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Patterns in Macrofaunal Abundance and Biodiversity at Sites in the Florida Keys

Cydney Wolff

ABSTRACT

Coral reef health in the Florida Keys, USA has been declining in recent years. To gain an understanding of the current state of macrofaunal abundance and biodiversity on these reefs, research was conducted to identify and count the macrofauna colonizing standardized settlement plates at two coral reef sites, one in the middle (Delta Shoal) and one in the lower (Pelican Shoal) Florida Keys. Plates were deployed for a one-month period in June 2023. At each site, the plates were placed at two heights: ocean bottom and 2 m above ocean bottom (two plates per height per site for a total of 8 plates). Across all plates, a total of ~6,000 organisms were identified. The mean (±SD) macrofauna count was 744 (±230) individuals per plate. The macrofauna identified represented seven animal phyla: Annelida, Arthropoda, Chaetognatha, Chordata, Cnidaria, Echinodermata, and Mollusca. No discernable patterns were observed in the abundance and biodiversity of macrofauna between sites or plate heights. These baseline data could be useful for tracking future monthly or annual changes in macrofaunal abundance and biodiversity at these reefs.

Keywords: macrofauna, abundance, biodiversity, coral reefs, Florida Keys

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Patterns in Macrofaunal Abundance and Biodiversity at Sites in the Florida Keys

by

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CONTENTS

INTRODUCTION

Coral reefs in the Florida Keys, USA have been losing their biodiversity, which has had negative implications for their ecological health (Toth et al., 2022). This is occurring within a backdrop of regionally declining coral reef ecosystems, with Caribbean reefs experiencing an estimated average 80% loss in stony coral cover (Gardner et al., 2003). Many people rely on healthy coral reefs as a source of essential resources, and therefore, these changes are concerning from a socioeconomic perspective (Rivera et al., 2020). Indeed, biodiversity in general is extremely important for supporting human lives and livelihoods (Raven et al., 2020; Hong et al., 2022). In particular, it is useful to understand the abundance and biodiversity of marine macrofauna on coral reefs, as these organisms are key indicators of the structure and health of the ecosystem (Gaines & Roughgarden, 1985).

Settlement plates are a standardized substrate that marine macrofauna will colonize and are therefore a good resource to study patterns in macrofaunal abundance and biodiversity on coral reefs (Feehan et al., 2019). Marine macrofauna are diverse organisms, 250 µm to 1 cm in size, and can include isopods, amphipods, and small gastropods and worms, among other taxa (Crew, 2017). Settlement plates that are made out of artificial plastic turf have been used in the past to mimic the algal turf environment of the coral reef to attract settling sea urchin larvae (Feehan et al. 2019). Research that has been conducted in the past with these collectors has focused on the settlement of sea urchins at coral reefs, as they are important in consuming the macroalgae that compete with corals (Feehan et al. 2019). However, the abundance and biodiversity of other taxa settling alongside the sea urchins has not been explored.

Here, plastic turf settlement plates were used to census the macrofauna at coral reef sites in the Florida Keys. This research occurred as part of a broader field sampling program aimed at measuring sea urchin settlement rates on these plates. The research had two main objectives: 1) to catalog all macrofauna occurring on settlement plates at two depths (ocean bottom and 2 m above ocean bottom) at each of two field sites (Delta Shoal and Pelican Shoal) and 2) to measure the abundance and biodiversity of the macrofauna across depths and sites. It was expected that Pelican Shoal (in the lower Keys) may have a greater abundance and biodiversity of macrofauna than Delta Shoal (in the middle Keys), given Pelican Shoal's closer proximity to currents originating from the Caribbean (Figure 1). It was further expected that the top plates, furthest above the ocean floor, would be colonized by taxa with greater swimming capacities (e.g., copepods, amphipods, shrimp, or isopods) (Figure 2). By studying macrofaunal abundance and biodiversity at these reefs, I can provide baseline data as a first step towards supporting conservation efforts in this region to retain this abundance and biodiversity.

METHODS

To catalog macrofauna and measure abundance and biodiversity, settlement plates were deployed in the month of June 2023 by divers at the Florida Fish and Wildlife Conservation Commission at each of two coral reef sites: Delta Shoal - in the Middle Keys - and Pelican Shoal - in the Lower Keys (Figure 1). Previous research in the Florida Keys indicated a peak in the abundance of sea urchin settlers in the month of June linked to the passage of an ocean eddy (Feehan et al. 2019), therefore, this research also focused on the month of June.

Two settlement plates were sampled at each site at each of two heights above bottom: 0 m above bottom (bottom plates) and 2 m above bottom (top plates) (Figure 2), yielding a total of eight plates across two sites and two plate heights. The settlement plates were secured in the water column on a rope held up by a subsurface buoy and weighed down with a concrete block on sandy bottom near the reef (Figure 2). The plates were left in the water column for ~1 month to collect settling macrofauna, which may include recently metamorphosed juveniles of species with planktonic larvae, such as sea urchins and molluscs. Mobile life stages of species such as isopods were also expected to be collected on the plates. Yet, highly mobile species, such as post-larval fishes, were not expected to be sampled on the plates given that the artificial turf does not trap mobile species. Following collection of the plates after a month by divers, the plates were immediately stored in 70% ethanol and shipped to the Feehan Lab at Montclair State University, where they were stored at 4°C until sample analysis.

Samples were sorted for macrofauna under a dissecting microscope. Small amounts of sample were searched at a time by using a petri dish with a marked ~10x10 grid of 1 cm squares. The dish was searched in a zig-zag pattern, starting at the leftmost top square, and moving down to the bottom in a left to right pattern to avoid double counting. Each square was stopped under the viewpoint of the microscope and the sample inside was carefully probed through to count the number and type of macrofauna present. Each time a macrofaunal organism was identified, a count was added to a corresponding column on a datasheet.

Photographs were taken of each type-organism when first encountered, and a stage micrometer was used to add a scale bar to the photographs. The following guidebooks were used to identify the organisms: Meglitsch (1972), Kaplan (1982), and Newell and Newell (1963). Macrofauna were identified to taxonomic levels ranging from Phylum, Class, Superclass, Subclass, Order, and Infraorder, depending on the identity of the macrofauna and to what level it could be definitively identified based on morphology alone. These broad categories were considered appropriate given that the focus of the study was on broad patterns of macrofaunal abundance and biodiversity. After tallying the organisms in a sample, the sample was deposited into a labeled jar with ethanol for future storage. After sorting, all count data were transcribed into an Excel spreadsheet for analysis. Tables and pie charts were used to visualize the count data.

RESULTS AND DISCUSSION

The abundance of macrofauna ranged across the settlement plate samples from 511 to 1171 individuals per plate, with an overall mean (±SD) of 774 (±230) individuals per plate (Table 1). The biodiversity on the plates, in terms of the total taxonomic groups recorded, ranged from 9 to 13 taxa, with an overall mean of 11 (± 2) taxa (Table 1).

The most abundant taxonomic group on six out of eight of the settlement plates was the group 'other Malacostraca', which included all Class Malacostraca other than the infraorder Brachyura (true crabs), which was categorized separately (Figure 3,4). Class Bivalvia was the most abundant group on the two remaining plates (Figure 3,4). The second most abundant taxonomic group was Class Bivalvia on two plates, other Malacostraca on one plate, Subclass Copepoda on two plates, Class Polychaeta on one plate, and Class Gastropoda on two plates (Figure 3,4). Other groups observed included Phylum Chaetognatha, Class Tunicata, Class Scaphopoda, Class Ophiuroidea, Superclass Osteichthyes (only a single specimen), Subclass Cirripedia, Order Isopoda, Class Anthozoa, Order Nudibranchia, as well as limited other unknown taxa which could not be identified here (Figure 3,4).

Abundance values (total individuals per plate) were similar between the two sites (Delta Shoal range: 511–1003 individuals per plate; Pelican Shoal range: 526–1171 individuals per plate) (Table 1, Figure 3). Taxa richness (total number of taxa per plate) was also similar between the two sites (Delta Shoal range: 10–13 taxa; Pelican Shoal range: 9–12 taxa) (Table 1, Figure 3). Similarly, there were no obvious differences in abundance and biodiversity between settlement plate heights (Table 1, Figure 3).

The results of this study indicate that the macrofauna settling at two coral reef sites in the Florida Keys include a total of seven animal phyla: Chordata (Superclass Osteichthyes and Class Tunicata), Echinodermata (Class Ophiuroidea), Arthropoda (Class Malacostraca, Subclass Copepoda, Infraorder Brachyura, Subclass Cirripedia, and Order Isopoda), Annelida (Class Polychaeta), Mollusca (Class Bivalvia, Class Scaphopoda, Order Nudibranchia, and Class Gastropoda), Cnidaria (Class Anthozoa), and Chaetognatha. These include phyla dominated by marine predators (e.g., Chaetognatha) to deposit feeders and filter feeders (e.g., Cnidaria and Echinodermata) and animals that are often sessile (e.g., Phylum Cnidaria) to quite mobile (e.g., Phylum Arthropoda).

One may have expected the top plates, furthest above the ocean floor, to be colonized by taxa with greater swimming capacities (e.g., copepods, amphipods, shrimp, or isopods). Accordingly, all four of the top plates had “other Malacostraca” (namely, shrimps and amphipods) as the dominant taxa, while only two of four bottom plates showed this pattern. By contrast, sessile macrofauna, such as bivalves, which were dominant on two of the four bottom plates, have limited mobility and rely on ocean currents for transport to a settling location during the planktonic larval stage. Indeed, bivalves spend their adult life as sessile organisms, only flapping their shell to swim short distances as a means of escape from predators (Johnson, 2020).

High abundance of bivalves on the bottom plates could be related to colonization of these plates by settling bivalve larvae, which sink out of the water column as they undergo metamorphosis (Jonsson & Lindegarth 1991). Hence, there may have been a bivalve larval recruitment pulse during this study. Yet overall, there were no overwhelming patterns in either the abundance or biodiversity of taxa between plate heights, suggesting little effect on overall macrofaunal colonization of a substrate being 0 m versus 2 m above the ocean floor.

One may also have expected higher abundance and biodiversity at Pelican Shoal than Delta Shoal, as the currents moving west to east through the Florida Straits (from the Caribbean) would have reached Pelican Shoal in the lower Keys first, and therefore, metamorphosing larvae might be "filtered out" at the first-encountered reef (Adams et al., 2006). However, there were no apparent differences in the abundance and biodiversity of taxa between the two sites, suggesting a limited effect on macrofaunal colonization of the ~60 km distance between these sites in the lower and middle Keys. This could be due to the predominance in the dataset of mobile macrofauna, such as amphipods, shrimp, and polychaetes, that likely originate from the surrounding coral reef, rather than being transported to the sites by ocean currents. It should be noted that the stomach contents of the macrofauna were not included in the analysis here, and organisms were on occasion noted within the stomachs of predatory macrofauna.

In future research on this topic, different collection methods could possibly be tested to examine the effects on the abundance and biodiversity of macrofauna observed. For example, sampling of the natural reef habitat (e.g., suction sampling of the reef), alongside settlement plate sampling, could act to confirm how well these plates represent the natural abundance and biodiversity of macrofauna on a coral reef. Plankton nets to sample marine invertebrate larvae also could be informative in order to compare the local abundance of larvae to their appearance at the next life stage (metamorphosed juveniles) on the settlement plates. This could act to confirm the appropriateness of this substrate as a settling habitat to a broad range of species. Moreover, it is clear that different sampling methods would be required to sample coral reef fishes (i.e., fish traps), as the current plates are not designed to attract or trap these species. While the current study provides baseline information on the abundance and biodiversity of macrofauna in a single month, future research should also be conducted to expand this information to cover multiple months of the year, as prevailing seasonal patterns could affect patterns of colonization. Additionally, eDNA could be a useful tool to measure the full genetic diversity of the settlement plate samples to expand upon these findings (Senapati et al., 2019). Finally, to determine if there are any future changes in the abundance and biodiversity of the macrofauna, sampling should be continued at these sites over an ecologically relevant timeframe of years.

In conclusion, while it is unknown how well the settlement plates sampled here reflect natural abundance and biodiversity of macrofauna on Florida's reefs, the results provide a useful baseline for comparing abundance and biodiversity on these specific settlement plates in the future to measure changes in the macrofauna community. The apparent low influence on abundance and biodiversity of plate heights and site locations indicates uniform patterns in abundance and biodiversity in space and time, however future studies could examine these patterns in more detail by sampling more plates at additional depths, sites, and through time.

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TABLES AND FIGURES

Table 1. Abundance (total individuals per plate) and biodiversity (total taxonomic groups per plate) on each of two settlement plates (1 and 2) at each of two heights (top plates and bottom plates) at each of two field sites (Delta Shoal and Pelican Shoal).

Site	**Height-Plate number**	**Abundance (ind./plate)**	**Diversity (# taxonomic groups)**
Delta Shoal	Top-1	706	12
Delta Shoal	Top-2	1003	12
Delta Shoal	Bottom-1	709	13
Delta Shoal	Bottom-2	511	10
Pelican Shoal	Top-1	617	9
Pelican Shoal	Top-2	1171	13
Pelican Shoal	Bottom-1	526	10
Pelican Shoal	Bottom-2	710	10
Overall Mean (SD)		**744 (230)**	**11 (2)**

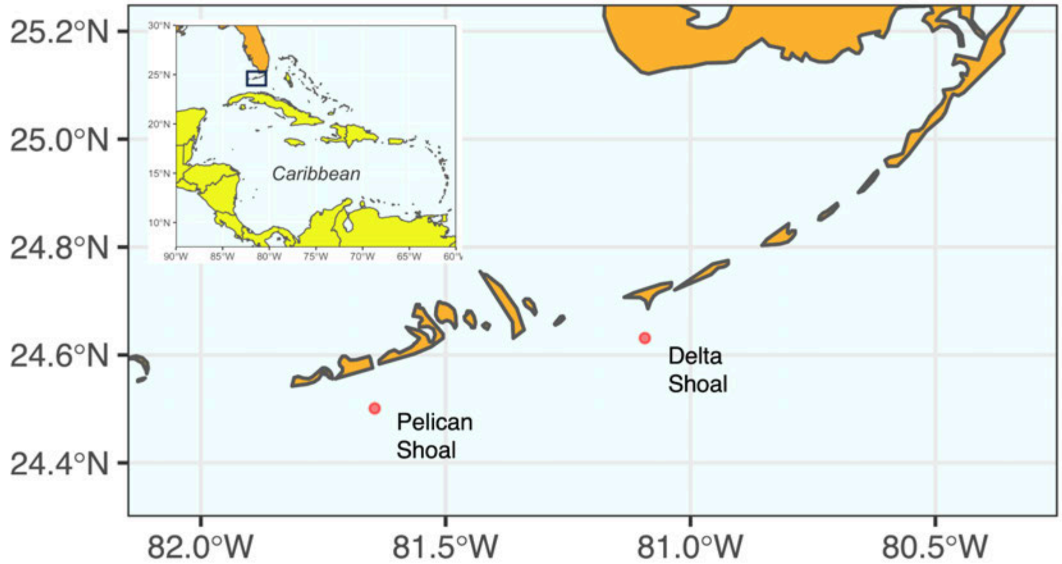

Figure 1. Map of field sites at Pelican Shoal (lower Keys) and Delta Shoal (middle Keys) in the Florida Keys and their relation to the Caribbean.

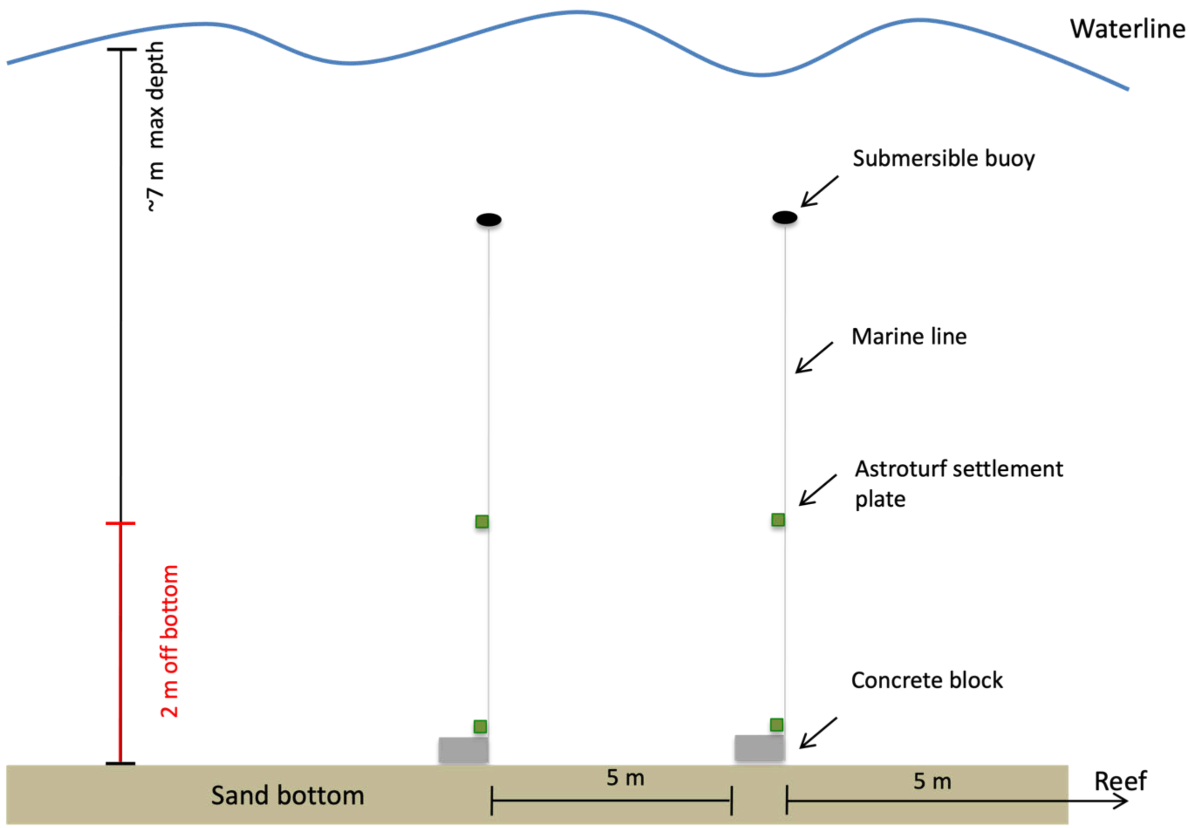

Figure 2. Diagram of settlement plate layout at a field site with plates positioned on two marine lines at both 0 and 2 m above bottom.

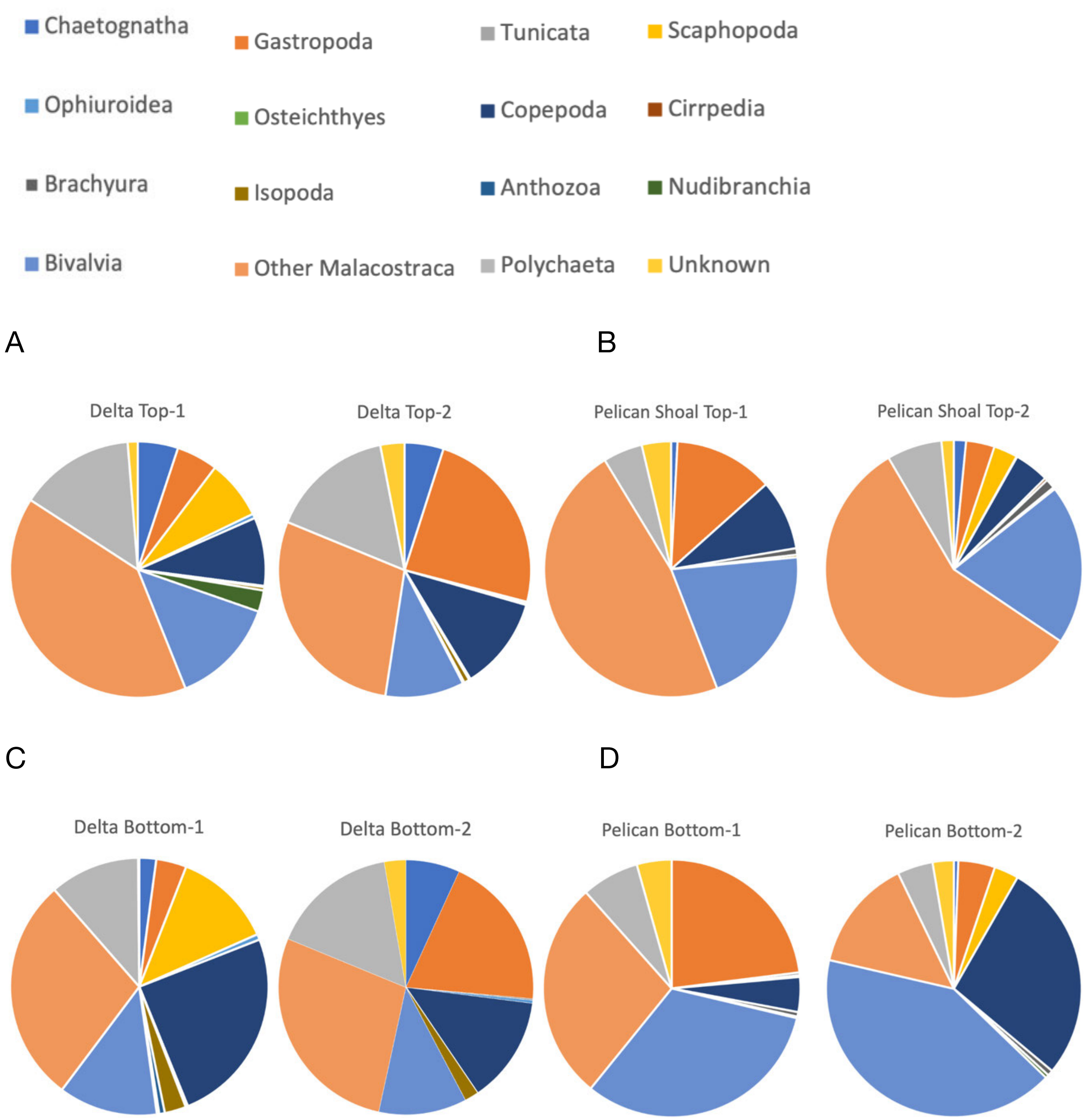

Figure 3. Pie charts of the percentage of each macrofauna taxa occurring in the two (1 and 2) Delta Shoal Top (A) and Bottom (C) and Pelican Shoal Top (B) and Bottom (D) settlement plate samples.

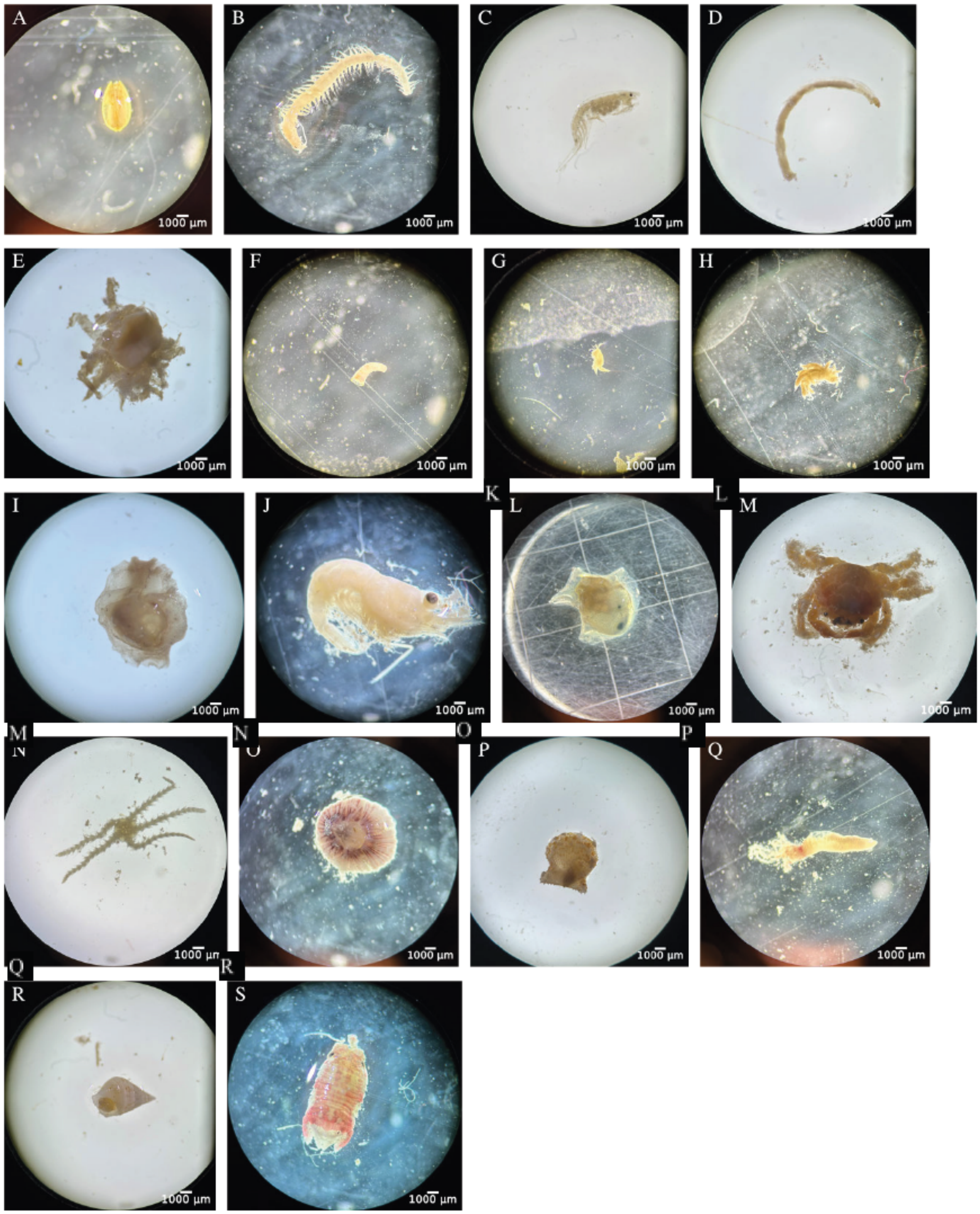

Figure 4. Microscope images of type-organisms from Florida Keys settlement samples. A. Class Bivalvia, B. Class Polychaeta, C. Class Malacostraca (Amphipod), D. Phylum Chaetognatha, E. Class Anthozoa, F. Class Scaphopoda, G. Subclass Copepoda, H. Order Nudibranchia, I. Order Nudibranchia, J. Class Malacostraca (Shrimp), K. Class Tunicata, L. Infraorder Brachyura, M.

Class Ophiuroidea, N. Subclass Cirripedia, O. Class Bivalvia, P. Class Polychaeta, Q. Class Gastropoda, R. Order Isopoda.