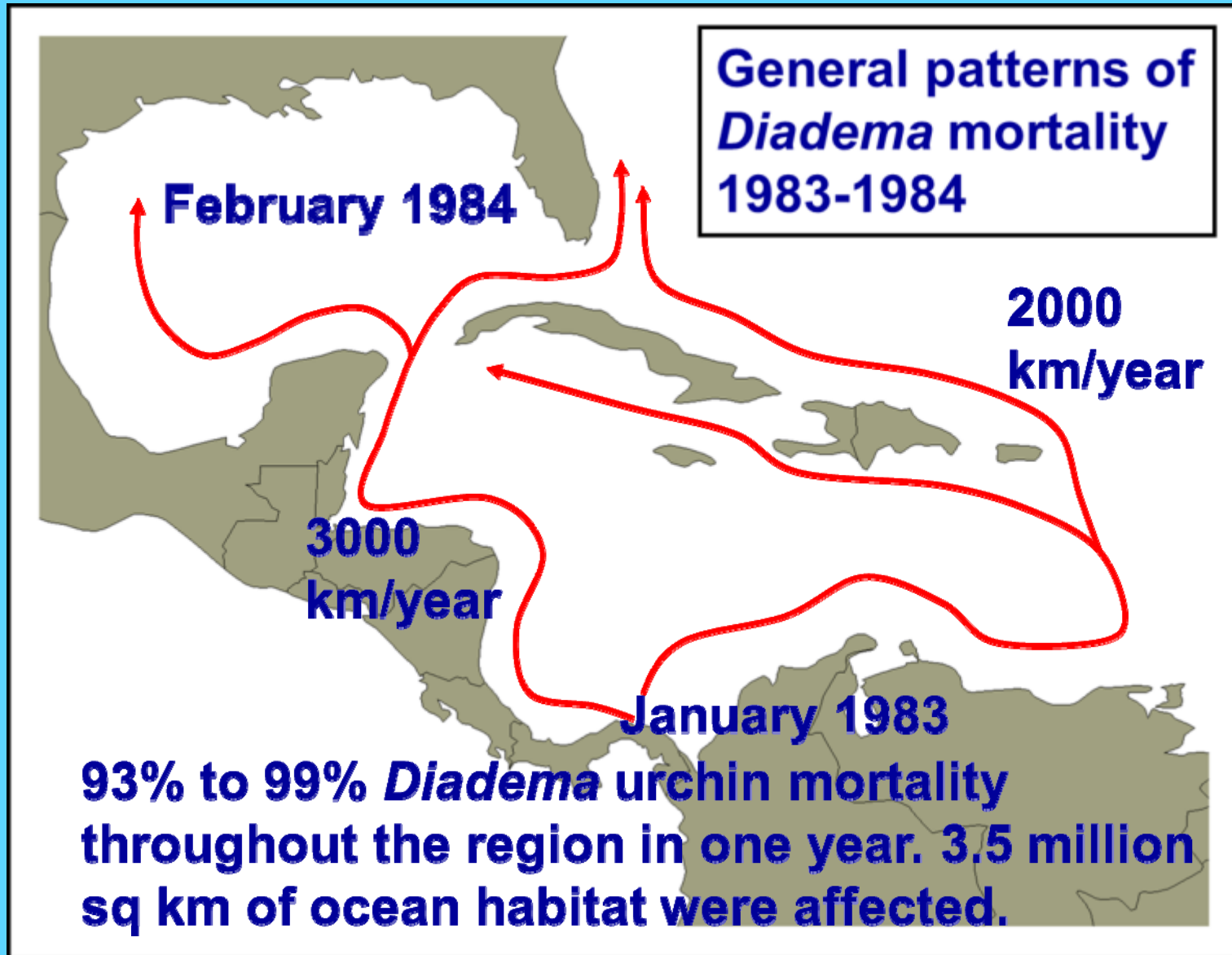


What larval culture of *Diadema antillarum*, the long-spined sea urchin, the keystone herbivore of western tropical Atlantic coral reefs, tells us about Keys water quality



Martin A. Moe

A disease in 1983 destroyed up to 98 percent of all the *Diadema* in this great area



They did not return. Macro algae quickly covered the reefs and out-competed corals for space and light. The benthic ecology of the reefs rapidly changed and *Diadema* and coral larvae could no longer settle and survive.

1980



2002



Our coral reefs can not be ecologically restored unless *Diadema* return to these reefs in ecologically functional numbers. After 32 years without the return of *Diadema*, hatchery culture to provide artificial recruitment to maintain effective *Diadema* populations on selected reefs is our best chance to restore the function of herbivory to our reefs.

The essentials of *Diadema* culture have been developed in my small lab and at the Mote Laboratory Summerland facility. Since 2008 hundreds of *Diadema* were reared to juveniles and some even to reproductively active adults at my lab, and thousands were reared through metamorphosis to early juveniles at the Mote facility in 2010 to 2012.



Moe lab



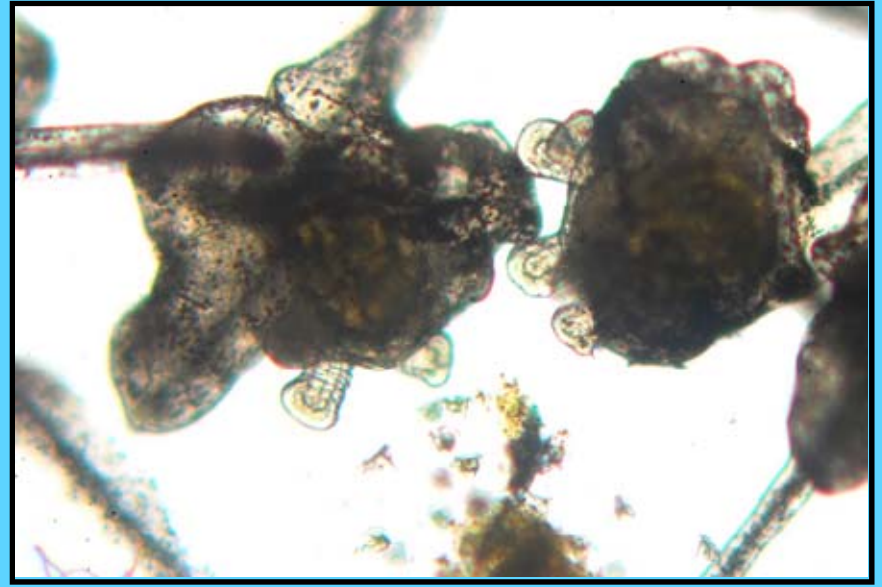
Mote lab

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Suddenly, in the summer of 2012, cultured larvae at both locations would not form rudiments. Rudiments are the formation of the juvenile urchin within the body of the larvae.

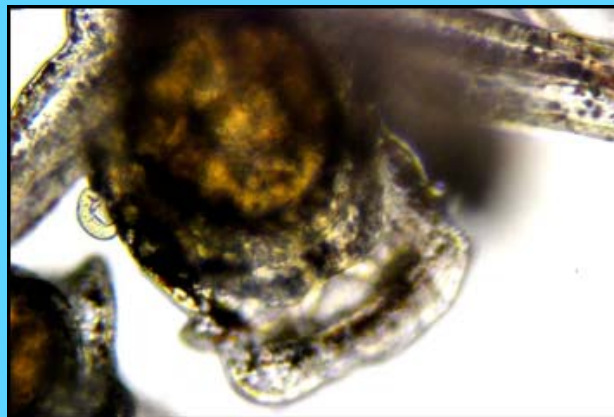


Day 40 larvae without rudiments, spawn of 1/5/2014



Day 32 larvae with mature rudiments, spawn of 2/8/2011

Two of the most critical events in larval sea urchin development are formation of the rudiment, and metamorphosis of the larvae into the early juvenile. “Communication” between organs and tissues through hormones is critical for normal larval development. Endocrine disrupting chemicals in extremely low concentrations in natural sea water could affect such development. Given the highly populated urban areas and extensive agriculture in South Florida, it is pretty much a certainty that endocrine disrupting chemicals are present at various times and at various concentrations in the near shore waters of the Florida Keys. Use of plastic nanoparticles in commercial products and medicine is also increasing. **And we have no idea what effects these chemicals may have on the ecology of our marine waters.**



Early rudiment formation



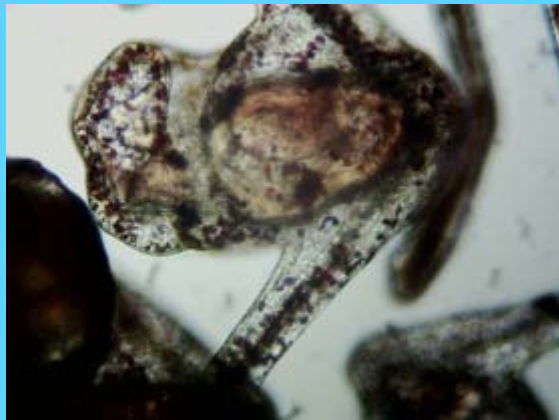
Mid stage metamorphosis

After 3 years of experimenting and failing to rear *Diadema* larvae through rudiment formation I decided to try an experiment to rear larvae in artificial sea water prepared with RO processed fresh water that could be tested against larvae from the same spawn reared in normally processed natural sea water. This experiment was conducted at my lab with *Diadema* larvae spawned on August 4, 2015. The spawn was shared with The Florida Aquarium at their Center for Conservation facility and the Mote lab on Summerland Key.

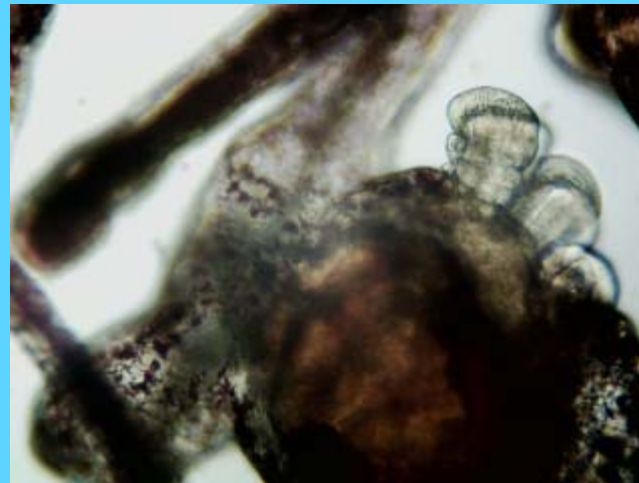


**Female releasing eggs on
August 4, 2015**

In my rearing run, the larvae in the artificial sea water did very well, grew normally and many, if not most larvae, developed strong rudiments, **whereas not a single larvae in natural sea water produced a rudiment**. The rearing run at the Florida Aquarium Center for Conservation also produced many larvae with late stage rudiment development in in offshore Gulf of Mexico water. The larvae at the Mote lab did not persist more than a few days, possibly due to low temperatures.



Day 36 larvae reared in natural sea water, no rudiments. 9/9/15



Day 36 larvae reared in artificial sea water, large rudiments 9/9/15

Day 35 larvae reared in offshore Gulf water, early metamorphosis



Although the results of these runs are only indicative, they do strongly point toward Florida Keys near shore waters as being not compatible with larval development of *Diadema* sea urchins, and if so, probably other organisms as well. The causative factor(s) for lack of normal development of *Diadema* larvae in Florida Keys waters since the summer of 2012 remains unknown, but in my opinion, endocrine disrupting chemicals are suspect.



Laboratory cultured juvenile *Diadema* on a strand of algae at day 57, spawn 3/20/12



Laboratory cultured juvenile *Diadema*
At day 153, spawn 3/20/12

Questions?