

## Abundance, size, and occurrence of *Arbacia stellata* in Orange County, California

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The geographic range of the sea urchin *Arbacia stellata* extends along the Pacific coast of North, Central and South America from southern California to Peru, and also includes the Galapagos Islands and the mainland and peninsular coasts of the Gulf of California (Mortensen 1935, Clark 1948, Brusca 1980, Houston 2006). *Arbacia stellata*, thought to be rare in southern California, is found in small numbers and often as single individuals (Morris et al. 1980, Carlton 2007). Given the scarcity of observations and data on density, size, or distribution, this paper presents some new insights on abundance, size, and occurrence of the species. Our observations show that *A. stellata* are locally more common at Laguna Beach, California than *Centrostephanus coronatus*, and the data suggest that *A. stellata* are not successfully reproducing in the area; instead, specimens of *A. stellata* are likely survivors from a previous recruitment event.

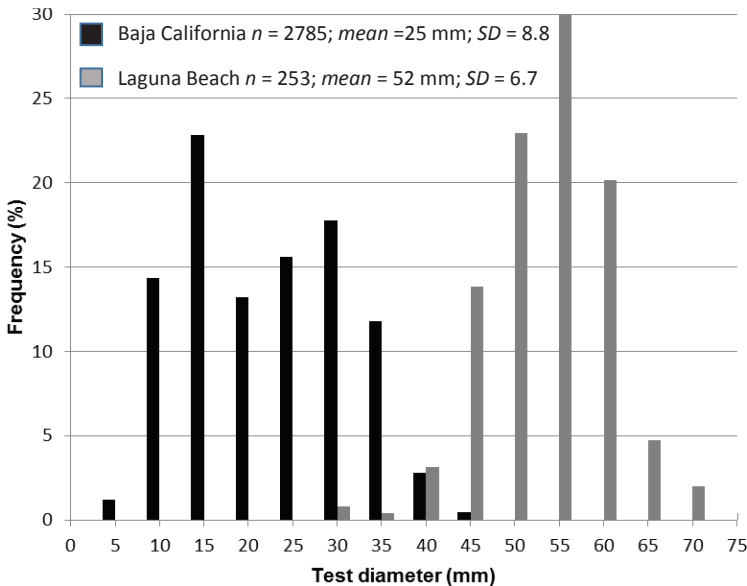
Sea urchins were collected in Orange County, California from 2007 to 2012 as part of a giant kelp (*Macrocystis pyrifera*) restoration project (Caruso 2007). One of the techniques employed was to reduce the number of sea urchins in a restoration area in order to lower grazing pressure on newly outplanted kelp. Working at depths ranging from 5 to 14 m, all sea urchins were removed from the restoration areas except those individuals that were tightly wedged in crevices and, thereby, difficult to collect. The collected urchins were tallied by species and relocated off-site in accordance with state permits.

Urchins were collected at six different restoration sites totaling 20,500 m<sup>2</sup> at Laguna Beach, California during the project, and those restoration sites are now within the boundaries of the Laguna Beach State Marine Reserve. *Arbacia stellata* was found at all the restoration sites. Among the four most commonly known sea urchin populations (*Strongylocentrotus franciscanus*, *Strongylocentrotus purpuratus*, *Centrostephanus coronatus*, *Lytechinus anamesus*), *A. stellata* was the third most abundant species at Laguna Beach (Table 1). At least one specimen was found in 56 of the 78 sea urchin collection events.

**TABLE 1.**—Densities, total numbers, and size ranges of five species of sea urchins collected at Laguna Beach, California, 2007–2012.

Species	Density (#/m <sup>2</sup> )	Total Number Collected	Size Range mm (n)
<i>S. purpuratus</i>	6	117,659	2 – 66 (1,909)
<i>S. franciscanus</i>	1	27,246	5 – 109 (1,461)
<i>A. stellata</i>	.01	291	29 – 72 (253)
<i>C. coronatus</i>	.002	38	54 – 65 (6)
<i>L. anamesus</i>	.0001	3	11 – 12 (2)
Total	7	145,237	

At Laguna Beach, *Arbacia stellata* were relatively large (29–72 mm) for the species. *A. stellata* is described as a small sea urchin with the majority of individuals in a population measuring  $\leq 30$  mm in test diameter (Clark 1948, Brusca 1980, Morris et al. 1980, Olguin 2004). However, 99.2% of the specimens collected at Laguna Beach were larger than 30 mm (Figure 1). Test diameters of *A. stellata* from Laguna Beach were compared to those from Baja California (Olguin 2004; as *A. inscisa*), the only comparable data available (Figure 1). The mean test diameter of *A. stellata* from Laguna Beach (52 mm) was significantly larger than the mean test diameters of Baja California populations (25 mm) (one-tailed *t*-test,  $P < 0.01$ ,  $t_{336} = 58.79$ ), and the size of the individuals collected at Laguna Beach did not change over time (Figure 2). During the observation period, we consistently found mean test diameters greater than 40 mm.



**FIGURE 1.**—Comparison of test diameters of *Arbacia stellata* populations from Baja California, Mexico and Laguna Beach, California. Baja California test diameters are from Gulf of California and Pacific Ocean populations May 1993, 1995, 1997 (Olguin 2004).

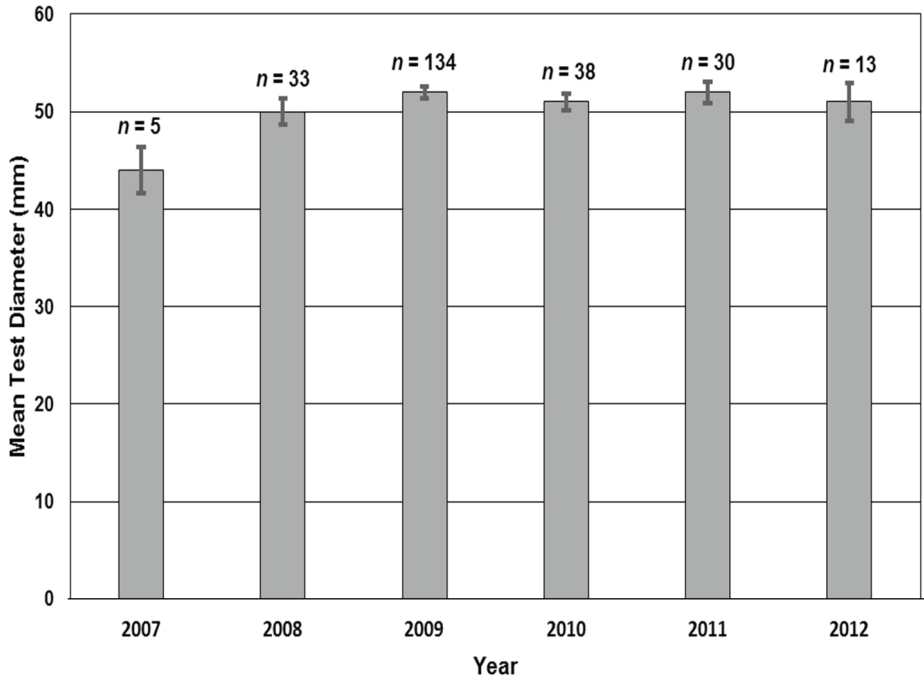


FIGURE 2.—Diameter ( $\bar{x} \pm SE$ ) of *Arbacia stellata* tests collected at Laguna Beach, California, 2007–2012.

In 2005, Lessios suggested that there are few *A. stellata* in Panama because the larvae may be traveling from “far away” places and settling out along the Panamanian coast. Emler (1995) reported that the larvae can take up to 22 days to settle in the laboratory. Engle and Richards (2001) reported the occurrence of *A. stellata* in the Channel Islands and concluded that, based on the timing of the species’ occurrence and size, larvae of individuals were most likely brought to these areas by warmer waters of the 1997–1998 El Niño.

The absence of juveniles and the existence of only larger sized individuals in the Laguna Beach populations of *A. stellata* suggest that the animals are older and possibly from previous warm water recruitment events. Our results further substantiate the findings of Engle and Richards (2001), who suggested that *A. stellata* may not be successfully reproducing in southern California but their presence may be the result of a recruitment event from warmer waters.

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