A. Grant Number: NA05NOS4261157

B. Amount of Grant: $87,275

C. Project Title: Effects of Invasive Algae on Larval Transport into Coral Reefs

D. Grantees: Michael G. Hadfield and Mimi A. R. Koehl

E. Award Period: From: 08/01/2005 To: 02/28/07

F. Period Covered by this Report: From: 12/01/05 To: 06/15/06

G. Summary of Progress and Expenditures to Date:

  I. Work Accomplishments: (as related to project objectives and schedule for completion)

     a. Provide a brief summary of progress, including results obtained to date, and their relationship to the general goals of the grant.

     Objective No. 1: Measure coral cover, algal encroachment and vertical dye transport along transects across the reef on the seaward side of Coconut Island to select field sties with and without heavy algal cover.

     We have conducted these measurements across two reef sites on Coconut Island to select field sites for more intense investigation. In addition, we have made comparable measurements at a number of other reef sites in Kaneohe Bay that are now overgrown with algae. We had measured vertical dye transport along transects across these reefs before they were overgrown, and thus could compare flow through these reef when clean versus when over-grown with algae. For all the transects that we have run so far, we have completed the digitization of our photographs to quantify percent cover of various species of algae, have completed analyses of vertical water transport, and have reported the results at scientific meetings (see G., 2., a. below). So far our data show that heavy algal cover can cut off vertical transport of water and materials into and out of a reef, but that partial cover has little effect. This gives us hope that we can develop a practical protocol for cutting holes in the algal cover that will help restore the water circulation in reefs.

     Objective No. 2: Measure instantaneous vertical and horizontal water velocities above and within the reef using electromagnetic flow meters.

     We have completed measurements of water velocity as a function of time at a number of reef sites with clean, healthy corals and of others with different degrees of algal cover. We found that the up-and-down water movement associated with the passage of waves, which pumps water into and out of the reef, is cut off by heavy algal cover. However, when holes are cut in the algal mats, water can flow into and out of the reef at similar velocities to those recorded in clean, healthy corals.

     Objective No. 3: Monitor how quickly holes of various sizes made in the mats of invasive algae fill in.
Thus far, we have conducted only preliminary laboratory studies. Using large, solid clumps of the invasive alga *Gracilaria salicornia*, we have punched holes measuring 2 cm, 4.5 or 5.5 cm in the center of the algal masses. These clumps have then been maintained in tanks with flowing seawater at the Kewalo Marine Laboratory and both photographed and measured 5 times per week. Over a period of 19 days, 2-cm holes have decreased in area by an average of 44%, indicating that holes created in algae on a reef to enhance water flow through the reef may “heal” quite rapidly.

**Objective No. 4:** Assess the effects of invasive algae on the transport of larvae into the reef by conducting field releases of larval mimic.

So far we have conducted two field-release investigations of dispersal patterns of larval mimics across algae-covered reefs, and nine on clean healthy reefs, and all the data have been analyzed. To date, the data suggest that larvae tend to land on the seaward sides of clean reefs, and to settle deep within the reef, where the hydrodynamic forces are low enough that they are able to adhere to reef surfaces. In contrast, on algae-covered reefs, larvae appear to be prevented from landing deep within the reef by the algal mats on top of the corals. We plan to run more such experiments this summer for algae-covered reefs to see if this trend is robust.

Additionally, using three invasive algal species -- *Kappaphycus* spp., *Gracilaria salicornia* and *Dictyosphaeria cavernosa* -- we have begun experiments to observe the interaction between algal surfaces and the settlement and metamorphosis of *Phestilla sibogae* and found that *Kappaphycus* spp. and *G. salicornia* have no effect, while *D. cavernosa* may even inhibit metamorphosis. Some species of algae appear to possess the capacity to take up coral cue when in the presence of *orites compressa* and release it to induce larval settlement. Thus invasive algae may have an additional adverse affect on larval settlement by inducing it in inappropriate locations on a reef.

**Objective No. 5:** Quantify the trajectories of individual larvae approaching a reef (at distances ≤ 10 cm from reef surfaces) with and without algal mats, in a wave tank at the Kewalo Marine Lab.

b. Provide a brief summary of work to be performed during the next year of support, if changed from the original proposal; and indication of any current problems or favorable or unusual developments; and any other significant information pertinent to the type of project support by COP, or as specified by the terms and conditions of the grant.

We will continue conducting our measurements of algal overgrowth and flow patterns along transects across reefs (objective #1) to monitor how these are changing with time. We plan to conduct more experiments assessing the effects of alga overgrowth on the deposition of larval mimics on the reef (objective #4) to have an adequate number of replicates for rigorous statistical analyses. We also plan to quantify the trajectories of individual larvae approaching a reef (at distances of ≤ 10 cm from reef surfaces) with and without algal mats, in a wave tank at the Kewalo Marine Lab to mimic flow conditions measured in the field over *P. compressa* reefs. (objective #5). We will initiate these experiments this summer by setting up the tank with the corals and establishing the correct flow regime. High-speed videography of living larvae of *Phestilla sibogae* and various species of corals in the tank will be conducted during the third and fourth quarters or this grant period.

We anticipate completing the project objectives by the end of the grant year. Because we will soon commence our summer 2006 field-research season, unexpected problems or results may lead us to some modifications in methods.
2. Applications:
   a. Publications, presentations, workshops;

   Koehl presented results from Objectives No. 1 and 2 in talks at the following meetings:

   Ocean Sciences Meeting (American Society of Limnology and Oceanography), Honolulu, Feb. 2006

   Rachel Carson Lecture, American Geophysical Union, Baltimore, MD, May 2006

   Koehl also presented results from Objectives No. 1 and 2 in lectures at the following universities:

   Riley Lecture, Department of Oceanography, Dalhousie University, Canada, March 2006

   Ecology, Evolutionary Biology, and Behavior Program, Michigan State University, April 2006

   b. Applications to management or research;

   None yet.

   c. Data and/or information products;

   None yet.

   d. Partnerships established with other federal, state, or local agencies, or other research institutions (other than those already described in the original proposal).

   We continue our collaboration with Dr. Steven Kolinski of the National Marine Fisheries Service, NOAA.

3. Expenditures:
   a. Describe expenditures scheduled for this period.

   We had not divided our needed expenditures by segments of the grant year, and thus had no “schedule” for encumbrance. Now that we are into our major summer field season, we will be purchasing equipment and supplies for the project beginning immediately.

   b. Describe actual expenditures this period.

   (1) University of Hawaii: $6,140.24

   Cawa Tran’s Graduate Assistantship, including $5,392 in salary and $748.23 fringe, through 05/31/06.

   (2) University of California:

   Research Assistant II, Lisa Katz, including $380.70 in salary and $18.60 in fringe benefits through 5/31/06.

   c. Explain special problems, differences between scheduled and actual expenditures, etc.
None. As explained above, we had not divided the grant year into sub-period for expenditures. U.C Berkeley experienced significant difficulties in receiving their share of funds (which finally became available to Dr. Koehl on May 15, 2006), which delayed hiring and purchase until very recently.

Prepared By: Michael J. Hadfield
Signature of Principal Investigator

June 28, 2006
Date

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