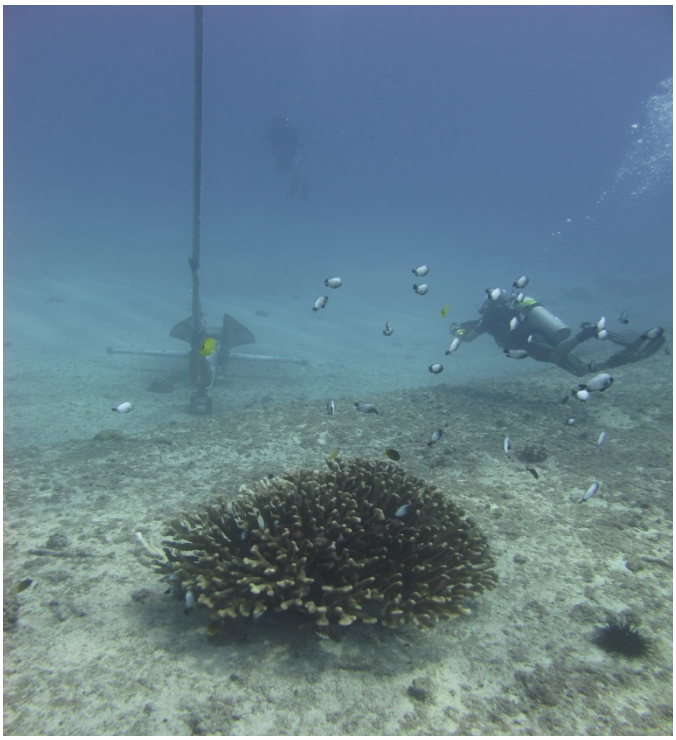
Ordnance Reef (HI-06), Hawaii
Coral Injury Assessment and Mitigation Recommendation Plan



JANUARY 2013

U.S. DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
National Marine Fisheries Service
Office of Habitat Conservation
National Ocean Service
Office of Response and Restoration
Office of National Marine Sanctuaries

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Acronyms

DoD	Department of Defense
DMM	Discarded Military Munitions
DSV	Demilitarization Support Vessel
EOD	Explosive Ordnance Disposal
MC	Munitions Constituents
HEA	Habitat Equivalency Analysis
NOAA	National Oceanic and Atmospheric Administration
ODASA(ESOH)	Office of the Department of the Assistant Secretary of the Army for Environment, Safety and Occupational Health
ORCC	Ordnance Reef Coordinating Council
RI/FS	Remedial Investigation/Feasibility Study
ROUMRS	Remotely Operated Underwater Munitions Recovery System
ROV	Remotely Operated Vehicle
RSV	ROV Support Vessel
UXO	Unexploded Ordnance

Introduction

Ordnance Reef (HI-06) is a Department of Defense (DoD) munitions disposal site that lies on the western, leeward side of Oahu, Hawaii. The nearest Hawaiian city is Waianae, which is approximately three miles to the northeast.

In 2002, at the request of the U.S. Army Corps of Engineers, Explosive Ordnance Disposal (EOD) divers conducted a visual survey of Ordnance Reef (HI-06) to determine the amounts and types of military munitions present. Military munitions located during the survey included naval gun ammunition, 105 mm and 155 mm artillery projectiles, mines, mortars and small arms ammunition. The munitions observed during this survey were categorized as discarded military munitions (DMM) and not unexploded ordnance (UXO).

In June 2006, NOAA conducted a hydrographic mapping and screening level assessment of Ordnance Reef (HI-06). The geographic boundaries of this effort encompassed a search area of approximately 3 by 1.5 nautical miles at a depth of 10 - 70 m (32 – 230 ft) of water. A variety of modern acoustic sonar instruments were used to image military munitions and define the spatial extent of the disposal site. NOAA also collected sediment, water and fish samples to assess the health of the ecosystem and potential threats to human populations living in close proximity to the disposal site.

During interagency review of the NOAA 2006 mapping and screening level assessment report, data gaps were identified by the Ordnance Reef Coordinating Council (ORCC), established through the Office of the Deputy Assistant Secretary of the Army for Environment, Safety and Occupational Health (ODASA(ESOH)). The need for an understanding of ocean currents in the offshore areas of Ordnance Reef (HI-06) was one of the data gaps the ORCC identified. In response to the review, the Army funded NOAA, under a Special Studies Agreement, to install ocean current monitoring sensors at five locations in or adjacent to Ordnance Reef (HI-06). These sensors collected information relating to the speed and direction of ocean currents throughout the water column for a full calendar year. These data are being used to validate ocean circulation and fate and trajectory computer models for munitions constituents (MC). Hypothetical contaminant release scenarios resulting from this work will inform decision makers as they consider future remedial options. The ocean current study will be published by NOAA under separate cover.

In November 2009, the University of Hawaii completed sampling for an environmental study at Ordnance Reef (HI-06) that follows the Comprehensive Environmental Response, Compensation, and Liability Act's (CERCLA) process for remedial investigations (RI). The purpose of the study was to determine whether the DMM present are posing a threat to human health or the environment. This study was a follow-on investigation to the 2006 screening level study conducted by NOAA (discussed above) and was focused on filling data gaps identified by the Army, community and regulatory agencies.

In fall 2009, the Army contracted with ARA, Inc (Fairfax, Virginia) Engineering and Sciences Division for the design, development and demonstration of the Remotely Operated Underwater Munitions Recovery System (ROUMRS) at Ordnance Reef (HI-06). The objective of this demonstration was to develop and demonstrate a system (ROUMRS) to provide a safe, cost effective alternative to using UXO-qualified divers to locate and recover military munitions located in shallow water (20 to 120

ft) on the ocean floor. The integrated system demonstrated was a package of technologies consisting of a remotely operated vehicle (ROV), adaptable attachments, specialized tools and lifting packages. The field implementation portion of the demonstration was confined to a maximum depth of approximately 120 ft. The duration of the field demonstration was approximately three weeks (21 straight days at sea). The primary intent of this effort was to demonstrate an ROV's capability by recovering as many munitions as possible during the 21 day field demonstration. During the demonstration, 76 munitions and 2,300 small arms ammunition items of the thousands of munitions present were recovered. The Army completed the demonstration in August 2011.

Because NOAA and the Army believed the demonstration, particularly the use of the ROV, would result in unavoidable impacts to corals, NOAA partnered with the Army to help it avoid or minimize such injuries and to assess any that occurred during the demonstration. This report documents the injuries that occurred. Recommendations regarding an appropriate coral mitigation strategy commensurate with the injuries that occurred are also provided.

The NOAA Coral Impact Assessment and Mitigation Project consists of three phases.

- Phase I of the project involved an assessment of the corals present in the area growing on and in the vicinity of the munitions to be removed. Specific tasks for this phase included:
  - Conducting pre-demonstration surveying and mapping of munitions and corals
  - Coordinating with contractor and relevant federal, state and local resource agencies and stakeholders on permit issues and identifying potential mitigation projects
  - Developing a relative risk matrix for avoidance and minimization of injury to corals to assist the Army and its contractor in the development of standard operating procedures

NOAA completed the Phase I effort in March 2011 (prior to the Army's demonstration). The Ordnance Reef Coral Avoidance and Minimization of Injury Plan (CAMIP) provides the results for Phase I (see http://www.ordnancereefhawaii.org/EA%20Files/04_AppendixC_CAMIP.pdf).

- Phase II of the project involved an assessment of the impacts to coral and the development of recommendations for appropriate coral mitigation activities. Specific tasks for this phase included:
  - Developing a plan to assess impacts to corals
  - Conducting post-munitions recovery coral surveys
  - Completing emergency restoration of corals shortly after the completion of the recovery efforts
  - Quantifying all impacts to corals
  - Identifying and scaling required coral mitigation activities
- Phase III of the project involves the actual completion of the necessary coral mitigation activities.

Injury Assessment

The greatest likelihood of injury to coral and coral reef resources was from physical impacts related to the operation of the ROUMRS' ROV and the recovery of munitions. To assess the degree and extent of these possible injuries, the assessment focused on four main pathways of injury related to: (1) anchor and mooring line deployment and retrieval from the ROV Support Vessel's (RSV) activities, (2) anchor and mooring line deployment and retrieval from the Demilitarization Support Vessel's (DSV) activities, (3) ROV activities (impacts from the ROV itself as well as its tether to the RSV and deployment and recovery of salvage baskets) and (4) coral lost that was growing on munitions that were recovered by the ROV. Injury assessments were conducted over the course of 8 days resulting in 56 dives within Work Area C, where the munitions recovery efforts were conducted (Figure 1). Overall the injury assessment covered an area of roughly 19 acres.

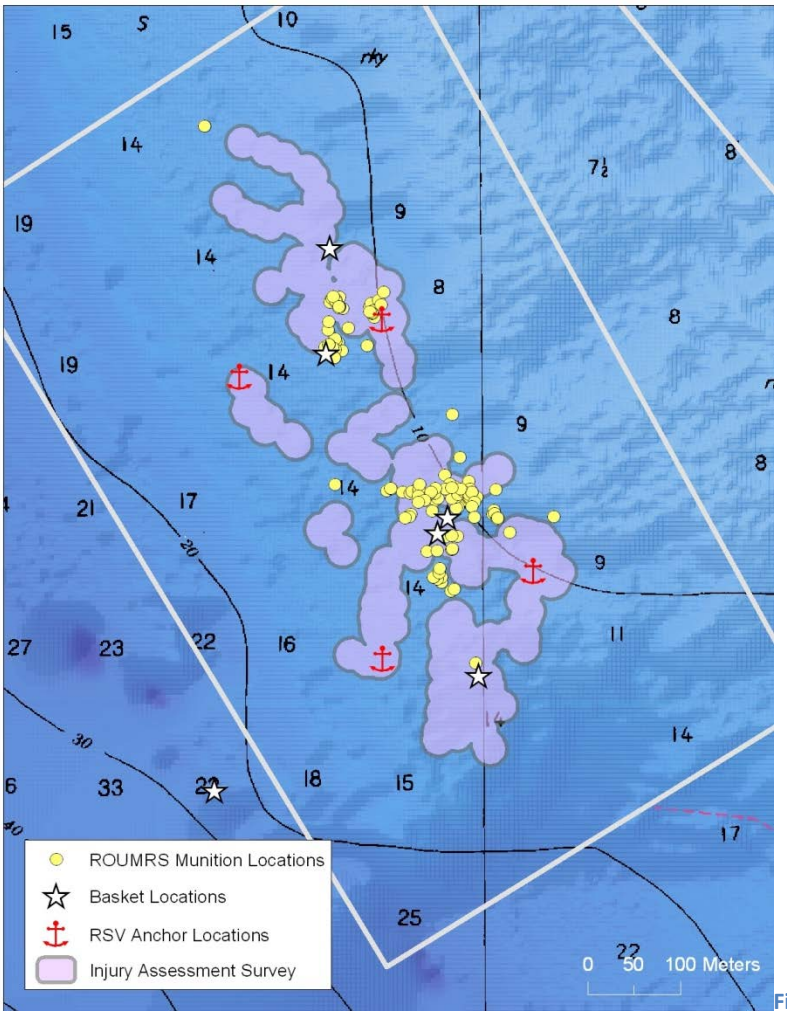

Figure 1. Map of injury assessment surveys in Work Area C (outlined in the white box), with locations of ROUMRS munitions, baskets, and RSV anchors.

During Recovery Activities

DSV Mooring Activities

NOAA and State of Hawaii divers verified the proposed inshore anchor sites for the DSV's anchor moorings and determined that they were in sand habitat and sufficiently far from any hard bottom substrate (Figures 2 and 3). The offshore anchor sites were too deep for divers to assess. There was no possibility for coral reef injury at the DSV's anchor sites because they were situated in sand. Positions of the anchor sites were recorded.

Figure 2. Diver verifying location for first inshore DSV mooring.

Figure 3. Marker buoy location for second inshore DSV mooring.

RSV Mooring Activities

NOAA and State of Hawaii divers verified the mooring locations of the RSV anchors in Work Area C once the anchors were placed and mooring lines attached. The anchors were all determined to be within the deep plateau area deeper than 60 ft depths (Figure 4). There was little evidence of initial injury during the mooring anchor deployments (Figures 5, 6 and 7) and positions of the anchor sites were recorded for post recovery work injury assessments.

Figure 4. Diver and RSV mooring anchor.

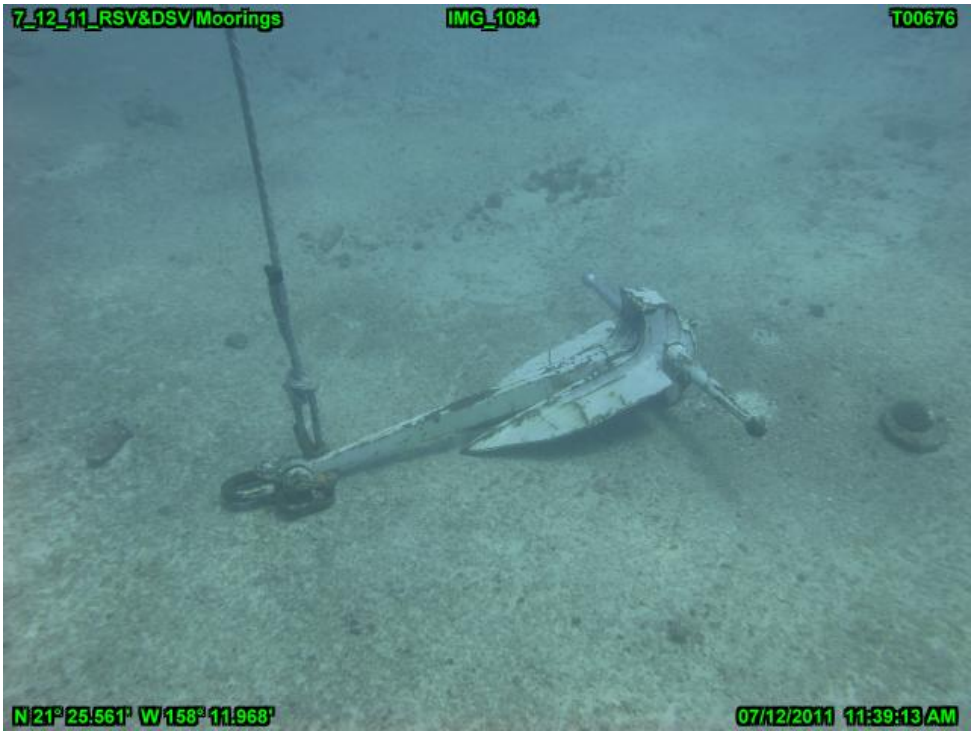

Figure 5. RSV anchor and mooring line.

Figure 6. RSV anchor and mooring line.

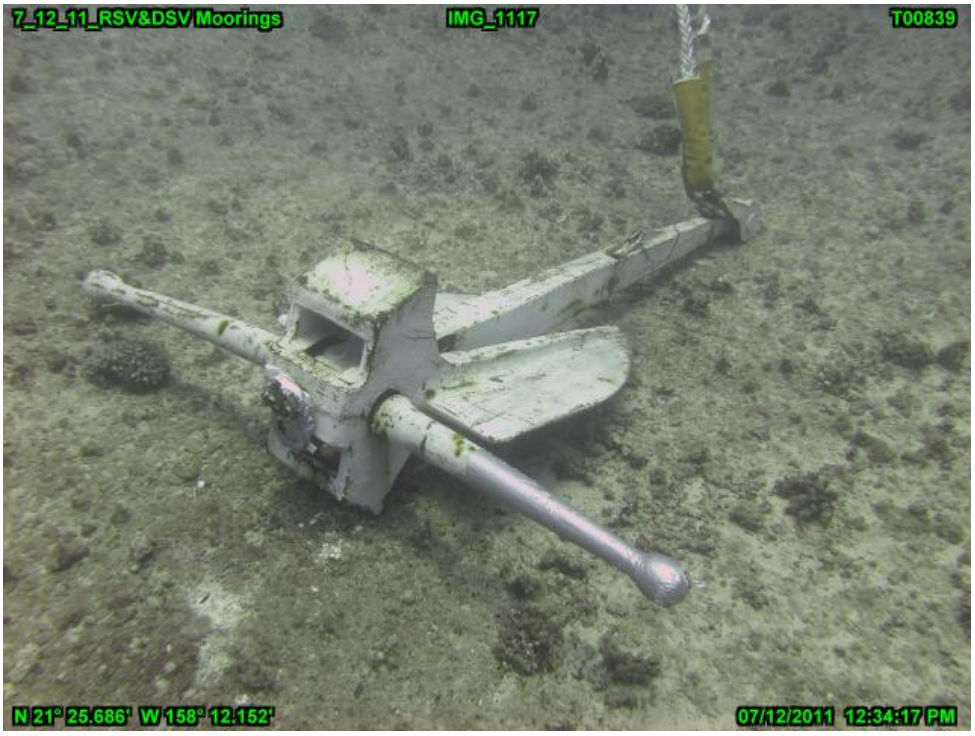

Figure 7. Close-up of RSV anchor and coral.

Post Recovery Activities

Injury from RSV and ROV activities

Assessment surveys were targeted in areas where the RSV moorings were located and where the ROV was reported to have been working. Visual surveys and direct measurements of freshly broken coral colonies were conducted immediately after completion of the technology demonstration. Injured and broken coral colonies were recorded by morphological-type (lobate, branching or encrusting forms) and binned into the following size classes based on measured length of longest axis: A (0-5cm), B (5-10cm), C (10-20cm), D (20-30 cm), E (30-40 cm) and F (> 40cm). Size classes for corals that were too badly damaged to directly measure were estimated. Corals that were intact but detached were set upright and placed in a stable position.

Areas of injury were located in clusters and easily tracked underwater by visual cues of fresh physical disturbances to the benthic substrate and corals (Figure 8). Other indicators denoting the areas of injury were fragments of munitions and associated organisms growing on them (Figure 9).

Figure 8. Fragments of impacted coral.

Figure 9. Fragmented munition with associated reef biota.

Sites of injury were surveyed in an expanding search pattern until physical disturbances were no longer apparent.

A total of 263 injured coral colonies of various morphological-types were attributed the RSV and ROV activities (Table 1). No distinction was made between lightly or heavily injured coral colonies; however, the majority of injuries observed indicated (by the amount of structural damage) that the coral colony would most likely not survive.

Table 1. Coral injuries by morphological-type and size class.

	A (0-5cm)	B (5-10cm)	C (10-20cm)	D (20-30 cm)	E (30-40 cm)	F (> 40cm)	Total
Lobate	2	29	30	7	-	-	68
Branching	78	61	35	11	4	4	193
Encrusting	-	-	2	-	-	-	2

Injury from Munitions Recovery Operations

An estimate of total corals lost that were growing directly on munitions recovered was determined by surveying a representative sample of munitions that remained in the work area after the demonstration project was completed (Figure 10). Field surveys were necessary to estimate this number since photographs of the corals growing on the actual munitions items removed were not available. A total of 29 munitions were opportunistically sampled in two separate areas in which the ROV had recovered munitions. Corals growing on the sampled munitions were measured, separated by morphological-type and binned by size in the same manner as the freshly broken corals.

Figure 10. Intact munitions with associated coral growth.

Using the data collected in the field, an average coral assemblage per munition was defined. This assemblage was then expanded to the 80 items (76 munitions and 4 non-munitions items) recovered resulting in an estimate of total corals lost on the 80 items recovered (Table 2).

Table 2. Estimate of total corals lost due to munitions recovery.

	A (0-5cm)	B (5-10cm)	C (10-20cm)	D (20-30 cm)	E (30-40 cm)	F (> 40cm)	Total
Lobate	422	44	11	-	-	-	477
Branching	138	0	3	-	-	-	141
Encrusting	223	25	3	3	-	-	254

A total of 872 coral colonies were estimated to have been lost due to munitions recovery, roughly 11 colonies per munition. The majority of these colonies (~ 90%) were less than 5cm in diameter.

Emergency Restoration Actions

During the demonstration, ARA's staff reported that a munitions recovery basket it deployed had impacted and heavily damaged a large coral colony. NOAA and State of Hawaii divers located the site (Figure 11) and conducted an emergency restoration effort to re-attach the coral fragments in an attempt to salvage some portions of the colonies.

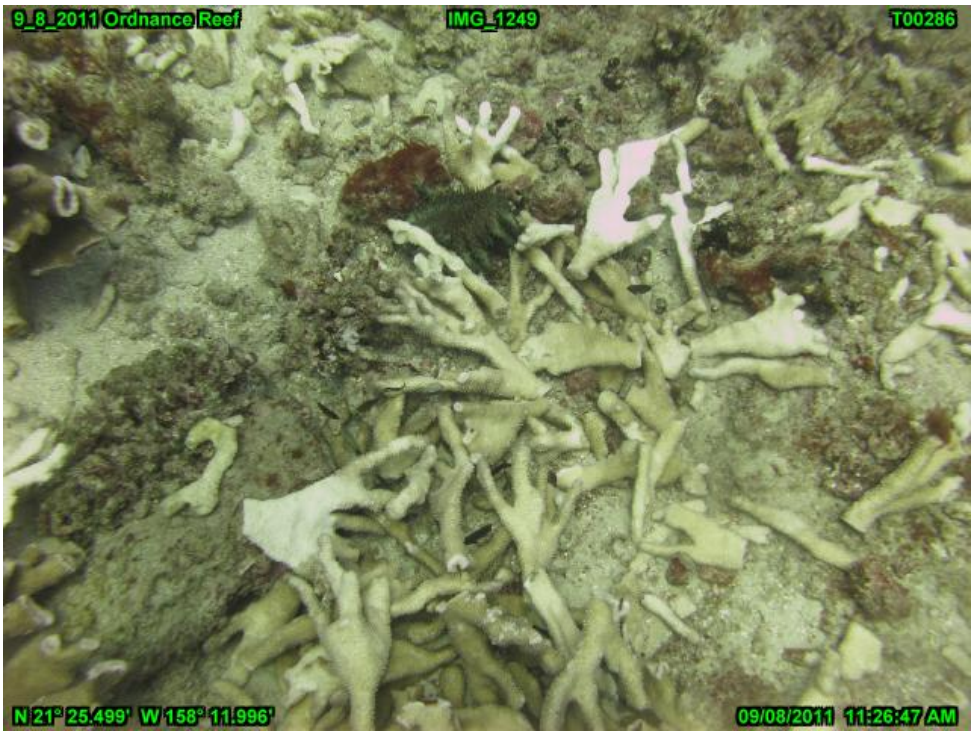

Figure 11. Damaged fragments from *Pocillapora eydouxi* colonies.

NOAA and State of Hawaii divers observed that the basket had damaged two large *Pocillopora eydouxi* colonies (determined from the presence of two distinct base portions). The two colony bases (Figure 11) and as many large fragments (Figure 12) as possible were re-attached to the substrate using cement.

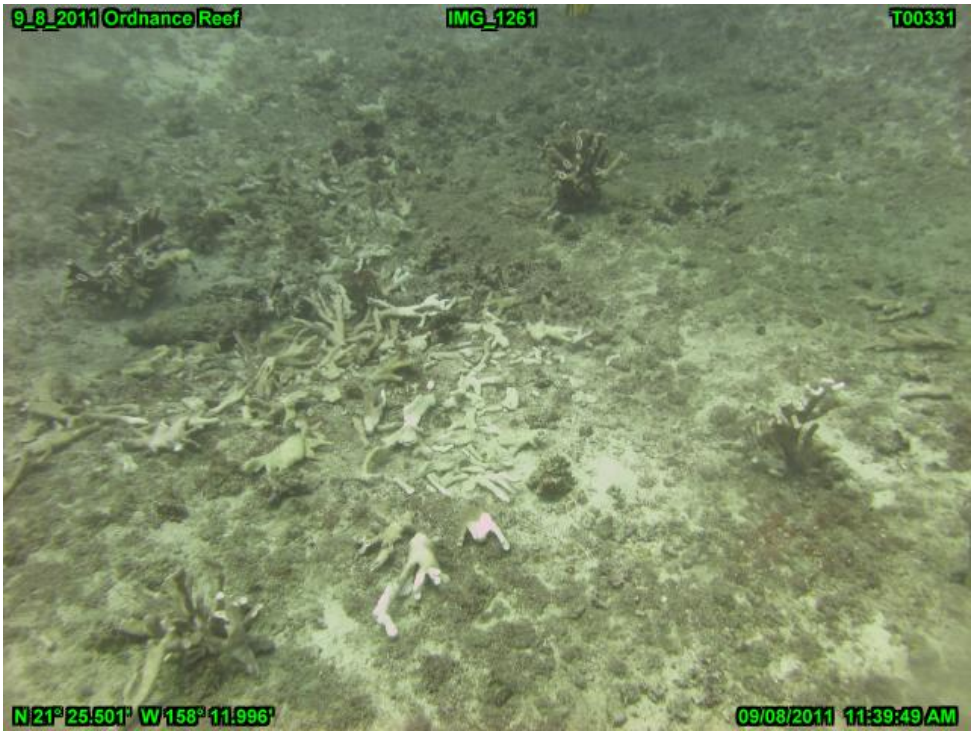

Figure 12. Re-attached coral colony bases as well as branch fragments.

Restoration Options

This report presents three possible restoration options. The options presented are not meant to exclude other restoration possibilities, but merely to present a subset of feasible concepts for consideration. The final restoration option (or suite of options) will be decided based on input from the ORCC and the public. Any substantial effort towards one or more of the listed restoration options will, with a high degree of certainty, provide ample restoration to compensate for the demonstration-related injuries documented.

The restoration projects presented here are suitable for particular injury types to coral reef habitat similar to those resulting from the demonstration. Small to medium scale intermittent injuries, mostly to individual coral colonies, can be successfully restored using the techniques presented.

➢ Orphan Vessel Injury Response

Coral debris, including blocks of coral rock, that is dislodged by vessel groundings can be moved by wave action and can crush, bury or abrade intact corals surrounding a grounding site. Restoration actions would include removal of loose coral rubble, reattachment of corals within the impact area that are still alive and reconstruction of some reef topography by cementing loose coral rock to the reef.

In this project, reef restoration would occur at orphan vessel grounding sites. This would primarily be accomplished by preventing ongoing injury to intact corals that are threatened by coral

debris generated by the grounding incident. Large loose portions of substrate that are a risk to nearby coral colonies would be stabilized using cement, if possible. Smaller loose material that cannot be stabilized and pose an abrasion risk to nearby corals would be removed either by hand or by use of a small scale suction dredge. Restoration crediting would be calculated based on the species and size composition of nearby at-risk coral assemblages.

Additional restoration credits could be gained for re-attaching intact loose colonies if dislodged corals remain in large enough fragments to be suitable for reattachment. Corals suitable for reattachment would be cemented to the substrate in areas that have been cleared of rubble and loose debris that would pose a risk to the survival of the colony. Restoration crediting would be calculated based on the species and size composition or reattached corals.

The same basic restoration process described here could also be applied to reef habitats that are threatened by similar injury-causing factors, such as loose derelict fishing gear and other debris. In all cases, this activity would only be pursued where no viable responsible party exists to do the necessary restoration, hence the term "orphan."

Subsequent effectiveness monitoring would take place after a reasonable amount of time had passed for the evaluation of coral mortality, recruitment, substrate stability and overall ecosystem level effects such as possible encroachment of invasive algae.

➢ Coral Nursery

Coral nurseries have been used effectively in Florida and Caribbean to help offset the losses of Acroporid species. To date, in-water coral nurseries have not been used in Hawaii. Anecdotal evidence from corals growing on mid-water structures, such as fish aquaculture cages, suggests that coral recruitment and growth on the structures could be quite high.

Using a small scale nursery, such as the line nurseries used in Florida, to grow out and transplant corals to injury sites, either at the Ordnance Reef (HI-06) or other impacted sites, would provide restoration crediting to offset the demonstration-related injuries.

Suitable coral colonies would be harvested, processed (paired down to a smaller size, injured tissue removed to prevent infection, etc.), and then attached to the line nurseries. Once attached, the line nurseries the corals could be grown out to larger sizes as needed for restoration.

The nursery would need to be maintained in order to track the growth and health of the coral colonies. Periodic cleaning of the nursery would be needed as well to avoid overgrowth from algae and other fouling organisms.

The availability of suitable donor coral material to start up a coral nursery can be problematic. Coral material would have to be found that would not be taking away from or reducing healthy natural populations. Corals growing on artificial structures scheduled to be removed (aquaculture cages) and corals that have naturally detached and would subsequently undergo mortality are just two possibilities for suitable donor material.

➢ Coral Salvage Project

Corals could be salvaged from circumstances, naturally or artificially induced, where they would otherwise be lost without any compensable restoration or mitigation requirements. These so called "corals of opportunity" would provide restoration crediting if they were saved and rehabilitated to ensure their survivability.

Once the corals are salvaged, a means to ensure long term survival of the colonies should be undertaken. Coral restoration crediting would only be appropriate if the corals salvaged are relocated in areas where they can provide commensurate resource services.

Viable coral salvage projects could be paired with either of the previously mentioned restoration projects. Corals of opportunity could be used to transplant into orphan vessel grounding sites or used as donor material within a coral nursery framework.

Recommended Mitigation Project

Establishing a coral nursery is the recommended restoration project. Loss of a total of 263 coral colonies was attributed to demonstration-related activities, with a total of 872 coral colonies estimated to have been lost due the recovery of munitions. To compensate for this combined loss, developing a small scale nursery to grow out and transplant corals to injury sites, either at Ordnance Reef (HI-06) or other impacted sites, would provide restoration crediting to offset the demonstration-related injuries. The approximate cost of this project, based upon Habitat Equivalency Analysis (HEA), would be $250K. This would cover establishing the nursery and upkeep, out planting and monitoring of coral transplants annually for a period of two years. Estimating a natural growth and mortality from transplanted corals, the nursery effort should fully compensate the public for the lost coral colonies resulting from the Army's technology demonstration. At the end of the two year project, the nursery, which could be taken over by the State of Hawaii, could continue to provide out-plant material for other injury sites on Oahu.