

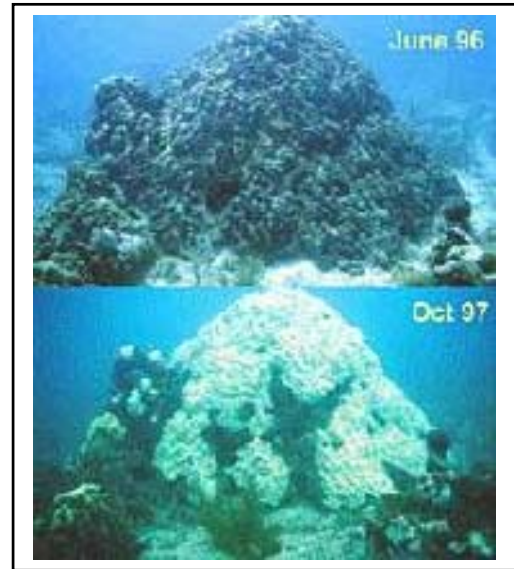
ISSUES – FIGURE SET

What's Killing the Coral Reefs and Seagrasses?

Charlene D'Avanzo ¹ and Susan Musante ²

1 - School of Natural Sciences, Hampshire College, Amherst, MA, 01002
cdavanzo@hampshire.edu

2 - Education and Outreach Program Manager, The American Institute of Biological Sciences, Washington, D.C. 20005, smusante@aibs.org



Bleaching in coastal Florida
©- Reef Relief, www.reefrelief.org)

Figure Set 2: Evidence for Nitrogen Limitation in the Ocean

Purpose: To help students understand why nutrient loading can cause algal blooms.

Teaching Approach: "Guided Class Discussion starting with first principles"

Cognitive Skills: (see Bloom's Taxonomy) — knowledge, comprehension, interpretation, application, synthesis

Student Assessment: essay quiz

BACKGROUND

Nutrient enrichment of coastal waters is a major problem in estuaries worldwide. In the US, every urban estuary is "culturally eutrophic" and polluted with nutrients from sewage, septic systems, agriculture, and road run-off.

Nutrient enrichment of the Florida Keys is a primary hypothesis explaining loss of corals and seagrass. Students need to understand what nutrient limitation is in order to follow the hypothesis that nutrient enrichment of the Florida Keys waters results in loss of seagrass beds and corals. The following set of questions will help you logically develop their understanding of this concept. This study done by Vince and Valiela shows that marine waters can be nitrogen limited. The researchers added N alone, P alone, N and P together, and nothing (C is the control) to seawater in containers incubated in the field (in the water). There are many studies showing that marine waters are N-limited and freshwater P-limited, although P or N limitation can occur in both marine and freshwater. Tropical waters like the Florida Keys can be limited by P because phosphate binds to calcium which is abundant in coral reefs.

STUDENT INSTRUCTIONS

Here is a list of questions we will be discussing in class:

- * What elements are organisms - plants, animals, bacteria - made of? What are the primary elements?
- * One hypothesis to explain the loss of corals and seagrasses is contamination of the Florida Keys water with the nutrients N and P. These are plant fertilizers that we use to fertilize our gardens and agricultural fields. How can it be that they can also act as "pollutants"?
- * Take several minutes to describe and interpret Figure 2. What is your interpretation?
- * Using what you have learned from Figure 2, what do you think happens when large amounts of N go into marine waters?
- * OK, so N loading (addition) to coastal waters results in blooms of algae. Why might this be a problem? How could this lead to loss of corals and seagrasses?

FIGURES

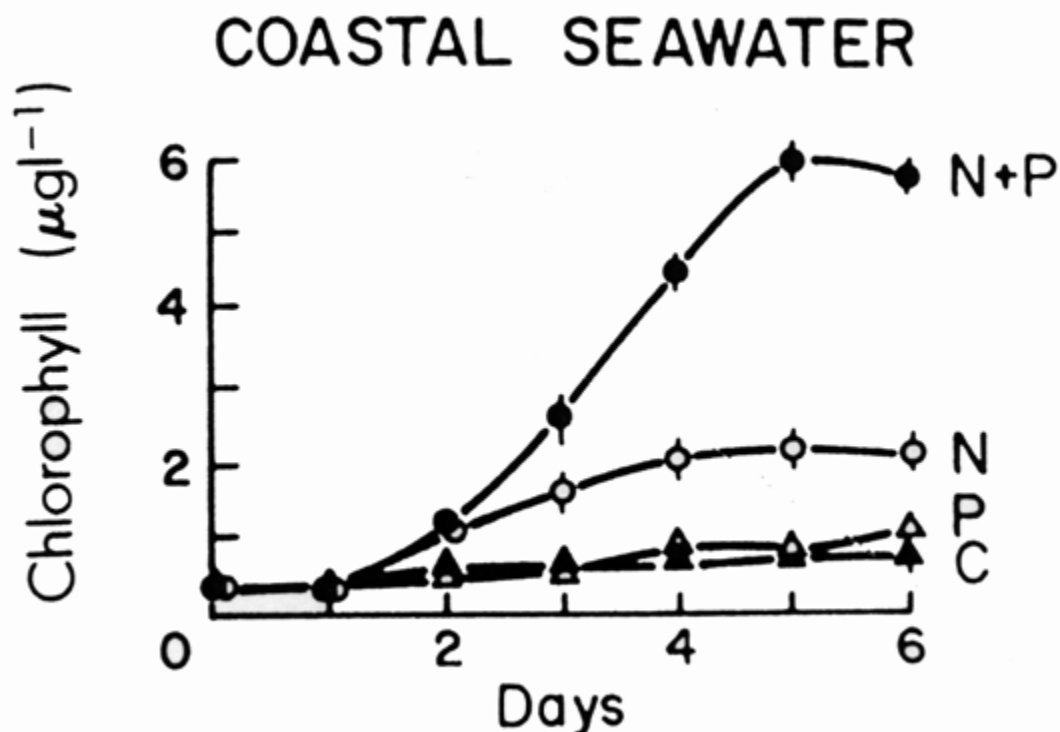


Figure 2. Change in chlorophyll (micrograms per liter) in coastal seawater in 4 treatments (Nitrogen and phosphorus together, N alone, P alone, and Control with no addition) over 6 days. (From Vince, S. and I. Valiela. 1973. The effects of ammonium and phosphate enrichment on chlorophyll a, pigment ratio, and species composition of phytoplankton of Vineyard Sound. *Marine Biology* 56: 111-134).

Students need to understand what nutrient limitation is in order to follow the hypothesis that nutrient enrichment of the Florida Keys waters results in loss of seagrass beds and corals. The questions in the Student Instructions section will help you logically develop their understanding of this concept.

NOTES TO FACULTY

First principles: in this "guided discussion" the questions are designed to help you lead students logically through the basic principles or concepts behind nutrient limitation. Therefore, a discussion based on first principles requires you - in stepwise fashion - to logically and quite carefully outline ahead of time the concepts or points of information that students need to understand. You must try to put yourself in the mind-set of your students and remember the core ideas/concepts that they may not know.

On the question - What elements are organisms – plants, animals, bacteria – made of? What are the primary elements? Someone usually comes up with C, O and H which you can put at the top of the list; N follows these, P is next and the rest are micronutrients. If nobody identifies C as a main element, ask what the products of wood burning are.

On the question - One hypothesis to explain the loss of corals and seagrasses is contamination of the Florida Keys water with the nutrients N and P. These are plant fertilizers that we use to fertilize our gardens and agricultural fields. How can it be that they are also pollutants? Students may know about eutrophication and the consequences of nutrient overenrichment of waters. If not, come back to this question.

On the question - Take several minutes to describe and interpret Figure 2. What is your interpretation? Explain the methods to them. You may also need to tell your students that the microscopic plants that are so abundant in water are called phytoplankton, which is Greek for wandering plant.

On the question - Using what you have learned from Fig. 2, what do you think happens when large amounts of N go into marine waters?

Discuss limitations to plant growth, algal growth, phytoplankton growth. Ask students where these plants get their N. What are possible sources of this N? Good answers include agriculture, sewage, septic systems, rain. Imagine floating on the water in the Florida Bay after a big rain carried in a load of nitrogen. What might the water column - the water below you - look like? Ans - Turbid with phytoplankton or algae and greenish.

On the question - OK, so N loading (addition) to coastal waters results in blooms of algae. Why might this be a problem? How could this lead to loss of corals and seagrasses? The response to this depends on knowledge levels of the students. Some may know that excess growth of phytoplankton and seaweeds can result in oxygen depletion and fish kills. If not, prompt the class with questions about plant matter settling to the bottom of the bay and decomposing. If this fails, you will have to explain the process of aerobic respiration to them. A common misconception for students is that plants produce but do not consume oxygen. Shading is another component of eutrophication problems in estuaries. In this case the seagrasses were likely stressed

by light limitation because of increased water turbidity and epiphytic macroalgal growth on their leaves.

An additional point is that corals become light limited when waters become turbid with excessive phytoplankton biomass. You will likely need to explain the symbiotic relationship between corals and their zooxanthellae and then ask students to explain why turbid water is problematic for corals.

Student Assessment: Essay quiz.

Explain the concept of nutrient limitation and the evidence for N vs. P limitation in the Vince & Valiela experiment.

Evaluating an Issue: How do you know whether it is working?

On-going (also called formative) evaluation of the approaches your are using is critical to the success of student-active teaching. Why try out new ideas if you don't know whether or not they are working? This is a brief overview of formative evaluation. For more information, go to the Formative Evaluation essay in the Teaching Section.

Course Goals:

Formative evaluation only works if you have clearly described your course goals - because the purpose of the evaluation is to assess whether a particular technique is helping students reach these goals. For instance, most of us have "learn important ecological concepts and information" as a course goal. If I reviewed the nitrogen cycle in a class, for evaluation I might ask students to sketch out a nitrogen cycle for a particular habitat or system. Each student could work alone in class. Alternatively, I might ask students to work in groups of 3 and give each group a different situation (e.g. a pond receiving nitrate from septic systems, an organic agricultural field, an agricultural field receiving synthetic fertilizer). The students could draw their flows on a large sheet of paper (or an overhead transparency) and present this to the rest of the class.

The Minute Paper:

Minute papers are very useful evaluative tools. If done well they give you good feedback quickly. Minute papers are done at the end of a class. The students are asked to respond anonymously to a short question that you ask. They take a minute or so to write their response in a 3x5 card or a piece of paper. You collect these and learn from common themes. In the next class it is important that you refer to one or two of these points so that students recognize that their input matters to you. The [UW - FLAG site \(www.wcer.wisc.edu/nise/cl1/flag/\)](http://www.wcer.wisc.edu/nise/cl1/flag/) gives a good deal of information about using minute papers including their limitations, how to phrase your question, step-by-step instructions, modifications, and the theory and research behind their use.