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RAPID: Assessing Tsunami Impacts on the Benthic Community of Robinson Crusoe Island

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Principal Investigator: Wahle, Richard A.
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RAPID: Assessing tsunami impacts on the benthic community of Robinson Crusoe Island

Project Participants

Senior Personnel

Name: Wahle, Richard
Worked for more than 160 Hours: Yes
Contribution to Project:

Name: Petraitis, Peter
Worked for more than 160 Hours: Yes
Contribution to Project:

Name: Perez Matus, Alejandro
Worked for more than 160 Hours: Yes
Contribution to Project:
Postdoc field assistant from Chilean university participated with Chilean support.

Post-doc

Graduate Student

Name: Bergeron, Charlene
Worked for more than 160 Hours: Yes
Contribution to Project:
Charlene is a graduate student and Research Associate in the Wahle lab. She has played a key role in helping to coordinate and participate in all 4 field trips to Robinson Crusoe Island. She participated in the field work and diving and is primarily responsible for data entry and initial analysis. Her salary and travel has been covered on this grant.

Name: Jaini, Mahima
Worked for more than 160 Hours: Yes
Contribution to Project:
Mahima is a graduate student in the Wahle lab and participated in the field work and diving on one of the 4 trips to Robinson Crusoe. Mahima's travel was covered; she volunteered her time.

Name: Henriquez, Luis
Worked for more than 160 Hours: Yes
Contribution to Project:
Graduate student field assistant from Chilean university participated with Chilean support.

Undergraduate Student

Name: Velez, Sebastian
Worked for more than 160 Hours: Yes
Contribution to Project:
Sebastian assisted in the video analysis as a UMaine work study student.

Note that Sebastians time was paid by UMaine's Work Study Program, not by this or any other NSF award. The reporting form, however, gives me no choice other than to select this award or other NSF award.

Name: Borgeaud, Ignacio

Worked for more than 160 Hours: Yes

Contribution to Project:

Undergraduate field assistant from Chilean university participated with Chilean support.

Name: Ledezma Perez, Alberto Enrique

Worked for more than 160 Hours: Yes

Contribution to Project:

Undergraduate field assistant from Chilean university participated with Chilean support.

Name: Bennett, Richard

Worked for more than 160 Hours: Yes

Contribution to Project:

Undergraduate field assistant from Chilean university participated with Chilean support.

Name: Petit Vega, Ignacio Javier

Worked for more than 160 Hours: Yes

Contribution to Project:

Undergraduate field assistant from Chilean university participated with Chilean support.

Technician, Programmer

Other Participant

Name: Palma, Alvaro

Worked for more than 160 Hours: Yes

Contribution to Project:

Dr. Palma is the lead investigator of the Chilean project supported by Fondecyt, Chile's NSF, that collected much of the pre-tsunami data that forms the basis for this NSF-RAPID grant. He and his own staff provided the primary logistic support for the project.

Name: Gaymer, Carlos

Worked for more than 160 Hours: Yes

Contribution to Project:

Dr. Gaymer is the co-investigator with Dr. Palma on the Chilean Fondecyte project that provided the logistical support for our NSF RAPID project.

Research Experience for Undergraduates

Name: Freytes, Ileana

Worked for more than 160 Hours: Yes

Contribution to Project:

Ileana joined the first trip to Robinson Crusoe as an REU through Bigelow Laboratory's REU program. Her travel was supported on this grant while stipend was covered under the Bigelow REU program. She participated in all aspects of the field work and incorporated some of the results in her REU project.

Organizational Partners

Pontificia Universidad Cat?lica de Chile

The nature of the collaboration is detailed in the original NSF proposal.

Other Collaborators or Contacts

Activities and Findings

Research and Education Activities:

Scientific Objectives

We conducted four 10-d trips to Robinson Crusoe Island, as planned, in June and November 2010, and January and March 2011. Most field objectives were accomplished according to plan although weather prevented some deployments and samplings. Paradoxically, during our final trip, the 9.0 magnitude earthquake in Japan on March 11th, 2011, triggered a tsunami alert through the entire Pacific rim including Robinson Crusoe Island. The Chilean Navy closed the island's only inhabited harbor, Cumberland Bay, and prohibited vessel operations for two days. Below we summarize our scientific objectives and activities to the end of the funded RAPID project. However, our Chilean colleagues continued their effort toward these objectives with their own final year of support through March 2012. Objectives 1-5 below were the original objectives set forth in our NSF-RAPID proposal. Objectives 6 and 7 were added during our first visit to the island to further characterize the benthic assemblage and the impacts of the tsunami, although pre-tsunami data were not available.

1. Resume censuses of lobster dens where lobsters were previously tagged to assess post-tsunami losses.
Spiny lobsters are social, and during the day reside in groups in dens. Since 2008 our Chilean colleagues have periodically monitored four established lobster dens by counting and measuring lobsters. Of particular interest was whether these den groups remained intact after the tsunami disturbance. Resuming diver surveys and tagging was therefore a high priority. Periodic tagging resumed during the four trips following the tsunami, lobster dens were revisited and lobsters with existing tags were recorded and measured and new lobsters were tagged. All lobsters were tagged, measured and reproductive and molt state recorded.

2. Retrieve and redeploy artificial settlement collectors left unattended after the tsunami to quantify newly settled postlarval lobsters and associated fauna.
Since 2009 and several months prior to the tsunami in 2010, our Chilean colleagues were successfully making the first-ever collections of newly settled postlarvae of the endemic Robinson Crusoe Island lobster using artificial mesh collectors. Each collector array consists of a mooring and plastic mesh collector panels at depths of 5, 25, and 80 m. Collectors were deployed at multiple sites. A key objective after the tsunami was to retrieve unattended collectors and to repair and redeploy them to continue the time series. On the first trip back to the island after the tsunami, in June 2010, none of the previously deployed collectors were found and were most likely destroyed by the tsunami. Two new collector arrays were assembled and deployed at two sites, one in June and the other in November. The one deployed in June 2010 was retrieved and deployed again in November 2010; both were retrieved and deployed again in January 2011.

3. Resume and expand benthic suction sampling time series of the cobble-dwelling invertebrate assemblage to assess post-tsunami changes.
Most of the relatively small-bodied subtidal decapod crustaceans and other invertebrate fauna inhabit interstitial spaces within the matrix of cobbles and boulders along the island's rocky shores. Since 2008 our Chilean collaborators have conducted suction sampling within replicate quadrats at multiple sites around the island. We assisted the Chilean team in resuming suction sampling at these locations to evaluate whether this habitat and its inhabitants were affected by the tsunami disturbance. Sampling resumed in June 2010, and each trip thereafter, at the two most accessible sites sampled before the tsunami, as well as five new sites to provide higher spatial resolution along the most accessible shoreline that had variable levels of visible tsunami impact. All benthic fauna in the samples were counted and identified to the highest level of classification practical. Decapod crustaceans, except for shrimp, were measured. To date the data on crustaceans, a group of primary interest have been worked up and preliminary results have been presented at scientific meetings.

4. Conduct video-monitored tethering experiments with juvenile Jasus frontalis to identify predators and evaluate relative predation rates by location and lobster body size.
Preliminary video monitored tethering experiments had begun in 2009. Additional photographic documentation collected prior to the tsunami suggested the potential for high levels of predation pressure by demersal fishes and octopus, some of which are endemic to the island. Although these predation experiments had not been fully implemented prior to the tsunami, deployment afterward continues the ecological characterization of the island's subtidal environment, and will help determine whether the predation regime has changed since the tsunami. Video monitored tethering experiments were conducted in January 2010 to evaluate predation rates on lobster juveniles. We ran tethering experiments at three sites to characterize local variability in predation pressure. At each site juvenile lobsters were tethered to metallic rods driven in the sediment bottom. At 17 h and 41 h experiments were checked by SCUBA divers for consumed lobsters. We related consumption to predator abundance as evaluated for fish in objective 7, but also for octopuses. For the latter, a free diver specialized in octopus fishing recorded the number of octopuses observed during 15 min at each of the 3 sites, at the same time of the day. This study was the research thesis

of an undergraduate student in Marine Biology at Universidad Cat?lica del Norte.

5. Collect planktonic larval sampling for distributional and molecular genetic analyses.
Since 2008 the Chilean team has conducted systematic nearshore plankton collections, during day and night, around Robinson Crusoe Island together with the recordings of basic hydrographic information. This is the most intense sampling effort ever undertaken for lobster larvae around Robinson Crusoe Island, the primary aim being to evaluate whether larvae are retained near the island. Tissue samples of all life stages from larvae in plankton tows, to postlarvae from artificial collectors, and benthic juveniles and adults have been collected and preserved in ethanol to compare the genetic structure among the island populations of the archipelago. In June 2010 plankton nets destroyed by the tsunami were replaced and sampling resumed. Sampling was conducted on all four trips. On each occasion, sampling was conducted during the day and night, at two depths and at locations near (within a few hundred meters of shore) and at some distance (several km) from shore. Samples were then sorted and phylosoma larvae of Robinson Crusoe Island lobster, J. frontalis, and the slipper lobster, Acantharctus delfini, were fixed in ethanol for molecular analysis.

6. Initiate a time series of video transects stratified by depth at multiple sites to quantify conspicuous tsunami impacts and post-tsunami recovery of epibenthic biota.
It became obvious upon arrival at the island that if we were to quantify impacts of the tsunami, it would be important to have video documentation of the sea bed, even if no pre-tsunami transects had been conducted. Video transects were implemented at the same sites suction sampling was conducted under objective 3. On all four trips 50-m video transects were conducted at all seven suction sampling sites. At each site video transects were taken at three depth strata (5, 10, and 20 m). Swimming in one direction along a 50-m tape, the diver aimed the camera vertically down at the seabed, and on the return trip aimed the camera horizontally for a landscape view. Videos were then reviewed in the laboratory. Vertical views were reviewed to document the substrate type, algal cover, conspicuous fauna, and evidence of human debris resulting from the tsunami. A subsample of 50 video frames were examined per transect to quantify changes in these variables during the post-tsunami months.

7. Evaluate behavioral response of predatory fishes to local trophic enhancement resulting from experimental small scale benthic disturbance.
This assay was implemented at the same sites suction sampling and video transects were conducted under objectives 3 and 6. Stationary video surveillance in the absence of divers can provide a useful index of fish species richness and abundance. Conducting a small scale disturbance (turning over rocks to expose prey) midway through surveillance gives an index of predator response to a change in prey availability. These assays were conducted at all seven sites on all four trips. The video camera was deployed with cobble habitat in the foreground view. Prior to the disturbance treatment, the resident fish assemblage was recorded for approximately 20-30 min in the absence of a diver. At the end of the pre-disturbance period a diver returned to the surveillance site and created a localized experimental disturbance in front of the camera by turning over rocks, removing algae and crushing live substrate on larger boulders. The diver then exited the scene. The response of the fish assemblage to this disturbance was measured as the change in density of fish in the foreground view during a 20-30 min period after the disturbance.

Educational and Training Opportunities
The project involved graduate and undergraduate students from both the US and Chile in the research by direct participation in the field work and data analysis. A US highschool student also participated. From the US, two UMaine graduate students, a UMaine undergraduate, a U Puerto Rico undergraduate, and a high school senior from Lincoln Academy, Maine, participated. The UPR undergrad was involved in the project through the NSF REU program at Bigelow Laboratory for Ocean Sciences in Maine and through supplementary support from NSF's International program. The highschool student participated in field activities and made this the subject of a video project fully narrated in Spanish for his Advanced Placement Spanish class.
For these students the project has provided specific research and training skills in several areas:
1. Coordination of logistics for field and dive research and safety in a remote location.
2. Design and execution of benthic diver-based video and suction sampling surveys, vessel-based plankton tows and passive larval collector deployment, lobster tagging, as well as conducting field experiments to evaluate fish predation.
3. Taxonomic identification of marine invertebrates and fishes.
4. Analysis of stationary video surveillance and transect data.
5. Intercultural collaboration.
6. Public presentation of scientific material

Outreach Objective
Our outreach objective was to leverage public interest in the dramatic land-based impacts of the tsunami, drawing them into the marine realm through a rich library of georeferenced digital photos, video and associated data files. A large amount of digital video and digital still image documentation has been collected during our four trips, both under and above water, that forms the basis of our outreach materials in the aftermath of the RAPID project. We are working with UMaine's Center for Ocean Sciences Education Excellence (COSEE) - Ocean Systems (OS). COSEE-OS will help frame our research through interactive media that is effective with educators. The media will be directly tied to the

National Geographic Society's 'Ocean Literacy' campaign, specifically addressing the concept 'Coastal regions are susceptible to natural hazards.'

Findings:

Scientific Objectives

1. Censuses of lobster dens and tagging.
Social groups of lobsters in dens remained largely intact after the tsunami. Just prior to the tsunami, in January and February 2010, the count of tagged lobsters in the four dens ranged from 16 to 23. Encouragingly, the first post-tsunami count in June revealed 28 tagged lobsters. Preliminary analysis of recapture histories of 80 tagged lobsters in all, using Cormack-Jolly-Seber mark-recapture models, suggest that post-tsunami survival has been high. Growth, in lobsters tagged after the tsunami was also not significantly different from those tagged prior to the tsunami.

2. Retrieval and redeployment of artificial postlarval settlement collectors.
Postlarvae on any given sampling occasion are characteristically rare in collector samples, but the emerging picture from the combined sampling since 2009 is that J. frontalis postlarvae consistently settle in relatively deep water. In November we checked the collectors from the June deployment at the one site. From the January 2011 sampling of the same collector array, and a new one deployed at a second site in November, we found one J. frontalis postlarva, and two A. delfini (slipper lobster) postlarvae, all at 80 m.

3. Benthic suction sampling time series.
Analysis of suction samples to date does not indicate a significant post-tsunami change in the density of cobble-dwelling invertebrates. The time series is providing a rich data set on the biodiversity of the Robison Crusoe Island cobble-dwelling fauna.
Also from these collections two specimens of a suspected new species of a diminutive clawed mud lobster (Family Axiidae) were sent for verification to Daryl Felder (University of Louisiana-Lafayette), an authority on decapod systematics. He confirmed identification to the family level, but could not determine if we had a new species from the limited material available. The specimens are archived with Dr. Felder.

4. Predation experiments.
Analysis of data collected from tethering experiments conducted at three sites in January 2011 indicate lobster survival decreased rapidly over approximately 48 h time scales. Survival rates ranged from 36 to 73% among the 3 sites over that period. Variable fish abundance, as measured by stationary video surveillance conducted under objective 6, is most likely to explain site-to-site differences in juvenile lobster survival. No statistical before-after tsunami comparison of predation rates was possible for these experiments.

5. Collect planktonic larval sampling for distributional and molecular genetic analyses.
The distribution and abundance of larvae around the island during day-time surveys exhibited a different pattern for the spiny and slipper lobster species. Phyllosoma of J. frontalis were less abundant than those of A. delfini. Densities between 2008 and 2010 ranged up to about 5 phylosoma per 100 m3 for J. frontalis and more than 10 per cubic meter for A. delfini. Jasus frontalis tended to be more concentrated on the northern side of the island, whereas A. delifini was more uniformly distributed around the island. In Cumberland Bay, on the north side of the island, where more frequent sampling was possible owing to its accessibility, larval numbers were variable throughout more than two years of monitoring. Phylosoma of both species tended to approach the surface strata of the water column during the night. Correlations between physical variables and the abundance of larvae were explored. For J. frontalis larval abundance was not significantly correlated with either temperature or salinity (Rs SST=-0.038, p=0.874; Rs SSS=0.313, p=0.191). On the other hand, A. delfini exhibited a statistically significant association with warm, saline waters (Rs SST=0.336, $p<0.05$; Rs SSS=0.511, $p<0.05$). Further analysis will explore evidence for nearshore larval retention mechanisms. Larval collections have been archived for molecular analysis which is now under way. These surveys and results became the core of a recent publication (Palma et al. 2011). The main finding was evidence of vertical migration by the two lobster species that can be related to their ability to stay close to the island system, contributing to our understanding of the endemism of these species.

6. Benthic video transects.
Evidence of tsunami impact from the video transects was conspicuous in some locations, primarily in Cumberland Bay, where the shoreline is gently sloping and human habitation exists. At the sites near the village, we documented extensive amounts of human debris underwater and evidence of overturned boulders and smaller rocks that resulted from the tsunami. We have also observed over the course of the four sampling trips an increasingly luxuriant bloom of benthic green algae (Ulva) at sites near the village and in the direction of prevailing circulation. Preliminary analysis of the video transect time series along with limited pre-tsunami photographs at the same sites suggests post-tsunami

nearshore eutrophication from terrestrial run-off from newly exposed land could explain the algal bloom in the months after the tsunami. Nutrient samples collected during the winter of 2012 are being analysed to evaluate the predicted spatial correlation of limiting nutrients and the extent of the algal bloom.

6. Stationary videos to evaluate fish response to local benthic disturbance.
Although variable among the 7 sites the fish response to the experimental disturbance was immediate and dramatic resulting in a several-fold increase in fish density in the immediate viscinity of the disturbance. The methodology in combination with suction sampling has the potential to become widely applied in evaluating trophic interactions between demersal fish and their prey in similar marine habitats around the world.

Training and Development:

This project involved graduate students, undergraduates and a high school student from the US and Chile in the research by direct participation in the field work and data analysis.

As for participation by US students, two UMaine graduate students, a UMaine undergraduate, a U Puerto Rico undergraduate and a high school senior from Lincoln Academy, Maine, have been involved in the project. The two UMaine graduate students, the UPR undergraduate and the high school student were directly involved in the field work in Chile. The UMaine undergraduate has been contributing to the analysis of the copious video documentation for objectives 6 and 7. The UPR undergrad was involved in the project through the NSF REU program at Bigelow Laboratory for Ocean Sciences in Maine and through supplementary support from NSF's International program.

The project has provided research and training skills in several areas:
1. Coordination of logistics for field and dive research and safety in a remote location.
2. Design and execution of benthic diver-based video and suction sampling surveys, vessel-based plankton tows and passive larval collector deployment, lobster tagging, as well as conducting field experiments to evaluate fish predation.
3. Taxonomic identification of marine invertebrates and fishes.
4. Analysis of stationary video surveillance and transect data.
5. Skills in intercultural collaboration.

Graduate (**) and undergraduate (*) students also contributed to, or delivered, the following presentations at international conferences:

Freytes-Ortiz, I.M.*, & Wahle, R.A. . 2011. Interoceanic comparison of predatory fish response to prey availability after habitat disturbance. ASLO Ocean Sciences Meeting, San Juan, PR. Feb 2011.

Bergeron, C.E.**, Wahle, R.A., Palma, ?., Freytes-Ortiz, I.M.*, Petraitis, P. 2012. Do it all in one dive! Rapid assessment of foodweb dynamics in shallow subtidal cobble communities. Benthic Ecology Meeting, Norfolk, VA, Mar 2012.

Palma, A.T., Bennett, R.S.*, Wahle, R.A., Bergeron, C.**, San Mart?n, B.A. 2012. Dwarfism in the coastal decapod assemblage of Robinson Crusoe Island, Chile: a predator-driven pattern? Benthic Ecology Meeting, Norfolk, VA, Mar 2012.

Bennett, R.S.*, Wahle, R.A., Petraitis, P.S., Bergeron, C.E.**, Riquelme-Bugue?o, R., Palma A.T. 2012. Post-tsunami effects on different trophic levels in the shallow benthic community of Robinson Crusoe Island, Chile. Benthic Ecology Meeting, Norfolk, VA, Mar 2012.

The project also contributed to an undergraduate thesis for a Chilean student:

Petit, I. 2012. Predaci?n sobre individuos juveniles de la Langosta de Juan Fern?ndez Jasus frontalis (predation upon juveniles of Juan Fern?ndez spiny lobster, Jasus frontalis). Marine Biologist honours thesis. Universidad Cat?lica del Norte, Coquimbo, Chile.

Outreach Activities:

Much digital video and digital still image documentation was collected during the four trips on this RAPID project, as well as by our Chilean colleagues prior to and after the project. These images, both under and above water, form the basis of our outreach materials.

In the aftermath of our RAPID project, we are working with education and outreach partners at the Centers for Ocean Sciences Education Excellence (COSEE) - Ocean Systems to implement an inquiry-based online tool for direct student investigation areas, both above and below the water line, that were affected by the tsunami. Media including time-series photographs and video will be geo-tagged to interactive maps that allow students to formulate hypotheses about the impact of the tsunami. The media will be directly tied to the National Geographic Society's 'Ocean Literacy' campaign, specifically addressing the concept 'Coastal regions are susceptible to natural hazards'.

We will also offer environmental change data(e.g., percentage cover of algae from video transect, etc.)that can be plotted by students to quantitatively address the tsunami's impact. COSEE - Ocean Systems will host the interactive tools on their website(cosee.umaine.edu), maximizing its potential to be discovered by their user community of educators and students. They will also provide online formative evaluation surveys to assess the quality of the tools and make adjustments as necessary to improve their effectiveness.

Other outreach activities conducted during the RAPID project are as follows.

In June 2010, the PI gave a presentation to the island's fishermens' association comparing the American lobster fishery in New England to that of Robinson Crusoe Island, with translation by Chilean collaborator, A. Palma.

In 2011 Dr. Palma gave a presentation to the Chilean Navy and the Ministry of the Environment on our tsumi-related research.

In February 2012 Drs. Palma and Gaymer prepared video material for presentations to the Mayor's office and the fisherman association of Robinson Crusoe Island,. A poster summarizing the main findings, was also donated to the local community.

Journal Publications

Palma, A.T., C??ceres-Montenegro, I., Bennett, R.D., Magnolfi, S., Henr??quez, L.A., Guerra, J.F., Manr??quez, K. & Palma, E.R., "Near-shore distribution of phyllosomas of the two only lobster species (Decapoda, Achelata) present in Robinson Crusoe Island and endemic to the Juan Fern??ndez archipelago.", Rev. Chil. Hist. Nat., p. 379-390, vol. 84, (2011). Published,

Books or Other One-time Publications

Web/Internet Site

URL(s):

http://cosee.umaine.edu/

Description:

As indicated in the Outreach section of this report, in the aftermath of our RAPID project, we are working with education and outreach partners at the Centers for Ocean Sciences Education Excellence (COSEE) - Ocean Systems at the University of Maine to implement an inquiry-based online tool for direct student investigation areas. This tool is not yet completed.

Other Specific Products

Product Type:

Audio or video products

Product Description:

Video Transects - 50-m downward and forward viewing video transects collected at 2-3 depth strata (5, 10, 20 m) at each of 7 study sites in June and November 2010, and January and March 2011.

Stationary video surveillance - 40-60 min video surveillance collected to assess fish response to local substrate disturbance. Collected at the 7 study sites at 10 m depth on all 4 trips (June 2010 to Mar 2011).

Sharing Information:

Digital video files are available from the PI. Video segments will be used in educational materials being developed by UMaine's COSEE Program.

Product Type:

Data or databases

Product Description:

Suction sampling data - Six 0.25 m2 quadrats from 7 sites collected at 10 m depth on each of 4 sampling occasions between June 2010 and March 2011. Includes counts and sizes of benthic invertebrates.

Video transect data giving percent cover of benthic algae, attached fauna and incidence of human debris from tsunami. Collected from 7 sites, 3 depth strata, on each of 4 sampling occasions between June 2010 and March 2011.

Stationary video surveillance data - on numbers and identity of fish before and after local experimental disturbance. 7 study sites, 4 dates between June 2010 and March 2011.

Sharing Information:

Data bases available from PI as Excel files. Selection of data available to UMaine COSEE program for development of educational materials.

Contributions

Contributions within Discipline:

The study of the ecological impact of tsunamis has scientific merit because of its relevance to an understanding of the resilience of marine ecosystems, biodiversity and fisheries to agents of disturbance at different scales and magnitudes. Our understanding of rare, short-lived, but potentially extreme ecological disturbances is inherently poor. To date, documentation of the ecological impact of tsunamis on marine benthic environments has been restricted to the relatively recent 'Christmas tsunami' of 2004, which largely affected tropical coral reef communities the coastal Indo-west Pacific. That tsunami resulted in 80% mortality to coral reefs and considerable reductions benthic macroalgal cover in the affected areas. The Japanese earthquake and tsunami of March 2011 occurred as the present project was under way. To our knowledge, there are no published studies of the impact of a tsunami on the benthic assemblages of temperate oceanic islands.
The insularity of the Juan Fernandez archipelago and the Chilean studies under way prior to and after the the tsunami are distinguishing features of this project.

The accumulated data and products from this collaboration with our Chilean colleagues not only contributes where it can to our understanding of the impacts of tsunamis, but it also contributes to the base of knowledge on the marine biota and biogeography of the little studied Southeast Pacific oceanic islands, and in particular the endemic lobster Jasus frontalis. Where before-after data were available, such as lobster tagging and benthic suction samples, it was also possible to assess the impacts of a recent tsunami on the benthic biota. Our results suggest that despite the devastating impact of the tsunami on land, the impact to the benthic environment was rather localized and limited to relatively low sloped shorelines where the horizontal component of the tsunami wave caused greatest disturbance.

The project also provided the opportunity to develop a general methodology that can be broadly applied to assess the behavioral response of demersal fish assemblage to local substrate disturbance.

Contributions to Other Disciplines:

Genetic analysis of endemic species on oceanic islands provides insights into evolution, dispersal and biogeography of marine benthic species. The Juan Fernandez lobster, Jasus frontalis, represents a biogeographic enigma. The center of diversity of the genus, Jasus, is in the temperate southwest Pacific (New Zealand and Australia). The genus extends westward to the Tristan de Cunha Islands in the Atlantic, and east as far as the Juan Fernandez Island off Chile where J. frontalis is found. Curiously, the genus does not occur on the South American continent, however. As a spiny lobsters have an extended larval stage that lives as long as 11 months in the plankton. While this might help explain the wide geographic coverage of the genus, it is unclear how larvae maintain their home range and diverge in the face of such great dispersal potential. Genetic analysis of the J. frontalis tissue samples collected and archived with support of this NSF-RAPID project will contribute to a better understanding of the phylogeography of this iconic group.

Contributions to Human Resource Development:

The project has involved American and Chilean undergraduates and graduate students listed elsewhere in this report. As for American students, we supported two undergraduates (one REU, one non-REU), two graduate students, and a high school student. The two American undergraduates were hispanic US citizens, one from the University of Maine, the other from the University of Puerto Rico.

All students have received training in a broad array of marine research methods, including benthic and plankton sampling, instrumentation and data manipulation.

Contributions to Resources for Research and Education:

As stated under the Outreach section of this report, we are working with education and outreach partners at the Centers for Ocean Sciences Education Excellence (COSEE) - Ocean Systems to implement an inquiry-based online tool for direct student investigation areas, both above and below the water line, that were affected by the tsunami.

Contributions Beyond Science and Engineering:

The project provided an important collaboration between US and Chilean marine scientists over a problems of mutual interest relating to tsunami impacts, benthic ecology and insular fisheries.

Conference Proceedings

Categories for which nothing is reported:

Any Book

Any Conference