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Determining the Processes that Control Kelp Spore Abundance

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California's towering canopies of giant kelp are the structure and substance for many of the state's most commercially valuable fisheries. Sea urchins, lobsters, crabs, rockfish, sea cucumbers and abalone all call the amber giant kelp forest home. As a source of alginates, texture-enhancing compounds put in ice cream, paint and medicines, kelp is itself a commercially important marine product.

Despite the kelp forest's biological and economic importance, kelp forest ecology is rich in unanswered, yet basic, scientific questions. What controls the abundance of kelp spores? Do spores from distant kelp beds re-seed local beds torn asunder by storms? Are many small kelp beds or fewer large ones better for maintaining healthy fisheries? All these are important questions for managing the state's marine resources and for preserving its remarkable natural history.

The Project

Kelp forest ecologist Dr. Paul Dayton of Scripps Institution of Oceanography and his graduate student Dr. Michael Graham, now a marine researcher at the University of California at Davis, were funded to study the reproductive processes of the Point Loma kelp forest in San Diego—one of the largest in the world, in bountiful years covering an area about 7 kilometers long and 1 kilometer wide.

Giant kelp plants, which technically are not plants but algae, reproduce like ferns by dispersing spores. Spores are produced on special kelp blades on adult plants.

Previous studies have shown that large, dense kelp beds alter the flow of water through them. With the outer plants acting as a giant underwater wind block, the interior of a kelp bed may be almost motionless—even during a mild swell.

The main focus of this project was to investigate the degree to which spore abundance can be expressed as a function of location in the kelp bed, proximity to reproductively active plants and ocean current speed.

The Method

During the nine months between February and November 1999, the scientists collected water samples 26 times at 5 sites in the Point Loma kelp bed. On each dive, the scientists also took counts of all reproductively active plants, data that were used to estimate spore production at each site.

Mature kelp forest with large giant kelp (*Macrocystis pyrifera*) plants. In terms of supporting a diversity of life, giant kelp forests are to cold ocean environments what the coral reefs are to the tropics. Photo: Eric Hanauer.

Using a technique refined specifically for the project, water samples were analyzed for the abundance of a photosynthetic pigment unique to giant kelp plants. Ocean current speeds were based on historic current meter data.

The Findings

In the center of the kelp bed, the scientists found that spore abundance in the water column mirrored spore production from nearby adult plants. Based on their estimates, about 77 percent of the variability in spore abundance was associated with the rate of spore dispersal from nearby plants.

In contrast, near the edges of the kelp bed, spore abundance was not related to the rate of spore production. Instead, ocean currents, tides and winds were rapidly transporting spores great distances.

The spore analysis was consistent with physical oceanographic data showing that kelp forests alter ocean currents. In the center of the kelp forest, where ocean currents are weak, spores do not travel far. On the outskirts, where currents can be intense, spores are whisked away.

Implications

Dr. Graham said: "The work suggests that if you are interested in stabilizing a kelp forest, you have to take into account how big the kelp forest is. A big forest is not the same as a little one. There is something special about a big forest in terms of its current flow and thus its ability to re-colonize itself.

"If individual kelp plants in the middle of a large kelp bed die, it is not a big deal because there will be plenty of spores to re-colonize the hole. For a smaller bed, the recovery process could be much more difficult since locally produced spores are transported elsewhere, with ocean currents.

"To protect a kelp forest, you don't want to focus entirely on the health of individual plants, but also on the density and size of the forest as a whole. It may not matter if there are healthy individuals. If you've changed the size and density of a bed, you've changed the currents and where the spores are going."

Publications

Graham, M.H. 2000. Planktonic patterns and processes in the giant kelp *Macrocystis pyrifera*. Ph.D. dissertation abstract, University of California, San Diego.

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Graham, M.H. Spatio-temporal variability in the abundance of kelp planktonic stages. 5th Temperate Reef Symposium. Capetown, South Africa, January 2000.

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Trainee and Thesis

Graham, Michael H., Ph.D. in Biological Oceanography, Scripps Institution of Oceanography, University of California, San Diego 2000, "Role of Pre-Settlement Processes in the Population Dynamic of Subtidal Kelp."

Awards

Best Student Paper Award (Honorable Mention), Graham, M.H. Spatio-temporal variability in the abundance of kelp planktonic stages. Western Society of Naturalists Annual Meeting, Monterey, California, December 1999.

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