

**Taxonomic composition and abundance of demersal  
zooplankton associated to seagrass and sandy  
substrates of a coral reef environment**

by

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## ABSTRACT

The purpose of this study was to examine the influence of different benthic habitats in the taxonomic composition and abundance of demersal zooplankton in the coral reef systems of La Parguera. Two techniques were used to sample zooplankton abundance; horizontal plankton tows between surface and near bottom and demersal traps for substrate sampling. Sampling of zooplankton abundance was performed from October 2005 to December 2006. Significant differences of total zooplankton abundance in neuston samples between surface and near bottom were found; the higher abundance of organisms was found in near bottom of *Thalassia* beds. Calanoid copepods were the main component of the near bottom samples. Differences of total zooplankton and holoplankton abundance revealed lunar pattern in night samples with higher abundance in new moon at sandy substrates. A pronounced pattern of higher abundance of holoplankton taxa in night samples was observed at *Thalassia* beds and sandy substrates, with peak abundances measured in *Thalassia* beds. Results of the present study indicate that the abundance or emerging zooplankters varied in relation to time of day, and substratum. The demersal zooplanktons are an important link between seagrass meadows and adjoining coral reef communities as well.

## RESUMEN

El propósito de este estudio fue proveer una caracterización taxonómica del zooplancton demersal y examinar los patrones de migración vertical en el hábitat marino de las praderas marinas y los sustratos de arena en Cayo Conserva, La Parguera, Lajas, Puerto Rico. Se aplicaron dos técnicas de muestreo para la abundancia del zooplancton; arrastres horizontales con red neuston entre superficie y fondo, y trampas demersales para el muestreo de sustrato. El muestreo se realizó de octubre 2005 a diciembre de 2006. Se encontraron diferencias significativas en abundancia entre superficie y fondo, la mayor abundancia de organismos se encontró en el fondo, cerca de las praderas de *Thalassia*. Los copépodos calanoides fueron el grupo dominante numéricamente. Las diferencias de abundancia del zooplancton total y holoplancton revelaron patrones lunares en las muestras tomadas de noche con mayor abundancia en luna nueva en el sustrato arenoso. Se encontró además mayor abundancia de holoplancton en las muestras nocturnas que en las diurnas tanto en sustrato de *Thalassia* y arena. Las mayores abundancias se midieron en fondo de *Thalassia*. Los resultados de este estudio indican que existe un patrón de migración vertical asociado al zooplancton demersal, el cual refleja mayores abundancias durante la noche. El tipo de hábitat béntico resulto ser importante en la composición taxonómica y abundancia del zooplancton demersal, siendo en fondo de *Thalassia* donde mayores mediciones de zooplancton fueron encontrados.

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Amaris N. Caraballo Marrero

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## **Dedication**

With love to my daughter Angelica and my beloved husband Miguel for providing the time and space needed while I was doing my research. I want especially thank my parents who always supported and helped in many ways on every step on my life.

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## Introduction

This study provides a general taxonomic characterization of the demersal zooplankton associated with seagrass and sandy habitats from a coral reef environment in La Parguera. Patterns of vertical migration by demersal zooplankton are examined for the marine habitat of sea grasses and sandy substrates. Another objective was to compare patterns of taxonomic composition and abundance of demersal zooplankton in sea grass vs. sandy substrates. The main hypothesis of this research is that there is a significantly higher abundance of demersal zooplankton associated with the seagrass habitat, as compared to the sandy habitat in the La Parguera coral reef ecosystem.

Sea grass meadows are considered a valuable resource acting as a shelter and providing food for many species, some of which are of economic importance and others that are considered endangered. Seagrass beds cover vast areas in coastal plains and remain one of the most productive marine habitats (Hartog, 1977). Seagrass communities are complex assemblages which fill multiple functional roles in coastal ecosystems: stabilizing bottom sediments by preventing shifting of sand; playing a role in reducing turbidity and shore erosion in coastal bays (Cottam and Minro, 1954; Clarke, 1954), and increasing the finer sediment fractions and organic matter in the sediments through a baffle effect (Ginsburg and Lowenstam, 1958; Odum and Zieman, 1969; Lafon, 1969). These seagrass meadows are an important habitat for fish of economic importance as the great barracuda, boquicolorados, snappers, groupers and others. These fish migrate from coral reefs to the seagrass beds for food (Casas et.al., 1992). Recruitment, lobster (*Panulirus argus*), conch (*Strombus gigas*) and various species of sea urchins (*Diadema antillarum*, *Litochinus variegatus*, *Echinometra* spp.) also receive food and shelter in these areas (Garcia-Rios, 2001). These plants also provide food for many herbivorous reef fish (William and Edwards, 1993). The most abundant and ecologically important seagrass in Puerto Rico is the turtle grass, *Thalassia testudinum*.

The demersal zooplankton is a group of small organisms, active swimmers, which hide in the substrate during the day but frequently migrate to the water column at night (Emery, 1969; Hammer and Carleton, 1979; Alldredge and King, 1980). These are the major food source for nocturnal fish and corals in the coral reef system (Robichaux et al. 1981; Alldredge, 2004). Since demersal zooplankton emerges from coral reef substrates at night in high densities, it has been suggested that they play an important role in the trophic structure of coral reef communities (Alldredge and King, 1977; Porter et al., 1977). However, it is not only the densities but also the temporal migration patterns of these organisms which ultimately determine the availability of demersal zooplankton as food for both pelagic and benthic predators (Alldredge and King, 1980). The emergence of demersal zooplankton primarily at night and the visual orientation of many nocturnally foraging fishes (Hobson, 1975) suggest that the timing of migration from the benthos throughout the night may be affected by light levels, particularly moonlight (Alldredge and King, 1980). Many of the adult fish that hide in the coral reef during the day come out at night to feed on the sea grasses, taking advantage of the availability of food and protection that the sea grass provide. Demersal zooplankton appear to be widely distributed and associated with substrates ranging from mud and sand to rock and coral (Cahoon and Tronzo, 1992). The emergence of zooplankton occurred predominately at night, and all taxa had a greater emergence to surface waters during full moon (Rios Jara, 1995). Few studies on demersal zooplankton associated with sea grasses have been performed regionally in the Caribbean Sea.

## Research Background

### Vertical Migration and Seasonal Variability of Demersal Zooplankton

Demersal zooplankton are small, actively swimming animals, predominantly crustaceans and polychaete worms that hide in the substrate of the reef during day but periodically migrate up into the water column at night. They are a major source of food for nocturnal fish and corals on coral reef (Alldredge, 2004). Continuous quantitative sampling of demersal zooplankton on a Philippine coral reef revealed a distinct pattern of nocturnal vertical migration (Porter and Porter, 1977). Demersal plankton lived within the reef by day and migrated into the water column at night. The amount of plankton rising from specific reef substrates is significantly related to the degree of three-dimensional structure of the substrates: branching coral provide the most demersal plankton and sand the least (Porter and Porter, 1977).

Vertical migration patterns of demersal zooplankton were reported by Alldredge and King (1980) in the Gulf of California. Three (3) general patterns of migration were observed: (1) polychaetes and cumaceans emerged from the benthos at dusk, regardless of the phase of the moon. Polychaetes returned to the benthos throughout the night while cumaceans returned near dawn; (2) species of amphipods and isopods exhibited significant avoidance of moonlight, delaying emergence until moonset or returning to the benthos at moonrise; (3) species of copepods, mysids, shrimp, *Branchiostoma* (cephalochordate), and tanaids emerged into the water column throughout the night. The timing of migration was highly variable and did not correlate with the presence or absence of moonlight.

Alldredge and King (1980) observed that large zooplankton migrated less frequently into the water column during moonlight periods than small forms, suggesting that nocturnal predation by visually oriented planktivorous fish may be an important selective pressure. Alldredge and King (1980) observed that significantly higher numbers of demersal zooplankton emerged into artificially

darkened emergence traps during daylight and during full and quarter moons, than into undarkened control traps, demonstrating that absence of light is a major cue stimulating migration. Reentry traps resting on the bottom captured higher densities of demersal zooplankton than either emergence traps or reentry traps suspended off the bottom. Most demersal zooplankton remained in the water column only a short time. Dispersal, particularly over short distances, may be a major advantage of migratory behavior.

Ohlhorst and Liddell (1982) studied the temporal patterns of migrations into the water column by reef zooplankton in St. Croix. Samples were collected for 6 days at 9 daily time intervals using mesh emergence traps, diver pushed plankton nets, and surface plankton net tows. Preliminary analysis from 2 days indicated that there was migration throughout the night, with increased activity prior to sunrise and sunset. Significantly more taxa were captured during the first hour of darkness than during any other time interval. There was no significant difference in the number of individuals collected between treatments using sealed and unsealed traps, or between those using unsealed traps over coral and sand substrata.

The distance demersal zooplankton swim vertically above the bottom at night was measured quantitatively on a subtidal sand flat in the Gulf of California by Alldredge and King (1985). Three patterns of migration were observed: (1) small-bodied animals, including copepods, ostracods and the amphipod *Metaceradocus occidentalis*, remained within 30cm of the bottom except at full moon when a significantly higher proportion of these animals swam up at least 1 m into the water column; (2) syllid polychaetes swam up at least 2 m into the water column irregardless of the phase of the moon, and (3) large-bodied forms (> 2 mm) swam throughout the water column, but gradually decreased abundances near the surface.

Nocturnally foraging planktivorous fishes feed primarily on the large-bodied, readily visible animals. Alldredge and King (1985) predicted that these large forms would remain near the relatively safety of the benthos. However,

movement of the larger demersal zooplankton higher into the water column than smaller, less visible forms suggests that factors other than predation, possibly dispersal, may be of selective pressure influencing the distance demersal zooplankton swim above the benthos.

Demersal zooplankton was sampled by reentry tramps at four locations in Onslow Bay, North Carolina, USA by Cahoon and Tronzo (1992). Vertical plankton tows were also taken to compare the fauna in the water column with the demersal zooplankton. Demersal zooplankton was captured in greater numbers at night and over sand substrates. Estimates of zooplankton abundance in Onslow Bay are generally higher than those reported from other habitats. They are concentrated at the sediment-water interface, and are likely to be important prey for zooplanktivores in the continental shelf ecosystem off North Carolina.

Zooplankton distribution, abundance and composition at Cahuita coral reef in Costa Rica, were studied by Morales and Murillo (1995). Copepods were predominant throughout the year (32-95%), followed by foraminiferans (1-34%), fish larvae and eggs (<1-28%), crustacean larvae (2-13.8%) and chaetognata (1-6.5%). Mollusk and echinoderm larvae were also present. High densities of zooplankton were obtained in January, August and October, with peak abundance in May. Low densities were found in April and November. Some groups like Copepoda, Chaetognata, crustacean larvae and Polychaeta showed significant differences in their abundances from station to station. Amphipoda, Urochordata, mollusk and echinoderm larvae as well as ichthyoplankton showed no such difference. Comparing the rainy and dry seasons, a significant difference was detected between holo- and merozooplankton abundances; holozooplankton population dominated both in number and diversity. The lower diversity of larval forms is assumed to be a result of strong sedimentation and sediment resuspension. The variability of zooplankton abundance and its distribution are influenced by the current system that predominates in Cahuita. Qualitative analysis suggests that zooplankton sampled in Cahuita coral reef corresponds more to pelagic-oceanic zooplankton than to demersal zooplankton.

Differences between sampling stations may reflect the intensity of exchange between the reef water and surrounding water.

The influence of lunar periodicity, type of substratum and climatological conditions upon temporal and spatial variations of zooplankton abundance was examined in a shallow coastal lagoon, Phosphorescent Bay, in southwestern Puerto Rico (Rios-Jara 1995). A combination of sampling techniques consisting of standard (conical) plankton net tows, sledge-net tows, emergence traps and hand-net tows were used to examine variations of zooplankton taxonomic composition and abundance patterns associated with substratum type and lunar periodicity. Sampling was performed night and day in surface waters, at or near the bottom between May and June, 1992. Six taxa were classified as demersal. Included in this assemblage were adult males and females of *Pseudodiaptomus cokeri*, amphipods, tanaids and cumaceans. The copepods *Oithona spp.* and *Acartia spp.*, and the chaetognaths were distributed throughout the water column during the day, including zones near the bottom; probably some species of these groups could be classified as demersal. Emergence predominately occurred at night; all taxa with significantly higher emergence to surface waters during a particular moon period predominated by full moon. Both adult and copepodite stages of *P. cokeri* were collected in greater numbers at the surface during full moon periods. Copepodites emerged in greater numbers to the surface than adults during moonlight nights, which suggest that the degree of vertical migration becomes less pronounced with age. Most taxa (>76%) were more common in samples from seagrass and sand + macroalgae, the two most structurally complex substrata, indicating that substratum heterogeneity enhances densities of animals on the bottom.

Changes in the near-bottom abundance of zooplankton on scales of centimeters to meters and hours to seasons are of great importance to corals and other benthic zooplanktivores. Yahel et. al (2005) characterized such spatio-temporal changes over several coral reefs in the Gulf of Aqaba (Red Sea). Using arrays of underwater pumps, they found a substantial depletion of zooplankton

near the bottom. Vertical gradients of zooplankton abundance were steeper during the night than day, mostly due to a greater nocturnal increase in zooplankton biomass higher in the water column. A long time series of biweekly samples, lasting 1.5 years, indicated a doubling of the biomass during night with no apparent seasonality. Yahel et. al (2005) demonstrated that the changes in the near-bottom abundance of zooplankton on scales of centimeters are of great importance to corals and other benthic zooplanktivores.

### **Recruitment patterns in sea grass**

Bauer (1985 a) examined temporal variations of demersal zooplankton in seagrass beds near Dorado, PR. Abundance of the principal nine caridean shrimp species was markedly seasonal, with highest abundance in late spring and summer and again in December and January. Population abundance lows were observed in October and November, and again in February and March. Caridean densities were much higher than those of most previous studies in seagrasses. The small mesh net used relative to other studies (1 mm) probably accounted, in part, for the high abundance measured for these very small carideans in the Dorado seagrass beds.

The motile invertebrate epifauna of Turtle grass (*Thalassia testudinum*) meadows at Dorado, Puerto Rico, was sampled monthly during the day and night for a year (Bauer 1985 b). The penaeoid shrimp component of the mobile epifauna was dominated by two small sicyoniids, *Sicyonia parri* and *S. laevigata*. All penaeoids shrimp were collected in significantly higher numbers at night. Laboratory observations indicated that all species burrow just under the bottom during the day but are active at night. The nocturnal emergence of these penaeoids and their increased susceptibility to capture at and after dusk was documented by sampling which began before and ended after sunset; numbers of shrimp taken increased dramatically with increasing darkness (Bauer 1985 b).

Sea grass meadows sampled monthly for one year by push net had a hermit crab fauna composed of four pagurid and four diogenid species (Bauer

1985 c). Three species dominated the paguroid samples: *Pagurus criniticornis* (32.2%), *Clibanarius antillensis* (30.3%), and *Cl. tricolor* (18.5%). Abundance in night samples was consistently higher than in day collections. Field observations indicated that hermit crabs on sea grass meadows congregate into clusters during the day and disperse over the meadow at night. Hermit crab species showed two seasonal peaks of abundance at this tropical location, the first in the spring or summer and the second in the winter.

Breeding and recruitment patterns were analyzed and compared in a group of nine caridean shrimp species assemblage from seagrass meadows in Dorado, Puerto Rico (Bauer 1989). Embryo production took place throughout the year in all species. Most females that carried embryos near hatching also had an ovary filled with vitellogenic oocytes ready for a new spawning. Median period of embryo incubation ranged from 5-10 days in female of eight species maintained in the laboratory. Reproduction thus appears to be continuous in these tropical shrimps. The monthly highs and lows of recruitment strength were concordant among species with no apparent seasonal pattern (Bauer 1989).

Emergence influences benthopelagic coupling and benthic community organization. Harpacticoid copepods are conspicuous among emergers; however, to achieve a predictive understanding of their behavior more study are required. Thistle (2003), conducted an emergence-trap study at 18 m depth on a sandy bottom in the northern Gulf of Mexico. Percent emergence was significantly greater in September than in December. In September, near-bottom flows are quiescent, and in December, near-bottom flows are frequently energetic. That emergence was less during the season of energetic flows fits expectations from the literature that energetic flows suppress emergence. In contrast, the observation on gender and life stage of emergers provided no support for the hypothesis that harpacticoids emerge primarily to find mates (Thistle 2003).

## Chapter I

### Plankton tows

#### Materials and Methods

The insular shelf of La Parguera, on the southwest coast of Puerto Rico, is characterized by an extensive development of coral reefs, sea grass beds, and mangrove forests. The dry, warm, and relatively stable climate, low wave energy, high water transparency, relatively wide shelf and oligotrophic offshore waters, are some of the factors that contribute to the conditions of the marine ecosystem of La Parguera. Interactions among coral reef, sea grass beds, and mangrove communities provide for a highly productive, structurally complex, and biologically diverse ecosystem. Mean surface salinity is 35.2, but it varies from 34 to 37. Mean temperature is 28.4°C, changing from 25°C to 31°C (García et al. 1998). Coral reefs are distributed in three parallel lines: (1) Inshore, (2) Mid-shelf and (3) Outer shelf (Almy and Carrión-Torres 1963, Acevedo and Morelock, 1988). The length and the wide range of the reef's depths produce physical, chemical and biological gradients providing a highly productive, structurally complex, and biologically diverse ecosystem (Morelock *et al.*, 1977, Acevedo and Morelock 1988). The most common mangrove species is *Rizophora mangle*, and *Laguncularia racemosa* to a lesser degree. Extensive sea grass beds are well established in La Parguera, and *Thalassia testudinum* and *Syringodium filiforme* are the most common and widely distributed species. Also, most extensive sea grass beds are found at the two meter depth and surrounding mangrove islands (García et al. 2003)

The taxonomic composition and spatial/temporal patterns of abundance by demersal zooplankton were examined at Cayo Conserva, (Figure 1) about 2km west of Magueyes Island, La Parguera, Lajas, Puerto Rico (17° 57.889'N, 057° 03.758'W). Samplings were performed during the months of October 2005, February, April, June and September 2006 in daylight during full moon. Samples were collected with horizontal plankton net tows (0.32m<sup>2</sup>) using a 0.5m mouth

diameter net (303  $\mu\text{m}$ ) fitted with a standard calibrated flowmeter (General Oceanics Inc.) at the surface and bottom near seagrass meadows. Surface and bottom (6.1m depth) samplings were conducted with tows lasting approximately 3 min. For the bottom sampling the net was hand-held by two divers about 10cm above the seagrass. Flowmeter readings were recorded before and after each tow in order to determine the volume of water filtered. All samples were preserved in a mixed solution of 5% formalin and seawater at the time of collection.

At least three replicate tows were taken, which is the minimum number recommended for characterization of spatial and temporal abundance patterns (Newell and Newell, 1963; UNESCO, 1968; Omori and Ikeda, 1984). Samples were analyzed for holoplankton and meroplankton abundance and classified into major taxonomic groups. Each plankton sample was labeled and accompanied by corresponding sampling data sheet with information consisting of station, date, GPS position, time at start and end of tow, filtered field volume, mesh size, replicate number and other pertinent data.

The samples were analyzed for taxonomic composition and abundance of demersal zooplankton. Holoplankton and meroplankton samples were sieved through a 202 $\mu\text{m}$  mesh and dispensed into a counting chamber. Zooplankton, fish larvae and eggs were analyzed using a dissecting microscope.

Counts of each broad holoplankton and meroplankton taxonomic group (at level of Order, e.g. calanoid copepods, cyclopods copepods, etc.) were multiplied by the dilution factor to obtain an estimate of total number of zooplankton individuals in the sample. The total number of individuals was divided by the volume filtered in the field to obtain abundance values. Holoplankton and meroplankton were reported as number of individuals per cubic meter ( $\text{Ind}/\text{m}^3$ ). Aliquot volumes of 5 ml of 500 ml were used for abundance determinations in water column samples.

Nonparametric statistics test (Kruskal Wallis) were performed on abundance data of total zooplankton, holoplankton and meroplankton in order to

examine differences between months and differences between surface and near bottom abundance.

### Results

The mean water temperature in La Parguera was 28.47°C and ranged from 26.46°C in February to 30.03°C in September. Salinity fluctuated from a minimum of 34.04‰ in October to a maximum of 36.02‰ in July (Figure 2).

A total of 30 zooplankton groups were identified from the plankton tow samples. Mean abundance of total surface zooplankton was 363.5 Ind/m<sup>3</sup> and near bottom 856.6 Ind/m<sup>3</sup>. Holoplankton was the numerically dominant assemblage of the total zooplankton with a total abundance mean of 722.9 Ind/m<sup>3</sup> near bottom and 295.4 Ind/m<sup>3</sup> the surface. Total meroplankton average 133.7 Ind/m<sup>3</sup> near bottom and 67.1 Ind/m<sup>3</sup> at the surface (Figure 4).

Significant differences of total zooplankton abundance between surface and near bottom were found (KW – H (1,30) =11.148, p=0.0008). Statistically significant differences were also found for total holoplankton (KW – H (1,30) = 10.068, p=0.0015) and total meroplankton (KW – H (1,30) =5.688, p=0.0171). The higher abundance of total zooplankton (856.6 Ind/m<sup>3</sup>), total holoplankton (722.9 Ind/m<sup>3</sup>) and total meroplankton (133.7 Ind/m<sup>3</sup>) was found for near bottom samples.

Monthly variations of total zooplankton abundance at the surface and near bottom are shown in Figure 4a. Temporal variations of zooplankton abundance were statistically significant (p<0.05) for surface (KW – H (4,15) =10.3, p=0.0357) and near bottom (KW – H (4,15) = 9.433, p=0.0511) samples. Also, temporal variations were significant for total holoplankton (surface KW – H (4,15) =10.6333, p=0.0310; near bottom KW – H (4,15) =9.5333, p=0.0491) and meroplankton (surface KW – H (4,15) =12.2333, p=0.0157; near bottom KW – H (4,15) =11.1, p=0.0255) abundance. Two peaks of abundance were found in total zooplankton at near bottom samples October 2005 and April 2006 (Figure 4a). For surface samples, abundance was stable during the period of October

2005 thru April 2006. Lower abundance was found in total zooplankton in June 2006 and September 2006 at the surface (Figure 4a).

Total holoplankton abundance in near the bottom samples, presented two peaks of abundance during October 2005 and April 2006, and a minimum abundance during June 2006 and September 2006. In surface samples abundance was stable during October 2006 thru April 2006, with abundance maxima and minima during June 2006 and September 2006 (Figure 4b). Total meroplankton showed a peak abundance in October 2006 for near bottom samples and minimum abundance in February 2006. In surface samples, abundance was highest in October 2005 and lower in June 2006 and September 2006 (Figure 4b). The differences of total zooplankton, total holoplankton, and total meroplankton abundance between surface and near bottom of *Thalassia* beds are shown in Figure 4. Higher abundance in near bottom samples is evident for these data.

Differences of abundance of holoplankton taxa between surface and near bottom are presented in Table 1. Calanoid copepod and larvaceans exhibited significant differences of abundance between surface and near bottom during all monthly samplings (KW H (1, 6) =3.85714 p=.0495). Cyclopoid and harpacticoid copepods, chaetognath worms and cumaceans showed significant differences in 3 out of 5 sampling months (KW H (1, 6) =3.85714 p=.0495). The higher abundance of organisms was associated with the samples at the near the bottom above *Thalassia* beds. These were mostly composed by calanoid copepods (Table 1).

Differences of meroplankton taxa abundance at the surface and near bottom were significant for caridean and polychaete larvae (KW H (1, 6) =3.857143 p=.0495) for almost all sampling months. The higher abundance of meroplankton taxa were found in near bottom samples mostly composed by caridean and brachyuran shrimp larvae.

Fish larvae were more abundant in near bottom samples with a mean abundance of 4.58 Ind/m<sup>3</sup>. The Gobiidae were most abundant among of fish

larvae collected by near bottom samples ( $2.22 \text{ Ind/m}^3$ ). The Clupeiformes larvae were the most abundant fish larvae ( $0.16 \text{ Ind/m}^3$ ) in surface samples (Appendix 1, 2).

## **Discussion**

Seasonal patterns of zooplankton abundances in La Parguera appear to be regulated by interactions of climatic and biological factors. The two main peaks of total zooplankton abundance registered during the month of October 2005 and April 2006 coincided with low salinities and high sea temperatures registered in La Parguera. The peaks of water temperature and low salinity correspond with the rainfall season (Figure 3). Previous studies in the Caribbean, including Puerto Rico, have shown that increments in rainfall stimulated phytoplankton and zooplankton productivity (Lewis and Fish, 1969; González, 1967; Nut and Yeaman, 1975; Youngbluth, 1976; Kidd and Sander, 1979; Youngbluth, 1979; Yoshioka et al., 1985, Santiago, 1988; Garcia and Durbin, 1993; Rios, 1995; Gonzalez-Figueroa, 2002, Alfaro 2002). Exogenous nutrient inputs may have a fertilizing effect either immediately or after a time lag (Purcell, 1980; Garcia and Lopez, 1989; Jordan et al., 1991). These biological responses to nutrient inputs suggest that zooplankton abundances are regulated mostly by food availability.

The peak of abundances in April 2006 can be explain with light penetration that is one of the climatic factors that can regulate temporal patterns of phytoplankton and zooplankton in the Caribbean (Alfaro, 2002). It has been observed, that during April, solar irradiance over the sea surface is highest due to a reduction of cloud cover (Alfonso, 2001, Alfaro 2002).

Total zooplankton, holoplankton and meroplankton registered more abundance in seagrass samples, suggesting that substratum heterogeneity promote higher densities of animals on the bottom. These results agree with observations from previous studies (Alldredge and King, 1977; Porter et al., 1977; Coull et al., 1979; Feeley et al., 1979; Stoner, 1980; Alldredge, 1985;

Stoner and Lewis, 1985; Hicks, 1986; Palmer, 1986; Jacoby and Greenwood, 1988, 1989; Rios, 1995). These abundance values of total zooplankton are within the range of those reported from previous studies in La Parguera (Pabon, 2001).

Holoplankton has been the numerically dominant planktonic assemblage in almost all studies reported from Puerto Rico (Youngbluth, 1980; Yoshioka et al., 1985; Santiago, 1988, Garcia et al., 1996; Pabon, 2001, Gonzalez-Figueroa, 2002, Alfaro, 2002). Calanoid copepods represented the most abundant component of holoplankton in seagrass samples; where the seagrass meadows are rich in food, particularly detritus, and the grass canopy of the meadows provides a greater number of refuges where demersal zooplankton can escape predation while in the water column (Alldredge, 1985). These factors contributed to the greater density of holoplankton observed in seagrass samples.

Abundance of meroplankton taxa was much lower than the holoplankton abundance at surface and near bottom samples. One factor that probably contributed to the lower density of meroplankton was that decapods, the most abundant meroplankton, are the preferred food items of fishes foraging over seagrass beds (Kikuchi, 1966, 1974; Reid 1954). Meroplankton taxa were represented by decapod crustaceans, such as caridean shrimps and brachyuran crabs. These were more abundant on seagrass samples because decapods crustacean are often a numerically important component of the motile epifauna in *Thalassia* meadows (Greening and Livingston 1982; Gore et al. 1981; Heck 1976, 1977).

In this study fish larvae remained very close to the bottom of *Thalassia* beds during daytime, a factor that contributed for that is that most of the Gobiidae fish larvae are found on sand or mud bottoms. Randall (1967) reported that the stomach contents of a few species of ostracods, copepods and large amount of fine sand were present with the food materials in the stomachs of Gobiidae fish.

The availability of such food items may have influenced the abundance of Gobiidae fish larvae in bottom samples. The role of seagrass beds as nursery and feeding grounds for young of many commercially important fish species has added to the relevance of vegetative bottoms in shallow tropical habitats (Polard, 1984).

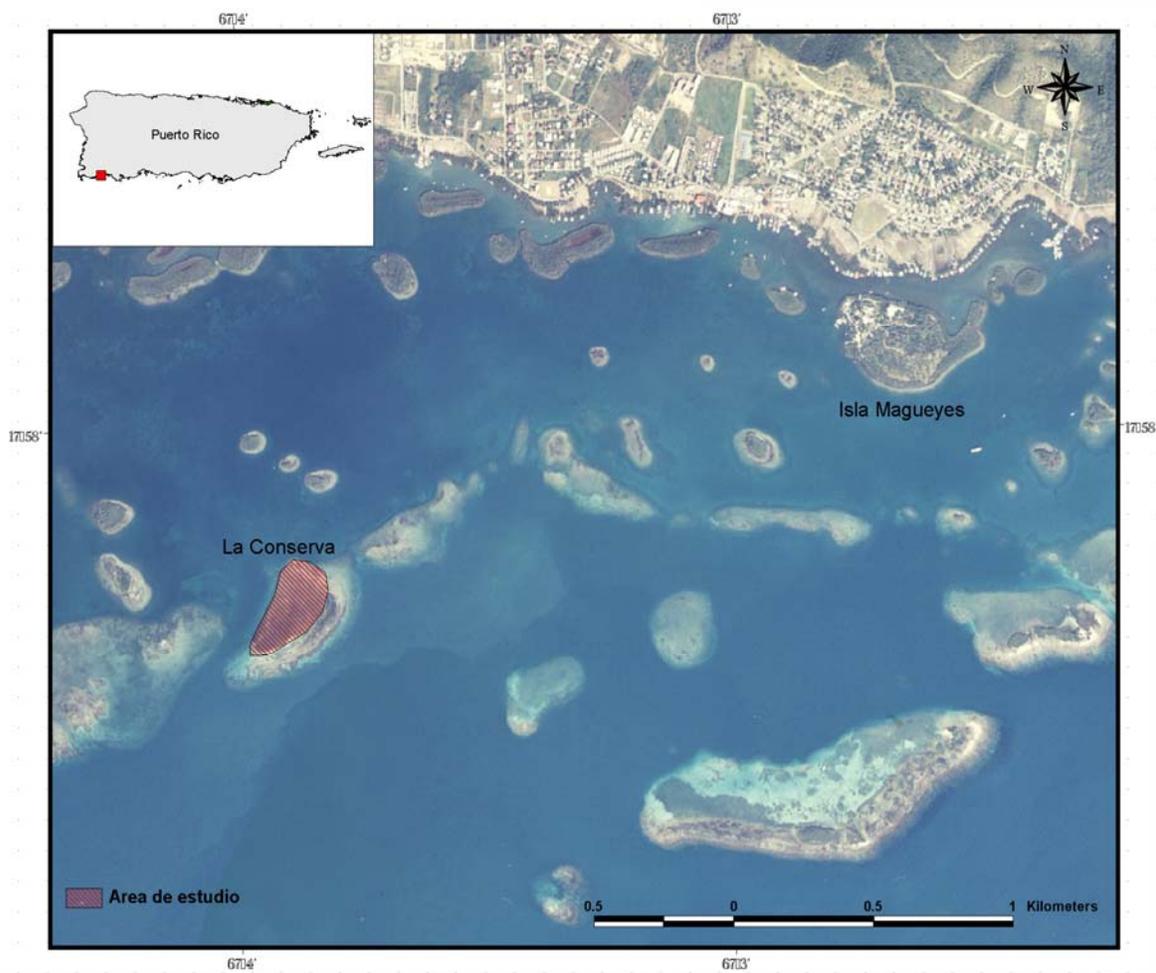


Figure 1 Location of sampling station at La Parguera, Lajas P.R.

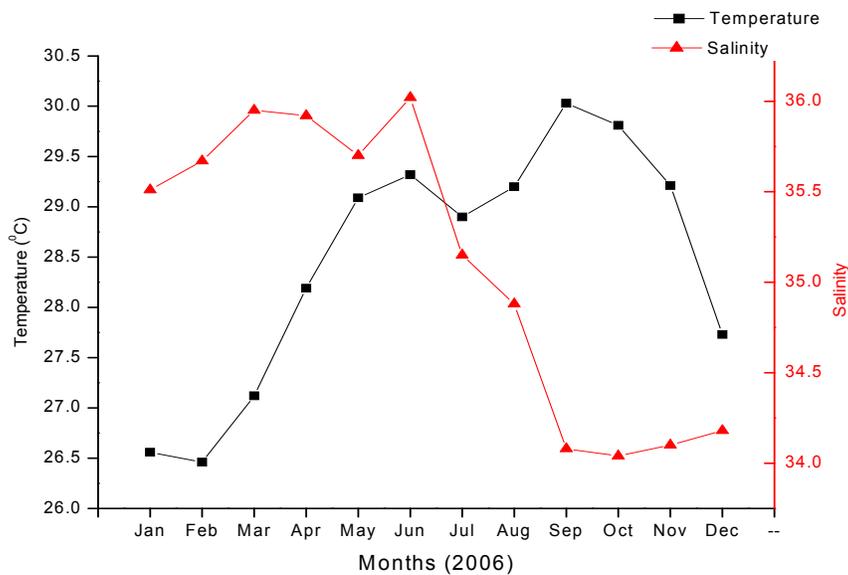


Figure 2. Water temperature and salinity at La Parguera during 2006. Source: NOAA AOML Integrated Coral Observing Program (ICON/CREWS).

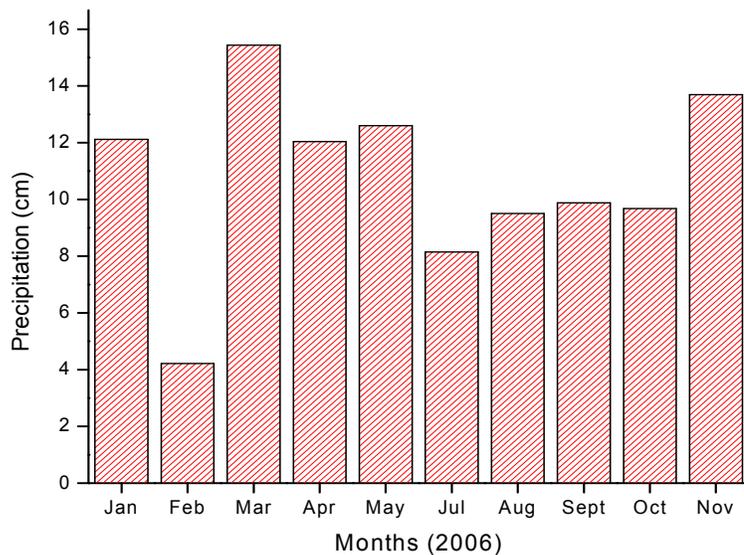
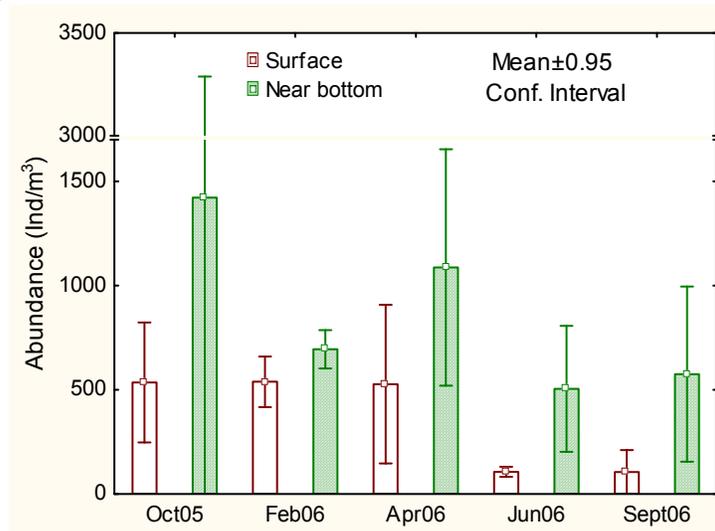
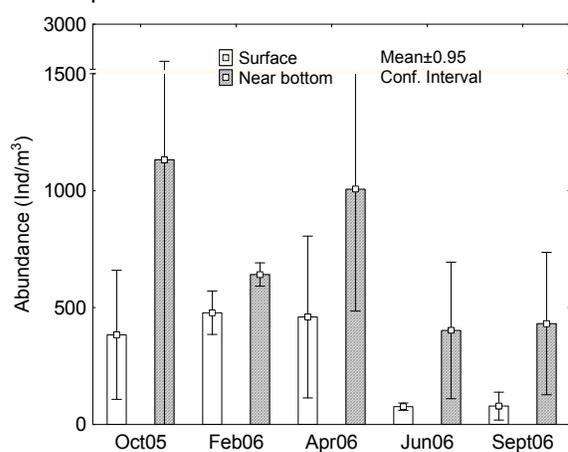


Figure 3. Monthly precipitation at Lajas substation, during 2006. Source: Caribbean Atmospheric Research Center at the University of Puerto Rico at Mayagüez.

## A Total zooplankton



## B Holoplankton



## C. Meroplankton

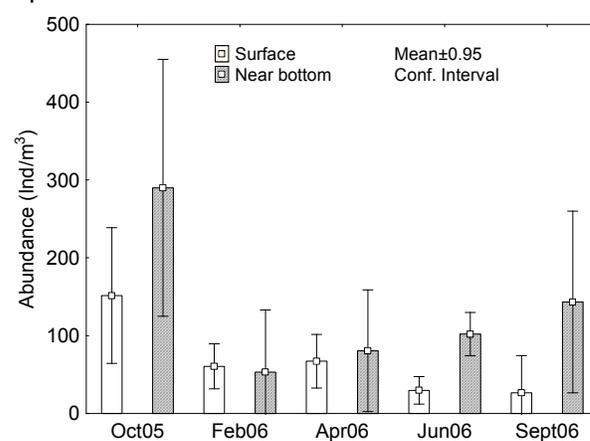


Figure 4. Monthly variations of mean abundance of (A) total zooplankton, (B) total holoplankton, (C) total meroplankton at surface and near bottom. Vertical bars represents 95% confidence intervals.

Table 1. Analysis of variance procedures (Kruskal Wallis) testing for differences of holoplankton and meroplankton abundance collected by plankton net tows between surface and near bottom. Underlined p-value indicates significant differences between surface and near bottom ( $p < 0.05$ ).

Thalassia	Oct-05			Feb-06			Apr-06			Jun-06			Sep-06		
	Surface	mean (Ind/m <sup>3</sup> ) Near bottom	pvalue	Surface	mean (Ind/m <sup>3</sup> ) Near bottom	pvalue	Surface	mean (Ind/m <sup>3</sup> ) Near bottom	pvalue	Surface	mean (Ind/m <sup>3</sup> ) Near bottom	pvalue	Surface	mean (Ind/m <sup>3</sup> ) Near bottom	pvalue
<b>Holoplankton taxa</b>															
Calanoid copepod	109.12	557.53	<u>0.0495</u>	172.73	518.33	<u>0.0495</u>	224.11	715.45	<u>0.0495</u>	34.84	258.32	<u>0.0495</u>	39.44	303.37	<u>0.0495</u>
Cyclopoid copepod	118.40	235.10	0.2752	86.39	14.83	<u>0.0495</u>	147.46	99.59	0.2752	4.41	11.15	<u>0.0495</u>	4.21	12.93	<u>0.0495</u>
Harpacticoid copepod	72.23	139.03	0.1266	96.45	20.13	<u>0.0495</u>	32.79	66.39	<u>0.0495</u>	27.35	48.65	<u>0.0495</u>	26.88	34.67	0.2752
Chaetognath															
Worms	10.40	38.30	<u>0.0495</u>	28.03	25.82	0.5127	30.97	46.17	0.2752	3.02	5.51	<u>0.0495</u>	2.64	22.21	<u>0.0495</u>
Larvaceans	18.14	64.44	<u>0.0495</u>	2.70	13.51	<u>0.0495</u>	4.27	42.08	<u>0.0495</u>	3.79	69.48	<u>0.0495</u>	1.85	52.24	<u>0.0495</u>
Sergestoid Shrimps	22.38	35.32	0.5127	47.12	17.25	<u>0.0495</u>	14.01	11.28	0.5127	0.10	5.22	<u>0.0495</u>	0.23	0.76	0.2752
Cumaceans	15.46	33.10	0.5127	43.13	16.48	<u>0.0495</u>	0.47	6.03	<u>0.0495</u>	2.35	0.69	<u>0.0495</u>	3.48	3.65	0.5127
Medusae	11.08	24.66	0.1266	1.11	15.07	<u>0.0495</u>	0.50	18.77	<u>0.0495</u>	0.44	2.76	<u>0.0495</u>	0.20	1.93	<u>0.0495</u>
<b>Meroplankton taxa</b>															
Caridean	20.37	91.60	<u>0.0495</u>	34.75	12.12	<u>0.0495</u>	18.02	21.41	0.8273	10.96	42.40	<u>0.0495</u>	3.62	53.45	<u>0.0495</u>
Brachyuran	23.66	39.85	0.2752	9.19	19.34	0.5127	19.27	34.29	0.5127	5.73	42.40	<u>0.0495</u>	1.85	76.88	<u>0.0495</u>
Gastropod Larvae	11.94	22.81	0.1266	9.75	9.17	0.5127	24.28	10.18	<u>0.0495</u>	0.37	0.42	0.8273	12.93	0.06	0.2752
Polychaete Larvae	0.12	0.49	<u>0.0495</u>	1.00	2.93	0.1266	1.11	3.65	0.1266	0.21	0.71	<u>0.0495</u>	0.06	0.72	<u>0.0495</u>
Cirriped Larvae	74.91	101.94	0.8273	3.44	5.65	0.2752	1.66	4.94	0.1266	4.09	3.00	0.8273	4.77	6.59	0.8273

## Chapter II

### Demersal Traps

#### Materials and Methods

The taxonomic composition and spatial/temporal patterns of abundance by demersal zooplankton were examined at Cayo Conserva (Figure 1) about 2 km west of Magueyes Island, La Parguera, Lajas, Puerto Rico (17°57.889'N, 057° 03.758'W). Six demersal traps constructed following Alldredge and King (1980) were used to sample demersal zooplankton abundance. Cone-shaped emergence traps (Figure 5), 0.17m<sup>2</sup> at the base, captured zooplankton migrating from the benthos into the water column. Zooplankton entering the traps swam through the 2cm opening of an inverted funnel, 56 cm above the bottom, and into a removable 4-L polypropylene catch bottle. The traps were placed on the bottom by scuba divers.

Demersal traps were deployed in two different substrates, seagrass meadows and sand. Samplings were performed biweekly during the months of June to August 2006, and from October to December 2006 during the day and night of the full and new moons. Traps were deployed at 8:00am and retrieved at 5:00pm in a seagrass bottom and sand substrate during day sampling. Traps were deployed at 6:00pm and retrieved at 7:30am for night samplings. All samples were preserved in a mixed solution of 5% formalin and seawater at the time of collection.

Samples were analyzed for holoplankton and meroplankton abundance and classified into major taxa. Each plankton sample was labeled and accompanied by corresponding sampling data sheet with information consisting of station, date, GPS position, filtered field volume, mesh size, replicate number and other pertinent data. Samples were analyzed for taxonomic composition and abundance of demersal zooplankton. The entire sample was sorted using

a dissecting microscope and the total number of individuals was divided by the area of demersal traps to obtain density values. Holoplankton and meroplankton were reported as number of individuals per square meter.

Nonparametric statistics tests (Kruskal Wallis) were performed on emergence rate data of total zooplankton, holoplankton and meroplankton in order to examine differences between months, full moon and new moon, day and night and between *Thalassia* and sand.

## Results

A total of twenty five zooplankton groups were identified in *Thalassia* bed samples and twenty-one organisms were identified in sand samples. Mean emergence rate of total demersal zooplankton for *Thalassia* beds was 418 Ind/m<sup>2</sup> in day samples and 1518 Ind/m<sup>2</sup> for night samples. In sand samples, the total mean emergence rate of demersal total zooplankton was 166 Ind/m<sup>2</sup> during day and 1537 Ind/m<sup>2</sup> at night (Figure 7). Holoplankton was the numerically dominant assemblage of the total zooplankton with a total mean emergence rate of 369 Ind/m<sup>2</sup> during day and 1394 Ind/m<sup>2</sup> at night in *Thalassia* beds and 166 Ind/m<sup>2</sup> during day and 1419 Ind/m<sup>2</sup> at night in sand samples (Figure 8). Meroplankton presented mean emergence rate of 48.5 Ind/m<sup>2</sup> during day and 123 Ind/m<sup>2</sup> at night in *Thalassia* beds and 30 Ind/m<sup>2</sup> during day and 137 Ind/m<sup>2</sup> at night in sand substrates (Figure 9).

Emergence rate of total zooplankton in samplings between full moon and new moon were not significantly different in *Thalassia* beds during day (KW – H (1, 72) = 0.034, p = 0.8526), and night samples (KW – H (1,72) = 0.3235, p = 0.5695). Emergence rate of total zooplankton was highest during June 2006 (KW H (1, 12) =8.307692 p=.0039) and July 2006 (KW: H (1, 12) =6.564103 p =.0104) in day samples; and during November 2006 (KW H (1, 12) =5.769231 p =.0163) in night samples. Emergence rate of total zooplankton from samples

taken at full moon and new moons over *Thalassia* beds (Figure 6) revealed no lunar pattern. The main pattern is that total zooplankton was always higher at night in *Thalassia* beds, no matter the phase of the moon.

Sand substrates presented homogeneous emergence rates between full and new moons in day samples (KW – H (1,72) = 0.0008, p = 0.978); but higher emergence rates at night (KW-H(1,72) = 7.0946, p= 0.008). Total holoplankton emergence rate presented significant differences between moon phases in night samples at sandy substrates, being more abundant in new moon samples (1616 Ind/m<sup>2</sup>) (KW – H (1,72) = 7.0346, p=0.008). Such differences of higher holoplankton in new moon were driven by calanoid copepods (KW - H (1,72) = 12.0735, p = 0.001) and cyclopoid copepods (KW – H (1,72) = 10.0396, p = 0.002), both of them highly abundant in new moon samples (1015 Ind/m<sup>2</sup>).

Day and night variations are shown in Figure 7. Total zooplankton presented a temporally consistent pattern of higher emergence rate in night samplings over *Thalassia* seagrass beds (KW H (1,144) = 82.3749, p=0.000), with higher emergence rate at night samples (mean: 1518 Ind/m<sup>2</sup>). Monthly variations of total zooplankton emergence rate in seagrass presented two peaks in June 2006 and July 2006 during day samples. Lower emergence rate of total zooplankton was found in August 2006. Two peaks of emergence rate were found in night samples at *Thalassia* beds during June 2006 and December 2006. Lower emergence rate was found in July 2006 and August 2006.

Holoplankton showed significant differences in emergence rates between day and night (KW - H (1,144) = 86.0404, p = 0.000) in *Thalassia* beds, with higher emergence rate in night samples (1394 Ind/m<sup>2</sup>). Total holoplankton emergence rate peaked in June 2006 and December 2006 during day. Lower emergence rate was found in August 2006. In night samples, at *Thalassia*

beds, total holoplankton emergence rate peaked in June 2006. Lowest emergence rates were observed during July 2006 and August 2006 (Figure 8).

Variations of holoplankton emergence rate in *Thalassia* beds during day and night are shown in Table 2. Harpacticoid copepods and chaetognath worms samplings presented significantly higher emergence rate on samplings during night all sampling months in seagrass beds (Table 2). Cyclopod copepod, larvaceans and amphipods presented higher night emergence rates in 5 out 6 month of sampling. Larvaceans were more abundant during day samples (Table 2).

Meroplankton presented consistent pattern of higher emergence rates at night in *Thalassia* beds (KW – H (1,144) = 35.524,  $p = 0.000$ ). Two peaks of emergence rate were observed in November 2006 and December 2006 (Figure 9). Polychaete larvae presented significantly higher emergence rate at night for almost all months of sampling, and were the taxa with higher emergence rate at night samples in seagrass (Table 2).

Sandy substrate presented a consistent pattern of higher emergence rate of demersal total zooplankton in night samples (KW-H(1,144) = 102.236,  $p = 0.000$ ), (1537 Ind/m<sup>2</sup>). Monthly variations in total zooplankton emergence rate at sandy substrates are shown in Figure 7. Emergence rate remained stable during day samplings (Figure 7). Peak of emergence rate was found in August 2006 for night samples, where as lowest emergence rate was found in November 2006.

Total holoplankton presented a consistent pattern of higher emergence rate at night in sand substrate (KW -H (1,144) = 102.2827,  $p = 0.000$  (1419 Ind/m<sup>2</sup>). Peak of emergence rates were observed in August 2006 for night samples and where as lowest emergence rate in November 2006 (Figure 8). Cyclopod and Harpacticoid copepods, larvaceans ostracods, cumaceans and amphipods presented significantly higher emergence rates at night in all

sampling months for sand substrate (Table3). Larvaceans presented a more emergence rate in day samples (Table 3).

Meroplankton presented a consistent pattern of higher emergence rate at night in sand substrate (KW-H(1,144) = 77.6275,  $p = 0.000$ ), (137 Ind/m<sup>2</sup>). A peak of emergence rate was found August 2006 for day samples, where as lowest emergence rate was found in November 2006 on sand substrate. Night samples showed a peak of emergence rate in August 2006 at sand, with lowest emergence rate in June 2006 (Figure 9). Polychaete larvae presented significantly higher emergence rate at night in all sampling months in sand substrates (Table 3).

Variations of emergence rate between *Thalassia* and sand substrates were found in total zooplankton (KW-H(1,144) = 60.872,  $p=0.000$ ) and total holoplankton (KW - H(1,144) = 68.3241,  $p = 0.000$ ), during day samples, being more abundant in *Thalassia* beds. Night samples show no significant substrate differences in emergence rate of total zooplankton, total holoplankton and total meroplankton (Figure 7, 8, and 9). Although night samples show no significant differences between substrate, the emergence rate of zooplankton, holoplankton and meroplankton were higher than day samples. At night samples both substrates show a similar monthly variation being more abundant in some month sand and other *Thalassia* beds, without a clearly defined pattern of emergence rate (Figure 7, 8, 9).

## Discussion

Daylight has a major effect on the behavior of demersal zooplankton (Jansson and Källander, 1968; Alldredge and King, 1980; Tranter et al., 1981; Walter et al., 1981; Ohlhorst, 1982; Youngbluth, 1982; Renon et al., 1985; Bell et al., 1986; Walters and Bell, 1986; Jacoby and Greenwood, 1988, 1989). In this and other studies, emergence predominately occurred at night.

Zooplankton distribution and emergence rate observed in La Parguera was related to patterns of emergence behavior (Rios, 1995). A number of hypothesis have been raised to explain the functional advantage of migration in marine and estuarine environments e.g. predator avoidance (Zaret and Suffern, 1976; Stich and Lampert, 1981; Iwasa, 1982; Gliwicz 1986; Vuorinen, 1987; Prichett and Halderson, 1988); metabolic and fecundity advantages, gained with differences in water temperature between surface and bottom water (McLaren, 1963, 1974); and nutritional benefits from higher phytoplankton emergence rate in surface waters (McLaren, 1963; Enright, 1977; Huntley and Brooks, 1982; Dagg et. al., 1989).

Previous work indicates variable effects of lunar period on emergence (Alldredge and King, 1980, 1985; Ohlhorst, 1982; Jacoby and Greenwood 1989, Rios, 1995). In this study zooplankton did not show any response to lunar periodicity in *Thalassia* beds. Emergence occurred at night no matter the lunar period. A mild pattern of higher demersal zooplankton emergence rate was detected during new moon in the sandy substrates. At Heron reef, in Australia, most demersal taxa emerged in greater numbers during lunar quarter or new moons (Jacoby and Greenwood, 1989). Emergence in lower numbers to certain moon periods could reduce exposure to predation. Most invertebrate larvae during this study showed no response of lunar period on emergence.

Demersal zooplankton emerge from coral reef substrates at night in high densities, it has been suggested that they play an important role in the trophic structure of coral reef communities (Alldredge and King, 1977; Porter et al., 1977). In this study the total zooplankton, holoplankton and meroplankton taxa were more abundant at night both in *Thalassia* and sand substrates. It is not only the densities but also the temporal migration patterns of these organisms which ultimately determine the availability of demersal zooplankton as food for both pelagic and benthic predators (Alldredge and King, 1985). Robertson and Howard (1978) found a direct correlation between the emergence rate of

demersal zooplankton in the water column and the numbers of these organisms found in the guts of planktivorous fishes foraging at night. The nocturnal timing of the migration of demersal zooplankton has probably evolved as a defense against visually oriented predators, whose sight is less acute at night (Hobson and Chess, 1979).

Most taxa in this study emerged in greater numbers from seagrass, indicating that substratum heterogeneity promote higher densities of animals on the bottom. These results agree with observations from previous studies (Alldredge and King, 1977; Porter et al., 1977; Coull et al., 1979; Feeley et al., 1979; Stoner, 1980; Alldredge, 1985; Stoner and Lewis, 1985; Hicks, 1986; Palmer, 1986; Jacoby and Greenwood, 1988, 1989; Rios, 1995). Grass clumps with their buried root systems and the presence of detritus from decaying grass probably increase the heterogeneity of benthos on seagrass meadows (Alldredge, 1985). Seagrass meadows are rich in food, particularly detritus, and the grass canopy of the meadows provides a greater number of refuges where demersal zooplankton can escape predation while in the water column than comparable sand substrate with no benthic vegetation (Alldredge, 1985). These factors contribute to the higher emergence rate of total zooplankton, holoplankton and meroplankton taxa in *Thalassia* beds. The presence of any structure has been observed to promote higher densities of animals, possibly from predators, or behavioral choice (Hicks, 1977; Nelson, 1979; Ravenel and Thistle, 1981; Stoner, 1982; Coull and Well, 1983; Edgar, 1983; Thistle et al., 1984; Leber, 1985; Kern and Taghon, 1986; Palmer, 1986; Dewitt, 1987).

Harpacticoid copepods are abundant in seagrass systems (Hicks, 1986; Walters and Bell, 1986; Hall and Bell, 1988, 1993), and are important as food for seagrass-associated fish (Sogard, 1984; Tipton and Bell, 1988) and invertebrates (Leber, 1985). In this study, Harpacticoid copepods were the dominant group in *Thalassia* beds at day and night samples, where active emergence is a common behavior in seagrass beds (Hicks, 1986; Walters and

Bell, 1986, 1994; Bell et al., 1988; Walters, 1991; Hall and Bell, 1993) and sand flats (Alldredge and King, 1985; Walters, 1991). The role of seagrass beds as nursery and feeding grounds for young of many commercially important fish species has added to the relevance of vegetated bottom in shallow tropical habitats (Polard, 1984). Calanoid copepods were more abundant in the sandy substrate.

Results of the present study showed that the emergence rate of emerging zooplankton varied in relation to time of day and substratum. Behavioral responses to diel changes of illumination are here advanced as possible explanations for daily variations. Substratum-related differences in the number of zooplankton captured reflect the influence sea floor heterogeneity upon zooplankton community structure. Demersal zooplankton may represent an important component of seagrass communities as a link between the benthos and the water column (Alldredge, 1985). Many demersal zooplanktons feed in the water column (Smith et al., 1979) and bring energy, in the form of fecal matter back to the benthos (Alldredge, 1985). The demersal zooplankton is an important link between seagrass meadows and adjoining coral reef communities as well (Alldredge, 1985).

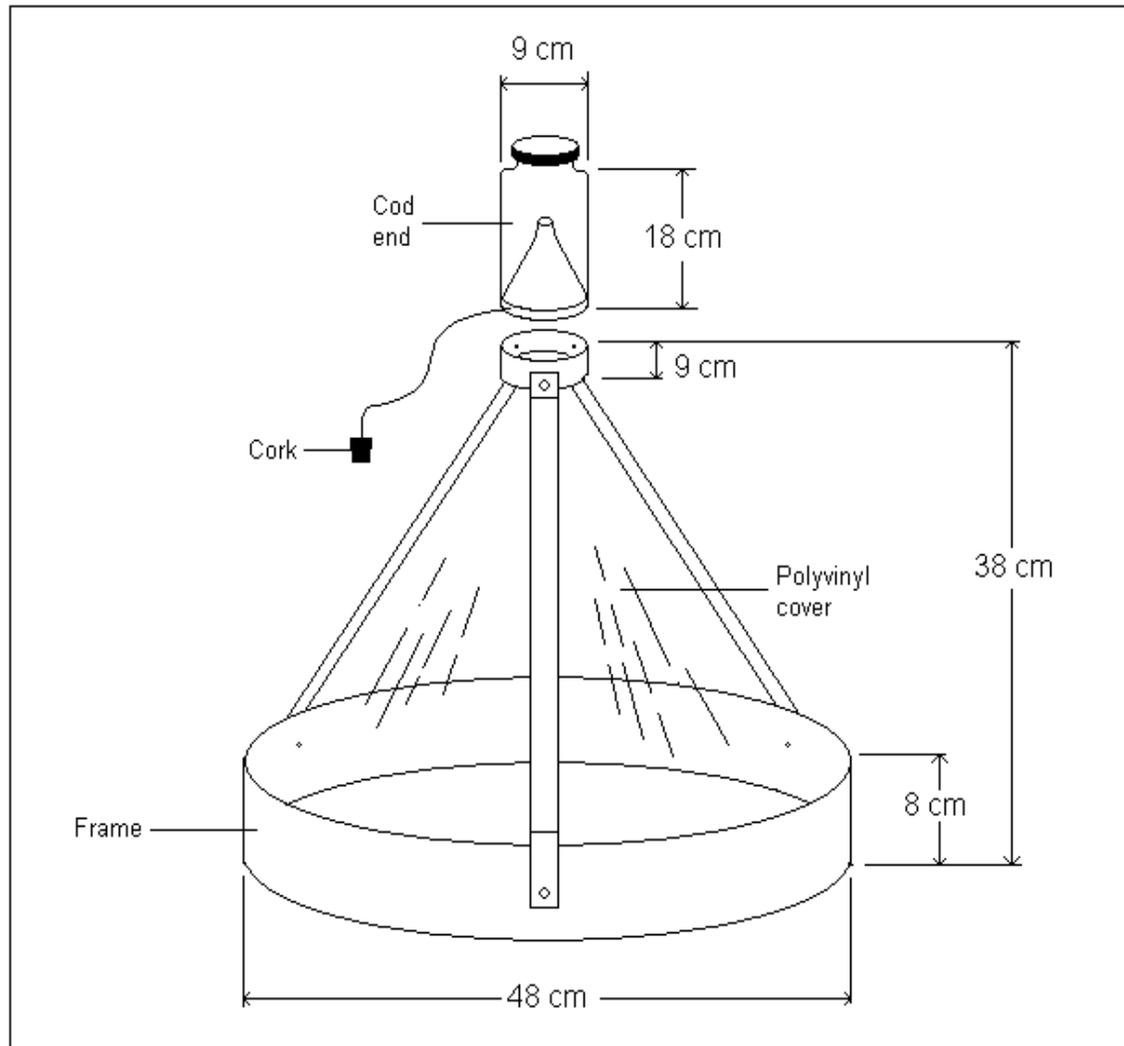


Figure 5. An emergence trap.

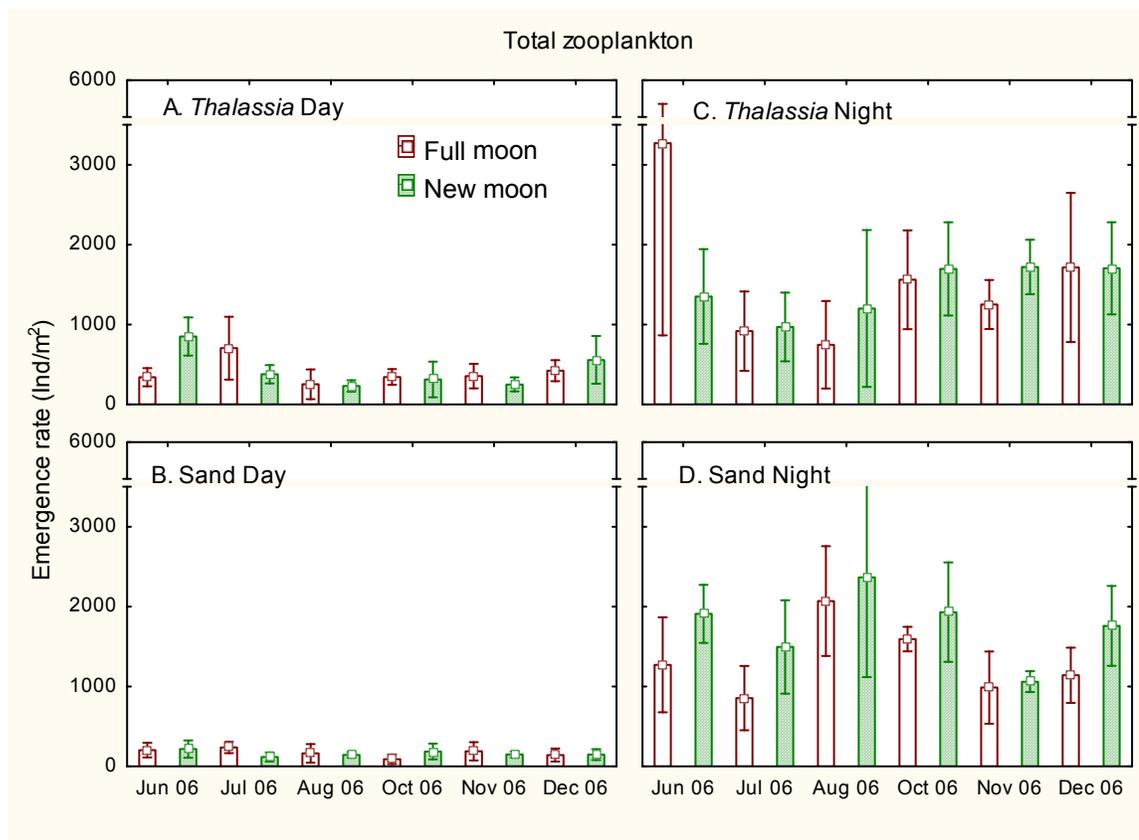


Figure 6. Monthly variations of total zooplankton emergence rate during full and new moons, in (a) *Thalassia* beds at day, (b) sandy substrates at day, (c) *Thalassia* beds at night and (d) sandy substrates at night. Vertical bars represent 95% confidence intervals.

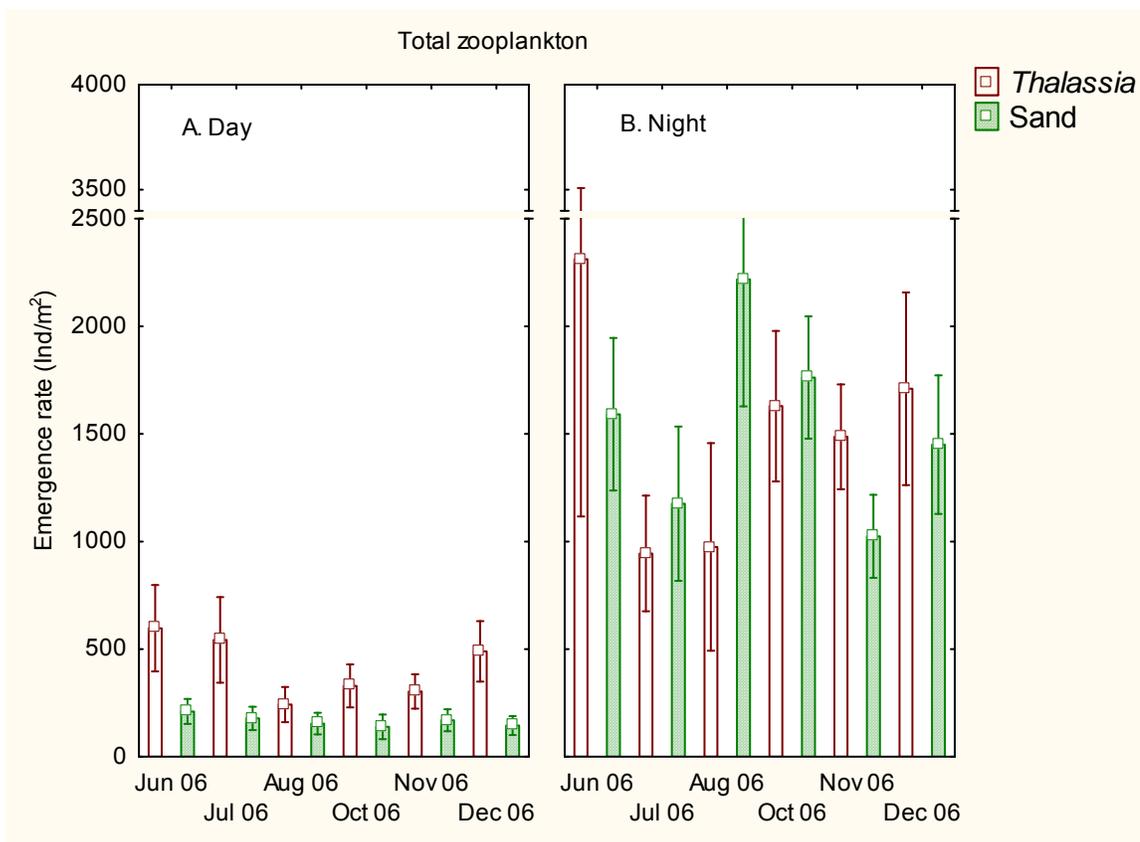


Figure 7. Monthly variations of total zooplankton emergence rate during (a) day and (b) night in *Thalassia* and sand substrates. Vertical bars represent 95% confidence intervals.

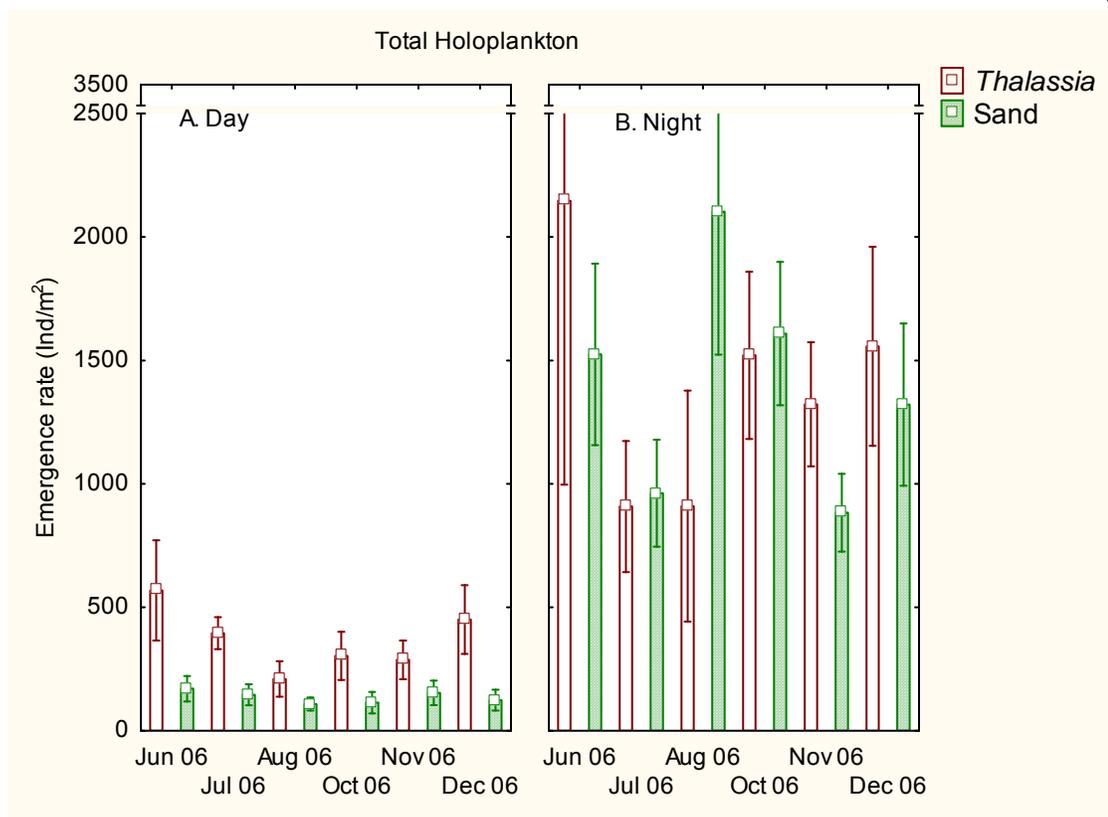


Figure 8. Monthly variations of total holoplankton emergence rate, during (a) day and (b) night in *Thalassia* and sand substrates. Vertical bars represent 95% confidence intervals.

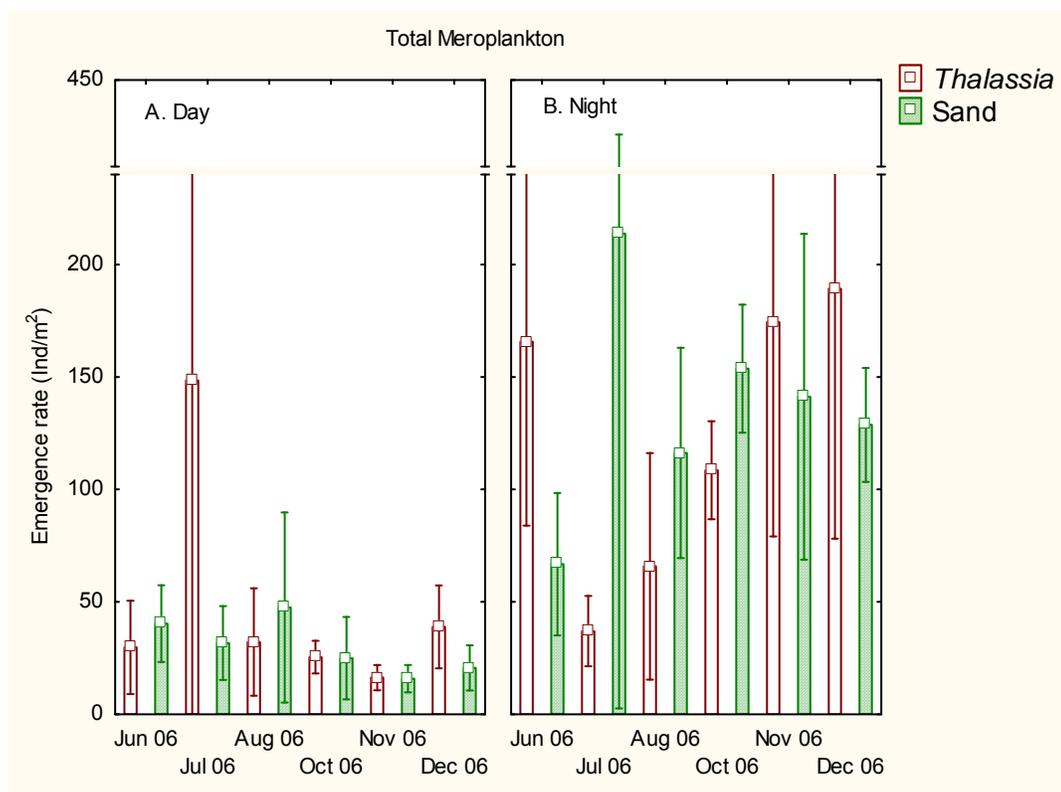


Figure 9. Monthly variations of total meroplankton emergence rate from *Thalassia* and sand substrates during (a) day and (b) night. Vertical bars represent 95% confidence interval.

Table 2. Analysis of variance procedures (Kruskal Wallis) testing for differences of holoplankton and meroplankton emergence rate between day and night collected by emergence traps at *Thalassia* beds Underlined p-value indicates significant differences (p<0.05).

<i>Thalassia</i>	Jun 06			Jul 06			Aug 06			Oct 06			Nov 06			Dec 06			
	Mean (Ind/ m <sup>2</sup> )		p value	Mean (Ind/ m <sup>2</sup> )		p value	Mean (Ind/ m <sup>2</sup> )		p value	Mean (Ind/ m <sup>2</sup> )		p value	Mean (Ind/ m <sup>2</sup> )		p value	Mean (Ind/ m <sup>2</sup> )		p value	
	Day	Night		Day	Night		Day	Night		Day	Night		Day	Night		Day	Night		
<b>Holoplankton</b>																			
Calanoid Copepods	49	42	0.10	59	133	0.09	37	124	0.08	87	139	<u>0.01</u>	81	209	<u>0.00</u>	124	451	<u>0.00</u>	
Cyclopoid Copepods	43	22	<u>0.02</u>	15	31	0.10	0	20	<u>0.00</u>	9	22	<u>0.01</u>	1	36	<u>0.00</u>	8	35	<u>0.00</u>	
Harpacticoid Copepods	209	1815	<u>0.00</u>	184	362	<u>0.03</u>	85	420	<u>0.00</u>	138	854	<u>0.00</u>	136	801	<u>0.00</u>	229	731	<u>0.00</u>	
Chaetognath Worms	4	41	<u>0.00</u>	6	19	<u>0.00</u>	2	17	<u>0.01</u>	4	50	<u>0.00</u>	3	33	<u>0.00</u>	11	32	<u>0.00</u>	
Larvaceans	10	2	0.12	36	2	<u>0.00</u>	13	3	<u>0.01</u>	15	1	<u>0.01</u>	47	4	<u>0.00</u>	49	2	<u>0.00</u>	
Ostracods	50	18	<u>0.03</u>	22	29	1.00	12	20	0.09	5	26	<u>0.00</u>	4	21	<u>0.01</u>	3	8	0.41	
Cumaceans	0	4	0.07	5	4	0.55	1	6	0.05	1	10	<u>0.00</u>	1	3	0.08	0	3	<u>0.01</u>	
Amphipods	188	171	0.86	53	291	<u>0.00</u>	43	250	<u>0.00</u>	20	331	<u>0.00</u>	10	158	<u>0.00</u>	11	251	<u>0.00</u>	
Medusae	14	30	<u>0.01</u>	15	37	<u>0.01</u>	13	25	0.12	17	30	0.14	5	26	<u>0.00</u>	9	24	<u>0.00</u>	
<b>Meroplankton</b>																			
Caridean	0.5	14	0.10	12	8	0.23	8	21	0.58	3	25	<u>0.00</u>	3	104	<u>0.00</u>	3	60	<u>0.00</u>	
Brachyuran	0.5	0	0.32	1	2	0.93	4	9	0.81	1	5	0.06	0.5	1	0.51	0.5	0.5	1.00	
Gastropod Larvae	8	12	0.93	98	10	0.16	13	4	0.16	7	6	0.52	4	7	0.26	15	5	<u>0.01</u>	
Bivalve Larvae	8	52	0.15	14	0.5	<u>0.00</u>	1	0.5	0.51	0	0	1.00	1	0	0.15	6	0	<u>0.01</u>	
Polychaete Larvae	3	84	<u>0.00</u>	8	12	0.40	1	29	<u>0.00</u>	2	69	<u>0.00</u>	4	48	<u>0.01</u>	6	86	<u>0.00</u>	

Table 3. Analysis of variance procedures (Kruskal Wallis) testing for difference of holoplankton and meroplankton emergence rate between day and night collected by emergence traps at sandy substrates. Underlined p-value indicates significant differences between day and night ( $p < 0.05$ ).

Sand	Jun 06			Jul 06			Aug 06			Oct 06			Nov 06			Dec 06			
	Mean (Ind/ m <sup>2</sup> )		p value	Mean (Ind/ m <sup>2</sup> )		p value	Mean (Ind/ m <sup>2</sup> )		p value	Mean (Ind/ m <sup>2</sup> )		p value	Mean (Ind/ m <sup>2</sup> )		p value	Mean (Ind/ m <sup>2</sup> )		p value	
	Day	Night		Day	Night		Day	Night		Day	Night		Day	Night		Day	Night		
<b>Holoplankton</b>																			
Calanoid Copepods	23	679	0.13	30	498	<u>0.00</u>	28.	1619	<u>0.00</u>	26	750	<u>0.00</u>	18	367	<u>0.00</u>	34	763	<u>0.00</u>	
Cyclopoid Copepods	4	25	<u>0.01</u>	1	14	<u>0.01</u>	4	15	<u>0.02</u>	2	18	<u>0.01</u>	2	19	<u>0.00</u>	3	23	<u>0.00</u>	
Harpacticoid Copepods	84	460	<u>0.00</u>	63	199	<u>0.00</u>	33	249	<u>0.00</u>	53	548	<u>0.00</u>	62	270	<u>0.00</u>	43	378	<u>0.00</u>	
Chaetognath Worms	5	11	0.07	10	9.	0.28	5	10	0.10	6	9	0.11	12	15	<u>0.01</u>	5	3	0.74	
Larvaceans	37	2	<u>0.00</u>	20	0	<u>0.00</u>	9	0.5	<u>0.00</u>	10	0.5	<u>0.00</u>	40	11	<u>0.02</u>	22	2	<u>0.00</u>	
Ostracods	7	68	<u>0.00</u>	4	26	<u>0.00</u>	9	26	<u>0.05</u>	3	39	<u>0.00</u>	10	54	<u>0.00</u>	5	31	<u>0.00</u>	
Cumaceans	0.5	71	<u>0.00</u>	2	44	<u>0.00</u>	4.	56	<u>0.00</u>	1	61	<u>0.00</u>	0	40	<u>0.00</u>	1	22	<u>0.00</u>	
Amphipods	7	199	<u>0.00</u>	9	151	<u>0.00</u>	12	103	<u>0.00</u>	4	150	<u>0.00</u>	3	68	<u>0.00</u>	5	82	<u>0.00</u>	
Medusae	1	10	0.21	7	16	<u>0.03</u>	4	12	<u>0.04</u>	8	19	<u>0.04</u>	7	21	<u>0.01</u>	5	13	<u>0.02</u>	
<b>Meroplankton</b>																			
Caridean	0	0	1.00	1	11	<u>0.02</u>	15	19	0.88	0.5	21	<u>0.00</u>	0	49	<u>0.00</u>	5	3	0.70	
Brachyuran	0	0.5	0.31	2	110	<u>0.04</u>	2	8	0.19	0	7	<u>0.03</u>	0	2	<u>0.03</u>	0.6	2	0.18	
Gastropod Larvae	29	25	0.60	15	17	0.49	18	26	0.08	12	10	0.38	4	7	0.38	9	16	0.08	
Bivalve Larvae	1	9	0.59	4	3	0.67	2	0	0.32	0.5	9	0.27	0.5	2	0.48	0.5	1	0.52	
Polychaete Larvae	7	29	<u>0.00</u>	5	71	<u>0.00</u>	7	61	<u>0.00</u>	3	104	<u>0.00</u>	2	73	<u>0.00</u>	5	100	<u>0.00</u>	

## Conclusions

1. Seasonal patterns of zooplankton abundance coincided with the rainfall season suggesting the influence of higher phytoplankton production associated with nutrients from rainfall runoff.
2. Higher zooplankton abundance in near bottom samples is indicative that substratum heterogeneity promotes higher densities of zooplankton on the bottom acting as protective habitat.
3. The finding of gobiid fish larvae near the bottom in seagrass beds may be associated with the availability of their preferred foods, thus in that habitats.
4. Previous work indicates variable effects of lunar period on emergence, in this study demersal zooplankton did not show any response to lunar periodicity on emergence patterns. Emergence occurred consistently at night, suggesting that predation is a major influence on zooplankton emergence behavior in seagrass beds.
5. Harpacticoid were the dominant group in *Thalassia* beds at day and night samples, suggesting active emergences in seagrass beds.

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Appendix 1. Taxonomic composition and mean abundance of holo/meroplankton at Cayo Conserva, La Parguera sampled by plankton tows over *Thalassia* beds surface.

Mesh ( $\mu\text{m}$ ) :303      Type of Tow : Neuston  
 Positions:17°57.889'N, 057° 03.758'W      Hour : 3 min

<b>Holoplankton Taxa</b>	<b>Oct 05</b> Ind/m <sup>3</sup>	<b>Feb 06</b> Ind/m <sup>3</sup>	<b>Apr 06</b> Ind/m <sup>3</sup>	<b>Jun 06</b> Ind/m <sup>3</sup>	<b>Sept 06</b> Ind/m <sup>3</sup>	<b>Mean</b> Ind/m <sup>3</sup>
Calanoid Copepods	109.1	172.7	224.1	34.8	39.4	116.1
Cyclopoid Copepods	118.4	86.4	147.5	4.4	4.2	72.2
Harpacticoid Copepods	72.2	96.5	32.8	27.4	26.9	51.1
Chaetognath Worms	10.4	28.0	31.0	3.0	2.6	15.0
Larvaceans	18.1	2.7	4.3	3.8	1.9	6.2
Sergestoid Shrimps	22.4	47.1	14.0	0.1	0.2	16.8
Ostracods	0.7	0.0	0.0	0.0	0.0	0.1
Cumaceans	15.5	43.1	0.5	2.4	3.5	13.0
Cladocerans	5.0	0.2	3.9	0.1	0.0	1.8
Medusae	11.1	1.1	0.5	0.4	0.2	2.7
Tanaidaceans	0.4	0.0	0.0	0.0	0.0	0.1
Parasitic Copepods	0.4	0.0	0.0	0.0	0.0	0.1
Siphonophores	0.0	0.3	1.6	0.0	0.0	0.4
<b>Total Holoplankton</b>	<b>383.6</b>	<b>478.1</b>	<b>460.0</b>	<b>76.4</b>	<b>79.0</b>	<b>295.4</b>
<b>Meroplankton Taxa</b>	<b>Oct 05</b> Ind/m <sup>3</sup>	<b>Feb 06</b> Ind/m <sup>3</sup>	<b>Apr 06</b> Ind/m <sup>3</sup>	<b>Jun 06</b> Ind/m <sup>3</sup>	<b>Sept 06</b> Ind/m <sup>3</sup>	<b>Mean</b> Ind/m <sup>3</sup>
Decapod Larvae						
Anomuran	0.0	0.4	0.1	0.1	0.0	0.1
Caridean	20.4	34.8	18.0	11.0	3.6	17.5
Brachyuran	23.7	9.2	19.3	5.7	1.9	11.9
Gastropod Veliger Larvae	11.9	9.8	24.3	0.4	12.9	11.9
Bivalve Veliger Larvae	10.7	0.0	0.0	0.0	0.0	2.2
Polychaete Larvae	0.1	1.0	1.1	0.2	0.1	0.5
Cirriped Larvae	74.9	3.4	1.7	4.1	4.8	17.8
Equinoderm Larvae	8.8	0.5	0.0	0.0	0.0	1.9
Ascidean Larvae	0.1	0.3	0.8	0.0	0.0	0.2
Stomatopod Larvae	0.0	0.2	0.2	4.5	0.0	1.0
Ophiuroid Larvae	0.0	0.0	0.0	0.2	3.2	0.7
<b>Fish Eggs</b>	<b>0.16</b>	<b>0.45</b>	<b>1.01</b>	<b>2.77</b>	<b>0.05</b>	<b>0.89</b>
<b>Fish Larvae</b>	<b>0.76</b>	<b>0.65</b>	<b>0.78</b>	<b>0.77</b>	<b>0.06</b>	<b>0.60</b>
Clupeiformes	0.06	0.16	0.31	0.29	0.00	0.16
Atherinidae	0.22	0.21	0.21	0.11	0.02	0.15
Gobiidae	0.07	0.01	0.00	0.03	0.00	0.02
Callionymidae	0.02	0.00	0.00	0.01	0.01	0.01
Pomacanthidae	0.04	0.00	0.00	0.00	0.00	0.01
Unknown	0.00	0.20	0.10	0.03	0.00	0.07
Unidentified	0.32	0.08	0.14	0.30	0.04	0.17
<b>Total Fish Larvae</b>	<b>0.76</b>	<b>0.65</b>	<b>0.78</b>	<b>0.77</b>	<b>0.06</b>	<b>0.60</b>
<b>Total Meroplankton</b>	<b>151.5</b>	<b>60.6</b>	<b>67.1</b>	<b>29.7</b>	<b>26.7</b>	<b>67.1</b>
<b>Total Zooplankton</b>	<b>535.1</b>	<b>538.7</b>	<b>527.2</b>	<b>106.1</b>	<b>105.6</b>	<b>362.5</b>

Appendix 2. Taxonomic composition and mean abundance of holo/meroplankton at Cayo Conserva, La Parguera sampled by plankton tows at near the bottom of Thalassia beds.

Hour : 3 min

Type of Tow : Neuston

Positions: 17°57.889'N, 057° 03.758'W

Mesh ( $\mu$ m) : 303

<b>Holoplankton Taxa</b>	<b>Oct 05</b> Ind/m <sup>3</sup>	<b>Feb 06</b> Ind/m <sup>3</sup>	<b>Apr 06</b> Ind/m <sup>3</sup>	<b>Jun 06</b> Ind/m <sup>3</sup>	<b>Sept 06</b> Ind/m <sup>3</sup>	<b>Mean</b> Ind/m <sup>3</sup>
Calanoid Copepods	557.5	518.3	715.5	258.3	303.4	470.6
Cyclopoid Copepods	235.1	14.8	99.6	11.2	12.9	74.7
Harpacticoid Copepods	139.0	20.1	66.4	48.7	34.7	61.8
Chaetognath Worms	38.3	25.8	46.2	5.5	22.2	27.6
Larvaceans	64.4	13.5	42.1	69.5	52.2	48.4
Sergestoid Shrimps	35.3	17.3	11.3	5.2	0.8	14.0
Cumaceans	33.1	16.5	6.0	0.7	3.7	12.0
Anhipods	0.0	0.0	0.0	0.5	0.0	0.1
Cladocerans	2.0	0.0	0.2	0.0	0.0	0.5
Medusae	24.7	15.1	18.8	2.8	1.9	12.6
Tanaidaceans	2.9	0.0	0.0	0.0	0.0	0.6
Siphonophores	0.0	0.0	0.4	0.0	0.0	0.1
Miller's Larvae	0.0	0.0	0.4	0.0	0.0	0.1
<b>Total Holoplankton</b>	<b>1132.3</b>	<b>641.4</b>	<b>1006.7</b>	<b>402.4</b>	<b>431.8</b>	<b>722.9</b>
<b>Meroplankton Taxa</b>	<b>Oct 05</b> Ind/m <sup>3</sup>	<b>Feb 06</b> Ind/m <sup>3</sup>	<b>Apr 06</b> Ind/m <sup>3</sup>	<b>Jun 06</b> Ind/m <sup>3</sup>	<b>Sept 06</b> Ind/m <sup>3</sup>	<b>Mean</b> Ind/m <sup>3</sup>
Decapod Larvae						
Anomuran	1.1	0.5	0.5	0.3	0.1	0.5
Penaeoid	1.0	0.0	0.0	0.0	0.0	0.2
Caridean	91.6	12.1	21.4	42.4	53.5	44.2
Brachyuran	39.9	19.3	34.3	42.4	76.9	42.6
Gastropod Veliger Larvae	22.8	9.2	10.2	0.4	0.1	8.5
Bivalve Veliger Larvae	9.2	0.0	0.0	0.0	0.0	1.8
Polychaete Larvae	0.5	2.9	3.7	0.7	0.7	1.7
Cirriped Larvae	101.9	5.7	4.9	3.0	6.6	24.4
Equinoderm Larvae	14.3	0.5	1.2	0.0	0.0	3.2
Ascidean Larvae	3.4	1.2	0.0	0.1	0.4	1.0
Stomatopod Larvae	0.0	0.0	0.4	1.7	0.6	0.5
Ophiuroid Larvae	0.0	0.0	0.4	0.3	0.0	0.1
<b>Fish Eggs</b>	<b>0.26</b>	<b>0.11</b>	<b>0.11</b>	<b>1.29</b>	<b>0.04</b>	<b>0.36</b>
<b>Fish Larvae</b>	<b>4.02</b>	<b>1.54</b>	<b>3.66</b>	<b>9.33</b>	<b>4.37</b>	<b>4.58</b>
Clupeiformes	1.15	0.24	0.77	0.03	0.00	0.44
Atherinidae	0.20	0.12	0.41	0.06	0.04	0.17
Gobiidae	1.33	0.23	0.13	6.65	2.78	2.22
Gerreidae	0.00	0.00	0.00	0.00	0.00	0.00
Syngnathidae	0.04	0.01	0.00	0.04	0.04	0.03
Opistognathidae	0.00	0.01	0.00	0.00	0.00	0.00
Pocentridae	0.00	0.03	0.00	0.00	0.00	0.01
Callionymidae	0.09	0.09	0.24	0.02	0.02	0.09
Labrisomidae	0.10	0.00	0.00	0.00	0.00	0.02
Unknown	0.06	0.36	1.31	0.00	0.02	0.35
Unidentified	1.05	0.45	0.81	2.55	1.48	1.27
<b>Total Fish Larvae</b>	<b>4.0</b>	<b>1.5</b>	<b>3.7</b>	<b>9.3</b>	<b>4.4</b>	<b>4.6</b>
<b>Total Meroplankton</b>	<b>289.9</b>	<b>53.1</b>	<b>80.6</b>	<b>102.0</b>	<b>143.3</b>	<b>133.8</b>
<b>Total Zooplankton</b>	<b>1422.2</b>	<b>694.5</b>	<b>1087.4</b>	<b>504.4</b>	<b>575.0</b>	<b>856.7</b>

Appendix 3. Taxonomic composition and emergence rate of holo/meroplankton at Cayo Conserva, La Parguera sampled by demersal traps during day in full moon on *Thalassia* beds.

Positions: 17°57.889'N,

057° 03.758'W

Area Traps: 0.17m<sup>2</sup>

<b>Holoplankton Taxa</b>	<b>Jun 06 Ind/m<sup>2</sup></b>	<b>Jul 06 Ind/m<sup>2</sup></b>	<b>Aug 06 Ind/m<sup>2</sup></b>	<b>Oct 06 Ind/m<sup>2</sup></b>	<b>Nov 06 Ind/m<sup>2</sup></b>	<b>Dec 06 Ind/m<sup>2</sup></b>	<b>Mean Ind/m<sup>2</sup></b>
Calanoid Copepods	49	72	38	37	132	120	74
Cyclopoid Copepods	66	22	0	18	2	9	20
Harpacticoid Copepods	102	224	59	162	129	151	138
Chaetognath Worms	2	5	0	0	5	13	4
Larvaceans	2	44	16	26	50	42	30
Sergestoid Shrimps	0	1	0	0	0	0	0.2
Amphipods	6	33	61	25	11	14	25
Medusae	26	25	17	29	7	11	19
Isopods	0	0	3	12	0	7	4
Mysids	0	0	0	0	0	1	0.2
Ostracods	51	31	10	8	2	4	17
Cumaceans	0	4	2	0	1	0	1
<b>Total Holoplankton</b>	<b>304</b>	<b>459</b>	<b>206</b>	<b>316</b>	<b>337</b>	<b>372</b>	<b>332</b>
<b>Meroplankton Taxa</b>							
	<b>Jun 06 Ind/m<sup>2</sup></b>	<b>Jul 06 Ind/m<sup>2</sup></b>	<b>Aug 06 Ind/m<sup>2</sup></b>	<b>Oct 06 Ind/m<sup>2</sup></b>	<b>Nov 06 Ind/m<sup>2</sup></b>	<b>Dec 06 Ind/m<sup>2</sup></b>	<b>Mean Ind/m<sup>2</sup></b>
Decapod Larvae							
Anomuran	1	0	0	0	0	0	0
Caridean	1	5	10	4	3	5	4
Brachyuran	0	1	8	0	1	1	2
Gastropod Veliger Larvae	5	191	21	4	2	17	40
Bivalve Veliger Larvae	16	21	3	0	2	11	9
Polychaete Larvae	6	11	1	2	8	8	6
Cirriped Larvae	0	7	1	0	1	6	2
Equinoderm Larvae	3	0	0	0	0	0	0
Ascidean Larvae	1	2	0	2	0	0	1
Ophiuroid Larvae	2	9	4	16	2	3	6
<b>Fish Eggs</b>	<b>0.0</b>	<b>0.0</b>	<b>0.0</b>	<b>0.0</b>	<b>0.0</b>	<b>0.0</b>	<b>0.0</b>
<b>Fish Larvae</b>	<b>0.0</b>	<b>0.0</b>	<b>1.0</b>	<b>0.0</b>	<b>1.0</b>	<b>0.0</b>	<b>0.3</b>
Unidentified	0.0	0.0	1.0	0.0	1.0	0.0	0.3
<b>Total Fish Larvae</b>	<b>0.0</b>	<b>0.0</b>	<b>1.0</b>	<b>0.0</b>	<b>1.0</b>	<b>0.0</b>	<b>0.3</b>
<b>Total Meroplankton</b>	<b>38</b>	<b>248</b>	<b>48</b>	<b>28</b>	<b>19</b>	<b>50</b>	<b>72</b>
<b>Total Zooplankton</b>	<b>342</b>	<b>707</b>	<b>254</b>	<b>344</b>	<b>356</b>	<b>422</b>	<b>404</b>

Appendix 4. Taxonomic composition and emergence rate of holo/meroplankton at Cayo Conserva, La Parguera sampled by demersal traps at night in full moon on *Thalassia* beds.

Positions: 17°57.889'N, 057° 03.758'W

Area Traps: 0.17m<sup>2</sup>

Holoplankton Taxa	Jun 06 Ind/m <sup>2</sup>	Jul 06 Ind/m <sup>2</sup>	Aug 06 Ind/m <sup>2</sup>	Oct 06 Ind/m <sup>2</sup>	Nov 06 Ind/m <sup>2</sup>	Dec 06 Ind/m <sup>2</sup>	Mean Ind/m <sup>2</sup>
Calanoid Copepods	1	137	85	174	152	306	142
Cyclopoid Copepods	37	25	7	27	23	40	26
Harpacticoid Copepods	2822	353	266	815	598	798	942
Chaetognath Worms	63	12	12	41	45	36	35
Larvaceans	4	1	1	2	4	3	2
Isopods	2	0	24	15	25	30	16
Mysids	0	0	7	4	2	2	2
Ostracods	2	34	17	18	11	3	14
Cumaceans	8	3	7	8	2	1	5
Amphipods	56	286	204	323	150	286	217
Cladocerans	0	2	0	0	0	0	0
Medusae	30	35	24	39	31	29	31
<b>Total Holoplankton</b>	<b>3024</b>	<b>887</b>	<b>653</b>	<b>1466</b>	<b>1041</b>	<b>1534</b>	<b>1434</b>
Meroplankton Taxa	Jun 06 Ind/M <sup>2</sup>	Jul 06 Ind/M <sup>2</sup>	Aug 06 Ind/M <sup>2</sup>	Oct 06 Ind/M <sup>2</sup>	Nov 06 Ind/M <sup>2</sup>	Dec 06 Ind/M <sup>2</sup>	Mean Ind/M <sup>2</sup>
Decapod Larvae							
Caridean	29	3	36	17	107	75	44
Brachyuran	0	0	14	4	0	0	3
Gastropod Veliger Larvae	6	11	3	5	8	8	7
Bivalve Veliger Larvae	65	1	1	0	0	0	11
Polychaete Larvae	145	12	39	61	89	98	74
Cirriped Larvae	3	1	2	6	0	0	2
Ascidean Larvae	0	2	0	0	0	0	0
Ophiuroid Larvae	0	2	0	2	2	0	1
Nemertea	0	0	0	0	5	0	1
<b>Fish Eggs</b>	<b>0.0</b>	<b>0.0</b>	<b>1.9</b>	<b>0.0</b>	<b>0.0</b>	<b>0.0</b>	<b>0.3</b>
<b>Fish Larvae</b>	<b>0.0</b>	<b>0.0</b>	<b>0.0</b>	<b>0.0</b>	<b>20.2</b>	<b>0.0</b>	<b>3.4</b>
Unidentified	0.0	0.0	0.0	0.0	20.2	0.0	3.4
<b>Total Fish Larvae</b>	<b>0.0</b>	<b>0.0</b>	<b>0.0</b>	<b>0.0</b>	<b>20.2</b>	<b>0.0</b>	<b>3.4</b>
<b>Total Meroplankton</b>	<b>248</b>	<b>32</b>	<b>98</b>	<b>95</b>	<b>231</b>	<b>181</b>	<b>147</b>
<b>Total Zooplankton</b>	<b>3272</b>	<b>918</b>	<b>751</b>	<b>1561</b>	<b>1272</b>	<b>1715</b>	<b>1581</b>

Appendix 5. Taxonomic composition and emergence rate of holo/meroplankton at Cayo Conserva, La Parguera sampled by demersal traps during day in new moon on *Thalassia* beds.

Positions: 17°57.889'N, 057° 03.758'W

Area Traps: 0.17m<sup>2</sup>

<b>Holoplankton Taxa</b>	<b>Jun 06</b> Ind/m <sup>2</sup>	<b>Jul 06</b> Ind/m <sup>2</sup>	<b>Aug 06</b> Ind/m <sup>2</sup>	<b>Oct 06</b> Ind/m <sup>2</sup>	<b>Nov 06</b> Ind/m <sup>2</sup>	<b>Dec 06</b> Ind/m <sup>2</sup>	<b>Mean</b> Ind/m <sup>2</sup>
Calanoid Copepods	49	46	37	138	30	129	71
Cyclopoid Copepods	20	8	0	0	1	8	6
Harpacticoid Copepods	317	144	111	113	143	307	189
Chaetognath Worms	6	8	5	9	1	9	6
Larvaceans	17	27	11	4	43	57	26
Sergestoid Shrimps	1	2	0	0	0	0	0
Isopods	0	1	0	0	1	3	1
Ostracods	49	12	15	2	6	3	15
Cumaceans	0	6	0	3	1	0	2
Amphipods	371	73	25	15	9	8	83
Medusae	2	5	10	6	3	7	5
<b>Total Holoplankton</b>	<b>833</b>	<b>331</b>	<b>214</b>	<b>291</b>	<b>237</b>	<b>529</b>	<b>406</b>
<b>Meroplankton Taxa</b>	<b>Jun 06</b> Ind/m <sup>2</sup>	<b>Jul 06</b> Ind/m <sup>2</sup>	<b>Aug 06</b> Ind/m <sup>2</sup>	<b>Oct 06</b> Ind/m <sup>2</sup>	<b>Nov 06</b> Ind/m <sup>2</sup>	<b>Dec 06</b> Ind/m <sup>2</sup>	<b>Mean</b> Ind/m <sup>2</sup>
Decapod Larvae							
Caridean	0	18	7	3	3	2	5
Brachyuran	1	2	0	3	0	0	1
Gastropod Veliger Larvae	12	6	6	11	6	13	9
Bivalve Veliger Larvae	0	8	0	0	0	1	1
Polychaete Larvae	1	5	1	3	1	5	3
Cirriped Larvae	3	6	0	0	0	2	2
Ascidean Larvae	2	0	0	2	0	0	1
Ophiuroid Larvae	1	4	4	2	4	5	3
Quiton	0	1	0	0	0	0	0
<b>Fish Eggs</b>	<b>0.0</b>	<b>0.0</b>	<b>0.0</b>	<b>0.0</b>	<b>0.0</b>	<b>0.0</b>	<b>0.0</b>
<b>Fish Larvae</b>	<b>2.9</b>	<b>0.0</b>	<b>0.0</b>	<b>0.0</b>	<b>0.0</b>	<b>0.0</b>	<b>0.5</b>
Unidentified	2.9	0.0	0.0	0.0	0.0	0.0	0.5
<b>Total Fish Larvae</b>	<b>2.9</b>	<b>0.0</b>	<b>0.0</b>	<b>0.0</b>	<b>0.0</b>	<b>0.0</b>	<b>0.5</b>
<b>Total Meroplankton</b>	<b>22</b>	<b>49</b>	<b>17</b>	<b>23</b>	<b>13</b>	<b>28</b>	<b>25</b>
<b>Total Zooplankton</b>	<b>855</b>	<b>380</b>	<b>232</b>	<b>314</b>	<b>251</b>	<b>557</b>	<b>431</b>

Appendix 6. Taxonomic composition and emergence rate of holo/meroplankton at Cayo Conserva, La Parguera sampled by demersal traps at night in new moon on *Thalassia* beds.

Positions: 17°57.889'N, 057° 03.758'W

Area Traps: 0.17m<sup>2</sup>

<b>Holoplankton Taxa</b>	<b>Jun 06</b> Ind/m <sup>2</sup>	<b>Jul 06</b> Ind/m <sup>2</sup>	<b>Aug 06</b> Ind/m <sup>2</sup>	<b>Oct 06</b> Ind/m <sup>2</sup>	<b>Nov 06</b> Ind/m <sup>2</sup>	<b>Dec 06</b> Ind/m <sup>2</sup>	<b>Mean</b> Ind/m <sup>2</sup>
Calanoid Copepods	84	129	164	104	267	596	224
Cyclopoid Copepods	7	37	34	16	48	29	28
Harpacticoid Copepods	809	371	573	893	1005	664	719
Chaetognath Worms	18	26	22	59	21	28	29
Larvaceans	0	3	5	1	4	2	2
Isopods	0	1	17	67	33	10	21
Mysids	0	0	2	30	3	0	6
Ostracods	35	24	23	34	31	13	27
Cumaceans	0	6	5	12	5	5	5
Amphipods	287	296	297	339	166	216	267
Medusae	30	38	25	20	21	18	25
<b>Total Holoplankton</b>	<b>1269</b>	<b>930</b>	<b>1167</b>	<b>1575</b>	<b>1603</b>	<b>1580</b>	<b>1354</b>
<b>Meroplankton Taxa</b>							
	<b>Jun 06</b> Ind/m <sup>2</sup>	<b>Jul 06</b> Ind/m <sup>2</sup>	<b>Aug 06</b> Ind/m <sup>2</sup>	<b>Oct 06</b> Ind/m <sup>2</sup>	<b>Nov 06</b> Ind/m <sup>2</sup>	<b>Dec 06</b> Ind/m <sup>2</sup>	<b>Mean</b> Ind/m <sup>2</sup>
Decapod Larvae							
Anomuran	0	0	0	1	0	0	0
Caridean	0	12	6	32	102	45	33
Brachyuran	0	4	4	6	3	1	3
Gastropod Veliger Larvae	18	10	5	7	7	3	8
Bivalve Veliger Larvae	39	0	0	0	0	0	7
Polychaete Larvae	22	13	18	77	7	75	35
Cirriped Larvae	3	1	0	0	0	0	1
<b>Fish Eggs</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>0</b>
<b>Fish Larvae</b>	<b>0.0</b>	<b>0.0</b>	<b>0.0</b>	<b>0.0</b>	<b>0.0</b>	<b>71.1</b>	<b>11.9</b>
Gobiidae	0.0	0.0	0.0	0.0	0.0	1.0	0.2
Unidentified	0.0	0.0	0.0	0.0	0.0	70.1	11.7
<b>Total Fish Larvae</b>	<b>0.0</b>	<b>0.0</b>	<b>0.0</b>	<b>0.0</b>	<b>0.0</b>	<b>71.1</b>	<b>11.9</b>
<b>Total Meroplankton</b>							
	<b>84</b>	<b>42</b>	<b>34</b>	<b>122</b>	<b>118</b>	<b>198</b>	<b>100</b>
<b>Total Zooplankton</b>	<b>1353</b>	<b>972</b>	<b>1201</b>	<b>1697</b>	<b>1721</b>	<b>1778</b>	<b>1454</b>

Appendix 7. Taxonomic composition and emergence rate of holo/meroplankton at Cayo Conserva, La Parguera sampled by demersal traps during day in full moon on sandy substrates.

Positions: 17°57.889'N, 057° 03.758'W

Area Traps: 0.17m<sup>2</sup>

<b>Holoplankton Taxa</b>	<b>Jun 06</b> Ind/m <sup>2</sup>	<b>Jul 06</b> Ind/m <sup>2</sup>	<b>Aug 06</b> Ind/m <sup>2</sup>	<b>Oct 06</b> Ind/m <sup>2</sup>	<b>Nov 06</b> Ind/m <sup>2</sup>	<b>Dec 06</b> Ind/m <sup>2</sup>	<b>Mean</b> Ind/m <sup>2</sup>
Calanoid Copepods	21	21	18	6	15	31	19
Cyclopoid Copepods	9	1	2	0	4	5	3
Harpacticoid Copepods	98	111	37	33	62	39	63
Copepod Nauplii	1	0	0	0	0	0	0
Chaetognath Worms	2	7	1	3	23	8	7
Larvaceans	40	21	13	13	47	20	26
Isopods	0	0	0	0	1	0	0
Ostracods	0	8	7	3	12	6	6
Cumaceans	1	4	8	1	0	3	3
Amphipods	0	11	14	5	1	7	6
Medusae	1	8	2	6	9	6	5
<b>Total Holoplankton</b>	<b>173</b>	<b>191</b>	<b>102</b>	<b>69</b>	<b>175</b>	<b>124</b>	<b>139</b>
<b>Meroplankton Taxa</b>							
	<b>Jun 06</b> Ind/m <sup>2</sup>	<b>Jul 06</b> Ind/m <sup>2</sup>	<b>Aug 06</b> Ind/m <sup>2</sup>	<b>Oct 06</b> Ind/m <sup>2</sup>	<b>Nov 06</b> Ind/m <sup>2</sup>	<b>Dec 06</b> Ind/m <sup>2</sup>	<b>Mean</b> Ind/m <sup>2</sup>
Decapod Larvae							
Caridean	0	2	12	0	0	3	3
Brachyuran	0	0	4	0	0	0	1
Gastropod Veliger Larvae	14	27	29	2	6	5	14
Bivalve Veliger Larvae	2	7	4	0	0	1	2
Polychaete Larvae	11	5	12	2	3	9	7
Cirriped Larvae	1	0	0	0	0	0	0
Ophiuroid Larvae	3	6	1	17	6	0	5
<b>Fish Eggs</b>	<b>0.0</b>	<b>0.0</b>	<b>0.0</b>	<b>0.0</b>	<b>0.0</b>	<b>0.0</b>	<b>0.0</b>
<b>Fish Larvae</b>	<b>0.0</b>	<b>0.0</b>	<b>0.0</b>	<b>0.0</b>	<b>0.0</b>	<b>0.0</b>	<b>0.0</b>
<b>Total Fish Larvae</b>	<b>0.0</b>	<b>0.0</b>	<b>0.0</b>	<b>0.0</b>	<b>0.0</b>	<b>0.0</b>	<b>0.0</b>
<b>Total Meroplankton</b>							
	<b>31</b>	<b>46</b>	<b>65</b>	<b>21</b>	<b>14</b>	<b>17</b>	<b>33</b>
<b>Total Zooplankton</b>	<b>204</b>	<b>237</b>	<b>167</b>	<b>90</b>	<b>189</b>	<b>141</b>	<b>171</b>

Appendix 8. Taxonomic composition and emergence rate of holo/meroplankton at Cayo Conserva, La Parguera sampled by demersal traps during night in full moon on sandy substrates.

Positions: 17°57.889'N, 057° 03.758'W

Area Traps: 0.17m<sup>2</sup>

<b>Holoplankton Taxa</b>	<b>Jun 06</b> Ind/m <sup>2</sup>	<b>Jul 06</b> Ind/m <sup>2</sup>	<b>Aug 06</b> Ind/m <sup>2</sup>	<b>Oct 06</b> Ind/m <sup>2</sup>	<b>Nov 06</b> Ind/m <sup>2</sup>	<b>Dec 06</b> Ind/m <sup>2</sup>	<b>Mean</b> Ind/m <sup>2</sup>
Calanoid Copepods	16	347	1473	532	344	549	543
Cyclopoid Copepods	8	14	12	15	9	12	12
Harpacticoid Copepods	677	210	197	558	272	304	370
Chaetognath Worms	6	8	10	8	21	5	9
Larvaceans	0	0	1	1	20	2	4
Isopods	1	0	1	10	6	1	3
Mysids	0	0	8	2	8	2	3
Ostracods	59	20	34	40	40	29	37
Cumaceans	108	48	62	66	34	23	57
Amphipods	306	86	110	157	70	51	130
Medusae	5	14	14	28	21	16	16
<b>Total Holoplankton</b>	<b>1185</b>	<b>748</b>	<b>1921</b>	<b>1417</b>	<b>844</b>	<b>993</b>	<b>1223</b>
<b>Meroplankton Taxa</b>							
	<b>Jun 06</b> Ind/m <sup>2</sup>	<b>Jul 06</b> Ind/m <sup>2</sup>	<b>Aug 06</b> Ind/m <sup>2</sup>	<b>Oct 06</b> Ind/m <sup>2</sup>	<b>Nov 06</b> Ind/m <sup>2</sup>	<b>Dec 06</b> Ind/m <sup>2</sup>	<b>Mean</b> Ind/m <sup>2</sup>
Decapod Larvae							
Caridean	0	2	5	20	17	3	8
Brachyuran	0	0	16	1	2	2	4
Gastropod Veliger Larvae	37	20	36	9	9	24	22
Bivalve Veliger Larvae	15	6	0	0	4	0	4
Polychaete Larvae	26	79	92	142	102	113	92
Cirriped Larvae	3	1	0	0	4	2	2
Ascidean Larvae	1	0	0	0	0	0	0
Ophiuroid Larvae	4	0	0	3	6	4	3
Trematode Worm	0	0	0	2	0	0	0
<b>Fish Eggs</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>0</b>
<b>Fish Larvae</b>	<b>1.0</b>	<b>0.0</b>	<b>0.0</b>	<b>0.0</b>	<b>1.0</b>	<b>0.0</b>	<b>0.3</b>
Unknown	1.0	0.0	0.0	0.0	1.0	0.0	0.3
<b>Total Fish Larvae</b>	<b>1.0</b>	<b>0.0</b>	<b>0.0</b>	<b>0.0</b>	<b>1.0</b>	<b>0.0</b>	<b>0.3</b>
<b>Total Meroplankton</b>							
	<b>87</b>	<b>108</b>	<b>149</b>	<b>177</b>	<b>144</b>	<b>148</b>	<b>135</b>
<b>Total Zooplankton</b>	<b>1273</b>	<b>856</b>	<b>2070</b>	<b>1594</b>	<b>988</b>	<b>1141</b>	<b>1320</b>

Appendix 9. Taxonomic composition and emergence rate of holo/meroplankton at Cayo Conserva, La Parguera sampled by demersal traps during day in new moon on sandy substrates.

Positions: 17°57.889'N, 057° 03.758'W

Area Traps: 0.17m<sup>2</sup>

<b>Holoplankton Taxa</b>	<b>Jun 06</b> Ind/m <sup>2</sup>	<b>Jul 06</b> Ind/m <sup>2</sup>	<b>Aug 06</b> Ind/m <sup>2</sup>	<b>Oct 06</b> Ind/m <sup>2</sup>	<b>Nov 06</b> Ind/m <sup>2</sup>	<b>Dec 06</b> Ind/m <sup>2</sup>	<b>Mean</b> Ind/m <sup>2</sup>
Calanoid Copepods	24	39	38	47	21	37	34
Cyclopoid Copepods	0	1	6	5	0	2	2
Harpacticoid Copepods	69	14	30	74	61	47	49
Chaetognath Worms	8	12	9	9	2	2	7
Larvaceans	33	19	5	6	32	24	20
Isopods	0	0	0	1	0	1	0
Foraminiferans	5	0	0	0	0	0	1
Ostracods	13	1	12	4	7	5	7
Cumaceans	0	0	1	1	0	0	0
Amphipods	14	8	9	3	5	3	7
Medusae	2	6	6	10	5	4	5
<b>Total Holoplankton</b>	<b>168</b>	<b>101</b>	<b>114</b>	<b>159</b>	<b>133</b>	<b>124</b>	<b>133</b>
<b>Meroplankton Taxa</b>							
	<b>Jun 06</b> Ind/m <sup>2</sup>	<b>Jul 06</b> Ind/m <sup>2</sup>	<b>Aug 06</b> Ind/m <sup>2</sup>	<b>Oct 06</b> Ind/m <sup>2</sup>	<b>Nov 06</b> Ind/m <sup>2</sup>	<b>Dec 06</b> Ind/m <sup>2</sup>	<b>Mean</b> Ind/m <sup>2</sup>
Decapod Larvae							
Caridean	0	0	18	1	0	7	4
Brachyuran	0	5	1	0	0	1	1
Gastropod Veliger Larvae	43	4	8	22	2	12	15
Bivalve Veliger Larvae	1	1	0	1	1	0	1
Polychaete Larvae	4	6	2	5	2	2	3
Ophiuroid Larvae	0	2	0	0	12	0	2
<b>Fish Eggs</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>0</b>
<b>Fish Larvae</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>0</b>
<b>Total Fish Larvae</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>0</b>
<b>Total Meroplankton</b>							
	<b>50</b>	<b>17</b>	<b>30</b>	<b>29</b>	<b>17</b>	<b>23</b>	<b>28</b>
<b>Total Zooplankton</b>	<b>218</b>	<b>118</b>	<b>144</b>	<b>187</b>	<b>150</b>	<b>147</b>	<b>161</b>

Appendix 10. Taxonomic composition and emergence rate of holo/meroplankton at Cayo Conserva, La Parguera sampled by demersal traps during night in new moon on sandy substrates.

Positions: 17°57.889'N, 057° 03.758'W

Area Traps: 0.17m<sup>2</sup>

<b>Holoplankton Taxa</b>	<b>Jun 06</b> Ind/m <sup>2</sup>	<b>Jul 06</b> Ind/m <sup>2</sup>	<b>Aug 06</b> Ind/m <sup>2</sup>	<b>Oct 06</b> Ind/m <sup>2</sup>	<b>Nov 06</b> Ind/m <sup>2</sup>	<b>Dec 06</b> Ind/m <sup>2</sup>	<b>Mean</b> Ind/m <sup>2</sup>
Calanoid Copepods	1341	649	1766	968	390	979	1016
Cyclopoid Copepods	41	13	18	21	30	34	26
Harpacticoid Copepods	242	188	302	537	269	451	332
Chaetognath Worms	16	11	10	11	10	2	10
Larvaceans	4	0	0	0	3	2	1
Sergestoid Shrimps	2	8	0	0	0	0	2
Isopods	0	0	5	4	9	1	3
Mysids	0	0	12	13	12	4	7
Ostracods	78	32	18	37	68	33	44
Cumaceans	34	40	49	55	47	21	41
Amphipods	91	216	96	143	65	112	121
Medusae	14	18	9	11	20	11	14
<b>Total Holoplankton</b>	<b>1864</b>	<b>1176</b>	<b>2284</b>	<b>1800</b>	<b>922</b>	<b>1649</b>	<b>1616</b>
<b>Meroplankton Taxa</b>							
	<b>Jun 06</b> Ind/m <sup>2</sup>	<b>Jul 06</b> Ind/m <sup>2</sup>	<b>Aug 06</b> Ind/m <sup>2</sup>	<b>Oct 06</b> Ind/m <sup>2</sup>	<b>Nov 06</b> Ind/m <sup>2</sup>	<b>Dec 06</b> Ind/m <sup>2</sup>	<b>Mean</b> Ind/m <sup>2</sup>
Decapod Larvae							
Caridean	0	19	34	21	81	3	26
Brachyuran	1	221	0	13	2	3	40
Gastropod Veliger Larvae	12	14	17	12	5	9	11
Bivalve Veliger Larvae	2	0	0	17	0	3	4
Polychaete Larvae	33	63	31	66	45	86	54
Cirriped Larvae	0	2	0	0	0	2	1
Ophiuroid Larvae	0	0	0	1	4	4	1
Salt Water Mite	1	0	0	0	0	0	0
Plathyelminthes	0	0	2	0	2	0	1
<b>Fish Eggs</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>0</b>
<b>Fish Larvae</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>0</b>
<b>Total Fish Larvae</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>0</b>
<b>Total Meroplankton</b>							
	<b>48</b>	<b>320</b>	<b>84</b>	<b>131</b>	<b>138</b>	<b>110</b>	<b>138</b>
<b>Total Zooplankton</b>	<b>1912</b>	<b>1496</b>	<b>2368</b>	<b>1931</b>	<b>1061</b>	<b>1759</b>	<b>1754</b>