Predator diversity and the strength of trophic cascades – Witman Lab at Brown University

Predator diversity has decreased dramatically in the world's oceans, yet for most ecosystems, we do not understand how important predator diversity and abundance is for ecosystem functioning.

Background

One of the most striking community-wide effects of top predators is the suppression of herbivores, which releases plants from consumption and leads to increased plant productivity in a Trophic Cascade (TC).

Recent studies have shown that predator diversity may reduce, increase, or have no effect on the strength of trophic cascades. Previous research has been limited by a lack of experimental realism, due to the small number of predator species that can be manipulated in simplified mesocosms. This makes it difficult to extrapolate results to natural ecosystems, where losses of predator diversity are actually occurring.

To better understand the consequences of predator diversity in marine ecosystems, our lab is conducting a series of experimental manipulations in the oceanic benthic ecosystems of the Galapagos Marine Reserve (GMR). We aim to measure trophic cascade strength by altering the diversity of predators and their herbivorous sea urchin prey at natural levels, in order to test hypotheses about their effects on benthic algae. The GMR provides an unusual opportunity to test predator diversity and develop biodiversity-ecosystem functioning theory, due to years of protection from industrial fishing as a UNESCO World Heritage Site and local conservation efforts. Higher trophic level predators (such as large fish and sharks) are diverse and abundant here, along with intermediate level fish and invertebrates that also prey on sea urchins.

Research objectives and questions

- How do naturally occurring, large ranges of oceanic predator diversity influence the strength of trophic cascades?
- How does environmental variation and conservation protection influence these processes?
- How does predation, recruitment and habitat structure shape sea urchin populations?

How we're doing it

After struggling for years to attach predator inclusion / exclusion cages to uneven rocky substrate, we went the "pre-fab" route, making our own substrate with hardware embedded in it to attach cages. They look like concrete pizza's (photo) and are more easily measurable and manipulable. We left them underwater for a year so that they could be colonized by algae to create a "consumable substrate" for sea urchins, parrotfish and surgeonfish.

The experimental design was "open" to most behavioral and consumptive interactions, which were documented by time-lapse photograpehy ~11 hrs. / day for 7-8 days. Preliminary results provide 1) the first experimental evidence that TCs occur in the GMR, with triggerfish rapidly consuming (<24 hrs.) *Eucidaris galapagensis* urchins, releasing benthic algae from urchin grazing, 2) that consumer prey preferences are crucially important as the most voracious urchin species, *Lytechinus semituberculatus,* was surprisingly avoided by predators - cautioning against pooling species together in order to invoke TCs, 3) that predator richness may be unrelated to TC strength as only 2 (triggerfish) out of 12 known predator species drove urchin mortality. Further analyses will test the potential for parrotfish and surgeonfish herbivory to compensate for the loss of urchins by top-down control.

This work is ongoing. We plan to manipulate prey (urchin) species diversity in 2013 experiments.

We are also broadly interested in figuring out which of the myriad predator–prey interactions in the Galapagos subtidal are strong interactions in order to construct functional food webs. Besides sea urchins, we have quantified the feeding habits of whelks and all conspicuous species of sea stars. To figure out interaction strengths and prey preferences, we have manipulated these predators in inclusion cages.

All experimental cages are removed from the sites once the experiments are concluded.