American Samoa
Passive Acoustic Monitoring Site ROSE
Rose Atoll, American Samoa

Ecological Acoustic Recorder (EAR) 14-March-2008 to 16-July-2009

Level 1 Analysis of Passive Acoustic Observations[1]

Synopsis

This document provides a level 1 analysis of the data obtained from ecological acoustic recorder (EAR) unit 9300638B041 deployed at Rose Atoll from March 12th 2008 to March 4th 2010. The EAR unit recorded acoustic data from March 14th 2008 to July 16th 2009. This initial report contains background information about the site, time-series of total acoustic energy, and analyses of event-triggered recordings.

Background

Monitoring the changing status of coral reef environments and associated biota is a critical management need and a considerable technological challenge, especially on reefs in remote locations. The Pacific Islands Fisheries Science Center (PIFSC) Coral Reef Ecosystem Division (CRED), in partnership with the Hawaii Institute of Marine Biology (HIMB), is using natural ambient sounds as a way to characterize the activity of marine organisms on coral reefs and in surrounding waters. By deploying a device known as the Ecological Acoustic Recorder (EAR), a cost-effective tool for recording biological and anthropogenic sounds, CRED investigates and monitors the presence and activity of sound-producing marine life and human activity. The EAR can be left in place unattended for up to two years, depending on the instrument's configuration. Passive acoustic observations are typically not compromised by bio-fouling. The EAR records the local ambient acoustic environment on a programmed schedule and is also triggered to record by high amplitude transient events, such as engine noise from passing vessels.

This level 1 report is the product of an initial analysis of the EAR dataset from EAR unit 9300638B041 deployed at Rose Atoll on the outer north-east side of the channel of the atoll from March 12th 2008 to March 4th 2010. The report includes a time series of total acoustic energy, an analysis of the event-triggered recordings, and a discussion of results. A subsequent level 2 report will include an analysis of additional concomitant variables collected in conjunction with the EAR that may include tidal phases, episodic storms, wave events, temperature, primary productivity, etc. The level 2 report will also include an analysis of cetacean vocalizations and a more detailed analysis of vessel occurrence. A level 3 report will describe unique fish sounds that have been isolated during bioacoustic analysis. The level 3 report will discuss the temporal variability in occurrence of these sounds and present summary tables and graphic products. A final level 4 report will be an integrative study comparing data from multiple years and multiple EAR monitoring sites

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at island or archipelagic scales. It is anticipated that level 4 reports will take the form of manuscripts for publication in peer reviewed scientific journals.

Deployment Site

American Samoa is the only US Territory south of the equator and is located east of the International Date Line in the Pacific Ocean (National Park Service, 2004). The total land area of American Samoa is 76.1 square miles (197.1 km^2), it includes five volcanic islands (Tutuila, Aunu'u, Ofu, Olosega, Ta'u) and two remote atolls (Rose, Swains) (Craig, 2009).

Rose Atoll is an uninhabited atoll located at the far eastern end of the American Samoa Archipelago, approximately 186 miles (300 km) east of Tutuila Island (Figure 1). Four other passive acoustic monitoring sites (ABAY, FBAY, NPAS1, and NPAS2) are currently maintained in the near-shore regions of Tutuila Island (Figure 1).

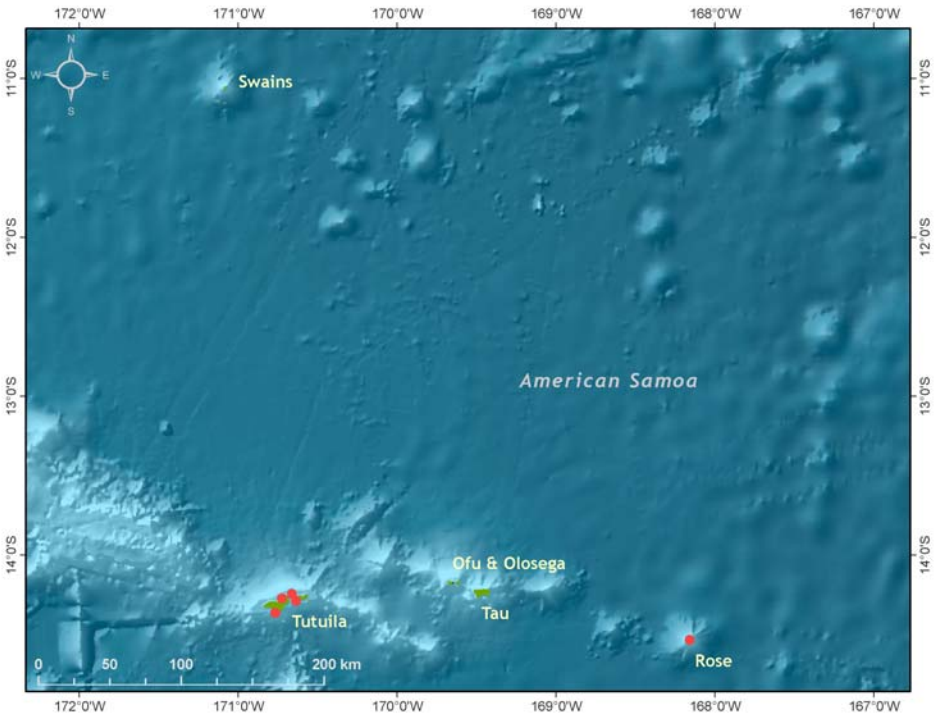

Figure 1. Currently there are five Ecological Acoustic Recorder (EAR) sites located in the American Samoa jurisdiction, four at Tutuila Island and one at Rose Atoll.

Rose Atoll (Figure 2) encompasses an area of 39,066 acres and was declared a National Wildlife Sanctuary in 1973. In 2009 deep ocean waters extending 50 miles seaward from Rose Atoll were protected from fishing and the area was designated the Rose Atoll Marine National Monument (Craig, 2009).

Rose Atoll supports 5 native plant species, 21 bird species, 2 geckos and 2 sea turtles (Craig, 2009). The barrier reef encloses approximately 6.5 km^2 (~1600 acres) of lagoon habitat, with a 40 m wide channel located in the northern corner of the atoll (Brainard et al, 2008). According to 2006 Coral Reef Ecosystems Division towed-diver benthic surveys, the location of the EAR deployment is in an area with 10 – 20 % live coral, 1-5 % stressed coral, 6 – 10% fleshy macroalgae and 31-50 % crustose coralline red algae. Mean density of giant clams within the lagoon declined from 2004 to 2006, leaving open ongoing speculation about poaching. Fish biomass surveys from 2002-2006 found the highest recorded biomass in American Samoa at Rose (2.1 ha^{-1}). Reef predators were more common inside the lagoon, while herbivores were more abundant on the southwest forereef (Brainard et al, 2008).

EAR unit 9300638B041 and associated salinity-temperature recorder (STR) 39292520901 were deployed on the north-east side of the channel at Rose Atoll Marine National Monument (Figure 2) at a depth of 15.2 meters. Following the recovery of the instruments, the EAR unit was replaced by EAR 9300596B113 on March 4th 2010.

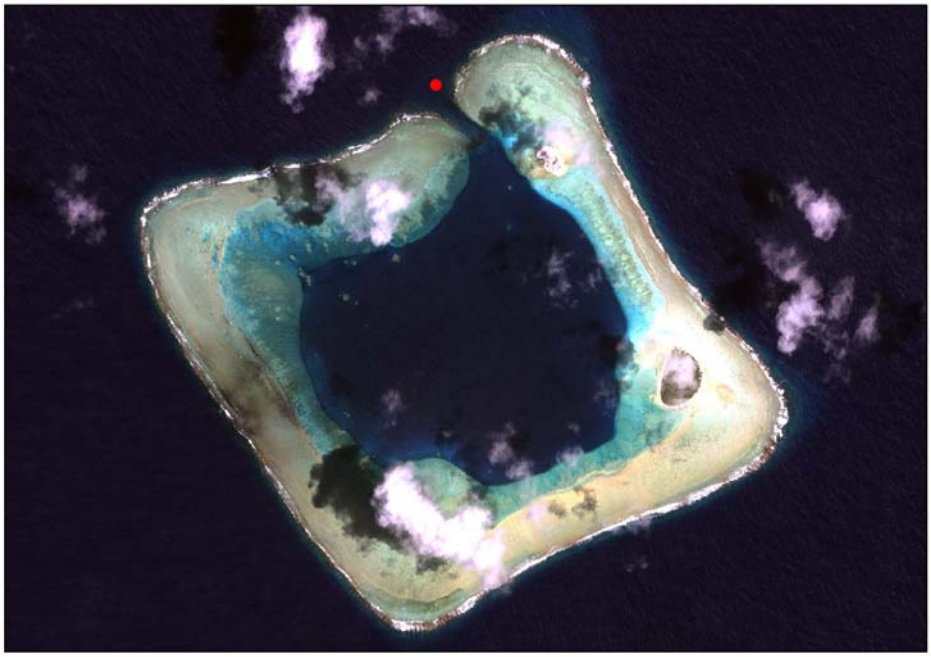

Figure 2. EAR monitoring site ROSE (red dot) is located on the north-east side of the channel at Rose Atoll National Monument.

Total acoustic energy

A time series of total acoustic energy provides a synoptic view of the major trends and variability of the acoustic activity at this site, as seen in Figure 3. The major source of ambient acoustic energy is from snapping shrimps, such that periodic variability can be

attributed to changes in their activity levels. Other contributing sources to ambient sound levels include vessel engines, whales, rain, and fish. Sporadic spikes in ambient acoustic energy levels represent episodic events involving one or more of these sources.

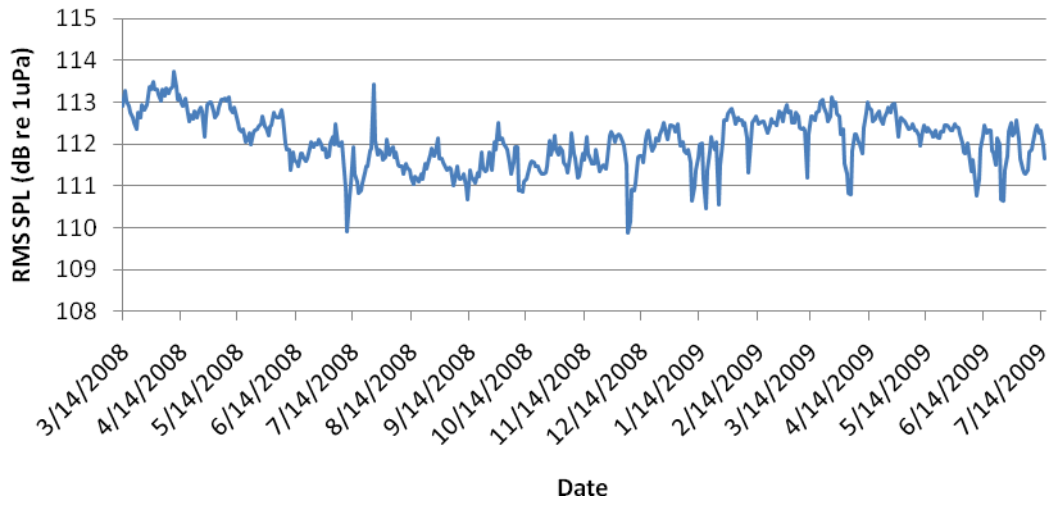

Figure 3. Daily average of ambient acoustic energy at site ROSE.

Total acoustic energy varies on temporal scales ranging from daily to seasonal. The acoustic energy record, as obtained from the duty-cycle (periodic) recordings made by the EAR, shows strong diel variability. Root-mean-square (RMS) sound pressure levels (SPL) are 1-2 dB higher at night than during the day, where nighttime is defined as the four-hour period from midnight to 4 AM and daytime is defined as the four-hour period

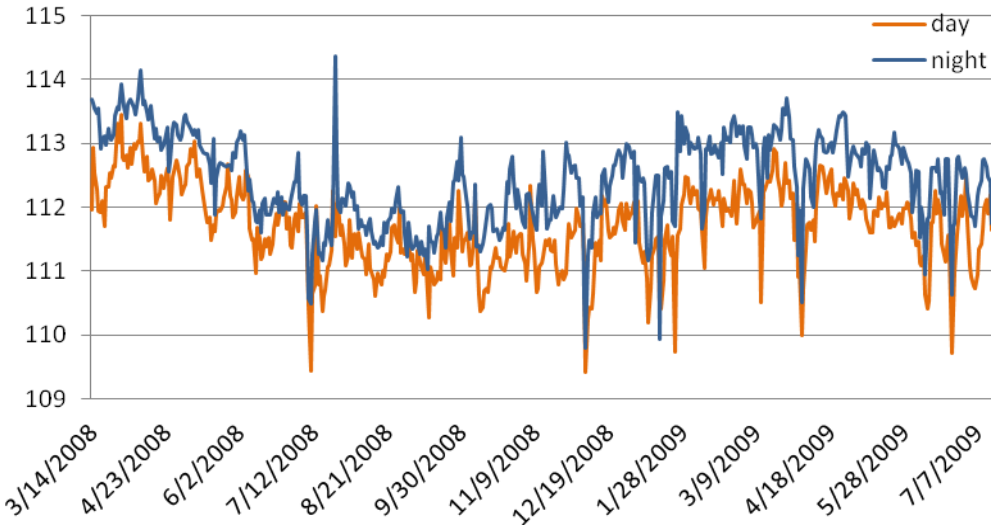

Figure 4. Average night and day sound pressure level (dB) at passive acoustic monitoring site ROSE, American Samoa.

from noon to 4 PM (Figures 4, 5). There is a second slight peak in SPL at midday (10:00-11:00) (Figure 5). In addition, there is evidence of periodic variability on the scale of several weeks (Figure 4). The change in levels over the course of the deployment suggests slight seasonal variability in snapping shrimp activity at this site (Figure 4). This contrasts with several other sites observed throughout the Pacific (including Fagatele Bay on the south side of Tutuila Island) where seasonal trends are more pronounced.

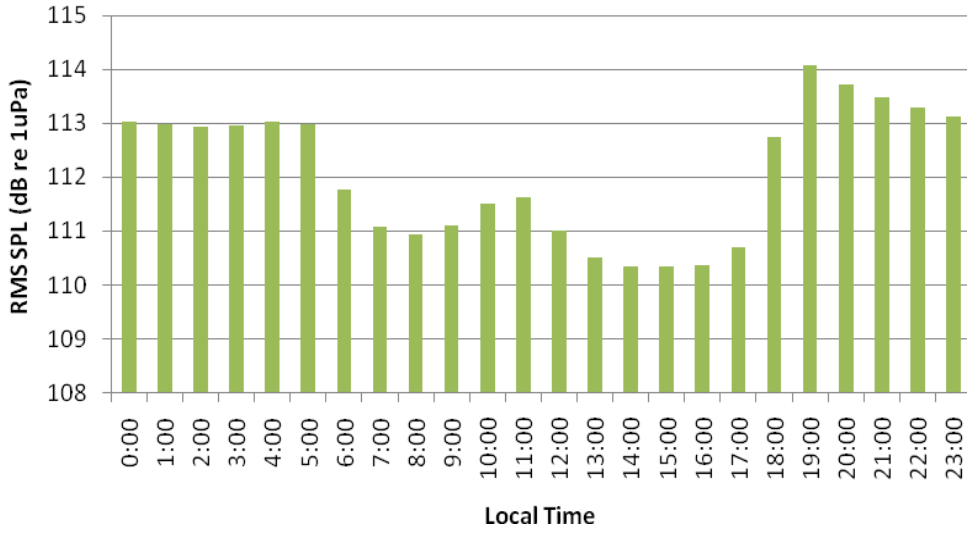

Figure 5. Averaged hourly sound pressure level at site ROSE, American Samoa.

Event-triggered recordings

An analysis of all the event-triggered recordings provides usage patterns of motorized vessels, cetaceans, and other acoustic sources. Figure 6 shows the classification of event triggered recordings at the site. Each vessel event recording is linked to the date/time of the recording to generate a plot of vessel occurrences in the vicinity of the monitoring site

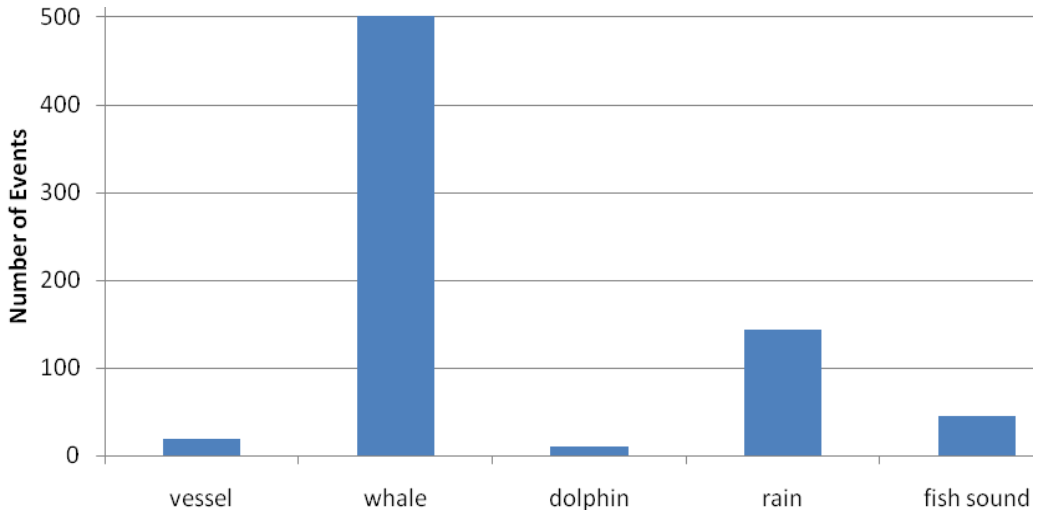

Figure 6. Classification of event detections at monitoring site Rose Atoll, American Samoa from March 2008 to July 2009.

by time a day (Figure 7) and by month of year (Figure 8). Similar analyses, not included in this report, can be performed on the other types of events (rain, cetaceans, fish sounds, etc). The complete record of event triggered vessel detections is included as Table 1.

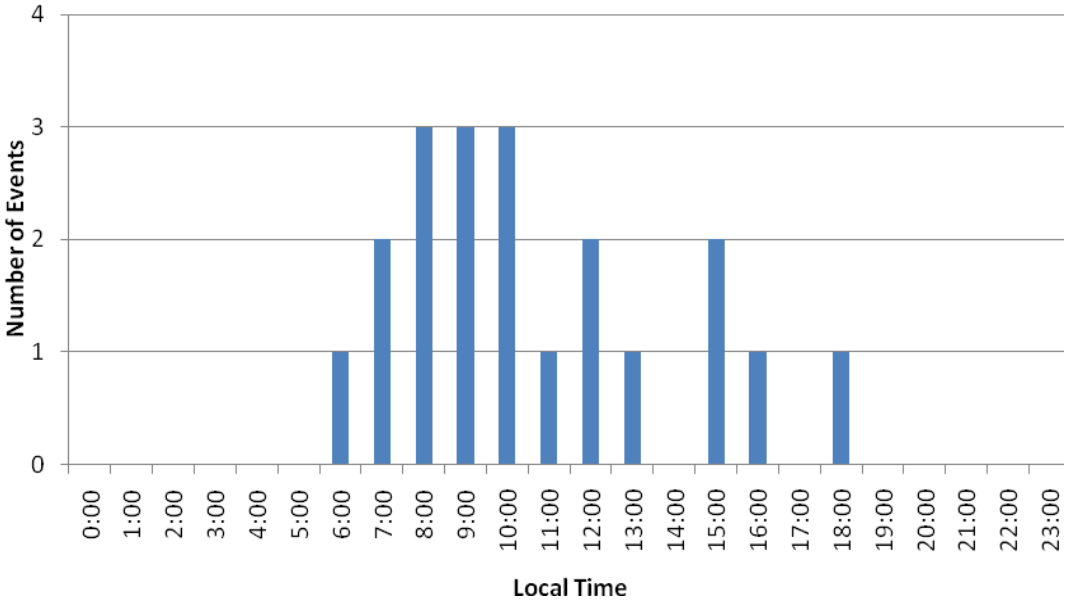

Figure 7. Vessel events classified by time of day (local time).

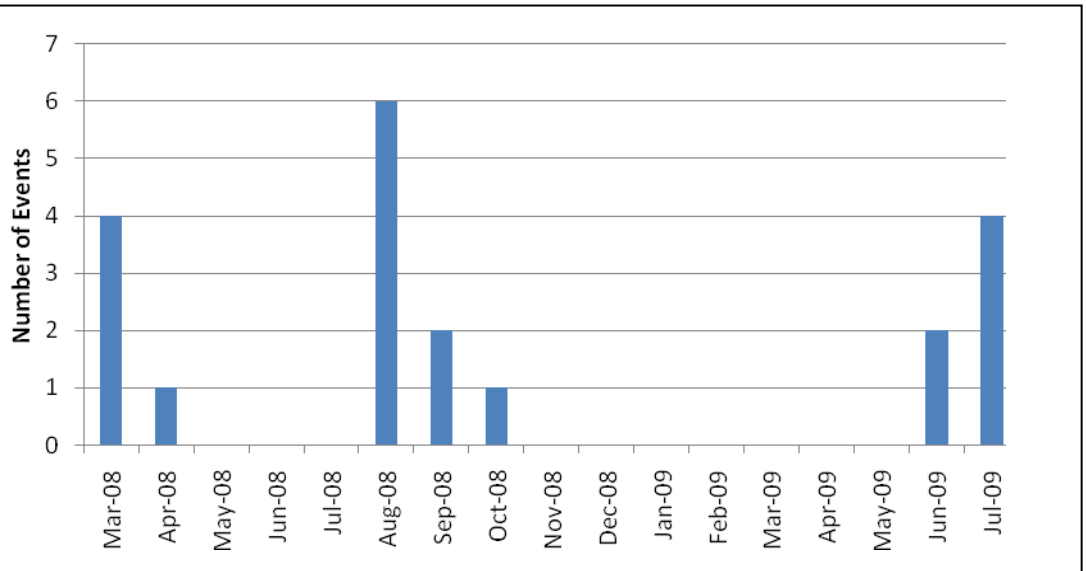

Figure 8. Vessel events classified per month.

Table 1. UTC and local date and time of vessel events at site ROSE, (Rose Atoll National Monument, American Samoa) from March 2008 to July 2009.

UTC		Local (UTC -11)	
Date	Time	Date	Time
3/14/2008	23:42	3/14/2008	12:42
3/15/2008	0:05	3/14/2008	13:05
3/15/2008	2:07	3/14/2008	15:07
3/14/2008	2:51	3/14/2008	15:51
4/27/2008	5:40	4/27/2008	18:40
8/6/2008	18:33	8/6/2008	7:33
8/6/2008	20:37	8/6/2008	9:37
8/6/2008	20:57	8/6/2008	9:57
8/25/2008	23:13	8/25/2008	12:13
8/26/2008	19:22	8/26/2008	8:22
8/27/2008	20:51	8/27/2008	9:51
9/25/2008	17:33	9/25/2008	6:33
9/25/2008	19:40	9/25/2008	8:40
10/1/2008	21:54	10/1/2008	10:54
6/22/2009	18:17	6/22/2009	7:17
6/22/2009	19:41	6/22/2009	8:41
7/10/2009	21:01	7/10/2009	10:01
7/11/2009	21:27	7/11/2009	10:27
7/13/2009	3:55	7/12/2009	16:55
7/13/2009	22:52	7/13/2009	11:52

Discussion

The EAR unit was deployed on March 12th 2008 and recovered on March 4th 2010. The unit recorded acoustic data from March 14th 2008 to July 16th 2009. This unit contained double the amount of batteries of previous EAR recorders, allowing for a longer deployment.

Rose Atoll National Monument is a marine protected area, where managers face difficulties in monitoring anthropogenic impacts to the remote ecosystem. The EAR provides an idea of the frequency and timing of human activities as revealed by motorized vessel presence in the area.

During the 17 month period of recorded data, there were 20 event-triggered recordings of vessels in the vicinity of the monitoring site. The greatest vessel activity was observed during the month of August (Figure 8). The vessel activity at the site happened between 6 AM and 6 PM (Figure 7). The four vessel detections that occurred in March coincide with the time period that the NOAA research vessel Hi'ialakai was in the area. The vessel-triggered event detections probably represent only a fraction of the traffic recorded by the EAR. Vessels transiting at a distance or at a slower speed (and therefore quieter) will not trigger the EAR. However, these may have been recorded during scheduled

recordings, which occurred every 15 minutes. A Level 2 analylsis, which involves a closer inspection of these recordings, will provide a more complete assessment of vessel traffic at Rose Atoll.

The most prevalent sounds that triggered the event detection on EAR unit 9300638B041 were humpback whale signals with 501 events (Figure 6). The frequency of whale signals indicates a considerable amount of whale activity in the area. This is most likely due to migrating humpback whales that feed in Antarctica in the summer months and migrate north to warmer waters for the winter months. Based on these preliminary data, Rose Atoll appears to be a wintering ground for South Pacific Humpback whales. The seasonal presence of humpback whales in American Samoa has been previously reported to be from August to October (Craig, 2009). The passive acoustic record indicates that humpback whales were present at Rose Atoll for a somewhat longer period, from July to November. Further analysis of the EAR's duty-cycle recordings will help establish a more precise date of arrival and departure of whales and reveal periods of peak presence.

Snapping shrimp, the dominant source of acoustic energy overall, showed greater acoustic activity at night than during the day, which is consistent with other EAR recordings in American Samoa and throughout the tropical Pacific. However, seasonal variability at the ROSE site was not as pronounced as at other EAR sites in American Samoa. It is not clear at this point what factors contributed to this difference. A more detailed comparative analysis of oceanographic variables may provide additional insights. Interestingly, multiple downward spikes in the total acoustic energy record indicate that snapping shrimp activity was periodically perturbed. Similar decreases have been observed at other locations, such as Kure Atoll in the Northwestern Hawaiian Islands. These periods of reduced activity appear to be tied to storm events. Further analysis of these periods could provide more information about abiotic events that may be affecting the reef ecosystem. Finally, the secondary period of acoustic activity observed between 10 and 11 AM in Figure 5 is a novel pattern not previously seen at other sites. Typically, ambient noise levels steadily decrease towards a minimum during mid-day and then increase again during evening hours, reflecting the diel activity level of snapping shrimp. The pattern seen at Rose Atoll deviates from this considerably and merits further analysis to establish the cause.

Note:

This report is distributed to NOAA offices and resource management agencies of the local jurisdiction. Due to the potentially sensitive nature of this data and to prevent vandalism or theft of the deployed instruments, discretion is advised when re-distributing the information contained in this report.

Contact Information:

The Ecological Acoustic Recorder (EAR) program is a collaborative effort of the Pacific Islands Fisheries Science Center and the Hawaii Institute of Marine Biology. For more information please visit the following URL or contact the following individuals.

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