Final Report

Submarine Canyon and Scavenger Communities in the Main and NWHI

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Executive Summary

Submarine canyons are becoming increasingly recognized as potential sites of elevated production and biodiversity. Research on canyon systems over the past decade has been carried out off the east and west coasts of the Continental United States, Canada, Australia, Chile, the Iberian Peninsula, Mediterranean, and the European Union has recently provided substantial funding for canyon research. With this study we provide the first major investigation of submarine canyon systems in isolated subtropical systems. The Pisces IV and V submersibles have been used to examine patterns of abundance and community composition in infaunal, megafaunal, and scavenger assemblages in and out of canyon systems off Nihoa Island and Maro Reef in the Northwest Hawaiian Islands, Oahu in the main Hawaiian Islands, and will finish in 2006 with work in two canyon systems off Moloka'i in the main Hawaiian Islands. Both cruises thus far have been overwhelmingly successful and with the completion of this years cruise we will have data for at minimum 4 major publications. Preliminary analyses support hypotheses of elevated levels of detritus in subtropical canyons, higher megafaunal abundances in canyons, and distinct canyon communities. Dissemination of results began with an oral presentation at a deep-sea fisheries workshop at WHOI in 2004 and continues with a poster presentation at the Deep-Sea Biology symposium this summer in England.

Purpose

Submarine canyons are common features along the ocean's slopes but remain very poorly explored. Canyons are potentially extremely important deep-sea habitats because they trap detrital materials moving across the shelf and slope, providing elevated food supplies to a variety of organisms. For example, suspension feeders benefit from accelerated canyon currents, demersal planktivores and cetaceans exploit dense layers of krill and other vertical migrators that concentrate in canyons, and detritivores benefit from enhanced sedimentation and macrophyte accumulations. In addition, canyons can serve a food-rich patches critical to the recruitment success of commercially important demersal fishes. Canyons are also likely to be hotspots of biodiversity due to their broad range of habitats resulting from rocky substrates, current intensification, detrital mats, organically enriched sediments, and seepage of reduced pore waters. We have nearly completed one of the first ecological studies of canyons associated with tropical oceanic islands and atolls, which are very common in the ocean.

Scavengers, which feed on the remains of macroscopic animals, are significant biomass components of canyon and open-slope faunas. These necrophages play important roles in the consumption and dispersal of organic matter in slope habitats and often are concentrated in canyons. Scavenger species throughout the world are economically important because they are often commercially exploited (e.g., shrimps, lobsters, crabs, hagfish, rattail fishes, virtually any species captured with baited trap or longline), they are consumed by higher trophic levels including marine mammals

such as the Hawaiian monk seal, they rapidly recycle discarded fisheries by-catch, and they act as pest consumers of trapped and hooked fish.

In 2003 we employed the Pisces IV and V submarines to canyons off Nihoa Island and Maro Reef in the Northwest Hawaiian Islands, as well as off Oahu in the main Hawaiian Islands. We will complete our field studies in 2006 with a cruise of the main Hawaiian Island of Moloka'i and analyze data to test several ecological hypotheses including:

1) *Hard-substrate, suspension-feeding biota (including deep-sea corals) are especially abundant and diverse in canyons.*
2) *Particular species of soft-sediment macro- and megabenthos have high population densities, and a relatively high proportion of reproductive individuasl,in canyons due to organic enrichment.*
3) *Macrophyte detritus is more abundant and supports denser fish and invertebrate assemblages in canyons than at open slope reference stations.*
4) *Food-web structure (as indicated by stable isotopic analyses) differs in canyons due to enhanced fluxes of macrophytic detritus from shallow water.*
5) *Scavengers are larger, aggregate more rapidly, and consume bait parcels more quickly in canyons than on the open slope.*
6) *Canyons adjacent to high islands receive greater organic input than those off low islands and atolls), resulting in increased biomass of deposit feeders and a stronger macrophyte carbon-isotope signal.*

Completion of the field portion of our project has been delayed because the Moloka'I cruise originally scheduled for 2004 will not be completed until September of 2006.

Approach

Using HURL's PISCES submersible and ROV, we have completed studies of background and scavenger assemblages along depth transects (200 - 1500 m) through 3 canyons and on 3 open slopes off the Hawaiian archipelago (a fourth canyon and open slope will be investigated in 2006). Two canyons originated near embayments (e.g., Kaneohe Bay) where macro-detrital inputs are likely to be largest. The other two canyons were on the slopes of shallow reef platforms (i.e., atolls) in the Northwest Hawaiian Islands (Nihoa Island and Maro Reef, respectively). The abundance and distribution of megafaunal fish and invertebrates, and macrophytic detritus were evaluated using video and photographic surveys conducted. The abundance and biomass of infaunal macrobenthos, and the organic-content of sediments, will be (the data are partly analyzed) assessed from box- and tube-core samples collected at depths of 200, 350, 700, and 1000 m meters along each transect. Scavenger assemblages were studied by deploying (with PISCES IV) 5-kg bait parcels, as well as baited traps,

at depths of 200, 350, 700, and 1000 m along each depth transect. The species structure and aggregation sizes of scavengers are being evaluated from videotapes.

Detritus, megafauna (fish and invertebrates), scavengers and sediment communities along each canyon axis and slope transect have been quantified as follows. At each sampling depth (200, 350, 700 and 1000 m) the following tasks will be performed:

I. The areal extent of macrophyte detritus was evaluated using video and photographic data from 3-4 ten minute transects per depth station. The length and number of surveys at each station depended on the depth, topography and habitat size. Transects were conducted with the vehicle flying level, just over the sea-floor during daylight hours, with half of the transects parallel and half normal to the canyon axis. Relative composition of the detritus was recorded, and detritus samples have been collected. Data will be continuously recorded using audio tapes and an external video camera system. Between transect comparisons will be made using multi-factor ANOVA, with depth, site (canyon versus non-canyon) and location (high island versus atoll) as factors.

II. Detritus, with its associated fauna was collected with the manipulator arms and placed in boxes mounted on the submersible. A the surface, samples were sieved on 300 μm, a subset of the animals frozen for stable isotopic analyses, and the remainder fixed in 10 % formalin. Animals inhabiting the detritus will be identified and abundance and biomass of the animals will be evaluated relative to dry weight of detritus. Sizes of infauna will be measured for comparison between stations and for estimation of secondary production using literature P:B ratios (production:biomass) (e.g., Banse and Mosher, 1980).

III. Five to ten, tube cores (7.5 cm diameter) and selected Ekman cores (20 x 20 cm) were successfully taken at each station to asses infaunal community structure. The top 10 cm of tube cores were fixed in a 10% formalin solution and processed for macrofauna as in Vetter and Dayton (1998). These data will form the basis of a Ph.D. dissertation by a student at U.H.

IV. Megafauna density and diversity were evaluated along the same transects used to estimate detrital cover. All data were recorded continuously on audio tape and on an externally mounted video camera. Still photography and manipulator collections were used to confirm identifications. Between transect comparisons in species abundance were made using the transect analysis techniques of Smith and Hamilton (1983) and Lauerman et al. (1996), and by using ANOVA, with depth, site (canyon versus non-canyon) and location (high island versus atoll) as factors. In addition, nonmetric multidimensional scaling will be used as in Vetter and Dayton (1998) to differentiate the community structures of the various depths and habitat types. Much of these statistical analyses await the completion of the field program in September 2006.

V. Bait parcels for assessment of scavenging assemblages were deployed during the first PISCES dive at each site. After deployment, each parcel was monitored for

30 minutes using a protocol developed in the northwest Hawaiian Islands by the National Marine Fisheries Service; this will allow comparisons of our data with existing fish-census data sets. In the NWHI we used 5 kg parcels of mackerel and 24 hr deployments of bait. For the high Hawaiian Islands his was changed to 10 kg parcels of marlin monitored at intervals over a single dive because 1) large scavengers including sharks and rays consumed or carried away many bait parcels in the NWHI, and 2) the change allowed us to sample additional stations.

VI. Standard scavenger traps (Ingram and Hessler, 1983) will be deployed on the seafloor within 10 m of bait parcels during the first dive at each depth station. Recovery of traps took place after 24 hours in the NWHI and after 4 hours in the high Hawaiian Islands. Subsamples of trapped scavengers have been frozen for stable isotopic analysis, and the remainder was fixed in 10 % formalin solution. ROV dives were performed at night to survey canyons and slope for sediment and habitat features, and to examine the distributions of megafauna, particularly hagfishes.

Craig Smith (University of Hawaii) has served as Chief Scientist on the NWHI cruise and will serve as such on the 2006 Moloka'i cruise. Eric Vetter (Hawaii Pacific University) served as Chief Scientist on the Oahu cruise. Ric Martini has been responsible for directing evening ROV missions. Drs. Vetter and Smith will oversee final analysis of scavenger and infaunal data which will form the basis of a M.S. and Ph.D. for two students at the U.H. Dr. Vetter will take the lead role in analysis of megafaunal fish and invertebrate communities while Dr. Smith will lead on stable isotope studies. Terminal analysis awaits data from the final cruise which will be completed in September, 2006 following a two year delay.

Findings

The first cruise for this project, to study canyon and slope habitats in the Northwest Hawaiian Islands, took place between September 3rd and 28th aboard the research vessel Ka'imi'kai O Kanaloa (KOK). The cruise was overwhelmingly successful in terms of submarine exploration, hypothesis testing, data collection, and dives made. All 12 Pisces IV dives went according to plan, and we made an additional 8 dives using the ROV RC-150.

Samples and data collected included quantitative megafaunal surveys (using video with the ROV and direct observations with Pisces IV), tube cores for infaunal and grain size analyses, quantitative observations of scavenger aggregations at standard baits, and trapping of scavengers with baited traps. These data will be used to examine differences in submarine and scavenger communities by depth and habitat (inside and outside of submarine canyons). Megafaunal assemblages will be analyzed for abundance, community structure, and diversity; infauna for abundance, diversity, and biomass; and scavengers for species assemblages, population genetics, and stable isotopes for trophic analysis.

Our physical samples, including sediments, scavengers, and videotapes will take considerable future effort to fully analyze; however, some preliminary analyses of megafaunal distributions have been made. These indicate that both fish and invertebrate megafaunal abundance and diversity increased in moving from the open slope into canyons, and in moving from shallow to deeper depths. As predicted, megafauna appear to be enhanced in regions with abrupt topography, which is much more common inside canyons. Unexpectedly, we found apparent enhancement of benthic populations by concentration of macrophyte detritus within the canyon investigated off Nihoa Island. The concentration of green algae detritus off a small, low island within a canyon with a deep (330 m) head located far from shore is remarkable. The increase in megafaunal abundance with depth was also very surprising because the flux of organic matter, and biomass of seafloor communities, normally declines exponentially with depth down slope. We hypothesize that the relatively low biomass at 350 m (relative to deeper depths) results from high predation pressure from shallow-water predators (e.g., the amberjack *Seriola dumerili*) that occasional forays into deep water. On many occasions, we observed amberjacks feeding on sluggish deepwater fishes at depths down to ~ 400 m, even though amberjacks are generally considered to be epipelagic predators. In addition, fish biomass at our deeper stations (650-1000 m) may be enhanced by the provision of prey in the form of vertical migrators (small nekton crustaceans and fishes) that feed in surface waters at night, and migrate below the depth of light penetration (~600 m) during daytime.

The scavenger communities were surprisingly large and extremely active, suggesting a remarkably large carrion flux to the slope around the Northwest Hawaiian Islands. Bait parcels at our 650 and 950 m stations typically attracted a number of large rays and sharks, totaling several 100 kg in biomass, within the first 0.5 hours. Scavengers included at least three species not previously observed by submersible in Hawaiian waters; the eel *Simenchelys parasitica* (first Hawaiian collection), a 3 m-long, six gill shark, *Hexanchus griseus*, and the 3-m false cat shark *Psuedotriachis acrages*. Other major scavengers included lysianassid amphipods, several species of large shrimp (genus *Heterocarpus*), and the voracious ray, *Plesiobatis daviesi*. Scavengers were larger, more abundant and more diverse inside canyons. Scavengers were also more abundant at our deeper stations (650-950 m), consistent with an expected concentration of biomass in this depth range.

We conducted similar studies off Oahu from November 18th – Dec 1st- 2003. This cruise funded by both NOAA's office of Ocean Exploration and the Hawaii Undersea Research Laboratory (NOAA-NURP) resulted in equally dramatic discoveries. We observed dramatically greater diversity and abundance of mobile megafauna within submarine canyons associated with embayments. Relative to sites out of canyons enhancement of diversity and/or abundance of animals within canyons was observed for fishes from depths of 600 – 1000 m, shrimp (*Heterocarpus ensifer*) from 300 – 500 m, and scavenging species in general at all depths observed (300-1500 m). The riot of life in the canyons appeared to be subsidized by large quantities of algal detritus which was observed at all depths in the canyons.

Evaluation

All of our objectives for our first two cruises were met with the exception of using a self-contained time-lapse video system to record scavenger visits to bait stations over a 24 hour period. This proved to be the one area that we were overly ambitious in our proposal. We were not able to employ this system because of space and weight limitations for equipment on the Pisces IV submarine.

Dissemination of Project Results

Dissemination of preliminary results began with a presentation by E. Vetter at the *Deep-sea Fisheries: Ecology, Economics and Conservation* meeting held September 12-14, 2004, and sponsored by the Woods Hole Oceanographic Institution and New England Aquarium. C. Smith will present data from this project at the 2006 *Deep Sea Biology Symposium* hosted by the National Oceanography Centre, Southampton UK. We plan to publish the scavenger studies in a special volume of Marine Ecology Progress Series in 2007. Publication of megafaunal community studies will follow late in 2007 or early 2008, with infaunal and stable isotope studies to follow. All studies will be presented at international conferences.