal reproduction in the spiny lobster, *Panulirus argus*, at Bimini, Bahamas. *Bull. Mar. Sci.* **26**:417-432.

Kanciruk, P. 1980. Ecology of juvenile and adult Palinuridae (spiny lobsters). In: J.S. Cobb and B.F. Phillips, eds., *The biology and management of lobsters*, Vol. **2**, pp. 59-92. Academic Press, New York, New York.

Lellis, W.A. and J.A. Russell. 1990. Effect of temperature on survival, growth and feed intake of postlarval spiny lobsters, *Panulirus argus*. *Aquaculture* **90**:1-9.

Little, E.J. Jr. 1977. Observations on recruitment of postlarval spiny lobsters, *Panulirus argus*, to the South Florida coast. *Florida Marine Research Publications*. **29**:1-35.

Little, E.J. Jr. and G.R. Milano. 1980. Techniques to monitor recruitment of postlarval spiny lobsters, *Panulirus argus*, to the Florida Keys. *Fla. Mar. Res. Publ.* **37**:1-16.

Lyons, W.G. 1980. The postlarval stage of scyllaridean lobsters. *Fisheries* **5** **(4)**:47-49.

Lyons, W.G., D.G. Barber, S.M. Foster, F.S. Kennedy, Jr. and G.R. Milano. 1981. The spiny lobster, *Panulirus argus*, in the middle and upper Florida Keys: population, structure, seasonal dynamics, and reproduction. *Fla. Mar. Res. Publ.* **38**:1-38.

MacDonald, C.D. 1986. Recruitment of the puerulus of the spiny lobster, *Panulirus marginatus*, in Hawaii. *Can. J. Fish. Aquat. Sci.* **43**:2118-2125.

Marx, J.M. 1986. Settlement of spiny lobster, *Panulirus argus*, pueruli in south Florida: an evaluation from two perspectives. *Can. J. Fish. Aquat. Sci.* **43**:2221-2227.

Marx, J.M. and W.F. Herrnkind. 1985. Macroalgae (Rhodophyta: *Laurencia* spp.) as habitat for young juvenile spiny lobsters, *Panulirus argus*. *Bull. Mar. Sci.* **36(4)**:423-431.

Mattox, N.T. 1953. A preliminary report on the biology and economics of the spiny lobster in Puerto Rico. *Proc. Gulf Carib. Fish. Inst.* **4**:69-70.

Munro, J.L 1974. The biology, ecology, exploitation and management of Caribbean reef fishes. Scientific report on the ODA/UWI Fisheries Ecology Research Project, 1969-1973. Part V.1. The biology, ecology and bionomics of Caribbean reef fishes: VI. Crustaceans (spiny lobsters and crabs). University of West Indies Zoology Department Research Reports. No.3, Kingston, Jamaica. pp.57.

Nichols, M. & E. Towle 1977. Water, sediments and ecology of the Mangrove Lagoon and Benner Bay, St. Thomas. *Island Resource Foundation. Tech. Report*. **1**:1-159.

Olsen, D. 1975. Analysis of catch data for the Virgin Islands commercial fisheries. Virgin Islands Department of Conservation and Cultural Affairs, Bureau of Fish and Wildlife. Annual Report for Project No.2-239R-1.

Peacock, N.A. 1974. A study of the spiny lobster fishery of Antigua and Barbuda. *Proc. Gulf Carib. Fish. Inst.* **26**:117-130.

Phillips, B.F. and P.S. McWilliam. 1986. The pelagic phase of spiny lobster development. *Can. J. Fish. Aquat. Sci.* **43**:2153-2163.

Sweat, D.E. 1968. Growth and tagging studies on *Panulirus argus* (Latreille) in the Florida Keys. *Florida Board of Conservation Marine Research Laboratory Technical Series*. **57**:1-30.

Swingle, W.E., Dammann, A.E. and J.A. Yntema. 1969. Survey of the commercial fishery of the Virgin Islands of the United States. *Proc. Gulf Carib. Fish. Inst.* **26**:110-121.

Ward, J. 1989. Patterns of settlement of spiny lobster (*Panulirus argus*) post larvae at Bermuda. *Proc. Gulf Carib. Fish. Inst.* **39**:255-264.

Witham, R. R.M. Ingle, and E.A. Joyce Jr. 1968. Physiological and ecological studies of *Panulirus argus* from the St. Lucie estuary. *Fla. Board Cons. Mar. Res. Lab. Tech. Ser.* **53**:1-31.