Enhancement of Spiny Lobster Survival by Artificial Shelters: Habitat, Scaling, and Spatial Effects upon Predation Intensity

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ABSTRACT

Marine habitats with limited refuge from predation but adequate food may support increases in spiny lobster abundance if artificial shelters placed in these habitats reduce predation-induced mortality. Moreover, the protective capacity of shelters may vary according to the scaling between shelter size and lobster size, habitat type (*e.g.*, reef versus seagrass), and habitat quality (*e.g.*, seagrass density). We tested these hypotheses experimentally in the field by quantifying the survival of tethered spiny lobster juveniles in nursery habitats. Experimental factors included the presence or absence of artificial shelter, lobster size, shelter size, site features, seagrass density, and distance of unprotected lobsters from artificial shelters. Artificial shelters were sunken concrete structures (casitas) that simulate lobster dens. We also quantified potential predators associated with casitas. This paper summarizes the available information for spiny lobster tethering experiments performed between July, 1987 and August, 1989 in Bahía de la Ascensión, Mexico.

In the tethering experiments, spiny lobster survival was:

1. higher in dense-seagrass algal-mat habitats than moderate seagrass habitats;
2. higher at casitas than at unsheltered locations 15 m and 70 m from the casita, but not at unsheltered sites 30 m from the casita;
3. higher for large juveniles than small juveniles;
4. generally higher in smaller rather than larger casitas, though the effect depended upon the relationship between lobster and shelter size; and
5. independent of site features.

Thus, spiny lobster survival depends not only upon the availability of shelter, but also on habitat quality and the scaling between shelter size and lobster size. Predator observations indicated that the size range, maximum size, and species diversity of predators increased with casita size, thereby imposing higher predation intensity in larger casitas. Furthermore, the protective attributes of scaled casitas were enhanced by placement in dense seagrass habitats. Thus, placement of appropriately-scaled artificial shelters, such as casitas, in suitable

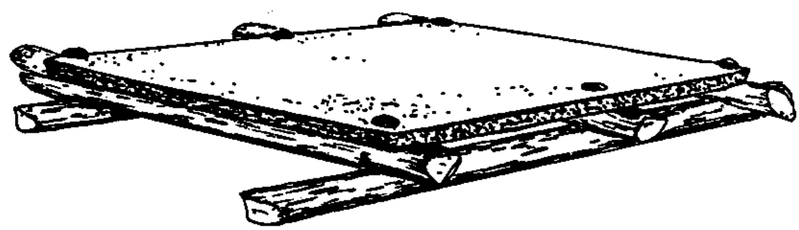

Figure 1. A large "casita" constructed with a frame of thatch palm and roof of cement.

nursery habitats is likely to augment the habitat carrying capacity for spiny lobster by increasing protection from predators.

INTRODUCTION

Since 1976, fishermen in Bahía de la Ascensión, Mexico have harvested spiny lobster (*Panulirus argus*) with artificial shelters (casitas, Figure 1) that simulate lobster dens (Miller, 1982; 1989). Casitas are positioned in shallow (2 – 7 m depth) back-reef and inner-bay areas and spaced some 20 to 30 meters apart. Captures are made by free-diving to the shelter and removing lobsters with a gaff or net. Using a net we have captured up to 109 lobsters (ranges 18 – 89 mm carapace length; CL) from a single casita. Currently, fishermen use over 10,000 casitas positioned throughout 160 km^2 of Bahía de la Ascensión. Their lobster fishing grounds are divided between 110 fishermen into approximately 150 parcels of water (campos), with each fisherman harvesting from his own campos (Miller, 1989). The fishery has been productive with annual landings ranging from 40 to 65 metric tons over the past 8 years.

Due to the intense fishing effort and high production of this fishery, we initiated experimental field tests in 1987 on the utility of artificial shelters in enhancing spiny lobster survival. The key issue concerns whether the artificial shelters increase spiny lobster production or merely concentrate lobsters for the fishermen. More than likely, the final answer will involve a mix of concentration and increased production of spiny lobster.

Our field experiments have emphasized the role of habitat structural complexity and shelter scaling in regulating predation-induced mortality rates of juvenile spiny lobster. We hypothesized that predation intensity would vary as a consequence of different habitat features (*e.g.*, seagrass density) and distance from the artificial shelter. Furthermore, the protective capacity of shelters may vary according to the scaling between shelter size and lobster size. To promote further research concerning the impact of artificial shelters on spiny lobster predator-prey dynamics and production in nursery areas, we summarize the available information (Eggleston *et al.*, 1990) on the efficacy of scaled artificial shelters in reducing size-specific mortality rates of juvenile *P. argus* within nursery habitats. We also summarize observations on potential lobster predators associated with casitas.

METHODS

Shelter scaling

Our scaling of smaller casitas began with a reduction in the height of casita openings. We assumed that existing large casitas (Figure 1, 177 cm length x 118 cm width x 6 cm height of opening) were suitable for concentrating large juveniles and adults (> 65 mm CL) entering the fishery. We then assigned casita opening heights of 3.8 cm to medium casitas and 1.9 cm to small casitas corresponding to medium (46 – 55 mm CL) and small (35 – 45 mm CL) juvenile lobsters, respectively. Reductions in casita opening height allowed for adequate entry of the targeted lobster size-class, but was also assumed to exclude larger predators. The resulting casita sizes were: medium casita (157.3 cm x 105.1 cm x 3.8 cm) and small casita (132.3 cm x 88.4 cm x 1.9 cm). Casitas were constructed of a reinforced concrete roof connected to a PVC pipe frame with plastic cable-ties and wire. Further details of the scaling procedure are provided by Eggleston *et al.* (1990).

Study site

Tethering experiments were conducted in Bahía de la Ascensión, Mexico (Latitude 19.45°N; Longitude 87.29°W, Figure 2), which is an important nursery area for juvenile spiny lobsters. Two experimental sites of contrasting habitat type were chosen to compare relative rates of predation: an inner-bay sand-seagrass flat located at the northwest portion of the bay, and an outer-bay turtlegrass (*Thalassia testudinum*) meadow adjacent to coral reefs (Figure 2). Relative rates of predation were also compared between two turtlegrass densities: moderate ($\bar{x}$ = 27.9 g/0.25 m^2) and dense with an algal mat ($\bar{x}$ = 52.5

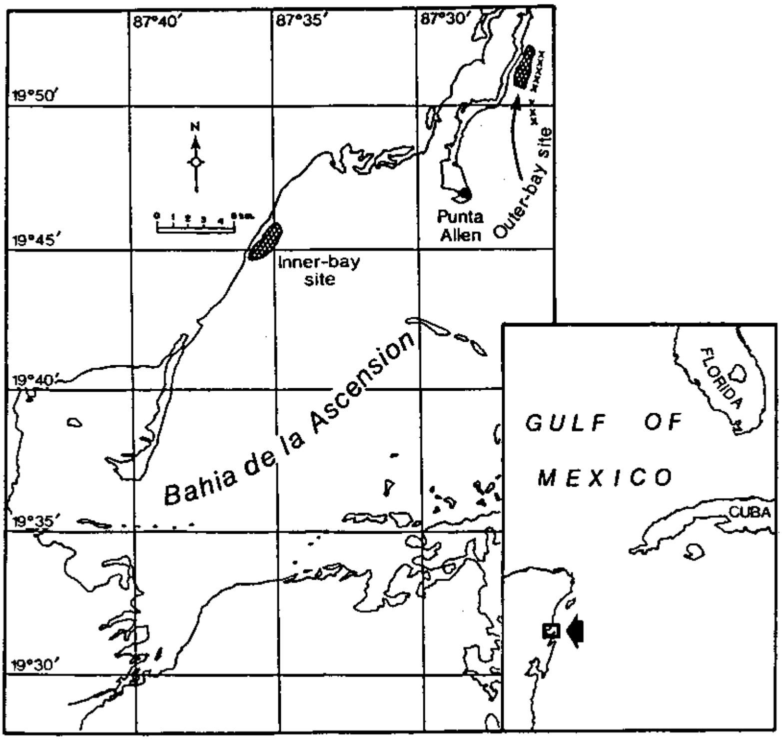

Figure 2. Study sites at Bahía de la Ascensión, Mexico.

g/0.25 m^2). Detailed descriptions of the study sites are provided by Eggleston *et al.* (1990).

Spiny lobsters were collected from existing casitas and held in traps for 1 – 2 days prior to initiation of each experiment. Only intermolt lobsters were used in tethering experiments. Tethers were constructed by locking a plastic cable-tie around the cephalothorax of a lobster, between the second and third walking legs, and securing the cable-tie with cyanoacrylate cement. The cable-tie was connected with 30-lb-test monofilament line either to another cable-tie and attached to a shelter, or attached to a J-shaped, stainless steel stake pushed into the sediment. The cyanoacrylate cement ensured that a piece of carapace remained on the line as evidence of predator-induced mortality (Herrnkind and Butler, 1986). Although tethering does not necessarily measure absolute rates of predation, it does measure relative rates of predation (Heck and Thoman, 1981), which can serve to compare mortality rates as a function of different experimental treatments.

Experimental design

Several tethering experiments were performed from July 1987 to August 1989. Experimental factors included lobster size (small: 35 – 45 mm CL; medium: 46 – 55 mm CL; and large: 56 – 65 mm CL), casita size (small, medium, and large), seagrass density (moderate and dense), site (outer-bay seagrass meadow adjacent to coral reefs and inner-bay sand-seagrass flat), shelter presence or absence (casita versus no casita), and distance from the casita (15 m, 30 m, and 70 m). Specific details of most of the experiments are given in Eggleston *et al.* (1990); Table 1 provides a synopsis of the different experimental designs.

Experimental treatments were systematically interspersed (Hurlbert, 1984) with three replicates for each factor. One replicate consisted of six lobsters of a single size-class tethered to a casita, or six lobsters tethered to stakes in the seagrass bed arranged in the same order as the length-width dimensions of the large casita.

Predation losses were scored and a visual census of potential predators taken every 1 – 2 days. Cumulative losses were converted to proportional mortality per day per casita and analyzed in multi-factor ANOVA's. During the July 1989 experiment, we used a stationary visual census technique (Bohnsack and Bannerot, 1986) to quantify the community structure and size-frequency of potential predators associated with each of the three casita sizes.

RESULTS

Most experimental data are given in Eggleston *et al.* (1990); the remainder is in preparation for publication (Eggleston, Lipcius, and Miller, unpubl. data). Briefly, in the tethering experiments, spiny lobster survival was:

Table 1. Synopsis of experiments and factors used to quantify survival of tethered spiny lobster juveniles in Bahía de la Ascensión, Mexico from July, 1987 to August, 1989. (See Methods for a description of the experimental factors).

(1) July-September 1987/Outer-bay site: lobster size (medium, large), seagrass density (moderate, dense), and shelter quality (no casita, large casita).
(2) July 1988/Inner-bay site: lobster size (medium, large) and casita size (medium, large).
(3) October 1988/Inner-bay site: lobster size (medium, large) and casita size (medium, large).
(4) October 1988/Outer-bay site (medium lobsters): shelter quality (no shelter, medium, and large casitas).
(5) January 1989/Inner-bay site: lobster size (medium, large), and shelter quality (no shelter, large casita).
(6) January 1989/Outer-bay site: lobster size (medium, large) and shelter quality (no shelter, large casita).
(7) July 1989/Inner-bay site: lobster size (small, medium) and casita size (small, medium, large).
(8) July 1989/Outer-bay site (medium lobsters): shelter quality (casita, no casita, and distance from the casita: 15 m, 30 m, 70 m).

1. Significantly higher in dense-seagrass algal-mat habitats than moderate seagrass habitats;
2. Significantly higher for large juveniles compared to medium juveniles, irrespective of seagrass density;
3. Significantly higher at casitas than at unsheltered locations 15 m and 70 m from the casita, but not at unsheltered sites 30 m from the casita;
4. Generally higher in smaller than larger casitas, though the effect depended upon the relationship between lobster and shelter size; and
5. Independent of site features (*i.e.* inner-bay sand seagrass flat versus outer-bay seagrass bed adjacent to coral reefs).

In addition, the visual census of potential predators at the inner-bay site during July 1989 indicated that total predator abundance, the mean number of predators per casita per sample, and mean predator length increased with casita size (Eggleston *et al.*, 1990). Large casitas concentrated more species of potential predators, followed in decreasing order by medium and small casitas (Eggleston *et al.*, 1990). The gray snapper (*Lutjanus griseus*) was the predominant potential predator, irrespective of casita size (Eggleston *et al.*, 1990).

We suspect that one of the key predators of juvenile spiny lobsters in Bahía de la Ascensión is the nurse shark (*Ginglyostoma cirratum*). On numerous occasions, after scoring high mortalities, we observed a nurse shark residing under the casita. Nurse sharks are documented predators of juvenile spiny lobsters in Cuba (Cruz and Brito, 1986). One of the more interesting predators in this area are bottlenose dolphin (*Tursiops truncatus*). Anecdotal observations by fishermen in Bahía de la Ascensión indicate that bottlenose dolphins systematically overturn rows of casitas and feed on resident juvenile lobsters. The fishermen have compensated for this problem by constructing casitas that will fish on either side. Thorough discussions of potential lobster predators in Bahía de la Ascensión, Mexico are given by Eggleston *et al.* (1990).

DISCUSSION

Our results suggest that spiny lobster survival depends not only upon the availability of shelter, but also on habitat quality and the scaling between shelter size and lobster size. Although previous work indicates that casitas concentrate numerous potential lobster predators (Eggleston *et al.*, 1990), these results show that casitas enhance survival of spiny lobsters. Furthermore, the protective attributes of scaled casitas are enhanced by placement in dense-seagrass algal-mat habitats. Thus, placement of appropriately-scaled artificial shelters (*e.g.*, casitas), in nursery areas like Bahía de la Ascensión, Mexico is likely to augment habitat carrying capacity for spiny lobsters by increasing protection from predators. However, final conclusions regarding the impact of artificial shelters on spiny lobster predator-prey dynamics and production in nursery areas warrant field manipulations that test the aforementioned hypotheses.

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