

Population consequences of indeterminate growth in tropical sea urchin *Diadema antillarum*:

A Sea Urchin's Response to Mass-Mortalities

The tropical black sea urchin *Diadema antillarum* is well known in the Caribbean for its long and poisonous spines. Before 1983, it was abundant and had a profound influence on coral reef communities. This urchin grazed up to 20 percent of the reefs primary productivity (Hawkins and Lewis 1982), bioeroded large areas of the reef (Stern and Scoffin 1977), competed with herbivorous fish (Hay and Taylor 1985, Carpenter 1986), and influenced the successful settlement and survivorship of corals (Sammarco 1982). *Diadema* is an extremely influential species in the Caribbean.

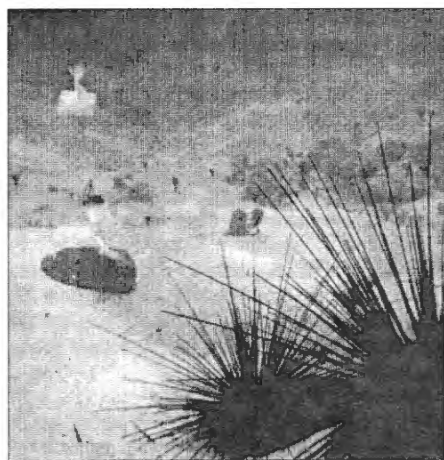
During 1983-84, a mass-mortality, due to an unknown pathogen, destroyed 99 percent of this species throughout the Caribbean (Lessios et al. 1984). With the help of the NPS in U.S. Virgin Islands, I have been investigating the population ecology of *Diadema* in an attempt to understand the dynamics which led up to and followed this unprecedented mortality event.

In the summer of 1983 (6 mo. prior to the mass-mortality), a census program was started on St. John, U.S. V.I. This monitoring effort indicated that *Diadema* exhibited an inverse relationship between body size and population density (Levitan 1988a). Laboratory and field experiments documented that this relationship was due to individual sea urchins adjusting body size by growing or shrinking based on food availability. Urchins growing or shrinking to a food- or density-dependent body size were not significantly different in measurements of test diameter, weight, gonad volume, or survivorship (Levitan, 1989a). Further experiments indicated that migration out of food-limited conditions on the reef was found to be disadvantageous, since predation pressure off the reef was significantly higher than on the reef (Levitan and Genovese, 1989).

These results may provide insight as to the rapid spread and magnitude of the mass-mortality. Increased population density, through planktonic settlement, results in reduced body size and not increased mortality (Levitan 1989a). Without density-dependent population regulation, population size increases unchecked. Previous to the mass-mortality this urchin was extremely abundant (i.e., 72/m² in Jamaica: Sammarco 1982). High population density may have facilitated the spread of the water-borne pathogen, by increasing the probability of urchin to urchin transmission (Lessios 1988, Levitan 1989a).

The monitoring program has continued on St. John, following the response of the surviving urchin population and its algal resource. By the summer of 1984 (6 mo. after the mass-mortality), urchin abundance had dropped from 15/m² to less than 0.1/m². The urchins resource, benthic algae, increased 3000 percent in biomass (Levitan 1988b). Since 1984, the surviving *Diadema* have increased in size dramatically. At present (June 1990), median urchin weight is over 300 g; an order of magnitude greater than the median weight of 20 g. previous to the mass-mortality (Levitan 1988b). Population density has not increased since 1984. Predictions suggested that this urchin would rapidly return to former abundances, since individuals were growing rapidly and producing large quantities of gametes. There are two probable reasons for the lack of juvenile recruitment.

The first reason involves the reproductive biology of *Diadema*. Sea urchins, like many marine invertebrates, release unfertilized eggs and sperm into the water. In order to guarantee a high rate of fertilization,



males and females must release gametes in close proximity to one another (Pennington 1985, Levitan 1989b). Following the mass-mortality, population density has been too low to insure fertilization success. Field experiments on St. John indicate that although urchins are now much larger and producing more gametes than before the mass-mortality, fertilization rates are so low that very few larvae are being produced (Levitan 1988c, 1989b).

The second reason for poor recruitment involves the scale of the mass-mortality. This event was widespread, affecting all Caribbean populations. If the event was local, other source populations could have restocked St. John; larval *Diadema* spend from 8 to 12 weeks in the plankton before settling (Carpenter personal communication). At present, the only known source population is in the Canary Islands, in the Eastern Atlantic (Lessios 1988). The only Caribbean island receiving substantial recruitment is Barbados, the eastern most Caribbean island (Hunte and Younglao, in press). It may be that larvae are traveling across the Atlantic and settling on Barbados (Carpenter personal communication). The high recruitment could also be due to island eddies keeping larvae produced at Barbados nearby, rather than dispersing them away (Hunte and Younglao, in press). If *Diadema* populations on Barbados can return to high enough densities, it may have a downstream cascading effect which could repopulate the rest of the Caribbean (Levitan 1989).

During the past year hurricane Hugo struck the Virgin Islands killing large numbers of *Diadema*. Adult population density declined almost an order of magnitude in many of the census sites. Fortunately, large numbers of urchins settled on St. John since the storm. Populations at such low numbers should be monitored carefully since the probability of local extinction is relatively high.

In any event, *Diadema antillarum* will not return to former densities for several decades, if at all. Since this species has a major influence on many reef processes, this suggests that Caribbean reefs will remain changed as well.

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