CORAL REEF RESTORATION THROUGH MARINE DEBRIS MITIGATION

Background

Surveys of the NWHI from 1979 to1983 reported relatively pristine reefs, but by 1996 the reefs were suffering from substantial anthropogenic damage, primarily due to the effects of derelict fishing gear. While land-based sources may be responsible for the majority of marine debris in the world's oceans, debris of a maritime origin may pose the greatest threat to ecosystem health in the NWHI. The remote central Pacific location and extensive shallow reefs of the NWHI filter derelict fishing gear originating throughout the Pacific Rim. The North Pacific Subtropical Convergence Zone provides a mechanism for debris accumulation in this region. Much of this accumulated debris is ultimately deposited on the coral reefs and beaches of the NWHI.

The movement of derelict fishing gear across shallow atolls threatens the ecological balance of the reef community. Once derelict fishing gear snags on the NWHI coral reefs, it begins a cycle of destructive activity. Derelict fishing gear modifies the reef structure by damaging the coral substrate that comprises the physical habitat for reef biota. After debris snags on coral reefs, wave action acting on debris breaks the coral heads on which debris is fixed, liberating the debris to subsequently snag and similarly damage additional coral. This action continues until the nets are removed, or become adequately weighted with abraded coral to sink.

Derelict fishing gear also poses a serious and lethal threat to macrofauna in environments where this debris is present. The reef communities of the NWHI include protected species and other wildlife. All marine turtles that occur in Hawaiian waters have documented entanglement records including the endangered hawksbill, olive ridley, and leatherback sea turtles, as well as threatened green sea turtles. Entanglement in derelict fishing gear is also a known cause of mortality to the critically endangered Hawaiian monk seal (Fig. 31). All six extant breeding subpopulations of this seal are located in the NWHI, and this species suffers the greatest entanglement rates (averaging 15 seals per year) of any pinniped (seal or sea lion) reported to date. In addition to marine mammals and sea turtles, seabirds, fish, and crustaceans are also at risk from entanglement in derelict fishing gear, thus broadening the ecological scale on which this waste of resources occurs.

Goals and Objectives

To address these concerns, the CREI conducts a comprehensive multi-agency program to assess, monitor, and mitigate the effect of marine debris on coral reef ecosystems of the U.S. Pacific Islands. The goals of this program are to:

- Assess the amount of marine debris present on the coral reefs of the U.S. Pacific Islands.
- Monitor debris accumulation on the coral reefs and beaches.

- Remove marine debris from coral reefs and beaches.
- Identify source fisheries responsible for debris recovered.
- Evaluate impacts of marine debris on coral reefs and protected species.
- Enhance public awareness and education of marine debris affecting the U.S. Pacific Islands.

Fig. 31. Entanglement in derelict fish gear is a known cause of mortality to the critically endangered Hawaiian monk seal.

Major Research Activities

Assessment and Monitoring Program

Annual *in-situ* surveys to assess derelict fishing gear in the coral reef ecosystems of the NWHI have been conducted since 1996. Surveys from 1996-2000 utilized the NOAA ship *Townsend Cromwell* as the primary support platform. The FY 2000 accomplishments included extensive reef surveys at Pearl and Hermes Atoll and Lisianski during a one-month field season. Reconnaissance surveys were also completed at Kingman and Palmyra Atolls and Jarvis, Howland, and Baker Islands in FY 2000. Since 2001, the CREI has expanded research and mitigation activities through the use of chartered vessels for extended marine debris research cruises. In FY 2001, activities included the use of three chartered ships at sea for three months conducting marine debris survey and removal work at Pearl and Hermes Atoll and Kure Atoll. Ongoing in FY 2002 is continuing work at all NWHI sites using two chartered vessels for a six-month field season. To date, extensive and detailed reef surveys for derelict

fishing gear have been conducted at five NWHI sites: FFS, Pearl and Hermes Atoll, Lisianski, Kure, and Midway Atoll. This work is conducted in partnership with the USFWS, State of Hawaii, and other non-governmental organizations. Key parameters documented *in-situ* during surveys includes type of debris (net or maritime line as well as net type: trawl, seine, gill, etc.), size, distribution, and density. Debris location is noted using GPS and debris is documented by still or video photography.

The most frequent type of derelict fishing gear encountered in the NWHI is trawl netting originating from trawl fisheries operating around the continental shelves of the Pacific Rim (thousands of kilometers from the NWHI). Much smaller amounts of gillnet and seine netting are also found. Debris ranging in size from less than 5-m^2 to greater than 25-m^2 has been documented. Measured debris densities range from 1-162 pieces of debris per km^2. In FY 2000-2001, research also confirmed that areas of greatest debris density at Pearl and Hermes Atoll, Lisianski, and Kure coincide with areas preferentially used by Hawaiian monk seals as nursery grounds, highlighting the need for continued mitigation of this problem to support the recovery of this critically endangered species. Preliminary results from other U.S. Pacific Islands suggest that the preponderance of North Pacific derelict fishing gear accumulates in the NWHI. Derelict fishing gear does not appear to be a significant threat to the coral reef ecosystems of American Samoa or the U.S. Line and Phoenix Islands.

Plans for FY 2003 (pending continued funding) include a 4-6 month field effort of continued extensive debris assessment and removal activity in the NWHI. This will include revisiting previously surveyed sites at Kure, Lisianski, and Pearl and Hermes Atoll to monitor debris accumulation and provide additional data to estimate derelict fishing gear accumulation rates over time. Since there have been unconfirmed reports of debris accumulations on the coral reefs of the northern islands of CNMI, CREI scientists plan to survey these reefs in 2003. Additionally, collections of unknown taxa encountered on debris will be used to document possible occurrence of alien species. After *in-situ* documentation, debris is removed to mitigate coral reef damage and wildlife entanglement as discussed below.

Marine Debris Restoration Program

In concert with marine debris assessment, the CREI conducts a Coral Reef Restoration Program through the marine debris removal from U.S. Pacific Islands. Efforts will focus on sustaining the existing CREI-led multi-agency cooperative efforts to remove marine debris from the coral reefs and beaches of the NWHI. These efforts were initiated in the early 1980s to reduce mortality and morbidity of endangered Hawaiian monks seals observed entangled in these nets an average of 15 times annually. In 1996, these efforts were expanded to include coral reef habitats in addition to NWHI beaches. Debris removal work revealed extensive damage to coral reefs and EFH by marine debris. Debris removal efforts were greatly facilitated in 1998 by partnering with the USCG,

USFWS, NOAA's Office of Marine and Aviation Operations, the UH and Alaska Sea Grant College Programs, Hawaii Coastal Zone Management Program, City and County of Honolulu, UH, Hawaii Metals Recycling, The Ocean Conservancy, Horizon Waste Services Inc., and NET Systems, Inc. This successful partnering earned Vice President Al Gore's National Performance Review (NPR) Silver Hammer Award for innovation and creativity in the Federal government. Since 1996, these cooperative efforts have removed almost 200 tons of marine debris from NWHI coral reefs (Fig. 32). Future activities will continue to focus on multi-agency cooperation from all sectors.

Fig. 32. 200 tons of marine debris removed from NWHI coral reefs since 1996.

Currently, CREI is leading a multiple ship, multi-agency 6-month cooperative marine debris removal effort at Pearl and Hermes Atoll, Lisianski, FFS, Laysan, Midway and Kure. Twenty-four NOAA divers were trained in the specialized skills necessary to remove debris while minimizing additional anthropogenic damage. In addition to marine debris removal, CREI marine debris divers opportunistically disentangle wildlife (Fig. 33). Additional 4-6-month marine debris removal expeditions are proposed for FY 2003. These efforts will focus on prioritizing regions and cleanup strategies to maximize efficiencies and benefits to overall ecosystem health, but depend on new funding.

Fig. 33. NOAA divers disentangle wildlife from marine debris.

As part of the coral reef assessment and monitoring activities of the other U.S. Pacific Islands, marine debris surveys and removal activities will be conducted. Whenever possible, removal activities will continue in partnership with other Federal, state, territorial, and local agencies, as well as many non-government organizations.

Remote Sensing Technologies to Improve Debris Mitigation

The CREI is enhancing collaboration between marine debris and coral reef research by investigating the use of aircraft and satellite-based remote sensing technologies to expand the spatial coverage and improve the temporal resolution of *in-situ* coral reef surveys, including derelict fishing gear components. These efforts are conducted in collaboration with other federal agencies, universities, and the private sector. The CREI assisted the NOS in conducting reconnaissance surveys at select sites in the NWHI using panchromatic and hyperspectral or multi-spectral imaging sensors in FY 2000. More thorough aerial mapping of the NWHI was conducted by NOS in FY 2001. By using different spectral channels it is possible to identify specific spectral signatures of features otherwise indistinct in the visible range. Use of specific channels or a combination of channels will hopefully make it possible to discern between

marine debris, algae, corals, and sand once the ground-truth work links the features to their respective spectral signatures.

Outreach and Education

CREI researchers were leading contributors to the International Conference on Derelict Fishing Gear in the Ocean Environment. The goal of the conference, held August 6-11, 2000 at the Hawaii Convention Center, was to convene international experts to evaluate the sources and ecological impacts of derelict fishing gear on coral reef and other marine ecosystems, with emphasis on the Pacific Ocean, and to recommend mitigation and prevention strategies based on environmental, economic, and political realities. The specific objectives of the conference included:

- Assess and identify new technology for prevention.
- Review sources and impacts of derelict fishing gear.
- Establish international and national partnerships to address the issue of marine debris.
- Increase national and international public awareness of derelict fishing gear by recommending political and educational strategies that will establish a stronger stewardship ethic for all stakeholders.
- Develop recommendations to prevent future impacts to marine ecosystems by derelict fishing gear.

CREI personnel have also contributed to scientific outreach on the problem of marine debris by participation as conference session chairs at the international conferences held by the Pacific Congress on Science and Technology held in July 2001 and 2002 in San Francisco and Tokyo respectively.

Future Plans

Coral Reef Protection Program and Recovery of Protected Species

The HL has proposed a plan to enhance protected species recovery and protect U.S. Pacific Islands coral reef ecosystems consisting of three primary components: 1) identification of derelict fishing gear and its source, 2) remote sensing to track and interdict marine debris at sea before it damages coral reef ecosystems, and 3) public awareness and education. Each of these preventive efforts is aimed at reducing the source of marine debris available to damage coral reef ecosystems and assist in the recovery of protected species.

Efforts are underway to identify the sources of derelict fishing gear based on gear types, materials, and construction methods (Fig. 34). These identification efforts will be increased. National and international efforts must be taken to characterize fishing gear so that the sources of marine debris can be positively identified. A manuscript is in preparation describing in detail parameters of derelict fishing gear recovered from the NWHI and identification of putative

Fig. 34. Identification of derelict fish gear.

source fisheries. Significant amount of marine debris continually circulates around the North Pacific Ocean gyre. CREI and Hawaii CoastWatch oceanographers are using a combination of remotely sensed observations of winds (scatterometers), temperature (AVHRR), sea surface height (altimeters), and ocean color (SeaWiFS) to define regions of oceanic convergence and the likely accumulation of marine debris (Fig. 35). In certain years (notably 1992 and 1998, during which El Niño conditions dominated much of the Pacific basin), the subtropical front crossed the Hawaiian Archipelago, allowing for increased rates of accumulation of marine debris in the MHI. This information will also be used to help identify source regions. CREI researchers are also currently serving as co-Principal Investigators on the first empirical efforts to identify driftnets and other derelict fishing gear at sea using aerial LIDAR and satellite-based synthetic aperture RADAR (SARSAT) by the Alaska GhostNet Project. Finally, recent efforts to educate the public about the marine debris problem will be continued and expanded. Efforts will focus on educating the commercial fishing and maritime industries about the damage to coral reef ecosystems by marine debris and on efforts to minimize future damage by reducing or eliminating the source. All aspects of this plan must involve collaboration with other Pacific Rim countries to ensure the long-term success of coral reef ecosystem conservation and protection in the Pacific Ocean.

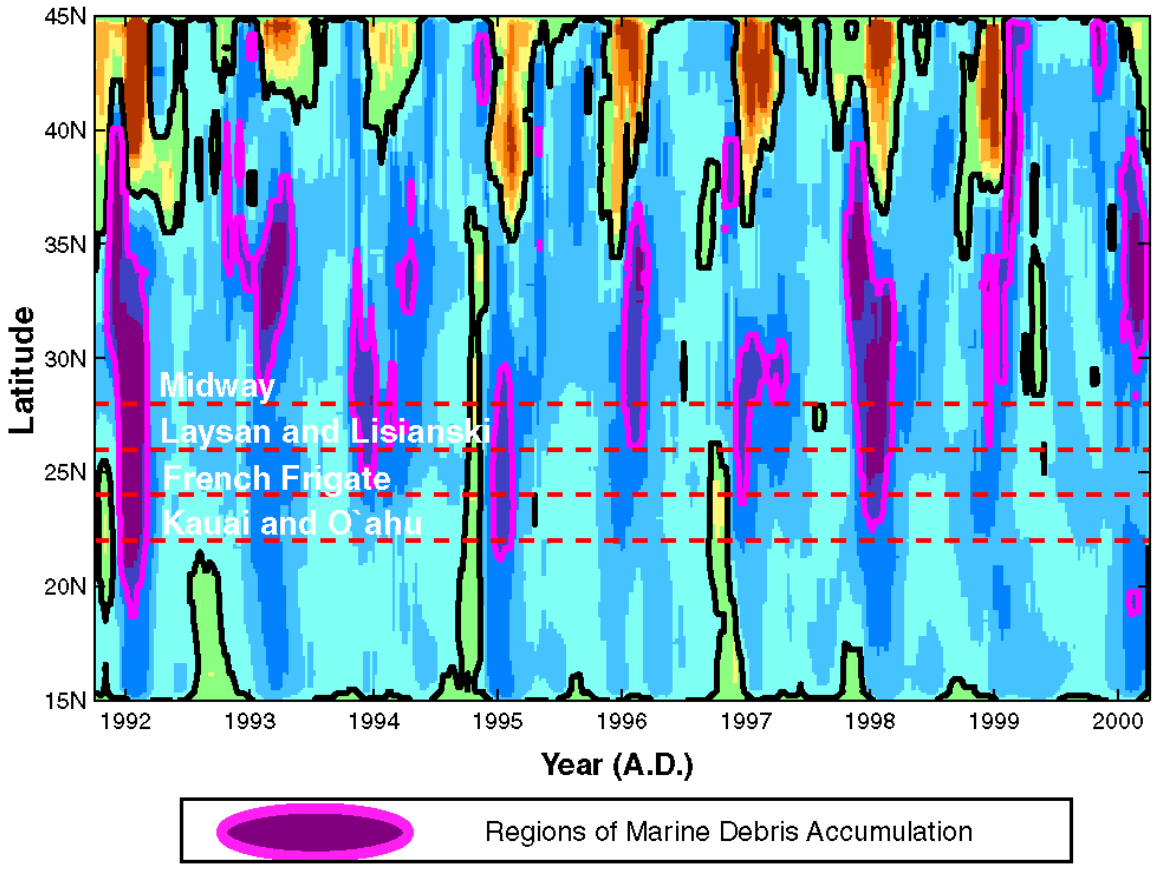

Fig. 35. Regions of oceanic convergence and the accumulation of marine debris.