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MARINE MANAGEMENT

SETTLEMENT HABITAT AND SEASONAL RELATIVE ABUNDANCE OF SPINY LOBSTER *PANULIRUS SP*. LARVAE AND ACCOMPANYING FAUNA IN THE GALAPAGOS MARINE RESERVE

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Settlement habitat and seasonal relative abundance of spiny lobster *Panulirus sp.* larvae and accompanying fauna in the Galapagos Marine Reserve

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Introduction

Spiny lobster and sea cucumber fisheries are of major economic importance for the artisanal fishing sector of the Galapagos Archipelago. In Galapagos two species of lobster belonging to the Palinuridae family are commercially exploited: red lobster (*Panulirus penicillatus*) and the green or blue lobster (*Panulirus gracilis*). Until 2006, both fishing and population indicators showed that the lobster resource had declined (Hearn *et al.*, 2006); however since then fishery indicators (catch per unit effort or CPUE and total catches) have shown a recovery of the resource (DPNG, 2014).

Larval dispersal and the recruitment index are determining factors in the life cycle and the relationship between larval, juvenile, and adult lobsters. Until a few years ago, however, this information was unknown for lobsters in the Galapagos Marine Reserve (GMR) (Hearn *et al.*, 2005). This lack of knowledge increases the uncertainty when implementing suitable management strategies (Cruz, 1999).

Understanding the natural contribution of ecosystems to lobster populations will help ensure population abundance of these species. The present study aims to obtain information about the distribution of the larval stages of lobster in order to help determine the life cycle of lobster species in Galapagos and the rate of recruitment in relation to population size.

The results are based on the Larval Monitoring Program initiated in 2006, under the framework of the GMR conservation project funded by the Japan International Cooperation Agency (JICA). The Galapagos National Park Directorate (GNPD) continues this work to this day.

Methodology

During the initial phase of the project, larval collectors used in various parts of the world were tested and one was eventually designed specifically for Galapagos. The Galapagos collector resembles a mass of artificial algae. It was developed using synthetic material (plastic straw, plastic straps, and plastic mesh) formed into a sphere measuring approximately 80 cm in diameter, tied to a 70-kg concrete anchor (Figure 1). Buoys were located inside the collectors to keep them suspended.

Figure 1. Checking a larva collector installed in Itabaca Channel.

Initially, a total of 18 larva collectors were distributed at nine sites (Table 1). However not all sites could be monitored regularly and larvae were only found in places with similar characteristics (shallow bays surrounded by mangrove). Therefore, the study turned its primary attention to Santa Cruz Island (Itabaca Channel and Tortuga Bay). Each time a collector was examined, it was raised out of the water and shaken 30 times to remove any larvae before being returned to its original position.

Table 1. Distribution of collectors by site and geographic position. Monitoring categories were: a) collectors monitored at least once, but no lobster larvae found; b) collectors with regular monitoring where lobster larvae were continuously found; and c) collectors monitored at least once with settlement of lobster larvae.

Island	Site	Number of collectors installed	Monitoring category	Latitude	Longitude
Isabela	El Finado	1	a	01°02'490"S	91°09'350"W
	Barahona	1	a	00°58'638"S	91°00'201"W
	Bolívar Channel	1	a	00°18'300"S	91°21'215"W
	Cartago Bay	2	a	00°43'148"S	90°48'340"W
Santa Cruz	Itabaca Channel	5	b	00°29'198"S	90°16'211"W
	Punta Estrada	1	b	00°45'664"S	90°18'218"W
	Tortuga Bay	4	b	00°46'072"S	90°21'091"W
	Las Palmitas	2	c	00°40'310"S	90°32'227"W
Fernandina	Across from Caseta Bolívar	1	a	00°18'253"S	91°23'587"W

Based on work with *Panulirus argus* (Cruz *et al.*, 1991; Cruz, 1999), larval specimens collected were divided into four stages of development (Figure 2):

1. ***Philosoma:*** pelagic phase with transparent cuticle, depressed body;

2. ***Puerulus:*** ability to swim, developed pleopods, migrate to the coast, 4-6 mm long;

3. ***Post-puerulus:*** algal phase, 6-15 mm long, occurs after metamorphosis during settlement;

4. **Juvenil:** phase with differentiation of sexes, which occurs when they reach 16-20 mm.

Larvae in the *philosoma* phase were captured during nocturnal samplings conducted by boat, traveling at 2-5 knots, far from the coast. This method sampled both

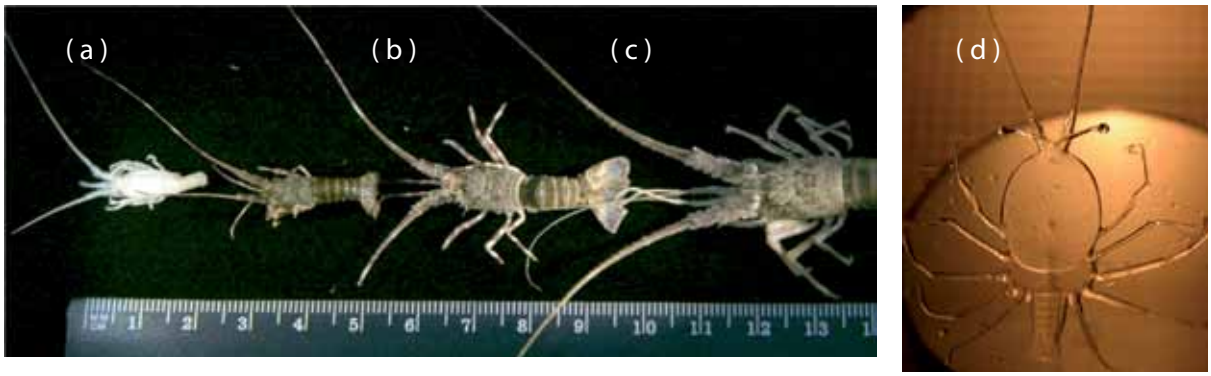

Figure 2. Different larval stages of the spiny lobster: a) *Puerulus*, b) *Post-puerulus*, c) Juvenil, d) *Philosoma*.

meso- and macrozooplankton. Two approaches were used. The first involved an oblique tow with a conical net of 335 microns (µ) being towed for approximately 15 minutes, raising it from a depth of 100 m to the surface. The second involved an hour-long surface tow of a conical net of 0.5 mm pore mesh. Alcohol (75%) was used to preserve post-*puerulus* and *philosoma* phases, and any additional fauna.

Results

The pilot phase of the project involved the design of the first working lobster larval collector for the GMR. Lobster larvae were captured in a systematic fashion, primarily in the collectors installed at three coastal sites on Santa Cruz Island (Itabaca Channel, Tortuga Bay, and Las Palmitas). Based on logistical considerations (some sites were difficult to monitor regularly) and preliminary results (larvae were found only in shallow bays surrounded by mangroves), from 2008 on, monitoring was concentrated at two sites (Itabaca Channel and Tortuga Bay).

In 2006 and 2007, six lobster larvae were collected in Itabaca Channel (Table 2). In 2008 the number captured increased to 29. The larval settlements at this site represent 67.2% of the total three-year catch for all sites. At Tortuga Bay, on the other hand, captures only occurred in 2007 and 2008, representing 29.5% of the total. At Las Palmitas, only two lobster larvae, or 3.3% of the total, were collected in 2007. Most of the larvae collected during the study were in the post *puerulus* phase.

The presence of larvae in the Itabaca Channel varied over time, peaking in March and May 2008 (Figure 4). In Tortuga Bay two peaks occurred, between February and March 2007. Itabaca Channel had fewer settlements in

Table 2. Number of lobster larvae (*Panulirus* sp.) captured by year and sampling site.

Site	Year			Percent of catch
	2006	2007	2008	
Itabaca Channel	6	6	29	67.2
Las Palmitas	0	2	0	3.3
Tortuga Bay	0	8*	10	29.5
Total	**6**	**16**	**39**	**100**

*This group includes one lobster that was observed and captured in its natural habitat.

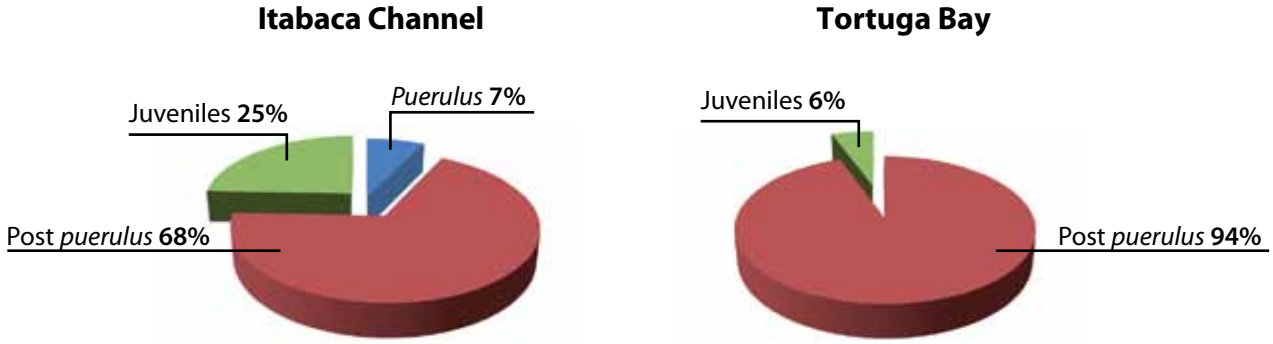

Figure 3. Percentage distribution of the larval stages found in Itabaca Channel and Tortuga Bay.

January, April, May, July, October, and November, with two individuals captured per month. Tortuga Bay had only one settlement in January, April, May, June and August.

Captures of *philosomas* of the genus *Panulirus* were carried out during three collection trips between 2006 and 2007, with a total of 18 individuals collected.

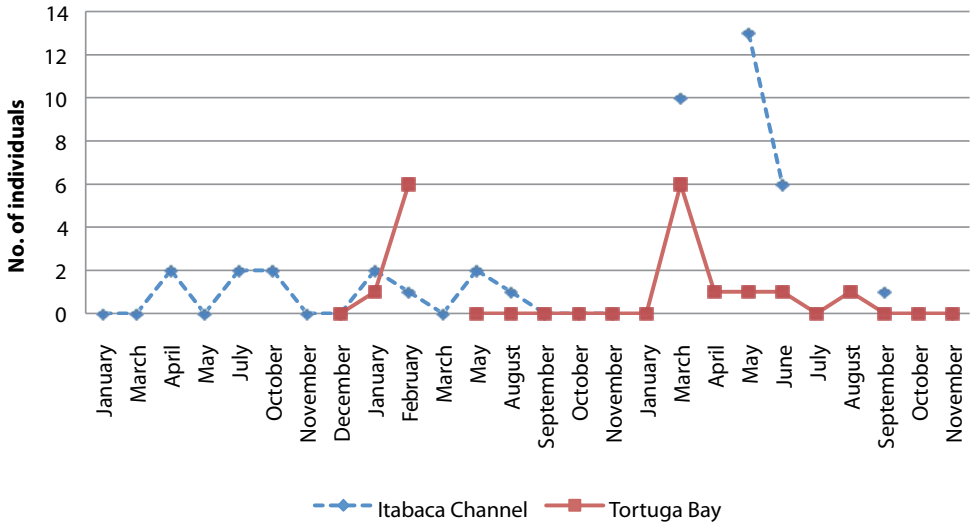

Figure 4. Number of lobster larvae (*Panulirus* sp.) captured during the monthly monitoring.

Conclusion and discussion

During this study we established that there are lobster recruitment sites in geographical areas with similar characteristics, such as mangrove-fringed bays with backwater currents and continuous water circulation.

The need to design a larval collector different from those used elsewhere suggests that the ecology of the settlement of spiny lobsters in Galapagos and their geographical and ecological characteristics are distinctive.

Between Tortuga Bay and Itabaca Channel on Santa Cruz Island, the greater presence of lobster larvae was found in collectors located in Itabaca Canal, possibly due to oceanographic conditions as the system of currents converging in the area generates high productivity, while Tortuga Bay is more confined and more exposed to continuous wave action.

Settlements of *puerulus*, post *puerulus,* and juvenile larvae in warm months (December to May) coincide with the reproductive peaks for both red and blue lobster described by Reck (1983).

In 2008, 23 more lobster larvae were collected than in 2007, probably due to increased reproduction or the action of currents and climatic conditions that favored the presence of a larger number of recruits. This suggests that this indicator would be directly related to fishery indicators for 2012-13, when an increase in the catch volume and CPUE of spiny lobster was observed.

Juvenile green lobsters have also been observed in the collectors. This should be confirmed with parallel studies (genetic testing) since red lobsters have a greater abundance and distribution in Galapagos.

Despite the fact that the monitoring did not demonstrate large scale recruitment, the results suggest that the levels of recruitment have some degree of seasonality and show patterns related to different oceanographic factors, such as sea temperature and potentially others that still need to be studied.

Given that spiny lobsters are one of the major fisheries of Galapagos, we recommend that this study be continued and strengthened with parallel monitoring of oceanographic variations, such as currents and circulation systems, and examining relationships with other organisms that colonize the same locations. Finally, the impact of environmental events on crustaceans is unknown and should be researched (Booth & Phillips, 1994).

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