I. Report Title, Author, Organization, OE Proposal Number, Grant Number, Date

Final Report: Deep sea corals as habitat for macroinvertebrates in the Gulf of Alaska

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OE Proposal Number: OE 140

Grant Number: Grant: G00001609

Date: August 8, 2006

The goals of the "Deep sea corals as habitat for macroinvertebrates" project in the Gulf of Alaska Seamount Expedition (July 30 to August 23, 2004) were to explore the invertebrate assemblages on corals on five previously unexplored volcanic seamounts in the Kodiak- Bowie Seamount chain in the northeastern Gulf of Alaska. The deep-sea submersible *Alvin* was used to conduct replicate 0.5 km or 0.2 km video transects at depths of 700 m, 1700 m and 2700 m on four of the five seamounts; after transects were completed at each depth, voucher specimens were collected. An additional dive was allocated on four of the five seamounts to explore areas of interest, to collect samples, and to increase the photographic inventory of macrofauna, corals and substrate. A total of 17 dives were made with the *DSV Alvin*; a dive on the last day of the cruise was cancelled because of high winds and adverse sea conditions. Submersible collections were augmented with a variety of baited traps positioned on the seamounts near transects and specified depths by means of the WHOI 'Elevator' the previous evening. The elevator is a platform fitted with an acoustic transmitter and receiver; location and recovery of the elevator was determined via acoustic telemetry. Comparisons were made between video transects and collections from different depths on each seamount and between seamounts. Hydrographic measurements were collected with CTD (conductivity, temperature, depth, transmissivity, oxygen) casts to a minimum of 3000 m depth; additional measurements were recorded by a CTD and Nansen water bottles attached to the *DSV Alvin*. A detailed bathymetry map was made of each seamount with multibeam mapping using the SeaBeam. Additional mapping of the seafloor and non-target seamounts was conducted during transits between seamounts. Daily logs of the cruise, photo essays, and interesting videos are included in the Ocean Exploration webpage (http://oceanexplorer.noaa.gov/explorations/04alaska/welcome.html).

All goals of the project were accomplished. Invertebrates were identified to lowest possible taxon and quantified to numbers per area or per coral host in all video transects. A number of species unknown to science were collected and are being described. Some species were bathymetrically restricted; others were found on only specific host species; and others were found only in the absence or presence of other species. Data collected during the cruise are the basis for a thesis of an M.S. student expected to graduate in the 2006-07 academic year. The cruise contributed to the training of a doctoral student and an undergraduate student, and an environmental professional. Results of the cruise have been presented orally and in posters at many international and national scientific meetings, and also at university, community and civic seminars presented across the country. The proposal, photo essays and data collected during the cruise were the basis for lesson plans and a workshop for K-12 teachers. Several seminars were presented to committees of the North Pacific Fisheries Management Council and professional fishing groups, which aided in the establishment of these seamounts as marine protected areas. A number of manuscripts are in review or draft form.

III. Purpose

A. Description of the purpose of the project.

Deep sea corals have been widely acknowledged as providing structural complexity and habitat for fish and invertebrates in the deep sea, however little is known about their spatial and bathymetric distribution, predators, commensals, or assemblages of organisms which utilize them for habitat, particularly in the North Pacific. In the face of increased commercial fishing activities such as bottom trawling, dredging and long lining, concern has been increasing for the well being of these slow growing organisms and those species that might utilize them for habitat. Few studies have investigated the assemblages associated with DSC species. Most studies which have examined fauna on deep sea corals have used remote sampling techniques, from which spatial relationships cannot be determined with certainty. The paucity of in situ observations and the expense involved in deep sea explorations are plausible explanations for the lack of substantiating data. If corals are critical habitat and serve as biodiversity 'hot-spots' in the deep sea, the fauna associated with them and their biological relationships should be investigated and quantified prior to further degradation by commercial fishing activities.

During a prior manned submersible investigation of macroinvertebrates on five seamounts (Chirikof, Marchand, Patton, Murray, Warwick) in the Gulf of Alaska in 2002, we quantified the organisms on at least 10 species of deep sea corals. Some macrofaunal species (e.g., chirostylid crabs) were highly selective of the coral species with which they were associated, while other species (*Asteronyx* basket stars) had contrasting selectivity. Most of the coral species and associated fauna had defined bathymetric ranges, which partially explained the host selectivity.

B. Objectives of the project

The primary objective of the project was to investigate the invertebrate assemblages associated with deep sea corals on at least four seamounts located in the northern Gulf of Alaska; an additional seamount was added for geological purposes. The number of seamounts to be explored was a product of the need for replication, limited by logistical concerns, i.e., the support vessel *RV Atlantis* and submersible *DSV Alvin* were available only for a limited period. These seamounts in the Kodiak-Bowie seamount chain are more northerly and closer to the continental shelf than those of the Patton seamount range investigated in our 2002 studies. The seamounts had depth ranges which encompassed the bathymetric distributions of the coral and invertebrate species we had previously studied. Other seamounts of similar depth range located in the vicinity would have accommodated the proposed invertebrate and coral studies, however these five seamounts also satisfied requirements necessary for other synoptic research projects on the same cruise.

IV. Approach

A. Detailed description of the work that was performed.

The invertebrate assemblages and their coral hosts or substrates were investigated on five seamounts: Denson, Dickins, Welker, Pratt, and Giacomini, in that sequence (Figure. 1). Two dive days were requested for Denson Seamount, primarily for geological studies, and four dive days were requested on each of the other seamounts, which were explored for biological and geological projects. The cruise plan was arranged to permit the vessel to arrive at the designated seamount on the evening prior to the initial dive, to allow multi-beam mapping for location of optimum transect sites. On most seamounts, detailed mapping of the entire seamount required at least two nights, but dive locations were selected after the initial night of mapping. Coordinates and depths were provided to the chief of submersible operations and the submersible pilot, the vessel bridge, and the scientific diving team, no later than 6 am the morning of the dive. After the initial dive at each seamount, all coordinates were provided the evening prior to the dive. Dive sites were selected along ridges, where the current flow and the coral abundance were anticipated to be higher (Genin et. al. 1986).

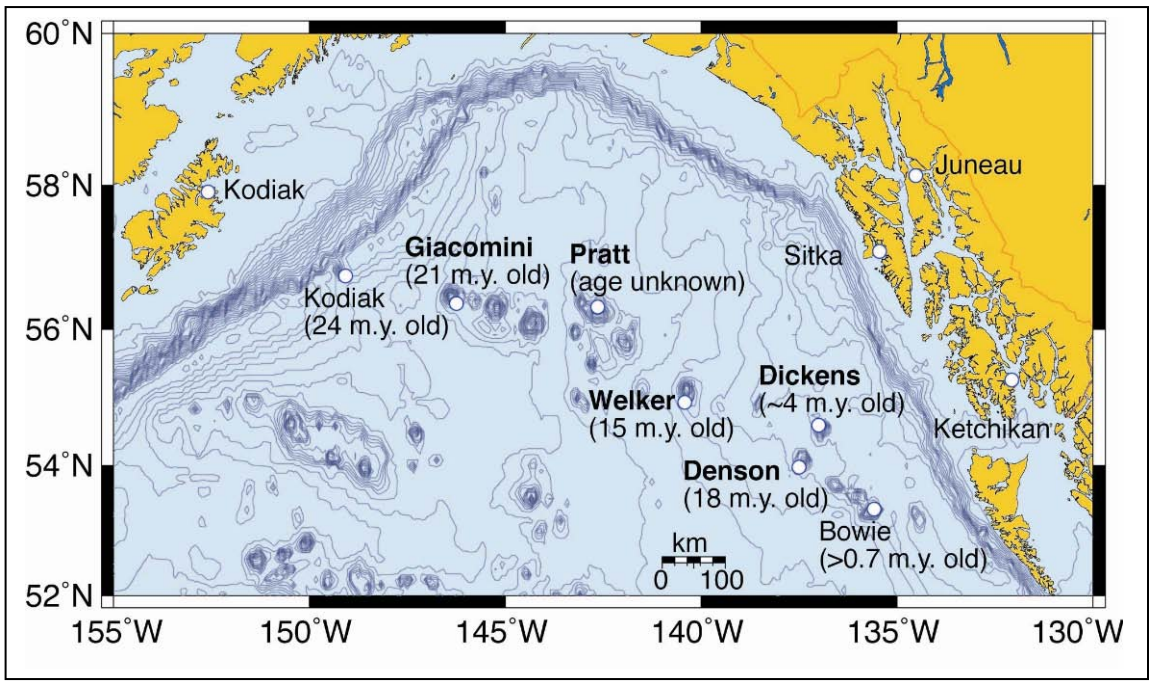

Figure 1. Map of Gulf of Alaska depicting Bowie-Kodiak Seamount Chain. Seamounts in bold are 5 seamounts explored during July 29-August 23, 2004.

Vertical and horizontal transects were conducted on each seamount. The submersible would settle to the bottom several hundred m deeper than the intended transect depth, obtain a location fix, then conduct a vertical transect upwards until the target depth was encountered. At the selected depth, another fix would be obtained, and a horizontal transect was conducted at a steady, slow speed at a fixed height above the substrate, as

consistently as current and topology permitted. Replicate horizontal transects of 500 or 200 m length were conducted at each of 3 depths: 700 m, 1700 m, and 2700 m on four of the five seamounts; each depth required a full dive day. For the first three seamounts, each transect was 500 m in length, but at subsequent seamounts transects were only 200 m in length, to allow more time for collections The shallowest depth of 700 m was selected as it encompassed the shallowest depth of all seamounts; the other two depths were arbitrarily selected in an attempt to encompass all bathymetric zones of the seamounts. An effort was made to have transects at all of the depths on the same general ridge line, or at least on the same aspect, of each sea mount as possible. We successfully completed 17 of the 18 planned dives, including 23 of the 24 planned horizontal transects.

Digital video data were collected by cameras on the *Alvin*. A 3-chip Sony MiniDV Handycam Vision DCR-TRV900 NTSC was attached to the right manipulator arm. An identical camera could also be used inside by an observer holding the camera, pointing it out the observation window. Cameras on the port and starboard sides of Alvin were under control of the scientific observers for pan, tilt, and zoom, and were 1-chip TRV18 models. Two lasers were attached to the port pan and tilt camera, measuring 10 cm apart, to provide calibration sizes to measure sizes of organisms. Cameras were set to continuously record once the *Alvin* landed on the bottom. During the transects the cameras were aligned so the lasers on the port side pan and tilt were in the field of view of the 3-chip camera on the manipulator arm. The hand-held 3-chip was used inside *Alvin* to record the seamount from the slope side observation window. In addition to the data recorded from these transects, a Canon G2 with an external strobe was attached to the outside of *Alvin*. This camera recorded still photographic images every 15 seconds for the duration of the dive. All images recorded, both single frame and video, were digital. A variety of hand-held digital still cameras were available for the observers and pilot to obtain high quality images through the viewing ports of selected specimens.

Following the completion of transects, as many voucher specimens as possible were collected of the predominant invertebrates (particularly crustaceans, echinoderms and sponges) following the completion of transects. A standard routine for collection of coral species was established: initially the subject coral would be photographed with a high resolution hand-held camera and a 3-chip video camera; then a small specimen of the coral would be collected with the hydraulic arm and placed in a separate and numbered, sealed container for later genetic analyses; all invertebrate specimens would be removed from the entire coral with a slurp gun; occasionally, larger invertebrates would be collected with the hydraulic arms; and, for species of coral newly encountered, entire coral specimens would be collected and placed in the basket.

A number of sampling techniques were used to collect invertebrates: direct collection of corals and larger organisms was made with the Alvin hydraulic arms; a framed net with 6 mm mesh was used by the Alvin hydraulic arm to cover collect entire smaller corals; a large, multi-chambered, slurp gun was used to ‘vacuum’ fauna from corals; and, smaller (single chamber) slurp guns were used to collect smaller organisms. The waters within

the chambers that housed corals on their way to the surface were later sieved through small mesh (0.125 mm) for collection of small organisms.

Submersible collections were augmented with a variety of baited pots and traps positioned on the seamounts near transects and specified depths by means of the WHOI 'Elevator' the previous evening. The elevator is a platform fitted with an acoustic transmitter and receiver; location and recovery of the elevator was determined via acoustic telemetry. Pots on the elevator included a dome-shaped crab trap equipped with an upper, circular entrance; a shrimp trap, fitted with two opposing lateral entrances; and two inverted cone traps with dual entrances (similar to minnow traps) fitted with 0.5 mm mesh. An additional pair of inverted cone traps were suspended 20 m above the bottom. All traps were baited with cut herring and assorted canned cat food (tuna, catfish and salmon); additionally, all traps were equipped with two luminescent light bars ("biolum sticks"), in an attempt to attract organisms that were positively phototactic. The traps were especially effective in collecting larger crustaceans, particularly lithodid and majid crabs, but also collected a large number of shrimp and smaller numbers of mysids, euphausiids, amphipods and isopods. The traps were ineffective in collecting suspension feeding organisms.

Hydrographic measurements were collected at night with an SBE 19 Seacat CTD Profiler (conductivity, temperature, depth, transmissivity, oxygen) mounted on a rosette; casts were launched from the *Atlantis II* and made to a minimum of 3000 m depth. Replicate casts were made on all but one seamount. Additional measurements were recorded Measurements for salinity and temperature were also taken near the bottom on each dive by a Seacat CTD on *Alvin*. Water samples were collected with a five bottle Niskin array mounted on *Alvin* during each dive. Dissolved oxygen of water samples was measured from the Niskin bottles with a YSI 550A Dissolved Oxygen Instrument in the lab on board immediately after the sub was safely stored.

After specimens were returned to the research vessel, macroinvertebrates were photographed, measured, labeled and either fixed in 70% ethanol or frozen for genetic analysis. Many specimens on corals, sponges and rocks had to be sorted under a dissecting microscope. All waters that had contained specimens were sieved through 0.125 mm mesh sieves and examined for specimens. After conclusion of the cruise, all specimens were examined and identified to the lowest possible taxon by means of taxonomic keys and literature. Voucher specimens had to be borrowed from some museums for some identifications.

After the cruise, direct determinations of abundances of organisms were attempted from the digital video transects. For predominant macroinvertebrates, a method similar to those used by Levin et al (1991), Fujita and Ohta (1990), and Tunnicliffe and Jensen (1987) was used to estimate density from the video data. The general transect estimator, as described in Thompson (2002) was used. This estimator uses the number sighted (y) divided by the area covered (a) to obtain an estimate of density (D). In order to find the area included within each transect, measurements of width and length are required. The submersible coordinates recorded during each dive were used to determine the length of

each transect. The width of the field of view of the camera was determined from the two calibration lasers mounted on the port side pan-and-tilt camera. The width was estimated by measuring the distance between the lasers on the port pan-and-tilt camera. The ratio of the width observed to the actual width of the screen, as compared to the actual distance between the lasers, was used to determine the width. The width of the field of view changes as the height of the submersible off the bottom changes; hence, the width for the entire transect was averaged by estimation of the width of the field of view of the camera every five seconds, then averaged over the entire length of each transect.

The number sighted was found by counting all macroinvertebrates in view of the camera. Whenever possible, direct determinations of abundances of organisms was attempted from the digital video transects. However, the abundance of smaller species could not be determined; many species tend to be small, hard to quantify, and cannot be identified with certainty from video images. To correct our estimate of density for organisms that may have been present but were not detected during the transect, a correction factor (p^) was included in the denominator. For areas where a direct count for taxa was not possible due to the density of the organisms, poor visibility, or other imagery problems, two methods were used to improve the density estimates. One method will be used to correct for smaller organisms such as ophiuroids on corals, and the others for those on substrate (rock or silt). The first method used the specimens collected during the dives. The number of organisms (e.g., ophiuroids) collected from each coral was counted. The corals collected for each dive were grouped by family. The total number of organisms collected for each family was divided by the total number of those corals collected, giving the average number of organisms per coral for each family. The number of corals in each family was counted for each transect, and multiplied by the average number of organisms collected per coral for each family. Density estimates using this method were likely to be conservative, as lab counts from collected specimens do not represent exact counts. Not all organisms were collected, and they were mixed together in the bioboxes onboard Alvin, so it was not always possible to differentiate which specimens came from which collection.

The second method to obtain more accurate estimates of density for organisms not on corals was to apply a correction factor obtained from the parts of the dive not included in the transects. During each transect where the cameras were zoomed all the way out, all organisms seen were counted, but some organisms were missed. The correction factor for these organisms was a ratio of the number of organisms observed when the camera is zoomed out to the number of organisms observed when the camera is zoomed in. This ratio was obtained from parts of the dive where the camera is zoomed all the way out, and then zoomed in close on the substrate. The ratio was obtained for as many times at the transect depth the camera zoomed in on the substrate, and then averaged for that dive to obtain a correction factor for each dive. The correction factor was assumed to be the same for each dive, because each dive was conducted with the same protocol, so visibility should be consistent from dive to dive. When this correction factor (p^) is added to the density estimate, it gives the following equation: $\boxed{\hat{D} = y / a\hat{p}}$

B. Project management: List individuals and/or organizations actually performing the work and how it was done.

The scientific party for "Deep sea corals as habitat for macroinvertebrates in the Gulf of Alaska" included:

Dr. Thomas C. Shirley, Principal Investigator, Professor, Univ. of Alaska Fairbanks
Danielle Parker (now D. Parker Underwood), M.S. student, Univ. of Alaska Fairbanks
David Miller, doctoral student, Univ. of Alaska Fairbanks
Jon Warrenchuk, Marine Biologist, Oceana
Matt Richards, Undergraduate student, Western Washington Univ.

Dr. Shirley wrote the initial proposal and subsequent quick-look and summary reports, and final cruise report, and served as Chief Scientist for all scientific projects aboard the cruise. He has assisted with identifications of specimens, overseen the analysis of video data, and is involved in the writing of all mss. resulting from the research.

All members of the scientific party above participated in the research cruise, made dives on the *DSV Alvin*, and assisted in all phases of data collection detailed in section IVA (above) while aboard the cruise. D. Miller and J. Warrenchuk did not receive funding for the project and volunteered their time; they have not been able to assist with post cruise processing of data or specimens. Jon Warrenchuk (Oceana) has taken the lead on one manuscript resulting from the cruise. Matt Richards (WWU) received support from an NSF REU (Research Experience for Undergraduates) grant to the University of Alaska Southeast; although he completed analysis of a secondary project after the cruise, he was not funded to assist with the objectives of the project.

Danielle Parker Underwood (UAF) has been responsible for quantifying all video transects, and for many of the identifications of collected specimens. She has been the workhorse for the project, even though her support from the project was for only a single year. Her M.S. thesis ("Bathymetric and spatial distribution of echinoderms on seamounts in the Gulf of Alaska") is based on data collected during this cruise.

All members of the scientific party listed above have made oral or poster presentations to various scientific societies, university or civic meetings, and several will participate in the writing of manuscripts to be submitted to scientific journals.

Representatives of this research project were present on eight of the 17 Alvin dives made during the cruise, but data and specimens were obtained from all dives. All 25 members of the scientific party of the cruise contributed greatly to the success of our project. All Principal Investigators agreed to standardizing the collecting and video transect protocols and generously donated their efforts, time, specimens and expertise. We graciously acknowledge their contributions to our project and the success of the cruise.

In particular, our research would not have been possible without the identification of coral specimens by Dr. Amy Baco-Taylor, WHOI, who also serves on the graduate

committee of Daniel Parker Underwood. Peter Etnoyer (Aquanautix) and G. P. Schmahl (Flower Garden National Marine Sanctuary) also assisted with identifications of corals and sponges, respectively. Dr. Randy Keller and Jason Chaytor (both of Oregon State University) were largely responsible for processing multi-beam data and producing detailed maps and coordinates of our sampling sites. Dr. Nicolas Alvarado (NOAA OE) was responsible for keeping detailed logs of collections and activities of all projects. Catalina Martinez (NOAA OE) was the expedition coordinator and worked to help all projects interact with each other, the *DSV ALVIN* submersible team, and the crew of the *RV Atlantis II*.

Dr. Jeff Short (NOAA NMFS) conducted chemical analyses of a number of specimens and will be an author on at least one ms. resulting from our research.

V. Findings

A. Actual accomplishments and findings.

My research group participated in a total of 8 of the 17 *Alvin* dives, with dives conducted on all seamounts; however, samples were collected for my research on all 17 dives on all five seamounts. A total of more than 300 collections of specimens were made. Representatives of 12 metazoan phyla and a large number of lower taxa were collected on corals. Suspension feeding organisms predominated, with Ophiuroidea (brittlestars) and Crustacea (crabs and shrimps) being the most conspicuous. The chirostylid *Gastroptychus iaspus* was perhaps the most conspicuous crab observed on corals; none were collected in traps, lending support to the suggestion that they are suspension feeders. The basketstar *Asteronyx* sp. was the most conspicuous ophiuroid in shallow waters (<900 m depth), but was replaced by other species of ophiuroids (*Amphigyptis* sp., *Ophiomoeris* sp.) at deeper depths. *Asteronyx* sp. rarely co-occurred with the chirostylid crabs. Crinoids (sea lilies) and anemones were also prevalent, but polychaets (scale worms), possible feeding on mucous or epibiota, were abundant on some corals. Taller corals supported larger associated fauna. Several predators and possible predators of corals were collected, including sea stars (*Hippasteria* sp., *Solaster* sp., others), sea spiders (Pycnogonida) and nudibranchs (Gastropoda). Densities of organisms on corals were often high: 656, brittle stars of a single species were counted from a single, small (<1200 cm^2), primnoid coral. These high densities of epibionts must impose energetic constraints on corals by impairing feeding and other physiological processes.

In general, corals provided a complex habitat for a diverse fauna, often with many different taxa occupying the same coral. Competitive or agonistic interactions between taxa appeared obvious, as sympatry between these species rarely occurred, even at the same depth on the same seamount. Some coral inhabitants had distinct bathymetric zonation (found only within certain depth ranges), while others were restricted to specific coral species. Some coral taxa, such as the black corals appeared to have fewer inhabitants, while others (e.g., primnoids and some bamboo) hosted diverse, dense communities.

A number of the taxa collected probably represent undescribed species or significant range extensions, however all await confirmation of identification in post-cruise processing. Additional specimens were collected of an undescribed galatheoid crab previously encountered on our Alaskan seamount expedition in 2002. Many of the smaller macrofauna (e.g., pycnogonids and munnid isopods) and the harpacticoid copepods probably contain undescribed species.

B. In significant problems developed which resulted in less than satisfactory or negative results, they should be discussed.

No significant problems were encountered. Ample data were collected to support a number of graduate theses or dissertations, however the small budget permitted only a single graduate student to receive funding from this grant. A larger budget would have permitted support of graduate students, and for them to assist with post-cruise identifications and analyses, and utilize the cruise results for thesis or dissertation research. Graduate students require a minimum of two to three years to complete their degree programs, with doctoral students requiring significantly longer times. This project was funded for only a single year, with a no-cost extension for additional time. Much of the major cost involved to OE is for vessel and submersible charter; additional funding for support of more students would return large dividends for the relatively small incremental increase.

C. Description of need, if any, for additional work.

The poor state of taxonomy and systematics of deep sea organisms has hindered the identification of many of the specimens collected; many remain identified only to higher taxa (family or generic level). Certainly many, particularly the smaller and less common organisms, are new to science.

Yes, much additional work remains to be conducted on the macroinvertebrate fauna of seamounts. We spent approximately four hours collecting during each dive, with a total of three to four dives on each seamount. Each of these seamounts are the size of large oceanic islands, with several miles of bathymetric relief. We have only scratched the surface of the biology of seamounts. All of our observations were only snapshots and descriptive in nature; no process-oriented research was conducted. A great dearth of knowledge exists about the biota and ecology of seamounts. How seamounts can support such a high diversity and density of organisms remains an enigma. The role of seamounts as biodiversity hotspots, stepping stones or refuges remains to be investigated, particularly in high latitude regions. Only 11 of the estimated 200 named seamounts in the Gulf of Alaska have been explored. Some preliminary data from the tagging of large, migratory species (e.g., salmon sharks, whales and other marine mammals) suggests that seamounts may serve as waypoints or refueling stations for these oceanic migrators. The number of new species remaining to be discovered and their biological interactions with each other are staggering.

VI. Evaluation

A. Describe the extent to which the project goals and objectives were attained. This description should address the following:

1. Were the goals and objectives attained? How? If not, why?

A resounding YES to attainment of goals and objectives. In addition to adding to scientific knowledge as detailed in this report, the project served as a wonderful educational tool to the graduate students on the cruise and the public in general. Also, a large number of newspaper, radio, TV resulted from the articles, and many presentations and seminars were given at meetings of scientific societies and civic organizations in a variety of locations around the world and U.S.: Spain, Germany, Oklahoma, Texas, Utah, Florida, California and Alaska.

2. Were modifications made to the goals and objectives? If so, explain.

No. No significant alterations were made to the goals and objectives listed in the original proposal.

B. Dissemination of Project results:

Explain in detail, how the project results have been, and will be, disseminated.

The expedition provided a superb educational experience that began before the cruise and continued while we were at sea. The cruise received signature coverage on the NOAA Ocean Explorer Web site (http://oceanexplorer.noaa.gov/explorations/04alaska/welcome.html), and the personnel of our project contributed many photo essays to the website, before, during, and after the cruise. Five satellite phone calls were conducted during the cruise to four different schools or institutes; I participated in these as both Chief Scientist and also as PI of my project. One telephone call occurred while I was in the *Alvin* conducting research, a mile beneath the sea. Our project contributed to the education of two graduate students and one undergraduate. Several Professional Development Institutes (PDI) were held for Educators during the cruise. A media event was conducted in Astoria, Oregon, on the day we returned to port, for newspaper, radio and television coverage and for local educators.

Selected list of articles, seminars and scientific presentations:

Enterprise-Record/Mercury-Register. 2004. Underwater volcanoes in Alaska Gulf to be topic of evening presentation. Tuesday, Nov. 9, 2004.

Gentes, L. Catching up: the school places students in a non-traditional environment. The Associated Press. Anchorage Times, August 25, 2004. (http://www.adn.com/alaska/story/5467754p-5405795c.html)

Griego, H. 2004. Islands of life bloom in the deep sea: an interview with Dr. Tom Shirley, UAF. Kodiak Daily Mirror, Octover 12, 2004.

Miller, D. 2005. Biology and geology of seamounts. Seminar given at Chandler High School, Chandler, Oklahoma.

Parker, D. and T. C. Shirley. 2005. Seastars (Asteroidea) on Gulf of Alaska seamounts. Poster presented at American Society of Limnology & Oceanography, Santiago de Compostela, Spain.

Parker, D., T. C. Shirley and J. Warrenchuk. 2005. Range extension for the mesopelagic scyphomedusa *Tiburonia granrojo*. ASLO National meeting, Salt Lake City, Utah, Feb. 21-25, 2005.

Shirley, T. C. 2005. Invertebrate assemblages on deep-sea corals. Invited speaker at Univ. of Texas Marine Science Institute. October 10, 2005.

Shirley, T. C. 2005. Islands beneath the sea. U.S. Forest Service Fireside Chat Series. January 21, 2005.

Shirley, T. C. 2005. Alaskan seamounts. Teacher Workshop at the Alaska SeaLife Center in Seward, Alaska, September 10, 2005.

Shirley, T. C. and R. Teasdale. 2004. Deep Water Biology & Geology: Explorations in the Gulf of Alaska from the Alvin Submarine" presented at the Museum Without Walls, Northern California Natural History Museum, Chico, CA, November 11, 2004.

Shirley, T.C., J. Warrenchuk and D. Parker. 2004. Big red (*Tiburonia granrojo*) a mesopelagic scyphomedusa, observed on seamounts in the Gulf of Alaska. Abstract of oral presentation made at the Annual meeting of the Western Society of Naturalists, Nov. 11-14, 2004. Rohnert Park, CA.

Shirley, T. C., A. Baco-Taylor, D. P. Underwood and J. Warrenchuk. 2005. Invertebrate assemblages on deep-sea corals. International Symposium on Deep Sea Corals, Miami, FL, Nov. 28-Dec. 2, 2005.

Welch, C. 2005. Coral concerns spur vast trawling ban. Seattle Times, February 11, 2005 (http://seattletimes.nwsource.com/html/localnews/2002177305_coral11m.html)

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Genin A, Dayton PK, Lonsdale PF, Spiess FN (1986) Corals on seamount peaks provide evidence of current acceleration over deep-sea topography. Nature 322:59-61.

Levin LA, Huggett CL, Wishner KF (1991) Control of deep-sea benthic community structure by oxygen and organic-matter gradients in the eastern Pacific Ocean. J Mar Res 49: 763-800.

Thompson SK (2002) Sampling. Second ed. Wiley & Sons, Inc., New York. Pgs 199-232

Tunnicliffe V, Jensen RG (1987) Distribution and behaviour of the spider crab *Macroregonia macrochira* Sakai (Brachyura) around the hydrothermal vents of the northeast Pacific. Can J Zool 65: 2443-2449.