Preliminary Observations on Habitat Use of Juvenile Caribbean Spiny Lobster (*Panulirus argus*) in South Caicos, Turks & Caicos Islands

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ABSTRACT

Habitat requirements of adult Caribbean Spiny Lobsters (*Panulirus argus*) have been described in many studies, but post-settlement and juvenile habitat requirements are still poorly understood. The purpose of the present study was to determine and describe habitats inhabited by juvenile lobster around South Caicos, TCI. Potential lobster habitats were described by estimating benthic coverage using 1 m^2 quadrats. Other potential lobster habitats were detected using spectral quality of satellite images. Visual surveys were carried out to estimate densities of juvenile lobster.

Juvenile lobsters were found in habitats with a relatively high abundance of the Rhodophyte, *Neogoniolithon* spp. and not in *Laurencia* spp. dominated habitats as observed in previous studies. Two areas were found to be important habitat for juvenile lobster: Gingerbread and East Bay. Gingerbread was found to be an extensive area with *Neogoniolithon* coverage of up to 50%. East Bay had densely covered areas with up to 80% of *Thalassia testudinum* and 10 to 20% of *Neogoniolithon* spp. Areas with a combined coverage of these two species contained high numbers of lobsters. Gingerbread was found to have a density of 138 lobster/ha, whereas East Bay was found to have a density of 1,199 lobster/ha. Lobster caught at East Bay were significantly smaller than lobster caught at Gingerbread.

KEY WORDS: *Neogoniolithon*, Rhodophyta, spiny lobster, West Indies

Valoracion del Habitat de la Langosta (*Panulirus argus*) Erizo Joven en South Caicos

Los diferentes habitats del la Langosta Erizo del Caribe (*Panulirus argus*) han sido descritos en numerosos estudios, pero los requisitos de post-asentameinto y de la langosta menor tienen un pobre entendimiento. El proposito de este estudio es determeinar y desctibir habitats habitdos por langostas jovenes al rededor de South Caicos. Habitats potenciales como lechos de hierba y algas fueron descritos en detalle. El porcentage de cobertura fue estimado usando 1m cuadrado cada 5 m a lo largo transectos de 30 m de largada. Otros habitats potenciales fueron detectados usando fotografias de satellite. Busquedas oculars fueron llevadas a cabo para

detectar y enumerar las langostas jovenes. Las langostas fueron capturadas con redes de mano para medirlas, pesarlas y sexarlas.

Las langostas jovenes mostraron preferencia por habitats con una relativa abundancia de alga roja especialmente *Neogoniolithon* spp. Se descubrieron dos areas principales donde se hallaron una relativamente densa poblacion de langostas: East Bay y Gingerbread. En East Bay se hallaron pequenyos parches de densidad de *Neogoniolithon* spp. rodeados por una densa zona de *Thalassia testudium*. Gingerbread consistia en uns extensa zona de menor densiada de *Neogoniolithon* spp. En East Bay se hallo la mayor densidad con 1200 langostas por hectarea, en contraste con la densidad de 138 langostas por hectarea de Gingerbread. El tamanyo de las langostas capturadas era mayor en East Bread era menor que el de las capturadas en Gingerbread.

La altura de la *Neogoniolithon* spp. quiza pueda ser la explicacion a la diferencia de densidad en la poblacion de las diferentes areas. El promedio de altura de la *Neogoniolithon* spp. era 13.4 y 7.3 cm. En East Bay y Gingerbread respectivamente. Las langostas se hallaron generalmente bajo los parches de mayor altura de *Neogoniolithon*, ya que estos proporcon mayor cobijo. La profundidad del agua fue otro factor de consideracion en lo que concierne a la densidad de poblacion de la langosta ya que los depredadores no alcanzan facilmente las zones menos profundas de East Bay.

PALABRAS CLAVE: *Neogoniolithon*, Rhodophyta, langosta erizo

INTRODUCTION

The spiny lobster, *Panulirus argus*, is one of the largest fisheries in the Caribbean and many stocks are seriously threatened by over-fishing and habitat destruction (Medley and Ninnes 1997, Eggleston et al. 1998). Along with queen conch, the spiny lobster is the most valuable marine resource in the Turks & Caicos Islands (TCI). To avoid over-fishing in the TCI, it is important that lobster stocks are sustained through careful management, research and monitoring.

Research and management have been focused on adult spiny lobster for decades. However, recruitment of juveniles is critical to the long-term sustainability of spiny lobster populations. Therefore, information on larval availability, larval settlement, and movement to stage specific habitats can help to understand the recruitment processes of the spiny lobster (Herrnkind and Butler 1986). However, juvenile lobsters are difficult to study, and hence little is known about the early juvenile stages (Herrnkind and Butler 1986, Lyons 1986, Butler et al. 1997).

After a relatively long larval period, lobsters migrate to shore where they settle in complexly structured habitats (Butler et al. 1997). *Laurencia* spp. have been described as favorable settlement substrate (Butler and Herrnkind 1992). Specimen of this genus provide shelter and habitat for gastropods, isopods and amphipods preyed upon by the juvenile lobster (Marx and Herrnkind 1985) as well as forming complex structures within which the lobsters can hide (Butler and Herrnkind 1992).

The preference for *Laurencia*-dominated habitats exists when the carapace length (CL) of the lobster is less than 18 mm. When the CL increases, lobsters search for shelter in crevices and caves (Butler and Herrnkind 1992). Accompanying this change in preferred habitat, lobsters discontinue solitary living and begin to aggregate (Butler et al. 1997, Eggleston et al. 1998).

The goal of this study was to describe juvenile lobster habitat and to examine lobster density and juvenile size ranges at multiple sites surrounding South Caicos.

MATERIALS AND METHODS

Habitat Description

Habitats were surveyed at eleven sites around South Caicos (Figure 1). South Caicos is the most southeastern island of the Caicos Bank, being part of the Turks & Caicos Islands. Sites with abundant *Laurencia* spp. were surveyed from October to December 2000. Additionally, local fishermen were interviewed to locate juvenile lobster habitat. Spectral quality of a satellite image was used to detect other areas of interest. As a result, two additional areas were surveyed: Gingerbread and East Bay (Figure 1). Gingerbread was located north of Middleton Cay and west of Moxie Bush on the Caicos Bank just outside the East Harbour Lobster and Conch Reserve (EHLCR). East Bay was located at the southeastern coast of South Caicos within the Admiral Cockburn Land and Sea National Park (ACLSNP). The habitat surveys of these two areas were carried out in March and April 2001.

Habitat was estimated by describing the percent cover of the benthic species present. A $1m^2$ quadrat was placed every 5 m along a 30 m transect line. The quadrat was divided by twine into 100 squares ($10 cm^2$ each) to ease the estimation. Multiple transects were run at each site. Most benthic organisms were determined to genus level. However, seagrasses were determined to species level, whereas all *Porifera* were grouped. For each analysis, tide, water depth and UTM coordinates were recorded.

Lobster Measurements and Density Estimates

Every surveyed quadrat of the benthic community was thoroughly searched for juvenile lobster. Four 50 m^2 plots were examined to estimate density of lobster at Gingerbread. Teams of divers swept the area in sections counting the total number of lobster. At East Bay, lobster counts were conducted by visually estimating the number of lobster in and around the patches of *Neogoniolithon*. The patches were then measured with a transect tape to calculate lobster density.

Lobsters were caught with small nets, measured, and immediately returned to substrate. Carapace length (CL) was measured with calipers (mm), weight was determined with a hand-held spring scale (5g increments), and each specimen was sexed. Observation of potential lobster predators was recorded.

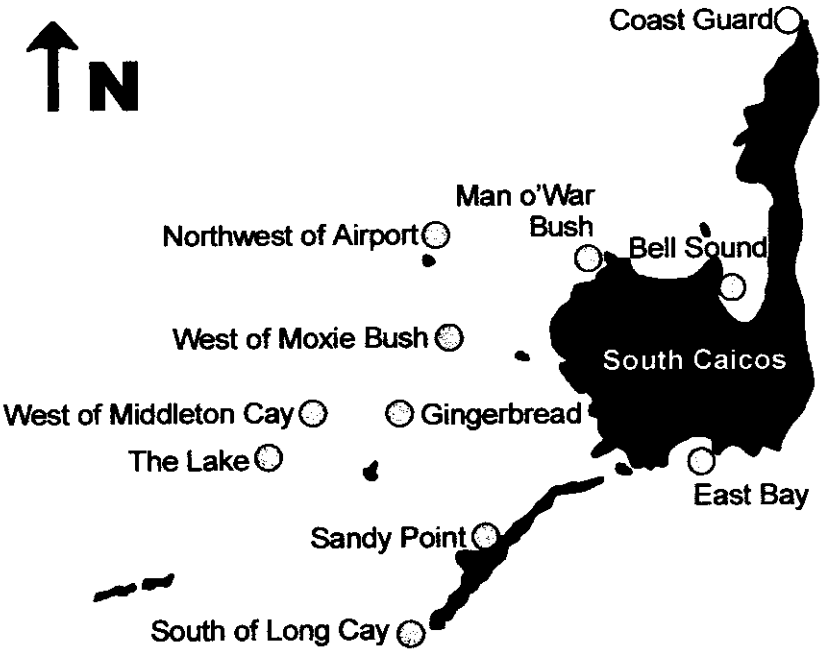

Figure 1. South Caicos and the 11 sites surveyed from October 2000 to April 2001

RESULTS

Benthic Cover

In total, 20 sessile benthic organisms were found at 11 sites (Table 1). Gingerbread and East Bay were the most diverse, however these sites were studied more intensively; the number of observations was 322 and 168, respectively. At other sites the number of observations ranged from 28 to 84 (Table 1).

Total benthic cover ranged from 9 to 53% in the *Laurencia*-dominated habitats (Figure 2). Man o'War Bush and West of Moxie Bush had the highest percentage of *Laurencia* of over 30%. However, no juvenile lobster were observed in these *Laurencia*-dominated habitats. The average water depth of these habitats ranged from 0.1 to 4.2 m. Local fishermen had suggested searching the area South of Long Cay. This area was found to be dominated by another Rhodophyte, *Neogoniolithon* spp., with a mean benthic cover of 18.9% (Figure 2). Again, no juvenile lobster were observed. A similar habitat was found off Sandy Point at Long Cay. *Neogoniolithon* dominated this habitat with a mean benthic cover of 39.6% (Figure

2). One lobster was observed at Sandy Point although *Laurencia* only covered 0.5% of the benthic community (Table 1).

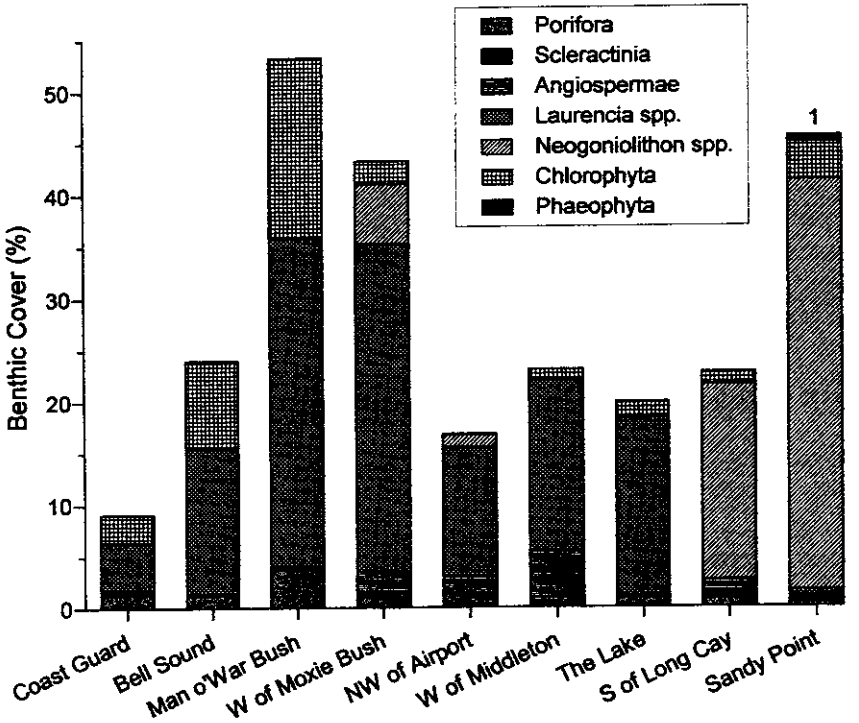

Figure 2. Percent coverage of benthic species for 9 sites surrounding South Caicos surveyed from October to December 2000 and in March 2001. Number of observed lobster is indicated on top of respective bar

As a result of the above patterns, we decided to survey other habitats than those dominated by *Laurencia*. Two areas were found that contained juvenile lobsters: East Bay and Gingerbread (Table 1). These areas were so extensive that an increased number of observations was made to get an accurate description of these habitats.

Gingerbread consisted of an area with dense benthic cover (50 - 70%) and a larger, less dense area with 30 to 40% benthic cover (Figure 3). All surveyed sites at Gingerbread showed a dominance of *Neogoniolithon* (20 - 60%). *Porifera* were present at all sites, mainly represented by the chicken liver sponge (*Chondrilla nucula*) with a benthic coverage up to 12% at some of the sites. Furthermore, low benthic coverage of seagrasses and Chlorophyta were found at all sites (Table 1).

Table 1. Average percent benthic coverage per Phylum (Porifera), genus or species for 11 studied sites off South Caicos. Percentage of sand, coral rubble and number of quadrats (n) are additionally shown.

Study area	Coast Guard	Bell Sound	Man o'War Bush	Northwest of Airport	West of Moxie Bush	West of Middleton	The Lake	South of Long Cay	Sandy Point	Gingerbread	East Bay
n	63	56	35	84	28	42	77	42	28	322	168
Chlorophyta					2.14						0.24
Acetabularia spp.		0.10								0.00	0.00
Batophora spp.	1.83	0.52		1.07	0.02	0.20	0.47		1.13	1.20	0.08
Caulerpa spp.	0.10	7.07	17.4	0.04	0.05				0.06	0.00	0.05
Halimeda spp.	0.13	0.19	0.00	0.08		0.15	0.25	0.94	2.28	0.02	0.16
Penicillis spp.	0.16	0.50	0.02	0.29	0.04	0.67	0.55	0.27	0.19	0.84	0.24
Rhipocephalus spp.	0.09	0.02					0.08			0.00	0.00
Udotea spp.	0.36	0.06				0.01	0.15	0.01			
Phaeophyta											
Dictyota spp.				0.10					0.61	0.29	0.05
Padina spp.							0.03				
Rhodophyta											
Laurencia spp.	4.54	14.1	35.4	12.5	31.7	16.5	17.2	0.01	0.54	0.60	0.46
Neogoniolithon spp.	0.02			1.19	5.79		0.03	18.9	39.6	43.2	10.8
Angiospermae											
Syringodium filiforme					1.98	0.18	0.03			0.00	2.01
Thalassia testudinum				2.68		5.27	0.03	1.03	0.21	1.75	43.2
Porifera	1.31	1.20	3.70	0.32	1.54	0.01	0.84	0.75	0.38	6.68	0.57
Scleractinia											
Favia fragum				0.01							
Isophyllia sinuosa										0.00	
Manicina areolata										0.00	
Porites porites	0.54	0.12	0.06			0.11		0.81	0.44	0.12	0.00
Siderastrea radians		0.08	0.20								
Siderastrea siderea			0.06							0.00	0.00
Sand	89.3	75.9	43.9	81.8	56.7	76.9	80.0	76.7	54.6	46.7	44.2
Coral Rubble	1.57	1.01					0.19	0.58			0.00

The water depth ranged between 0.7 and 1.7m depending on the tide. In total, three lobsters were found within the quadrats (Figure 3), and more were observed in the surrounding area. Sharks, rays, and other lobster predators were regularly observed in this area.

East Bay was dominated by *Thallassia testudinum* and showed the highest benthic coverage of all surveyed sites of up to 82% (Figure 4). A total number of 30 lobsters was found during four observations which all had a total benthic coverage of 10 to 20% of *Neogoniolithon*. No lobsters were found at the sites that

had a lower portion of *Neogoniolithon* (Figure 4). The sites at East Bay had a water depth ranging from 0.2 to 1m. A small lemon shark was observed once at high tide.

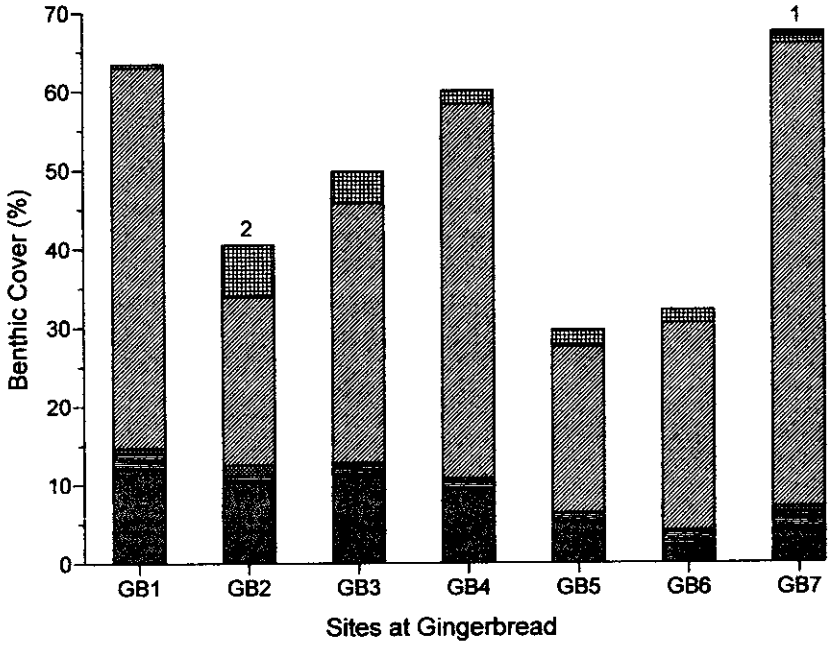

Figure 3. Percent coverage of benthic species for seven locations at Gingerbread off South Caicos surveyed from March to April 2001. Legend can be found in Figure 2. Number of observed lobster is indicated on top of respective bar.

Juvenile Lobster Densities

The average densities found at East Bay and at Gingerbread in dense benthic coverage were relatively high with 1,199 and 138 lobster/ha, respectively. The area surrounding Gingerbread with less dense benthic coverage and at Sandy Point relatively low densities of 4.0 and 6.2 lobster/ha were found.

The carapace length of lobster found at East Bay ranged from 14 to 56 mm with an average of 37.2 mm (n = 30). The carapace length of lobster measured at Gingerbread ranged from 28 to 76 mm with an average of 53.4 mm (n = 30). Lobsters were significantly smaller (t-test, $P < 0.01$) at East Bay than at Gingerbread. The one lobster found at Sandy Point had a CL of 58 mm.

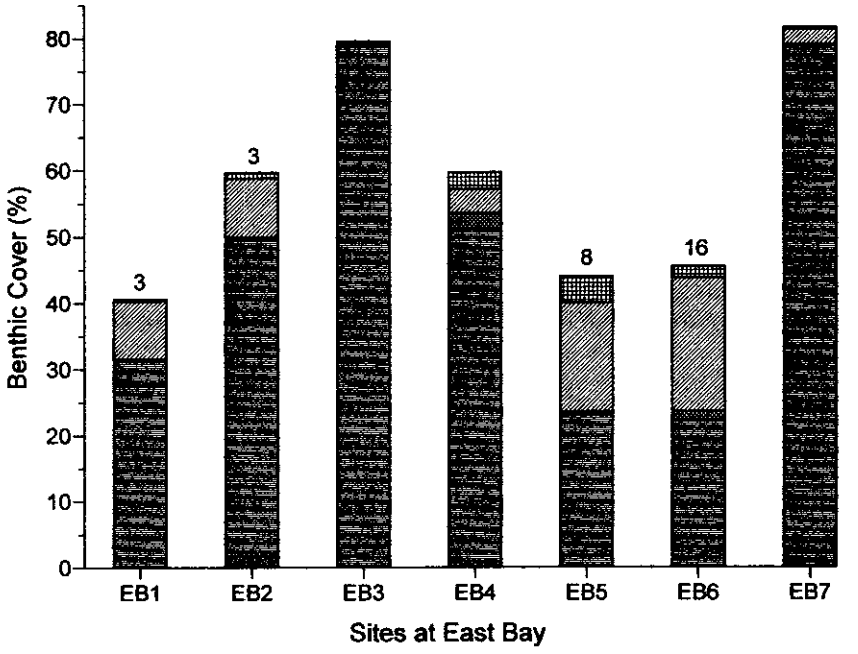

Figure 4. Percent coverage of benthic species for 7 locations at East Bay off South Caicos surveyed from March to April 2001. Legend can be found in Figure 2. Number of observed lobster is indicated on top of respective bar.

DISCUSSION

Laurencia versus *Neogoniolithon*

Previous studies indicated that juvenile lobster prefer to settle in complexly structured habitats of selected Rhodophytes (Butler et al. 1997). The genus *Laurencia* has been described as favorable settlement substrate for spiny lobster (Butler and Herrnkind 1992). The complex structure provides lobster space in which to hide. At the same time, prey species of juvenile lobster like gastropods, isopods and amphipods hide in these structures (Marx and Herrnkind 1985).

The *Laurencia*-dominated habitats surveyed during the present study (Figure 2) should have been ideal habitat for young juvenile lobster according to these previous studies. However, juvenile lobster were not observed in the *Laurencia*-dominated habitats (Figure 2). Even at the sites with highest benthic cover of *Laurencia* (35.4% at Man o'War Bush; Table 1) no lobsters were observed.

Ecological knowledge obtained from local fishermen indicated that juvenile lobster could be found in patches of another Rhodophyte of the genus *Neogoniolithon*. Curiously, previous studies have never linked lobster populations with this red alga. *Neogoniolithon* is the genus of a variety of calcareous red algae that thrive in shallow clear waters. These benthic algae either form a thin layer across the bottom, or grow upwards forming complex reef structures with crevices, caves and holes (Steneck et al. 1997). *Neogoniolithon* spp. support a unique set of algae, fish and invertebrates, possibly providing the lobster with sufficient prey.

The first habitats surveyed with an abundance of *Neogoniolithon* spp. were South of Long Cay and Sandy Point (Figure 2). At Sandy Point the first lobster was found to be hiding in a crevice underneath a patch of *Neogoniolithon*. Although this was only an indication that lobster inhabited this habitat, satellite images were used to detect similar habitat types. Gingerbread and East Bay were found to have a relatively high benthic coverage of *Neogoniolithon*. Gingerbread was dominated by *Neogoniolithon* with a coverage of up to 60% (Figure 3). In East Bay, *Neogoniolithon* was the second dominant species with a coverage of up to 20% (Figure 4). The importance of this observation may be that the lower density of *Neogoniolithon* supported the highest density of juvenile lobster. Juvenile lobster were found to densely populated *Neogoniolithon* patches in East Bay, where the habitat was dominated by *Thalassia testudinum*. Juvenile lobster have been shown to prefer dens with *T. testudinum* growing close by (Herrnkind et al. 1994). The seagrass provides food and shelter for the lobster when they leave their dens. In this study, the combination of *T. testudinum* and *Neogoniolithon* was found to be a relatively good habitat for juvenile lobster supporting high lobster densities.

Lobster Size

Significantly smaller lobsters were found in East Bay than in Gingerbread, which could have been due to a variety of factors. The close proximity of a coral reef and open ocean to East Bay may enable lobster to migrate to adult habitat at a smaller size than at Gingerbread. Migration to the reef from the relatively isolated Gingerbread may be a dangerous undertaking for lobster.

Another reason for the difference in size of lobster between East Bay and Gingerbread may have been the presence of predatory fish and sharks. Juvenile lobster prefer shallow waters (Lipcius and Cobb 1994) and the protected nature and shallowness of East Bay (0.2 – 1.0 m) allows large predators to enter only during high tides. Since lobster become less vulnerable to predation as they grow larger (Smith and Herrnkind 1992), the smaller specimen at Gingerbread may have been caught by predators. Small juvenile lobster may have a decreased mortality rate in the shallows of East Bay.

The smaller size lobster at East Bay may also have been related to fishing activities. The larger specimens at East Bay may have been taken by humans, which would have decreased the average size of lobster in the bay. Close proximity to shore and the town of Cockburn Harbour makes poaching in East Bay a realistic threat.

The size of lobster observed in the present study ranged from 14 to 76 mm carapace length. However, averages of carapace length of 37.2 mm in East Bay and 53.4 mm in Gingerbread indicated that the majority of the lobster were over 30 mm CL. When lobsters reach a CL of 15 to 18 mm, they leave their settlement habitat and move to den structures (Butler and Herrnkind 1992). As observed in this study, *Neogoniolithon* spp. provided these den structures, whereas no lobsters were observed in the *Laurencia* habitat (Figures 2 - 4). Continued surveys in South Caicos are planned to describe the habitat where pueruli settle and post-settlement lobsters hide. The enclosed character of East Bay may help out in these future surveys. East Bay is enclosed by land and reef and has only a small seagrass connection to the bank in the western corner of the bay. Since juvenile lobsters of all size ranges have been observed here, it is expected that all life stages are present and that settlement takes place in East Bay.

The purpose of the present study was to gain a better understanding of the processes affecting the distribution of the juvenile spiny lobster in South Caicos. Investigating larval settlement, determining habitats preferred by juvenile spiny lobsters and analyzing the structure of these habitats need to be continued to increase the knowledge of juvenile lobster behavior and life history processes. Managers may use this information to conserve and perpetuate the critical habitat for long-term sustainability of the Caribbean spiny lobster.

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