POPULATION REGULATION OF THE PURPLE SEA URCHIN, *STRONGYLOCENTROTUS PURPURATUS*, AT THE CALIFORNIA CHANNEL ISLANDS

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ABSTRACT

We studied purple urchin populations at the Channel Islands National Park at 16 sites from 1992 to 1998 to better understand factors associated with the abundance and distribution of this important grazer. Recruitment did not explain variation in adult abundance. Urchin abundance increased as invertebrate predators (sunflower stars and spiny lobsters) decreased. High urchin densities were subject to bacterial disease that impacted urchin abundance in a density-dependent fashion. Eastern sites typically had lower predator abundance, higher urchin abundance, and more frequent disease dynamics than western sites. An exception to this geographic pattern was a marine protected area at Anacapa Island with a high density of lobsters, a low density of urchins and a near absence of disease.

Keywords: Urchins, *Strongylocentrotus*, lobsters, disease, bacteria, recruitment, predation.

INTRODUCTION

Because of their importance in structuring kelp forests, we investigated the role of recruitment, natural enemies, and disease in the population dynamics of purple sea urchins (*Strongylocentrotus purpuratus*) at the California Channel Islands. Sea urchins are grazers that often live in crevices where they feed on drift algae (Harrold and Reed 1985). The role of sea urchins in kelp forest communities came to light when southern Californian kelp forests failed to recover from storm damage in the 1950s (Pearse et al. 1970). Normally, kelp recruitment follows storms and kelp forests recover in two or three seasons (Rosenthal et al. 1974). The discharge of raw sewage which sea urchins can utilize for nutrition (Pearse et al. 1970) appears to have led to increased urchin densities. Following the elimination of the source of drift algae, a subsequent formation of urchin "barrens" inhibited the recruitment of kelps (North and Pearse 1970). The recovery of many kelp forests took place in association with urchin control programs and improved sewage treatment (North 1983). The decline of sea otters, an important predator on sea urchins, has also led to the formation of urchin barrens where kelp forests were once present (Estes and Palmisano 1974). In addition to predation and food limitation, diseases have depressed urchin abundance in many areas around the world (Harrold and Pearse 1987). In some cases, these disease events have been catastrophic (Pearse and Hines 1987).

METHODS

We used data collected by the Channel Islands National Parks long-term kelp forest monitoring program (KFM). The Park established the KFM in 1982 (Davis et al., in prep.). The KFM annually samples sixteen sites from the north and south sides of Santa Barbara, Anacapa, Santa Cruz, Santa Rosa, and San Miguel islands. Each site consists of a 100-meter permanent transect. The KFM uses a variety of methods to quantify taxa such as urchins, sea stars, lobsters and fishes. Kushner et al. (1995a), Kushner et al. (1995b), Kushner et al. (1997a), Kushner et al. (1997b), Kushner et al. (in progress) describe each year's monitoring efforts and results from 1992 to 1998. For example, divers count urchin densities using quadrats spaced along each transect. The KFM divers informallycategorize the health of the urchin population as: disease free, fewer than five sick, between five and 25% sick, between 25% and 75% sick, and greater than 75% sick. The KFM collects recruitment data from caged concrete modules placed at ten of the sites. We classified individual purple urchins smaller than 15 mm as the young of the year's recruits.

The KFM also collects in situ temperature using data loggers that record temperature several times per day. We calculated monthly means from these data. We filled occasional gaps in the record by interpolating among sites and dates. In addition, we calculated the average temperature between the preceeding November through June and the average temperature between the following July through November.

RESULTS

There was a negative association among sites and years between urchin abundance and algal abundance. Warm southern sites tended to have high recruitment, but the year to year variation in recruitment at each site tended to decrease with increasing water temperature. Sites that received high recruitment did not necessarily have high adult abundance. Urchin abundance declined with the abundance of invertebrate predators but not fish predators. Disease was rare or absent at San Miguel and Santa Rosa islands. At Santa Cruz, Anacapa, and Santa Barbara islands, disease was common. Disease occurred at high densities but was surprisingly independent of water temperature. Diseased populations appeared food limited. Disease outbreaks tended to occur at higher than average densities at a site and were followed by a reduction in density the following year. Healthy populations showed the opposite trend (lower relative densities and a tendency to increase). At Landing Cove (Anacapa Island), a marine reserve, lobster abundances were relatively high, presumably due to restrictions on fishing. Urchin abundances at Landing Cove, as predicted by our analyses, were low, and disease was rare.

DISCUSSION

Our observation that the percent cover of algae declines with sea urchin density is consistent with other studies (Harrold and Pearse 1987) and implies that sea urchins can structure kelp forest communities at the Channel Islands. Although years with high recruitment lead to subsequent increases in urchin abundance, populations do not appear to be recruitment limited. The fact that the abundance of invertebrate predators is the factor most strongly associated with urchin abundance is consistent with observations of the former importance of lobster predation on urchins on the East Coast (Mann and Breen 1972). At northern sites, lobsters are rare and the sunflower star seems to be the most important urchin predator (also see Duggins 1983). At southern sites, spiny lobsters are potentially important but heavily fished in most areas. This is probably why urchins are presently more abundant in southern sites. In cases where sea urchins reach high densities, urchins may change the kelp forest to barrens. In a barrens situation, urchins may be starved and not be able to commit sufficient resources (such as acid phosphatase (Shimizu and Nagakura 1993)) to battling bacterial infections. High urchin densities may also increase the transmission efficiency of diseases among individuals. Finally, high densities may force urchins from their crevices in search of food, exposing them to surge which may kill them directly or damage them such that they are more susceptible to infection (Gilles and Pearse 1986). Sea urchin disease does not appear to be due to high temperatures. This lack of an association is true for other studies as well (Margosian et al. 1987). Declines in urchin density following disease events suggest that disease operates as a density dependent regulator of population density in cases where populations are released from predation. Only in marine reserves are lobsters apparently abundant enough to prevent sea urchins from reaching high abundance (G. E. Davis, unpublished) and experiencing disease dynamics.

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