

## Recent settlement trends in *Panulirus argus* (Decapoda: Palinuridae) pueruli around St. Thomas, U.S. Virgin Islands

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**Abstract:** Puerulus settlement of the western Atlantic spiny lobster, *Panulirus argus*, was monitored using modified Witham collectors from December 1996 to March 1998 at seven sites around St. Thomas, U.S. Virgin Islands. A total of 605 pueruli were collected from 553 samples for a catch per unit effort (CPUE) for all sites of 1.09 pueruli. The greatest settlement occurred on sites within a recently declared marine reserve, which had an overall CPUE of 1.77 pueruli. Settlement in non-reserve sites was much lower with an overall CPUE of 0.31 pueruli. Pueruli recruitment declined 67% at inshore sites and 53% at offshore sites between July 1992 - April 1994 and February 1997 - March 1998. Also, only 10% of months sampled in 1997-98 had a CPUE > 0.5 compared to 55% in a previous study in 1992 - 1993. Despite the decline in pueruli CPUE in 1997-98 compared to 1992-94, the commercial lobster catch in the 2000-01 fishing season, and by inference the adult lobster population (legal lobster size in the US Virgin Islands is  $\geq$  3.5 cm carapace length), remained stable.

**Key words:** Marine protected areas, lobster, recruitment, catch effort, fisheries, Caribbean.

The western Atlantic spiny lobster, *Panulirus argus* (Latreille 1804), is fished commercially in the US Virgin Islands (USVI) by traps, free diving, and scuba diving and recreationally by free diving and scuba diving. Spiny lobster landings in the USVI increased from an average of 19 tons between 1980-88 (NOAA 1992) to approximately 39-41 tons between 1996-2001 (Tobias *et al.* 2000, this paper). Today, the spiny lobster is an important component of the USVI commercial fishery comprising 9% of the total commercial catch. Selling at an average retail price of \$7 pound<sup>-1</sup> (\$15.4 kg<sup>-1</sup>), it comprises 16% of the total income derived from the commercial catch (Tobias *et al.* 2000). In St. Thomas/St. John District, the focus of this study, there were 38 licensed

commercial fishermen who landed lobster in 1999-2000 (33 trap fishermen, 5 divers).

Acknowledging the importance of this industry and the potential for overfishing, regulations were adopted by both the Caribbean Fishery Management Council and USVI Government in 1985. These regulations restrict harvest to lobsters with a minimum carapace length of 3.5 inches (89 mm), prohibit harvest of females with eggs, require landing lobsters whole, and prohibit the use of poisons, drugs, spears, hooks or gigs when harvesting lobster.

Despite the adoption of these regulations, two recent studies indicate that the USVI spiny lobster fishery is showing signs of overfishing (Bolden 2001, Mateo and Tobias 2001). The over fished status of these stocks is

based on data indicating a decline in the length class containing the majority of spiny lobsters, a significant negative trend in the mean annual carapace length, a decline in sex ratios, and a decrease in trap catch per unit effort (Bolden 2001). Finally, a stock assessment study of spiny lobster on St. Croix, based on yield per recruit analysis and surplus production models, found that the St. Croix spiny lobster is currently harvested beyond their optimum exploitation levels (Mateo and Tobias 2001).

An understanding of population dynamics of a species is essential for determining the "predictability" of recruitment to a fishery based on larval abundance. Changes in the levels of recruitment to fishery stocks often result from changes in the survival of young (Cushing 1973). Puerulus settlement data have been used to predict forward commercial catches. Since 1981, Western Australia has used puerulus settlement to provide a 3-4 year forward estimate of catch of the rock lobster, *Panulirus cygnus* (Brown and Phillips 1994). Witham collectors have given a good relative measure of the number of pueruli in an area (Witham *et al.* 1968) and have been used to make general comparisons of abundance of pueruli among sites (Quinn and Kojis 1997) and regions (Little and Milano 1980).

Knowledge of trends in pueruli abundances can assist in the management of marine protected areas and possibly help to regulate catch limits.

We used modified Witham collectors to examine the spatial and temporal variation of lobster pueruli settlement within Caribbean coastal waters adjacent to the east end of St. Thomas. Specifically this study examines: 1) the distribution and abundance of pueruli within and outside St. Thomas marine reserves, 2) changes in pueruli abundance between 1992-94 and 1997-98, and 3) the relationship between pueruli settlement rates and commercial lobster catches in St. Thomas/St. John District.

## MATERIALS AND METHODS

Sampling was done using modified Witham collectors identical to those used in Quinn and

Kojis (1997) and Quinn *et al.* (1998) on seven sites on the east and south sides of St. Thomas. Four sites, Christmas Cove, Great St. James Island, (CC) (18°18.75'N; 64°50'W); Cas Cay (CCa) (18°18.5' N; 64°51'W); Nazareth Bay (NB) (18°19.1' N; 64°51.3'W); and Mangrove Lagoon (ML) (18°18.4'N; 64°52.5'W), were within the Mangrove Lagoon /Cas Cay and St. James Marine Reserves. Three sites, Buck Island (BI) (18°16.5'N; 64°53.8'W), Lovango Cay (LC) (18°21.9'N; 64°47.9'W) and Shark Island (SI) (18°20.25'N; 64°50.7'W), were outside the marine reserves adjacent to small islands. Three replicate collectors were set approximately 15 m apart at each site except SI where only two were installed. Collectors were set at a depth of 3 m in water approximately 8 m deep except for the CCa and ML site where collectors were set 1 m below the surface in water approximately 2 m deep. Collectors were installed between December 1996 and January 1997. ML and CCa collectors were located in a mangrove estuary. The remaining collectors were set over sand substrate approximately 100 m from rocky shorelines inhabited by coral communities.

Of the sites sampled in 1997-98, ML, was identical to the site sampled by Quinn and Kojis (1997) in 1992-94; CC was within the same bay in both 1992-94 and 1997-98; and BI, an offshore island south of St. Thomas, was similar to Saba Island, a site also sampled by Quinn and Kojis (1997). The data from these three sites were used to compare variation in pueruli settlement rates 1992-94 and 1997-98.

From December 1996 - January 1997 through May 1997, collectors were sampled approximately weekly at all sites except CCa. Weekly sampling commenced at CCa in May 1997. From June 1997 to March 1998, collectors were sampled every two weeks approximately five days after the new and full moon phases in a procedure identical to Quinn and Kojis (1997). All pueruli were removed from the collector, staged (Lewis *et al.* 1952, Quinn and Kojis 1997), counted, and released. Catch per unit effort (CPUE) was determined by dividing the total number of pueruli caught per collector at each site by the number of collectors sampled at the site on each sampling date.

TABLE 1

*St. Thomas, USVI: Number of Panulirus argus pueruli of different stages settling at each site (Dec. 1996 to Mar. 1998)*

Site	N	Juvenile	Clear	Semi-pigmented	Pigmented	Total
Buck Island	55	0	0	1	6	7
Cas Cay	54	9	10	21	121	161
Christmas Cove	128	0	4	8	13	25
Lovango Cay	70	0	3	2	18	23
Mangrove Lagoon	109	9	5	18	97	129
Nazareth Bay	87	2	48	76	115	241
Shark Island	50	1	2	4	12	19
Total	553	21	72	130	382	605

N = total number of samples (one sample = the number of pueruli on one collector at one sampling date).

TABLE 2

*Comparison of catch per unit effort (CPUE) of Panulirus argus pueruli between sites inside and outside the St. Thomas Cas Cay /Mangrove Lagoon and Great St. James Marine Reserves, Dec. 1996 to Mar. 1998*

Marine Reserve Sites	CPUE	Standard Error	% sampling days pueruli present
Cas Cay	2.98	0.97	79
Christmas Cove	0.23	0.17	59
Mangrove Lagoon	1.20	0.25	77
Nazareth Bay	2.65	0.57	84
Mean	1.77		75
Non-marine Reserve Sites			
Buck Island	0.15	0.07	22
Lovango Cay	0.38	0.14	41
Shark Island	0.39	0.12	37
Mean	0.31		33

The statistic is directly comparable with that used by Quinn and Kojis (1997). Catches from the weekly sampling were pooled yielding samples similar to the fortnightly sampling period.

Commercial fisheries statistics were derived from commercial landings reported by the Division of Fish and Wildlife (Tobias 1997; Tobias *et al.* 2000) and directly from Division of Fish and Wildlife databases. The commercial lobster catch was standardized by calculating the percentage of fisherman reporting compared with the total number of licensed commercial fishermen in the St. Thomas /St. John District and adjusting the reported catch (Tobias *et al.* 2000).

## RESULTS

A total of 605 pueruli were collected from 553 samples (Table 1) for a mean CPUE (MCPUE) for all sites of 1.09 pueruli. Settlement of at least one individual was observed in 55% of the samples. A maximum of 21 pueruli settled on a single collector at a single sampling time. Seventy-two (11.9%) of the pueruli collected were clear, 130 (21.5%) semi-pigmented, and 403 (66.6%) pigmented/juvenile (Table 1).

Three of the four sites within the marine reserve had the highest levels of settlement. There was a significant difference between the MCPUE for reserve and non-reserve sites

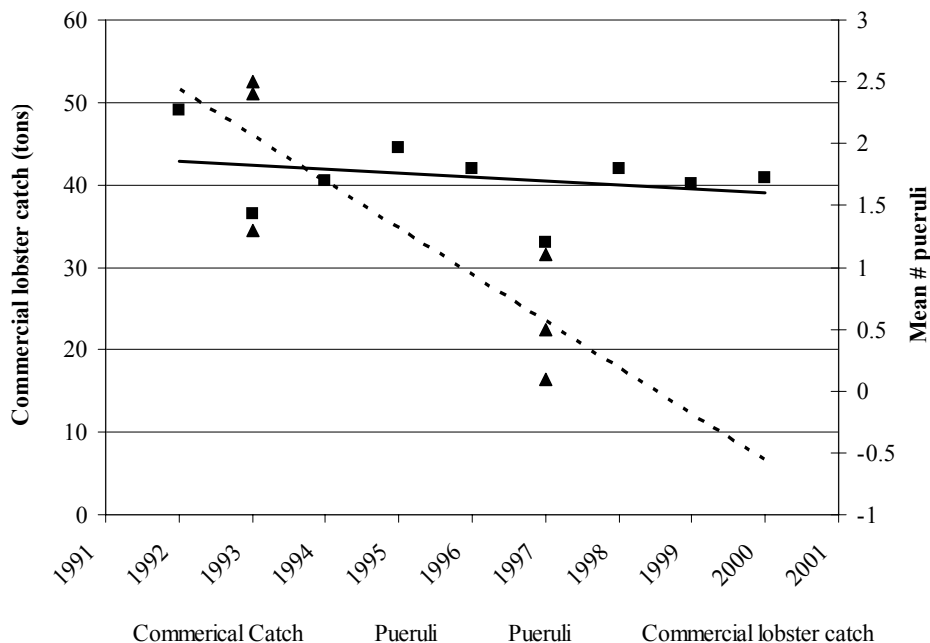


Fig. 1. Comparison between commercial fisher's landings of *Panulirus argus* (Tobias, 1997; Tobias *et al.* 2000) and pueruli settlement in St. Thomas, USVI.

(One Way ANOVA,  $N = 9$ ;  $p = 0.03$ ). Pueruli were present at each of the four marine reserve sites on 59% to 84% of sampling days and these sites had an overall CPUE of 1.77 pueruli (Table 2). Settlement was highest at Cas Cay (CCa) and Nazareth Bay (NB) (Table 2). The CCa site borders the Mangrove Lagoon while the NB site is east of the Lagoon. The Mangrove Lagoon (ML) site, located in a channel in the inner lagoon, had the third highest CPUE. However, it was less than half of CCa and the NB sites. The other four sites were at offshore cays and their CPUE ranged from 0.15 to 0.39 pueruli (MCPUE of 0.29 pueruli) or less than 15% of the CCa and NB sites (MCPUE of 2.8) (Table 2).

The total commercial landings for St. Thomas/St. John District from the 1992-93 fishing year to 1997-98 (the fishing year extends from July 1 to June 30) varied between 35 to 50 tons. There is no statistically significant trend for commercial lobster catches ( $N = 7$ ,  $r = 0.39$ , n.s.). The correlation coefficient for pueruli settlement CPUE by years is significant ( $N = 6$ ,  $r = 0.83$ ,  $p = 0.04$ ) (see Fig. 1).

## DISCUSSION

This study showed a statistically significant decline in pueruli settlement rates between 1992-94 (Quinn and Kojis 1997) and 1997-98 (this study), while the commercial lobster landings remained nearly static (Fig. 1). If pueruli settlement is a predictor of future landings and spiny lobster take approximately three years to achieve legal size (89 mm carapace length) (Moe 1991), then the low pueruli settlement rate observed in 1997-98 should result in a decline in commercial lobster catches in the 2000-01 fishing year. In contrast, the commercial lobster catch in 2000-01 was 40.9 tons, similar to previous years. The decline in pueruli CPUE does not appear to be effective in forecasting the commercial lobster catch for the 2000-01 fishing season, and by inference estimating the reproductive lobster population. However, because no size measurements were taken to provide the age distribution of the commercial catch, the value of sampling *P. argus* pueruli to predict the commercial lobster catch in the Virgin Islands still

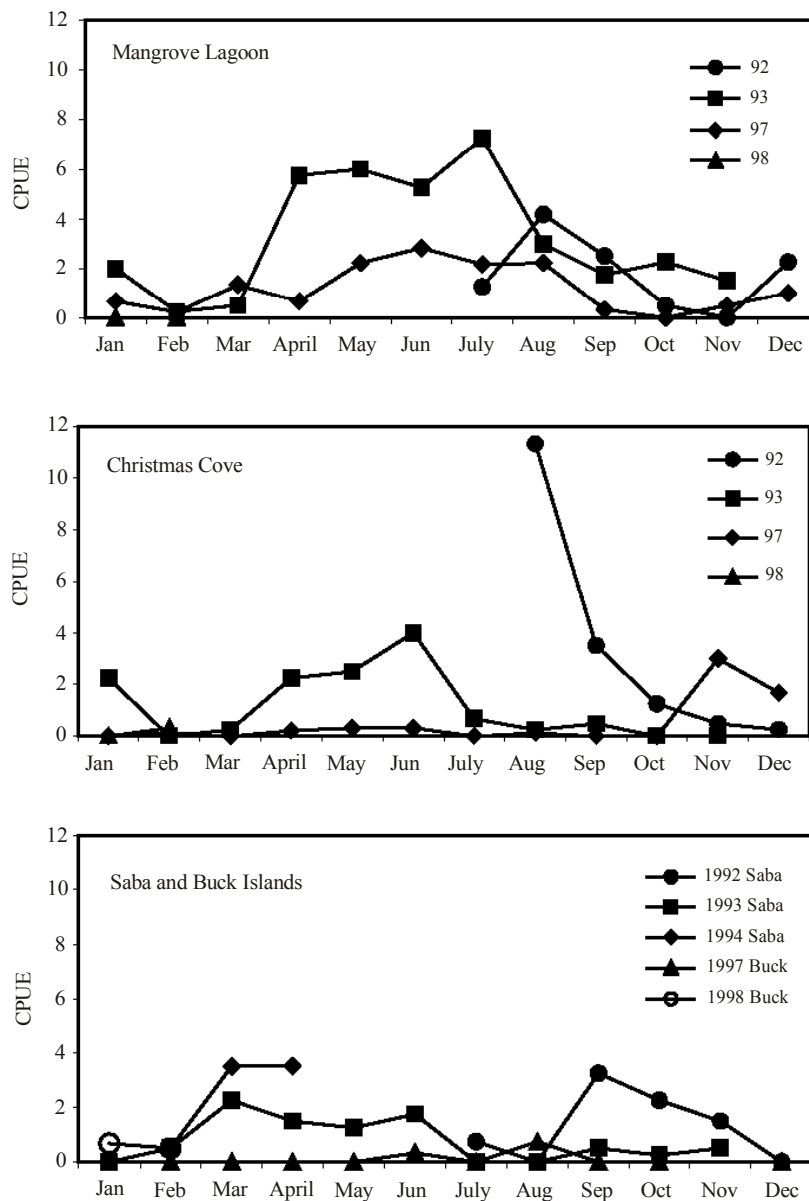


Fig. 2. Comparison of *Panulirus argus* pueruli settlement between the Mangrove Lagoon and Christmas Cove and between Saba Island and Buck Island near St. Thomas, USVI. Data 1992-1994 (Quinn and Kojis 1997), 1997-1998 data from this study.

needs further testing. The commercial catch in 2000-01 may have consisted primarily of lobsters older than three years.

In order to determine if pueruli abundance is a good predictor of adult Atlantic spiny lobster populations, pueruli should be sampled continuously for three to five years and com-

mercial lobster catches should be sampled annually for the size/age distribution of the catch.

Compared with 1992-94 (Quinn and Kojis 1997), pueruli settlement during 1997-98 was generally much less for all months at the comparable sites (Fig. 2). In 1997-98, the overall CPUE in the Mangrove Lagoon, Buck and

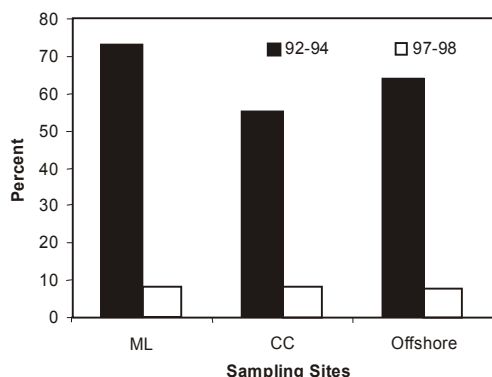


Fig. 3. St. Thomas, USVI: Percentage of months that the *Panulirus argus* pueruli settlement was > 0.5 CPUE. 1992-1994 data from (Quinn and Kojis 1997), 1997-1998 (this study). CC = Christmas Cove, ML = Mangrove Lagoon. Offshore = Saba Island (Quinn and Kojis 1997) and Buck Island (this study).

Saba Islands, and Christmas Cove was 1.2, 0.1 and 0.5 pueruli compared with 2.5, 1.3 and 2.4 pueruli in 1992-94, respectively. In 1997-98, less than 10% of the months sampled at the three comparable sites had a pueruli settlement rate > 0.5 MCPUE compared with an average of more than 55% of the months during 1992-94 (Fig. 3) (Quinn and Kojis 1997, Quinn *et al.* 1998).

Previous work in St. Thomas (Quinn and Kojis 1997, Quinn *et al.* 1998) showed that the areas now designated as marine reserves had a higher pueruli settlement rate than other sites. This study reports similar results. Four of the sites in this study are within the Cas Cay/Mangrove Lagoon and St. James Marine Reserves and Wildlife Sanctuaries, and three of these sites had the highest MCPUE for pueruli. Knowledge of the ecological characteristics associated with areas of high settlement is necessary to develop management strategies for identifying and preserving habitat of particular concern for spiny lobster pueruli. Additional studies describing the sites in detail and identifying factors that make them preferred settlement sites are required once areas of high settlement are identified.

A high CPUE at the Nazareth Bay and Cas Cay sites may have been, in part, the result of concentrations of pueruli caused by the large island mass and partially enclosed bay. Tidal

and easterly trade wind driven currents drive water into the Mangrove Lagoon and Nazareth Bay. When easterly trade winds blow greater than  $7 \text{ m sec}^{-1}$  (14 knots), wind driven surface currents at the entrance to Cas Cay and the Mangrove Lagoon reach  $0.1 \text{ m sec}^{-1}$  (Nichols and Towle 1977). This funneling of water into the bays could result in a higher volume of water passing around the collectors in this area increasing the numbers of pueruli available for settlement. However, since the protected Mangrove Lagoon site also had a high CPUE, we suggest that one of the primary reasons for the high settlement rates at these sites is that they lie within or adjacent to preferred pueruli settlement habitat.

Legislation designating the Mangrove Lagoon and Great St. James Marine Reserves was approved in September 1994. The reserves are closed to the take of all invertebrates and plants and only allow fishing by permit with cast net within ~15 m of shore and with hook and line. No take of any kind is permitted in the inner Mangrove Lagoon.

The relatively high CPUE in the three sites nearest the mangroves is consistent with the hypothesis that mangrove environments are important juvenile nursery areas in the life history of lobsters (Little 1977). Establishment of marine reserves protecting these habitats is an important step toward maintaining and enhancing lobster stocks. However, the Mangrove Lagoon/Cas Cay Marine reserve is subjected to non-point source pollution, *e.g.* sediment and toxins from upland sources, as well as point source pollution, *e.g.* sewage. These pollutants are currently seriously affecting the water quality within the Cas Cay/Mangrove Lagoon Marine Reserve (Nichols and Towle, 1977, Wernicke and Towle, 1983, Anonymous 1984) A new sewage treatment plant scheduled for completion in 2002 is expected to eliminate point source sewage discharges into the Mangrove Lagoon. This plant will also treat leachate from the landfill that currently seeps into the Lagoon. Further study is necessary to determine whether an anticipated improvement in water quality results in an increase in settlement of pueruli and survival of juvenile spiny lobster within the marine reserve.

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## RESUMEN

El asentamiento de puerulos de la langosta espinosa del Caribe, *Panulirus argus* fue monitoreado usando colectores modificados tipo Witham, entre diciembre de 1996 y marzo de 1998 en siete sitios alrededor de St. Thomas, Islas Vírgenes. En general, para todos los sitios estudiados se colectaron un total de 605 puerulos en 553 muestras, que representan un esfuerzo por unidad de captura (EPUC) de 1.09 puerulos. El mayor asentamiento registrado ocurrió en sitios declarados recientemente Reservas Marinas, para los cuales se alcanzó un EPUC de 1.77 puerulos. El asentamiento en sitios no protegidos fue más bajo (EPUC = 0.31 puerulos). El reclutamiento de puerulos descendió 53% en lugares hacia mar afuera entre febrero de 1997 y marzo de 1998. Solamente en el 10% de los meses muestreados (entre 1997 y 1998) se alcanzó un EPUC > 0.5, comparado al alcanzado en un 55% de los meses de monitoreo en un estudio previo entre 1992 y 1993. A pesar del decline del EPUC entre estos dos periodos comparados, la captura comercial de langostas durante la temporada de pesca 2000-2001, y por inferencia la población adulta de este crustáceo (la talla mínima legal de captura de langosta en las Islas Vírgenes es de  $\geq 3.5$  cm longitud del caparazón), permanece estable.

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