

# NOAA American Samoa Tsunami-generated Marine Debris and Coral Damage Response Report



US Department of Commerce  
National Oceanic and Atmospheric Administration

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# **NOAA AMERICAN SAMOA TSUNAMI-GENERATED MARINE DEBRIS AND CORAL DAMAGE RESPONSE REPORT**

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## Executive Summary

This report outlines the NOAA marine debris and coral reef damage response undertaken following the September 2009 tsunami that impacted American Samoa. It also addresses Governor Togiola Tulafono's request for a document summarizing actions that remain to be done to ensure recovery of coral reefs and communities in American Samoa. NOAA's response mission described in this report strategically committed limited, existing program resources to deliver the highest possible return on the investment. The response focused on the marine debris damage to Tutuila's coral reefs, which was mitigated through assessment and debris removal. Tutuila is the largest island in American Samoa and is home to about 95 percent of the population. Working for 19 days on site, NOAA program offices coordinated with territorial agencies, surveyed roughly one-third of the coastline of Tutuila for marine debris and coral damage, and removed over four tons of tsunami-generated marine debris that threatened coral reefs. This response was beneficial, but much remains that could be done to address tsunami-generated marine debris impacts and to increase the hazard resilience of American Samoa communities. Similarly, this tsunami event pointed out areas for improvement in Federal responses to future disaster events. It is important to comprehensively respond to and mitigate the impacts of disasters across inland, coastal, and in-water environments.



*Metal roofing material (top) was brought to the surface by free-divers (bottom), by hand or with ropes. (photos courtesy NOAA)*

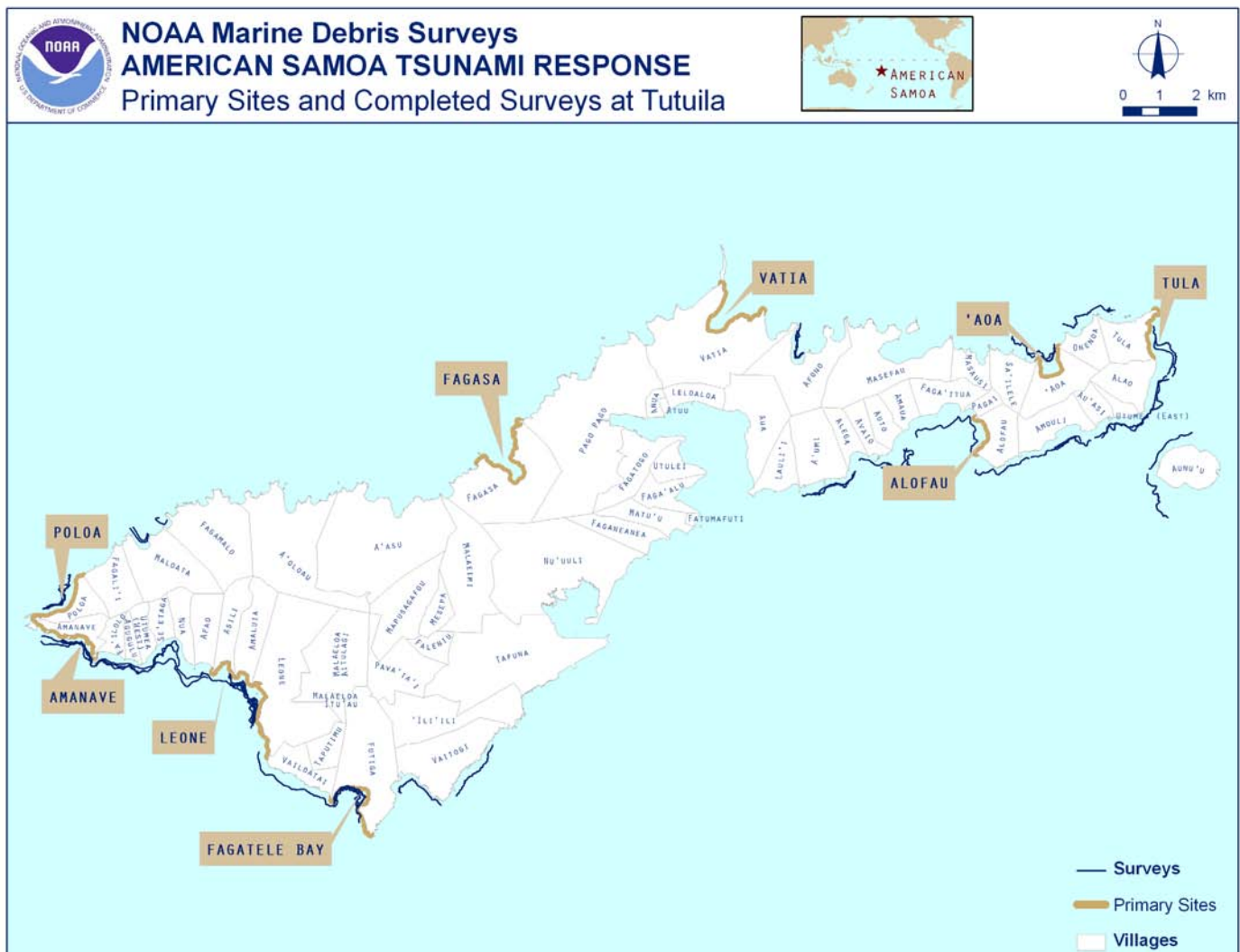
*Fabric smothering coral reef (top) was removed, revealing injury scar (bottom). (photos courtesy NOAA)*

## Overview of Tsunami and Federal Assistance

On 29 September 2009 at 7:04 am Samoa time (SST), the National Oceanic and Atmospheric Administration (NOAA) Pacific Tsunami Warning Center issued a Tsunami Watch and Warning for American Samoa as a result of the magnitude 8.1 earthquake recorded 197 miles southwest of Pago Pago at a depth of 18 km (U.S. Geological Survey). Prior to this formal announcement, at 7:01 am SST, the Weather Service Office in Pago Pago, American Samoa, issued a verbal Tsunami Warning and asked the American Samoa Department of Homeland Security to activate the Emergency Alert System. The Federal Emergency

Management Agency (FEMA) reported American Samoa (population 65,000) was subsequently struck by a tsunami, causing flooding, damage, and 32 fatalities (plus 2 missing). A Presidential major disaster was declared on 29 September 2009 for individual assistance, public assistance, and hazard mitigation.

FEMA's coordination of the Federal assistance to the Territory addressed emergency provision of food, power, and medical assistance; infrastructure damage; hazardous materials removal; and debris removal on land. Concern over tsunami-related damage to coral reefs prompted Governor Togiola Tulafono on 20 October to request FEMA's assistance with marine debris removal and long-term recovery



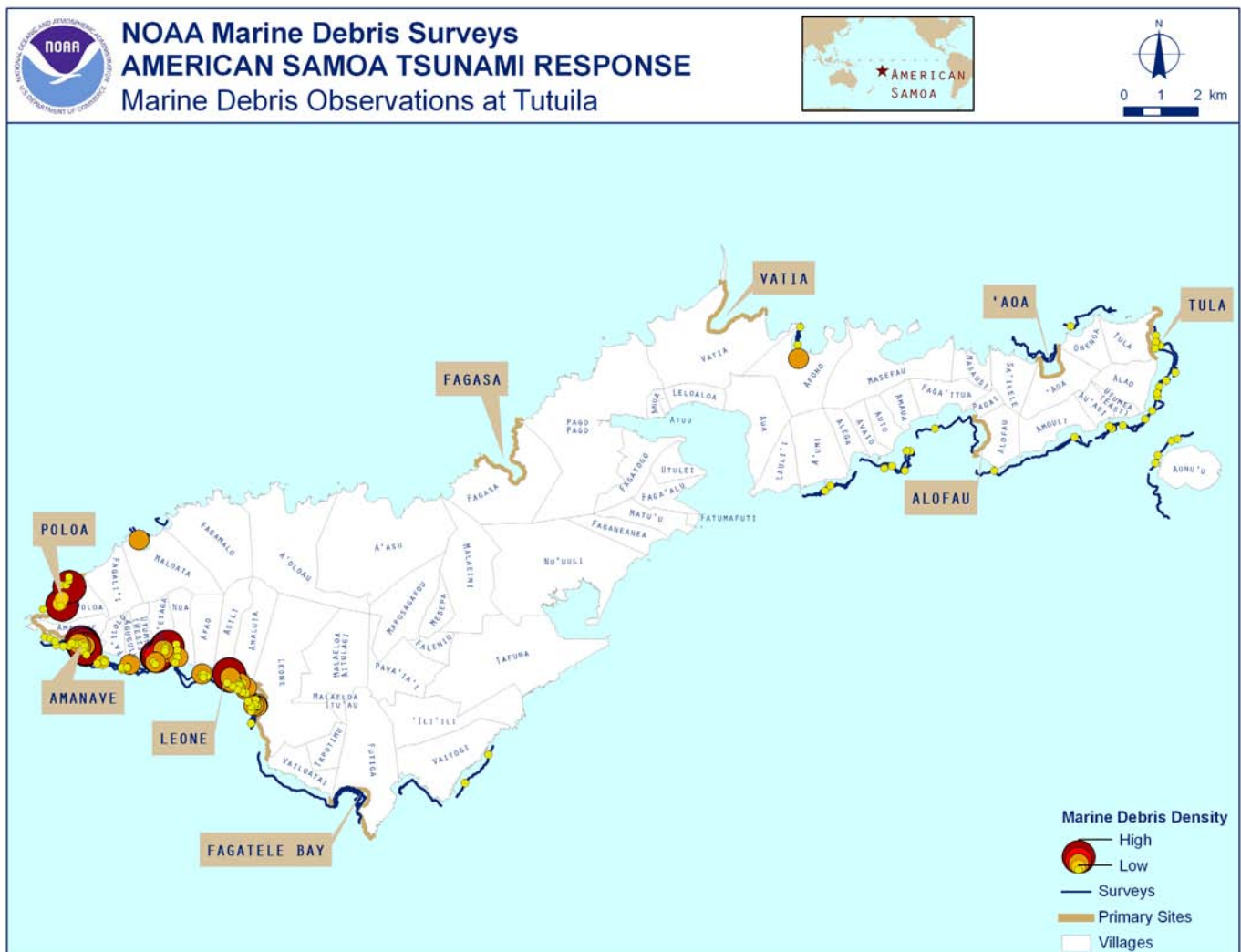
efforts. NOAA's expertise was specifically requested for marine debris removal as well as for coral reef restoration and long-term remediation and restoration activities. NOAA was copied on that letter. In a letter dated 14 November 2009, FEMA declined the request for action on non-hazardous tsunami-generated marine debris.

## NOAA Efforts

The coral reef system surrounding American Samoa serves many functions vital to the safety and way of life of the Samoan people. Healthy reefs serve as a natural buffer to minimize wave impacts and storm surges. The reefs also serve as habitat essential

to healthy fisheries, thus providing the people of American Samoa an inexpensive, healthy source of protein and allowing them to promote and continue a variety of cultural practices, as well as providing for recreational activities.

In October and November 2009, NOAA program offices with expertise in critical need areas that were outlined in the Governor's request—marine debris, coral reefs, and community resilience—met to determine ways to address the requests in three categories: (1) activities already under way or planned that would support tsunami recovery but were not triggered by this event, (2) efforts to respond to this tsunami that could be accomplished with existing resources, and (3) efforts to respond to this tsunami



**Estimated weight (in pounds) of debris removed during NOAA mission, December 9 to 16, 2009.**

Date	12/9	12/10	12/11	12/12	12/13	12/14	12/15	12/16	Totals
<b>Tires</b>	891	1023	1188	66	66	264	759	99	4,356
<b>Roofing</b>	385	32	35	11	595	497	270	235	2,058
<b>Fabric</b>	123	20	5	0	5	30	150	20	353
<b>Household</b>	691	100	150	100	250	250	120	420	2,081
<b>Totals</b>	2,090	1,175	1378	177	916	1,041	1299	774	8,848

that could be accomplished if additional resources were made available. This report describes the marine debris effort and provides a list of potential efforts that, if additional resources were available, could help American Samoa with marine debris removal, coral damage assessment, and longer-term recovery efforts.

Given NOAA's expertise in marine debris assessment and removal in marine environments and FEMA's denial of the Governor's request for assistance with marine debris removal, NOAA offices proposed a short-term effort to specifically address the request for assistance with damage to coral reefs from tsunami-generated marine debris. While NOAA does not have an emergency response reserve, funds from the NOAA Marine Debris Program and Coral Reef Conservation Program were pooled with in-kind services from the Pacific Islands Fisheries Science Center Coral Reef Ecosystem Division and the Office

of National Marine Sanctuaries to allow a targeted effort focusing on three objectives:

- Conduct a strategic assessment of tsunami-generated marine debris in nearshore, high-priority areas.
- When appropriate, perform emergency restoration (righting) of corals toppled by the tsunami that are still alive and viable, at marine debris survey sites.
- Conduct marine debris removal as time, conditions, and debris size permit.

NOAA successfully completed its three tsunami response objectives over a three-week period, working closely with American Samoa territorial agencies. A team of National Marine Fisheries Service (NMFS) and National Ocean Service (NOS) personnel traveled to American Samoa on 29 November and 4 December 2009. Meetings were held with territorial agencies to



*Fabric weight was estimated by volume, and volume was translated into area. (photo courtesy NOAA)*

determine the primary marine debris survey sites on the main island of Tutuila. These determinations were based upon destruction of man-made structures on shore, in-water debris observations, and coral cover.

Operations commenced on 6 December 2009. NOAA surveyed a total of approximately 56 kilometers of coastline, which constitutes 32% of Tutuila's coastline. Surveys took place in seven of nine pre-determined primary survey areas. In the remaining two primary survey areas, water quality, visibility, or high seas prevented dive surveys from being completed. An additional ten opportunistic areas were surveyed.

By 12 December 2009, visual surveys were complete in areas that were easily accessible and had acceptable water quality and visibility. Divers determined that overturned corals were unlikely to benefit from righting because in the ten weeks since the tsunami, the polyps on the overturned surfaces had died. In cases where live tissue remained, it was concluded that attempted emergency restoration would likely cause additional damage or stress to coral colonies. Man-made materials that were swept off the land, on the other hand, were found to be an imminent and ongoing threat to corals, through

breakage, abrasion, and shading. Removal of debris was determined to be the best option for promoting coral recovery and preventing further damage, and that remained the focus of operations through 16 December 2009. NOAA's on-the-ground efforts in American Samoa were suspended on 17 December 2009.

## NOAA Findings

Marine debris was found to be concentrated in dense pockets peppered throughout coral reef habitats. Areas with a combination of built environment on the shoreline, high inundation by the tsunami, and spur and groove benthic habitats were those with the greatest concentrations of marine debris. In cases where coral colonies were still alive and viable but were overturned, the corals were not righted because it was determined that righting them would create more damage. Over four tons of debris was removed in the short time of the NOAA mission, and the majority of debris was removed from the hardest-hit areas in southwestern Tutuila. Using a combination of freedivers and scuba divers, NOAA was able to remove approximately 8,850 pounds of debris from the reef slope. Of this, tires were the heaviest fraction, at 4,350 pounds, with roofing material and household goods each contributing about 2,000 pounds. Fabric, at an estimated 350 pounds, was the lightest component. However, its large surface area and tendency to snag on coral heads made it a particularly damaging component. The fabric collected was estimated to have the potential to cover as much as 4,200 square feet.

In spite of the efforts at removal, a tremendous amount of debris remains in several of the surveyed areas around Tutuila. It is important to remove the debris that was surveyed both where it is currently covering corals and preventing recolonization and where it is adjacent to coral reefs. Storms or other extreme wave events may remobilize debris and cause further damage to coral reefs. In addition



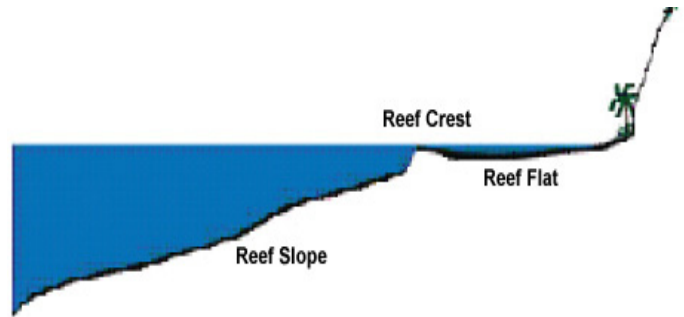
*Debris collected from coral reef environments was offloaded from the ONMS 10-meter boat and stacked on DMWR's pier. (photo courtesy NOAA)*

to the survey sites, some areas outside the primary survey areas were found to have significant debris. For example, the snorkel team completed a brief swim survey at Maloata and found debris, but this area was not identified as a primary survey site. Finally, the NOAA survey team did not survey reef flats around the island. Territorial agencies such as the Department of Marine and Wildlife Resources documented that reef flats have significant amounts of marine debris generated by the 29 September 2009 tsunami; this debris will continue to pose a threat to corals on the reef flat and may gradually move down the reef slope through a combination of wave and tidal forcing.

## Potential Actions

As a direct result of the initial assessment, NOAA has the information necessary to inform a focused recovery plan that will deliver remediation benefits to coastal environments and provide targeted assistance to the American Samoa government in its own efforts to strengthen coastal resiliency.

NOAA has identified potential actions to build on the assessment and removal work that was started and to assist the territory with long-term recovery,



*Morphology of a typical fringing coral reef morphology in American Samoa.*

corresponding to the Governor's requests for FEMA assistance. These actions are grouped within the following topics: surveys and assessments, debris removal, logistics, increasing community resilience, outreach and education, and data and modeling. More details on each of these actions are provided in the appendix.

NOAA has been an active partner with the American Samoa government prior to the tsunami in several areas, including coral reef monitoring, coastal zone management, weather service products, hazard preparedness and mitigation, community resiliency, and marine protected areas. For example, NOAA program offices have worked on tsunami preparedness and public awareness; biennial Reef Assessment and Monitoring Program (RAMP) cruises, which could provide baseline information against which to measure coral damage; and through regional coordination related to risk management, NOAA has developed decision support tools for permitting and land use planning. NOAA will continue to work with the territory in these areas post-tsunami to the extent possible.

The aftermath of this tsunami event shines a light on American Samoa's resilience infrastructure to coastal hazards. NOAA respects American Samoa's developing its own action plan and priorities to address the needs of its people and stands ready to provide technical assistance and operational resources in areas of special NOAA expertise in a coordinated Federal effort. The following lists potential actions



*Tsunami-generated debris on the reef flat can be removed by snorkelers trained in safe removal. (photo courtesy NOAA)*

that could be undertaken to build upon the initial NOAA effort:

**Surveys and Assessments**

- Continue debris surveys with divers
- Consider alternative survey methods

**Debris Removal**

- Continue debris removal on reef slopes and reef flats
- Train personnel on debris removal methods
- Remove tsunami-generated debris on land
- Remove tsunami-generated derelict vessels

**Logistics**

- Repair boat ramps

**Increase Community Resilience**

- Provide permitting assistance
- Build capacity for hazard preparedness and resilience planning
- Develop long-term village recovery and redevelopment plans
- Decrease potential for marine debris generation in future disasters

**Outreach and Education**

- Ensure education and outreach materials have consistent and accurate messages focused on tsunami awareness, evacuation, and land-use planning

**Data and Modeling**

- Acquire lidar data to support a comprehensive tsunami hazard risk assessment

## Lessons Learned

Timely and coordinated response can mitigate the existing damage and minimize the ongoing damage caused by marine debris generated by a tsunami or other disaster event. Removing marine debris will allow for natural recovery of the coral reefs and their functions to protect infrastructure from wave action, support coral reef fisheries, and provide recreation and tourism opportunities.

Coordination with and support of territorial agencies was crucial to the success of the NOAA mission. Events like the 29 September 2009 tsunami occur infrequently and unexpectedly. The initial response and the continuing Federal support for American Samoa reveal significant milestones in the cooperation among Federal agencies that work on coastal hazards. They also point the way for the growth of ever more effective models for collaboration to benefit impacted communities. Response efforts, particularly in ocean-dependent communities, must take place both on land and in the water.

## Appendix

Details on the potential actions are provided below.

### SURVEYS AND ASSESSMENTS

The marine debris surveys conducted by the NOAA team covered just 53% of the coastline in primary areas (15 of 28 km), and 32% of the entire coastline (56 of 175 km). NOAA surveys were carried out from the reef crest seaward to 20 meters depth, omitting the reef flats and depths greater than 20 meters. Much additional area remains to survey.

#### Continue debris surveys with divers

Two of the primary areas targeted for NOAA survey, Fagasa and Vatia, were not surveyed due to weather conditions or water quality. When conditions allow, these areas should be surveyed. Areas outside of those identified for NOAA surveys should also be surveyed if there is potential for tsunami-generated marine debris. In addition, the status of debris in waters deeper than 20 meters remains unknown.

#### Consider alternative survey methods

Side scan sonar, a remotely operated vehicle, or an autonomous underwater vehicle may provide access



*Derelict vessels in Pago Harbor present a safety hazard and may cause damage in future storms. (photo courtesy NOAA)*

to areas where divers cannot go. At a minimum, there are approximately 12 square nautical miles of area that should be surveyed with a method other than divers, including the following areas out to the 20 fathom line. These areas were selected because of the presence of corals, likelihood of debris, and accessibility or water-quality concerns.

- Matuli Point to Cape Matatula
- Masefau Bay
- Vatia Bay
- Fagasa Bay
- Cape Taputapu to Fagamalo

### DEBRIS REMOVAL AND DISPOSAL

While a significant amount of debris was removed from the water offshore of the reef slope in southwestern Tutuila in a short time, much debris remains in the water, threatening the health of coral reefs. The removal of remaining debris is especially critical as storms during the current hurricane season (November through April) can remobilize debris and cause additional injury.

#### Continue debris removal on reef slopes and reef flats

While NOAA divers removed most of the larger debris between the reef crest and 20 meters depth in specific areas, much remains to be removed. Trained and experienced free divers, operating to depths of 10 meters, and scuba divers, operating to 20 meters, can remove, manually or with hand lines, materials such as metal roofing panels, tires, household goods, and fabric. Removal of larger items is more technical in nature and would require more training, equipment, and time.

The NOAA diver surveys were conducted in areas offshore of the reef flat; however, it was clear that debris on the reef flat is being washed over the reef slope. Removal of debris on the reef flat may be easier since shore access is better and water is calmer and shallower. Wave action, tidal cycles, and storms

can all move debris off the reef flat into depths where additional damage can be done and where removal is more difficult and dangerous. Debris on reef flats should be removed as soon as possible.

### **Train personnel on debris removal methods**

Training should be provided for local personnel on safe marine debris removal techniques that do not cause further damage to natural resources.

### **Remove tsunami-generated debris on land**

The Territory could follow up with FEMA to ensure that tsunami-generated debris on land is removed and disposed of. Remaining land debris can be washed into the ocean during storms. It is easier and cheaper to remove and properly dispose of debris while it's still on land.

### **Remove tsunami-generated derelict vessels**

The Territory could follow up with FEMA to ensure the seven derelict and abandoned vessels are removed from the harbor. These vessels may move during storms and cause further damage to harbor structures and vessels, and disrupt commercial activities in the Port.

### **Dispose of debris in a responsible manner**

Coordination with FEMA and the American Samoa Power Authority is advisable to ensure that debris is disposed of in a manner that minimizes impacts on the environment. This may involve disposal in the territory's landfills or shipping off-island.

### **LOGISTICS**

#### **Repair boat ramps**

The lack of functioning boat ramps around Tutuila limited access to areas distant from Pago Pago Harbor. For example, the boat ramp in Fagasa was damaged by the tsunami, and large boulders and rubble blocked the base of the boat ramp. Lack of functioning boat ramps will be a limiting factor in future efforts to survey and remove debris and document coral damage.

### **INCREASE COMMUNITY RESILIENCE**

Increasing resilience throughout the Territory is essential to protecting life, property, and natural resources in the face of future events. Building up social, infrastructure, and environmental systems will allow communities to recover following a



*Tires are frequently used as landscaping materials, but in a tsunami or other inundation event, they may be swept into coral reef environments and cause breakage and abrasion. (photos courtesy NOAA)*

natural disaster. Reaching this goal will rely upon partnerships between Federal and territorial agencies and the villages to assess vulnerabilities, and develop enforceable policies that will guide development for the future.

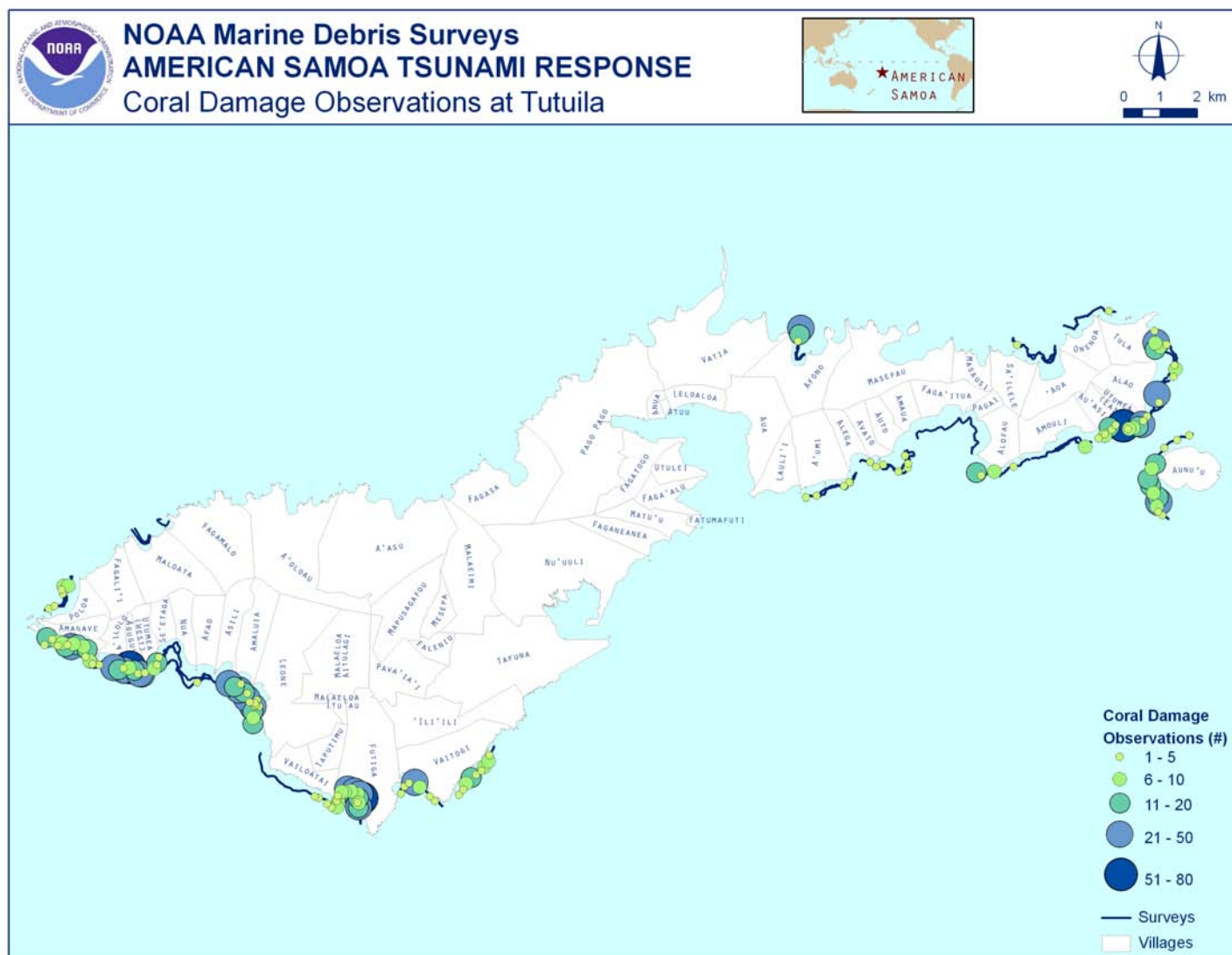
### Provide permitting assistance

The American Samoa Coastal Management Program is overwhelmed with permit application review given the amount of rebuilding that is beginning to occur following the tsunami. While NOAA staff in the Office of Ocean and Coastal Resource Management have identified experts in GIS and long-range planning to spend two weeks in American Samoa

to assist the territory with project review and GIS activities, longer-term planning assistance is also needed.

### Build capacity for hazard preparedness and resilience planning

Increasing the capacity of territorial government agencies to undertake disaster preparedness and resilience planning will lead toward mitigating impacts and reducing recovery time in the face of future events. Natural resources and infrastructure should be clearly assessed to understand how they will be impacted, and agencies should develop the proper policies to reduce the vulnerability to these



systems. Capacity must also be addressed in agencies responsible for preparedness planning, warnings, first response, cleanup, and resilience planning.

### **Support the implementation of long-term village recovery and redevelopment plans**

NOAA can provide assistance toward building and enhancing village-level preparedness and planning to promote community resilience throughout the territory. It is crucial that the Government of American Samoa support the development and implementation of these plans. Developing a community/village action plan using participatory, learning, and action approaches will help to improve community resilience and enhance local participation resulting in mitigation of coastal impacts, improved coral reef conditions, and environmental sustainability.

### **Decrease potential for marine debris generation in future disasters**

- **Tires as landscaping materials:** Tires made up a large proportion of debris sighted in the water. Many of these tires were clearly used as planters or lawn ornaments. Because of their weight and longevity, tires can be harmful in the water and difficult to remove. Through outreach, regulation, recycling incentives, or other methods, decrease the use of tires and other persistent and harmful potential debris items as landscaping elements.
- **Household waste:** Conduct regular shoreline cleanups to decrease the amount of litter and household waste available in the inundation zone to be swept out to sea. Conduct effective outreach to decrease illegal dumping and littering. Enforce regulations prohibiting dumping and littering.
- **Building materials:** Consider planning and permitting to minimize the use in the tsunami inundation zone of building materials likely to

become persistent marine debris if a tsunami strikes.

### **OUTREACH AND EDUCATION**

In February and July 2009, NOAA provided briefs focusing on local preparedness to government agencies. As was evidenced in American Samoa, a tsunami can strike in minutes, demonstrating that education, awareness, and knowing a tsunami's natural warning signs are paramount to saving lives. Disaster preparedness outreach, which included tsunami preparedness, during National Disaster Preparedness Month in September 2009 is credited with maintaining and creating awareness and saving lives.

As American Samoa crystallizes the communications elements of its comprehensive approach to resilience, NOAA's education and outreach specialists can develop materials that support and empower individual action, from minimizing personal use of items that readily become marine debris to thinking ahead to develop personal evacuation routes and plans.

### **Produce education and outreach materials with accurate messaging, utilizing effective media**

Outreach and education are essential components of many of the recommendations listed in this report. Any post-tsunami activity should be considered as an opportunity to conduct outreach and education. Technical expertise on creating video products and coordinating the development of accurate and consistent outreach messages could be offered by NOAA. Outreach materials could be developed on the following topics:

- Earthquake and tsunami awareness and education
- Threats related to earthquakes and tsunamis
- Evacuation planning
- Coastal land use planning
- Marine debris threats and recovery
- Coral reef monitoring and restoration

## DATA AND MODELING

### **Acquire light detection and ranging (lidar) data to support a comprehensive tsunami hazard risk assessment**

Current tsunami risk zones for American Samoa are based on elevation contours, but as evidenced by the 29 September 2009 tsunami, the impact varied heavily across coastal areas. To adequately prepare for a tsunami, emergency managers need access to accurate tsunami hazard risk data. A comprehensive tsunami hazard risk assessment would identify earthquake sources that could potentially generate a tsunami and have the greatest impact on American Samoa. NOAA has plans and resources to conduct a tsunami hazard risk assessment but lacks high-resolution topography and bathymetry data to complete the study. Supporting the acquisition of lidar data will allow NOAA to build high-resolution digital elevation models that will support tsunami forecasting and modeling efforts.



*Effective outreach can save lives. (photo courtesy NOAA)*



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